

Rec'd 6/23/77

Vol.1, No.1

Oct 1976

(NITS) AD-A034166

ANSI #75-181 to #75-186

ANSI #76-1 to #76-70

ANSI #77-(none)

**BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION**

A Digest of Current Literature

**A Quarterly Publication
Produced for
Office of Telecommunications Policy
and
United States Navy**

*Literature Selected and Abstracted
by
Biomedical Group, Science Information Services Department*

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CURRENT LITERATURE

4500

EFFECTS OF MICROWAVES ON THE TWENTY-FOUR HOUR RHYTHM AND TWENTY-FOUR HOUR URINARY EXCRETION OF SEVENTEEN HYDROXYCORTICOIDS AND SEVENTEEN KETOSTEROIDS (SYMPOSIUM SUMMARY). (Eng.) Szady, J. (Postgraduate Medical Center, Military Medical Acad., ul Szsaserow 128, Warszawa 60, Poland); Siekierzynski, M.; Dziuk, E.; Jedrzejczak, W. W.; Czarnecki, C. *J. Microwave Power* 11(2): 139-140; 1976.

The urinary excretion of 17-hydroxycorticoids (OHCS) and 17-ketosteroids (KS) was determined in subjects exposed to microwave radiation. Investigations were carried out in two groups. Group I comprised 12 male subjects aged 20-22 years, working under exposure to microwave radiation pulse-modulated at different frequencies, used in radiolocation and at a mean energy beam density of 2-60 W/m². Group II (control) contained 15 males of the same age not exposed to microwave radiation. In all subjects the urinary excretion of 17-OHCS (Porter-Silber method) and 17-KS (Norymberski-Zimmerman method) was determined, and changes in the 24-hour rhythm of excretion of these hormones were analyzed. The determinations were performed at four-period time intervals during 48 hours, i.e., on a workday and the following day. The results failed to demonstrate differences in 17-OHCS and 17-KS excretion between these groups, and the 24-hour rhythm of excretion of these hormones corresponded to the normal physiologic rhythm. (No refs.)

76-2
4501

COMPARATIVE STUDY OF THE ACTION OF THREE TYPES OF MICROWAVE FIELDS UPON THE BEHAVIOR OF THE WHITE RAT (SYMPOSIUM SUMMARY). (Eng.) Servantie, B. (Ecole d'Application du Service de Sante pour la Marine--Centre d'Etudes et de Recherches Biophysiques appliquees a la Marine, 83800 Toulon Naval, France); Gillard, J.; Servantie, A. M.; Obrenovitch, J.; Bertharion, G.; Perrin, J. C.; Creton, B. *J. Microwave Power* 11(2): 145-146; 1976.

Behavioral perturbations induced in the white rat were studied after two weeks exposure to 2.45 GHz continuous wave field, 9.4 GHz, 0.15 μ sec, 2000 Hz and 9.4 GHz, 0.5 μ sec, and 1000 Hz microwave fields. Rats were first exposed to a 9.4 GHz field modulated with 2000 Hz, 0.15 μ sec pulses, with a low average power density (0.7 mW/cm²). Their behavior was modified: in control animals, locomotor activity, emotivity, and watchfulness decreased during the test, while exploratory activity increased; in irradiated animals; locomotor activity remained uniform, watchfulness at first increased then decreased, and exploratory activity increased more slowly. The same test was used to compare the action of three different fields: a 2.45 GHz continuous wave field with a power density of 5 mW/cm²; a 9.4 GHz pulsed field with 0.15 μ sec pulses, 2000 Hz pulse repetition frequency, and an average power density of 0.7 mW/cm²; a 9.4 GHz pulsed field with 0.5 μ sec pulses, 1000 Hz pulse repetition frequency and an average power density of 0.7 mW/cm². After 15 days of exposure to a field the rats were subjected to the test. The 2.45 GHz continuous wave field and the 9.4 GHz 0.15

0.5 μ sec pulsed field produced only weak alteration: behavioral alterations; on the contrary, the 9.4 GHz μ sec pulsed field produced only weak alterations. The theoretical values of the fields into the rat head were computed using data from the literature. It is postulated that the action of microwave fields on the behavior of rats is linked to the peak power density and not to the average power density. Moreover, this action seems to be independent of the modulation of the field. (No refs.)

76-3
4502

BIOLOGICAL MEASUREMENTS IN RODENTS EXPOSED CONTINUOUSLY THROUGHOUT THEIR ADULT LIFE TO PULSED ELECTROMAGNETIC RADIATION. (Eng.) Baum, S. J. (Armed Forces Radiobiology Res. Inst. Defense Nuclear Agency, Bethesda, MD 20014); Ekstrom, M. E.; Skidmore, W. D.; Wyant, D. E.; Atkinson, J. L. *Health Phys.* 30: 161-166; 1976.

Possible late effects in Sprague-Dawley rats continuously exposed to a total of 2.5×10^3 pulses of electromagnetic pulse (EMP) for 94 weeks of their adult life were investigated. The EMP generator produced 5 pulses/sec for 2.5×10^3 pulses and a maximum electric field strength of 447 kV/m. Blood chemistry, chromosomal damage, red blood cell production, fertility and reproductive capabilities, blood and bone marrow cellular concentration, and appearances of tumors or other defects were monitored. Exposed rats and controls showed no differences in nucleated bone marrow. The final combined mean number of nucleated cells/mm³ of bone marrow was $8.1 \times 10^5 \pm 10^5$. Early in the study exposed rats showed an increase in the number of reticulocytes, but this difference disappeared in the last 25 weeks of the study. The incidence of tumors was similar for both groups. Rat pairs exposed to 3.4×10^7 EMP showed no loss of fertility and no anatomic abnormalities were recorded for progeny. In effect, EMP was believed to pose no biologic hazard to the rodents, although it is difficult to prove that minute somatic changes had not occurred that could be of future deleterious consequences. (9 refs.)

76-4
4503

EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON *PHYSARUM POLYCEPHALUM*. (Eng.) Goodman, E. M. (Univ. Wisconsin-Parkside, Kenosha, WI 53140); Greenebaum, B.; Marron, M. T. *Radiat. Res.* 66(3): 531-540; 1976.

Effect of extremely low frequency (ELF) electromagnetic fields (EMF) was studied on microplasmodia of the slime mold *Physarum polycephalum*. Experiments included observations of vegetative growth, spherulation or encystment, sexual life cycle, and protoplasmic streaming. Ten experimental plates (versus 10 controls) were continually subjected to a particular EMF, then the mitotic cycle ascertained by ethanol fixed smears. The ability of plasmodia to form spherules or to encyst was determined by pigment extraction. The ability of plasmodia to sporulate and germinate, and then fuse to form plasmodia was studied in experiments on the sexual cycle. Protoplasmic streaming was determined by the oscil-

latory period of four streaming channels and choice of 4-10 channels per culture. ELF EMF exposures of 75, 60, and 45 Hz, 2.0G, 0.7 V/m caused lengthening of the mitotic cycle and slowing of shuttle streaming at 14, 90, and 120 days of exposure, respectively. These results may indicate that mitotic delay is frequency dependent. Delay in cycle may be due to interference with the mitotic cycle. Threshold intensities for affect are between 0.4 and 2.0 G, and 0.15 and 0.7 V/m. Mitotic delay is reversible. EMF had no significant effect on ability to form spherules or encyst, but delay in nuclear division was noted. (17 refs.)

76-5

4504 USE OF 300-MSEC MICROWAVE IRRADIATION FOR ENZYME INACTIVATION: A STUDY OF EFFECTS OF SODIUM PENTOBARBITAL ON ACETYLCHOLINE CONCENTRATION IN MOUSE BRAIN REGIONS. (Eng.) Modak, A. T. (Univ. Texas Health Science Center at San Antonio, San Antonio, TX); Weintraub, S. T.; McCoy, T. H.; Stavinoha, W. B. *J. Pharmacol. Exp. Ther.* 197(2): 245-252; 1976.

Microwave irradiation (300 msec) was used to inactivate cholinesterase and choline acetyltransferase to study the effects of sodium pentobarbital on acetylcholine concentrations in the brain of male Sprague-Dawley rats. Microwave irradiation of 6 kw at 2450 MHz for 300 msec was used to sacrifice mice and rats treated intraperitoneally with sodium pentobarbital (50, 80, 100 mg/kg). This technique rapidly causes irreversible inactivation of the brain enzymes. Not only did the enzyme levels remain close to *in vitro* levels, but the tissue was fixed, thus simplifying microdissection of the brain. The highest levels of acetylcholine were found in the striatum (81 nmol/g), while the cerebellum had the least (17 nmol/g). Increases of acetylcholine in the brain after treatment with sodium pentobarbital was found not to be due to hypothermia or anoxia. The drug caused an increase of acetylcholine in all areas of the brain studied, except the cerebellum, where there was a decrease. Central nervous system depression was correlated with high acetylcholine levels. When neuronal activity returned to normal, acetylcholine levels decreased. (31 refs.)

76-6

4505 SOME ASPECTS OF ETIOLOGICAL DIAGNOSIS IN OCCUPATIONAL DISEASES DUE TO THE ACTION OF MICROWAVE RADIATION. (Rus.) Gus'kova, A. K. (Inst. of Industrial Hygiene and Occupational Diseases of the U.S.S.R. Academy of Medical Sciences, Moscow, U.S.S.R.); Kochanova, E. M. *Gig. Tr. Prof. Zabol.* (3): 14-18; 1976.

Predisposing risk factors for cardiovascular diseases were analyzed in 21 men, aged 35-54 year, who had been occupationally exposed to intense super high frequency radiation for a prolonged time, and in whom radiowave sickness was diagnosed. The duration of the occupational exposure was over 10 years in 19 patients. Clinical examinations revealed hypertonic neurocirculatory dystonia in 7 patients, hypertension in 10 patients, ischemic heart disease in 2 patients, and hypothalamic insufficiency in another 2. A re-examination 2-3 years after the cessation of the

occupational exposure showed no marked improvement. Among the risk factors predisposing to cardiovascular diseases were nervous-emotional stress, which was found in 14 cases, overload factors due to combination of work and study in 4 cases, night shifts in 17 cases, regular smoking in 7 cases, moderate alcohol consumption in 7 cases, moderate alcohol consumption in 7 cases, hereditary load in 5 cases, cranial trauma in the anamnesis in 3 cases, overweight in 5 cases, hypercholesterolemia in 12 cases, and arterial hypertension in 10 cases. Combination of 3-6 of the above risk factors was found in 10 patients. The findings indicate that microwave radiation may be one of the risk factors of cardiovascular pathology rather than a sole factor of the disease. (16 refs.)

76-7

4506 THE RELATION OF SEX, AGE, AND WEIGHT OF MICE TO MICROWAVE RADIATION SENSITIVITY. (Eng.) Rugh, R. (U.S. Dept. of Health, Education and Welfare Public Health Service, Food and Drug Administration, Bureau Radiological Health, 5600 Fishers Lane, HFX-120 Rockville, MD 20852). *J. Microwave Power* 11(2): 127-132; 1976.

Male and female CF₁ strain mice were irradiated to death to determine whether sex, age, or weight affected their sensitivity to microwave radiation. Weanling (one month old), sexually mature (two months old) and aged mice (fourteen months) were exposed to 2450 MHz radiation at 7.5 watts forward power. A total of 114 mice were used with a minimum of 14 per group. Results show that under the same radiation condition both sexes displayed an increase in time of death with increased age and weight. Time to death increased from 4.10-7.66 minutes for males and from 3.80-5.56 minutes for females. Absorbed dose in J/g at death rose slightly, but not significantly, with age for males (43.9-47.80) but declined slightly with age for females (42.90-39.30). The slight depression in absorbed dose at death for females is believed to be sex related and due to the physiological stress of bearing approximately 100 offspring. In the same sex group, the mean absorbed lethal dose was essentially the same for all ages and weights but differed considerably between the sexes. All males absorbed more microwave energy in J/g at death than comparable females, and therefore, are more radioresistive. Normal male mouse temperature was 37.9°C and 38.4°C for females. Lethal rectal temperature was >43°C. There was no evidence of change in radioresistance with age. (11 refs.)

76-8

4507 MODIFICATION OF THE REPAIR OF RADIATION DAMAGE OF HAEMATOPOIESIS IN MICE BY MICROWAVES (SYMPOSIUM SUMMARY). (Eng.) Rotkowska, D. (Inst. Biophysics, Czechoslovak Acad. Sciences, Brno, Czechoslovakia); Vacek, A. *J. Microwave Power* 11(2): 141-143; 1976.

Microwaves (2450 MHz, 100 nW/cm²) were used to modify postirradiation repair of hematopoiesis in the mouse in an early period until 24 hours after whole-

body sublethal exposures to X-ray irradiation. Experiments were performed with C57BL/10 strain mice subjected to whole-body irradiation with a sublethal dose of 600 to 750 R. The animals were irradiated with microwaves (100 mW/cm², 2450 MHz, 5 min) at different times until 24 hours after X-ray irradiation. A control group was exposed solely to X-ray irradiation. In contrast to the control group, the number of hematopoietic stem cell colonies in the spleen increased after combined irradiation, and the difference between the control and experimental groups became statistically significant ($p < 0.01$) for the intervals of 30 minutes, 6 hours, and 12 hours. Increased repair of the radiation damage of hematopoiesis was also demonstrated by a higher percentage of ⁵⁹Fe incorporation in the spleen and a more rapid improvement of the peripheral indicators of hematopoiesis as compared with that of X-ray controls. On day 8 and day 20 after combined irradiation, the number of leukocytes in peripheral blood was twice that of controls. In addition, the microwave irradiation resulted in a prolonged mean survival period of the experimental groups as compared with controls. The results demonstrate that microwave irradiation can modify the course of repair processes in the hematopoietic stem cells in an early period following the exposure to X-rays. (No refs.)

