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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME II

NUMBER 1

SEPTEMBER, 1977

A DIGEST OF CURRENT LITERATURE

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



"The views and conclusions contained in this documentation are those of the author and should not be interpreted as necessarily representing the officials' policies, either expressed or implied, of the Office of Telecommunications Policy or of the U.S. Navy."

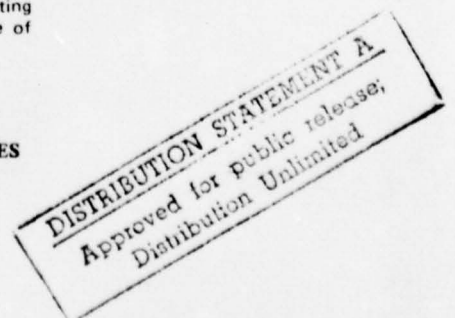


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**BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION .**
Volume II, Number 1.
A Digest of Current Literature .

7 Quarterly rept. Jun - Sep 77

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

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

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

11 Sep 77

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

September, 1977 Volume II, Number 1

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PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under a contract with the U.S. Navy and administered by the Office of Telecommunications Policy.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed, and disseminated on a regular basis. *Biological Effects of Nonionizing Electromagnetic Radiation* is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume II, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as summary abstracts.

ABBREVIATIONS AND ACRONYMS

| | |
|---------------------------------------|---------------------------------------|
| A, amp - ampere(s) | n - nano-- |
| Å - angstrom(s) | NBS - National Bureau of Standards |
| BRH - Bureau of Radiological Health | NIH - National Institutes of Health |
| C - centigrade | NSF - National Science Foundation |
| cm - centimeter(s) | NIOSH - National Institute for |
| cps - cycles per second | Occupational Safety and Health |
| dB - decibel(s) | NTIS - National Technical Information |
| EPA - Environmental Protection Agency | Service |
| FDA - Food and Drug Administration | Oe - oersted(s) |
| g - gram(s) | OSHA - Occupational Safety and Health |
| G - Gauss | Administration |
| GHz - gigahertz | OTP - Office of Telecommunications |
| HEW - Health, Education, and Welfare | Policy |
| hr - hour | PHS - Public Health Service |
| Hz - hertz | rad - radiation absorbed dose |
| IEEE - Institute of Electronic and | R - roentgen(s) |
| Electrical Engineers | rpm - revolutions per minute |
| IMPI - International Microwave Power | sec - second(s) |
| Institute | USAFSAM - U.S. Air Force School of |
| IU - international unit(s) | Aerospace Medicine |
| J - joule(s) | USDA - U.S. Department of Agriculture |
| k - kilo-- | UV - ultraviolet |
| l - liter(s) | V - volt(s) |
| m - meter(s) | VA - Veterans Administration |
| m - milli-- | W - watt(s) |
| M - mega-- | Wb - Weber(s) |
| mho - unit of measurement of | WHO - World Health Organization |
| conductivity | wk - week(s) |
| min - minute(s) | wt - weight |
| mo - month(s) | yr - year(s) |

μ - micro--

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NEWS ITEMS

MICROWAVE BREAST CANCER DETECTION PROGRAM

To help in the all-important early discovery of a disease that has reached epidemic levels in the U.S. (90,000 cases a year), radiologists at Boston's Faulkner Hospital are using microwaves to spot breast cancers. Although microwaves can damage tissue at high energies, Faulkner microwaves are perfectly safe since the radiation is emitted not by the detector, as in conventional mammography, but by the body itself. Because of its rapid growth rate and increased blood supply, a tumor is hotter than normal tissue, and it therefore gives off more radiant energy. The Faulkner breast cancer detection program employs a sensitive antenna that picks up the weak microwave (or heat) emissions from a tumor up to 10 cm below the surface. The antenna is placed against nine different sites on the breast and held at each for about 10 sec. If one spot is significantly hotter than a comparable area on the other breast, the supervising radiologist can make other checks for a tumor, including x-rays. About 70% accurate, the gadget is less precise than mammography (90%). But since there is no radiation risk, the microwave detector could at the very least be used for prescreening--especially those under 35 who are ordinarily not encouraged to have mammograms unless they have a family history of breast cancer or symptoms of the disease.

Time 109(25): 80; 1977.

BRITISH INVESTIGATING MICROWAVES' NON-THERMAL EFFECTS

The British National Radiological Protection Board (NRPB) is investigating the validity of Soviet theories that non-thermal doses of microwaves can cause neurasthenic, cardiovascular, and testicular damage, and endocrine and blood disorders. Details of the project are given in the NRPB's latest report, which outlines results of experiments on mice in addition to research on occupational radiation hazards.

Occupational Health 29(5): 200; 1977.

DIGEST AVAILABLE THROUGH NTIS

Previous issues of this digest can be obtained from the National Technical Information Service (NTIS), Springfield, Virginia 22151, at a nominal cost. The accession numbers for these issues are noted below.

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MOSCOW EMBASSY EMPLOYEES SHOW NO ILL-EFFECTS

Although the Russians are still beaming microwave radiation at the U.S. Embassy in Moscow, tests of Americans who used to work there have shown no harmful health effects, according to the State Department. However, Herbert Pollack, a physician and government consultant states that a third of one group of State Department employees showed a slight, apparently harmless, change in their blood composition. In testimony before a Senate Commerce subcommittee, Pollack said "There have been no medical ill effects observed in individuals whose lymphocyte counts have been elevated." He added, "The condition disappears after departure from Moscow." The Russians have been aiming microwave radiation at the embassy since the early 1950's, but in 1975 the signal was intensified, and there were fears that the radiation might reach harmful levels. Although the beaming has declined, the radiation level at the embassy measures above the standard the Russians have set for themselves as being safe.

New York Times June 28, 1977

MICROWAVES HOT ISSUE IN DC

The subject of biologic effects of microwave radiation is becoming an increasingly important issue in the nation's capital this year. Interest is already accelerating in several forums, including the Environmental Protection Agency (EPA). For example, in a recent presentation before the government's Electromagnetic Radiation Management Advisory Council (ERMAC), EPA scientists unveiled preliminary evidence that supposedly "safe" levels of microwave exposure lower body's ability to resist disease and could cause certain types of birth defects. But they claim such levels are found only in occupational settings. Meanwhile, Rep. Henry Waxman has written Federal Communications Commission chairman Richard Wiley demanding something be done about the lack of regulation in the area. "It appears that the responsibility of extensive biological damage from microwave radiation exposure is increasing in some proportion to the proliferation of microwave technology," wrote Waxman. "This raises the most serious questions regarding the health and safety of the American people and the technological basis of the telecommunications industry." Wiley had not responded to the message at presstime, while House Communications Subcommittee Chairman Lionel Van Deerlin favors deferring jurisdiction in the area to the Subcommittee on Health and Environment, chaired by Rep. Paul Rogers. Waxman is a member of both panels. EPA researchers at the Experimental Biology Division of Health Effects Research Lab in Research Triangle Park, NC, claim that equivalent exposures to microwave radiation (at frequencies used by UHF television and microwave ovens) of pregnant mice and rats lowers a body's ability to fight disease. Additionally, such exposures might prompt low inci-

NEWS ITEMS

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dence of a birth defect called encephalocele, failure of the brain case to close over the brain. But EPA researcher Dr. Ezra Berman says he's not positive about the birth defect. Researchers have not yet determined a "safe" level for microwave exposure, although the standard of 10 mW/cm² has been tagged by the American National Standards Institute. In any case, EPA indicates that the typical city comes nowhere near the level.

Microwaves 16(4): 23; 1977.

ELECTRICAL STIMULATION POSES RISKS FOR PATIENTS WITH PACEMAKERS

Electrical stimulation during electromyography and nerve conduction velocity studies should be used with extreme caution in patients with pacemakers according to Food and Drug Administration researcher, James R. Veale. Electrical stimulation for neurological tests is usually below 5-100 mamp when surface electrodes are used. Although the current density in the region of the pacemaker site will most likely be extremely small when the currents are applied to the extremity nerves, the closer the stimulator is to the pacemaker and pacing leads, the greater the chance for inducing a voltage of sufficient amplitude to inhibit the pacer. Veale cautions, "Scrupulous attention should also be paid to the grounding, if the stimulator is ac (alternating current) powered and has a grounded output, especially if monitoring equipment is used or the patient is grounded in some way." Veale concludes that the patient's condition should be carefully monitored throughout the procedure for any indications of pacemaker dysfunction.

JAMA 237(16): 1736, 1977.

INTERNATIONAL GROUP TO STUDY NON-IONIZING RADIATION HAZARDS

The International Radiation Protection Association (IRPA) plans to set up a new international committee for protection against non-ionizing radiation, particularly at microwave frequencies. The decision, taken at IRPA's fourth international congress in Paris in late April, follows recommendations of a working group that pointed out the lack of international agreement on the effects and control of such radiation. The working group was made up of Danish, Polish, French, and American members, including a representative of the National Bureau of Radiological Health. The proposed committee will help find solutions to potential health problems in commercial areas.

Electronics 50(10): 53; 1977.

ITEMS FROM THE COMMERCE BUSINESS DAILY

□ RESEARCH PROGRAM DEFINITION FOR THIS STUDY OF BIOLOGICAL AND ECOLOGICAL EFFECTS OF ENERGY TRANSMISSION BY MICROWAVES, EFFECTS OF CHRONIC LOW-LEVEL 2450 MHz ILLUMINATION ON PLANT GROWTH AND DEVELOPMENT.

The National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California is soliciting proposals for the above study. (April 29, 1977)

□ STUDY THE BEHAVIORAL EFFECTS OF ANIMALS EXPOSED TO MICROWAVE RADIATION.

The Department of Health, Education, and Welfare, Public Health Service, Food and Drug Administration, Rockville, Maryland will negotiate with Randomline, Inc., Huntingdon Valley, Pennsylvania for a continuation of the above study. (April 27, 1977)

□ STUDY OF RF PARAMETERS THAT AFFECT THE BRAIN AND BEHAVIOR AT LOW POWER DENSITIES.

The Department of Health, Education, and Welfare, Food and Drug Administration, Rockville, Maryland, has contracted with Randomline, Inc., Huntingdon Valley, Pennsylvania for the above study. (June 24, 1977)

□ R&D STUDY OF 2450 MHz MICROWAVE ABSORPTION IN LARGE AND SMALL ANIMALS AND ITS BIOBEHAVIORAL EFFECTS ON BIRDS AND REPTILES.

The National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California is soliciting proposals for the above study. (April 29, 1977)

□ RESEARCH ON SAFE PROCEDURES FOR ELECTRICAL STIMULATION OF THE NERVOUS SYSTEM.

The Contracts Management Branch, National Institute of Neurological and Communicative Disorders and Stroke, National Institutes of Health, Bethesda, Maryland is negotiating with EIC Corp. for a continuation of the above study. (June 6, 1977)

□ STUDY TO DEFINE MICROWAVE RESEARCH PROGRAM.

The National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California is negotiating with Techcoor, Palo Alto, California for the above study. (May 6, 1977)

□ **RESEARCH STUDY TO INVESTIGATE DIRECT
SOLAR TO MICROWAVE ENERGY CONVERSION TECHNOLOGY.**

The Procurement Office, National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Alabama will negotiate with Teledyne Brown Engineering, Cummings Research Park, Huntsville, Alabama for the above study. (June 24, 1977)

□ **EFFECTS OF MICROWAVE IRRADIATION ON
EMBRYONIC BRAIN TISSUE.**

The Contracting Branch, Logistics Division, U.S. Army Medical Research and Development Command, Washington, D.C. is negotiating with the Institute for Behavioral Research, Inc., Silver Spring, Maryland for the above study. (May 9, 1977)

MEETINGS AND CONFERENCES

SEVENTH EUROPEAN MICROWAVE CONFERENCE

Date: September 5-8, 1977
Place: Copenhagen, Denmark: Bella Center
Sponsor: Dansk Ingeniorgorening
Requests for Information: Professor Preben Gudmandsen, Conf. Chairman, Electronics Inst., 348 Technical Univ. of Denmark, DK-2800 Lyngby, Denmark

Selected Bibliography of Papers Presented:

BIOLOGICAL EFFECTS BY MICROWAVES. (invited)
 A. J. Berteaud

A MICROWAVE RADIOMETRIC METHOD FOR THE STUDY OF THE SEMICONDUCTOR PROPERTIES OF LIVING TISSUE.

J. Rigu-del-Blanco, A. Schneider, J. C. Beal

USE AND APPLICATION OF SPECIAL MICROWAVE INTERFEROMETERS FOR NONINVASIVE STUDIES OF BIOLOGICAL EFFECTS.

W. Griffin

A MODIFIED RADIOMETER FOR TEMPERATURE AND MICROWAVE PROPERTIES MEASUREMENTS OF BIOLOGICAL SUBSTANCES.

A. Mamouni, F. Bliot, Y. Leroy, Y. Moschetto

TERATOGENIC POWER OF SHF FIELDS. FURTHER EXPERIMENTS ON *TENEbrio MOLITOR COLEOPTERON*.
 G. d'Ambrosio, V. La Manna

MILLIMETER WAVE THERMOGRAPH AS SUBCUTANEOUS INDICATOR OF JOINT INDICATOR OF JOINT INFLAMMATION.

J. Edrich, C.J. Smyth

WESTERN ELECTRONIC SHOW & CONFERENCE

Date: September 20-23, 1977
Place: San Francisco, CA
Sponsor: Inst. Electrical Electronics Engineers (Los Angeles & San Francisco Councils); Electronic Reps. Assoc.
Requests for Information: W. C. Weber, Jr., WESCON, 999 N. Sepulveda Blvd., El Segundo, CA 90245

INTERNATIONAL ELECTRICAL AND ELECTRONICS CONFERENCE AND EXHIBIT

Date: September 26-28, 1977
Place: Toronto, Canada: Exposition Place (Auto Bldg.)
Sponsor: Inst. Electrical & Electronics Engineers (Can. Region)
Requests for Information: IEEE, Can. Regional Office, 7061 Yonge St., Thornhill, Ontario, Canada L3T 2A6

AMERICAN ACADEMY OF OCCUPATIONAL MEDICINE 29TH ANNUAL MEETING

Date: October 5-7, 1977
Place: Denver, CO
Sponsor: American Academy of Occupational Medicine
Requests for Information: W. Bentley, AAOM

WESTERN OCCUPATIONAL HEALTH CONFERENCE

Date: October 6-8, 1977
Place: San Francisco, CA: Fairmont
Sponsor: Am. Industrial Hygiene Assoc.; Health Physics Soc. (USA); World Occupational Medical Assoc. (USA); World Assoc. Industrial Nurses (USA); Am. Soc. Safety Engineers
Requests for Information: B. H. Bravinder, WOMA

INTERNATIONAL CONFERENCE ON RADAR (RADAR 77)

Date: October 25-28, 1977
Place: London, United Kingdom
Sponsor: Inst. Electrical Engineers (Electronics Div.) (UK); Inst. Electrical & Electronics Engineers (Aerospace Electronics Society; (Int.); Inst. Electronics & Radio Engineers
Requests for Information: Conference Dept., IEE or K. Milne, Plessey Radar, Southleigh Park House, Eastleigh Rd., Havant, Hants PO9 2PE, UK

INTERNATIONAL SYMPOSIUM ON BIOLOGICAL EFFECTS OF ELECTROMAGNETIC WAVES

Date: October 30-November 4, 1977
Place: Airlie, Virginia
Sponsor: International Union of Radio Science Commissions A and B
Requests for Information: Professor Saul W. Rosenthal, Chairman, Symposium Steering Committee, Polytechnic Inst. NY, Route 110, Farmingdale, NY 11735

ENGINEERING IN MEDICINE AND BIOLOGY CONFERENCE

Date: November 5-9, 1977
Place: Los Angeles, CA
Sponsor: Alliance for Engineering in Medicine and Biology

MEETINGS AND CONFERENCES

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Requests for Information: Mrs. P. I. Horner, Asst. Dir. & Conf. Coordinator, Alliance for Engineering in Medicine and Biology, Suite 1350, 5454 Wisconsin Ave., Chevy Chase, MD 20015

ELECTROMAGNETIC COMPATIBILITY CONFERENCE

Date: April 4-7, 1978
Place: Guildford, United Kingdom: Univ. Surrey
Sponsor: Inst. Electronic & Radio Engineers (UK); in assoc. with Inst. Electrical Engineers (UK); Inst. Electrical & Electronics Engineers (Int.); Inst. Quality Assurance (UK); Inst. Marine Engineers (UK); Royal Aeronaut. Soc.
Requests for Information: P. M. Elliott, IERE

AMERICAN OCCUPATIONAL HEALTH CONFERENCE

Date: April 9-14, 1978
Place: New Orleans, LA
Sponsor: American Occupational Medical Assoc.; American Assoc. Occupational Health Nurses
Requests for Information: H. N. Schulz, AOMA

FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY: Annual Meeting

Date: April 9-14, 1978
Place: Atlantic City, NJ
Sponsor: FASEB
Requests for Information: Mrs. H. B. Lemp, FASEB

INTERNATIONAL MICROWAVE SYMPOSIUM

Date: May 15-17, 1978
Place: Ottawa, Canada: Univ. Ottawa
Sponsor: Inst. Electrical & Electronics Engineers (Microwave Theory Technique Group)
Requests for Information: A. L. Van Koughnett, Communications Research Center, Box 11490, Station "H", Ottawa, Ottawa, Ontario, Canada

MICROWAVE POWER SYMPOSIUM 1978

Date: May 17-19, 1978
Place: Ottawa, Canada: Univ. Ottawa
Sponsor: International Microwave Power Inst.
Requests for Information: Dr. W. R. Tinga, IMPI

Selected Bibliography of Papers Presented:

ENERGY ABSORPTION OF SIMULATED BODY MATERIAL. Q. Balzano, D. Garay, F. R. Steel

INFLUENCE OF QUALITY ON BIOEFFECTS OF ELECTROMAGNETIC RADIATION. S. K. Ghosh

MEASUREMENTS & INSTRUMENTATION FOR MICROWAVE RADIATION SAFETY. M. A. Stuchly

EMISSION & EXPOSURE STANDARDS FOR MICROWAVE RADIATION. M. H. Repacholi, M. A. Stuchly

CURRENT RESEARCH

- 0165 FACTORS AFFECTING THE COLD ACCLIMATION OF CONTAINER-GROWN WOODY ORNAMENTAL PLANTS. Maronek, D. M.; Stoltz, L. P.; Lockard, R. G. (Univ. Kentucky, Agricultural Experiment Station, Limestone & Euclid, Lexington, KY 40506).

