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BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION

A Digest of Current Literature and a Forum of Communication

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The Biological Effects of Electromagnetic Radiation serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radio-frequency radiation) are compiled, condensed, and disseminated on a regular basis. BEEMR is intended to be a highly useful current awareness tool for scientists engaged in research ore 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.

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Biological Effects Electromagnetic Radiation I(3), December 1974

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PREFACE

Biological Effects of Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under a grant from the U. S. Army Research Office. The grant is co-sponsored by the Bureau of Radiological Health, Food and Drug Administration; Office of Naval Research; U. S. Navy Bureau of Medicine and Surgery; U. S. Air Force School of Aerospace Medicine; and the Walter Reed Army Institute of Research. The U. S. Environmental Protection Agency is cooperating in this project.

Biological Effects of Electromagnetic Radiation 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 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 Electromagnetic Radiation is published quarterly. Volume I, 1974, consists of three issues, which cover the scientific literature published from July, 1973 through December, 1974. The first several issues also cover past work of importance. The quarterly 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. Articles carried over because of space limitations and materials for which full text is not available will be included as citations. When available, a special report section, technical note, book review, or topical retrospective literature survey will be included.

ABBREVIATIONS AND ACRONYMS

A - ampere (also amp)
ac - alternating current
ACTH - *a*drenocorticotrophic *h*ormone
AF - Air Force
AMP - *a*denosine *m*onophosphate
ANSI - American National Standards Institute
ATP - *a*denosine *t*riphosphate
bpm - beats per minute
BRH - Bureau of Radiological Health
c - cyclic
C - Centigrade
CL - Current Literature
cm, cm^2 - centimeter, square centimeter
CNS - central nervous system
cps - cycles per second
CR - Current Research
CRT - cathode ray tube
CW - continuous wave
dB - decibel
dc - direct current
DNA - *d*eoxyribo*n*ucleic *a*cid
DOD - Department of Defense
dopa - *d*ihydr*o*xyphenyl*a*lanine
ECG - *e*lectro*c*ardio*g*ram
EEG - *e*lectro*e*ncephalo*g*ram
E-field - electric field strength (V/m)
EHF - extremely high frequency
ELF - extremely low frequency
EM - electromagnetic
EMC - electromagnetic compatibility
EMF - electromagnetic field
EMI - electromagnetic interference
EMP - electromagnetic pulse
EMR - electromagnetic radiation
EPA - Environmental Protection Agency
ERP - effective radiated power
ESF - electrostatic fields
f - frequency
F - Farad
FDA - Food and Drug Administration
FM - frequency modulation
FSH - follicle stimulating hormone
g - gram
GABA - *g*amma-*a*mino*b*utyric *a*cid
GH - growth hormone
GHz - gigahertz
GMP - *g*uanosine *m*onophosphate
Hb - hemoglobin
HEW, DHEW - Dept. of Health, Education and Welfare
HF - high frequency
HFC - high frequency current
Hg - hectogram
hr - hour
Hz - hertz
IEEE - Institute of Electronic and Electrical Engineers
IMPI - International Microwave Power Institute
i.p. - intraperitoneal
ISM - assigned industrial, scientific and medical frequencies
i.v. - intravenous
J - joule
kg - kilogram
kHz - kilohertz
km - kilometer
kV - kilovolt
kW - kilowatt
l - liter
LD - lethal power density
LED - light-emitting diode
LF - low frequency
LH - luteinizing hormone
m, m^2 - meter, square meter
mc - megacycle
MF - medium frequency
mg - milligram
mho - unit of measurement of conductivity
MHz - megahertz
MIC - microwave integrated circuit
min - minute
ml - milliliter
mm - millimeter
mmho - millimho
mR - milliRoentgen
mW - milliwatt
Mw - megawatt
MW - microwave
mV - millivolt
NaCl - sodium chloride
NADH - reduced *n*icotinamide-*a*denine *d*inucleotide
NBS - National Bureau of Standards
NIH - National Institutes of Health
NIR - non-ionizing radiation
nm - nanometer
NMR - nuclear magnetic resonance
NSF - National Science Foundation
NTIS - National Technical Information Service
ONR - Office of Naval Research
P - pulsed
PEMF - pulsed electromagnetic field
PHA - phytohemogglutinin
PHS - Public Health Service
p-p - pulsed power
pps - pulse per second
PRR - pulse repetition rate
R - Roentgen
rad - radiation absorbed dose
RBC - red blood cell
RC - resistance-capacitance
RF - radiofrequency
RMF - rotating magnetic field
rms - root mean square
RNA - *r*ibo*n*ucleic *a*cid
rpm - revolutions per minute
s.c. - subcutaneous
sec - second
SHF - super high frequency
TEM - transverse electromagnetic mode
TSH - thyroid stimulating hormone
UHF - ultra high frequency
USAFSAM - U.S. Air Force School of Aviation Medicine
USDA - U.S. Dept. of Agriculture
UV - ultraviolet
V - volt
VA - Veterans Administration
VLF - very low frequency
W - watt
Wb - unit of measurement of magnetic flux
WBC - white blood cell
WG - waveguide
WHO - World Health Organization

Symbols

ε - dielectric constant
λ - wavelength
μ - micro
σ - specific conductance
Ω - ohm

