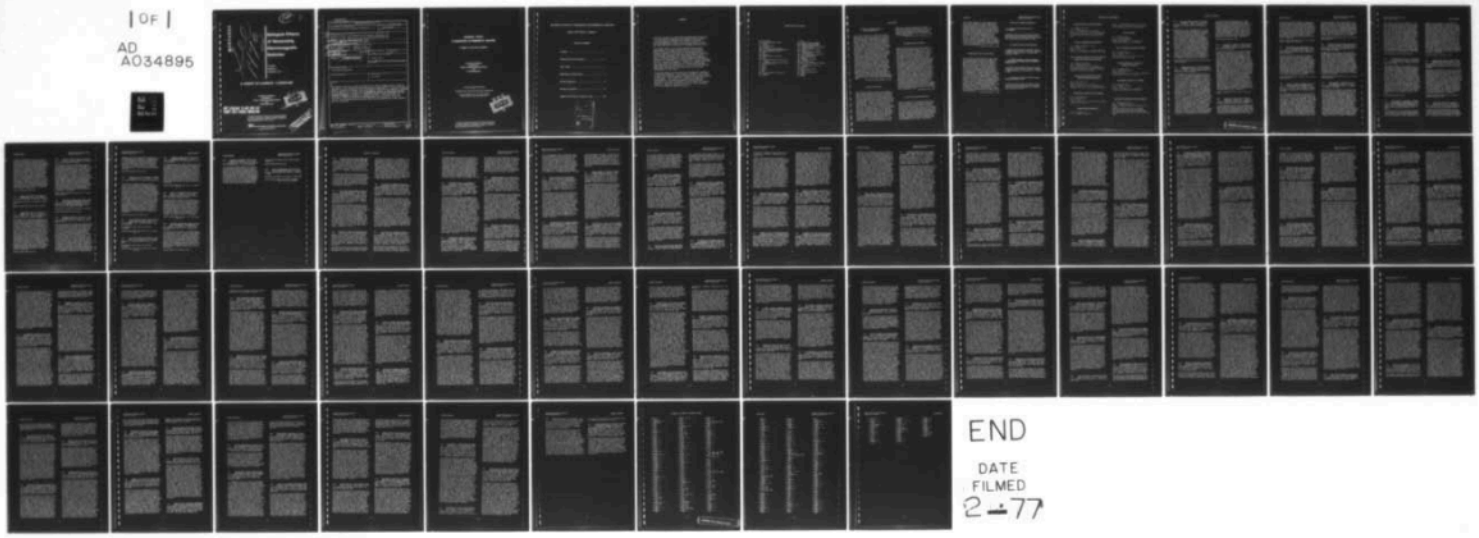
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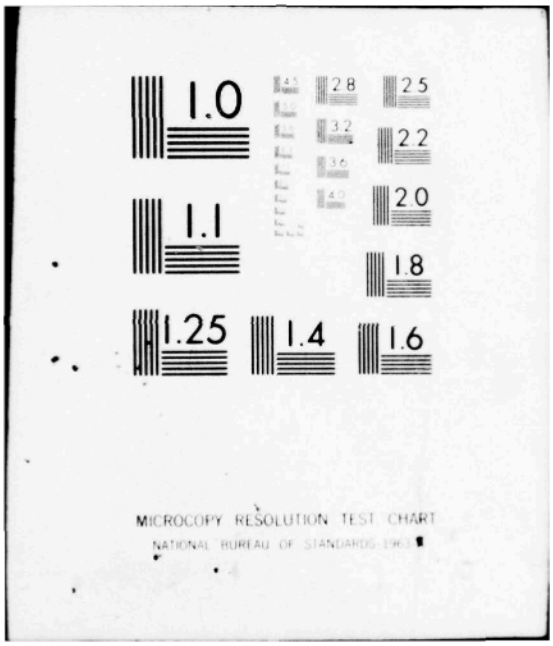
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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME I
NUMBER 2
JANUARY, 1977

A DIGEST OF CURRENT LITERATURE

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

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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 of 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.