The effect of photoperiod and temperature on cold acclimation of plant roots and stems will be studied in addition to the effect of abscisic acid on cold acclimation of plant tops and roots. Investigators will also determine if in vitro culture can be used to evaluate cold hardiness of whole plants, plant parts, or callus tissue. Woody ornamental plants will be grown under controlled photoperiod and temperature regimens to determine how these environmental factors affect the differential rates of cold acclimation and maximum hardiness levels in stems and roots. An attempt will be made to determine the effect of electromagnetic fields on organogenesis of in vitro cultured woody plants. (10/76-9/77)

Supporting Agency: U.S. Dep. Agriculture, Cooperative State Res. Service, Kentucky

- 0166 RESEARCH AND ENGINEERING STUDIES FOR ELECTROMAGNETIC THAWING OF LARGE ORGANS. Ecker, H. A. (Georgia Inst. Technology, Graduate Sch., 225 North Ave., N.W., Atlanta, GA 30332).

An engineering study of the interaction of electromagnetic energy and biologic tissue will be performed. The research will focus on long-term cryopreservation and short-term preservation by electromagnetic thawing of biologic organs. Several separate but interrelated research tasks comprise the engineering effort. These include determining the electrical properties of canine kidneys, the optimum frequency assignments, the precise temperature and phase state, and the electromagnetic field distributions within the organ. Finally, a methodology will be developed to rapidly and uniformly thaw cryogenically preserved large organs. (8/77-7/78)

Supporting Agency: NSF, Div. Engineering

- 0167 MICROWAVE EXPOSURE EFFECTS ON BEHAVIORAL ACTIONS OF PHARMACOLOGICAL AGENTS. Thomas, J. R. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

This research will determine if exposure to microwave radiation modifies the effects of pharmacologic compounds on behavior. It is important to determine if microwave radiation interacts with other agents, which may produce potential hazards by changing the efficacy and safety of drugs, medication, and compounds commonly used by military personnel. Initial studies will evaluate how microwave radiation can affect the manner in which organisms react to pharmacologic agents. The research techniques involve the development of complex patterns of

behavior in animals. The developed behavioral baselines will be used to assess the effects of both acute and chronic drug regimens under both normal and radiation conditions. Assessment of irradiation effects with low-level microwave energy (near and below 10 mW/cm²) will be emphasized. Dose-response functions will be determined for a range of radiation intensities for a variety of parameters (frequency, pulse repetition rate, pulse versus continuous wave, acute versus chronic exposure). Using this methodology, modifications in behavior due to interactions between drugs and microwave exposures will be empirically determined. Based on such determinations, re-evaluation of exposure limits for navy personnel and specific recommendations for drug and medication usage in a microwave environment can be made. (10/76-9/77)

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

- 0168 RF EFFECTS OF IMMUNE SYSTEMS. Liburdy, R. P.; Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The effects of electromagnetic radiation (EMR) stress on immune systems will be investigated. Specifically, the magnitude and direction, causes, and thresholds of EMR-induced changes in immune responsivity will be determined. Nonpunitive thresholds for frequency and power dependency of continuous and pulsed wave EMR stress on immune function will be established. Initially, the effects of EMR stress on the ability of test animals to mount a viable in vivo cell-mediated immune response to antigenic challenge will be quantitated. Subsequently, the effects of EMR stress on specific cell-mediated effector mechanisms operating in delayed hypersensitivity will be delineated through in vitro techniques. (10/76-9/77)

Supporting Agency: U.S. Dep. Def., Air Force

- 0169 MICROWAVE-INDUCED DAMAGE IN THE MAMMALIAN BRAIN. Catravas, G. N. (U.S. Dept. Defense, Armed Forces Radiobiological Research Inst., Bethesda, MD 20014).

Changes in levels of neurotransmitters and activities of enzymes involved in neurotransmitter metabolism in the central nervous system of microwave-irradiated animals will be determined. Eastern European studies have indicated that microwave irradiation at low, nonthermal levels results in a number of neurologic and behavioral effects in animals and humans. To substantiate Russian data, a systematic study will be conducted to determine if and to what extent neurochemical mechanisms in mammalian brain are affected by exposure to low level microwave radiation. Groups of rats will be exposed to continuous low-level microwave radiation of 2,450 MHz and approximately 10 mW/cm². At various postirradiation time intervals, levels of acetylcholine,

CURRENT RESEARCH

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norepinephrine, dopamine, and serotonin will be determined in discrete brain areas of experimental animals and sham-irradiated controls. Radiation-induced changes in activity of brain enzymes, choline acetyltransferase, acetylcholinesterase, tyrosine hydroxylase, cryptophan hydroxylase and monoamine oxidase, which are involved in neurotransmitter metabolism, will also be determined. In another series of experiments the effect of microwave radiation on adenylylase-cyclic adenosine monophosphate and prostaglandin system will be determined. (10/76-9/77)

Supporting Agency: U.S. Dep. Def., Defense Nuclear Agency

0170 PROBLEM SOLVING IN RHESUS MONKEYS AS INFLUENCED BY MICROWAVES. Delorge, J. O.; Nelson, T. D. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

This project will investigate the influence of low-level microwave radiation on learning in primates. Rhesus monkeys will be trained on a task that requires the animal to learn a sequence of stimuli. The correct sequence will be changed daily so that the animal's learning ability can be assessed from session to session. This repeated acquisition will serve as a learning baseline on which the effects of microwaves pulsed at low frequencies and short durations can be evaluated. The average power density of the microwaves will be less than 30 mW/cm² at 6 GHz. (10/76-9/77)

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

0171 ASSESSMENT OF PERFORMANCE BASED ON FUNCTIONAL VISION. Devine, J. V. (Univ. Texas, Sch. Liberal Arts, El Paso, TX 79902).

This research will determine changes in functional vision in Air Force crew members exposed to operational and weapons hazards during mission performance. Nonionizing radiation (radio frequency and laser emitters) as well as ionizing hazards (tactical nuclear weapons) will be assessed to develop survivability/vulnerability mathematic models of aircrew performance during specific Air Force missions. Functional vision decrements will be established based on a series of nonhuman primate experiments which employ empirical procedures to determine the minimal amount of energy density able to produce a barely noticeable difference in visual perception as measured by standard psychophysical procedures. This effort involves the determination of pre-exposure visual capability as measured by functionally tracking moving targets, quantification of eye damage, post-exposure visual capability, and follow-up assessment of functional vision. Measures of tracking ability before and after retinal lesion placement will be compared with the known visual acuity loss obtained following similar lesions in the fovea. Stable baseline data will be obtained prior to experimental utilization, and follow-up assessment

of functional vision will be performed for a minimum of 10 days. Ophthalmoscopic examinations, fundus photography, angiograms, and appropriate histologic procedures will be performed as part of the follow-up assessment procedure. (10/76-9/77)

Supporting Agency: U.S. Dep. Def., Air Force

0172 RADIOFREQUENCY ELECTROMAGNETIC ENVIRONMENT SIMULATION AND MEASUREMENT. Allen, S. J.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The objectives of this project are to develop the equipment and methodology and to perform experiments necessary to define radio frequency (RF) energy transfer to animals and man. The results will enable modification of the personnel exposure criteria for Air Force (AF) RF operations. Instrumentation will be developed to monitor incident fields and absorbed power for biologic systems exposed to RF fields in the range of operational AF systems, namely 10 MHz-10 GHz. Present power absorption techniques are usable from 10-50 MHz. Methodology will be developed to measure power absorptions in the 50 MHz-10 GHz frequency range. Modeling of animals will continue until a suitable model is found able to perform the theoretic analysis necessary to predict power absorption over the stated frequency range. (10/76-9/77)

Supporting Agency: U.S. Dep. Def., Air Force

0173 EFFECTS OF MICROWAVE RADIATION ON BEHAVIORAL BASELINES. Thomas, J. R.; Yeandle, S. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

No descriptive information is available. (10/76-9/77)

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

0174 NAVY ENVIRONMENT: NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS DUE TO MICROWAVE FIELDS. Lovely, R. H.; Guy, A. W. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

To provide a better understanding of the hazards associated with microwave fields and establish a scientific basis for safety standards, this study will quantify the biologic effects of continuous wave and pulsed microwaves as well as their frequency and intensity dependence through controlled exposure of test animals. The research involves: (1) theoretic investigation of energy distribution inside animal bodies exposed to microwave fields, (2) experimental study of dosimetry utilizing thermographic determinations of temperature distributions, (3) observation of behavioral change

due to both acute and chronic exposure to microwave fields, (4) monitoring neuroendocrine/metabolic activity during and after chronic microwave exposure, and (5) delineating mechanics of microwave hearing phenomena, its transduction processes as well as an analysis of prior findings relating to behavioral effects of exposure to low-level pulsed microwave fields. (10/76-9/77)

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

0175 LASER EYE MEASUREMENT AND EVALUATION
SYSTEM. Bruckner, A. P.; Auth, D. C.
(Univ. Washington, Sch. Engineering, 206 Guggenheim
Hall, Seattle, WA 98105).

This project will develop a system to quantitate eye abnormalities for radio frequency radiation personnel hazard assessment. Specifically, a portable device(s) capable of both holographic recording and short pulse scattering measurements in the eye will be developed. The device is required to quantitate and study radio frequency radiation-induced eye opacities. Previous research resulted in the development of two promising techniques for non-invasive optical evaluation of radio frequency-induced cataracts in the eye in vivo. The first uses short pulse laser ranging and scattering measurements to determine the thickness of ocular layers. The second records holographically the three-dimensional internal structure of the eye including microcataracts. These techniques will be incorporated into a system that can be used to quantitate eye changes and provide permanent records of such changes. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force

0176 NON-IONIZING RADIATION EFFECTS ON MUSCLE
AND NERVE CELLS--SAFETY OF ELECTROMAGNETIC
RADIATION GENERATED BY NAVAL OPERATIONS. Portela,
A.; Perez, J. C. (Natl. Council of Science &
Technology, Junin 956, Buenos Aires, Argentina).

This research will investigate the effects of non-ionizing radiation on cellular and subcellular structures to discriminate between thermal effects and direct field (non-thermal) effects. Studies of effects on nerve and muscle cells will be performed first, with the cells removed (in vitro) and then with the cells intact, exposing whole animals. Dielectric properties of biologic molecules and tissues will be studied as well as the microwave effects on bound water. Additionally, the combined

effect of electromagnetic fields and other environmental factors will be studied. (10/76-9/77)

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

0177 ELECTROMAGNETIC INSTRUMENTATION TO ACCEL-
ERATE BONE HEALING. Bassett, C. A.
(Columbia Univ., Sch. Medicine, 630 W. 168th St.,
New York, NY 10032).

The recent demonstration on over 30 human patients that electromagnetic fields can assist in fracture healing will be exploited in a two-phase research program to specify the engineering factors required to design practical equipment for clinical evaluation in orthopedic and dental surgery. The first phase will investigate pulse characteristics designed to stimulate bone repair with intermittent rather than continuous pulsing. These tests will use tissue culture procedures to survey a wide selection of possible pulse characteristics. Pulse regimens likely to yield good results will be tested in two animal models. The second phase will include biologic safety tests to establish that the prospective applications to accelerate simple fracture repair time will not induce side effects. (11/76-4/78)

Supporting Agency:NSF, Div. Adv. Products Research
& Technology

0178 NAVY ENVIRONMENT: EXPERIMENTAL DEVELOP-
MENT OF SIMULATED BIOTISSUES. Cheung, A.
(Univ. Maryland, Graduate Sch., College Park, MD
20740).

An attempt will be made to develop a systematic procedure enabling researchers in microwave dosimetry to simulate any biologic tissue electrically at any given temperature. Frequency sweep measurement of dielectric properties of various mixtures of simulated muscle, bone, and fat will be made at several temperatures. Dependence, relative dielectric constant, and conductivity as a function of frequency, temperature and composition will be determined in addition to complex dielectric properties. Compositions and physical properties will be tabulated in handbook form for different temperatures and frequencies, and other physical properties. (10/76-9/77)

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

CURRENT LITERATURE

- 5028 COLOUR THERMOGRAPHY AND MICROWAVE RADIOMETRY: THEIR APPLICATION TO BIOLOGICAL SYSTEMS UNDER MICROWAVE RADIATION EXPOSURE. (Eng.) Bigu del Blanco, J.; Romero-Sierra, C. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at the University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 10-19; 1975. (4 refs)

Experimental results demonstrating the potential applicability of microwave and infrared (IR) radiometry in studies involving microwave exposures (X-band frequencies) of biological specimens are reported. For the IR radiometry (thermography) studies, the application of color thermography was investigated using a color thermovision unit with a sensitivity of 0.1°C at 30°C. The spectral range was 2-5.6 μm . A comparison of black and white and color thermograms of radiation patterns produced in an irradiated microwave-absorbing material by a microwave field of 30 mW/cm^2 revealed that color thermograms show substantially larger amounts of information than black and white thermograms. Color thermograms also show the complexity of the radiation pattern. Time-lapse color thermograms of a microwave-absorbing material, an anesthetized rabbit, and a plant exposed to 30 mW/cm^2 of X-band microwave radiation revealed marked differences in the patterns recorded by the thermograph, emphasizing the dynamics of the interaction and the transient behavior for each of the three cases. If irradiation time is extended, a steady state is reached that is evident from thermography. This steady state differs markedly from the transient behavior, with the latter being vitally important in biological processes. After the microwave disturbance is removed, the thermographic patterns show a return to the initial state. Microwave radiometry experiments involving the measurement of the brightness temperature of an anesthetized rabbit before and after exposure to a 30 mW/cm^2 X-band microwave field for 2.5 min were performed with a Dicke radiometer with a center frequency of 9.2 GHz and a bandwidth of 100 MHz. The brightness temperature differential between the time shortly before the onset of the microwave field and 3 sec after its removal was about 1.8 Kelvin. The results obtained with microwave radiometry are qualitatively consistent with the results obtained using thermography. However, due to the large tissue penetration depth of radiation at microwave frequencies as compared with IR frequencies, microwave radiometry permits measurement of the microwave radiation emitted from structures within the test specimen. IR thermography, on the other hand, possesses a high spatial resolution and may be used to complement microwave radiometry in studying microwave-exposed specimens.

- 5029 REACTION OF THE ENDOCRINE SYSTEM TO THE EFFECT OF ELECTROMAGNETIC FIELD OF INDUSTRIAL FREQUENCY (50 Hz). (Rus.) Prokhvatilo, E. V. (A. N. Marzeev Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR). *Vrach Delo* (11): 135-139; 1976. (12 refs.)

The effect of prolonged exposure to electromagnetic fields generated by high-voltage power transmission lines on the thyroid and adrenal functions was studied in rats. The animals were exposed to fields of 100-5,000 V/m for 3-4 mo. Compared with a control group, reduced iodine uptake in the thyroid, delayed iodine release, and reduced endogenous thyroxine level in the blood were observed. These changes were most pronounced at the end of the experiment, and they completely disappeared in 1-1.5 mo after the experiment. No hypertrophy of the adrenal glands was observed. Eosinopenia observed in animals exposed to 2,000-5,000 Oe fields indicated neuroendocrine reaction and the involvement of the central nervous system, especially of the hypothalamus.