Biological Effects Electromagnetic Radiation I(3), December 1974

NEWS ITEMS

BIOLOGICAL EFFECTS OF LOW LEVEL RADIO WAVES MAY BE UNDERESTIMATED

A report released by the Office of Telecommunications Policy (OTP), in June of this year, suggests that low intensity microwave radiation over long periods may have greater effects on the nervous system and growth processes than originally thought. Part of a long-term study under the impetus of the Electromagnetic Radiation Management Advisory Council (ERMAC), the report indicates "that effects may occur, in the nervous system and behavior, normal developmental and growth processes, and possibly in some metabolic and biochemical parameters, at lower levels of radio wave radiations than anticipated in the past." The report emphasizes these are preliminary observations not yet scientifically validated. OTP will ask Congress for $15.2 million, a doubling of its 1974 budget, to continue the studies, with emphasis on chronic exposure over extended periods of time. [*Microwaves*, July, 1974, 13(7), p.21]

TWO PERSONAL MICROWAVE MONITORS ARE DEVELOPED

Two small, personal monitors to protect against excessive exposure to microwave energy have been developed. A unit consisting of an antenna, detector, level sensor, keyed oscillator and speaker which may be easily carried in a coat pocket or attached to a belt has been developed by the California Institute for Technology (*NASA Tech Brief*, B74-10097, August 1974). A second monitoring device developed at the University of Newcastle-upon-Tyne in England makes use of the absorption of rf power in germanium films (see CL 0284, page 34, in this issue.) As the radiation is absorbed, the film temperature increases and its resistance changes.

The antenna of the pocket-sized monitor may be a single equiangular spiral or a set of orthogonal slot dipoles. The signal detector is a simple diode in a small package; the level sensor a standard integrated circuit. Potentiometers set the trip level of sensitivity and the level at which the equivalent microwave input would represent a safety hazard. A gated astable multivibrator is a dual-gate integrated circuit, which is wired as an astable multivibrator to furnish the warning tone. The multivibrator is gated on by the output of the level sensor; tone output is amplified and drives a small speaker. Requests for information about this device may be directed to: Technical Utilization Office, NASA Pasadena Office, 4800 Oak Grove Drive, Pasadena, California 91103.

By depositing germanium on a heated glass surface, germanium films 3 μm thick with a conductivity of $1.75 \times 10^3/\Omega/m$ have been obtained for the English exposure monitor. This type of germanium sensor can reliably monitor power levels from 1 mW/cm^2 to 1 W/cm^2. Light-emitting diodes driven by the outputs of a decade counter display the exposure level. The device may be switched on or activated automatically when a danger level is reached. An integrated exposure-level indicator is used to show the accumulated radiation over a week.

NBS AUTOMATES MICROWAVE POWER MEASUREMENT

The National Bureau of Standards, Boulder, Colorado, has announced an automated system which calibrates bolometer units (waveguide and coaxial connector types) in the power level range from 1 to 10 mW. The NBS system employs a commercial automatic network analyzer (ANA), and can calibrate a bolometer unit at any frequency from 2 to 12.4 gigahertz (GHz, one billion cycles per second). Costs for calibration covering 20 frequencies in one of the bands 2-4, 4-8 and 8-12.4 GHz has been reduced from $400 to $35 per frequency point. The device calibrates a precision working-standard bolometer unit as a function of frequency by using a microcalorimeter as its primary standard for microwave power measurements. At each frequency the effective efficiency of the bolometer unit being calibrated is obtained in terms of the effective efficiency of a working-standard bolometer unit. As of now, this data is certified only at fixed frequencies of the manual calibration systems. NBS intends to specify the accuracy of the system at intermediate points soon. For further information contact: E. L. Komarek, Electromagnetics Division, NBS, Boulder, Colo. 80302. [*Dimensions/NBS*, 58(8):184, Aug., 1974]

IMPI REPORTS. . .

The April *International Microwave Power Institute Newsletter* [2(2):3-5] reported the new Canadian regulations for microwave ovens. Briefly, they call for safety features such as indicators for on/off, interlock failure, maximum or minimum power application; lock and key starting when the microwave generating capacity is 25 kilowatts or more; leakage-proof doors; covering that prevents insertion through any portal while power source is in operation; doors that cannot be opened while source is on, and vice versa; and user and service controls that do not produce leakage when on maximum. Visible and permanent labeling is required for manufacturing specifications and standards, as are various warning signs. Regulations and requirements for leakage limits, detection and indication for both microwave and x-ray emissions are set forth; a standard warning sign specified; and life-time adherence to functioning standards required for whole system and replacement components.

In June [2(3):34-36], IMPI drew attention to the Division of Compliance's revised guidelines for reports by microwave oven manufacturers. The reports

are used by the Division for evaluation of the radiation safety of product lines. Copies of the guidelines are available from the Consumer-Industrial Products Branch, Division of Compliance, Bureau of Radiological Health, 5600 Fishers Lane, Rockville, Maryland 20852.

In a final disposition of the Consumers' Union petition to amend the U. S. microwave oven performance standards, the Food and Drug Administration has proposed that two separate warning labels be permanently attached to microwave ovens, viewable during use and servicing. One would warn of door leakage, the other of proper service procedures and precautions.

