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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME III

NUMBER 1

SEPTEMBER, 1978

A DIGEST OF CURRENT LITERATURE

A Quarterly Publication Produced for
National Telecommunications and Information Administration
and United States Navy

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

Volume III, Number 1

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(9) Quarterly rept. Jun-Sep 78

(14) 80G-C5003-01

(11) Sep 78

Literature Selected and Abstracted
by
Biomedical Group, Science Information Services Organization

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(12) 54 p.

(15) TP-7AC024

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

September, 1978 Volume III, Number 1

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PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication research and prepared by the Franklin Research Center, Science Information Services Organization, under contract with the U.S. Navy and administered by the National Telecommunications and Information Administration.

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

μ - micro--

NEWS ITEMS

AIR FORCE IS PREPARING PAVE PAWS ENVIRONMENTAL IMPACT STUDY

The Air Force has announced that it will prepare a statement on the environmental impact of its new PAVE PAWS (Precision Acquisition of Vehicle Entry, Phased Array Warning System) radar facility at Otis Air Force Base, MA. Officials estimate that the impact statement may take 9 to 18 months to complete. A coalition, composed of several groups and individuals opposing PAVE PAWS, filed a lawsuit in Federal District Court in March, 1978, to force the Air Force to prepare an impact statement. The suit also seeks to halt all testing and operation of the radar facility until an independent environmental impact statement is completed. A pentagon spokesman said, however, that the Air Force has no intention of stopping the PAVE PAWS testing schedule while the environmental statement is being prepared. Low-power tests, begun in April, were said to emit less than 1 μW of microwave radiation, a level generally considered safe within even conservative standards.

New York Times April 13, 1978

GOVERNMENT REPORT SAYS MICROWAVE LEVELS MAY BE DANGEROUS

Nonionizing radiation is a "large and complex" area and "strong coordination is vital" among federal agencies responsible for controlling it, according to the General Accounting Office (GAO). In a March 29 report triggered by inquiries from Congresswoman Elizabeth Holtzman, GAO says nonionizing electromagnetic radiation sources "are increasing while the health efforts of such exposures at low levels is a controversial subject." Human exposure to high levels of nonionizing radiation--about 10,000 $\mu W/cm^2$ [*sic*]--increases body temperature and results in problems such as heat stress, cataract formation [*sic*], cardiovascular effects, testicular effects, and brainwave pattern changes, the GAO report states. The report adds that EPA "estimates that the potential danger from nonionizing radiation has risen dramatically since 1954" and that radio frequency and microwave sources are "increasing by 15 percent annually." It says that the major nonionizing radiation sources include 950 ultra-high- and very-high-frequency television stations, 7,800 AM and FM radio stations, and "millions of microwave ovens." "EPA states that these sources result in measurable exposures to the population and are becoming a major concern" because, the report says, the threshold for environmental damage from nonionizing radiation is not known, and the U.S. standard for extended human occupational exposure to microwave radiation is about 1,000 times greater than the Soviet Union's standard. According to one EPA deputy administrator, the median exposure level for roughly 98% of the U.S. general population is less than 1.0 $\mu W/cm^2$. He added, however, that "for between one and three percent of the population" exposure levels may be as high as 100 $\mu W/cm^2$ and that there "is a problem to be looked at" for a small segment of the population. EPA, under its authority to protect the U.S. population and environment from avoidable radiation exposure, could issue recommendations that would be published as guidance to all federal agencies in formulating radiation standards, according to the agency's charter. If EPA Administrator Douglas M. Costle determines that authority is inadequate to control nonionizing radiation, legislation would be necessary to authorize regulations and enforceable standards.

Chem. Regulation Reporter 2(2): 45-46; 1978.

BIOELECTROMAGNETICS SOCIETY FOUNDED

To enhance the exchange of scientific information and stimulate research concerned with the interaction of electromagnetic energy and acoustic energy with biologic systems, researchers have founded the Bioelectromagnetics Society. The society will publish a scientific journal, whose first slated appearance is summer, 1979, and a newsletter, which will replace the current *Bioeffects Newsletter* prepared by the Office of Naval Research. The society will also sponsor topical workshops and symposia and an annual meeting. Membership is open to persons who have made scientific contributions in the areas of electromagnetic- or acoustic-biologic interactions by independent research or to persons who have rendered some special service to these areas. Information regarding membership may be obtained from Bioelectromagnetics Society, P.O. Box 3651, Arlington, VA 22203.

UNIVERSITY OF UTAH BIOENGINEER DIES

Curtis C. Johnson, Professor and Chairman of Bioengineering, University of Utah died March 25 in Sandy, Utah. Dr. Johnson was internationally recognized for his work in bioinstrumentation and the biologic effects of microwaves. He was appointed Chairman of the Department of Bioengineering in 1974 and was subsequently appointed Research Associate Professor in the Department of Surgery and Research Professor in Electrical Engineering. Dr. Johnson's publications include two textbooks in electromagnetic theory, contributions to three other books in bioengineering, and more than 65 journal articles. He also filled several editorial positions. He holds seven patents. He served on numerous national and international committees, including the Committee on Radiation Protection and the National Committee of the International Union of Radio Science. Contributions to the Curtis C. Johnson Memorial Fellowship Fund, established in his memory, may be made payable to the

ville, MD. The microwave oven amendments would change the phrase "power density" to "plane-wave power density" because the original phrase is technically incorrect, delete the aperture limit specification for the leakage measurement instrument because the specification is redundant and unenforceable, and remove the 1-dB limit for the measurement instrument because the restriction is not technically feasible. The Committee also was briefed on Bureau activities and plans concerning other electronic product radiation safety standards, policies, and recommendations including the microwave diathermy standard, which is being prepared for publication as a proposed rule. Following discussion of the concerns of a clinician and investigator with respect to the emission limit and the availability of manufacturers willing to provide equipment that meets the standard, the Committee recommended that these concerns be addressed in the proposal. It also indicated that it recognizes the need for the standard and recommended that the Bureau proceed with publication of the proposed rule.

BRH Bull. 12(11): 1-2; 1978.

CALL FOR PAPERS FOR THE ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM

Prospective authors are invited to submit papers for inclusion in the *Symposium Record* of the third bienniel Electromagnetic Compatibility Symposium & Exhibit, which is planned for May 1 through May 3, 1979, at Rotterdam, Holland. Topics of the symposium include social and economic impact of electromagnetic compatibility; electromagnetic pollution, control, and enforcement; electromagnetic compatibility hazards, biological effects of radio frequency energy, and measuring methods and instrumentation. Three copies of English summaries of up to 500 words with full address and phone number should be sent to Professor F. L. Stumpers, Elzentlaan 11, Eindhoven, Netherlands (Phone: 040-115512) no later than September 15, 1978. Best papers will be awarded monetary prizes.