- 5030 EFFECTS OF DIFFERENT SHF ENERGY LEVELS ON THE FUNCTIONAL STATUS OF THE BODY. (Rus.) Shandala, M. G. (A. N. Marzeev Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR); Rudnev, M. I.; Nozdachev, S. I. *Vrach Delo* (12): 113-116; 1976. (3 refs)

The effects of exposure to super high frequency (SHF) energy (50 $\mu\text{W}/\text{cm}^2$ for 7 hr/day for 10 days, or 500 $\mu\text{W}/\text{cm}^2$ for 7 hr) were studied in rats and rabbits. Artificial renal hypertension was produced in some animals, while others were exposed to hypoxia corresponding to altitudes of up to 8 km. Irradiation with the larger dose had a more pronounced effect on hemodynamics, water-salt balance, and bioelectric activity than repeated exposures to 50 $\mu\text{W}/\text{cm}^2$. The increase in the respiratory rate was most pronounced in animals with renal hypertension after exposure to multiple small doses. Altitude hypoxia had a compensatory effect on the irradiation-induced increase in the heart rate. The increase in the heart rate was most pronounced after exposure to a single large dose and in animals with renal hypertension. Irradiation caused an increase in the oxygen tension in the tissues. Irradiation had depressing effect on the excretion of water, salts, and free hydrogen ions by the kidneys. There were no qualitative differences in the effects of irradiation on rats and rabbits.

- 5031 THE TEMPERATURE-DEPENDENCE OF RESPONSES OF ESOPHAGEAL SMOOTH MUSCLE TO ELECTRICAL FIELD STIMULATION (ABSTRACT). (Eng.) Christensen, J. (Univ. Iowa Coll. Medicine, Iowa City, IA 52242); de Carle, D. J.; Szabo, A. C. *Fed Proc* 36(3): 462; 1977. (0 refs)

The temperature-dependence of responses of esophageal smooth muscle to electrical field stimulation was studied using strips of smooth muscle, cut transversely from the opossum esophagus. The strips were superfused with oxygenated Krebs solution at 37°C in a bath that allowed electrical field stimulation of intrinsic nerves and continuous temperature recording. Three-5-sec trains of rectangular pulses (0.5 msec long at 10 Hz) were delivered at 30-sec intervals at supramaximal current strength. In

strips from the esophageal body, each train resulted in a twitch, the off-response that followed the end of the train with a particular latency. Strips from the esophagogastric junction relaxed during the train. Temperature was then varied above and below 37 C to observe the temperature-dependence of the responses. Latency of the off-response varied exponentially with temperature. Amplitude of the off-response showed a linear decline with changes in temperature, both above and below 35 C, with the zero intercepts being 19.6 C and 42.3 C, respectively. The excitatory response of the strips to exogenous acetylcholine was constant over the range of temperatures tested. Amplitude of relaxation of strips from the junction varied little between 20 C and 37 C but declined sharply beyond those limits, with the zero-intercepts being 14.2 C and 42 C, respectively. The inhibitory response of the junctional strips to isopropyl norepinephrine was unchanged over the range of temperatures tested.

- 5032 PROSPECTS FOR HYPERTHERMIA IN HUMAN CANCER THERAPY. PART I: HYPERTHERMIC EFFECTS IN MAN AND SPONTANEOUS ANIMAL TUMORS. (Eng.) Miller, R. C. (Dept. Radiology, Univ. Arizona Medical Sch., 1501 North Campbell Ave., Tucson, AZ 85724); Connor, W. G.; Heusinkveld, R. S.; Boone, M. L. M. *Radiology* 123(2): 489-495; 1977. (39 refs)

A Phase I study involving the use of radio frequency-induced hyperthermia and X irradiation for the treatment of spontaneous animal tumors is described. An RF generator operating at 500 kHz supplied power for localized heating. Needles were implanted in regular geometry encompassing the tumor and were connected proximally with metal braid to act as electrodes. The RF generator, capable of delivering up to 20 W of power, is adequate for small tumor volumes; for larger volumes, an RF amplifier, capable of delivering 200 W of power, can be used. To date, 24 animals with various malignant histologies have been subjected to more than 80 treatments of RF-induced hyperthermia in combination with X irradiation. Of the total number of tumors, 50% have shown marked regression (complete remission in nine cases). Preliminary results indicate that RF currents can be used to produce localized hyperthermia for cancer therapy and that effective thermal doses are probably in the range of 43-45 C for 30 min. Normal tissues within the treatment volumes have tolerated the heat and heat plus radiation doses employed.

- 5033 SPERMATOZOAN ACTIVITY AND INSEMINATION IN *TENEbrio MOLITOR* FOLLOWING RADIOFREQUENCY ELECTRICAL TREATMENT (COLEOPTERA: TENEBRIONIDAE). (Eng.) Rai, P. S. (Dept. Entomology, Univ. Agric. Sciences, Bangalore 24, India); Ball, H. J.; Nelson, S. O.; Stetson, L. E. *Ann Entomol Soc Am* 70(2): 282-284; 1977. (8 refs)

Spermatozoan activity and insemination in *Tenebrio molitor* insects were examined following exposure to radio frequency (RF) radiation. First, adult females were exposed to a 39 MHz RF field at an electrode

voltage of 2.5 kV for 4.0 sec and were paired with untreated males of the same age. Untreated males transferred spermatozoa to about 50% of the RF-treated females in contrast to 100% of control females. Because the treated females rested on their dorsa after RF treatment, making normal copulation difficult, a second experiment was conducted in which egg hatch after RF exposure was evaluated. Males and females were collected soon after eclosion; and after the first cluster of eggs was oviposited, females were exposed to RF fields at 1.5 and 2.5 kV for 4.0 sec. The mean number of eggs laid per female exposed to 39 MHz radiation at 1.5 or 2.5 kV was significantly lower than the mean per untreated female control. The egg hatch percentage for females inseminated before RF treatment and subsequently exposed to RF energy was significantly lower than that for untreated controls. In a third experiment, spermatozoan activity in the spermathecae of females treated with 39 MHz RF energy at 2.5 kV for 4.0 sec decreased directly with time after treatment; whereas, spermatozoan activity 72 hr post-treatment for nontreated females was very high. The activity of spermatozoa in the seminal vesicles of males exposed to 39 MHz fields for 4.0 sec at 1.5 or 2.5 kV 3 days after emergence was also measured, and the mean number of active spermatozoa in the seminal vesicles of RF-treated males was less than 50% of the number observed for untreated males. No morphologic damage to spermatozoa from adults exposed to RF treatment was evident at the treatment levels used.

- 5034 NORMAL DEVELOPMENT OF THE FRUITFLY *DROSOPHILA* IN VLF MAGNETIC FIELDS. (Ger.) Goetz, K. G. (Max-Planck-Institut fuer biologische Kybernetik, Tuebingen, West Germany); Goetz, S. *Z Naturforsch* 32c(1/2): 125-132; 1977. (28 refs)

A strain of wild type males of normal viability and subnormally viable *Attached-X y w* females of *Drosophila melanogaster* were exposed to a steady or rotating homogeneous magnetic field of 9.6 kHz and about 2.5 G for 54 days. The yield and sex ratio of the progeny revealed developmental damage and sex-linked recessive lethal mutations. Compared with subsequent generations of the control group, the subsequent generations in the exposed groups showed no developmental or hereditary load.

- 5035 MECHANISM OF REACTION OF THE HYPOPHYSO-ADRENAL SYSTEM ON STRESS ACTION OF THE ALTERNATING MAGNETIC FIELD. (Rus.) Udintsev, N. A. (Dept. Biochemistry of Medical Inst., Tomsk, USSR); Moroz, V. V. *Izotol Fiziol Eksp Ter* (6): 72-74; 1976. (13 refs)

The effect of permanent or intermittent exposure to alternating magnetic field (200 Oe, 50 Hz) on the function of the hypophyseo-adrenal system (adrenocorticotrophic hormone [ACTH] level in the pituitary gland, steroidogenesis, plasma 11-oxy corticosteroid level) was studied in male rats. Continuous exposure for 15 min caused a 94% increase in the plasma

11-oxy corticosteroid level compared with controls. The increase gradually declined from 94% to 50% as the duration of the exposure increased to 24 hr. Intermittent exposure for 6.5 hr daily for 3 days caused a 32% increase, while exposure for 4-7 days caused a decrease compared with the control. Permanent exposure for 24 hr caused a 31% increase in the ACTH level, while intermittent exposure 6.5 hr daily for 4 days caused a 16% decrease. Similar changes were also observed in the activity of steroidogenesis, depending on permanent or intermittent exposure. It was concluded that the effect of magnetic fields was mediated through the hypophyseal-adrenal system and that the intensity of the effect was dependent on the period of the exposure.

- 5036 EFFECTS OF REPEATED MICROWAVE IRRADIATIONS TO THE ALBINO RABBIT EYE. (Eng.) Hirsch, S. E. (Ophthalmic Pathology Div., Armed Forces Inst. Pathology, Washington, DC); Appleton, B.; Fine, B. S.; Brown, P. V. K. *Invest Ophthalmol* 16(4): 315-319; 1977. (4 refs)

Albino rabbits were exposed to repeated 3,000 MHz microwave irradiations at power densities of 50, 100, 200, 300, 400, or 500 mW/cm² for 15 min/day over a period of 30 days, and clinical examinations were performed for up to 1 yr to detect microwave effects on the eye. Below power densities of 300 mW/cm², no ocular changes were detected. At 300 mW/cm² and above, all eyes showed congestion of the limbal vessels, pupillary constriction, and evidence of iritis. Posterior subcapsular iridescence (PSI) developed on the average of 17.5 days after irradiation at the 300 mW/cm² level. At 400 mW/cm², PSI appeared after an average of 5 days; vacuoles in the posterior cortex of the lens appeared after an average of 8 days, and posterior cortical cataractous changes appeared after an average of 10 days at 400 mW/cm² power densities. The lenticular opacities progressed but were limited to the posterior cortex during the following year of observation. It appears that the cataractous changes are dependent on the production of local temperature elevations sufficient to injure the lens' cortical cells which, because of their inability to dissipate heat, undergo first reactive changes (intercellular vacuolation) and subsequently necrotic (cataractous) changes.

- 5037 THE EFFECT OF CONSTANT MAGNETIC FIELD ON ECG IN EXPERIMENTAL ANIMALS. (Eng.) Gonet, B. (Zakład Patologii Ogoinej i Doswiadczalnej PAM, 70-111 Szczecin, Powstancow 72, Poland). *Acta Physiol Pol* 26(2): 165-168; 1975. (24 refs)

Rats, mice, and hamsters were exposed to a constant homogenous magnetic field of 7,000 Oe over periods of up to 60 min to investigate electrocardiogram (ECG) changes. The ECG of rats generally did not change during exposure, although in some cases there was a tendency towards increased T-wave amplitude. The magnetic field likewise failed to change the ECG of mice. When hamsters were exposed to the field, significant ECG changes appeared after

30 min of exposure and consisted mainly of increases in the T-wave amplitude which amounted to an average of 22.8% after 30 min and 28.11% after 60 min of exposure. When the magnetic field was switched off, the ECG pattern returned to its initial shape; however, sometimes there was a delay of several min and a decrease in the T-wave amplitude. Since the ECG changes observed during exposure to the magnetic field involved the T-wave, it appears that the magnetic field affects mainly the process of repolarization in the myocardium.

- 5038 EFFECTS OF MICROWAVE RADIATION ON EGGS, EMBRYOS, AND CHICKENS. (Eng.) Davidson, J. A. (SHUR-GAIN Div., Canada Packers Ltd., Box 130, Winnipeg, Manitoba); Kondra, P. A.; Hamid, M. A. K. *Can J Animal Sci* 56(4): 709-713; 1976. (12 refs)

A series of experiments to assess the immediate and long-term effects of single high-wattage doses of microwave energy (produced by a Raytheon Radarange) on 1-day-old Leghorn hybrid chicks were performed. The minimal lethal dose of microwave energy input for the day-old chick was established at approximately 88.6 W/sec over a 9-sec interval or a total of 800 W-sec (J). Sublethal radiation at 596 W-sec (6-sec exposure) caused unconsciousness for up to 5 min and 42% mortality; survivors showed some cutaneous burns associated with reduced early growth. From 3-40 wk of age, there were no effects on growth, mortality, or reproduction. Radiation at 392 W-sec (4-sec exposure) had no immediate or long-term effects on the birds. A safe maximum exposure dose of 1 mW/cm² over 9 sec is proposed for 1-day-old chicks.

- 5039 CONTROL OF NON-IONIZING RADIATION EMITTING DEVICES IN CANADA. (Eng.) Repacholi, M. H.; Ghosh, S. K.; Benwell, D. A.; Dutt, G. C. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th*. International Radiation Protection Association. pp. 337-340; 1977. (3 refs)

The control of nonionizing radiation (NIR) emitting devices in Canada is discussed. Over 60 NIR devices are being considered for possible regulatory control, and high priorities have been given to the following: ultrasound (diathermy, diagnostic, and industrial cleaning devices); microwaves (diathermy, bloodwarmers, commercial communications devices, and active metal detectors); and ultraviolet (sun lamps, dental polymerizers, mercury lamps, and industrial sterilizers). Draft regulations on the above devices are at various preliminary stages. Final form safety codes, which outline how to use the devices in a safe manner and how to install necessary precautions to ensure that personnel exposures are within acceptable levels, have been completed on open beam microwave devices, closed cavity microwave devices, active metal detectors, and demonstration lasers. A survey in Ottawa area schools indicated that some demonstration lasers are sufficiently powerful to produce eye damage quicker than the "blink" reflex to students who might view

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the direct beam. Investigations of the possible effects of ultrasound or microwave radiation on blood enzyme activity have indicated that no effect is detectable when the temperature of the specimen is held constant.

- 5040 CANCER AND THE LAW OF WORK—A CLASSICAL PHYSICS APPROACH. (Eng.) Obermann, W. (New York: Vantage Press); 102 pp.; 1976. (15 refs)

The use of direct current for the treatment of cancer is discussed theoretically in terms of the physical process of forced ion migration. It is contended that cancerous tissue contains a higher than normal negative ion concentration, which leads to changes in cellular biochemistry that in turn produce cancer cell proliferation. The effectiveness of radiation therapy against cancer is analyzed as being the result of forced migration of existing ions, which causes cellular biochemical changes that lead to cancer cessation. It is proposed that such forced migration of existing ions can also be produced by small direct currents with potentials of around 6-9 V (battery power). It is suggested that two 15-min sessions with such direct current on successive days plus a 4-wk wait period should be adequate for producing regression of small tumors on the hand or foot of a human volunteer.

- 5041 AN EXPERIMENTAL AND THEORETICAL STUDY ON THE INTERACTION OF ELECTROMAGNETIC FIELDS WITH ARBITRARILY SHAPED BIOLOGICAL BODIES. (Eng.) Guru, B. S. (Ph.D. dissertation, Michigan State Univ., 1976); 212 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-58101].

An experimental verification of a numeric technique for calculating the electric field induced inside and scattered by biological systems of arbitrary shape and composition when irradiated by electromagnetic waves is presented. The numeric approach involved the use of an integral equation, which was transformed into a set of simultaneous equations for numeric solution. Experiments were conducted on regularly and irregularly shaped biologic models containing saline solutions at frequencies ranging from 1.7-3.0 GHz (with 1 kHz modulation), with the electromagnetic field either at normal or end-on incidence. The effects of increasing the conductivity of a given region were examined, and the induced field and absorbed power density inside adults and children's torsos were quantified. The numeric technique was also used to quantify the above parameters inside cell samples. When human amnion cells were exposed to 2.45 GHz at 20.6 V/m for 60 min or 41.3 V/m for 8 min or longer, chromosomal aberrations were observed. Such aberrations were also observed in human lymphocyte cells exposed to 20.6 V/m for 40 min or 42.84 V/m for 5 min. These chromosomal aberrations were nonthermal in nature, since the temperatures of all cell samples were kept at 37 C or below during the exposures. These exposures were substantially lower than the U.S. safety standard of 194 V/m.

- 5042 PROGRESS REPORT OF THE IRPA STUDY GROUP ON PROTECTION AGAINST NON IONIZING RADIATION. (Eng.) Jannet, H. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th.* International Radiation Protection Association. 9 pp.; 1977. (0 refs)

Sources of nonionizing radiation (electromagnetic radiation of photon energy equal to or less than 10 electron V) are surveyed. Hazardous sources of visible light include projector bulbs, spotlights, and floodlights. Occupational health hazards arising from exposure to infrared (IR) and ultraviolet (UV) radiation are associated with metal welding and cutting (UV); the fabrication, control, and use of fluorescent and mercury vapor lamps (UV); UV sterilization; and outdoor activities under the sun. Medical exposure to IR and UV radiation is increasing owing to the expanded use of thermotherapeutic (IR) and phototherapeutic (UV) methods. Lasers also present an optical hazard with occupational exposure representing the chief potential health problem. Sources of microwave and radiofrequency radiation include radars, radiotelecommunication links and repeaters, television, and radio broadcasting stations. Occupational exposure remains the main source of chronic and high level exposure with respect to the following activities: broadcasting, telecommunications, air and shipborne radar navigation, air traffic control, satellite communication, meteorology, metallurgy, food processing, sterilization, scientific research, and medical practice. Major occupational sources of exposure to ultrasound are industrial cleaning, machining, plastics welding, emulsifying, flaw detection, electronic signal processing, sonar detection of submerged objects, and medical uses (which are the most rapidly increasing source of exposure). The need for international agreements on exposure limits and guidelines for equipment performance standards is stressed.