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BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION

A Digest of Current Literature

A Quarterly Publication
Produced for
Office of Telecommunications Policy
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Literature Selected and Abstracted
by
Biomedical Group, Science Information Services Department

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

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

January, 1977 Volume 1, Number 2

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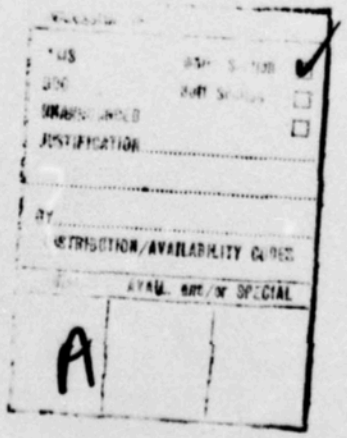
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PREFACE

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 I, 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)
BRH - Bureau of Radiological Health
C - centigrade
cm - centimeter
cps - cycles per second
dB - decibel(s)
EPA - Environmental Protection Agency
ERDA - Energy, Research and Development Agency
FDA - Food and Drug Administration
g - gram(s)
G - Gauss
GHz - gigahertz
HEW - Health, Education, and Welfare
hr - hour(s)
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
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)
UHF - ultra high frequency
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)
WHO - World Health Organization
wk - week(s)
wt - weight
yr - year(s)

NEWS ITEMS

PENTAGON CITES POTENTIAL PERIL OF SOVIET MICROWAVE WORK

A recently declassified U.S. Defense Intelligence Agency report states that extensive Soviet research into microwaves "has a great potential for development into a system for disorienting or disrupting the behavior patterns of military or diplomatic personnel." The report claims that Soviet scientists are fully aware of biologic effects of low-level microwave radiation which have potential antipersonnel applications. The report says that one biologic effect that could offer antipersonnel uses is microwave hearing. "Sounds and possibly even words, which appear to be originating intracranially, can be induced by signal modulation at very low average densities." In addition to research into microwave hearing, the Soviets have studied various changes in body chemistry and functioning of the brain resulting from exposure to microwaves and other frequencies of electromagnetic radiation. The report cites the use of microwaves to induce heart seizures experimentally in frogs by synchronizing the pulses of a microwave signal with the animal's heartbeat and beaming the radiation at the chest area. The report adds that "a frequency probably could be found which would provide sufficient penetration of the chest wall of humans to accomplish the same effect," i.e., heart attacks. Another potential antipersonnel use of microwaves could be based on their effect on the blood brain barrier. As a result of such an application, the report says, "an individual could develop severe neuropathological symptoms and either die or become impaired neurologically."

The Evening Bulletin November 22, 1976

TO BEAM OR NOT TO BEAM?

Vincent Everett of Texas A & M University cautions that a recent proposal to transmit a 10-cm wavelength beam of microwave radiation from space and "convert" it on earth to 40,000 volts DC warrants careful appraisal. Everett points out that the proposal failed to indicate the power density needed to produce 40,000 volts DC (taking into account the loss to transmission and conversion). "Even if the power density was less than 10 mW/cm^2," he says "it is possible that the hazardous effects of microwaves would show up many years later (that is, 1 hr in a 10 mW/cm^2 field equals 1000 hr in a .01 mW/cm^2 field)." Everett cites Soviet experiments in which microwaves of 10 cm and power densities of 100 mW/cm^2 proved lethal to 50% of the rats exposed for 15 min. Supporters of the proposal, however, claim that the hazards of high power density in a solar-power beam radiated to earth from space were considered and that they would be offset by diffusing the incoming microwave beam over a very large antenna. It was calculated that a man at the edge of a 7 km antenna would be exposed to as much radiation as if he were standing in a kitchen in front of a microwave oven with the door closed. Supporters point out that unlike exposure to ionizing radiation, there appears to be no evidence that biologic effects are cumulative with prolonged exposure to microwave energy.

Popular Sci. pp. 8, 12; February, 1976

ELECTROSURGICAL DEVICES DEBATED

Commenting on the safety of electrical surgical devices, Saul Aronow of the National Fire Protection Association claims that although the newer solid state devices are smaller, technologically superior, and usually less powerful, they are not necessarily safer than the older spark-gap machines. Aronow acknowledges that the solid-state devices may be more effective for some purposes but are less so for others. He claims, "There are hazards associated with the use of such intentionally destructive high-power devices (spark-gap units), but these hazards and complications are largely attributable to lack of knowledge or inadequate training of medical personnel operating them and not the faults of the apparatus." However, Philadelphia physician, Stephen L. Corson, asserts that spark-gap units are notoriously unreliable and that he knows of no clinical circumstance in which they are to be preferred over solid state devices. Corson says that electrosurgical generators that depend on spark-gap circuitry show great variations between individual machines at similar dial settings. Moreover, he claims that spark-gap units are affected by conditions such as humidity, and in general, vary tremendously from calibrated settings soon after being serviced. Corson concludes that whatever the surgical procedure, the larger solid state units have sufficient generator capacity and, like other solid state electronic components, demonstrate little fluctuation in performance over a long period of time.