SOVIETS DEVELOP LABOR-PAIN ELECTROANALGESIC DEVICE

Scientists in the Soviet Union have developed a method for controlling labor pain based on intermittent-action electroanalgesia without increasing the mean current by raising the pulse repetition rate only. A rubber ring mask is placed on the head of the patient for fixing the split cathode near the forehead, while the anode is set near the neck. The rhythmic pulses of a circuit are fed to a pulse repetition rate adjuster, connected to a pulse duration controller for transmission to a pulse shaper. The latter feeds an amplitude setter, which is connected to the anode via a protective circuit and current indicator. The protective circuit switches off the supply pack when the set threshold of current is exceeded, while a switch connects the constant duty cycle control circuit when the pain killing has to be turned on at the start of birth activity.

Sov. Inventions Illustrated (A07): 3; 1978

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **FURTHER RESEARCH ON MICROWAVES.**

The Office Of Naval Research, Arlington, VA has contracted with the Board of Regents of the University of Washington, Seattle, WA for the above study. (April 3, 1978)

☐ **RESEARCH ON MICROWAVE DISPERSION AND ABSORPTION IN TISSUE.**

The Office of Naval Research, Arlington, VA has contracted with the Trustees of the University of Pennsylvania, Philadelphia, PA for the above study. (May 24, 1978)

☐ **RESEARCH ON THE EFFECTS OF PULSED MICROWAVE RADIATION FROM NAVY RADAR ON MAMMALIAN BLOOD CELLS.**

The Office of Naval Research, Arlington, VA has contracted with the Virginia Commonwealth University, Richmond, VA for the above study. (May 24, 1978)

☐ **RESEARCH ON THE MECHANISMS OF MICROWAVE-INDUCED BLOOD-BRAIN BARRIER ALTERATIONS.**

The Office of Naval Research, Arlington, VA has contracted with Wayne State University, Detroit, MI for the above study. (June 1, 1978)

Biological Effects of Nonionizing Electromagnetic Radiation III (1), September 1978

☐ **INVESTIGATIONS INTO THE PERIPHERAL AND CENTRAL RECEPTORS MEDIATING EFFECTS OF MICROWAVE RADIATION ON BRAIN ACTIVITY.**

The Procurement Office, National Institute of Environmental Health Sciences, Research Triangle Park, NC is soliciting proposals for the above study. (June 29, 1978)

MEETINGS AND CONFERENCES

INTERNATIONAL CONFERENCE ON LARGE HIGH VOLTAGE ELECTRIC SYSTEMS: 27th Session

Date: August 30-September 7, 1978
Place: Paris, France: UNESCO Conference Bldg.
Sponsor: International Conference on Large High Voltage Electric Systems (CIGRE)
Requests for Information: CIGRE, R. Pelissier, Sec. Gen., 112, bd Haussmann F-75008, Paris, France

EIGHTH EUROPEAN MICROWAVE CONFERENCE

Date: September 4-7, 1978
Place: Paris, France: Hotel Meridien
Sponsor: Societe des Electriciens, des Electroniciens et Radioelectriciens (Groupment des Industries Electriques)
Requests for Information: Professor E. Constant, Conference Chairman, Centre Hyperfrequences et Semiconducteurs, Universite des Sciences et Techniques, BP 36, 59650, Villeneuve d'Ascq, France

Selected Bibliography of Papers to be Presented:

MICROWAVE FIELD INFLUENCE ON SOME CHEMICAL AND BIOLOGICAL OBJECTS. (invited paper)
A. I. Tereshchenko

PASSIVE SUBCUTANEOUS TEMPERATURE MEASUREMENTS FOR INVESTIGATION OF THERMOREGULATION.
A. Mamouni, Y. Leroy, Y. Houdas, Y. Moschetto

SLOTTED CYLINDER ANTENNA FOR SELECTIVE ELECTROMAGNETIC HEATING INSIDE THE HUMAN BODY.
W. Buck

MULTIMODE SQUARE WAVEGUIDE APPLICATORS FOR MEDICAL APPLICATIONS OF MICROWAVE POWER.
S. S. Stuchly, M. A. Stuchly

CLINICAL APPLICATION OF MICROWAVE THERMOGRAPHY AT THREE FREQUENCIES.
P. C. Myers, N. L. Sadowsky, A. H. Barrett

A SIMPLE MICROWAVE GAUSSIAN-BEAM LAUNCHER FOR SELECTIVE PARTIAL-BODY EXPOSURES OF BIOLOGICAL SUBSTANCES.
P. S. Neelakantaswany, K. K. Gupta, D. Banerjee

EFFECTS DUE TO MICROWAVES IN AN ENZYME-SUBSTRATE SYSTEM.
C. W. Smith

NEW PROBES FOR ELECTROMAGNETIC FIELDS.
A. Deficis, E. Gimonet, A. Priou

SECOND EUROPEAN THERMOGRAPHIC CONGRESS

Date: September 11-15, 1978
Place: Barcelona, Spain: Palacio de Congresos
Sponsor: European Thermographic Assoc.
Requests for Information: General Secretariat, Cruz Blanca, Pelayo, 40, Barcelona-1 Espana. Telef. (93)301 78 78
Content: Sessions on thermography in ecology, in breast pathology, and on cancer in general will be included.

AMERICAN ACADEMY OF OCCUPATIONAL MEDICINE: Thirteenth Annual Meeting

Date: September 20-22, 1978
Place: Williamsburg, VA
Sponsor: American Academy of Occupational Medicine (AAOM)
Requests for Information: AAOM, 150 N. Wacker Dr., Chicago, IL 60606

NINETEENTH INTERNATIONAL CONGRESS ON OCCUPATIONAL HEALTH

Date: September 25-30, 1978
Place: Dubrovnik, Yugoslavia
Sponsor: Permanent Commission & International Assoc. of Occupational Health (PCIAOH)--organized by Assoc. of Occupational Health of Yugoslavia (AOHY) & Inst. for Medical Research & Occupational Health
Requests for Information: Professor M. Saric, Inst. for Medical Res. & Occupational Health, 41000 Zagreb, 158 Mose Pijade, POB 291, Yugoslavia

WESTERN OCCUPATIONAL HEALTH CONFERENCE

Date: October 12-14, 1978
Place: Los Angeles, CA: Hyatt Regency Hotel
Sponsor: American Industrial Hygiene Assoc., Health Physics Society; Western Occupational Medical Assoc. (WOMA); Western Assoc. Industrial Nurses; American Society Safety Engineers
Requests for Information: B. H. Bravinder, WOMA, Box 201, Alamo, CA 94507