This issue also announced that the Division of Electronic Product's new high performance microwave power density calibration facility is now operational. The basic components of the system are an anechoic chamber, high-power microwave transmitter and antennae, National Bureau of Standards-calibrated power meter, closed circuit TV with a high-power telephoto lens, and a non-metallic remotely controlled cart for precise positioning of the instrument to be calibrated. Another facility, developed by the Division of Biological Effects, is an environmentally controlled waveguide irradiation facility. The chamber is designed to insure reproducibility of experiments by controlling temperature, relative humidity, and airflow.

IMPI is making its first call for papers for the 10th Annual Microwave Power Symposium to be held at the University of Waterloo, Waterloo, Ontario, Canada, on May 27-30, 1975. Original and review papers are being solicited in non-communication areas of microwave power such as biological effects, medical applications, and equipment safety and interference. Deadline for submission of a 40-word abstract and 500-word summary is January 15, 1975. Abstracts should be sent to: J. R. White, Gerling Moore, Inc., 1054 E. Meadow Circle, Palo Alto, Calif. 94303.

MEETINGS & CONFERENCES

**** SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY USSR ACADEMY OF SCIENCES

Date: January 17-18, 1973
Place: P. N. Lebedev Physics Institute, Moscow
Sponsor: USSR Academy of Sciences

Selected Bibliography of Papers Presented:

INFLUENCE OF MILLIMETER-BAND ELECTROMAGNETIC RADIATION ON BIOLOGICAL OBJECTS. N. D. Devyatkov (no affil.). (See CL 0263)

CERTAIN METHODOLOGICAL PROBLEMS AND RESULTS OF EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF MICROWAVES ON MICROORGANISMS AND ANIMALS. E. B. Bazanova (no affil.), A. K. Bryukhova, R. L. Vilenskaya, E. A. Gel'vich, M. B. Goland, N. S. Landau, V. M. Mel'nikova, N. P. Mikaélyan, G. M. Okhokhonina, L. A. Sevast'yanova, A. Z. Smolyanskaya, and N. N. Sycheva (Gen. Ed.: N. D. Devyatkov). (See CL 0264)

A STUDY OF THE EFFECTS OF MILLIMETER-BAND MICROWAVES ON THE BONE MARROW OF MICE. L. A. Sevast'yanova (no. affil.) and R. L. Vilenskaya. (See CL 0265)

EFFECTS OF MILLIMETER-BAND ELECTROMAGNETIC RADIATION ON THE FUNCTIONAL ACTIVITY OF CERTAIN GENETIC ELEMENTS OF BACTERIAL CELLS. Z. A. Smolyanskaya (no affil.) and R. L. Vilenskaya. (See CL 0266)

EFFECTS OF MILLIMETER-BAND RADIO WAVES ON CERTAIN PROPERTIES OF BACTERIA. V. F. Konrat'eva (no affil.), E. N. Chistyakova, I. R. Shmakova, N. B. Ivanova and A. A. Treskunov. (See CL 0267)

EFFECTS OF MILLIMETER-BAND ELECTROMAGNETIC WAVES ON CERTAIN ASPECTS OF PROTEIN METABOLISM IN BACTERIA. S. E. Manoĭlov (no affil.), E. C. Chistyakova, V. F. Kondrat'eva, and M. A. Strelkova. (See CL 0268)

REACTIONS OF LIVING ORGANISMS TO EXPOSURE TO MILLIMETER-BAND ELECTROMAGNETIC WAVES. N. P. Zalyubovskaya. (See CL 0269)

EFFECTS OF MILLIMETER-BAND ELECTROMAGNETIC WAVES ON THE CELL AND CERTAIN STRUCTURAL ELEMENTS OF THE CELL. R. I. Kiselev (no affil.) and N. P. Zalyubovskaya. (See CL 0270)

OUTLOOK FOR STUDY OF THE MECHANISMS OF THE NONTHERMAL EFFECTS OF MILLIMETER- AND SUBMILLIMETER-BAND ELECTROMAGNETIC RADIATION ON BIOLOGICALLY ALIVE COMPOUNDS. V. I. Gaĭduk (no affil.), Yu. I. Khurgin and V. A. Kudryashova. (See CL 0271)

REMARKS ON TWO POSSIBLE MECHANISMS OF THE EFFECTS OF MICROWAVES ON HEMOGLOBIN. D. S. Chernavskiĭ (no affil.). (See CL 0272)

**** 45th ANNUAL SCIENTIFIC MEETING, AEROSPACE MEDICAL ASSOCIATION

Date: May 6-9, 1974
Place: Washington, D. C.
Sponsor: Aerospace Medical Association
Requests for Information: Dr. M. H. Goodwin, Exec. Vice Pres., Aerospace Medical Assn., Washington National Airport, Washington, D. C. 20001

Selected Bibliography of Papers Presented:

OVERVIEW OF AEROSPACE MEDICAL IMPLICATIONS OF NON-IONIZING RADIATION. J. E. Pickering (Radiobiol. Div., USAFSAM, Brooks AFB, Tex.).