JAMA 236(15): 1690; 1976

OTP STUDY UPDATES RADIATION HAZARDS

The White House Office of Telecommunications Policy (OTP) has released its fourth study of the biologic hazards of nonionizng electromagnetic radiation. And while the OTP says that it is still too early to draw definite conclusions from most of the studies, the past year's efforts have netted many new findings. The study claims, for example, that "when human subjects are irradiated with appropriate pulse-modulated microwave energy, they report perceiving a sound that appears to originate from within or slightly behind the head. The generally accepted explanation for this phenomenon today is that it results from sound waves generated in the tissues of the head by a

rapid thermal expansion of tissues when the microwave energy is deposited as heat. Research this past year has given rise to reports that normal cochlear mechanisms are involved. It is hoped that experimentation currently in progress will resolve the exact mechanism of action." The entire electromagnetic radiation research program funding for the government is approximately $9.5-million for fiscal year 1977--less than adequate according to the Electromagnetic Radiation Management Advisory Council. "The shortness of funds has posed a particular problem to the initiation of long-term studies," says OTP--"for example, those continuing for the life of the experimental animal or extending through successive generations in order to establish a definitive reading on the possible effects of low-level, long-term exposures."

Microwaves 15(8): 19; 1976

BENSON NAMED DEPUTY BUREAU DIRECTOR

James S. Benson, formerly Director of the Division of Training and Medical Applications (DTMA), has been appointed Deputy Director of the Bureau of Radiological Health. Mr. Benson will replace Dr. Robert L. Elder who left the Bureau to become Deputy Associate Commissioner for Science in the FDA Office of Science. Mr. Benson's experience in the field of radiologic health dates back to 1962 when he joined the Public Health Service and was assigned to work with state health programs on the management of radioactive materials. Following a year of graduate study in 1966-1967, he worked in private industry as a management and training consultant until 1970, at which time he rejoined the Bureau as Assistant Director of the former Office of Training. In 1972 Mr. Benson was designated Director of DTMA, a position in which he headed such Bureau activities as the implementation of educational programs aimed at reducing unnecessary exposure from the use of radiation in clinical medicine, the development of voluntary recommendations for radiation exposure reduction, and the setting of professional standards and guidelines for improving medical radiation practice.

BRH Bulletin 10(18): 2; 1976

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **EFFECT OF ELEVATED TEMPERATURE ON CARCINOGENESIS.**

The National Institute for Occupational Safety and Health, Rockville, Maryland has contracted with Ohio State University, Research Foundation, Columbus, Ohio, for the above study. (October 4, 1976)

☐ **ELF RADIATION EFFECTS ON MIGRATING BIRDS.**

The Office of Naval Research, Arlington, Virginia, is negotiating with the Marine Biological Laboratory, Woods Hole, Massachusetts, for the above study. (October 27, 1976)

☐ **RESEARCH TO ASSESS THE EFFECTS OF CHRONIC, LOW-LEVEL MICROWAVE EXPOSURE ON THE HEMATOPOIETIC SYSTEM OF MICE.**

The Office of Naval Research, Arlington, Virginia, is negotiating with the Battelle Memorial Institute, Richland, Washington, for the above study. (October 7, 1976)

☐ **RESEARCH ON THE EFFECTS OF CHRONIC LOW-LEVEL MICROWAVE EXPOSURE ON MICE.**

The Office of Naval Research, Arlington, Virginia, has contracted with the Battelle Pacific Northwest Laboratories, Richland, Washington, for the above study. (October 13, 1976)

MEETINGS AND CONFERENCES

IEEE INTERNATIONAL PULSED POWER CONFERENCE

Date: November 9-11, 1976
Place: Lubbock, Texas
Sponsor: IEEE, Texas Technical University
Requests for Information: Dr. T. R. Burkes, or Dr. M. Kristiansen, Department of Electrical Engineering, Texas Technical University, Lubbock, Texas 79409