EIGHTEENTH HANFORD LIFE SCIENCES SYMPOSIUM: Biological Effects of Extremely-Low-Frequency Electromagnetic Fields

Date: October 16-18, 1978
Place: Richland, WA
Sponsor: Battelle-Northwest
Requests for Information: Mrs. Judith A. Rising, Biology Dept., 331 Bldg., Battelle-Northwest, Richland, WA 99352

INTERNATIONAL MICROWAVE SYMPOSIUM

Date: March 30-April 2, 1979
Place: Orlando, FL: Sheraton Twin Towers
Sponsor: Inst. Electrical & Electronic Engineers (IEEE)--Microwave Theory & Techniques Group
Requests for Information: R. E. Henning College of Engineering, Univ. South Florida, Tampa, FL 32620

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS: Region 6 Annual Conference

Date: April 25-27, 1979
Place: Sacramento, CA
Sponsor: Inst. of Electrical & Electronics Engineers (IEEE)--Sacramento Section
Requests for Information: R. J. Paul, 2700 Watt Ave., Room 4132, Sacramento, CA 95821

INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS CONFERENCE (ELECTRO 79)

Date: May 22-25, 1979
Place: New York, NY: The Coliseum
Sponsor: Inst. of Electrical & Electronic Engineers (IEEE)--Region One
Requests for Information: W. C. Weber, Jr., ELECTRO, 999 N. Sepulveda Blvd., El Segundo, CA 90245

0331 ELECTROMAGNETIC DOSIMETRY VIA NON-PERTURBING TEMPERATURE PROBES. Kantor, G.; Bassen, H. (U.S. Dept. Health, Education & Welfare, Bureau of Radiological Health, Electromagnetics Branch, 5600 Fishers Lane, Rockville, MD 20852).

Microwave-induced temperature elevations in actual and simulated biologic tissue are being measured via various temperature probes, designed to minimally perturb internal field distributions that exist in the tissue in the absence of such probes. One probe, developed for Bureau of Radiological Health (BRH), incorporates as a sensor a stable birefringent crystal (lithium-tantalate) chip (1 mm diameter). The sensor is interrogated via light, directed by a fiber-optic-glass waveguide. Precise temperature calibrations using NBS-calibrated standards are performed on this and other temperature probe prototypes. The degree of interaction and perturbation of internal fields is studied in simulated biologic tissue using thermographic camera techniques. Dosimetric studies in simulated tissues, objects, and living animals exposed to high level (50-200 mW/cm^2 microwave fields will be performed in conjunction with BRH's and National Institute of Health's researchers. (1/78-12/78)

Supporting Agency:HEW, PHS, FDA, BRH

0332 MICROWAVE RADIATION EFFECTS—OCCUPATIONAL EXPOSURE TO RADAR. Robinette, C. D. (Natl. Acad. Sciences, 2101 Constitution Ave. N.W., Washington, DC 20037).

To assess the possible risks to human health from exposure to microwaves, a follow-up study of Navy veterans of the Korean War is being conducted. The retired records of naval technical schools have been used to construct the study population of approximately 20,000 men who were occupationally exposed to radar (equipment repair) and 20,000 controls who served as equipment operators. Follow-up information has been obtained from existing records and computer tapes for: (1) mortality by cause of death for the years 1955-1974, (2) morbidity in Navy hospitals for 1950-1959, (3) morbidity in Veterans Administration hospitals for 1963-1976, and (4) claims for disability compensation, up to 1976. A measure of occupational exposure to radar, an exposure index, has been developed and calculated for all men who died (except those who died from accidents) and for a random 5% of all others. Analysis has been completed, and a final report is being prepared. (1/77-12/77)

Supporting Agency:HEW, PHS, FDA, BRH

0333 A PRELIMINARY SURVEY OF VETERANS WHO MAY HAVE BEEN EXPOSED TO CATARACT PRODUCING RADIATION. McAfee, R. D.; Cazenavette, L. L.; Holland, M. G.; Robinette, C. D. (U.S. Veterans Admin. Hosp., 1601 Perdido St., New Orleans, LA 70140).

The National Academy of Sciences, National Research Council, Medical Follow-up Agency will cooperate in enlarging an original pilot study to a full scale investigation of electronic technicians who may have been exposed to microwave radiation (as well as controls). The names and addresses of selected groups of veterans to whom a shadowgraph device will be mailed will be obtained, and the Medical Follow-up Agency will also participate in the statistical interpretation of the data. (12/77-11/78)

Supporting Agency:U.S. Veterans Admin.

0334 MICROWAVE THAWING OF FROZEN TISSUE. Lehr, H. B.; Holst, H. I.; Ketterer, F. D. (Univ. Pennsylvania, Sch. Medicine, Dept. Surgery, 36th & Hamilton Walk, Philadelphia, PA 19104).

The objectives of these experiments are: (1) to measure the unknown electrical properties of frozen tissue, (2) to calculate the heating potential distributions of solid organs and develop equipment to apply microwaves evenly to these organs, and (3) to prove that properly prepared frozen solid organs are viable in mammals. Direct measurements of the electrical properties of ice, physiologic saline with cryoprotectants, gelatin molds, and frozen mammalian tissue will be performed. The thawing equipment will comprise commercially available microwave ovens in different frequency ranges, and the mammalian test organs will be rabbit and canine kidney. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, NIAMDD

0335 BEHAVIORAL EFFECTS OF MICROWAVES ON RATS. Reiter, L. W.; Gray, L. E (Environmental Protection Agency, Environmental Biology Div., Durham, NC 27711).

Neonatal Sprague-Dawley rats are being exposed to microwaves from 4 to 16 hr/day in anechoic chambers for the first 3 wk following birth to study the effects on central nervous system development. Neurologic (reflex) and behavioral (spontaneous locomotor activity and social behavior) development is being measured. (10/77-9/78)

Supporting Agency:EPA

0336 ELECTROMAGNETIC RADIATION EFFECTS ON BRAIN TISSUE PERMEABILITY. Oscar, K.; Stokes, N. (U.S. Army, Mobility Equipment Res. & Development Command, Fort Belvoir, VA 22060).

The functional relationship of microwave parameters to changes in the permeability of small inert polar molecules in the blood-brain barrier of rats will be determined. Rats will be exposed to pulsed and continuous wave microwave energy to assess the uptake of low molecular weight saccharides and anti-

cancer drugs in certain areas of the brain. A quantitative radioactive isotope method, which uses a highly diffusible substance as an internal standard, will be employed to measure the loss of a labeled test substance to the brain tissue as a function of different microwave exposure parameters. (10/77-9/78).