76-9

4508 HUMAN AUDITORY SYSTEM RESPONSE TO LOWER POWER DENSITY PULSE MODULATED ELECTROMAGNETIC ENERGY: A SEARCH FOR MECHANISMS (SYMPOSIUM SUMMARY). (Eng.) Eichert, E. S. (Randomline, Inc., County Line and Mann Roads, Huntingdon Valley, PA 19006); Frey, A. H. *J. Microwave Power* 11(2): 141; 1976.

The human auditory system response to lower power density, pulse modulated, electromagnetic energy may provide a new tool to investigate the human auditory system and new insight into nervous system and behavioral effects. Several mechanisms, which have been suggested, were studied including thermally launched acoustic waves, direct neural stimulation, and direct interaction with portions of the auditory system. These proposals were considered in conjunction with the entire body of radio frequency-sound data. New data, particularly human responses to pulse pair and pulse train modulation, interferometric studies with animals, and reports of cochlear microphonics during ultra high frequency exposure were included in the analysis. Most of the suggested mechanisms were either difficult to test or inconsistent with available data. The models' success and failure as explanatory mechanisms are discussed, and additional lines of investigation are suggested. (No refs.)

76-10

4509 CYTOTOXIC EFFECTS OF ELECTROMAGNETIC RADIATION ON CHINESE HAMSTER CELLS IN CULTURE (SYMPOSIUM SUMMARY). (Eng.) Chen, K. C. (Dept. Biology, Wayne State Univ., Detroit, MI 48202); Lin, C. J. *J. Microwave Power* 11(2): 140-141; 1976.

The cytotoxicity of Chinese hamster cells produced after irradiation was demonstrated in terms of growth

rate, morphological transformation, and colonizing capacity. By employing an improved fluid-filled wave guide exposure chamber originally designed by Lin and Chen (1975), the nonthermal effect of 2450 MHz microwave radiation on Chinese hamster cells in culture was demonstrated. The differential effects of microwave radiation on Chinese hamster cells were examined as a function of the position of the cell within its generation cycle. The cytotoxicity of the cells produced after irradiation was compared over a 12-day incubation period. Although a clearcut cyclic response of mammalian cells to microwave radiation could not be established, the results with Chinese hamster cells indicate that the growth rate of irradiated cells showed a decrease of 10-60%, depending on the level of the microwave exposure. Consistent with previous observations, a great number of the "giant-ruffle cell" transformations were seen when a high level of incident power density of microwave was applied. Such microwave-induced morphological transformations in the Chinese hamster cell appeared to be irreversible. (No refs.)

76-11

4510 INFLUENCE OF PULSED MICROWAVES ON HAEMATOPOIESIS OF ADOLESCENT RATS (SYMPOSIUM SUMMARY). (Eng.) Pazderova-Vejlukova, J. (Clinic of Occupational Diseases, Charles Univ., Prague, Czechoslovakia); Frank, Z. *J. Microwave Power* 11(2): 139; 1976.

Pulsed electromagnetic fields caused a transient decrease of weight increment, hematocrit, and alkaline phosphatase activity in the course of intermittent irradiation of growing rats. Twenty male rats (initial average weight 65.53 g) were irradiated for seven weeks (5 days/week, 4 hours/day) by pulsed electromagnetic fields with the following parameters: working frequency 2736.5 MHz, repetition frequency 395 Hz, pulse width 2.6 μ sec, polarization vertical, mean power density 24.4 mW/cm² (accuracy of measurement ± 6). The rectal temperature of the irradiated animals increased an average of 0.3°C after 3 hours of irradiation. The weight, hematocrit, leucocyte count, differential count, leucocyte alkaline phosphatase activity, and nucleoli of lymphocytes of the irradiated rats were compared with findings in 20 controls. After the first week of irradiation the weight increment was significantly lower, persisting for one week after the irradiation. The hematocrit was lower in the middle of the irradiation period and during the first month after exposure. After the beginning of the fourth week of irradiation the average leucocyte count was lower due to the decrease of the absolute number of lymphocytes. Recovery took place 2 months after irradiation. The alkaline phosphatase activity was lower at the end of irradiation only. All the differences presented were in the 1% level of significance. (No refs.)

76-12

4511 HUMAN THERMAL LOADING BY EXPOSURE TO EMISSIONS FROM A MICROWAVE OVEN (SYMPOSIUM SUMMARY). (Eng.) Prucha, R. V. (Range Component Engineering, General Electric Company, Building 2, Room 248, Louisville, KY 40225). *J. Microwave Power* 11(2): 160; 1976.

Thermographic measurements in full scale human phantoms exposed to emissions from a microwave oven were used to calculate temperature rise in a thermal model of the human body. Full scale phantom models of a two-year-old child and a woman were exposed to emissions from a forced leak in a microwave oven. The operating frequency was 915 MHz. Thermographic analysis using the technique developed at the University of Washington and reported in a companion paper by A. W. Guy provided data on specific absorption rate (SAR) and identification of the heating pattern. These data, which relate to the defined leakage source intensity, were used as the basis for heat input and temperature rise calculations in thermal models of humans. Both worst case and typical case calculations based on movement patterns were made and the results were compared with those produced by other heating means, such as, changes in metabolic rate (deep heating) and exposure to normal sunlight (surface heating). Results also were compared with medical diathermy practice. These results show the very conservative nature of the current microwave oven emission standards. (No refs.)

76-13

4512 EFFECT OF MICROWAVES ON VIRUS MULTIPLICATION IN MAMMALIAN CELLS *IN VIVO* AND *IN VITRO* (SYMPOSIUM SUMMARY). (Eng.) Luczak, M. (Center of Radiobiology, Radioprotection, 00-909 Warsaw, Poland); Szmigielski, S.; Janiak, M.; Kobus, M.; de Clerq, E. *J. Microwave Power* 11(2): 173-174; 1976.

It has been suggested that microwaves at subthermal field power densities may influence multiplication of virus particles *in vitro*. Experiments on virus multiplication *in vitro* were performed using WISH cells (continuous line of human embryonic cells) and myxovirus para-influenza 3. The cell cultures were irradiated with 3 GHz microwaves at far field conditions in anechoic chambers (30 minutes) at field power densities 5 or 20 mW/cm². Inoculation with viruses (0.01 TCID₅₀/cell) was performed 2 hours before, simultaneously, 2, or 24 hours after irradiation with microwaves. Irradiation of cells at a field power density of 5 mW/cm² resulted in an increase of virus multiplication in cultures inoculated 2 hours before, simultaneously, or 2 hours after inoculation. This suggests that the increased multiplication is due to stimulation of cell metabolism (protein and nucleic acid synthesis). Irradiation of WISH cells at 20 mW/cm² resulted in lowered multiplication of viruses in cells irradiated at 2 hours before or after inoculation. In cultures irradiated 24 hours after inoculation normal multiplication of viruses was found. *In vivo* experiments were performed on young CFW mice infected intravenously with vaccinia or Herpes viruses. The animals were irradiated for 7 days postinfection (3 GHz microwaves, anechoic chamber, far field conditions, field power density 40 mW/cm², 2 hours daily). Several of the infected and irradiated animals were additionally injected with Cytosar or cytosine arabinoside (ARA-C). The results indicate that irradiation with microwaves influenced the course of viral infections in mice, the effect being dependent on the schedule of irradiation. Exposure to microwaves after

infection resulted in lowered multiplication of Herpes viruses (as measured by number of lesions on tails) and enhanced the inhibiting effect of Cytosar and ARA-C. (No refs.)

76-14

4513 MICROWAVE THERAPY AND MUSCLE BLOOD FLOW IN MAN (SYMPOSIUM SUMMARY). (Eng.) McNiven, D. R. (Physiotherapy Dept., Inst. Neurological Sciences, Southern General Hosp., Govan Road, U.K.); Wyper, D. J. *J. Microwave Power* 11(2): 168-170; 1976.

The effect of microwave therapy on muscle blood flow in man was studied. Five healthy subjects (3 male and 2 female), in the age range 20 to 40, were investigated. Muscle blood flow was measured using the xenon-133 clearance technique. Xenon-133 (200 μ Ci) dissolved in 0.1 ml of sterile isotonic saline was injected into the muscle (vastus lateralis). A scintillation counter was used to monitor the count rate. A single injection of xenon-133 was used to measure muscle blood flow at rest, during application of the microwave therapy, and during static exercise. Once a steady value was obtained for the resting flow, the microwave apparatus (2450 MHz) was switched on, with the power output adjusted to produce the maximum comfortable heating. After about 8 minutes, the slope of the clearance curve was observed to increase, indicating an increase in muscle blood flow. On obtaining a new steady value, the apparatus was switched off. Flow was maintained at the higher level for about 5 minutes before gradually decreasing. The investigation was concluded by the subject performing static quadriceps contractions. A highly significant increase in muscle blood flow was produced in all subjects; the mean values being 2.9 ml/100g/min at rest and 11.4 ml/100g/min at the end of microwave application. No significant correlation was found between athletic fitness and blood flow or between resting blood flow and the time delay between the start of microwave application and the blood flow increase; this varied from 5 to 12 minutes. (No refs.)

76-15

4514 ACUTE MICROWAVE IRRADIATION AND CATARACT FORMATION IN RABBITS AND MONKEYS (SYMPOSIUM SUMMARY). (Eng.) Kramer, P. (U.S. Public Health Service Hosp., Seattle, WA); Guy, A. W.; Emery, A. F.; Harris, C. *J. Microwave Power* 11(2): 135-136; 1976.

The special characteristics of the leakage field from an imperfect microwave oven were investigated. Effective power density (EPD)/time levels were chosen as single, acute exposures in adult New Zealand rabbits to determine the cataractogenic threshold, using the near field of the 2450 MHz slot applicator. In all cases the right eye was irradiated, while the left eye served as the control. The lowest cataractogenic level was found with an EPD level of 180 mW/cm² applied for 140 minutes with a peak specific absorption rate (SAR) level of 99.4 W/kg. Within one to two days following radiation, typical posterior cortical banding was found with the biomicroscope. SAR patterns in two young-adult rhesus monkeys were determined by placing the hori-

zonally oriented dipole with its center 5 cm from the bridge of the nose. Although peak SAR in the eye was again found in the lens (2.9 W/kg/W), less power was absorbed in the monkey than in the rabbit (5.4 W/kg/W). An additional SAR pattern was determined in one monkey with the slot centered over one eye. Peak SAR in the eye was found in the lens, with relatively symmetrical surface heating of the periorbital tissues. This SAR pattern may be used as a basis for determining the cataractogenic threshold in the monkey. (No refs.)

76-16

4515 EFFECT OF MICROWAVES COMBINED WITH INTERFERON AND/OR INTERFERON INDUCERS (POLY I-POLY C) ON DEVELOPMENT OF SARCOMA 180 IN MICE (SYMPOSIUM SUMMARY). (Eng.) Szmigielski, S. (Center for Radiobiology, Radioprotection, 00-909 Warsaw, Poland); Luczak, M.; Bielec, M.; Janiak, M.; Kobus, M.; Stewart, W. E., II.; de Clerq, E. J. *Microwave Power* 11(2): 174-175; 1976.

Neoplastic cells are highly sensitive to elevated temperatures. The use of microwave radiation for cancer treatment by hyperthermia (choice of wave frequency, control of temperature, perspectives, and problems) is reviewed, and the experiments on tumor-bearing mice irradiated with 3 GHz microwaves in combination with cytostatics (Endoxan), high doses of vitamin A, streptolysin S, or staphylococcal toxins are discussed. Mice with transplanted Sarcoma 180 were irradiated with 3 GHz microwaves (anechoic chamber, far field conditions, 40 mW/cm², 2 hr daily) during the whole period of tumor growth. Part of control (tumor-bearing) and irradiated animals were injected with interferon (highly concentrated mouse interferon 100 IU/g daily) or Poly I-Poly C (2 mcg/g, daily). Size and weight of tumors, as well as incorporation of tritiated precursors of nucleic acids and proteins and intracellular level of cyclic AMP, were checked 14 days after tumor transplantation. Irradiation with microwaves (general hyperthermia) inhibited tumor growth in about 25-30% of mice, while combination of microwaves with interferon and Poly I-Poly C led to inhibition of tumor growth in about 75% of animals. Mechanisms leading to tumor inhibition *in vitro* and *in vivo* by general and local hyperthermia were discussed, as well as perspectives in the use of microwaves for cancer treatment by intensive local hyperthermia (42-44°C). (No refs.)