U.S. AND EASTERN STANDARDS FOR EXPOSURE TO ELECTROMAGNETIC RADIATION. P. Tyler (Navy Dept., Washington, D. C.).

INTERACTIONS OF MAN AND ANIMALS WITH RADIO-FREQUENCY FIELDS. J. W. Frazer (Radiobiol. Div., USAFSAM, Brooks AFB, Tex.).

RESULTS OF HUMAN EXPOSURE TO NON-IONIZING RADIATION. D. E. Beischer (Naval Aerospace Med. Res. Lab., Pensacola, Fla.).

OCULAR STATUS OF PERSONNEL OCCUPATIONALLY EXPOSED TO MICROWAVES. B. Appleton (Walter Reed Army Med. Ctr., Washington, D. C.).

SPECIAL PROBLEMS OF GENERAL PUBLIC EXPOSURE TO RF RADIATION. J. C. Mitchell (Radiobiol. Div., USAFSAM, Brooks AFB, Tex.).

METABOLIC AND THERMOREGULATORY RESPONSES TO MICROWAVE RADIATION IN YOUNG MALE RATS. W. M. Houk (Naval Aerospace Med. Res. Lab., Pensacola, Fla.). (See CL 0208)

EXPOSURE OF MAN TO MAGNETIC FIELDS ALTERNATING AT EXTREMELY LOW FREQUENCY. J. D. Grissett (Naval Aerospace Med. Res. Lab., Pensacola, Fla.).

**** 10th ANNUAL MICROWAVE POWER SYMPOSIUM, INTERNATIONAL MICROWAVE POWER INSTITUTE

Date: May 27-30, 1975
Place: University of Waterloo, Waterloo, Ontario, Canada
Sponsor: International Microwave Power Institute
Requests for Information: IMPI, Box 1556, Edmonton, Alberta, Canada.

1974 USNC/URSI–IEEE MEETING

Date: October 14-17, 1974
Place: Boulder, Colorado
Sponsor: The U.S. National Committee (USNC) of the International Union of Radio Science (URSI) in cooperation with the Inst. of Electrical and Electronics Engineers (IEEE).
Requests for Information: R. Y. Dow, Natl. Academy of Science, 2101 Constitution Ave., Washington, D. C. 20418

Selected Bibliography of Papers Presented:

ELECTROMAGNETIC FIELDS IN A HOMOGENEOUS MODEL OF MAN. P. W. Barber (Dept. Electr. Bioeng., Univ. Utah, Salt Lake City). (See CL 0300)

ELECTROMAGNETIC FIELD MEASUREMENTS FOR BIOEFFECTS EXPERIMENTS AND THE CONTROL OF POTENTIAL HAZARDS. R. R. Bowman (Natl. Bur. Stands., Boulder, Colo.). (See CL 301)

MEASUREMENT OF POWER ABSORBED IN THE TISSUES OF MAN AND ANIMALS EXPOSED TO ELECTROMAGNETIC FIELDS. A. W. Guy (Univ. Washington, Seattle). (See CL 0302)

LONG WAVELENGTH ANALYSIS OF PLANEWAVE ELECTROMAGNETIC POWER ABSORPTION OF A PROLATE SPHEROIDAL TISSUE BODY. C. H. Durney (Dept. Electr. Bioeng., Univ. Utah, Salt Lake City), C. C. Johnson and H. Massoudi. (See CL 0322)

**** HEALTH PHYSICS SOCIETY, 8TH MIDYEAR TOPICAL SYMPOSIUM

Date: October 21-24, 1974
Place: Knoxville, Tennessee
Sponsor: Health Physics Society
Requests for Information: J. C. Hart, Route 1, Box 287A, Lenoir City, Tennessee 37771

Selected Bibliography of Papers Presented:

USE OF AN AUTOMATED POPULATION DATA BASE IN POPULATION EXPOSURE CALCULATIONS. T. W. Athey (U.S. Environ. Prot. Agency, Electromagnetic Rad. Anal. Br., 9100 Brookville Rd., Silver Springs, Md.).

BIOMEDICAL EVALUATION OF LOW FREQUENCY (LONG WAVE) ELECTROMAGNETIC RADIATION ASSOCIATED WITH ELECTRIC POWER TRANSMISSION. R. S. Pogrund (Sch. Pub. Hlth., Univ. Illinois, PO Box 6998, Chicago).

CURRENT LITERATURE

0179 VITREO-RETINAL INJURIES DUE TO MICROWAVE RADIATION. *(E.)* Alani, S. (no affil.). *Acta Opthalmol (Kbh)* 51(5):742-743, 1973.

Eye examinations were performed on 15 radar transmitter workers before, and during or immediately after their summer vacations. Before the vacations, 10 of the 15 workers showed scotomas bilaterally in the visual fields and two showed unilateral scotomas. After the vacations, only one worker showed bilateral scotomas and another had a unilateral scotoma. In two patients the slit lamp revealed very fine, whitish, irregular filaments immediately behind the lens, showing arborization with nodes and thickening in a vertical direction. Very fine punctate retinal or chorodial scars, whitish-yellow in color, were seen in the central parts of the fundus in two men, and a third showed a small cystic degeneration in the macular region, simulating a macular hole without affecting visual acuity. None of the workers complained of eye symptoms and all appeared in excellent physical condition. However, eight had a high erythrocyte sedimentation rate, five gave a positive antistreptolysin titer, and eight a positive antistaphylolysin titer. (No references)

0180 RADIO FREQUENCY FIELDS: A NEW ECOLOGICAL FACTOR. *(E.)* Bigu del Blanco, J. (Dept. Anat., Queen's Univ., Kingston, Canada), C. Romero-Sierra and J. A. Tanner. *Proc. IEEE 1973 Electromagnetic Compatibility Symp.*, June 1973, p. 54-59.