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

0337 DESIGN, CONSTRUCTION AND TESTING OF AN ANECHOIC CHAMBER FOR RFR STUDIES. Naber, T. (Emerson Electric Company, 24003 Ventura Blvd., Woodland Hills, CA 91302).

An anechoic chamber facility that will provide for controlled environmental testing of biologic specimens exposed to radio frequency radiation (RFR) will be designed, installed, and tested. The anechoic structure will absorb scattered RFR, allowing the exposure fields for biologic experiments to be well defined. The chamber will operate in the 1-10 GHz frequency band. An environmental control system will keep the inside of the chamber at a constant temperature; it will provide temperatures between 55 and 95 F. This will allow measurement of synergistic effects of RFR and environmental temperatures. The chamber will be constructed in the RF laboratory at Brooks Air Force Base, and the contractor will provide measurements of the anechoic properties of the chamber. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Air Force

0338 MICROWAVE IRRADIATION OF BRAIN THROUGH CRANIOPLASTY. Sutton, C. H. (Univ. Miami, Sch. Medicine, Dept. Oncology, 1400 N.W. 10th Ave., Miami, FL 33124).

This project is part of a broader program that supports the Comprehensive Cancer Center for the State of Florida as a multi-disciplinary cancer center. The center's participants are involved in clinical and basic cancer research, cancer education at all levels, and intensive community outreach programs throughout Florida. Cooperative programs have been established with the state's other universities, the American Cancer Society, and Dept. of Health, Education & Welfare. The overall objectives of this program are the establishment of a core of excellence in cancer research for the State of Florida and the development of interrelationships with other cancer-directed interests in the State (and nation). (6/77-5/78)

Supporting Agency:HEW, PHS, NIH, NCI

0339 OCCUPATIONAL EXPOSURE TO MICROWAVES AND CONGENITAL MALFORMATIONS IN OFFSPRING. Stellman, J. (American Health Foundation, Inc., Occupational Health and Toxicology Div., 1370 Ave. of the Americas, New York, NY 10019).

The association between low level exposure of fathers to radio frequency energy and the incidence of birth defects, particularly clubfoot, among their offspring will be evaluated. In addition, the relationship of such exposure to fertility, pregnancy outcome among their wives, and the incidence of illnesses and symptoms purportedly related to radio frequency exposure will be assessed. By means of a retrospective mail survey of physical therapists with occupational exposure to radio-waves and a control group without such exposure, exposure data, work history, family, reproductive and medical histories will be collected. The survey questionnaire and study protocol are being finalized, and the pretest should be conducted in fiscal year 1978. (5/77-9/78)

Supporting Agency:HEW, PHS, FDA, BRH

0340 BIOCHEMICAL PREPARATION AND SPECTROSCOPIC INVESTIGATION OF SYNTHETIC AND NATURALLY OCCURRING BIOMEMBRANE SYSTEMS. Thompson, T. E.; Gaber, B. P. (Univ. Virginia, Sch. Medicine, Dept. Biochemistry, Box 246, Charlottesville, VA 22901).

The data on possible interactions of continuous wave and pulsed non-ionizing electromagnetic radiation with biomembrane systems will be obtained to substantiate or refute the implications of low-level effects and aid in establishing a safety level. The University of Virginia will establish a biochemical facility in the Naval Research Laboratory's (NRL) Optical Techniques Branch. The contractor will furnish synthetic and naturally occurring biomembrane systems. Spectroscopic experiments will then be performed in collaboration with the contractor using the existing laser spectroscopic facility located in the Optical Techniques Branch at NRL. (10/77-9/78)

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

0341 NAVY ENVIRONMENT: TEMPERATURE INCREASE IN TISSUE SPHERES EXPOSED TO MICROWAVES FROM NAVAL OPERATIONS. Kritikos, H.; Schwan, H. P. (Univ. Pennsylvania, Sch. Engineering & Applied Sciences, Dept. Bioengineering, 4001 Spruce St., Philadelphia, PA 19104).

When microwave fields generated by Navy radar encounter human tissue, heat may be generated. It is vital that the temperature distribution of the heat be determined. Calculations have been made of the temperature inside spheres (such as the human head) without considering redistribution of heat due to blood flow. This research will compare the deposited energy with the resulting steady-state temperature distribution in the sphere, assuming physiologically appropriate values for the tissue blood flow and thermal conductivity. This is a theoretic study requiring a highly sophisticated computer program to solve the necessary equations.

All calculations will be performed using the Univac 70/90 computer located in the Moore School of the University of Pennsylvania. To facilitate computations, a portable remote terminal will be purchased. (10/76-9/77)

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

0342 MICROWAVE EFFECTS ON EXCITABLE MEMBRANE SYSTEMS. Cleary, S. F.; Liu, L.; Hoffman, R. (Virginia Commonwealth Univ., Sch. Basic Science & Graduate Studies, 901 W. Franklin St., Richmond, VA 23284).

The effect of electric fields at microwave frequencies on the induction of action potentials in excitable membrane systems will be investigated. The objective of the research is to differentiate between effects due to the impressed microwave electric field as contrasted with other microwave-specific thermal and nonthermal effects. A waveguide irradiation technique will be used to expose the algae *Chara australis* and other excitable cell systems to low intensity microwave radiation in the frequency range of from 2 to 4 GHz in a thermostated irradiation chamber. Initially, continuous wave microwaves will be employed, followed by pulse-modulated fields. The cell systems will be of sufficient size to permit the measurement of action potentials with electrodes exterior to the waveguide, minimizing interactions between the microwave field and the detection system. Prior to microwave exposure the mean threshold electric field strength for the induction of the action potential will be determined by a variable amplitude pulsed current stimulator. Thresholds will be redetermined during and after exposure of the cell system to microwave radiation of known field strength. Variations in the excitation threshold will be interpreted in terms of the summation of the field strengths of the impressed stimulus and the microwave field. The independent variables to be investigated will be microwave field strength, microwave frequency, pulse duration and amplitude, latency for recovery of pre-exposure threshold, and temperature. (2/78-1/79)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0343 MICROWAVE CATARACTOGENESIS. Ferri, E. (U.S. Dept. Health, Education & Welfare, Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20852).