76-17

4516 INFLUENCE OF MICROWAVES ON GENETICAL PROCESSES OF *ASPERGILLUS NIDULANS* (SYMPOSIUM SUMMARY). (Eng.) Baranski, S. (Military Inst. Aviation Medicine, 01-755 Warszawa, krasinskiiego, 54 Poland); Debiec, H.; Kwarecki, K.; Mezykowski, T. J. *Microwave Power* 11(2): 146-147; 1976.

The influence of microwave radiation on the genetic processes of *Aspergillus nidulans* was investigated to determine whether microwave radiation at non-thermal power densities is mutagenic. *A. nidulans* was chosen for investigation, since it is a haploid

under experimental conditions. As induced mutations are usually recessive, they are phenotypically noticeable in first generations only in the case of haploids. In addition, chromosomal mutations appear phenotypically as morphological changes in mycelium, which enables quick and easy detection of mutants. In this experiment, irradiation was performed in plastic containers at 2450 MHz, at power densities ≤ 10 mW/cm², for 10-240 minutes. The results do not show any mutagenic effects of microwaves. Currently, results of other experiments are being evaluated, in particular experiments in which different inhibitors of DNA repairing systems (e.g., caffeine) were used. (No refs.)

76-18

4517 EFFECT OF CONSTANT MAGNETIC FIELDS ON MACROMOLECULES. (Rus.) Miroshnichenko, F. D.; Stadnick, A. D. (Zaporozhe State Pedagogical Institute, Zaporozhe, U.S.S.R.). *Biofizika* 21(1): 178-179; 1976.

The exposure of discs of polymethylmethacrylate measuring 2 mm in thickness and 20 mm in diameter, previously heated to 100° in an electromagnetic field for 60 min led to a particular electric state with a superficial charge density of about 10^{-10} Coulombs/sq cm, depending on the magnetic field potential. The appearance of charges was due to the orientation of the magnetically anisotropic macromolecules and their segments. The magnetic susceptibility, decreasing with time, increased with increasing field potential in a range of 0.0032-0.123 A/m. The decrease of the diamagnetic susceptibility is apparently due to the orientation process being accompanied by an increase in polarization paramagnetism. The changes in magnetic susceptibility explain some peculiarities of the mechanism of the effect of magnetic fields on biological objects. (3 refs.)

75-182

4518 MICROWAVE HEARING IN MAMMALS. (Eng.) Rissmann, W. J. (Dept. Electrical Engineering, Bioacoustics Res. Laboratory, Univ. Illinois, Urbana, IL 61801); Cain, C. A. *Natl. Electron. Cong. Proc.* 30: 239-244; 1975.

Threshold levels for the acoustic perception of microwaves were determined for the cat, dog, chinchilla, and several human subjects. Beckman type scalp electrodes (3 ohm impedance at 1000 Hz) were used to monitor auditory responses of nonhuman species. A speaker, and microwave generator were used as the stimulators. The restrained animal was exposed to speaker clicks and irradiated with 10 msec wide 3 GHz microwave pulses, both applied at a repetition rate of 0.5 Hz. The evoked responses appeared similar, except for a delay factor in the air conducted acoustic stimuli. No response was recorded when microwaves were replaced with a 50 ohm dummy load. The average energy density threshold for small mammals was 8.8 μ J/cm². Five of eight human subjects heard a click, which appeared to originate from in-

side the head when irradiated with a 15 msec pulse of 3 GHz microwave energy. The average threshold energy density level for humans was $10.5 \mu\text{J}/\text{cm}^2$. Threshold levels seemed to be directly dependent upon the energy density per pulse rather than the peak power density per pulse. It is suggested that the differences in the human ability to detect microwaves was due to a hearing loss in a high frequency range that could not be tested. (15 refs.)

75-183

4519 NEUROENDOCRINE RESPONSE TO MICROWAVE IRRADIATION. (Eng.) Vetter, R. J. (Bionuleonics Dept., Sch. Pharmacy and Pharmacal Sciences, Purdue Univ., West Lafayette, IN 47907). *Natl. Electron. Cong. Proc.* 30: 237-238; 1975.

The effect of low level exposures to microwaves on the function of the neuroendocrine system was investigated. Pregnant rats were exposed for 15 days (days 6-21 of gestation) for 10 or 20 minutes to 0, 5, or 25 mW/cm^2 of 2450 MHz continuous wave microwave radiation. The rats were kept in an anechoic chamber with a -40 dB quiet zone. Blood samples were tested by radioimmunoassay for thyro-binding capacity. The results show that the thyro-binding ability of the blood serum increased with microwave exposure; thus thyroid hormone levels decreased. Results were inconclusive. First studies indicated a slight decrease in hormone levels and variance was high. Serum also was tested for protein transferrin by measuring serum iron and iron binding capacity. Protein levels increased with increasing energy exposure, indicating that protein synthesis was affected. Results show an attempt by the body to adjust to moderate temperature increases induced by microwaves (i.e., acclimatization). Further study is needed to determine whether the effects of long-term low level radiation (microwaves) are the results of adaptation or are subtle and dangerous effects. (6 refs.)

76-19

4520 EFFECTS OF MICROWAVES ON NORMAL AND TUMOR CELLS AS SEEN BY LASER-RAMAN SPECTROSCOPY (SYMPOSIUM SUMMARY). (Eng.) Webb, S. J. (Dept. of Physics, Univ. South Florida, Tampa, FL 33620). *J. Microwave Power* 11(2): 138; 1976.

The microwave absorption spectrum, between 50 and 200 GHz for tumor cells, differs from that of their homologous normal ones. The observed differences in the spectra of cells appear due to differences in the frequency constant that separates the absorbed frequencies in one or more of the series of frequencies absorbed by different cell types. Some *in vivo* energy states have been displayed as laser-Raman spectral lines from synchronized populations of cells. Many of these Raman lines are transient. Thus given that *in vivo* energy states are present, *in vivo*, only during specific stages of the cell cycle, this timed sequence of particular energy states seems to reflect the specific metabolic time clock of a given cell type. A study of the effect of exposure to various microwave frequencies on the time of appearance of given raman-shift lines has revealed that absorbed frequencies of 2-4 GHz in-

crease the rate of the entire cell cycle. The exposure of cells to absorbed frequencies >50 GHz, however, does not increase the overall rate of the cell's metabolic time clock. All microwave effects seem to be frequency, or frequency series, specific and by far the most prevalent of them is the absence, in the raman spectrum of irradiated cells, of specific raman-shift lines. Thus, since tumor cells absorb frequencies that are not absorbed by normal cells, the metabolism of tumor cells may be selectively altered by their exposure to frequencies harmless to normal cells. (No refs.)

76-20

4521 EFFECT OF ELECTROMAGNETIC ENERGY ON THE FORMATION OF TRIGLYCERIDES: FREQUENCY INFLUENCE (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (Centre d'Etudes Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Laurens, S.; Plurien, G. *J. Microwave Power* 11(2): 137-138; 1976.

A study was carried out on the effect of microwave frequency and power on the rate of formation of triglycerides in male Swiss mice. The authors tried to determine whether results, obtained at 2.4 GHz, would be duplicated at other frequencies between 2 and 10 GHz. Groups of 12 animals were placed in multimode cylindrical cavities of a 600 cm^2 cross section. Irradiations took place during 9 days (15 hours/day). The frequency between 2.4 and 9.4 GHz at 1.5 and 3.3 mW/cm^2 powers was investigated. Serum triglycerides were determined in 200 μl of serum by standard technique. Controls received infrared radiation. At 1.5 mW/cm^2 no difference was found between the triglycerides rate of the control animals and that of the animals exposed to microwaves, at any frequency. At 3.3 mW/cm^2 the triglyceride rate was the same in the control mice and mice exposed to microwaves at 2.9, 5.4, 9.4 GHz but significantly higher at 2.4 GHz. A study made at several power levels indicates that microwaves cause an increase in the rate of serum-triglycerides formation in mice at 2.4 GHz frequency. (No refs.)

76-21

4522 PULSED RADIOWAVE (27.12 MHz) EFFECTS ON *IN VIVO* AND *IN VITRO* TUMOR GROWTH (SYMPOSIUM SUMMARY). (Eng.) West, B. L. (Div. Medical Oncology, Box 273, Medical Coll. Virginia, Virginia Commonwealth Univ., Richmond, VA 23298); Regelson, W. *J. Microwave Power* 11(2): 176-177; 1976.

Inhibition of subcutaneous Lewis lung tumor was determined in BDF₁ mice after 23 daily 20-minute periods of exposure to a pulsed 27.12 MHz field. Mice were inoculated subcutaneously with 1×10^6 syngeneic Lewis lung carcinoma cells. Groups of eight mice were simultaneously irradiated at one of three different average power levels prior to tumor inoculation. Six groups received similar power levels of radiation immediately after inoculation. All groups were subsequently irradiated daily, twenty minutes per day, for 23 days. Significant reduction in tumor mass was observed in all postinoculated, irradiated groups. Measurement on postinoculation day 16 and 20 revealed a 60-90% inhibition of tumor mass when compared to controls. Pre-tumor inoculation radia-

tion demonstrated no change from control or an increase in tumor size. For both pre- and post-treated animals, no significant effects on survival were seen. An *in vitro* study was conducted to evaluate the response of tumor and normal cells to the same pulsed radiowave field. Each cell suspension, containing 1 ml (1×10^6 cells) was irradiated for twenty minutes. Post-radiation vital staining yielded a marked reduction of viability in 50-67% of all Lewis lung cells. In contrast, lethality for normal mouse embryo cells was 40%. In the case of Lewis lung tumor cells, the greatest lethality was observed in the cell suspensions experiencing the highest peak and average power outputs. L1210 leukemia cells obtained from DBA₂ mice were similarly processed and irradiated with a 60-90% lethality occurring, with toxicity directly related to the average power output. (No refs.)

75-184

4523 PHYSIOLOGICAL RESPONSES TO MICROWAVE EXPOSURE. (Eng.) Kinnan, E. (Dept. Electrical Engineering, Univ. Rochester, Rochester, NY 14627); Bogardus, R.; Lu, S.; Michaelson, S. *Natl. Electron. Cong. Proc.* 30: 233-236; 1975.

Five anesthetized dogs were exposed for 60 minutes to 60 mW/cm² incident power density at 2450 MHz continuous wave microwaves to determine the effect on temperature regulation. Exposure began 60 minutes after anesthetizing to allow for temperature stabilization. The tympanic, rectal, inguinal, axillary, back, hind toe and fore toe regions were monitored. Mean slopes of temperature curves for sham exposures (anesthetized, but not irradiated) did not become less negative by more than 0.36°C/hr. The change in mean slope for exposed animals appeared to be determined by size. Reduction of cooling rate was 1.5°C/hr for an 8.8 kg dog, 0.54°C/hr for a 12.6 kg dog and 0.62°C/hr for the remaining dogs weighing 23.5±0.9 kg. Rectal temperature was highest of recorded body temperatures 90 minutes after anesthesia in eight of nine experiments. Fore and hind toes showed a sudden increase in rate of cooling not apparent in other temperature curves during 6 of 9 experiments. Except for back, hind and fore toes, temperature differed in other locations on the same animal from between 0.5-2.9°C. Results show that animals remained homeothermic. Body heat regulation occurred through cooling of the extremities, aided by altered blood flow and was not dependent on microwave exposure. High rectal temperatures imply conduction and convection of heat from body core to skin or head. Convection to head is slowed or reversed during exposure. This study indicates significant changes in temperature gradients occur in anesthetized animals with or without head exposure to microwaves. (5 refs.)

76-22

4524 POTENTIAL MICROWAVE INJURIES IN CLINICAL MEDICINE. (Eng.) McRae, D. I. (National Inst. Environmental Health Sciences, Research Triangle Park, NC 27709). *Annu. Rev. Med.* 27: 109-115; 1976.

The use of microwaves in clinical medicine may be

harmful, and their use requires precaution and an understanding of the potential danger. Microwaves have the valuable capability of penetrating biological materials to produce deep heating. The eyes and testes, however, are highly susceptible to damage by microwave exposure, since they have a limited blood flow for removal of heat. Exposure has been shown to cause cataracts in rabbits at 2450 MHz with a threshold at 150 mW/cm² for 100 minutes or for 10 minutes at 500 mW/cm². The eyes, therefore, should be shielded from exposure during diathermic treatment in the head region. The temperature sensitivity of testes has been demonstrated in one experiment in which Sprague-Dawley rats suffered testicular degeneration after 10 minutes of microwave exposure at 35°C and 2450 MHz. Effects on the central nervous system include headaches, increased fatigability and irritability, sweating, difficulties in concentration and memory, and emotional instability. Other hazards include incorrect use of microwave blood-warmers, which may result in hemolysis, and possible electromagnetic interference with medical electronics, especially cardiac pacemakers. Proper administration techniques, therefore, should be used by trained personnel, with care taken to expose only the portion of the body being treated with adequate protection of the operator and those in surrounding areas. (27 refs.)

76-23

4525 THE PRACTICE OF MICROWAVE RADIATION SAFETY (SYMPOSIUM SUMMARY). (Eng.) Rexford-Welch, S. C. (RAF Consultant in Radiobiology, AWRE Aldermaston, Near Reading, Berkshire, U.K.); Lindsay, I. R. *J. Microwave Power* 11(2): 160-162; 1976.