The role of radio frequency (RF) fields as a new ecological factor is justified by the well-established interaction of RF radiation with living systems and the continuous increase in the RF radiation background due to the proliferation of RF devices. Experiments on the interaction of RF radiation with biological systems were performed from the audiofrequency region (few Hz to about 20 kHz) to microwave (MW) region (up to 19 GHz). The following phenomena were observed: collapse of birds in moderate MW fields; changes in egg production of chickens in low intensity MW fields; changes in EEG patterns under MW radiation; effects of MW on plant vegetation; demyelination of peripheral nerves in high frequency fields; changes in the diffusion rate of aqueous electrolyte solutions through membranes under MW radiation; effects of MW fields on the rate of flow and mass flux of liquids flowing along small diameter tubes; converse piezoelectric effect in bird feathers in and beyond the audiofrequency region; and characteristics of bird feathers as dielectric aerials in the MW region. In biosystems, some RF effects were very sensitive to radiation threshold (dose rate) whereas other effects were very sensitive to radiation exposure (integral dose). This suggests the possibility of using living systems as RF radiation monitors and integration radiation dosimeters. Results of measuring natural MW emission from living systems indicate the potential capability of MW radiometry in the problem of bio-information transfer. Alternative approaches to RF exposure standards are reviewed. (41 references)

0181 BIOLOGICAL EFFECTS DIVISION: RESULTS OF A MICROWAVE STUDY. *(E.)* Galloway, W. D. (Div. Biol. Effects, Bur. Radiol. Hlth., Rockville, Md.). *IMPI Newsletter* 2(2):31, 1974.

Behavioral effects associated with microwave irradiation were explored. Such effects as a "general irritability syndrome," a decreased sensitivity of sensory systems and interference with learned behavior have been assumed to result from absorption of MW power in the CNS. In testing this assumption, a monkey's head was irradiated to determine if behavioral changes occur in a dose-related fashion. Prior to the irradiation 5 monkeys were trained to perform prescribed tasks. Two behavioral experiments were used to evaluate effects on discriminative performance and acquired learning. In a discriminative performance experiment, the task was to respond to a particular stimulus, a light, and not to respond to another stimulus, a different color light. In a behavior acquisition experiment, the monkey was to determine in what order three levers should be pressed in order to produce a reward. This order was changed each day. Once the tasks had been learned, the monkey was placed in an experimental chamber irradiated with 2450 MHz CW MWs. Two minute exposures were administered at total dose rates of 5, 10, 20 and 25 watts. Following irradiation, which produced either skin burns or convulsions, the monkey's performance of the previously learned task was tested. No behavioral deficits were indicated. (No references)

0182 1969 ANNUAL REPORT TO THE CONGRESS ON THE ADMINISTRATION OF THE RADIATION CONTROL FOR HEALTH AND SAFETY ACT OF 1969 PUBLIC LAW 90-602. *(E.) Bur. Radiol. Hlth. Report* No. OBD 70-3, April 1, 1970, 100 p.

This report covers 1969 DHEW activities in administering the Radiation Control for Health and Safety Act relating to x-rays, ultraviolet, visible light, infrared, microwaves, radiofrequency radiation, laser radiation, infrasonic, sonic, ultrasonic vibrations, and magnetic fields. Subject areas of the report are appraisals of the incidence of biological injury and effects, including genetic effects, of exposure to electronic product radiation; Federal radiation control standards; the degree of observance of such standards; priority problems in administration of the Act; research activities and technological progress achieved during 1969; completed or pending judicial actions; dissemination of technical and consumer-oriented information; and cooperation between Government and industry and other interested parties. Appendix material includes technical reports published by the Bureau of Radiological Health, 1969; short-term courses in radiological health presented in 1969; a log of staff visits to agencies, organizations, and industries; and membership of the Technical Electronic Product Radiation Safety Standards Committee. A report to the Congress on Bureau studies on electronic product radiation control and a list of study reports are included as Attachments. (20 references)

0183 THE EFFECTS OF RADIO-FREQUENCY ENERGY ON Corynebacterium diphtheriae AND Clostridum welchii TOXINS. *(E.)* Schmidt, P. (U.S. Army Med. Res. Lab., Fort Knox, Ky.). *US Army Med. Res. Lab. Report* No. 603, March 31, 1964, 24p.