The effect of microwave radiation on the eye will be determined with emphasis on the histopathology and biochemistry of cataract formation, as well as dosimetry and frequency parameters. The approaches to be taken include: (1) determination and physical characterization of microwave fields with exposure apparatus under use conditions, (2) construction of phantom eyes for estimation of intraocular temperature and calorimetric determination of absorbed dose in the eye, (3) opthalmic inspection of irradiated rabbit eyes, histopathologic study of irradiated lenses from experimental animals, and comparison with lenses from humans known to have prior exposure to microwaves, (4) measurement of changes in absorbic acid in rabbit eyes at various post-irradiation intervals after acute and repetitive exposures, and (5) comparison of the cataractogenesis associated with either pulsed or continuous wave (CW) sources and effects of repetitive low-level exposure on a cataract prone species. Heat alone has been ruled out as the causative factor involved in alterations of ascorbate in the microwave-irradiated rabbit eye. Increased intraocular temperature occurring during microwave irradiation is not the sole causative factor in microwave cataractogenesis. Histopathologic changes associated with the development of microwave cataracts were studied in serial sections of preserved rabbit eye lenses at post-irradiation intervals ranging from 12 hr to 123 days. It was found that during the first 2 days post-irradiation, lens fibers in the posterior subcapsular cortex became hydropic with slight swelling or with many tiny vesicles. This was interpreted as an initial response to microwave heating. During the fourth day, epithelial cells migrated from the equator posteriorly under the capsule and numerous mitotic figures indicated proliferative activity. In the ensuing 5 days, swollen "balloon cells" appeared at the equator or in the posterior cortex; these appeared to represent abortive attempts of the cells to differentiate into new lens fibers as they normally do. The posterior migration of epithelial cells and transformation of some of them into "balloon cells" have been described previously as a characteristic response to ionizing radiation. (10/76-9/77)

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

0344 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF THE ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Univ. Washington, Medical Rehabilitation Res. & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The purpose of this investigation is to advance the existing knowledge on the human body and to provide realistic guidelines for safety standards of human exposure. The electromagnetic field patterns from external sources of energy, both in and exterior to the tissues of human subjects and test animals, will be established quantitatively. The test animals will be exposed to the various continuous wave and modulated electromagnetic sources at both thermal and nonthermal lower levels, and the energy in the tissues will be monitored. The physiologic and behavioral characteristics of the animals will be observed before, during, and after exposure to electromagnetic radiation. The time and power density thresholds for cataract production will be determined in animals exposed to microwave radiation. Safe human exposure levels will be determined, taking into proper account the source, configuration, frequency, and location. The theoretic analysis involves the solution of Maxwell's equation for the absorbed power by

biologic systems for a host of different geometries. The experimental studies involve controlled exposure of test animals to select sources of electromagnetic energy with the aim of quantifying observable effects and changes on the biologic systems. (10/76-9/77)

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

0345 USE OF SYNAPTOSOMES AS AN EXPERIMENTAL MODEL FOR EVALUATING THE EFFECT OF ELECTROMAGNETIC RADIATION (EMR) ON NEURAL MEMBRANE FUNCTION. Millar, D. B.; Christopher, J. P. (U.S. Navy, Biochemistry Div., Bethesda, MD 20014).

Synaptosomes will be used as a neural membrane model to evaluate the potential hazard that electromagnetic radiation (EMR) poses to military personnel during performance of critical, defense-related tasks. Synaptosomes will be prepared from guinea pig brains and purified by density gradient centrifugation. Neural membrane function will be reflected by changes in the permeability of isolated synaptosomes. Permeability will be monitored by the uptake of radiolabeled choline, release of radiolabeled calcium, and by the measurement of internal membrane viscosity with appropriate fluorescent probes. The results will serve as baseline values for permeability in the absence of EMR. Synaptosomes will then be exposed to radiation of various doses with a frequency of 2.8 GHz (radar). Power levels will be determined as specific absorption rates, and proper thermal controls will be employed in each case. Threshold values for EMR-neural membrane interaction will be determined in this manner. Neuropharmacologic drugs will then be screened for those that minimize the effect of EMR on the stability of synaptosomes. (10/77-9/78)

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

0346 FACTORS AFFECTING THE COLD ACCLIMATION OF CONTAINER-GROWN WOODY ORNAMENTAL PLANTS. Maronel, D. M.; Stolz, Lockard, R. G. (Univ. Kentucky, Dept. Horticulture, Agricultural Experiment Station, Limestone & Euclid, Lexington, KY 40506).

An attempt will be made to determine the effect of electromagnetic fields on organogenesis of in vitro cultured woody plants. Magnolia seedlings have been propagated for cold hardiness studies, and experimental procedures are being worked out for determination of abscisic acid (ABA) content in hardy and non-hardy magnolia plants. Translocation studies of ABA in magnolia seedlings has also been initiated. In vitro callus cultures of *Betula lenta*, *Cornus Florida*, and *Abelia grandiflora* have been established, and attempts are now being made to reproduce large quantities of these callus tissues for cold hardiness studies. Production of callus tissue from nine other woody plant species has not been successful. Mycorrhizal fungi have been isolated from roots of woody plants and are being reproduced in large quantities using aseptic culture techniques. Experiments for determining the effect of mycorrhizal fungi on termination of plant growth and subsequent cold hardiness are being instituted. A model production field and container nursery and experimental growth chambers have been designed and are being constructed for growing plants used in cold hardiness and plant growth studies. The effects of electromagnetic fields on plant growth are also being conducted. Results suggest that electromagnetic effects are species specific. No increase in germination of herbaceous ornamental plants has been found. (10/77-9/78)

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

0347 EFFECTS OF ACUTE ELECTROMAGNETIC RADIATION ON THE CENTRAL NERVOUS SYSTEM: MORPHOLOGICAL STUDY OF HYPOTHALAMIC AND SUBTHALAMIC REGIONS. McKee, A. E.; Dorsey, C. H. (U.S. Navy, Experimental Pathology Dept., Bethesda, MD 20014).

The effects of microwave irradiation on the central nervous system (CNS) will be investigated. Morphologic studies of the CNS will be conducted to evaluate and characterize histologic alterations. Efforts will be made to establish thresholds relative to time and power densities and to determine whether morphologic changes are reversible or permanent. Morphologic changes in the CNS of Chinese hamsters following exposure to acute continuous wave microwave irradiation will be evaluated by light and transmission electron microscopy. Two groups of Chinese hamsters, each divided into two subgroups, will be used in this study. The first group will be irradiated at a frequency of 1.7 GHz and at power densities of 10 and 25 mW/cm^2. The second group will be irradiated at a frequency of 2.45 GHz and at power densities of 10 and 25 mW/cm^2. The exposure time will range from 30, 60, and 120 min. Animals from each group will be sacrificed either immediately after exposure or after a recovery period of 15 days. (10/77-9/78)

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

0348 SLOW CHANGES IN BLOOD BRAIN BARRIER IN THE RAT FOLLOWING EXPOSURE TO MICROWAVE RADIATION. Gruenau, S. P.; Rapoport, S. I. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