- 5043 INDUCTION OF LH RELEASE AND OVULATION IN RATS BY RADIOFREQUENCY LESIONS OF THE MEDIAL BASAL TUBER CINERUM (MEETING ABSTRACT). (Eng.) Everett, J. W. (Dept. Anatomy, Duke Univ. Sch. Medicine, Durham, NC); Tyrey, L. *Anat Rec* 187(4): 575; 1977. (0 refs)

The effects of non-specific tuberal lesions made by radiofrequency were examined in 4-day cyclic rats (Charles River CD strain) under pentobarbital during the pro estrus critical period. The active electrode was a 0.13 mm platinum wire encased for stiffening in 0.4 mm Pt tubing and insulated except at the very tip. The indifferent electrode was a brass rod in the rectum and descending colon. Current (2 MHz) was adjusted by trial to make lesions about 0.5 mm diameter when continued for 30 sec. Bilateral basal lesions centered approximately 1.5 mm apart and 2 mm behind the optic chiasma caused full ovulation overnight in five of five rats, while approximately eight controls were anovulatory (including two rats in which the electrodes had merely been inserted and left for 2 min). Unilateral lesions centered 0.9 mm or farther from the midline failed uniformly to produce ovulation in seven rats. When lesions were

centered 0.5 mm or less from the midline (i.e., impinging on the median eminence) six of six rats presented full ovulation next morning. Radioimmunoassay of serum luteinizing hormone (LH) in 0.5 ml blood samples taken by cardiac puncture 60 and 90 min after near-midline lesioning disclosed concentrations of 278 ± 66 and 449 ± 139 ng/ml ($N=6$ and 5 , resp.). The continuing rise of LH long after the brief lesioning procedure implied either (1) continuing release of luteinizing hormone releasing hormone (LHRH) (possibly caused by persistent irritation at the electrode site) or (2) initial dumping of a large amount of LHRH.

- 5044 NONIONIZING RADIATION EXPOSURE IN URBAN AREAS OF THE UNITED STATES. (Eng.) Janes, D. E.; Tell, R. A.; Athey, T. W.; Hankin, N. N. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th*. International Radiation Protection Association. pp. 329-332; 1977. (7 refs)

EPA measurements of radio frequency (RF) field strengths made at 72 sites located in Atlanta, Boston, Miami, and Philadelphia are reported for the 54-900 MHz frequency range. Within this range of frequencies, the frequency-modulated band contributed the most to RF exposure. The three television bands contributed about equally, and land mobile bands made an almost negligible contribution to the total power density. The maximum power density at any site summed over all bands was $2.5 \mu\text{W}/\text{cm}^2$. Four sites, or about 6%, fell in the range of $1-2.5 \mu\text{W}/\text{cm}^2$; therefore, some of the population is potentially exposed to values in excess of $1 \mu\text{W}/\text{cm}^2$. An estimation of population exposure based on information on the distribution of RF levels and population distribution indicate that less than 1% of the population is exposed to values greater than $1 \mu\text{W}/\text{cm}^2$. This estimate holds only for populations residing in areas where an unobstructed measurement is made 6 m above ground.

- 5045 CURRENT VIEWS ON MECHANISM OF INTERACTION OF MICROWAVE AND RADIOFREQUENCY RADIATION WITH LIVING SYSTEMS. (Eng.) Czerski, P. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th*. International Radiation Protection Association. pp. 315-317; 1977. (2 refs)

Possible mechanisms for the interaction of microwave (300 GHz to 300 MHz) and radiofrequency (RF) (300 MHz to 0.1 MHz) radiation with living systems are discussed. The thermal approach is suggested as being insufficient for explaining several empirical observations. For example, it has been demonstrated that different bioeffects are induced in the nervous system and hematopoietic system of animals exposed to 3,000 MHz radiation depending on the mode of generation (pulsed versus continuous) at the same mean energy density. Frequency dependence of effects on mitosis in bacterial and animal cells as well as on colicin synthesis in *Escherichia coli* have been demonstrated in the USSR. Frequency dependence of effects

on the nervous system has been demonstrated following exposures to 147 MHz radiation which was amplitude modulated at frequencies between 8 and 20 Hz. An explanation to account for some of these phenomena has been proposed that consists of developing a quantitative electrochemical concept of the greater neuronal membrane comprising the neuronal phospholipid sheet of the cell membrane and the constituents of the intercellular spaces in brain tissue and serving as a physical substrate for electromagnetic field interaction with the nervous system. Quantum mechanical approaches may offer possible explanations for the primary interaction of microwaves and RF radiation with living systems.

- 5046 RADIATION LEAKAGE CONTROL OF A RADIOFREQUENCY INDUSTRIAL SYSTEM. (Eng.) Grandolfo, M.; Ranghiasi, C. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th*. International Radiation Protection Association. pp. 325-328; 1977. (6 refs)

Preliminary results on the E-intensity pattern existing in the vicinity of a typical radiofrequency sputtering system, a relatively low power apparatus operating at a frequency of 13.56 MHz, are reported. Leakage intensity measurements were made with a field-strength meter at eye level in zones near the unit where personnel could be exposed in the normal course of their duties. Results obtained along an axis perpendicular to the sputtering apparatus at working power levels of 400 and 600 W indicate that leakage levels of no greater than 20 V/m at a distance of 10 cm from any accessible surface can be achieved with proper maintenance and inspection.

- 5047 PRACTICAL EXPERIENCE IN THE GDR AT THE MEASUREMENT OF THE ELECTRICAL COMPONENT OF THE ELECTROMAGNETIC FIELD. (Eng.) Eggert, S.; Goltz, S.; Kupfer, J. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th*. International Radiation Protection Association. 8 pp.; 1977. (0 refs)

A near field strength meter for measuring electromagnetic fields over the frequency range of 60 kHz to 300 MHz (high frequency range) in occupational situations is described. The device includes two dipole probes: one for frequencies between 60 kHz and 30 MHz and the other for frequencies between 10 MHz and 350 MHz. The measurement ranges for the two probes are 3-2,500 V/m and 1.5-1,250 V/m, respectively. The accuracy of the instrument is $\pm 20\%$, and its response time is 1 sec. The device operates off of two 9-V batteries, which power it sufficiently for at least 10 hr. The minimum distance that must be kept between the dipole probes and the conducting parts of the high frequency installation being monitored is 25 cm for the lower frequency range and 10 cm for the higher frequency range. The field strength meter is suited for optimizing screening devices and for checking their screening effects as well as for determining the degree of homogeneity and the size of the electrical field in animal exposure chambers.

CURRENT LITERATURE

- 5048 INFLUENCE OF VARIOUS PHYSICAL FACTORS ON THE DEVELOPMENT OF *ARTEMIA SALINA* EGGS. (Fre.) Gaubin-Blanquet, Y. (Laboratoire de Biologie medicale, Faculte de Medecine, 37 allees Jules Guesde, 3100 Toulouse, France); Pianezzi, B.; Massue, J. P. *C R Soc Biol (Paris)* 170(6): 1305-1310; 1976. (5 refs)

The effects of acceleration, vibration, low temperature, vacuum, and magnetic fields on the hatching capacity of normal dry eggs of *Artemia salina* were studied. Exposure to a permanent magnetic field for 3-24 hr caused no reduction in the hatching rate compared with the control (93.33-94.48% after exposure to 15,000 kOe and 91.20-95.77% after exposure to 25.25 kOe vs 94.67% in the control). Exposure to a pulsed magnetic field (150 kOe, 50 or 100 pulses/min) also did not reduce the hatching rates; they were 92.23% and 90.97%, respectively. The hatching rate was practically the same as in the control after exposure to 0.00015 Oe (66% vs 67% in the control after 16 hr, 88% vs 86% in the control after 21 hr, and 89% vs 87% in the control after 42 hr).

- 5049 MUTAGENIC ACTION OF NON-IONIZING RADIATIONS: ITS IMPLICATION IN RADIATION PROTECTION. (Eng.) Madhvanath, U.; Subrahmanyam, P.; Sankaranarayanan, N.; Singh, D. R. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th.* International Radiation Protection Association. pp. 333-336; 1977. (6 refs)

Reversion to prototrophy of the diploid yeast strain BZ34 following exposure to electromagnetic radiation ranging from cobalt-60 gamma rays to 2,450 MHz microwaves was investigated. The intrinsic efficiency of different radiations (in absorbed energy, erg/cell) to induce 100 revertants/ 10^6 survivors was as follows: 1.54×10^{-5} for gamma radiation, 0.92 for ultraviolet (254 nm) radiation, 6.5 for near ultraviolet (313 nm) radiation, and 645 for black light (365 nm). No increase in the reversion frequency was observed for visible light (480 nm). Exposures to short pulse (5 sec) and long pulse (60 sec) infrared laser beams at fluences of 48 and 120 J/cm² also resulted in no increase in the reversion frequency. Reversion frequency was also not increased by exposure to 2,450 MHz microwave radiation. Even at energy densities sufficient to raise the temperature to 55 C, only 37% of the yeast cells survived. Therefore, nonionizing radiation appears to be mutagenic only up to wavelengths of about 450 nm; above this wavelength, mutagenicity is not observed.

- 5050 CURRENT RADIO-FREQUENCY ELECTROMAGNETIC RADIATION SAFETY STANDARDS AS APPLIED TO MOBILE AND PORTABLE TELECOMMUNICATIONS TRANSMITTERS. (Eng.) Thiel, J. F.; Wukasz, M. C. In: *IVth International Congress Proceedings, Vol. 2, held in Paris, France on April 26-27th.* International Radiation Protection Association. 5 pp.; 1977. (9 refs)

Radiofrequency electromagnetic radiation safety standards as applied to mobile and portable transmitters

are discussed, and power density measurements of the reactive near field of a citizens-band radio transmitter (27 MHz) are presented. Using NBS techniques, reactive near field measurements were made for a 27 MHz transmitter operating at radiated powers of 185 W with a 1.0 m top-loaded antenna, 100 W with a 0.5 m top-loaded antenna, 180 W with a 1/4 wave stainless steel antenna, and 150 W with a 1/4 wave fiberglass antenna. The measured left, rear, and right fields in mW/cm² for the above sources were: 0.7, 1.0, 0.7, respectively; 0.5, 0.2, 0.3, respectively; 0.3, 0.2, 0.3, respectively; and 0.3, 0.2, and 0.3, respectively. It is suggested that near field energy densities associated with mobile and portable telecommunications equipment may exceed currently accepted Occupational Safety Standards. The current occupational exposure standard as found in the American National Standards Institute Standard (ANSI) C95.1-1974 (1) is as follows: for normal environmental conditions and for incident electromagnetic energy of frequencies from 10 MHz to 100 GHz, the continuous wave radiation protection guide is 10 mW/cm² and the equivalent free-space electric and magnetic field strengths are approximately 200 V/m (root mean square) and 0.5 A/m (root mean square). For modulated fields, the power density and the squares of the field strengths are averaged over any 0.1 hr period. Current evaluation techniques for near field radiation hazards present problems, since the propagation times of the field parameters generated by the various elements of the antenna result in a significant phase difference.

- 5051 MICROWAVE DIATHERMY EQUIPMENT. (Eng.) Darby, C. F. (BioEngineering and Medical Physics Unit, PO Box 147, Liverpool Univ., Liverpool L69 3BX, United Kingdom). *J Med Eng Technol* 1(1): 44-45; 1977. (3 refs)

Possible hazards associated with the use of microwave diathermy equipment are discussed. Between 50 and 75% of the incident microwave energy is reflected back off the patient, and almost 100% is reflected off the instrument case into the treatment room. Thus, due to this chance reflected microwave radiation and the rather wide microwave beam produced by some microwave applicators, the possibility of excessive microwave exposure to the physiotherapist or patient exists. It is important that the most sensitive parts of the human anatomy, that is, the eyes, are not subjected to excessive microwave radiation levels. The monitoring of microwave power levels and microwave field distribution is recommended. A simple monitoring device for this purpose, which can be used as a teaching aid or to indicate approximate microwave levels in the absence of more accurate and expensive monitoring equipment, is schematically illustrated.

- 5052 A MEASUREMENT OF RF FIELD INTENSITIES IN THE IMMEDIATE VICINITY OF AN FM BROADCAST STATION ANTENNA. (Eng.) Tell, R. A. (Environmental Protection Agency, Office of Radiation Programs AW-461, Washington, D. C. 20460). 12 pp.; 1976. [available through National Technical Information Serv-

vices, Springfield, VA 22161, Document No. PB-257 698]. (14 refs)

Electric field energy density measurements were made on a frequency modulated (FM) broadcast antenna tower to determine the radiofrequency (RF) exposure levels to which personnel performing repair and maintenance work on such towers would be exposed. The transmitting power of the radio station was 105 kW (effective radiated power) in both the horizontal and vertical planes. The tower was 120 feet high, and the antenna center of radiation was about 80 feet above ground. Power density levels on the tower ranged from 1.9 to more than 180 mW/cm². It was estimated that in order to prevent a worker's exposure from exceeding the OSHA standards (10 mW/cm² for 6 min or longer to 500 mW/cm² for 7.2 sec) the worker could work in this field for only 20 sec in each 6-min period. Since this is impractical, it is suggested that tower work be performed only when the transmitter is not operating.

5053 EFFECT OF UHF FIELD OF SMALL INTENSITY ON INDICES OF THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS. (Rus.) Rudnev, M. I. (Lab. Biological and Hygienic Studies, Kiev Scientific Res. Inst. of General Communal Hygiene, Kiev, USSR); Nozdachev, S. I.; Tarasiuk, N. E. *Vrach DeLo* (4): 131-132; 1976. (0 refs)

The effect of induced renal hypertension, exposure to ultra high frequency (UHF) irradiation (50 μ W/cm², 7 hr a day for 10 days), and their combination on the heart and respiration rates was studied in rats. Neither induced renal hypertension nor irradiation alone produced any appreciable changes in the electrocardiogram and respiration rates, but irradiation of rats combined with renal hypertension caused a statistically significant increase in the respiration rate ($p < 0.05$) (122/min versus 97/min in the irradiated group, 86/min in the group with renal hypertension, and 88/min in the intact controls).

5054 VASCULAR CHANGES IN ANTERIOR SEGMENT OF THE EYE IN WORKERS SUBJECTED TO THE ACTION OF LOCAL VIBRATION AND HIGH-FREQUENCY ELECTROMAGNETIC RADIATION. (Rus.) Katorgina, O. A. (Dept. Eye Diseases, Lvov Medical Inst., Lvov, USSR); Semenova, G. S.; Andrianova, E. I.; Fil'ts, M. A.; Buzalo, A. F.; Zhernokova, S. A. *Oftalmol Zh* 31(3):273-277; 1976. (24 refs)

Industrial workers exposed to high frequency electromagnetic fields were examined for vascular changes in the anterior segment of the eye. Ninety-six workers were exposed to electromagnetic fields with frequencies of 2-15 kHz; and 134 workers were exposed to fields with frequencies of 400-1,000 kHz. The field intensity was 3-5 V/m. At the end of the workshift, complaints about eye fatigue, lacrimation, "veil before the eyes", pain in the eyeballs, headache, and sensation of a foreign body in the eye were expressed by 87% of the workers. The biomicroscopic examinations revealed vascular changes in 70.9% of

the workers exposed to the lower frequency and changes in 76.9% of the workers exposed to the higher frequency fields. The biomicroscopic changes included spastic-atonic changes of the vessels of the conjunctiva and episclera (spasm of arteries, arterioles, variations in their diameters, disturbances in the tonus of the veins, blood stasis), petechial hemorrhages, dilatation and hypervascularization of the limbus, and dystrophic changes of the stroma of the iris and of the inner edge of the iris. The frequency of the vascular changes increased with length of service.