The safety regimen adopted by major users of microwave radiation generally includes safety officer appointments, the production of safety instructions, area control, and classification and medical surveillance of workers, and incident investigation. Appointment of a safety officer for non-ionizing radiation requires no certified level of competency. This reflects the need for training, stated by the World Health Organization. Safety orders are produced by major users without the spur of legislation and the guidance of codes of practice. The need for exposure standards for frequencies outside the microwave range, particularly 1-30 MHz, has to be recognized. Restricted areas are based on the microwave radiation personnel exposure standard (MPE) with only authorized entry during operation and hazard areas with no entry during operation. Also, it is imperative to reassess areas after equipment modification, new installation, and following an incident. Health surveillance should prevent the employment of persons who could be adversely affected by microwave radiation exposure. The classification of microwave radiation workers, based on the MPE of 10 mW/cm² and with required medical surveillance, is proposed, and the voluntary participation of associated workers in epidemiologic studies of exposures below this MPE is urged. Any untoward occurrence in a controlled area should be investigated as soon as possible, and preferably by a specialized team. This will include early technical assessment of the operating conditions and medical examination of exposed workers. Finally, the definition of a permissible exposure

level is paramount to any protection program, since it is not easy for the practitioner of microwave radiation safety to work with the divergence in recommended standards. (No refs.)

76-24

4526 THERMOSTABILITY OF THE ERYTHROCYTES OF MICE EXPOSED TO THE ACTION OF A MAGNETIC FIELD. (Eng.) Sebestik, V. (Inst. Hematology, Blood Transfusion, 128 20 Prague 2, U nemocnice 1, Czechoslovakia); Petz, R. *Physiol. Bohemoslov.* 25(3): 241-244; 1976.

The effect of a magnetic field, formed by the poles of a rotating permanent magnet of 200 gauss induction, on the thermostability of mouse erythrocytes was discussed. Fifteen CBA-strain female mice, 23-25 weeks of age, were exposed for an average of 17 weeks to the magnetic field; 15 additional mice served as a control group. These groups were compared to six animals exposed to the magnetic field during gestation. Erythrocyte thermostability was determined for this group three months postpartum. Results indicated that the rate of heat hemolysis of erythrocytes was significantly higher in the test groups exposed to the magnetic field, especially at 5 and 10 minutes of heating ($p < 0.01$). After five minutes of heating, hemolysis in the exposed group had a mean value of 8.11 ± 4.36 , while the mean of the group exposed *in utero* was 14.33 ± 6.24 . The control group had a mean value of 3.76 ± 1.67 . At 45 minutes, the differences between all groups were not significant. These results indicate that the effect of the magnetic field on the embryonic organism persists long after (three months) removal of the field. The decrease in the thermostability of the erythrocytes was associated with a decrease in their osmotic resistance, which was probably a direct result of the magnetic field on the erythrocyte cell membrane. (9 refs.)

76-25

4527 SCATTERING OF MICROWAVES BY DIELECTRIC MATERIALS USED IN LABORATORY ANIMAL RESTRAINTERS. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202); Wu, C-L. *IEEE Trans. Microwave Theory Techniques* 24(4): 219-223; 1976.

In most experimental investigations of the biological effects of microwave radiation, it is necessary to use low-loss dielectric materials for restraining animals under irradiation. Because of the complexity of the analysis of the animal-restrainer combination, an analysis was made of the scattering of microwave fields by a simplified model of the restrainer with no animal present. The model chosen was that of a plane wave incident at an arbitrary angle upon a rectangular slab of finite width and thickness. Numerical results indicated that the scattered fields within a square region of one wavelength in distance from the slab surfaces are greatly enhanced and highly nonuniform. In particular, the maxima for parallel incidence exceeded those for normal incidence by almost a factor of 2. The results suggested that for minimal perturbation the broad face of an animal holder should be oriented

toward the direction of propagation. Further, the individual members of the restraining device should be as thin as practicable, and the dielectric materials should correspond to the characteristics of free space. (5 refs.)

76-26

4528 EFFECTS OF MICROWAVE-INDUCED LOCAL HYPERTHERMIA ON MAMMARY ADENOCARCINOMA IN C3H MICE. (Eng.) Mendecki, J. (Dept. Radiotherapy, Montefiore Hosp. and Medical Center, 111 East 210th St., Bronx, NY 10467); Friedenthal, E.; Botstein, C. *Cancer Res.* 36(6): 2113-2114; 1976.

Microwave-induced hyperthermia, produced by a 10 W microwave generator at a radiation frequency of 2450 MHz, was focused locally upon mammary adenocarcinoma implanted in C3H mice when the tumor reached 6 mm in diameter. In 54 treated mice, all tumors diminished in size after the first exposure (43°, 45 minutes) and disappeared completely following the second treatment. No other effects from heat application were apparent. All the mice in the microwave-treated group survived the whole period of observation (4 months) without any evidence of tumor, while 18 nontreated controls died within 4 weeks after inoculation. (9 refs.)

76-27

4529 NON-PERTURBING MICROPROBES FOR MEASUREMENT IN ELECTROMAGNETIC FIELDS (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (O.N.E.R.A.-C.E.R.T., Laboratoire du D.E.R.M.O., 2 Avenue Edouard Belin, B.P. 40-25, 31055 Toulouse Cedex France); Priou, A. *J. Microwave Power* 11(2): 148-149; 1976.

The possibility of obtaining a dielectric microprobe that would not interfere with electromagnetic waves has been studied. Two types of probes were defined: one operating in the temperature range of 10°C to 40°C, another within the range -40°C to +20°C. Both probes included a head (different according to the temperature range or density to be measured) but comprising a thermosensitive dielectric material, dielectric light conductors (optical fibers), and associated electronics. The first probe, (a "cholesteric crystal and optical fibers dielectric probe"), had a head composed of an optical transducer, a thermal sensor made of micro-encapsulated cholesteric liquid crystals, and coating absorbing waves formed by a thin film of colloidal graphite. In this system only two optical fibers were used: one bringing in the light, the other collecting the reflected light containing information on the temperature or power density variations. The second probe was a dielectric thermometer operating within a range of -30°C to +10°C. The principle of the probe was based on the reflection of a light beam on a thermally dilatable liquid, contained in a capillary glass pipe of small dimension. The electronics was similar for both probes. A white light source powered the optical fiber(s). The reflected light was collected by a photomultiplier driven by a power supply. The analysis of the reflected light was then made either by recording on a plotter or by any other process. (No refs.)

76-28

4530 FAILURE OF 2- AND 10-METER RADIO WAVES TO
INDUCE GENETIC DAMAGE IN *DROSOPHILA*

MELANOGASTER. (Eng.) Mittler, S. (Dept. Biological
Sciences, Northern Illinois Univ., DeKalb, IL 60115).
Environ. Res. 11(3): 326-330; 1976.

Adult male *Drosophila melanogaster*, exposed to non-
thermal radio waves, were studied to assess whether
radio waves used for transmissional purposes pose
a mutational hazard. *Drosophila*, in vials, were
attached to two antenna and exposed for 12 hours to
the frequencies of 136.34 and 29.00 MHz, respectively.
The progeny of the exposed *Drosophila* were tested
for sex-linked recessive lethals, loss of X or Y
chromosomes, and non-disjunction. There was no
significant difference between offspring of the
control and exposed flies with respect to the genetic
mutations. Spermatogenesis also was unaffected.
It is concluded that the average portable trans-
mitter does not pose a threat to the genetic integrity
of its operator, since the frequencies tested are
in the radio wave band regions used by police,
emergency vehicles, radio amateurs, and civilian
radio operators. (13 refs.)

76-29

4531 DETERMINATION OF POWER ABSORPTION IN MAN
EXPOSED TO HIGH FREQUENCY ELECTROMAGNETIC
FIELDS BY THERMOGRAPHIC MEASUREMENTS ON SCALE MODELS.

(Eng.) Guy, A. W. (Bioelectromagnetics Research
Lab., Sch. Medicine, Univ. Washington, Seattle,
WA 98195); Webb, M. D.; Sorensen, C. C. *IEEE Trans.*
Biomed. Eng. 23(5): 361-371; 1976.

A technique is described in which thermographically
determined power absorption measurements in scale
phantom models of man exposed to very high frequency
fields are used to obtain power absorption character-
istics in full scale man exposed to high frequency
fields. When the body of man, small compared to a
wavelength, is exposed to high frequency electromag-
netic fields, the absorbed power density patterns and
total absorbed power may be approximated by the simple
super-position of the internal electric fields obtained
from the quasistatic coupling characteristics of the
electric and magnetic field components determined
independently. A VHF resonant cavity was used to
provide the necessary field strengths for producing
measurable power absorption patterns under simulated
HF exposure conditions. Results indicated that peak
power absorption densities as high as 5.63 W/kg could
be produced in man exposed to 10 mW/cm², 31 MHz
radiation fields. The results show that the absorp-
tion decreased as the square of the frequency, as
predicated by theory for frequencies below 31 MHz.
(8 refs.)

76-30

4532 ELECTROMAGNETIC FORCES AND CIRCADIAN
RHYTHMS (LETTER TO EDITOR). (Eng.) Hope-
wood, P. S. (Univ. Vermont, Coll. Medicine, Burling-
ton, VT). *N. Engl. J. Med.* 294(9): 501-502; 1976.

It is questioned whether a procedure, electromagnetic
bouglenage, (Hendron and Hale, *New England Journal*
Medicine 293:428, 1975), will interfere with a new-
born's ability to perceive geophysical stimuli, thus

changing diurnal rhythms, necessary hormonal re-
sponses, and subsequent growth development. This
concern is based on the belief that man's circadian
rhythm is cued by a geophysical sensor, which inter-
prets information from magnetic fields, cosmic
radiation, and gravity. Evidence indicates that
planaria and mud snails will change direction with
a change in magnetic field. In addition, electric
fields have been used to shorten man's diurnal
rhythm. If geophysical phenomena can be registered,
then perhaps this information can be used by the
central nervous system to alter bioelectric activity
and diurnal rhythms. (7 refs.)

76-31

4533 ELECTROMAGNETIC PULSE INTERACTION WITH
MAMMALIAN CRANIAL STRUCTURES. (Eng.)

Lin, J. C. (Dept. Electrical Engineering, Wayne
State Univ., Detroit, MI 48202). *IEEE Trans. Biomed.*
Eng. 23(1): 61-65; 1976.

The transmitted field strengths in homogeneous
spherical models of human and animal heads were
determined to be a function of time and position,
using frequency analytic techniques for an impinging
pulse of Gaussian character. A Debye relaxation
model and constant conductivity model were considered
for the electrical behavior of brain matter. The
constant conductivity model was used to predict
continued decreases in pulse amplitude as it advanced
in the head starting from the leading surface; however,
the relaxation model predicted reduction only from
the surface to the center. Moreover, it appears
that the transmitted pulse in a spherical model of
the head was always related to the time derivative
of the incident radiation. Numerical results in-
dicate that the transmitted pulse amplitude is quite
small and can be estimated using the constant con-
ductivity model. (13 refs.)

76-32

4534 PAIN SENSATIONS ASSOCIATED WITH ELECTRO-
CUTANEOUS STIMULATION. (Eng.) Mason, J.

L. (Dept. Electrical Engineering, University of
Canterbury, Christchurch, New Zealand); Mackay, N.
A. M. *IEEE Trans. Biomed. Eng.* 23(5): 405-409;
1976.

The results of experiments to determine the feasi-
bility of using electrocutaneous stimulation in
sensory substitution systems are discussed. The
system may provide some facility for sound localiza-
tion to the totally deaf by directing auditory
information to an alternate sense. One of the main
drawbacks to the development of this system has been
the sharp, pricking pain often associated with
electrocutaneous stimulation. This has been found
to be a result of thermal damage to the corneal
layer of the skin. The high-energy densities re-
quired to create this damage often occur, even at
moderate stimulation currents, because of the highly
nonhomogeneous nature of the skin-electrode inter-
face. However, this pain can be controlled without
resorting to electrode pastes by adopting a simple
procedure for applying the electrode. The dynamic
range and the stability of the sensation magnitude
have been measured under paste-free conditions, and

the conclusion was reached that electrocutaneous stimulation would be a viable alternative to mechanical stimulation in certain sensory substitution applications. (9 refs.)

76-33

4535 ELF COUPLING TO SPHERICAL MODELS OF MAN AND ANIMALS. (Eng.) Spiegel, R. J. (NIT Res. Inst., Washington, DC 20006). *IEEE Trans. Biomed. Eng.* 23(5): 387-391; 1976.

The induced fields, currents, and power absorbed by spherical models of humans or animals when exposed to extremely low frequency (ELF) electromagnetic fields were calculated. Spherical models can be expected to provide values of the right order of magnitude. The induced fields were a sum of the quasistatic solutions for a sphere irradiated by a uniform electric and magnetic field. Calculations were provided for ELF fields emanating from the proposed Navy's Sanguine antenna and extra high voltage (EHV)/ultra high voltage (UHV) transmission lines proposed by the utility industry. Converting the predicted absorbed power into the average heat produced in a 70-kg man by the ELF field was found to be approximately 10^{-5} cal/g. This induced heat production is considered too low to interfere with normal biologic function; however, this should be verified. (16 refs.)