Techniques are being developed at National Institute of Health for measuring subtle changes in blood-brain-barrier (BBB) permeability in local regions of the brain with a time resolution of .5 hr. An absolute sensitivity of 10^{-9} cm/sec, and a standard error of about 20%. This technique has been used to measure BBB permeabilities of glycerol, mannitol, sucrose, and inulin, independent of variations of cerebral blood flow. The technique has demonstrated how long and to what extent microwave radiation induces changes in the BBB. Rats will be exposed to 2,450 MHz pulsed microwave radiation, pulse repetition rate 500 Hz, and 2 μsec pulse duration for a

period of .5 hr at power densities $\leq$15 mW/cm^2. At various times following the irradiation, the BBB permeability to ^{14}C sucrose in different parts of the brain will be assayed by the above-described technique. Because animal sacrifice is required for the measurement, different animals will be used for different times. Animals subjected to both sham and experimental radiation will be studied. The time course over days of microwave-induced changes in the BBB permeability will be determined. Future plans include searching for long-lasting BBB changes in animals chronically exposed to about 100 mW/cm^2 at various pulse repetition rates and pulse widths. Irradiation values that cause BBB changes will provide guidelines for the formulation of safe human exposure levels for naval personnel. (10/77-9/78)

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

0349 EFFECTS OF MICROWAVE RADIATION ON THE BEHAVIORAL DEVELOPMENT OF LEARNING PROCESSES: ACUTE AND CHRONIC EXPOSURE. Maitland, G.; Thomas, J. R. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

The overall objective of this research is to determine whether acute and chronic exposures to low power levels of microwave radiation produce effects on the acquisition of new behaviors. It is important to determine whether the learning process is modified by microwave radiation levels similar to those produced by the electromagnetic emitting equipment operated by naval, surveillance, and communication systems. Acquired behavior is weaker and more susceptible to environmental influences than maintained well-established behavior. Established effects of low-level radiation on the development of behavior can be used to aid in specification of permissible levels of exposure across a range of frequencies for military personnel under functionally similar conditions. The methodology involves several new behavioral techniques that have been developed for studying repeated acquisition of behavioral chains with individual subjects. These techniques, which have proved to be extremely sensitive to the effects of a range of environmental variables, will be used to measure low-level radiation effects on behavior acquisition in animals as modified by several important radiation parameters. Frequency (initially 1 to 3 GHz), modulation values, and exposure time will be explored. Acute exposures as well as continuous exposures under chronic conditions (up to 90 days) will be emphasized. (10/77-9/78)

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

0350 AN INVESTIGATION OF THE MECHANISM OF MICROWAVE INDUCED CHANGES IN MEMBRANE PERMEABILITY. Finch, E. D. (U.S. Navy, Div. Medical Biochemistry, Bethesda, MD 20014).

This research will determine the interaction mechanisms responsible for microwave-induced changes in membrane permeability and, in particular, elucidate the role of modulation and temperature. Radioisotopic methods will be employed to monitor the membrane transport properties of mammalian cells exposed to microwave radiation. Studies will be carried out systematically to determine the exact dependence of any observed permeability changes on modulation and temperature. To further elucidate the interaction mechanisms responsible for any observed permeability changes, dynamic measurements will be used to monitor structural changes that occur in the biologic membrane and its environment during a single microwave pulse. These data will help identify the mechanism of interaction of the microwave field with the biologic membrane. The transport data combined with the dynamic measurements should identify thresholds for any observed effects. (10/77-9/78)

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

0351 BIOLOGIC CONSEQUENCES OF PULSED VERSUS CONTINUOUS WAVE RADIOFREQUENCY RADIATION (RFR). Cain, F. (Georgia Technical Res. Inst., Atlanta, GA).

See Current Research 0352. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Air Force

0352 BIOLOGICAL CONSEQUENCES OF PULSED VERSUS CONTINUOUS WAVE RADIO FREQUENCY RADIATION (RFR). Guy, A. W.; Chou, C. K. (Univ. Washington, Sch. Medicine, Dept. Rehabilitation Medicine, 500 17th Ave., Seattle, WA 98122).

This contract will provide data regarding the relative abilities of continuous wave (CW) and pulsed (P) radio frequency radiation (RFR) to produce biologic effects and determine whether the rapid rise and fall of electric and magnetic fields of P RFR are more stressful than CW RFR. Test animals will be exposed in both P and RFR fields to establish relative biologic effects. Effects will be characterized as to frequency, incident power, absorbed power, pulse and modulation characteristics, tissue temperature, and duration of exposure. This is a multi-source contract. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Air Force

0353 THE THERAPEUTIC RATIO AND EXPERIME[illegible] RADIOTHERAPY. Phillips, T. L.; F[illegible] K.; Goldstein, L.; Begg, A. C.; Harris, J. (Univ. California, Sch. Medicine, 551 Parn[illegible] Ave., San Francisco, CA 94122).

A group of experimental systems that allow the determination of quantitative endpoints in normal tissue and in tumors in the mouse will be used to search for improved therapeutic methods. Measurement of normal tissue damage to be applied include pulmonary lethality, esophageal lethality, renal lethality, whole brain lethality, intestinal crypt

cell assay, skin reaction grade assay, and the mouse bone marrow colony-forming unit assay. Tumor endpoints to be applied include the EMT6 mouse mammary tumor in vivo as a solid tumor, tumor located in the leg or flank as pulmonary microcolonies and as pulmonary macrocolonies. Assay methods will include in vivo treatment and in vitro assay, lung nodule assay, and regrowth delay time assay. Additional tumor systems to be employed include the Yuhas pulmonary carcinoma, the colon 26 and 36 carcinomas, the Lewis lung carcinoma, and the B16 melanoma. Using these systems, the damage to normal tissue versus tumor will be determined, and combinations or individual radiation regimens yielding improved tumor kill for a given normal tissue damage determined. The measured therapeutic ratio will be compared for various tumor types and for various specific critical normal tissues. Methods of enhancing tumor damage vs normal tissue damage to be explored include the effect of multiple or hyperfractionation of the radiation dose, the effect of alterations in radiation dose rate, the effects of anti-cancer chemotherapeutic agents, the effects of chemical radiation protective of sensitizing compounds, the relative effectiveness of high linear energy transfer heavy particles, including 15 MeV neutrons, helium ions, carbon, neon, and argon ions, and the effects of hyperthermia on tumor and normal tissue. (5/78-4/79)

Supporting Agency:HEW, PHS, NIH, NCI

0354 THE EFFECT OF MICROWAVE RADIATION ON ANIMAL BEHAVIOR. Monahan, J. C. (Dept. Health, Education & Welfare, Bureau of Radiological Health, Biological Effects Div., 5600 Fishers Lane, Rockville, MD 20852).