Changes in toxicity and antigenicity of exotoxins after exposure to continuous microwave irradiation at 158 megacycles/sec were investigated. *Clostridum welchii* toxin (type A) was not affected by radiofrequency exposure, as determined by human serum opacity studies and i.v. lethality studies on Swiss mice. A guinea pig skin-reaction assay indicated a slight reduction in the toxicity of *Corynebacterium diptheriae* toxin, rather than the 10-fold decrease in skin toxicity observed by other workers. A small decrease in toxicity of *C. diphtheriae* was also suggested by assays involving intracerebral inoculation of Swiss mice and i.p. inoculation of chicks. No change in antitoxin combining capacity or antigenicity was demonstrated by flocculation tests, nor were any gross qualitative changes in antigenic character detected by immunodiffusion. The efficacy of the available assay procedures is questioned. (24 references)

0184 MICROWAVE POWER DENSITY MEASUREMENTS IN THE PRESENCE OF BIOLOGICAL SPECIMENS OF SIZE COMPARABLE TO THE FREE-SPACE WAVELENGTH OF THE IMPOSED RADIATION. *(E.)* Bigu del Blanco, J. (Dept. Anat., Queen's U., Kingston, Canada) and C. Romero-Sierra. *Control Systems Lab. Report, Ottawa, Canada* LTR-CS-128, NRC, May 1974, 34 p.

To emphasize the limited validity of free-space power density as a biological and behavioral exponent of microwave (MW) radiation effects, power density measurements at X-band frequencies were conducted in the absence and presence of biological specimens (animals and plant vegetation). Color thermography (infrared scanning) partly permitted evaluation of energy deposition in living tissue. In all cases diffraction and scattering of the electromagnetic wave took place in the presence of a specimen. These effects, together with the presence of a movable platform in the anechoic chamber and of the MW probe, resulted in multipath field formation and therefore in unpredictable hot and cold spots and in the irregular power density contour lines observed. The data show that direct measurement is the only reasonable way to obtain information on power density levels in the presence of biosystems. MW dosimetry should consider (1) more realistic electromagnetic field/biosystem configurations; (2) the magnetic field associated with the microwave field; (3) measurement of electric and magnetic field vectors; (4) the potential capability of noninvasiye techniques such as MW radiometry; and (5) improved tissue implantation dosimetry techniques. (17 references)

0185 RF RESPONSE OF RADIATION SURVEY INSTRUMENTS. *(E.)* Bradley, F. J. (New York State Dept. Labor, Div. Ind. Hyg., New York, N.Y.) and A. H. Jones. *Electronic Product Radiation and the Health Physicist*, NTIS: PB-197 772. Oct. 1970, p. 173-181.

A survey of the radiofrequency (RF) response of radiation survey meters indicated that the following instruments and frequencies should be used with caution around RF equipment because of a steady response mimicking ionization radiation: end-type GM type Model 2650, 100 and 400 MHz; "Juno" ionization type, 200, 300, 400, and 600 MHz. In a TV repair shop survey, a scintillation type survey meter was used to locate sources of ionizing radiation around TV sets and an RF shielded ionizing type detector to obtain readings in mR/hr. Of 108 color sets checked, 1.9% or two sets were leaking radiation above 0.5 mR/hr; 2.8% were leaking some radiation but below the acceptable standard; and 95.3% were at background. (1 reference)

0186 MICROWAVE OVEN REPAIR: HAZARD EVALUATION. *(E.)* Eden, W. M. (Florida Dept. Hlth. Rehabil. Services, Jacksonville). *Electronic Product Radiation and the Health Physicist*, NTIS: PB-195 772. Oct. 1970, p. 159-172.

Persons attempting to repair microwave ovens are subject to acute damage from sudden, high levels of exposure. Power density measurements around microwave ovens, with outer cabinet panels removed, indicated potential exposures in excess of currently accepted radiation protection guides for radiofrequency (e.g., 1-10 mW/cm^2 for incidental or occasional exposures). Repairs are attempted by microwave oven owners, radar technicians, electronics servicers, electrical appliance repairmen, restaurant equipment suppliers' service personnel, and food vending firms. Only a few manufacturers are represented by authorized repair firms. Corrective measurements should include adequate training regarding microwave hazards, utilization of microwave detection equipment, protective clothing, and eye protection. Personnel monitoring for radiofrequency and periodic eye examinations for microwave oven repairmen would provide indications of exposure levels. Shielding and warning labels for microwave tubes would provide further hazard reduction. (14 references)

0187 THE DIPOLE/SLOT RADIATION PATTERN AND ITS USE IN UNDERSTANDING MICROWAVE LEAKAGE AND SURVEY TECHNIQUES. *(E.)* Coats, G. I. (Northeastern Radiol. Hlth. Lab., Winchester, Mass.), C. B. Nelson and R. G. Underwood. *Electronic Product Radiation and the Health Physicist* NTIS: PB-195 772, Oct. 1970, p. 141-158.

The theory of the dipole/slot radiation pattern is examined and its application to MW monitoring instruments and techniques is discussed. Comparison is made with ionizing radiation since the same survey techniques are applicable to both types of radiation. The major differences are that MW radiation is coherent and measurements are complicated by resonance,

interferences, and elastic reflections. To estimate the biological hazard of thermal heating of tissues by MWs on the order of 2450 MHz, the most suitable quantity to measure is power density, which, like the rate of heat development, is proportional to the square of the electric field. A crossed dipole survey meter, designed for MW oven measurements and calibrated for 2450 MHz or 915 MHz, reads power density directly and with multiple probes provides a range from 0.01-200 mW/cm^2. A spherical bolometer with adjustable impedance might provide the basis for development of a detector electrically similar to human tissue of interest; i.e., the lens of the eye. The meter is independent of polarization and frequency from 400 MHz to 40 GHz. (8 references)

0188 EFFECTS OF EXPOSURE TO MICROWAVES: PROBLEMS AND PERSPECTIVES. *(E.)* Michaelson, S. M. (Sch. Med. Dent., Univ. Rochester, N.Y.). *Env. Hlth. Perspectives* 8:133-156, 1974.