5055 EFFECT OF ELECTROMAGNETIC OSCILLATIONS IN THE MICROWAVE RANGE ON THE IRON, COPPER, AND ALLIED METALLOPROTEIN CONCENTRATIONS IN BLOOD AND ORGANS (EXPERIMENTAL STUDY). (Rus.) Mints, S. M. (Dept. Pathophysiology, Ivano-Frankovsk Medical Inst., Ivano-Frankovsk, USSR); Padalka, E. S.; Lazarovich, V. G. *Vopr Kurortol Fizioter Lech Fiz Kult* (3): 44-46; 1976. (1 ref)

The effect of microwave irradiation (60 mW/cm², 10 min/day for 7-28 days) on iron saturation of serum transferrin, ceruloplasmin, iron, and copper levels in the blood and organs was studied in male rats. Significant reduction of the iron concentration was found in serum transferrin (0.14 conventional units on day 28 versus 0.22 conventional units in controls), blood (44.71 mg% on day 28 versus 60.86 mg% in controls), muscles (1.66 mg% on day 28 versus 1.85 mg%), and in the heart (7.08 mg% on day 28, 7.06 mg% on day 7 versus 8.25 mg%). The iron level in the muscles tended to normalize by the end of the experiment (1.23 mg% on day 21, 1.66 mg% on day 28). The iron levels in the liver were 19.95 mg% on day 7, 15.58 mg% on day 14, 13.15 mg% on day 21, and 14.33 mg% on day 28 versus 13.88 mg% in controls. Irradiation on day 28 versus 0.18 mg% in controls), liver (0.46 mg% on day 28 versus 0.42 mg% in controls), muscles (0.30 mg% on day 28 versus 0.20 mg% in controls), and in the heart (0.35 mg% on day 28 versus 0.30 mg% in controls). The increase in the copper level in the liver was not significant. Irradiation caused insignificant increase in the serum ceruloplasmin level (59.11 conventional units on day 28 versus 54.16 conventional units in controls).

5056 HEALTH HAZARDS FROM TELEMETRY RF EXPOSURE? A REVIEW ON THE INTERACTIONS BETWEEN ELECTROMAGNETIC FIELDS AND BIOSYSTEMS. (Eng.) Neukomm, P. A. In: *Biotelemetry III. 3rd International Symposium on Biotelemetry, Pacific Grove, California, May 17-20, 1976*. (New York: Academic Press): 41-44; 1976. (12 refs)

Possible health hazards associated with telemetry radio frequency (RF) exposure are reviewed. Low power densities of RF radiation can produce both thermal and nonthermal effects in biologic organisms. A power density of 10 mW/cm² produces less heat than the metabolic rate (1.3 W/kg) for the total human body and is therefore harmless from a thermal viewpoint. The lowest RF level for irreversible damage

is evidenced by lens opacity of the rabbit's eye and is either 100 mW/cm² of 2.4 GHz for more than 1 hr or 10 mW/cm² for 7 hr. Regarding nonthermal effects, teratogenic effects of 9 GHz radiation at power levels down to 170 μ W/cm² have been observed when pupae of the darkling beetle *Tenebrio molitor* were exposed to this level. Electrophysical investigations of isolated frog nerves and muscle fibers revealed slowed conduction of impulses, increased synaptic delay, lengthening of latent and refractory periods, and changes in action potentials at exposures to 5 μ W/cm² of RF radiation. Alteration in electroencephalograms, conditioned reflex activity, and in several metabolic processes were observed in rats and rabbits after irradiation with less than 10 μ W/cm² of 50 MHz radiation for 12 hr/day. The United States standard for RF exposure is 10 mW/cm², averaged over 0.1-hr periods at an energy density of 1 mW/hr/cm² for a frequency range of 10 MHz to 100 GHz. This standard applies to both partial and whole body irradiation. Most telemetry equipment operates over a frequency range of 10-1,000 MHz, with the radiated power varying from a few μ W to about 2 W.

- 5057 PERSPECTIVES ON SATELLITE SOLAR POWER.
(Eng.) Glaser, P. E. (Arthur D. Little, Inc., Cambridge, MA). *J Energy* 1(2): 75-84; 1977. (31 refs)

The possible development of a Satellite Solar Power Station (SSPS), which utilizes microwaves for the transmission of solar power to earth, is discussed along with its possible biologic impact. The design concept of the SSPS involves the conversion of solar energy in the geosynchronous orbit to a 2.45 GHz microwave signal that can be transmitted to the earth for subsequent conversion (rectification) to a direct current (dc) output signal. This signal is designed for either direct interface with high voltage dc transmission networks or conversion to 60-Hz alternating current. The SSPS design is intended to incorporate several fail-safe features to assure control of the microwave beam pointing and instantaneous shutoff of power to the microwave generators. Failure of the microwave beam-pointing system is not expected to result in exceeding the international standards for microwave exposure. Predictions, analyses, and measurements of the SSPS's specific microwave-induced biologic effects will be an essential component of the development program. Possible effects on birds flying through the microwave beam will have to be established. Preliminary evidence indicates that birds can be affected at microwave exposures of greater than 25 mW/cm².

- 5058 MODULATED ELECTROMAGNETIC FIELD AS A FACTOR OF SELECTIVE EFFECT ON THE MECHANISMS OF PURPOSEFUL BEHAVIOR IN ANIMALS. (Rus.) Sudakov, K. V. (P. K. Onokhin Scientific Res. Inst. of Normal Physiology, USSR Acad. of Medical Sciences, Moscow, USSR). *Zh Vyssh Nerv Delat* 26(5): 899-908; 1976. (26 refs)

The effect of an electromagnetic field (39 MHz, po-

tential 30-120 V/m), modulated sinusoidally with 50 Hz, on the purposeful behavior (synthesis, decision making, acceptance of action results) of rats was studied. Exposure to the field for 5-45 min caused an inadequate defensive reaction to the replacement of a white wall of the cage by a black one, while exposure for 45-60 min suppressed the reaction totally. Prolonged exposure depressed the motor activity. Exposure for 5-15 min increased fluctuations in the reaction time to conditioned food stimulus; prolonged exposure caused an increase in the reaction time. The modulated electromagnetic field considerably inhibited the extinction of the conditioned alimentary reflex. The experiments demonstrate that modulated electromagnetic fields have a selective effect on the emotional reactions; greater disturbances are observed in the mechanisms of appraisal of action and of decision-making and anticipation of future results of actions.

- 5059 MICROWAVES INDUCE AN INCREASE IN THE FREQUENCY OF COMPLEMENT RECEPTOR-BEARING LYMPHOID SPLEEN CELLS IN MICE. (Eng.) Viktor-Jedrzejczak, W. (Div. Cellular Immunology, Dept. Clinical and Experimental Immunology, Naval Medical Res. Inst., Bethesda, MD 20014); Ahmed, A.; Sell, K. W.; Czerski, P.; Leach, W. M. *J Immunol* 118(4):1499-1502; 1977. (17 refs)

A single 30-min exposure of CBA/J mice to 2,450 MHz amplitude-modulated 12 Hz microwaves (12-15 mW/g body weight) in an environmentally controlled waveguide facility induced a 33.5% increase in the proportion of complement-receptor positive lymphoid cells in the spleen on day 6 after exposure. When mice were exposed to 2,450 MHz microwaves for 30 min/day for 3 days, separated by 3-day intervals and under the same conditions, this effect was further enhanced. Additionally, a significant increase in the proportion of cells bearing surface immunoglobulin was noted on day 6 after the last exposure. The proportion of cells bearing theta antigen on their surface and the total number of spleen cells remained unchanged. The increase in the frequency of complement-receptor positive lymphoid cells after exposure to microwaves was not secondary to microwave-induced increases in body temperature. The temperature inside the waveguide was maintained at 25 C, which caused the body temperature after exposure to be slightly lower than before exposure.

- 5060 IN VITRO AND IN VIVO INHIBITION OF VIRUS MULTIPLICATION BY MICROWAVE HYPERTHERMIA. (Eng.) Szmigielski, S. (Center Radiobiology and Radioprotection, Warsaw, Poland); Luczak, M.; Janiak, M.; Kobus, M.; Laskowski, B.; De Clercq, E.; De Somer, P. *Arch Virol* 53(1/2): 71-77; 1977. (19 refs)

The effects of microwave (3 GHz) hyperthermia (41 and 43 C) on virus multiplication were studied in vitro with herpes simplex virus type 1 (HSV-1)-infected primary rabbit kidney cultures and in vivo with mice infected with HSV-1 or vaccinia virus. In vitro, virus yields were significantly decreased when the

cells were exposed to hyperthermia within the first hours after infection. Hyperthermia applied for periods of 3 or 12 hr decreased virus yield without detectable impairment of cell viability. Heating of cells for 3 hr prior to infection had no effect. In mice inoculated intranasally with HSV-1, microwave hyperthermia (mean field power density of 40 mW/cm²) applied immediately after infection resulted in a significant decrease in mortality rate, that is, 8/22 and 4/18 and 6/22 for three groups of heat-treated animals as compared with 30/32 for a control group. A significant decrease in the number of specific tail lesions (0.8 versus 17.9 for controls) was observed in mice inoculated intravenously with vaccinia virus and exposed to microwave hyperthermia within the first 3 days after infection; no protection was observed when the hyperthermia was restricted to the pre-infection period or delayed until 3 days after virus challenge. It is suggested that microwave hyperthermia interferes directly with the virus multiplication cycle both in vitro and in vivo.

- 5061 PACEMAKERS AND EXTERNAL INTERFERENCE.
(Eng.) Elmqvist, H. (Siemens-Elma AB, Solna, Sweden). *Acta Med Scand* (596, Suppl.): 83-86; 1976. (2 refs)

Common sources of external electromagnetic interference and their effect on different types of pacemakers are reviewed. Remote interference sources are primarily microwave ovens, radar installations, and radio transmitters as well as some electrical machines under certain circumstances. Microwaves can influence all types of pacemakers, but the required power densities are large and of the same magnitudes as those considered safe for the human body. However, a microwave oven with a radiation leak might induce interference at a distance of up to 0.5 m. Direct contact interference sources include diathermy, defibrillation, and short wave treatment equipment, as well as household appliances or other electrical machines with inferior insulation. Although amplifying and detection circuits of pacemakers are designed to distinguish between signals from the heart and external signals, signals emanating from 50-60 Hz power lines are easily detected. Pacemaker interference filters are ineffective against microwave and high frequency fields acting directly on the timing circuit. Metal encapsulation of modern pacemakers can effectively reduce the effect of microwave radiation and to some extent the influence of other high frequency fields.

- 5062 CHANGES IN RATE OF GROWTH, AND BRAIN AND LIVER ENZYMES IN RATS LIVING IN 45 Hz ELECTRIC FIELDS (ABSTRACT). (Eng.) Noval, J. J. (Temple Univ. Medical Sch., Philadelphia, PA 19140); Sohler, A.; Reisberg, R. B.; Coyne, H.; Straub, K. D.; McKinney, H. *Fed Proc* 36(3): 517; 1977. (0 refs)

Approximately 500 adult male Sprague Dawley rats were maintained 30-40 days in 45 Hz vertical electric fields, varying from 100 V/m to 0.1 V/m in

eight experiments to assess changes in rate of growth and in brain and liver enzymes. Rats were kept without contact with electric sources in plastic cages housed in air-conditioned railroad cars, which shielded experiments from ambient extremely low frequency (ELF) electric fields. Exposure to 45 Hz fields produced statistically significant changes, which were similar in fields from 100 to 0.1 V/m, as compared to unexposed controls: (1) a 20-30% decrease in rate of body weight gain; (2) a marked decrease in abdominal fat deposits; (3) an 18-20% decrease in activity of the neuronal enzyme, choline acetyltransferase (ChAc), in the brainstem; whereas, ChAc levels in the cerebrum of exposed rats remained normal; and (4) a large increase in liver tryptophan pyrrolase activity (TPA). Exposed rats were similar to controls in food and water intake and appeared healthy. The data suggest that rats have brainstem neurons that are especially responsive to ELF fields. Brainstem neurons regulate body growth, fat deposition, and levels of adrenal hormones, which induce liver TPA.

- 5063 THE EFFECTS OF MICROWAVE RADIATION ON MICROTUBULES AND AXONAL TRANSPORT. (Eng.) Paulsson, L-E. (Res. Lab. Electronics, Chalmers Univ. Technology, Goeteborg, Sweden); Hamnerius, Y.; McLean, W. G. *Radiat Res* 70(1): 212-223; 1977. (21 refs)

The in vitro effects of 3.1 GHz pulsed microwave radiation on colchicine-binding properties, on axonal transport, and on microtubules of brain extracts obtained from albino rabbits were studied. When the effect of microwave irradiation on the colchicine binding activity of rabbit brain extracts was measured, no significant effect was observed with absorbed microwave energy in the range of $3.4-21.9 \times 10^7$ Wsec/m³. Viscometric measurements of the effect of microwave irradiation on microtubule assembly at absorbed power densities of 4.3×10^5 W/m³ revealed a mean difference of $-4.2 \pm 5.8\%$ between the specific viscosity of 16 control and 16 irradiated samples, indicating no significant microwave effect. Studies of the transport of tritiated-leucine-labeled proteins in rabbit vagus nerves exposed to microwave irradiation also failed to reveal any microwave effect at absorbed power densities of 10^4-10^5 W/m³.

- 5064 ELECTRO-ACUPUNCTURE ANALGESIA IN MONKEYS: A BEHAVIORAL & NEUROPHYSIOLOGICAL ASSESSMENT (ABSTRACT). (Eng.) Sandrew, B. B. (College Physicians and Surgeons, Columbia Univ., New York, NY 10032); Yang, R. C. C.; Wang, S. C. *Fed Proc* 36(3): 561; 1977. (0 refs)

To study the analgesic effect of electro-acupuncture, monkeys were initially trained to press a lever to escape noxious electrical stimulation applied to electrodes on one leg. During testing sessions monkeys were presented with electrical stimuli (1-3 sec duration) of successive intensity increments beginning at zero intensity with random interstimulus

intervals (ISIs). If the monkey made a lever-press, the stimulus intensity was immediately dropped to zero. The same sequence of increasing stimuli was then presented with a new series of random ISIs. After the establishment of a stable threshold measure of lever-pressing, 30 min of electro-acupuncture (6 V, 180 ppm) was applied to traditional points on both legs. The results revealed that electro-acupuncture dramatically increased (100-300%) the lever pressing threshold for approximately 16 min, indicating an analgesic effect. In acute monkey preparations immobilized with gallamine, spike activity of single neurons in n. Parafascicularis of the thalamus, evoked by noxious electrical stimulation (3 pulse train, consisting of 1 msec biphasic pulses, 1 mA intensity) to the sciatic nerve, was recorded. The evoked activity of only nociceptive specific neurons was either eliminated or markedly reduced for at least 1 hr following 30 min of electro-acupuncture applied to traditional points on both legs. The observations made by these two experimental approaches suggest that electro-acupuncture exerts an analgesic effect on artificially induced nociception.

- 5065 EFFECTS OF RADIOFREQUENCY RADIATION ON MURINE PERIPHERAL WHITE BLOOD CELL POPULATIONS (ABSTRACT). (Eng.) Liburdy, R. P. (USAFSAM, Brooks Air Force Base, TX 78255). *Fed Proc* 36(3): 1059; 1977. (0 refs)

Radio frequency electromagnetic radiation (RF-EMR) induced a transient in vivo shift in mouse peripheral white blood cell populations. Brief exposure (10-15 min) to RF-EMR at 5 or at 26 MHz for an E-field intensity of 5200 V/m each resulted in a marked lymphopenia and neutrophilia maximal at 3 hr followed by a gradual recovery to pre-exposure values at 72 hr. Triple exposure at 3-hr intervals achieved a sustained marked lymphopenia and neutrophilia for a 12-hour period. Exposure at 26 MHz resulted in a 2-3 °C increase in mouse colonic temperature, while exposure at 5 MHz resulted in no measurable increase in animal core temperature. Size distribution of the white blood cell population in the same animals showed a marked decrease in small leukocytes (10 μ) over that of relatively large leukocytes (17 μ) maximal at 3 hr postexposure. Populations reverted to normal size distributions by 48-72 hr. These results indicate that RF-EMR at 5 or at 26 MHz leads to transient shifts in white blood cell subpopulations corresponding to lymphopenia and neutrophilia and that these shifts can be maintained by multiple exposures.

- 5066 DIFFERENTIAL HEATING OF CELL-TYPES OF ABSORPTION OF MAGNETIC ENERGY (ABSTRACT). (Eng.) Czerlinski, G. H. (Northwestern Univ., Chicago, IL 60611). *Fed Proc* 36(3): 693; 1977. (0 refs)

A new temperature jump method, which utilizes absorption of magnetic energy by special mediators, may be utilized to heat cell types selectively. Phagocytotic cells pick up intravenously injected

ferromagnetic mediator particles directly, and to the extent phagocytosis may be directed by agents, accumulation in various types of cells differs substantially and causes highly differentiated heating. While phagocytosis is believed to involve energy consumption, a nonenergy consuming particle transport is believed to be involved in instances where vesicles are used consisting of lipid components of the membrane. Particles of considerable size (up to at least 5,000 Å length) can be transported by this latter method using lecithin-containing mixtures. To the extent this latter type of particle transport into cells can be directed by agents, accumulation would differ among cell types and thus allow highly differentiated heating. Magnetic coupling to mediators is of much greater value than electric coupling (to ferroelectric mediators), as the latter is also associated with (unspecific) dielectric (and conductive) heating at high frequencies (as periodically damped pulses).