NATIONAL TELECOMMUNICATIONS CONFERENCE

Date: November 29-December 1, 1976
Place: Dallas, Texas
Sponsor: IEEE
Requests for Information: J. H. Tilley, Collins Radio Co., North Alma Road, Richardson, Texas 75080

SECOND INTERNATIONAL CONFERENCE & WINTER SCHOOL ON SUBMILLIMETER WAVES & THEIR APPLICATIONS

Date: December 6-10, 1976
Place: San Juan, Puerto Rico
Sponsor: IEEE, Optical Society of America
Requests for Information: J. J. Gallagher, Engineering Experimental Station, Georgia Institute of Technology, Atlanta, Georgia 30332

MEETING ON COMPUTER METHODS FOR CIRCUIT DESIGN AND MICROWAVE APPLICATIONS

Date: April 19-21, 1977
Place: Hull, U.K.
Sponsor: IEEE, University of Hull, U.K.
Requests for Information: A. C. Davies, The City University, Saint John Street, London ECIV 4PB, U.K.

INTERNATIONAL RADIATION PROTECTION CONGRESS

Date: April 24-30, 1977
Place: Paris, France
Sponsor: IRPA
Requests for Information: G. Bresson, BP 33, 92260-Fontenay-aux-Roses, France

MICROWAVE POWER SYMPOSIUM 1977

Date: May 25-28, 1977
Place: Minneapolis, Minnesota
Sponsor: International Microwave Power Institute
Requests for Information: Mr. O. P. Snyder, University of Minnesota, Saint Paul, Minnesota 55108

IEEE–URSI MEETING

Date: June 20-24, 1977
Place: Palo Alto, California
Sponsor: IEEE, USNC/URSI
Requests for Information: J. B. Damonte, 1716 Hillman Avenue, Belmont, California 94002

IEEE–MIT INTERNATIONAL MICROWAVE SYMPOSIUM

Date: June 21-23, 1977
Place: San Diego, California
Sponsor: IEEE
Requests for Information: R. Casey, Code 1300, NELC, San Diego, California 92152

SECOND ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM AND EXHIBITION

Date: June 28-30, 1977
Place: Montreux, Switzerland
Sponsor: Swiss PTT
Requests for Information: Mr. T. Dvorak, Hochfrequenztechnik, 8092 ETH Zurich, Switzerland

ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM

Date: July 26-28, 1977
Place: Seattle, Washington
Sponsor: IEEE
Requests for Information: B. L. Carlson, Jr., Boeing Co., Box 3029, Seattle, Washington

ENGINEERING IN MEDICINE AND BIOLOGY CONFERENCE

Date: November 5-9, 1977
Place: Los Angeles, California
Sponsor: Alliance for Engineering in Medicine and Biology
Requests for Information: Mrs. P. I. Horner, Assistant Director and Conference Coordinator, Alliance for Engineering in Medicine and Biology, Suite 1350, 5454 Wisconsin Ave., Chevy Chase, Maryland 20015

0064 PRE- AND POSTNATAL EFFECTS OF MICROWAVE IRRADIATION. Jensh, R. P.; Brent, R. L.; Weinberg, I.; Vogel, W. (Thomas Jefferson Univ., Sch. Medicine, 1025 Walnut St., Philadelphia, PA 19107).

The objectives of this investigation are to further develop techniques and instrumentation for the determination of exposure and dosimetric parameters at 915 MHz and 2450 MHz and to determine the influence of pulsed and continuous exposure, peak power, and average power (pulsed irradiation). Dosage and monitoring procedures will be developed through refinement of techniques and instrumentation for quantitative measurement of modulated and pulsed transmission of 2450 MHz, and 915 MHz, and power ranges at or near those currently considered acceptable. This investigation will determine the effects of low dose chronic prenatal microwave irradiation on: (a) embryonic and fetal development in the rat, (b) postnatal development in the rat, (c) the reproductive capacity of the rat, and (d) the central nervous system of the exposed adult offspring. The procedure will include three power ranges at two transmissions and two frequencies (2450 MHz and 915 MHz) at four time periods in the rat pregnancy plus paired controls. (6/76-5/77)

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

0065 BIOLOGIC RESPONSES TO A CHRONIC MICROWAVE ENVIRONMENT. Lebovitz, R. M.; Kiser, R. S.; Seaman, R. L. (Univ. Texas, Sch. Medicine, 5323 Harry Hines Blvd., Dallas, TX 75230).