The effects of microwave radiation on the behavioral matrix of three animal species (monkeys, rats, mice) will be determined. Special emphasis will be given to determining threshold radiation levels and the effects of frequency, as well as environmental conditions. Monkeys will be trained to perform behavioral tasks, shown to be sensitive to variables that produce changes in learning and memory. The subjects will then be irradiated (2,450 MHz continuous wave) during task performance, and their behavioral responses will be analyzed. The effect of long-term repeated exposures to microwaves (915 MHz continuous wave) will be evaluated in terms of learned behavioral patterns in a classical conditioning paradigm. Rats will also be employed to evaluate the effect of 915 MHz continuous wave radiation on a learned avoidance behavior (taste aversion). In a separate but related study, mice will be used to evaluate the noxious stimulus properties of 2,450 MHz continuous wave radiation. Both active and passive avoidance behavioral procedures will be employed, and the effects of environmental conditions and radiation thresholds will be evaluated. The results of the studies involving monkeys strongly suggest an interactive effect between microwave radiation and fenfluramine, a serotonin depleter. The studies employing mice and rats have shown that microwaves can act as a noxious stimulus that results in behaviors that allow the subject to avoid or escape the radiation. In addition, the environmental temperature can significantly alter the radiation threshold necessary to produce these behavioral changes. (10/76-9/77)

Supporting Agency:HEW, PHS, FDA, BRH

0355 ELECTROMAGNETIC DOSIMETRY VIA IMPLANTABLE ELECTRIC FIELD PROBES. Bassen, H. (Dept. of Health, Education & Welfare, Bureau of Radiological Health, Electromagnetics Branch, 5600 Fishers Lane, Rockville, MD 20852).

Electric field strengths within simulated and actual living animals and man are to be measured during exposure to low-level (1-10 mW/cm^2) radio frequency (RF) and microwave radiation. Miniature dipoles (1.5 mm) with microelectronic diode chips and high resistance-detected signal leads have been developed using thin film technology. Both 3-axis probes (containing three orthogonal dipoles) and single axis probes have been fabricated and evaluated in simulated biologic tissue objects. With a proper low-dielectric-constant insulator surrounding the probe tip, internal electric field strengths in finite objects (small spheres and rectangles) exposed to low-level microwave radiation (450-2,450 MHz) may be accurately measured. Measured data agree with theoretically predicted values within ± 2 or ± 4.5 dB, using only free space calibration factors for the probe. Proximity to dielectric interfaces (boundaries between air and simulated muscle) does not affect the probe's accuracy. Efforts to improve absolute accuracy, increase the frequency range to 100 MHz, and reduce probe size are under way. The development of a readily available, biocompatible probe should be complete in fiscal year 1978. Applications in the dosimetric measurement of fields with a living cat's brain, a human skull filled with simulated brain material, and a rabbit's eye have begun with promising initial results. (10/76-9/77)

Supporting Agency:HEW, PHS, FDA, BRH

0356 NAVY ENVIRONMENT: INTERACTIVE MECHANISMS AND EFFECTS OF LOW-LEVEL MILLIMETER WAVES ON LIVING CELLS. Motzkin, S. M.; Rosenthal, S. W. (Dept. Chemistry, Polytechnic Inst. New York, Graduate Sch., 333 Jay St., Brooklyn, NY 11201).

Mechanisms that underlie the effects of microwaves at the cellular and subcellular level will be studied. Using millimeter waves in the frequency range between 30 and 60 GHz, attempts will be made to define the field specific effects and mechanisms that occur when microwaves interact with biologic systems. In the first year, the necessary millimeter wave equipment will be set up in an appropriate facility, and a test chamber will be developed for retaining microorganisms and tissue culture cells for exposure to the microwaves. Once the exposure systems are complete, several Soviet experiments will be duplicated. In addition, pre-

liminary studies will investigate permeability and transport in mitochondria. In the second year, mitochondrial characteristics and functions will be examined with respect to permeability, facilitated transport, active transport, cytochrome oxidase, electron transport, and adenosine triphosphatase. Studies will be undertaken with red blood cell membranes. (10/76-9/77)

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

0357 NAVY ENVIRONMENT: DETERMINATION OF BOUND WATER IN BIOLOGICAL TISSUE AND ENERGY DISSIPATED IN BOUND WATER BY LOW-LEVEL MICROWAVES. Grant, E. H.; Sheppard, R. J. (Univ. London, Campden Hill Rd., W8 7AH, London, England).

This study will elucidate the role of bound water in microwave energy absorption, which leads to undesired effects in humans exposed to low-level microwaves generated by naval operations. Dielectric (permittivity and conductivity) measurements will be made on low density lipoproteins of human serum. These lipoproteins have varying amounts of bound water, depending on the source. The absorption of microwave energy (at several frequencies) by bound water will be studied, and an attempt will be made to characterize the dielectric parameters of bound water. (10/77-9/78)

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

0358 MUTAGENIC EFFECTS OF MICROWAVES. Buchta, F. L. (Dept. Health, Education & Welfare, Bureau of Radiological Health, Genetic Studies Section, 5600 Fishers Lane, Rockville, MD 20852).

The possible mutagenic effects of low-level 2,450-MHz microwave radiation are being investigated. Auxotrophic bacteria are exposed in liquid culture under carefully controlled temperature and absorbed dose levels. Locus reversion is monitored by plating on appropriate indicator media. Exposures have been carried out at levels of 50, 100, and 200 mW/g absorbed dose using 30-min radiation times and a controlled exposure temperature of 37 C. (10/76-10/77)

Supporting Agnecy: HEW, PHS, FDA, BRH

0359 FLUORESCENT DYES AS EMR PROBES. Friend, A. W. (U.S. Navy, Electromagnetic Radiation Div., Bethesda, MD 20014).

No method for directly observing electromagnetic radiation (EMR) interactions at cellular levels within living tissues is currently available. Fluorescent dyes have been found to act as optical probes of transmembrane action potentials in cells. This research will investigate the possibility that fluorescent dyes may also be able to detect the fluctuating transmembrane potentials induced by external EMR fields at frequencies into the radio frequency (RF) range. Fluorescent dye molecules will be attached to cell membranes. Their fluorescence and absorption characteristics at optical frequencies will be monitored as functions of fluctuating transmembrane potentials in both the audio and low RF ranges. The frequency responses and signal to noise ratios of absorption, fluorescence, and electrochromism will be plotted for a series of merocyanine dyes. (10/77-9/78)

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

0360 POSSIBLE EFFECTS OF MICROWAVES ON NERVES. Brandt, H. E. (U.S. Army, Harry Diamond Lab., 2800 Powder Mill Rd., Hyattsville, MD 20783).