- 5067 CATARACT AFTER EXPOSURE TO NON-IONIZING RADIANT ENERGY. (Eng.) Zaret, M. M. (1230 Post Road, Scarsdale, NY 10583); Snyder, W. Z.; Birenbaum, L. *Br J Ophthalmol* 60(9): 632-637; 1976. (16 refs)

Two case reports of cataract development after exposure to non-ionizing radiant energy are presented. The reports involve a 46-yr-old wife and a 55-yr-old husband, each with different histories of exposure. Each individual developed a specific type of ocular lesion relatable to exposure. The woman, who received medical diathermy treatment for a back injury and in later years cooked on an electric oven and range, developed capsular cataracts in both eyes. The delayed type of cataractogenesis after diathermy therapy, instead of remaining latent, appeared to be exacerbated and hastened by additional exposure to infrared emission from the stove. Her husband, who had a longer history of exposure to the electric range only, developed first a retinopathy and later a lens capsule opacity, both resembling injury from non-ionizing radiation.

- 5068 EXPERIMENTAL ARRANGEMENT FOR IN VIVO X-RAY AND MICROWAVE IRRADIATION OF SMALL ANIMALS (ABSTRACT). (Eng.) Baker, R. J. (Univ. California, San Francisco, CA 94143); Smith, V. *Phys Med Biol* 22(1): 147-148; 1977. (0 refs)

An apparatus for studying the synergistic effect of combined X irradiation and microwave-induced hyperthermia in small laboratory animals is described. The test device consists of a microwave power source and an industrial X-ray cabinet. The X-ray cabinet is used for the microwave irradiation and the therapeutic X irradiation, as well as for radiologic in situ examination of the position of various test components. Radiofrequency (RF) power is fed to the enclosure via a coaxial cable, which terminates in a coax-to-waveguide adapter then feeds the applicator. The enclosure is lined with a microwave absorbing material, providing an anechoic volume. Two RF power sources are available. One is a basic high

frequency—very high frequency—ultra high frequency generator that accepts various plug-in cavity oscillators. The two plug-in modules currently available provide continuous wave power, which is continuously adjustable from 50 mW to 65 W at any frequency from 500-2,000 MHz. The second RF power source is a 100 W C-band (5-45 GHz) generator.

- 5069 DETERMINING INTRAVITAL CHARACTER AND TIME OF POSTMORTEM INJURY OF TISSUES AND ORGANS BY SUPERHIGH RADIOFREQUENCIES. (Rus.) Kriukov, V. N. (Dept. Forensic Medicine, Altai Medical Inst., Barnaul, USSR); Mazur, V. F.; Martsinkevich, V. N.; Ten'kov, A. A. *Sud Med Ekspert* 19(2): 16-19; 1976. (0 refs)

The dielectric constant of the brain and of muscles was measured at super high frequency (not reported) in 50 human cadavers to establish the time of death and time of injury (intravital or postmortem) to the brain. The dielectric constant of the brain increased constantly during the first 13-15 days after death, but it remained practically unchanged for several months thereafter. The increase paralleled the putrefaction process, regardless of the cause of death. The dielectric constant of muscular tissue, which was traumatized postmortem, was always lower than that of the nontraumatized tissue, and the dielectric constant of muscular tissue traumatized intravitaly was even lower than that of muscles traumatized postmortem ($p < 0.0001$).

- 5070 EFFLUX OF CALCIUM AND AMINO ACIDS FROM CEREBRAL TISSUE WITH WEAK LOW-FREQUENCY ELECTRIC FIELDS (ABSTRACT). (Eng.) Adey, W. R. (Dept. Anatomy & Physiology, Univ. California, Los Angeles, CA 90024); Bawin, S. M. *Fed Proc* 36(3): 589; 1977. (0 refs)

This study examines effluxes of $^{45}\text{Ca}^{2+}$, ^3H -GABA and ^3H - β -alanine from isolated chick cerebral hemispheres equilibrated for 30 min with a calcium Ringer's solution containing $0.434 \text{ nM } ^{45}\text{Ca}^{2+}$ (specific activity 11.5 Ci/g Ca), or $0.0109 \text{ nM } ^3\text{H}$ -GABA (specific activity 36.73 Ci/nM), or $0.0111 \text{ nM } ^3\text{H}$ - β -alanine (specific activity 36.0 Ci/nM). Washed tissue was exposed to a 20 V/m , 16 Hz field for 20 min. Efflux was then measured in 0.2 ml supernatant and compared with the efflux from unexposed control samples. A significant reduction in calcium efflux occurred; however, only nonsignificant reductions occurred in the GABA efflux, and the β -alanine efflux remained unchanged.

- 5071 CATARACTS IN AVIATION ENVIRONMENTS (LETTER TO EDITOR). (Eng.) Zaret, M. M. (New York Univ. Sch. Medicine, New York, NY); Snyder, W. Z. *Lancet* 1(8009): 484-485; 1977. (8 refs)

The occurrence of a capsular cataract in nine aviation workers who were exposed to nonionizing (hertzian) radiation is reported. Three of the workers

were radar technicians aboard aircraft, five were air-traffic controllers, and one was an airline pilot. Histologic examination of one of the cataracts confirmed the presence of a capsular lesion, vacuolization, and degeneration of the subcapsular epithelium and capsular adhesions. These findings were consistent with the clinical diagnosis of chronic hertzian radiation cataract, a capsular cataract which develops slowly over the years after repeated irradiations at non-thermal intensities without any evidence of burn. The lesion, instead, resembles a delayed-type purely radiation effect.

- 5072 INFLUENCE OF A 1400-GAUSS MAGNETIC FIELD ON THE RADIOSENSITIVITY AND RECOVERY OF EMT6 CELLS IN VITRO. (Eng.) Rockwell, S. (Dept. Therapeutic Radiology, Yale Univ. Sch. of Medicine, 333 Cedar St., New Haven, CT 06510). *Int J Radiat Biol* 31(2): 153-160; 1977. (15 refs)

EMT6 mouse mammary tumor cells in vitro were exposed to an almost uniform $1,400\text{-G}$ magnetic field during or after irradiation with 120-kV X-rays. Exposure of unirradiated control cultures to this field for up to 48 hr did not alter the viability or growth of the cells. The exposure of exponentially-growing cultures to the magnetic field during irradiation did not alter the survival curve over radiation doses of $250\text{-}1,250$ rads. When exponentially-growing cultures were exposed to the magnetic field between two 500-rad doses of X-rays, the pattern or magnitude of recovery from sublethal damage was not significantly altered. The exposure of plateau phase cultures to the magnetic field after irradiation with $1,000$ rads did not alter significantly the pattern or magnitude of recovery from potentially lethal damage. Thus, the effects of the above exposures on the production and repair of radiation damage appeared to be minimal in this system.

- 5073 INTERFERENCE WITH CARDIAC PACEMAKER FUNCTION. (Eng.) Ohm, O. J. (Medical Dept. A, Univ. Bergen, Sch. Medicine, Bergen, Norway). *Acta Med Scand* (596, Suppl.): 87-95; 1976. (54 refs)

Factors affecting cardiac pacemaker function are reviewed in terms of external and internal interference and pacemaker defects. While asynchronous pacemakers are little affected by external interference, demand pacemakers (i.e., QRS-inhibited and QRS-triggered pacemakers) are rather sensitive to electromagnetic interference. Electrical equipment emitting continuous wave energy with a frequency of $50\text{-}60 \text{ Hz}$ can interfere with pacemaker function. Household appliances and electrocardiographic recording equipment are capable of causing such interference. Interference may also occur if the pacemaker is near pulsed energy sources, such as, radio transmitters, radar, telemetry devices, motor vehicle ignition systems, and arc welders. Interference can occur by direct contact with electrical razors and various household appliances. Diathermy equipment is particularly dangerous because of current leakage.

A survey of 2,200 patients with pacemakers uncovered only 10 patients who were affected by electromagnetic interference. There were no serious or fatal complications. Four of the 10 cases were patients with pacemakers that were no longer in use. Improved shielding of pacemaker pulse generators with steel or titanium appears to have reduced the danger of interference from electromagnetic radiation.

- 5074 CELLULAR CHANGES IN THE BONE MARROW UNDER THE INFLUENCE OF SUPER HIGH FREQUENCY RADIATION COMBINED WITH IMIPHOS. (Rus.) Sevastianova, L. A. (No affiliation given); Potapov, S. L.; Vasileva, N. N.; Krusanova, N. I.; Kubatkina, E. I.; Vilenskaia, R. L. *Biol Nauki* (7): 36-39; 1976. (8 refs)

The combined effect of super high frequency irradiation (wavelength 7.1 mm, intensity 2.5 mW/cm², irradiation time 1 hr) and 3-[Bis(1-aziridinyl)phosphinyl]-2-methyl-thiazolidine (imiphos: single dose of 50 mg/kg, or 10 mg/kg 3x/wk for 5 wk, ip) on bone marrow cells was studied in C₅₇Blx/CBA male mice. The animals were irradiated once or repeatedly after imiphos administration. The reduction of the bone marrow cell count was less pronounced with irradiation than with imiphos alone. Myeloid cell count was also less reduced under combination treatment. Imiphos caused a smaller increase in the lymphocyte and reticulum cell counts than when combined with irradiation. The erythroblast count dropped to lower values after combined treatment than after administration of imiphos alone. Necrosis of the germinal epithelium of the testes, and almost complete absence of spermatozoa in the canaliculi of the testicular appendage were observed after repeated irradiation with imiphos treatment. The findings indicate the protective effect of irradiation on the bone marrow.

- 5075 BIOLOGICAL EFFECTS OF LOCALLY APPLIED MICROWAVES ON THE THYROID GLAND OF DOGS. (Eng.) Magin, R. L.; Lu, S. T.; Michaelson, S. M. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 117-124; 1975. (8 refs)*

A series of localized microwave exposures were undertaken in the anesthetized dog to study the effects of microwaves on the thyroid gland. One thyroid gland was exposed with a dielectrically loaded waveguide applicator (2 inches by 1 inch) at a frequency of 2,450 MHz, while the other gland was used as a control. The temperature of both glands was measured continuously during each experiment using a thermistor near the unexposed gland and a liquid crystal fiber optic temperature probe near the exposed gland. When the left thyroid gland was locally exposed to microwaves with a measured net forward power of 3 W, the temperature of the left gland increased by 3 C to approximately 39 C. A slight elevation of the thyroxine release

rate (TRR) was also observed for the microwave heated gland. When thyroid-stimulating hormone (TSH) (10 IU) was administered prior to localized microwave exposure (5 W power), the microwave-heated gland showed a significant rise in temperature to approximately 42 C, while the temperature of the control gland remained between 36 and 37 C. The TRR of the control gland increased during the experiment, a normal response of a thyroid gland to TSH; the microwave-heated thyroid gland showed an irregular TRR response with respect to exposure duration, with the TRR less than that of the control gland. The TRR of both glands were parallel after the microwave power was turned off. The results indicate that the secretory output of the thyroid gland can be altered by microwave exposure, and the temperature of the exposed gland seems to be the factor that determines the degree of effect.

- 5076 MEASUREMENT OF RF POWER-ABSORPTION IN BIOLOGICAL SPECIMENS (10 TO 100 MHZ). (Eng.) Greene, F. M. (Electromagnetics Div., Natl. Bureau of Standards, Boulder, CO 80302). 26 pp.; 1976. [available through Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, Catalog No. C13.46:687]. (11 refs)

A method for accurately determining the radiofrequency (rf) power being absorbed by a biological specimen during non-ionizing radiation exposure testing using the NBS RF Near-Field Synthesizer in the frequency range of 10-100 MHz is described. The method is based solely on measuring the forward and reflected power on the transmission line feeding the synthesizer, and commercially available rf wattmeters can be used for this measurement. An automatic data acquisition system can be used to read the meters and rapidly calculate, display, and record the rf power flow. The method has the advantage that the exact measuring point on the feed line is not critical in contrast to methods employing direct impedance measurements. Also, the required measurements can be made without interfering with the exposure tests.

- 5077 LOW-LEVEL MICROWAVE INTERACTION WITH ISOLATED MAMMALIAN HEARTS. (Eng.) Olson, R. G.; Durney, C. H.; Lords, J. L.; Johnson, C. C. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada. International Power Institute. (Edmonton, Alberta, Canada): pp. 76-78; 1975. (2 refs)*

The effect of low-level microwave energy on isolated rat heart preparations was studied. The isolated heart preparations were back-perfused through the aorta with a pumped, oxygenated, and heated mammalian Ringer's solution. Microwave energy was applied to the heart using a stripline configuration that opened into parallel plates between which the heart was placed. The heart was allowed to stabilize for 30 min, and microwave power was applied during a 30-min period following stabilization. Within 2 min after the application of 1.5-2.5 mW/cm² absorbed

power (calculated from liquid crystal optical fiber temperature probe measurements), a pronounced bradycardia occurred. In some experiments, the heart rate showed a regular decrease to a value of 15-40% below the pre-irradiation rate; in other experiments, temporary cessations of heart contractions, lasting from 5-12 sec, occurred. In instances when transitory bradycardia was observed, the heart rate initially slowed and then returned to the pre-irradiation value within 2-8 min during irradiation. Bradycardia was not expected as a result of the application of microwave power because heating of any consequence would be expected to produce tachycardia.

- 5078 THE OCULAR LENS AND CATARACT. (Eng.)
Michaelson, S. M.; Magin, S. W. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 111-112; 1975. (0 refs)

The relationship between microwave exposure and cataract development in the human is discussed. Although cataracts have been produced in some animals after exposure to microwaves at certain power density/time relationships, there is no unequivocal case of a microwave-induced cataract in humans. Investigations, which may prove useful in clarifying the possible role of microwave exposure in human cataractogenesis, should concern the following: the incidence of the principle types of cataracts as a function of age, sex, and occupation; the frequency of cataract occurrence; thermal influences on the lens (i.e., infrared, microwave); the effect of other radiant energy influences on the lens; similarities and differences between cataracts produced by physical agents, chemicals, degenerative or metabolic diseases, and senility; an analysis of latency periods and cumulative effect versus threshold; and a review and analysis of literature on radio frequency- and microwave-induced cataracts.

- 5079 ELECTRON MICROSCOPIC EVALUATION OF THE LENSES OF RABBITS EXPOSED TO LONG-TERM 2450 MHZ CONTINUOUS MICROWAVE ENERGY AT 10 MW/CM². (Eng.) Williams, P. J.; McKee, A.; Finch, E. D.; Fulk, D. W. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 113-114; 1975. (0 refs)

An electron microscopic evaluation of eye lens damage in New Zealand white male rabbits exposed to long-term continuous microwave energy at a frequency of 2,450 MHz and a power field density of 10 mW/cm² was performed. The exposures were given repeatedly, usually from 1-2 hr/day, 5 days/week, for a total of 175 hr of exposure over a period of 7 mo. At the end of the experiment, nine irradiated animals could not be distinguished from three controls on the basis of slit-lamp biomicroscopy.

However, when sections of the lenses were examined by scanning and transmission electron microscopy, changes in the posterior subcapsular and equatorial regions of irradiated lenses were observed. These alterations consisted of local vacuolization of fibers and densification and reduplication of fiber membranes.

- 5080 ENERGY DEPOSITION IN HOMOGENEOUS AND MULTILAYER TISSUE SPHERES AND EFFECT OF CIRCULATION. (Eng.) Schwan, H. P.; Kritikos, H. N. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 5-9; 1975. (0 refs)

Calculations on the normalized absorption differential crosssection (NADC) (i.e., ratio of absorbed power volume density to incident power surface density) caused by microwaves impinging on spherical models of man's head were performed. The relative peak of the NADC occurred near the center of the sphere; for a small sphere (radius of 5 cm) at a radiation frequency of about 1,000 MHz, the peak became pronounced and was approximately the same (1 cm⁻¹) for both uniform and multilayer spheres. Temperature elevation calculations for the case where a sphere with a radius of 5 cm was irradiated with an incident power of 10 mW/cm² (1,000 MHz frequency) indicated a peak temperature rise of 0.5 C (blood and tissues), assuming normal blood flow. This peak temperature rise occurred in approximately 600 sec. A peak temperature rise of 1.2 C under similar conditions was calculated for the case where no blood flow exists, indicating the importance of blood flow as a convective mechanism for the removal of heat. These findings infer that the potential hot spots occurring at the 10 mW/cm² incident power level do not necessarily pose a serious hazard.