As microwave energy becomes increasingly present in our environment, an unmonitored population is placed at risk, since data exists regarding the biologic effect of such exposure. The basic aim of this project will be to determine the effects of a long term (four mo) exposure to microwave radiation (MWR) (i.e., less than 10 mW/cm^2 incident power density). Data will be obtained from several behavioral and biochemical variables, and a dose-response curve over the range 0-20 mW/cm^2 will be defined. The chronic MWR environment will comprise a pair of radiofrequency anechoic chambers into which control and experimental groups will be introduced for eight hr of whole body MWR exposure per day. Pulse modulated MWR at 2450 MHz will be used. In the first part of this study, the effects of 0, 10, and 20 mW/cm^2 MWR on open field behavior and on instrumental behavior for liquid reward will be determined in rats. Besides the 0 mW/cm^2 group, an additional control group will be exposed to a mild thermal stress. In the second part of this study, the instrumental behavior of monkeys for liquid reward during chronic MWR will be determined to initiate the extrapolation of the results to human exposure. Dose-response curve again will be defined, via radiation at 5, 10, and 20 mW/cm^2 with dual control groups, as above. Coincident with these behavioral studies, 24 hr urine samples of selected subgroups of rats and monkeys will be quantitatively analyzed for stress-related steroid fractions and for excreted 5-hydroxyindoleacetic acid. These studies will provide new and needed data regarding the extent to which low level MWR specific effects can be understood as secondary to mild thermal stress. A pattern of MWR-specific responses that departs from that induced by ambient thermal stress, under identical conditions, would suggest that the results of chronic MWR encompass more than a hypothalamic reaction to thermogenesis. Null or negative results would enable us to more critically evaluate the extent of the risk derived from chronic, whole body MWR exposure of the adult animal. (5/76-4/77)

Supporting Agency:HEW, PHS, FDA.

0066 FLUID SHEAR OR MAGNETIC ALIGNMENT OF BLOOD COMPONENTS. Gardner, R. A. (Washington Univ., Sch. Engineering & Applied Science, 4559 Scott Ave., St. Louis, MO 63130).

The objective of this project is to identify quantitatively field mechanisms of interaction in blood due to either fluid flow (rate-of-shear) or externally applied fields (electric or magnetic). Two such effects, which have been documented recently, are the delay of *in vitro* thrombus formation due to either increasing rate-of-shear in the flow or the application of an external magnetic field. This research will focus on the working hypothesis that the mechanism that results in these effects is the preferential alignment of one or more of the macromolecular participants in the *in vitro* thrombus-formation process. Fresh whole blood (wb) or platelet-rich-plasma (prp) from fasted normal donors will be used to produce coagula under the controlled *in vitro* flow conditions of a modified Chandler rotating loop system. The effects to be studied include the dependence of thrombus-formation time in prp and wb on field strength and rate-of-shear, and the dependence of thrombus structure in wb and prp on field strength and rate-of-shear. The reduced sedimentation of erythrocytes in wb or single protein solutions in a transverse field will be examined theoretically and experimentally in order to identify orientation effects. Solutions of single blood proteins will be examined using spectrophotometry, spectropolarimetry, and birefringence to quantify their orientation in a transverse magnetic field. (6/76-5/77)

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

0067 MAGNETICALLY COUPLED DRIVE OF THE EAR. Moushegian, G.; Rupert, A. L.; Gerkin, G.; Glorig, A.; Owens, F. (Callier Center Communication Disorders, 1966 Inwood Road, Dallas, TX 75235).

An electromagnetic device will be developed and evaluated to drive the ossicular chain more efficiently than the currently used hearing aids. Such a device may ultimately be used as a hearing prosthesis, which would not have the disadvantages of body aids. The cochlear potentials generated by an electromagnetic

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drive will be measured in animals and compared with the potentials generated by acoustic stimulation in a systematic manner to assess the dynamic range of this artificial form of stimulation. The possibility will be assessed, in animals, of permanently affixing a magnet either by glue or surgery. It will be determined furthermore whether a long-term implant can be tolerated without adverse effects. Finally, the electromagnetic device will be used in normal and deaf subjects to determine audiometrically and psychophysically the efficacy of this form of stimulation. (7/74-5/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Neurological & Communicative Disorders.