76-34

4536 ARE MOUSE FETUSES WHICH SURVIVE MICROWAVE RADIATION PERMANENTLY AFFECTED THEREBY? (Eng.) Rugh, R. (U.S. Dept. Health, Education and Welfare, Public Health Service, Food and Drug Admin., Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20852). *Health Phys.* 31(1): 33-39; 1976.

Time-mated CFI white mice (118) were exposed when their fetuses were at 9, 12, or 16 days gestation to 7.4 W forward power of 2450 MHz microwave radiation for 4 minutes--a sub-lethal exposure. Mean absorptions of energy ranged from 22.4 to 27.1 J/g and were inversely proportional to weight and gestation age. After a normal delivery, these fetally irradiated mice were again exposed to the same irradiation as previously, from two months of age until death. Death was electronically monitored on a polygraph. A parallel group of 25 two-month-old controls were similarly irradiated, and the absorbed dose in J/g and the time in min to kill were taken as the measure of radiation tolerance or radio-sensitivity of the originally irradiated fetuses. Males initially exposed to microwave energies at 12 and 16 days gestation, and females irradiated at 16 days gestation showed a slight but statistically significant reduction in the mean time to kill. Only the 12 day males showed a significant reduction in the mean absorbed dose at death. None showed mean absorbed doses greater than did the controls; hence, there was no evidence of any acquired resistance to radiation effects. All males initially exposed *in utero* had mean body weights significantly lower than did the control males at two months of age. Females initially irradiated at 16 days gestation

were, at two months, statistically lighter in mean body weight than any of the other irradiated or control females. There was no significant difference between the sexes in J/g absorbed dose to kill at two months of age, but there was a significant lowering of the time to death for those males previously irradiated at 12 and 16 days gestation age and females at 16 gestation days compared with their respective controls. (13 refs.)

76-35

4537 INFLUENCE OF 2450 MHZ CW MICROWAVES ON RATS EXPOSED *IN UTERO* (SYMPOSIUM SUMMARY). (Eng.) Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Univ. Rochester, Sch. Medicine and Dentistry, Rochester, NY 14642); Guillet, R.; Catallo, M. A.; Small, J.; Inamine, G.; Heggeness, F. W. *J. Microwave Power* 11(2): 165-166; 1976.

Rats exposed *in utero* to 2450 MHz continuous wave microwaves were examined for indices of maturational deficits. Long-Evans rats at 9 and 16 days of gestation were exposed to 2450 MHz continuous wave microwave radiation at 10 mW/cm² or 40 mW/cm² for 1 hour. These exposures did not seem to adversely affect the rat or her offspring; parturition was normal with no change in gestation duration, and there was no difference in litter size (10-16 pups) from exposed and sham-irradiated dams. Oxygen consumption in cold stressed neonates from the 40 mW/cm² exposed dams was increased (about 75 ml O₂/min/kg) relative to controls and 10 mW/cm² exposures (about 50 ml O₂/min/kg and 43 ml O₂/min/kg respectively). Preliminary results suggest that corticosterone and thyroxine levels were comparable in all neonates examined. Corticosterone levels in the first 24 hours of life ranged from 10-25 µg% then dropped and remained at <2µg% through the 14th day. Plasma thyroxine (T4) levels in the neonatal rat were low (<3µg%) for the first 10 days of life in pups from both exposed and non-exposed dams. At days 11-12 a rise in plasma T4 levels to 4-8 µg% (normal adult levels) was seen in both groups. (No refs.)

76-36

4538 TEMPERATURE CHANGES GENERATED BY MICROWAVE THERAPY IN THE THIGHS OF HUMAN SUBJECTS (SYMPOSIUM SUMMARY). (Eng.) Stevens, A. (Dept. Physical Medicine and Electromyography, Univ. Leuven, Faculty of Medicine, B-3000 Leuven, Belgium); Peluso, F. *J. Microwave Power* 11(2): 170-171; 1976.

Deep tissue temperature elevations generated after exposures to microwave therapy were studied in human subjects. The right antero-lateral thigh of 20 male subjects of around 25 years of age were exposed to microwave radiation at 2450 MHz. A power output of 50 W was applied at a 10 cm distance from the skin surface for 10 minutes. Tissue temperatures were measured immediately after exposure, and 5, 10, and 15 minutes thereafter at six depths, i.e., at the skin surface, 2, 6, 11, 16 and 21 mm beneath it. Temperature elevation decreased with depth. Immediately after exposure very modest temperature elevations in the various tissue layers were found, i.e., from 2.5°C ± 0.6 on the surface to 1.0°C ± 0.3 at 21 mm underneath. The temperature changes in

muscle were smaller, i.e., from 1.9°C at 11 mm depth to 1.0°C at 21 mm. Fifteen minutes after the end of the radiation, the temperature elevations in the muscle and at the fat-muscle interface were still significant. This after-exposure heating effect suggests that only small changes in blood flow occur and that other mechanisms may have to be invoked to explain the therapeutic success obtained with this type of therapy. (No refs.)

76-37

4539 MICROWAVE RADIATION AND OTHER HARMFUL FACTORS OF WORKING ENVIRONMENT IN RADIO-LOCATION: METHOD OF DETERMINATION OF MICROWAVE EFFECTS (SYMPOSIUM SUMMARY). (Eng.) Siekierzynski, M. (Postgraduate Medical Center, Military Medical Acad., ul. Szaserow 128, Warszawa, 60, Poland); Czarnecki, C.; Dziuk, E.; Jedrzejczak, W. W.; Szady, J. *J. Microwave Power* 11(2): 144-145; 1976.

This analysis included 841 males with occupational exposure to pulse-modulated microwave radiation. The subjects were divided into two groups: Group I consisted of 507 subjects exposed to energy beam densities exceeding 2 W/m² (sometimes exceeding 60 W/m²), and Group II consisted of 334 subjects exposed to energy beam densities never exceeding 2 W/m². The incidence of functional disturbances, gastric and duodenal ulcer, the functional state of the thyroid, lens transparency, causes of disability, to work, consequences of excessive accidental radiation exposure, and changes in the abnormalities after cessation of exposure to radiation were determined. No differences were observed in the health state between groups differing only in the degrees of exposure to microwave radiation. It was found that the incidence of many abnormalities was influenced by increasing age of the subjects and not by the duration of work connected with exposure. This observation does not support the hypothesis of cumulative effects of microwave exposure with increasing length of work under conditions of exposure. The presence of various functional disturbances in nearly 60% of the subjects in both compared groups indicated a highly neurotizing influence of the whole complex of environmental factors other than microwave radiation. (No refs.)

76-38

4540 AN UPPER BOUND ON COEFFICIENT OF TRANSMISSION OF MICROWAVE LEAKAGE INTO BIOLOGICAL TISSUES (SYMPOSIUM SUMMARY). (Eng.) Kamal, A. A. (Dept. Electronics and Communications, Faculty of Engineering, Cairo University, Giza, Cairo, Egypt); Al-Badwaihy, K.; Hashish, E. *J. Microwave Power* 11(2): 159-160; 1976.

An attempt to find an upper bound on the transmission coefficient U for various near zone fields was undertaken. A planar model consisting of a half space of homogenous biological tissues with known electromagnetic properties (permittivity, conductivity and permeability) was used in the study. The source was an elementary electric or magnetic dipole located in the free space region above the biological half space. The incident field was decomposed into a continuous spectrum of cylindrical waves. For each

component wave the transmitted field was found, and an integration gave the value of total transmitted field into the biological material. It is concluded that as the height of the dipole decreases, the maximum of the transmission coefficient U shifts towards the dipole projection. Also, its value increases, and for low values of the dipole heights, the maximum value of transmission exceeds that based on a plane wave assumption. (No refs.)

76-39

4541 VARIATION OF SERUM TRIGLYCERIDES RATE UNDER THE ACTION OF ELECTROMAGNETIC WAVES: POWER LEVEL INFLUENCE (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (Centre d'Etudes et de Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Laurens, S.; Plurien, G. *J. Microwave Power* 11(2): 136-137; 1976.

The effect of electromagnetic field exposures on the lipid metabolism of mice was investigated. Groups of 12 mice (Swiss origin, male) were exposed for nine days (15 hours/day) to electromagnetic fields of 2.4 GHz at power densities ranging from 1-3.3 mW/cm². Three microwave power levels were applied to the animals. In the lowest case (1 mW/cm²), the triglyceride rate was the same in every animal. However, at both other power levels (1.5 and 3.3 mW/cm²), a significant increase in the triglyceride rate was observed in the exposed animals. In a second experiment, the triglyceride rate for animals exposed to electromagnetic radiation was compared to that of animals exposed to infrared radiation. At 1.5 mW/cm², the triglyceride rate was the same for every animal. However, this rate was significantly higher in animals that were exposed for nine days to microwaves at 3.3 mW/cm² than in animals that were exposed for the same period and at the same power level to infrared radiation. The results suggested the possibility that microwaves act on the lipid metabolism through an internal mechanism, which is noticeable only over a certain exposure level. (No refs.)

76-40

4542 RETINAL SENSITIVITY TO SHORT WAVELENGTH LIGHT (LETTER TO EDITOR). (Eng.) Marshall, J. (Inst. Ophthalmology, Judd St., London WC1H 9QS, U.K.); Weale, R. A. *Nature* 262: 629; 1976.

Conclusions in a recent article in *Nature* on potential hazards due to exposure of the primate retina to visible radiation of short wavelengths are questioned. The lesions were thought to be mediated by a photochemical mechanism; however, the reciprocity law was not obeyed in the data of the article, although both human rods and cones obey the law in the author's timespan. Thermal effects were minimized, even though the action spectrum resembled the absorption spectrum of melanin. The role of the crystalline lens as protection for the retina was emphasized, although the vitreous may be at risk in aphakic eyes. The morphology of the lesion was ignored. The authors also implied that viewing the sun under their experimental conditions, below the threshold for lesions of 100/sec, is safe. It should

not be inferred, however, that a shorter period is safe in their experimental conditions. (6 refs.)

76-41

4543 RETINAL SENSITIVITY TO SHORT WAVELENGTH LIGHT--AUTHOR'S REPLY (LETTER TO EDITOR). (Eng.) Ham, W. T. (Dept. Biophysics, Medical Coll. Virginia). *Nature* 262: 629-630; 1976.

There are at least three types of radiation damage to the retina in the range (1,400-400nm). These are shock damage, thermal damage, and photochemical damage. Marshall's report appeared to belong in the thermal damage category. In response to the letter from Marshall and Weale, not even thermal lesions obey a reciprocity law, and the authors do not know the relationship of rods and cones to the observed fundoscopic pathology. Thermal effects were minimized only for long term exposure to the shorter wavelengths in the visible spectrum where maximum temperatures in the retina do not exceed a few °C above ambient. The absorption spectrum of melanin would be expected to correspond to the action spectrum for thermal damage. Hazard to the retina rather than to the vitreous for aphakic eyes was emphasized because the vitreous does not absorb radiation appreciably between 300 and 1,400 nm. The morphology of the lesion was undetermined; however, light and electron microscopy are currently being used to determine the nature of the lesion. Calculations showed that the minimal irradiance on the retina in Marshall's experiments were greater by a factor of 10^3 than those reported by the author. Marshall, then, was dealing with the phenomenon of thermal injury; whereas, the author sought to characterize a long term photic damage mechanism or mechanisms in the retina. (9 refs.)

76-42

4544 RATE EFFECTS IN ISOLATED TURTLE HEARTS INDUCED BY MICROWAVE IRRADIATION. (Eng.) Tinney, C. E. (Biosystems Dept., Naval Undersea Center, San Diego CA); Lords, J. L.; Durney, C. H. *IEEE Trans. Microwave Theory Techniques* 24(1): 18-24; 1976.

It is known that continuous wave microwave irradiation at 960 MHz causes bradycardia in isolated poikilothermic (turtle) hearts in Ringer's solution. Tachycardia is usually produced by generalized heating, suggesting the possibility of a different mechanism in this case. The effect occurs only over a narrow power range of approximately 2-10 mW/g absorbed by the heart. In this study, the hypothesis that microwave radiation causes neurotransmitter release either by excitation of the nerve remnants in the heart or by some other mechanism, producing bradycardia over a restricted range of power absorption, was investigated. Approximately 8 mW/cm² continuous wave microwave radiation at 960 MHz was applied to groups of isolated turtle hearts for a period of 1/2 hour in the presence of a parasympathetic nerve blocking agent (atropine) and in the presence of a sympathetic nerve blocking agent (β blocker), alone and in combination. In the presence of atropine, the heart rate increased, while in the presence of β blocker, the heart rate decreased. When both

atropine and β blocker were added in combination to the heart preparation, the effects of both the sympathetic and parasympathetic transmitter were blocked. Microwave irradiation then caused only very slight changes in heart rate. A generalized heating effect, causing tachycardia, was predominant at higher levels of absorbed power (above approximately 15 mW/cm²). It is concluded that the neural effect (possible transmitter release due to microwave irradiation) is dominant at lower power levels, although the exact location of the stimulation causing the observed effects has not yet been determined. (5 refs.)

76-43

4545 A PASSIVE ELECTRODELESS METHOD FOR DETERMINING THE INTERIOR FIELD OF BIOLOGICAL MATERIALS. (Eng.) Brodwin, M. E. (Dept. Electrical Engineering, Northwestern Univ., Evanston, IL 60201); Taflov, A.; Matz, J. E. *IEEE Trans. Microwave Theory Techniques* 24(8): 514-521; 1976.