Available literature on the biological effects of microwave exposure is categorized according to biophysical principles (absorption, reflection, scattering, heat sources, and molecular and cellular biology); biomedical manifestations in experimental animals; and clinical response of man. Data are presented on microwave bioeffects on the eyes, reproductive organs, and central nervous system. Extensive experimental and clinical investigations are required to determine the presence of these reported effects in man. Despite numerous investigations, there is no conclusive evidence of subtle, long-term, or cumulative effects of microwave exposure. Good laboratories with proper microwave sources, exposure and dosimetry facilities, and animal facilites are needed to assess microwave hazards. An interdisciplinary approach involving physical and biophysical scientists is another imperative. Discrepancies between U.S. and Eastern European microwave exposure standards are noted and attributed to differences in instrumentation and philosophy. (143 references)

0189 A COMPARISON OF MICROWAVE DETECTION INSTRUMENTS. *(E.)* Moore, R. L. (Bur. Radiol. Hlth., Rockville, Md.), S. W. Smith, R. L. Cloke, and D. G. Brown. *Electronic Product Radiation and the Health Physicist* NTIS: PB-195 772, Oct. 1970, p. 423-430.

Commercial MW detection instruments utilizing thermocouple sensing elements, thermistors set in a bridge circuit, and a helix antenna with a diode detector circuit were compared at 2450 MHz using a plane EM wave. The comparison covered sensitivity, readable range, ease of measurement, reliability and repairability, and stability. Test results show that the thermocouple device is best suited to measure leakage close to a slot source such as a MW oven at a frequency of 2450 MHz. (5 references)

0190 CENTRAL NERVOUS SYSTEM EFFECTS AS MEASURED BY REACTION TIME IN SQUIRREL MONKEYS EXPOSED FOR SHORT PERIODS TO EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS. *(E.)* Grissett, J. D. (Naval Aerospace Med. Res. Lab., Pensacola, Fla.) and J. de Lorge. *Naval Aerospace Med. Res. Lab. Report* No. 1137, Aug. 1971, 13p.

Possible acute instantaneous CNS effects of exposure to extremely low frequency EM radiation were investigated by reaction-time measurements taken on three squirrel monkeys for 37 daily sessions. No significant changes in these measurements were observed between control sessions and sessions in which the animals were exposed to 3 gauss at 45 Hz or to a field of 3 gauss at 7 Hz. Two other indexes of performance, reinforcement ratio and efficiency ratio, were also unchanged. The small number of subjects does not permit a firm conclusion; however, the evidence indicates that the magnetic field does not produce a CNS response measurable by the techniques employed. (7 references)

0191 RADIATION INCIDENTS REGISTRY REPORT 1970. *(E.)* Mills, L. F. (Bur. Radiol. Hlth., Rockville, Md.) and P. Segal. *Natl. Tech. Inf. Service*, U. S. Dept. Commerce, PB 198078, December 1970, 56p.

The Radiation Incidents Registry, established by the Bureau of Radiological Health, has after 1 yr of operation provided data on 209 reported incidents resulting from exposure to ionizing and non-ionizing radiation and ultrasonic waves. These incidents include potential and overt biological injuries to 276 persons. Of the persons included in the Registry, 59% were exposed to ionizing radiation and 41% to non-ionizing radiation. Approximately 210 persons were reportedly exposed to electronic project radiation prior to October 18, 1968, while 66 have been reportedly exposed since that date. Of the persons for whom age data were available, 57 were between the ages of 16 and 30, 55 between the ages of 31 and 40, and 36 over age 45. There were 200 males, 31 females, and 45 whose sex was not reported. Individuals were exposed in the following decreasing order by occupation: technicians in the fields of engineering, physical science, and miscellaneous professional services; persons employed in electrical equipment industries; hospital personnel; and students performing experimental work in educational institutions. Eye injury, skin damage, and various blood disorders were the most frequently reported effects due to electronic product radiation. Exposure to ultraviolet equipment used in laboratories and to ultraviolet radiation produced by arc welding equipment accounted for the majority of cases (26%) involving non-ionizing radiation. Another 10% of reported incidents were due to microwave-generating equipment and microwave radiation from ovens, radar, and one diathermy unit. (25 references)

0192 THE EFFECTS OF FM AND TV BROADCAST STATIONS UPON CARDIAC PACEMAKERS. *(E.)* Vreeland, R. W. (Dept. Med. Surg., Univ. California, San Francisco), M. D. Shepherd and J. C. Hutchinson. *Proc. IEEE 1974 Electromagnetic Compatibility Symp.*, July 16-18, 1974, p. 1-8.