- 5081 A MODEL FOR THERMAL CATARACTOGENESIS. (Eng.) Foster, M. R. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 115-116; 1975. (0 refs)

A physical model for microwave heating in the eye is presented based on the assumption that cataracts are the result of a lesion produced when the temperature in the eye exceeds a critical value, called the lesion temperature. Using a sphere to approximate the vitreous body as a heat sink, the heat diffusion equation of this lossy dielectric, with an internal heat source and fixed peripheral temperature, is solved. The solution gives the steady-state transient temperature distribution (time constant of approximately 1 min) in this spherical model of the eye. A hyperbolic threshold-for-damage curve is derived from plotting power absorbed against exposure duration. The curve results from a linear

rise in temperature with respect to time for exposure durations, which are short compared with the time constant (assuming a critical lesion temperature). For exposure times which are long in comparison to the time constant, the temperature rise of the heat sink (which results from a rise in temperature of the blood of the entire animal), if linear, again results in a hyperbolic curve but with a different slope. Although the problem becomes more complicated by involving a physiologic response of the animal, the peripheral circulation must be included in the analysis of the thermal dose to the eye proper for exposure times which are long compared with the time constant. A significant fraction of the heat will be convected away from the eye proper, and experimental measurements of blood flow are, therefore, needed. It is also concluded that the relationship between the biologic stress associated with elevated temperature and the magnitude of the temperature elevation should be studied experimentally.

- 5082 LIGHT AND ELECTRON MICROSCOPIC OBSERVATIONS ON HAMSTERS AFTER MICROWAVE IRRADIATION. (Eng.) Albert, E. N. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 125-126; 1975. (0 refs)

Histologic and electron microscopic observations on Chinese hamster brain, liver, and heart after whole body irradiation at power densities of 10, 25, and 50 mW/cm² and frequencies of 1,700, 2,450, and 3,000 MHz are reported. The hypothalamus seemed the most susceptible brain tissue to microwaves; while the cerebral cortex, cerebellar cortex, thalamus, pons, medulla, and spinal cord were resistant to microwave radiation at the above parameters. After fixation, sectioning, and staining of brain sections, the neurons of the hypothalamus showed vacuolation and chromatolysis. Some axonal degeneration, dendritic swelling, and vascular congestion were also observed. Electron microscopic studies of the liver revealed that the mitochondria of hepatocytes were swollen, their cristae disrupted, and dense granules present in their matrix. All of these observations are signs of injury and cell death. Adenosine triphosphate levels, however, were no different in experimental and control animals. Myocardial cells exhibited swelling of the endoplasmic reticulum and disruption of the myofibrillae.

- 5083 OCULAR EFFECTS OF 35 AND 107 GHZ CW MICROWAVES. (Eng.) Birenbaum, L.; Kaplan, I. T.; Rosenthal, S. W.; Metlay, W.; Zaret, M. M. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 105-110; 1975. (4 refs)

The ocular effects of 35- and 107-GHz continuous wave microwave exposures on anesthetized rabbits

were investigated. The animals were positioned with the eye in gentle contact with the rim of a circular horn applicator (1.27 cm in diameter). The waveguide tuner was adjusted to cancel reflections from the eye; the power level was adjusted to the desired level; and the eye was irradiated for a predetermined time interval. A total of 67 animals were exposed to 35 GHz over exposure times ranging from 15-80 min. Powers entering the eye varied from 5-50 mW. Observable damage to the corneal epithelium (outermost cellular layer) occurred at absorbed power levels of 5 mW or more and for exposure times of 30 min or more at 35 GHz. This damage was reversible at power levels of 50 mW or less. An absorbed power level of 50 mW and an exposure duration of 30 min produced injury not only to the corneal epithelium but also to the underlying stroma. A definite threshold power level (not specified) as a function of exposure time existed for stromal injury. A similar threshold was not found for epithelial injury; in this case, the extent of injury decreased with decreasing absorbed power but was still present after 30-min exposures to 5 mW. The results of exposures at 107 GHz are currently being evaluated.

- 5084 NEUROENDOCRINE AND CARDIODYNAMIC RESPONSE OF THE DOG SUBJECTED TO CRANIAL EXPOSURE TO 2450 MHZ MICROWAVES. (Eng.) Lu, S.; Jones, J.; Pettit, S.; Lebda, N.; Michaelson, S. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): p. 63; 1975. (0 refs)

Neuroendocrine and cardiodynamic responses of the dog subjected to localized cranial microwave exposure (2,450 MHz continuous wave, 40 mW/cm²) revealed an alteration in threshold for excessive skin (paradoxical) cooling. This level of microwave exposure affected heat conservation by causing a decrease in peripheral circulation and consequently a decrease in heat loss to the environment. Thus, an activation of the heat conservation center in the microwave-exposed animal was demonstrated. Measurement of growth hormone levels confirmed earlier observations that exposure of the head to a power of 40 mW/cm² influences growth hormone release and/or degradation. Under the same conditions of anesthetization and microwave exposure, secondary changes in T4 levels were evidenced by a deviation from the effects of anesthesia.

- 5085 ELECTROMAGNETIC THAWING OF FROZEN GRANULOCYTES. (Eng.) Burns, C. P.; Burdette, E. C.; Popovic, V. P. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 105-110; 1975. (5 refs)

An electromagnetic process for thawing frozen granulocytes is described. By placing different

dielectric materials in a 3-inch by 6-inch rectangular horn designed for operation at 2,450 MHz, an effective match was obtained for thawing a 2-inch by 6-inch bag of frozen white blood cells. A larger flared rectangular horn was similarly constructed for thawing 3-inch by 9-inch clinical bags. The use of a powdered dielectric consisting of a combination of silicon dioxide and titanium dioxide allowed the blood bag to be in direct contact with the dielectric and resulted in rapid and uniform thawing of bags of frozen rat and human granulocytes, monocytes, and lymphocytes. In vitro viability and phagocytosis tests were performed on granulocytes and monocytes, and a trypan-blue dye-exclusion analysis was performed on lymphocytes. Positive results were obtained in each case for lymphocyte viability and in a number of cases for granulocyte and monocyte viability. Experiments to determine the sensitivity of white blood cell viability to variations in exposure time, power level, and total energy absorbed revealed that optimum results were obtained when a relatively rapid thawing rate was used at a power level not so high as to cause a thermal runaway condition. A power level of approximately 300 W with an exposure sequence of 10 sec "on" and 10 sec "off" yielded the greatest numbers of viable cells. For cells frozen to -70 C, about 40 sec of "on" time was needed; cells frozen to liquid nitrogen temperature required 70-90 sec of "on" time, depending on dimethylsulfoxide (a cryoprotectant added to the blood before freezing) concentration and cell concentration. Freezing and microwave thawing techniques are useful for maintaining long-term supplies of granulocytes which can be used for treating leukopenia in cancer patients receiving anticancer drug therapy.

- 5086 BIOLOGICAL ALTERATIONS OBSERVED UNDER MICROWAVE IRRADIATION. (Eng.) Deficis, A.; Dumas, J. C.; Laurens, S. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 48-58; 1975. (9 refs)

Biological alterations observed in Swiss male mice exposed to microwave radiation (300 mW, continuous wave) in cylindrical cavities were investigated. Irradiations were given during 9 nights over 15-hr periods/24-hr cycle. Microwave irradiation at a frequency of 3 GHz increased the total dose of the curar drug, gallamine (administered via 500 µg/ml/min intraperitoneal perfusions) required to produce the appearance of breathing spasms and definitive breath stops in 150 mice. Experiments in which sheep red blood cell antibodies were induced in 380 mice, which were exposed to different microwave frequencies, indicated that the antibody rate was generally not modified by irradiation. However, it increased slightly at frequencies of 2.4 and 3.9 GHz and decreased considerably at 4.9 GHz. Studies of the granulopoietic activity of the reticulo-endothelial system (RES) in 520 mice revealed that microwave exposure usually resulted in a decrease in the phagocytosis activity of the RES. A clear decrease in the corrected granulopoietic index was noted at a fre-

quency of 2.4 GHz. It was concluded that the tests on more than 1,000 animals show a non-negligible effect of weak electromagnetic waves on the mouse.

- 5087 EFFECTS OF RF FIELDS ON NERVOUS ACTIVITIES. (Eng.) Kritikos, H.; Takashima, S.; Schwan, H. P. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 64-65; 1975. (0 refs)

The effects of low frequency and radiofrequency fields (10 Hz to 30 MHz) on the nervous activity of isolated single axons (300-800 micron in diameter) from squids and myxocolas were investigated. The field was applied to axons directly by the use of platinum electrodes at low frequencies; at high frequencies, capacitive coupling was used within a small cavity. Observations of the firing of action potential over frequencies of up to 10-20 kHz for squid axons and 2-5 kHz for myxicola axons revealed that such firings depended on the carrier frequency but not on the repetition rate of pulses provided that the pulse interval was longer than the refractory period and that the pulse duration was not too short. The cutoff frequency of the firing for pulsed fields was about the same (not specified) as that for continuous waves. Thus, pulsed fields do not appear to be particularly effective in triggering action potentials from isolated single nerve axons. Attempts to excite nerve axons above these cutoff frequencies up to a frequency of 30 MHz generated negative results. Nerve activity in the presence of alternating current (AC) fields was studied by first triggering action potentials by direct current (DC) pulses and then applying AC fields in addition to the DC field. The threshold voltage and the height of action potential were used as the criteria for the effect of AC fields. No attenuation of action potentials and no elevation of threshold voltage was observed in the presence of pulsed AC fields. However, if a large current was applied, the AC field became rectified due to nonlinear electrode processes; and a frequency modulation of firing was observed under these conditions. The application of AC fields under conditions where the calcium concentration in the external medium was low appeared to change the rate of spontaneous firing induced by the low calcium concentration. The significance of this observation remains to be clarified by statistical analysis.

- 5088 LOW LEVEL MICROWAVE EFFECTS ON THE TOTAL IRON BINDING CAPACITY OF PREGNANT RATS. (Eng.) Travers, W. D.; Vetter, R. J. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 59-62; 1975. (2 refs)

The effect of low level microwave exposure on the

total iron binding capacity (TIBC), and thus serum protein transferrin level, of pregnant rats was investigated. Starting on the 6th day of pregnancy, rats were exposed daily for 15 days to 0, 5, or 25 mW/cm² of 2,450 MHz continuous wave microwave radiation over exposure periods of 10 or 20 min. Serum iron and unsaturated iron binding capacity (UIBC) were determined by light spectroscopic analysis of blood samples that were taken intracardially before irradiation (day 5 of pregnancy) and following exposure periods on days 10, 15, and 20 of pregnancy. Elevation of the TIBC was found to occur with increasing power density. A significant drop in TIBC (apparently due to stress) after 5 days of irradiation was observed in animals exposed to 0 or 5 mW/cm² of microwave. This drop was observed both for animals receiving 10-min and 20-min exposures. Animals receiving either 10-min or 20-min exposures to 25 mW/cm² of microwave power did not demonstrate this initial decline in TIBC, and the animals exposed to 25 mW/cm² for 20-min durations showed a statistically significant increase in TIBC. The serum iron component of the TIBC varied almost directly with the TIBC. The UIBC levels of animals exposed to 25 mW/cm² were significantly higher after 5 days than those of animals exposed to 0 and 5 mW/cm². Increased TIBC levels following 15 days of exposure to either 5 or 25 mW/cm² microwave power levels indicated an increase in the level of the protein transferrin. This suggests that the microwave exposure stimulated protein synthesis.

5089 A NEW TECHNIQUE FOR MEASURING POWER DEPOSITION PATTERNS IN PHANTOMS EXPOSED TO EM FIELDS OF ARBITRARY POLARIZATION--EXAMPLE, THE MICROWAVE OVEN. (Eng.) Guy, A. W.; Webb, M. D.; McDougall, J. A. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 36-47; 1975. (2 refs)

A technique for measuring power deposition patterns in phantoms exposed to electromagnetic fields generated by microwave ovens was developed using bisected models. The models were fabricated of styrofoam and were filled with synthetic biologic tissue. Each half section of the model was covered with a silk screen so that good adhesion and electrical coupling could be achieved between the two hemispheres. Several models with the electrical properties of human or beef muscle were constructed in the form of spheres ranging from 6-14 cm in diameter and ellipsoids with axial ratios of 2:1 and lengths of 17.2 cm. The models were exposed to microwave fields in three different microwave ovens, including two operating at a frequency of 2,450 MHz and one operating at a frequency of 918 MHz. Each intact model was exposed in each oven for 5-60 sec, and thermograms of the plane of separation were taken before and after exposure of the phantom model. Scans were made of the half models corresponding to the three major planes of orientation. Up to 50 thermogram rasters were stored on a magnetic disk memory unit, and photographs were taken of intensity, profile,

and single scans for each case. The net power to the oven and the maximum absorbed power density was calculated from the thermograms. The absorbed power density at various locations in the model was estimated by comparing the various heights of the profile to the maximum height, which is equivalent to the maximum absorbed power density. The data indicate a pronounced focusing of the cavity fields into the center of the smaller spheres; they also show a marked superiority of the 918 MHz oven in terms of power penetration and absorbed power uniformity in the larger objects.

5090 THE GENERATION OF ACOUSTIC SIGNALS IN MATERIALS IRRADIATED WITH MICROWAVE PULSES --A THEORETICAL ANALYSIS. (Eng.) Borth, D.; Cain, C. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 95-98; 1975. (0 refs)

A theoretic analysis of the stress gradients produced in materials irradiated with electromagnetic energy was conducted by solving a one-dimensional nonhomogeneous wave equation for liquids confined to planar geometries. A closed-form solution was found that consisted of a stationary part, whose effect is important only in the immediate region of the incident electromagnetic wave, and a traveling part, which propagates unattenuated through an ideal liquid. To qualify these results, a numeric example using physiologic saline was considered, and it became apparent that thermal expansion was approximately four orders of magnitude more effective than radiation pressure in converting electromagnetic energy to acoustic energy. A study on the effect of varying incident microwave pulse widths on the power spectral density of the induced acoustic wave was conducted for a 3 GHz microwave pulse incident on a constrained surface with a peak transmitted intensity of 10 W/cm² and a distance of 10 cm within the liquid. Pressure waveforms generated by thermal stress alone were obtained for microwave pulse widths of 1, 10, and 100 μ sec, and the frequency dependence of the acoustic waveforms on microwave pulse width was obtained by taking the Fourier transform of the stress waveforms and then normalizing the results. These results may be useful in interpreting the conflicting reports concerning the dependence of the auditory thresholds for microwave pulses on microwave pulse width and microwave pulse energy.

5091 STRIPLINE TECHNIQUES IN THE STUDY OF MICROWAVE BIOLOGICAL EFFECTS ON ISOLATED NEURAL PREPARATIONS. (Eng.) Seaman, R. L.; Wachtel, H.; Joines, W. T. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 99-102; 1975. (0 refs)

The use of stripline for studying the effects of microwaves on isolated neural preparations is dis-

cussed. Holes in the ground conductor of the stripline allow for direct access to the preparation during irradiation and illumination. Absorbed power within the sample is obtained as a function of input power to the stripline. Intracellular recordings from neurons of the marine mollusk *Aplysia* revealed that endogenous patterns of electrical activity exhibited by certain neurons were sensitive to absorbed power levels of a few mW/cm². A preliminary study indicated that synaptic efficiency may be affected by absorbed powers on the order of 10 mW/cm². A study was also made to determine the effect of microwaves on a photo response by the Limulus eye, with recordings being made with a suction electrode from the optic nerve of an excised eye. The study indicated that microwaves down to levels of a few mW/cm² influence neural output. The most important advantage of using the stripline irradiation techniques is that the power to the preparation and the electrical activity of the preparation are monitored during irradiation, thus providing information about direct action on the preparation. The extremely low leakage from the stripline allows for essentially artifact-free electrical recording.

- 5092 EFFECT OF MICROWAVE FIELD ON MUSCLE CONTRACTION. (Eng.) Chou, C. K.; Guy, A. W. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada*. International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 79-86; 1975. (4 refs)

In vitro experiments of the effects of microwaves on isolated rat diaphragm muscle in a modified S-band waveguide are reported. The muscle was fixed at one end of the waveguide and connected to a tension transducer with a sensitivity of 1 V/10 g of force at the other. In one series of experiments, the isolated muscle at the center of the waveguide was exposed to 2,450 MHz microwave pulses producing peak power absorption densities of 0.3, 3, 30, and 220 kW/kg. The pulse widths were 1 and 10 μ sec with recurrence rates of 1,000 and 100 pulses/sec, respectively. Continuous waves were also applied, producing absorbed power densities of 0.3, 3, 30, 300, and 1,500 W/kg in the muscle preparation. Tests for possible direct influence of microwave fields on muscle tension were performed in the absence of electrical stimulation with average absorbed microwave power densities of 1,500 W/kg for continuous wave and 220 kW/kg peak for pulsed fields. Exposure of isolated rat diaphragm muscle to either continuous wave or pulsed microwave power did not result in either amplitude or time course changes in contractile tensions induced by electrical stimulation when the temperature of the solution was held constant at 37 C. There were also no observed changes in muscle tension during continuous or pulsed microwave exposure when the electrical stimulation was turned off. At the maximum applied power levels, the muscle twitches were smaller in amplitude and shorter in latency; this was consistent with a 1 C rise in the bathing solution temperature. After irradiation was discontinued and the temperature returned to 37 C, the time course of the twitch was restored,

but a complete recovery of the amplitude was not observed for either heat- or microwave-mediated changes. During tetanic contractions, neither continuous nor pulsed microwave irradiation produced any effects on the tensile characteristics of the muscle.