A passive remote-sensing method was developed for the measurement of the electric-field distribution within a biological sample. The instrument was used to analyze the intermodulation spectrum reradiated by a diode imbedded within the sample exposed to a dual-frequency illumination. Experimental results in a waveguide system indicated that the relative intensities of the intermodulation products were a unique function of the field intensity at the diode. These results were also used to determine the basic scattering properties of the diode. A low-power free-space apparatus is described which was used to expose the principal problem associated with this method: the inadvertent generation of intermodulation frequencies. Isolation techniques eliminated this problem. Finally, an analysis of a complete system revealed that at 910 MHz, fields could be measured in 4.0 cm of soft tissue, $\tan \delta = 0.5$, without exceeding an incident power density of 10 mW/cm². (6 refs.)

76-44

4546 MATERIALS FOR SELECTIVE TISSUE HEATING IN A RADIOFREQUENCY ELECTROMAGNETIC FIELD FOR THE COMBINED CHEMOTHERMAL TREATMENT OF BRAIN TUMORS. (Eng.) Moidel, R. A. (Dept. Neurosurgery, Univ. Pittsburgh, Pittsburgh, PA 15213); Wolfson, S. K., Jr.; Selker, R. G.; Weiner, S. B. *J. Biomed. Mater. Res.* 10(3): 327-334; 1976.

A technique of creating localized heating by implanting carbon steel rods and Hysterloy (1000 and 655 calorimetry/g-min, respectively) in the brain of a squirrel monkey and inserting the head into a radio-frequency electromagnetic field is described. Heating of these materials was done primarily by eddy current (37 kHz), since their heating rates were significantly affected by their shapes and orientation in the field; the rods oriented parallel to the field produced the most heat. This preliminary experiment shows that carbon steel and Hysterloy were successful in producing localized heating in live squirrel monkey brains. (8 refs.)

76-45

- 4547 EFFECTS OF THE SURROUNDINGS ON ELECTRO-MAGNETIC-POWER ABSORPTION IN LAYERED-TISSUE MEDIA. (Eng.) Bernardi, P. (Inst. of Electronics, Univ. Rome, Rome, Italy); Giannini, F.; Sorrentino, R. *IEEE Trans. Microwave Theory Techniques* 24(9): 621-625; 1976.

A model for studying the interaction between electromagnetic (EM) waves and biological tissue is introduced. The influence of the surroundings, the thickness of the irradiated tissue, and of the disuniformity of the incident field was examined by schematizing the environment by a perfectly conducting screen placed beyond the irradiated tissue. The effects of standing waves, which were created in this situation, were determined as a function of the electrical and geometrical parameters of the structure. In particular, the hazard increase due to the presence of the screen combined with a phase disuniformity of the incident field--an elementary schematization of the "near-field"--was pointed out. (13 refs.)

75-185

- 4548 DIFFERENTIAL EFFECTS OF ELECTROMAGNETIC FIELDS IN THE TREATMENT OF NEUROSES AND DEPRESSION. (Eng.) Grunner, O. (Res. Centre Inst. Balneology, Lazne Pesenik, Czechoslovakia). *Act. Nerv. Super.* 17(4): 294; 1975.

The effects of the cerebral application of electronic broad-band noise (EBBN) (I = 20 mA) to 20 patients with neurotic and depressive disorders were compared. Electric skin resistance (ESR) increased after treatment by more than 1/3; whereas, it decreased in patients treated with a "placebo." This indicates a significant inhibitory effect. Some neurotics complained of dizziness and heightened irritability, while others stressed heightened psychic activity during treatment. Patients with depression, treated similarly, indicated no side effects. An EBBN of lower intensity (1-2 mA) or squared pulse-current (0.8-1.2 mA) was suitable for treatment of anxious neurotics. Application of a continuous direct magnetic field (CDMF) for one hour on anxious neurotics with insomnia and heightened irritability exercised a significant inhibitory effect (increase in ESR). Repeated (CDMF) applications, 9 times in 3 weeks, on 12 anxious neurotics with insomnia confirmed this finding. It is suggested that the effectiveness of the treatment depends on the type and intensity of the electric current and magnetic field. (3 refs.)

76-46

- 4549 MICROWAVE-INDUCED HYPERTHERMIA AS AN ADJUVANT TO CANCER THERAPY (SYMPOSIUM SUMMARY). (Eng.) Wallen, C. A. (Dept. Radiation Biology and Biophysics, Univ. Rochester, Sch. Medicine and Dentistry, Rochester, NY 14642); Michaelson, S. M. *J. Microwave Power* 11(2): 175-176; 1976.

A review of the application of microwave-induced hyperthermia as an adjuvant to ionizing radiation and chemotherapy in cancer treatment is presented. The effects of hyperthermia and the temperature levels, which must be maintained, are also discussed.

Therapeutically effective hyperthermia must raise the intratumor temperature to approximately 42°C with an operational range in animals and man of 41.5°C to 42°C. Higher temperatures have been found to give more rapid tumor destruction. However, host tolerance considerations, contraindicate the use of temperatures exceeding 42°C, which should be maintained for a sufficient time to inactivate the aerobic and hypoxic tumor cells, while not damaging adjacent normal tissue. It also has been noted that non-uniform heating enhances growth and metastasis of a tumor. Microwave-induced hyperthermia may provide unique possibilities for minimizing the problem of non-uniform heat distribution in the tumor. The thermal effects of high intensity microwave absorption in biological tissue is well established. The allowed frequencies for diathermy are 27.12, 915, and 2450 MHz in the United States and 433 MHz in Europe. In contrast to infrared and surface heating, the relatively long wavelengths of microwave radiation permit the energy to penetrate deeper into biological tissue. Therefore, a more rapid and uniform generation of heat is possible using this modality. Hyperthermia has been shown to interact with radiotherapy and chemotherapy synergistically. This synergistic combination could lead to improved cures since lower levels of both modalities could be used. (10 refs.)

76-47

- 4550 MICROWAVE HEATING OF MALIGNANT MOUSE TUMORS AND TISSUE EQUIVALENT PHANTOM SYSTEMS. (Eng.) Robinson, J. E. (Div. Radiation Therapy, Dept. Radiology, Univ. Maryland, Sch. Medicine, Baltimore, MD 21201); McCulloch, D.; Edelsack, E. A. *J. Microwave Power* 11(2): 87-98; 1976.

This study investigated the use of microwaves to produce stable and reproducible temperatures (44±25°) in malignant mammary mouse tumors (1 cm in diameter) and tissue equivalent phantom systems. A 200 watt pulse mode, 2450 MHz diathermy machine was the microwave source. Initial tumor temperatures were well below body temperature, between 28°C and 31°C. Phantom tumors showed a notable increase in heat compared with mouse tumors. Heat variations may have been due to thermoregulation. Temperature profiles were obtained for tumors under four conditions: unheated, microwave heated, air heated, and microwave and air-heated. Similar size tumors were also compared under these conditions. Results indicated that both core temperature and thermal distribution depended appreciably upon ambient temperature. Microwave heating at room temperatures resulted in unacceptably high non-uniform profiles. This technique, which combined microwave and air-heating, decreased thermal nonuniformities, reduced microwave power requirements for elevated temperatures (up to 45°C) in tumor core, and allowed for reproducible tumor temperatures (within ±1°C). However, this is still considered an excessive deviation. (6 refs.)

76-48

- 4551 USE OF AN INDUSTRIAL PROTOTYPE MACHINE FOR DRYING AND STERILIZING PHARMACEUTICAL AMPOULES BY MICROWAVES AT 2.45 GHz (SYMPOSIUM SUMMARY). (Eng.) Mothiron, J. C. (Etablissement Rene Anrep,

CURRENT LITERATURE

Zone Industrielle du Menetou, 37000 Tours, France); Vialard-Goudou, A.; Maupas, P. *J. Microwave Power* 11(2): 200-201; 1976.

An experimental bacterial contamination of empty pharmaceutical ampoules, by different microbial strains, made it possible to test the sterilizing power obtained with an industrial prototype machine using microwaves at 2.45 GHz. Gram-positive and gram-negative bacteria in vegetative and sporulated forms were used to contaminate the washing water of ampoules treated subsequently with microwaves. With a period of four minutes and a power of 3 kW, drying was complete and sterilization satisfactory. Results indicated that with massive contamination the majority of ampoules were sterilized, although some ampoules still contained a few viable germs. There does not seem to be any significant difference in the sterilization of vegetative forms using microwave and between gram-positive and gram-negative bacteria. The influence of the germ concentration, at a given power, is a non-negligible parameter and leads to variable results depending on the bacterial species and more particularly with sporulated forms. It seems that sterilization is due only to the thermal effect obtained. The results of drying-sterilization with microwaves are favorable and make it possible to envisage industrial applications. (No refs.)

76-49

4552 INFLUENCE OF RADIO AND TELEVISION SETS ON IMPLANTED CARDIAC PACEMAKERS. (Ger.)

Bisping, H.-J.; Irnich, W. (Abteilung Innere Medizin I, Technische Hochschule, 5100 Aachen, Goethestr. 27-29, West Germany). *Dtsch. Med. Wochenschr.* 101(17): 669-672; 1976.

The possible interference by radiation emitted by television and radio sets and their accessories with implanted pacemakers with low threshold was investigated. The leakage fields generated by ultrasonic remote controls for television and radio sets, with a frequency of 30-65 kc/s, had too low an intensity to interfere with pacemaker function. Flexless infrared earphones, with an infrared emitter generating a carrier frequency of 100 kc/s installed in a television or radio set, also represented no danger for pacemaker patients. The interfering frequency emitted by the tuning oscillator of the television set during tuning was in the range of 85-900 Mc/s. Its intensity was too low to cause interference with pacemakers. It was concluded that pacemaker wearers may go near television and radio sets and use remote control accessories without any danger. (6 refs.)

76-50

4553 THE CONTINUING MEDICAL SURVEILLANCE OF PERSONNEL EXPOSED TO EXTREMELY LOW FREQUENCY (ELF) ELECTROMAGNETIC FIELDS. (Eng.) Houk, W. M. (Naval Aerospace Medical Res. Lab., Pensacola, FL). *Naval Medical Res. Lab. Report No.* 2225: 17

pages; March 1976.

The medical surveillance (range 2-5 years) performed on a small group of personnel operating the extremely low frequency (ELF) communications test station in Clam Lake, Wisconsin is reported. In 1971, 24 age-sex pairs of control and exposed personnel entered this study, aimed at investigating the effects of ELF electromagnetic radiation on the health of personnel. In 1973, the seven individuals remaining in the surveillance program underwent physicochemical and psychometric testing. Physicochemical tests included: serum lipid, carbohydrates, blood alcohol, eye, audio, radiography, electroencephalograph (EEG), photic stimulation, glucose tolerance (GTT), electrocardiograph (EKG), triglycerides, and cholesterol. The results indicated little change in health status from 1971 in these seven volunteers. In 1974/75, five of six subjects had elevated GTTs. However, there was no evidence that exposure to the ELF electromagnetic field had any causal relation to this finding. Elevated GTT can be found in connection with lipid abnormalities, obesity, hypertension and heart disease. Except for one individual, all EKGs taken at rest were normal; EEGs, X-rays, and pap smears were all normal. Psychological testing indicated no apparent changes. With the limited number of subjects, it is difficult to determine the possible effects of ELF electromagnetic fields on the health of the general public. (9 refs.)

76-51

4554 POINT ELECTROANESTHESIA: REPORT III: GENERAL ELECTROPHARMACEUTICAL ANESTHESIA.

(Eng.) Limoge, A. (Institut de Recherche d'Electro-anesthesie, Faculte de Chirurgie-Dentaire, Paris V, 1, rue Maurice-Arnoux, 92120 Montrouge, France); Debras, C.; Louville, Y.; Atinault, A.; Lepresle, E.; Manne, J.; Degos, J. -D.; Boissontier, M. -T. *U.S. Army Medical Research and Development Command Report* (ADA0 25075): pp. 13-55; February 1976.

This report presents the progress toward total elimination of drugs from anesthesia and the advance of pure electroanesthesia. The report includes a hemodynamic study on animals under electroanesthesia. Eight dogs (15 kg average weight), placed under electroanesthesia, had a stable and deep sleep followed by a rapid awakening. There appeared to be no difference between neuroleptanalgesia and electropharmaceutical anesthesia except for an increase in oxygen consumption during the initial waking period. Human clinical studies are discussed with applications of electroanesthesia for thoracic, cardiac, and urological surgery. Electroanesthesia was found to be useful in high risk patients on whom it would be difficult to operate under narco-neuroleptanalgesia. Three types of tests were used to compare patients administered classical or electropharmaceutical anesthesia: modifications of neurological exams after anesthesia, quality of awakening following intervention, and the state of memory function. The study of psychological manifestations included testing for modifications of personality and memory. The results of these tests do not provide

a significant difference between classical and electroanesthesia before or after intervention. Further studies will be needed to establish conclusively that electroanalgesia does not cause any deterioration of intellectual functions, and that personality alterations are similar to those resulting from classical anesthesia. (No refs.)