The possible effects of microwave radiation on the propagation of action potentials in nerve fibers will be determined. A computer program for integrating the perturbed Hodgkin-Huxley equations (nonlinear diffusion equation) will be developed to calculate the effect of various current field perturbations on nerve pulse shape and velocity. The possible interactions of perturbing fields with the cell membrane resulting in alternations of the ion gating mechanisms will be investigated, and thermal effects will be calculated. The penetration of an external radio frequency field through surrounding tissue and into an axon will be calculated in addition to the effect of such a perturbation on action potential transport. (10/77-9/78)

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

0361 WORKSHOP ON THE PHYSICAL BASIS OF MICROWAVE INTERACTIONS WITH BIOLOGICAL SYSTEMS. Anonymous. (U.S. Navy, Office Naval Res., 800 N. Quincy St., Room 724, Arlington, VA 22217).

Under joint sponsorship with the Navy, a workshop was held in June of 1977 to discuss the mechanism of interaction of microwave radiation with biologic systems and appropriate methods of measurement of physical parameters. The proceedings have been published and are available. The workshop generated interest in this complex problem among new areas of the scientific community and brought new ideas to the forefront. A more concentrated follow-up workshop will be held in 1979. (1/77-12/77)

Supporting Agency:HEW, PHS, FDA, BRH

0362 HYPERTHERMIA--A DIFFERENTIAL RADIOSENSITIZER IN VIVO. Gibbs, F. A. (Utah Higher Education System, Sch. Medicine, Dept. Radiology, 1400 E. 2nd St., Salt Lake City, UT 84112).

The potential of hyperthermia as a radiosensitizer will be evaluated for a rapidly proliferating normal murine tissue (duodenal crypt lining epithelium), a slowly-turning-over normal murine tissue (spinal cord), as well as a slow-growing (slow line) and a fast-growing (S102F) C3H mouse mammary tumor. This combination of tissues will allow the assessment of

hyperthermic radiosensitization for both the early and late effects on normal tissue and on tumors with widely varying growth kinetics. The hyperthermia will be induced locally via a 915 MHz microwave system, and the effects on the tissues will be assayed, respectively, by microcolony crypt survival, hind-leg dysfunction, tumor growth delay and local tumor control (TCD50/120). Several temperatures and heating intervals will be studied as will heating before and after x-irradiation. The therapeutic indices for tumor versus normal tissue will be determined for the various protocols. The long-term goal is to assess the feasibility of introducing hyperthermia as an adjuvant for clinical radiation therapy. (5/77-4/79)

Supporting Agency:HEW, PHS, NIH, NCI

0363 BOSE-EINSTEIN CONDENSATION IN BIOLOGICAL SYSTEMS. Wu, T. (State Univ. New York, Sch. Science & Mathematics, Dept. Physics, Vestal Parkway E., Binghamton, NY 13901).

Biological systems contain dipolar elements (H-bonds, proteins, DNA that are capable of electric oscillations at certain specific frequencies. Longitudinal electric modes in a frequency range of 10^{11}-10^{12}/sec are typical. A model created by Frohlich suggests that if energy is supplied above a critical rate to the branch or branches of electric modes, Bose-Einstein Condensation into the lowest energy state occurs. Hypothetically, this phenomenon provides a means of energy storage for life-sustaining biologic processes, such as, cell division and protein synthesis. Several recent Russian experiments provide strong support for the Frohlich theory. These experiments involve the microwave irradiation of living organisms. A criticism of Frohlich's theoretic model is analyzed, and a possible alternative microscopic approach to this problem is proposed using perturbation theory. In light of recent Russian and American political developments concerning microwaves, this problem takes on added interest and may be a theoretic means of explaining, in terms of straightforward physical concepts, a very complex set of bioprocesses. (2/78-1/79)

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

0364 STUDY OF BRAIN METABOLISM USING RAPID MICROWAVE HEATING. Stavinoha, W. B. (Univ. Texas, Sch. Medicine, Dept. Pharmacology, 7703 Floyd Curl Dr., San Antonio, TX 78284).

The technique of microwave inactivation of the enzymes of the rat brain will be applied to the study of the neurochemistry of the brain. The time required for enzyme inactivation will be on the order of 200-400 msec for the rat and 50 msec for the mouse. Rats monitored by electroencephalograph will be sacrificed by microwave enzyme inactivation while either awake, in slow wave sleep, or in paradoxical sleep. The following neurochemicals will be analyzed in regions of the brain: (1) neurotransmitters: acetylcholine, 5HT, GABA; (2) cyclic nucleotides: cyclic adenosine monophosphate and cyclic guanosine monophosphate; (3) high energy compounds: adenosine triphosphate, adenosine diphosphate, adenosine monophosphate, Pi, creatine phosphate, and glucose metabolism. Studies will also be done on the correlation of cyclic nucleotides and the cholinergic and adrenergic systems, cyclic nucleotides and compromised nutrient delivery, glucose metabolism in regions of the brain with barbituates and ethanol, and acetylcholine synthesis rate in the brain with therapeutic agents. (3/78/2/79)

Supporting Agency: HEW, PHS, Alcohol Drug Abuse & Mental Health Admin., NIMH

0365 NAVY ENVIRONMENT: NON-IONIZING RADIATION EFFECTS ON MUSCLE AND NERVE CELLS--SAFETY OF ELECTROMAGNETIC RADIATION. Portela, A.; Perez, J. C. (Natl. Council Science & Technical Res., Rivadavia 1917, Buenos Aires, Argentina).

The response of cellular and subcellular structures to non-ionizing electromagnetic radiation will be investigated to discriminate between thermal and direct field (nonthermal) effects. In vitro and in vivo studies of effects on nerve and muscle cells will be performed first. Dielectric properties of biologic molecules and tissues will be studied as well as the microwave effects on bound water. The combined effect of electromagnetic fields and other environmental factors also will be studied. (10/77-9/78)

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

0366 RADIATION THERAPY ONCOLOGY GROUP. Plenk, H. P.; Speiser, B. L.; Roland, T. A.; Sause, W. T.; Matthes, D. C. (Radiation Center Latter Day Saints Hosp., 325 8th Ave., Salt Lake City, UT 84103).

Instrumentation to improve heating by microwaves and thermometry of hyperthermia and radiation will be combined in an attempt to improve the results of radiation therapy in advanced cancer. Specifically, basic development of equipment and of measurements with a 434-MHz applicator will be carried out. Newly developed solid state probes to measure heat in depth within microwave fields will be tested. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, NCI

0367 BIOLOGICAL THERMOMETRY SYSTEMS USING OPTICAL SENSORS. Christensen, D. A.; Johnson, C. C. (Utah Higher Education System, Sch. Engineering, Dept. Bioengineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

Considerable success has been achieved in this