To predict the possible effects of a new transmitting tower on pacemaker performance at a medical center, *in vitro* pacemaker performance tests were conducted in the vicinity of local FM and TV transmitters. Three external demand pacemakers stopped in an area where the maximum average field intensity was 0.63 V/m. The other pacemakers (three external demand, two implantable, and one fixed rate) functioned normally in an area where the highest measured field intensity was 1 V/m. Only the old fixed rate functioned normally under all test conditions in an area where the highest measured field intensity was 2.8 V/m. The data indicate that the critical worst-case thresholds for pacemakers are between 1 and 2.8 V/m. A tentative standard requires that the maximum field intensity within the medical center's hospital not exceed 1 V/m as measured with an average reading detector or 1.5 V/m as measured with a peak reading detector of 0.54 sec time constant. (21 references)

0193 MICROWAVE HAZARDS SURVEILLANCE AND CONTROL. *(E.)* Thompson, R. L. (Environ. Hlth., Cape Kennedy Air Force Station, Fla.). *Electronic Product Radiation and the Health Physicist*, NTIS: PB-195 772. Oct. 1970, p. 463-464.

Of 200 Air Force radar workers included in a 6-yr eye examination program, 18.5% showed the first indication of microwave eye damage. Early eye damage, determined by slit-lamp examination, usually resulted in localized opacification of the posterior portion of the lens capsule. It sometimes had a honeycomb appearance. Annual reexamination of exposed workers has identified only one case of incipient cataracts. Ophthalmological examinations appear to provide a suitable method for determining early indications of microwave exposure. (1 reference)

0194 EFFECT OF LOW LEVEL-LOW INTENSITY ELECTRIC FIELDS ON EEG AND BEHAVIOR IN Macaca nemestrina. *(E.)* Gavalas, R. J. (Brain Res. Inst., Univ. California, Los Angeles), D. O. Walter, J. Hamer, and W. R. Adey. *Brain Res.* 18:491-501, 1970.

The effects of low-level, low-frequency electric fields on the behavior and EEG of monkeys were studied. Three monkeys were implanted with subcortical and cortical EEG electrodes and trained to press a panel on a fixed interval-limited hold schedule. The monkeys were rewarded for pressing the panel once every 5 sec within the 2.5-sec period during which it was possible. After the animals were performing well, they were tested under low-level electric fields (2.8 V p-p); the voltage was applied to two large metal plates 40 cm apart so that the monkey's head was completely within the field. Field frequencies were set at 5 or 10 c/sec within the range of typical EEG recording (0-33 c/sec). Four-hr daily tests of fields-on were randomly interspersed with 4-hr runs with fields-off. Under the 7 c/sec fields, the monkeys showed a significantly faster interresponse time in five of six experiments. Mean differences between fields-on and fields-off were 0.4 sec or greater. The 10 c/sec fields did not produce a reliable effect on behavior. Analysis of EEG data showed a relative peak in power at field frequencies for the hippocampus in all three monkeys. Similar peaks were seen less consistently in the amygdala and the center median. (19 references)

0195 EQUIPMENT SURVEYS FOR RF RADIATION HAZARDS. *(E.)* Lamaster, F. S. (Grnd. Electon. Eng. Instl. Agency, Griffis AFB, Rome, N.Y.). *Electronic Product Radiation and the Health Physicist* NTIS: PB-195 772, Oct. 1970, p. 420-422.

Equipment surveys for RF hazards are a regular part of the USAF Radiation Hazards Prevention Program. The surveys include a preplanning phase in which hazards are located or identified by a prediction process. Measurement personnel check areas of high side or bottom lobe radiation, reflection areas, and the RF blanking in radar and other equipment with scanning antennas. Other key areas of concern are the accuracy of existing radiation drawings; the site standard operation procedure file; and the radiation warning sign development. Investigation in these areas may result in the need for additional measurements and recommendations for changed procedures regarding site hazard control. (2 references)

0196 A REVIEW OF INTERNATIONAL MICROWAVE EXPOSURE GUIDES. *(E.)* Swanson, J. R. (Int. Labor Off., Occup. Safety Hlth. Branch, Geneva, Switzerland), V. E. Rose, and C. H. Powell. *Electronic Product Radiation and the Health Physicist* NTIS: PB-195 772, Oct. 1970, p. 95-110.

A review of MW exposure criteria used in the United States and other western countries in the past 10 yrs indicates a general acceptance of the power density exposure level of 10 mW/cm^2. The USSR and Poland specify permissible levels one thousand times lower at 10 $\mu W/cm^2$, while Czechoslovakia has a proposed sliding scale allowing 25 $\mu W/cm^2$ for an average working day exposure. In general, these differences arise from the acceptance of data showing nonthermal functional changes from MW radiation exposure of animals and humans. The first standards developed in the United States considered the 10 mW/cm^2 value to be a maximum permissible levels which should not be exceeded. These standards considered only the power density level. The two latest exposure criteria developed in the United States incorporate exposure time and permit exposures to power densities in excess of 10 mW/cm^2 for a limited duration. This concept has been accepted by France for military guidelines. Czechoslovakia has also accepted this newer concept by proposing a sliding scale of allowable radiation intensity while retaining a much lower allowable daily exposure level as the starting point. In applying the concept of