76-52

4555 CHROMOSOME STUDIES OF RADAR CENTER STAFF EXPOSED TO ELECTROMAGNETIC RADIATION. (Ita.) Ciaccia, A.; Malacarne, P.; Piffanelli, P.; Della Piccola, A. (Direzione Sanita, 1^a R.A., Milan, Italy). *Minerva Med.* 67(24): 1557-1560; 1976.

Five subjects (ages 32-52) chronically exposed to electromagnetic radiation in radar centers (10, 17, 25 years) were studied for chromosomal alterations. Approximately 450 metaphases were analyzed in short-term cultures of peripheral blood for each subject, including five controls. Hypotonic shock was obtained with sodium citrate in two employees and two controls, and with potassium chloride in the others. Results showed chromatid alterations, two presumed chromosomal alterations in exposed personnel, and five chromosome breaks in controls. There was no statistical difference between the two groups. There was a significant difference between the two hypotonic mediums in the exposed personnel with regard to chromatid and isochromatid alterations (2.05 and 2.17 respectively). (no refs.)

76-53

4556 ASSESSMENT OF THE EM FIELD COUPLING OF 915 MHz OVEN LEAKAGE TO HUMAN SUBJECTS BY THERMOGRAPHIC STUDIES ON PHANTOM MODELS (SYMPOSIUM SUMMARY). (Eng.) Webb, M. D. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington, Sch. Medicine, Seattle, WA 98195); Guy, A. W.; McDougall, J. A. *J. Microwave Power* 11(2): 162-164; 1976.

Full-sized human female (1.63 m tall; weight, 59 kg) and child (0.94 m tall; weight, 15 kg) phantom models with dielectric properties equivalent to those of muscle were exposed to electromagnetic leakage radiation from a microwave oven. A power amplifier, tuned to 919.5 MHz, was used. The models were exposed in three different positions. The female model was placed 5 cm, 10.1 cm, and 35.5 cm from the power amplifier. The exposure time was 300 sec for each position. The child model was placed at eye level 4.8 cm, 9.9 cm, and 35.3 cm from the power amplifier. The exposure time was 120 sec for all three positions. The regions of maximum specific absorption rates (SAR) were found to be those closest to the power amplifier; moderate levels of SAR were also observed in the neck region of the child. In all other regions of the models, the SAR was too low to be determined. The energy absorption distribution along the normal direction into

the female model was similar to that predicted for a plane slab of the same material. The maximum SAR of 136 mW/kg per mW/cm² occurred at the surface and decreased exponentially with depth. The energy absorption pattern in the child's head showed the nasal region to have the maximum SAR of 455 mW/kg per mW/cm² at the surface. There was also significant absorption in the forehead, nose and mouth. For all of these regions, the maximum SAR occurred at the surface and decayed exponentially with depth. It is concluded that a power density leakage level of 5 mW/cm² should be expected to have negligible thermal significance in comparison to the metabolic rate of the human. (No refs.)

76-54

4557 STYROFOAM CAGES FOR RATS USED IN MICROWAVE RESEARCH: COATING WITH QUININE. (Eng.) Catravas, G. N. (Armed Forces Radiobiology Res. Inst., Bethesda, MD 20014). *Health Phys.* 31(1): 68-69; 1976.

The design for a quinine coated styrofoam cage for confinement of rats during exposure to electromagnetic radiation microwaves is discussed. Of all plastic materials used to construct cages for the confinement of rats during exposure to electromagnetic radiation only styrofoam has been found to be transparent to microwaves. Styrofoam sheets 0.5 inches thick were glued together with Elmers casein glue to make a cage of height 6 inches, width 6.5 inches and length 10 inches. Feces and urine were removed from the bottom of the cage by a series of parallel plexiglas tubes 0.375 inches outside diameter, 0.0625 inches wall thickness, and 0.25 inches apart to insure that waste materials would not perturb the electromagnetic field. One end of the tube was embedded in 1 inch thick styrofoam. Good ventilation was achieved by similarly constructed covers. A 10% solution of quinine in absolute methanol was applied to the inner sides of the cage to determine whether this solution is effective in deterring rats from chewing their way out of the cage. Sprague-Dawley rats, 8-10 weeks old, were placed in coated and uncoated cages. Rats in coated cages remained in the cage for the duration of the experiment (24 hours), while rats in uncoated cages chewed their way out within 1-2 hours. Coated and uncoated cages were identical in terms of microwave transparency. (8 refs.)

76-55

4558 EXPERIMENTAL AND CLINICAL ASPECTS OF HYPERTHERMIA APPLIED TO THE TREATMENT OF CANCER WITH SPECIAL REFERENCE TO THE ROLE OF ULTRASONIC AND MICROWAVE HEATING. (Eng.) Har-Kedar, I. (Oncological Dept., Sheba Medical Center, Tel Hashomer, Israel); Bleehen, N. M. *Adv. Radiat. Biol.* 6: 229-266; 1976.

The role of hyperthermia alone, and in combination with radiation and chemotherapy in the treatment of cancer, is discussed, with special attention given to the use of microwaves and ultrasound. The follow-

ing mechanisms for the action of hyperthermia are considered. Tumor masses lack a good blood supply system, and therefore, are more sensitive to heat because heat dispersion is poor. Hyperthermia may act by inhibiting DNA synthesis in tumor cells. Autoradiographic studies indicate that above 39°C there is a drop in DNA synthesis. Large temperature differentials have been achieved by cooling the body to 30-32°C and heating the tumor to 42-43°C. Microwaves and ultrasound beams can be focused at deep seated tumors, and therefore, have potential for widespread clinical use. Further, it is suggested that cancer cells may be more vulnerable than normal cells to certain microwave range frequencies. Cancer cells may contain more bound water than normal cells, and microwave energy absorption has been shown to be greater at certain frequencies for bound water. The use of whole body heating and localized limb perfusion, however, is considered limited, and the theoretical advantages of microwaves over other methods of achieving hyperthermia remain to be demonstrated. (198 refs.)

76-56

4559 HEALTH HAZARDS FROM MICROWAVE EXPOSURE (LETTER TO EDITOR). (Eng.) Bush, D. (Univ. Radiation Protection Officer, Univ. Birmingham, Birmingham, B15 2TT, England). *Annu. Rev. Med.* 27: 431; 1976.

It is stressed that the maximum permissible levels of exposure to non-ionizing radiation in the United States may be too high. The maximum permissible level in the U.S.S.R. is 0.01 mW/cm², while it is 10 mW/cm² in the United States, and the United Kingdom. The U.S.A./U.K. standard is based on aberrations due to thermal effects, while the U.S.S.R. standard considers damage to the nervous system, inhibition of growth, and functional changes. These effects occur at a level well below the present U.S. standard. Due to the large increase in the use of microwave power sources, the author urges the International Radiation Protection Association to seek an international agreement on maximum permissible exposure levels to non-ionizing radiation, especially microwaves. (14 refs.)

76-57

4560 PASSIVE TELEMETRY FOR IN VIVO MEASUREMENT OF FIELDS IN BIOLOGICAL MATERIALS (SYMPOSIUM SUMMARY). (Eng.) Brodin, M. E. (Northwestern Univ., Evanston, IL 60202). *J. Microwave Power* 11(2): 151-152; 1976.

A passive remote sensing method is described for the measurement of electric fields within biological samples. The intermodulation spectrum reradiated by an implanted diode was used to determine the field. The diode was exposed to dual frequency illumination and, because of inherent nonlinearity, the reradiated field contained intermodulation components. The power distribution among the intermodulation components was uniquely related to the field intensity at the diode, and by measuring the power of the components, the field was determined. The theoretical relation between the incident field and the reradiated intermodulation components was developed and applied to a

biological sample. Microwave experiments are described, which verify the theory, and the results of a calculation for the expected observations in a biological sample are presented. Using these results and assuming soft tissue, it was demonstrated that for a material with a loss tangent of 0.5 and the diode implanted 4.0 cm from the surface, 24 dBw would be required for the observation. This corresponds to an input density of 10 mW/cm². Similar calculations were performed for 2450 MHz. (No refs.)

76-58

4561 SEARCH FOR CORRELATION BETWEEN GEOMAGNETIC DISTURBANCES AND MORTALITY. (Eng.) Lipa, B. J. (Inst. Plasma Res., Stanford Univ., Stanford, CA 94305); Sturrock, P. A.; Rogot, E. *Nature* 259: 302-304; 1976.

An attempt was made to correlate the daily number of deaths in the United States due to coronary heart disease and stroke from 1962-66, with different geomagnetic activity. Various Soviet studies have claimed a positive correlation exists between geomagnetic storms and the incidence of some human diseases. In this study, mortality rates were compared with corresponding Ap indices (world indices for geomagnetic activity) using three methods. Mortality data was normalized to remove weekly and seasonal variations and a long term secular trend. No evidence for correlation at the 3σ significance level was found. In an alternate procedure, superposed epoch diagrams were constructed for deaths on days with Ap in selected ranges. No diagram indicated a statistically significant association between daily deaths and magnetic index. The third method of presentation was to plot averaged deaths as a function of magnetic index for -20 ≤ Kp ≤ 20. These studies did not support the findings of Soviet studies, which claim a positive correlation exists between geomagnetic activity and disease. The Soviet results were either not statistically significant or not due to a causal relationship between geomagnetic disturbances and coronary heart disease and stroke. (10 refs.)

76-59

4562 ESTIMATION OF THE OCCURRENCE OF NEUROTIC DISORDERS IN SEA ECONOMY WORKERS EXPOSED TO THE ACTION OF ELECTROMAGNETIC WAVES. (Eng.) Dolmierski, R. (Inst. Maritime and Tropical Medicine, Gdynia, Poland); Nitka, J. *Bull. Inst. Marit. Trop. Med. Gdynia* 27(1): 57-61; 1976.

The incidence of neurosis in 12 persons exposed to electromagnetic waves is investigated. Of the 42, 18 were wireless operators, and 24 were employees of the Maritime Radio Service. Daily exposure had been four hours with length of exposure between 2-24 years. (12.5 average). They were administered the following tests: cuneostatic, orthostatic, Aschner 100, Aschner 150, hyperventilation, and time of maximum apnoea. Clinical examination showed 20 normal, 19 borderline, and 3 neurotic. This group was compared to groups of 40 normal and neurotic sailors. The test group did not differ from controls in orthostatic, hyperventilation, and time of maximum

apnoea tests. However, the cuneostatic tests were similar for wireless operators (-4.5) and neurotic sailors (-4.5). The Aschner 100 and Aschner 150 tests also showed a correlation between neurotic sailors and workers exposed to microwaves. Neurotic symptoms in more than 50% of the test group indicated an increased risk of neurosis for workers exposed to microwaves. These results demonstrate a need for periodic psychoneurologic examinations and exclusion of persons susceptible to neurosis from work with microwaves. (8 refs.)

75-186

4563 BIOMEDICAL EFFECTS OF MICROWAVE RADIATION--
A REVIEW. (Eng.) Lin, J. C. (Dept.
Electrical Engineering, Wayne State Univ., Detroit,
MI 48202). *Natl. Electron. Cong. Proc.* 30: 224-232;
1975.

Research conducted in the Soviet Union, Eastern Europe, and the United States on the biologic effects of microwave radiation is reviewed. The clinical, hygienic and experimental studies from the Soviet Union and Eastern Europe indicate changes that occur in the nervous, cardiovascular, digestive, excretory, and hematopoietic systems due to microwave radiation. The main effect, however, is on the nervous and cardiovascular system, while other effects (i.e., lethargy) are secondary manifestations of generalized excitation of the central nervous system. These changes occurred in humans at low level exposures of 10 mW/cm² or less and were generally reversible. Recent United States investigations included studies on neural, behavioral, cataractogenic, testicular, and genetic effects. Rabbits exposed to near zone 2450 MHz for a minimum of 150 mW/cm² for 100 min developed lens opacity. However, under controlled hypothermia, rabbits similarly exposed did not produce lens opacities. Genetic studies showed only 24% of irradiated pupae of mealworm beetles exposed to 10 GHz continuous wave developed normally. Quail eggs exposed at 2450 MHz with an absorbed energy of 14 mW/gm showed no influence on cellular differentiation. The author stresses a need for studies on long term exposure effects, large scale epidemiologic investigations, and a better understanding of the mode of interaction between microwave radiation and biologic systems. (80 refs.)

76-60

4564 INTERACTION OF TWO CROSS-POLARIZED ELECTRO-
MAGNETIC WAVES WITH MAMMALIAN CRANIAL
STRUCTURES. (Eng.) Lin, J. C. (Dept. Electrical
Engineering, Wayne State Univ., Detroit, MI 48202).
IEEE Trans. Biomed. Eng. BME-23(5): 371-375; 1976.

The interaction of two cross-polarized plane electromagnetic waves with six-layered spherical models of a mammalian head was studied. The numerical results indicated that the absorbed powers induced inside small animal and human heads by incident circularly polarized waves and linearly polarized waves were very similar, except that the absorbed power in the planes transverse to the direction of propagation is uniform for the cross-polarized wave. It was also shown that the average absorbed

power depended strongly on the frequency and head size involved. The maximum absorbed powers in a given size spherical head varied only slightly with frequency for the two frequencies studied. However, since a greater amount of the absorbed power occurs in the inner sphere representing the brain of a human head when 918 MHz rather than 2450 MHz is used, the former constitutes a greater health hazard to man at the same incident power. (13 refs.)