- 5093 MEDICO-SOCIAL ASPECTS OF LABOR PERFORMED WITHIN THE RANGE OF ELECTROMAGNETIC HIGH FREQUENCY RADIATION. (Pol.) Korniewicz, H. (No affiliation given). *Ochrona Pracy* (12): 6-7; 1976. (0 refs)

Regulations dealing with the protection of individuals employed within the range of high frequency electromagnetic radiation are discussed. In 1963, the chief contraindications for work exposure to microwave radiation were determined, and the general medical certification procedures leading to temporary or permanent removal of a worker in the event of certain medical contraindications were introduced. A complementing regulation consisted of gynecologic examination (1x/yr) and electroencephalogram (1x every 5 yr), apart from general checkups, ophthalmologic, neurologic examinations, laboratory tests and electrocardiogram. Physicians were also expected to certify whether individuals with impairments could continue to work or could be shifted to a substitute occupation in the same plant. A system of prophylactic shift rotation, which would accommodate the interests of industry and workers, was suggested.

- 5094 BIOPHYSICAL ASPECTS OF HIGH WAVELENGTH ELECTROMAGNETIC RADIATION. (Ita.) Carletti, L. (Servizio di Fisica Sanitaria, Ospedale Civile di Padova, Padova, Italy); Avanzo, R. C. *Quad Radiol* 40(3): 171-187; 1975. (11 refs)

The biological effects of electromagnetic radiation are best understood by considering the chemical components of living matter and the fundamental physical processes that take place within matter. The interaction of cellular molecular structure and function that interplay with electromagnetic radiation of different wavelengths are described. The study of radiation-living matter interactions distinguishes three types of radiation. High energy electromagnetic radiation, which is far greater than the biomolecular ionizing radiation, essentially affects the atomic electrons, produces photoelectric and Compton-effects, and creates electron couples. Charged particle radiation ionizes and directly excites, producing the same effects as high energy electromagnetic radiation. Neutral particle radiation collides with the nuclei and essentially creates charged energy particles, which ionize and excite by coulomb interaction. When the radiation's energy is high and greater than that of the cell's levels of electronic and molecular excitation, destructive molecular eruptions and excitation occur. Also damaging are the eventual chemical reactions, which may occur with the highly reactive biomolecular fragments. When

exposed to low energy electromagnetic radiation, the biomolecules usually acquire, in part or completely, the photon's energy without damaging effects. A new device, the R.S. 25, is described which produces electromagnetic radiation and is especially appropriate to study the principles described.

- 5095 **CONDITIONED TASTE AVERSIONS IN THE RAT INDUCED BY A SINGLE EXPOSURE TO MICROWAVES.** (Eng.) Lovely, R. H.; Guy, A. W. In: *Microwave Power Symposium 1975 Proceedings held May 28-30, 1975 at University of Waterloo, Waterloo, Ontario, Canada.* International Microwave Power Institute. (Edmonton, Alberta, Canada): pp. 87-94; 1975. (18 refs)

Conditioned taste aversions were induced in Wistar rats by single exposures to microwaves. After an adaptation period, rats in individual cages were presented with 0.1% sodium saccharin in water during a 20-min drinking period. Immediately following the drinking session, six rats each were either sham-irradiated or were exposed for 10 min to 918 MHz continuous wave microwave radiation at incident power densities of 5, 20, 25, 30, 35, 40, and 45 mW/cm². The day after the microwave exposure, each rat in each group was given a two-bottle preference test between water and saccharin. Sham-irradiated rats as well as rats exposed to 5 and 20 mW/cm² microwave power showed strong saccharin preferences, while those exposed to incident power densities of 25 mW/cm² or more showed a significant decrease in saccharin consumption, drinking only half as much as the control rats. The above behavior effects appeared to correlate with peak absorbed power densities of approximately 22.5 W/kg.

- 5096 **CHANGES OF BACKGROUND AND EVOKED RHYTHMS OF BRAIN POTENTIALS IN RABBITS IN A STRONG STATIC MAGNETIC FIELD.** (Rus.) Smirnova, N. P. (Moscow, USSR); Klimovskaia, L. D. *Zh Vyssh Nerv Delat* 26(2): 403-410; 1976. (7 refs)

Rabbits with electrodes implanted in the sensorimotor and optic regions of the cerebral cortex, in the dorsal hippocampus, in the preoptic region, in the medial parts of the hypothalamus, in the reticular formation of the midbrain, and in the vermis cerebelli were exposed to a static electromagnetic field of 1,000-4,000 Oe intensity for 1 hr to study the background and light flash-induced brain potentials. Intensification of the bioelectrical activity, especially in the range of the alpha- and beta-frequencies, was observed, while there were no marked changes in the intensity of the delta- and theta-rhythms. This effect intensified with increasing field intensity. Exposure to 1,000 Oe tended to facilitate the photic driving after stimulation with a flashing light with a frequency increasing from 2 to 24 Hz. The driving reaction was weakened by exposure to 3,000 Oe, but it was rapidly restored after cessation of the exposure.

- 5097 **USE OF DIADYNAMIC CURRENTS IN THE TREATMENT OF INJURIES OF JOINTS.** (Rus.) Zarembo, S. I. (Lvov Div. Railroad Hosp., Lvov, USSR); Keselman, S. A. *Vopr Kurortol Fizioter Lech Fiz Kult* (3): 33-34; 1976. (6 refs)

A total of 146 patients with trauma (contusion with or without hemarthrosis and sprain) of the joints of the hands, legs, and feet were treated with diadynamic current. (Specific data not reported). The cathode was applied to the traumatized area. The patients received five to ten treatments. Continuous current was applied for 2 min and intermittent current, for 2 min. The direction of the current was changed because of pain or other conditions. As a result of the treatment 111 patients were cured, and 30 improved. The findings indicate the therapeutic effectiveness of diadynamic current in the treatment of traumas of the joints.

- 5098 **EFFECT OF STATIC ELECTRICITY ON THE HUMAN ORGANISM UNDER THE CONDITIONS PREVAILING IN THE CITY OF FRUNZE.** (Rus.) Manuilenko, Iu. I. (Kirgiz Scientific Res. Inst. of Epidemiology, Microbiology, Hygiene, Frunze, USSR); Frolov, A. F.; Zimskaia, Z. G. *Zdravookhr Kirg* (1): 11-14; 1976. (0 refs)

The health status of workers exposed to high static electricity in a knitting mill was studied. Charge densities of 6-16 μ Coulombs/m² were measured on the workers' body. Negative potentials of 300-900 V were measured on their shoes and clothes, and the corresponding charge densities were 2-3 μ Coulombs/m². Many workers complained about headache (54.5%), irritability (51.2%), epicardial pains (50.3%), sleep disorders (34.4%), and epigastric pains (29.5%). The medical investigations revealed pathologic changes of the nervous system (vegetative-vascular dystonia, impaired visual acuity, conjunctivitis, blepharitis, and keratitis) in 31.1%, diseases of the ear, nose and throat in 28.4%, cardiovascular diseases (hypertension, hypotension, myocardial dystrophy, sclerosis of the coronary and cerebral vessels) in 23.5%, and respiratory diseases in 8.7%.

- 5099 **EFFECT OF IMPULSE ELECTRICAL CURRENT ON REPARATIVE REGENERATION OF THE BONE TISSUE.** (Rus.) Landa, V. A. (N. N. Pridorov Central Inst. Traumatology and Orthopedics, Moscow, USSR); Poliakov, A. N.; Baranov, V. K. *Ortop Traumatol Protes* (10): 55-59; 1976. (14 refs)

The effect of weak pulsed current (5-15 mA, pulsed duration 1 sec at 4-sec intervals) on reparative regeneration of the resected diaphysis of the radius was studied in rabbits. The cathode or the anode was placed into the bone defect, and the other electrode was placed 1.5 mm from the edge of the defect. Starting 2-3 days after traumatization, the animals were treated 1-1.5 hr daily five times a wk for 21 days. With the cathode in the bone defect, current of 8-10 mA intensity had pronounced stimulating effect on osteogenesis, which manifested in an in-

creased amount of bony tissue at the expense of cartilaginous and fibrous tissue. There was, however, no change in the maturation and mineralization processes compared with the control. The stimulating effect was less marked at a current intensity of 5-8 mA. Stimulating effect was also observed at a current intensity of 11-15 mA with the anode placed in the bone defect, but it was accomplished by suppurative and inflammatory processes at the implantation site. The incidence of these processes increased with the current intensity.

- 5100 LONG-TERM CONTROL OF MYOCARDIAL THRESHOLD MEASURED BY MEANS OF A RADIOFREQUENCY SYSTEM (RADIOCOR) DESIGNED FOR IMPLANTATION IN SERIES WITH ANY KIND OF PACEMAKER. (Ita.) Rossi, P. (Divisione di Cardiologia, Ospedale Maggiore della Carità, Novara, Italy); De Bellis, F.; D'Aulerio, M.; Ellena, O.; Calafiore, A. M. *Minerva Cardioangiol* 24(10): 705-710; 1976. (15 refs)

A radio frequency system, Radiocor, was implanted in series within various types of pacemakers in 685 patients to monitor the chronic threshold of myocardial stimulation. The threshold was determined every 15 days or 3 mo for 1 to 4 yr. The pacemakers were also calibrated by direct threshold measurement upon implantation or replacement. Marked chronic threshold variations were observed during the first few days after implantation. There was an excellent correspondence between the two monitoring methods. The Radiocor was sensitive to within 0.1 mA. A constant chronic threshold of 3.6-9.5 mA was observed in 240 patients. The threshold displayed moderate transitory variations of about 20% in 50 patients and marked fluctuations of about 40% in 25 patients. The latter group was treated with cortisone, and the threshold stabilized in 18 cases. There was a progressive increase in the chronic threshold in 35 patients. The Radiocor can be used as an emergency stimulator in case of a pacemaker breakdown or to treat arrhythmia.

- 5101 UHF TREATMENT AND CALCIUM ELECTROPHORESIS IN THE THERAPY OF PYELONEPHRITIS IN CHILDREN. (Rus.) Gromova, V. N. (Moscow Inst. Pediatrics and Pediatric Surgery, Russian SSR Ministry of Public Health, Moscow, USSR); Korovina, N. A.; Orlova, G. I.; Nikitinskaia, L. S. *Vopr Kurortol Fizioter Lech Fiz Kult* (2): 39-42; 1976. (16 refs)

A total of 58 children 3-12 yr of age with primary pyelonephritis were treated with ultra high frequency (UHF) radiation in 10-12 sessions of 7-10 min each. The electrodes were separated from the dorsal and ventral skin surfaces by air gaps and 2-3 cm. The UHF treatment caused a decrease in the urine leukocyte count in 25/28 patients with moderate leukocyturia, while the urinary erythrocyte count remained normal. An initial increase in leukocyturia was of no significance for the therapy result. Significant increase was observed in the ammonia and hydrogen ion clearance in 26/32 patients investigated after the treatment. Disappearance of dysuria and

abdominal pains, and increased minute diuresis were also observed. The findings indicate the therapeutic effectiveness of UHF irradiation in patients with primary pyelonephritis.

- 5102 CLINICAL EPIDEMIOLOGICAL CHARACTERIZATION OF CHRONIC LYMPHOID LEUKEMIA. (Rus.) Plotnikov, I. K. (First Dept. Clinical Therapy, D. I. Ulianov Kuibyshev Medical Inst., Kuibyshev, USSR). *Vopr Onkol* 22(12): 69; 1976. (0 refs)

Clinical epidemiologic data are presented concerning 434 cases of chronic lymphoid leukemia registered in the Kuibyshev Oblast during the 1965-1974 period. All patients were 32-79 yr of age. The average annual morbidity rate was 1.60/100,000: 2.41/100,000 for men and 1.07/100,000 for women. The incidence of occupational exposure to petroleum products, organic dyes, exhaust gases of internal combustion engines, ionizing radiation, and to ultra high- and super high frequency fields was 1.3 times higher in the leukemia patients than in the control group.

- 5103 EFFECT OF SHF ELECTROMAGNETIC ENERGY AND OF CONSTANT MAGNETIC FIELD ON MUTAGENESIS IN THE PRESENCE OF ANTIBIOTICS. (Rus.) Danilenko, I. I. (Kiev, USSR); Mirutenko, V. I. *Elektronnaya Obrabotka Materialov* (3): 66-67; 1976. (5 refs)

The effect of super high frequency (SHF) electromagnetic fields and of constant magnetic field on mutagenesis induced by N-methyl-N-nitro-N-nitrosoguanidine (MNN) in *C. tropicalis* D-2 in the presence of puromycin was studied. Neither constant magnetic field alone nor SHF field alone had an effect on the survival of *C. tropicalis* compared with the control; however, the morphologic variability doubled. Exposure to MNN and constant magnetic field with an intensity of 500 Oe in the presence of puromycin resulted in a reduction of the survival to 43±7%, vs 67±6% without the antibiotic. The morphologic variability increased considerably with puromycin. Exposure to SHF in the presence of MNN and puromycin resulted in a reduction of the survival to 72±4% of the control value and in an increase in the morphologic variability to 72±6%. Increased percentage of prototrophic mutants was observed both in SHF and in constant magnetic fields.

- 5104 EFFECTS OF SOME PHYSICAL ENVIRONMENTAL FACTORS ON INDICES OF WATER-SALT BALANCE. (Rus.) Grin, A. N. (A. N. Marzhev Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR). *Vrach Delo* (12): 116-117; 1976. (0 refs)

The effects of super high frequency irradiation (single exposure to 500 $\mu\text{W}/\text{cm}^2$, or to 50 and 500 $\mu\text{W}/\text{cm}^2$ on 10 consecutive days) with and without artificially induced hypoxia on the water-salt balance were studied in adult albino rats. Reduction in the daily diuresis by 15%, increase in the urine pH from 6.9 to 8.0, and reduction in the total chloride con-

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tent and in the chloride concentration of the urine were observed after exposure to $50 \mu\text{W}/\text{cm}^2$ for 10 days. These changes were more pronounced after irradiation with a single $500 \mu\text{W}/\text{cm}^2$ dose. However, irradiation with one dose at $500 \mu\text{W}/\text{cm}^2$ 1 mo after 10 irradiations with $50 \mu\text{W}/\text{cm}^2$ had a weaker effect on diuresis and on the urine content. While 20-min hypoxia immediately after the 10-day irradiation course failed to modify the effect of irradiation, it diminished the irradiation-induced changes when applied 1 mo after the irradiation, indicating that such irradiations render the organism less susceptible to hypoxia.

PREPRINT

5105 "EMISSION AND EXPOSURE STANDARDS FOR MICROWAVE RADIATION" (SUMMARY). (Eng.)
Repacholi, M. H. (X-rays and Radiation Devices Div.,

Radiation Protection Bureau, Health and Welfare Canada, Ottawa K1A 0L2, Canada); Stuchly, M. A. [Paper presented at the IEEE Conference and Exhibit, Toronto, Canada, September 26-28, 1977]. (4 refs)

The difficulties involved in formulating maximum permissible microwave exposure levels in Canada are discussed with reference to the differences in international microwave exposure standards (Eastern bloc and Western countries). The Federal Department of Health and Welfare's Radiation Protection Bureau proposes that for exposure to pulsed or continuous wave microwave radiation, the average energy flux shall not exceed $1 \text{ mW hr}/\text{cm}^2$ for whole body exposure in any one period, and the average power density shall not exceed $25 \text{ mW}/\text{cm}^2$. This exposure applies to the frequency range of 10 MHz to 300 GHz. Canadian maximum permissible levels are set between the US and the USSR values, since the US value does not take into consideration the large body of evidence on nonthermal effects presented by Eastern bloc countries.

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| 13. ABSTRACT <p>This quarterly digest presents current awareness information on the biological effects of nonionizing electromagnetic radiation (Microwave and radiofrequency) in the range of 0 Hz to 100 GHz. The effects of magnetic and electric fields (static and alternating) are also covered. Each issue contains abstracts of English and foreign current literature, summaries of ongoing research investigations, news items, and a directory of meetings and conferences.</p> <p>Accession Numbers</p> <table><tr><td>AD-A034926</td><td>AD-A034430</td></tr><tr><td>AD-A034423</td><td>AD-A034166</td></tr><tr><td>AD-A034893</td><td>AD-A034895</td></tr><tr><td>AD-A034426</td><td>AD-A039956</td></tr><tr><td>AD-A034429</td><td>AD-A040681</td></tr></table> | | | | AD-A034926 | AD-A034430 | AD-A034423 | AD-A034166 | AD-A034893 | AD-A034895 | AD-A034426 | AD-A039956 | AD-A034429 | AD-A040681 |
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