0068 INVESTIGATION OF MICROWAVE RADIATION EFFECTS ON NEUROLOGICAL FUNCTIONING. McRee, D. I.; Somjen, G. (U.S. Dept. Health, Education, Welfare, Public Health Service, Natl. Inst. Health, Durham, NC 27709).

The spinal cords of cats were directly exposed to 2450 MHz continuous wave microwave radiation in order to study the effect on reflex response and synaptic function. A small but statistically significant increase in the reflex response was detected in the first series of experiments, which indicates enhancement of the synaptic transmission. However, this effect was not observed in a second series of experiments in which the incident power density was increased from 10 mW/cm^2 to 20 mW/cm^2, and a more rigorous experimental design was employed. The slight changes that were observed in the second series could be attributed to small temperature variations during the experiment. (7/75-6/76)

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

0069 EFFECTS OF 2450 MHz MICROWAVES ON THE EMBRYONIC DEVELOPMENT OF JAPANESE QUAIL. McRee, D. I.; Hamrick, P. E.; Thaxton, J. P.; Parkhurst, C. R. (U.S. Dept. Health, Education, Welfare, Public Health Service, Natl. Inst. Health, Durham, NC 27709).

Fertilized Japanese quail eggs were exposed to 2.45 GHz continuous wave microwave radiation for four hr per day for the first five days of development, and for 24 hr the second day of development to 30 mW/cm^2 power density. The newly-hatched quail were examined for changes in percent hatch, gross deformities, and hematological changes. No changes in hatchability or number of deformities were observed. A significantly lower level of hemoglobin was measured in the exposed birds. Fertilized quail eggs were also exposed for the first 12 days of development to 2450 MHz continuous wave microwave radiation at a power density of 5 mW/cm^2. The effects on hatchability, number of deformities, and hematological parameters again were measured in the 2-day-old birds. In this series of tests, a small statistically significant increase in hemoglobin and a large decrease in monocytes were measured. The above experiments were repeated, but now the quail were kept to maturity and mated. It was found that the exposed male when mated with either the control or exposed female produced a 20% decrease in fertility. The exposed females when mated with control males produced no decrease in fertility. These birds were sacrificed at 22 weeks, and changes in the size of the liver, bursa, and spleen were observed in the exposed birds. (7/75-6/76)

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

0070 EFFECTS OF 2450 MHz MICROWAVE RADIATION ON BIOLOGICAL MATERIALS AT CELLULAR LEVEL. Hamrick, P. E.; Fox, S. S. (U.S. Dept. Health, Education, Welfare, Public Health Service, Natl. Inst. Health, Durham, NC 27709).

The objectives of this project were to determine how 2450 MHz microwave radiation interacts with biological material at the cellular and macromolecular level, to observe any effects of this interaction, and to relate the amount of microwave energy absorbed to the effects. Biological systems employed in the study included bacteria and bacteriophage, solutions of DNA, 2-4 cell stage embryos from mice, rabbit erythrocytes, and rat lymphocytes. The temperature, humidity, and various other growth conditions were carefully monitored in order to eliminate any effects not intrinsically caused by the microwave radiation. Results revealed very few differences between exposed and control samples that could not be explained by the thermal heating of the microwave radiation. (7/75-6/76)

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

0071 TUMOR RESPONSE TO HYPERTHERMIA AND IONIZING RADIATION. Wallen, C. A. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

The objective of this study is to investigate the effect of microwave-induced hyperthermia as an adjunct to radiation therapy of tumors in rats. Female Fisher rats with transplanted mammary adenocarcinoma (R3230) are treated 21-24 days after transplant when the tumors have a diameter of 2.0-2.5 cm. Hyperthermia is induced by 2450 MHz continuous modulation microwave energy coupled to the tumor by an applicator fabricated from a dielectrically loaded, tapered, rectangular waveguide to permit relatively uniform heating of the tumors. It is understood that the 12.2 cm wavelength of 2450 MHz is appropriate for this tumor size; for larger tumors, a longer wavelength of microwaves or radiofrequency would be indicated. The X-ray source is a Maxitron 300 and exposure conditions are 200-300 kV with high voltage level of 102 mm Cl and an exposure rate of 50-100 rad/min (to match typical clinical conditions). The animal is shielded to