76-61

4565 STUDY OF THE EFFECTS OF CHRONIC LOW LEVEL
MICROWAVE RADIATION ON RABBITS (SYMPOSIUM
SUMMARY). (Eng.) Guy, A. W. (Sch. Medicine, Univ.
Washington, Seattle, WA); Harris, C.; Kramer, P. O.;
Emery, A. F. *J. Microwave Power* 11(2): 134-135;
1976.

A special exposure system was developed and used to chronically irradiate rabbits to a power density level of 10 mW/cm² for a period of six months. The system allowed a total of eight rabbits to be studied simultaneously--four receiving continuous 2450 MHz continuous wave microwave radiation and four serving as controls. Lines of constant specific absorption rate (SAR) values were measured and plotted for rabbits exposed in the chamber. The results were obtained by observation of temperature increases in the exposed rabbit carcasses by thermography. The results indicated that a peak SAR of 14 W/kg could be expected in the head of the rabbit when the animal was in the normal resting position in the cage. Four New Zealand albino rabbits weighing approximately 4 kg were exposed each day for 23 hours a day for a period of six months in the system. Periodic examination of the eyes with a biomicroscope and ophthalmoscope were made and the following parameters were monitored throughout the exposure period: body weight, urinary output, rectal temperature, hematocrit, hemoglobin, white cell count with differential, platelet count, and basic blood coagulation studies. No significant differences were found between experimental and control animals. (No refs.)

76-62

4566 EFFECT OF ELECTROMAGNETIC PULSE ON AVOIDANCE
BEHAVIOR AND ELECTROENCEPHALOGRAM OF A
RHESUS MONKEY. (Eng.) Mattsson, J. L. (Armed
Forces Radiobiology Res. Inst., Bethesda, MD 20014);
Oliva, S. A. *Aviat. Space Environ. Med.* 47(6):
644-648; 1976.

A 12-kg male rhesus monkey was exposed to an electromagnetic pulse (EMP) field with pulse characteristics similar to those of industrial systems and at a field intensity and pulse rate much greater than those in typical work areas. The effect of the EMP was determined by electroencephalogram (EEG) and Sidman avoidance behavior. An EMP exposure at 266 kv/m, 5 pulses/sec was begun in the second Sidman session and ended one hour later, midway in the sixth session (18,700 pulses). During Sidman performance sessions, the monkey consistently avoided a 0.2-sec shock, administered with an interval of less than 10 sec. Sessions lasted 10 minutes with

five minute rests. No significant changes in Sidman avoidance behavior or EEG were noted. Almost all EMP energy in this study was in the frequency range below 30 MHz, where wavelengths are long. Model studies predict only minimal energy deposition when wavelengths are long relative to subject size. Also, there was a broad distribution of energy across the lower frequency so that only a small electric field existed at a specific low frequency. Future EMP experiments should consider the wavelength to body size relationship of man in an EMP field. (19 refs.)

76-63

4567 MICROWAVE-INDUCED COCHLEAR MICROPHONICS IN CATS (SYMPOSIUM SUMMARY). (Eng.) Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington, Sch. Medicine, Seattle, WA 98195); Guy, A. W.; Galambos, R. J. *Microwave Power* 11(2): 171-173; 1976.

Recordings of Cochlear Microphonics (CM) from cats exposed to pulsed microwave radiation from an aperture antenna were made. Microwave pulses (10 μ sec) of 918 MHz were provided by a square aperture source (13 X 13 cm) located 8 cm away from the occipital pole of the cat and were fed by the AML PH40K microwave pulse generator. A piezoelectric crystal transducer was also attached to the skull of the same cat providing acoustic stimuli by bone conduction. Upon death of the cat, the nerve responses disappeared before the CM. After several minutes, CM also disappeared, but the artifact persisted, indicating the 38 kHz oscillatory signal was a genuine physiological response. A CM produced mechanically by the piezoelectric crystal had the same frequency and duration as that produced by the microwaves. The 38 kHz CM induced by microwaves, pulses appeared to be related to the size of the cat skull when compared with the 50 kHz CM of guinea pigs. This frequency is also consistent with the fact that masking noises of 50 Hz to 15 kHz did not effect the threshold of evoked responses in the medial geniculate of cats. (No refs.)

76-64

4568 MICROWAVES ACTION IN PROCARYOTIC AND EUCARYOTIC CELLS AND A POSSIBLE INTERACTION WITH X-RAYS (SYMPOSIUM SUMMARY). (Eng.) Averbeck, D. (Fondation Curie, Institut du Radium, Section de Biologie, 26, rue d'Ulm, 75005 Paris, France); Dardalhon, M.; Berteaud, A-J. *J. Microwave Power* 11(2): 143-144; 1976.

Microwaves at frequencies between 70 and 75 GHz and at a power density 5 to 100 mW/cm², were used to determine effects on bacterial growth and lethal and mutagenic effects in bacteria and yeast cells. A growing culture of *Escherichia coli* K 12 wildtype was exposed to microwaves. No global thermal effects were observed in the power range used. In a second approach the effects of microwaves were studied at a power density of up to 100 mW/cm² on the survival and induction of nuclear mutations in *E. coli*. The results show that microwave irradiation for 30 minutes at frequencies between 70 and 75 GHz and at the power density of up to 60 mW/cm² did not induce any

killing in mutant and wildtype strains. Effects of microwaves on the induction of nuclear reversions in *E. coli* and in *Saccharomyces cerevisiae* were investigated. In yeast the induction of cytoplasmic mutations were studied. The results clearly demonstrate that microwave irradiation produced no mutagenic effects. Reversion rates observed after microwave treatment were always the same as the spontaneous mutation rates. X-rays were shown to affect various targets in the cell. The sensitivity of *E. coli* cells against X-irradiation became variable when cells were treated with microwaves before or after exposure to X-rays. (No refs.)

76-65

4569 USE OF THERMOGRAPHY FOR QUANTITATION OF ENERGY ABSORPTION IN ANIMALS IRRADIATED WITH MICROWAVES (SYMPOSIUM SUMMARY). (Eng.) Bielec, M. (Centre for Radiobiology and Radioprotection, Warsaw, Poland); Szmigielski, S. *J. Microwave Power* 11(2): 152-153; 1976.

Color thermovision (AGA-680) with temperature resolution of 0.5°C was used for quantitative analysis of the amount and distribution of energy absorbed in dead and live rats irradiated with 3 GHz microwaves. Dead rats were frozen, covered with a thin layer of metacrylate, and cut alongside the longitudinal axis of the body. Both parts of the body were put together and irradiated at 3 GHz (60 mW/cm²) under far field conditions. Thermographic analysis of the internal surface (section) was performed every 3 minutes after irradiation. Living animals (rats and rabbits) were irradiated at identical conditions, and the thermographic analysis was performed from the body surface. Both dead and living animals were irradiated in frontal (head-tail) or long-side position to the microwave antenna. The results obtained showed dependence of energy absorption and distribution depending on position of the irradiated body in the microwave field. In rats irradiated at a frontal position, the highest temperatures were found at the brain base and base of the tail, while in those irradiated the highest temperatures were found at the long-side position in chest and pelvis. "Hot" points were found both in dead and living animals and were localized in the head and chest.

76-66

4570 A COMPARATIVE PERFORMANCE STUDY OF SPACED APPLICATORS IN MICROWAVE DIATHERMY (SYMPOSIUM SUMMARY). (Eng.) Kantor, G. (Division of Electronic Products, Bureau of Radiological Health, FDA, 12721 Twinbrook Parkway, Rockville, MD 20852); Witters, D. M., Jr. *J. Microwave Power* 11(2): 164-165; 1976.

Spaced applicators in clinical use and appropriate for microwave diathermy were evaluated by comparing near field measurements of external fields in free space and in the presence of phantoms, together with resulting heating patterns. Spatial variations of the field components were mapped in the vicinity of the applicators with a miniature isotropic probe. Digital minicomputer techniques were used to map

free space and scattered fields. The results indicated that for a microwave diathermy setting of 100 W, the total free field was typically 500 mW/cm² (equivalent plane wave power density). It also was shown that measured scattered fields around spaced applicators loaded with phantoms of simulated fat-muscle tissue strongly depended on the relative size of applicators and phantoms and exceeded 10 mW/cm² (equivalent plane wave power density) for typical treatment conditions. Heating patterns of spaced applicators irradiating planar, arm, and thigh phantoms were obtained by exposing the midplane of each phantom to an infrared thermographic camera. Temperature profiles in the region of maximum intensity were obtained. For planar phantoms, the transverse fields and temperature profiles had similar shapes. Thus, for normal incidence, the longitudinal component does not significantly contribute to the heating pattern.

76-67

4571 BIOCHEMICAL CHANGES IN THE BRAIN OF RATS EXPOSED TO MICROWAVES OF LOW POWER DENSITY (SYMPOSIUM SUMMARY). (Eng.) Catrivas, G. N. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014); Katz, J. B.; Takenaga, J.; Abbott, J. R. *J. Microwave Power* 11(2): 147-148; 1976.

The effects of microwaves on macromolecular constituents of the brain of Sprague-Dawley rats were investigated. Groups of rats, weighing 200-220 g, were exposed to continuous wave microwave radiation of 2450 MHz frequency and 10 mW/cm² power density (8 hours/day for 8 days) in an anechoic chamber. Control rats were effectively protected from the microwave beam. The microwave-induced changes in the PGE₁-stimulated brain adenylyl cyclase and serotonergic systems were determined. Preliminary results indicated an increased sensitivity of brain adenylyl cyclase to PGE₁, with a shift of the dose/response curve to the left. This shift was more pronounced in irradiated animals euthanatized 8 hours post-exposure than those euthanatized immediately after exposure. However, the maximal adenylyl cyclase activity did not appear to be affected. Marginal changes (increase) in the activity of tryptophan hydroxylase and levels of serotonin in the hypothalamic-thalamic region were also observed. No changes in monoamine oxidase activity were seen. (No refs.)

76-68

4572 MICROWAVE HEATING OF THE UTERINE WALL DURING PARTURITION (SYMPOSIUM SUMMARY). (Eng.) Daels, J. (Kliniek Maria Middelares, Gent, Belgium). *J. Microwave Power* 11(2): 166-168; 1976.

Microwave heating of the uterine wall during parturition was carried out in a selected group of 2000 patients. The apparatus used was the Radarmed 12 S 230 with the curved Grossfeldstrahler widefield radiation electrode. Treatment was applied intermittently only during the uterine contractions.

The dose administered varied between 80 and 100 mW. The results were compared with a control-group of 2000 patients whose pregnancies and deliveries were similar. Of the 2000 patients treated, 1936 described the analgesic effect as good, the remaining 64 experienced only moderate attenuation. The "transcency-group" required significantly less sedation than the control group. Comparison of the average duration of the dilation stage revealed a significant shortening of the average duration of the dilation period in those receiving microwave transcency: 108 minutes for primiparae and 43 minutes for multiparae. This acceleration was localized mainly in the latent phase. No side-effects of microwave heating of the tissues were observed. After intermittent microwave transcency, temperature of the amniotic fluid never exceeded 36.5°C. The temperature of the newborn was slightly increased but never exceeded 37.8°C. (No refs.)

76-69

4573 PACEMAKER INTERFERENCE: A LOW RISK. (Eng.) Anonymous. *Med. World News* 17(17): 40; 1976.

It has been publicized that electromagnetic radiation (i.e., from microwave ovens) may interfere with the operation of cardiac pacemakers. Experts, however, feel that the chances of such an occurrence are rare and would seldom be fatal. The R-wave-inhibited demand pacemaker, used in about 90% of recent implants, operates by stimulating the heart if an R-wave is not detected. This device is susceptible to electromagnetic interference (EMI), which may cause the heart to skip a beat, temporarily "control" the heart, or stop it. Moving away from the EMI source remedies the situation. Recently, manufacturers have designed better shielding and filtering circuits to minimize the risk. FDA, Biomedical Engineer, J. R. Veale, feels the risk of EMI of pacemakers is low, except in some work areas where 15-20% of pacemaker wearers under age 60 come into contact with high powered electrical equipment. Automobile mechanics may have their pacemakers stop within a foot of a well-tuned operating Volkswagen engine. It is suggested by Veale, that employers warn pacemaker wearers of the potential EMI of pacemakers and be aware of the electromagnetic radiation levels of their equipment. Dr. Doris Escher, a cardiologist at the Albert Einstein College of Medicine does not feel the risk of EMI is great, but suggests caution to pacemaker wearers when using electrical equipment. (No refs.)

76-70

4574 AN INVESTIGATION OF THE USE OF MICROWAVE RADIATION FOR PULMONARY DIAGNOSTICS. (Eng.) Pedersen, P. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Johnson, C. C.; Durney, C. H.; Braggs, D. G. *IEEE Trans. Biomed. Eng.* 23(5): 410-412; 1976.

A new technique is described in which penetrating microwave radiation was used for the diagnosis and monitoring of pathologic cardiopulmonary conditions, such as, pulmonary edema. Edema was shown to cause changes in the electromagnetic characteristics of the lung tissue, which in turn produced a change in the reflected and transmitted microwave radiation. Both the amplitude and phase changes of the microwave signals were measured and correlated with lung volume. (5 refs.)