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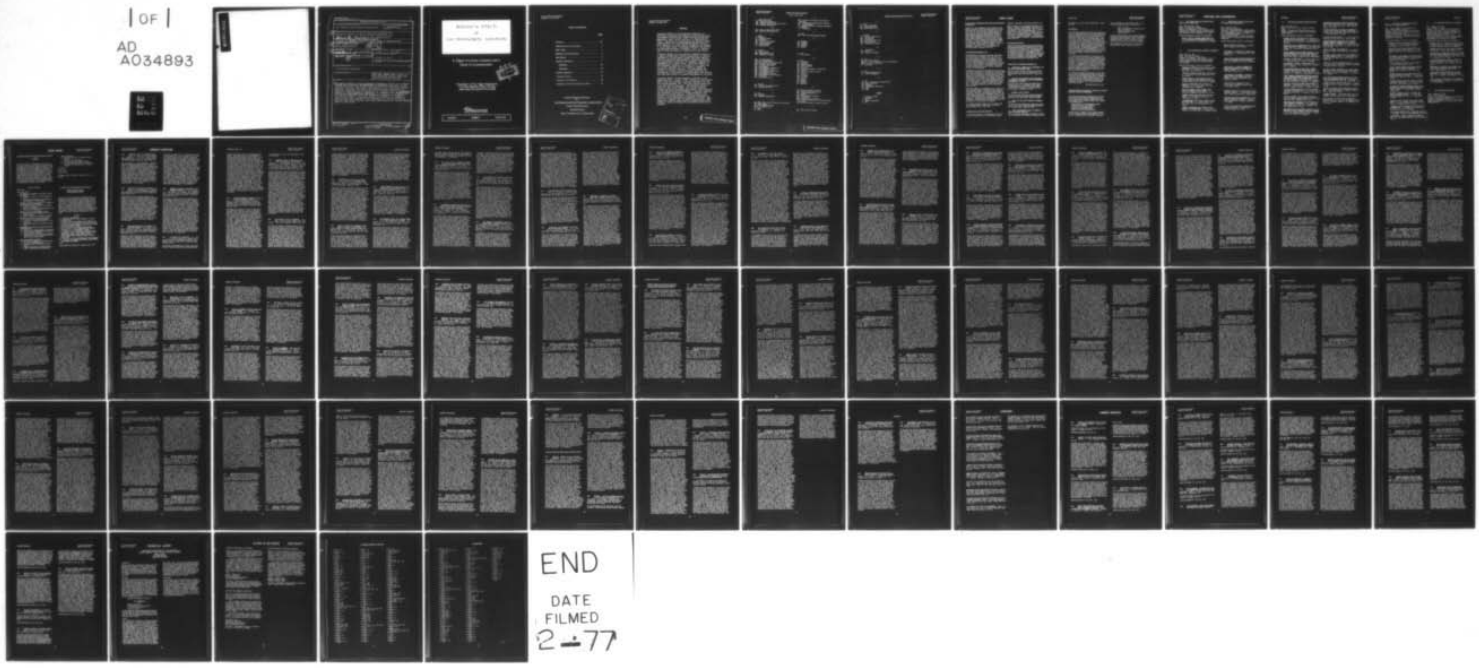

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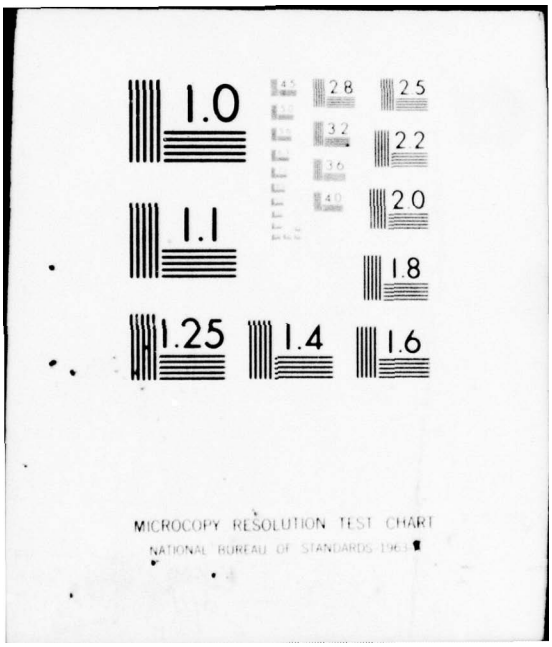
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13. ABSTRACT

Biological Effects of Electromagnetic Radiation serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of non-ionizing 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 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 ELECTROMAGNETIC RADIATION

A Digest of Current Literature and a Forum of Communication

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THE FRANKLIN INSTITUTE
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VOLUME II NUMBER 1 MARCH 1975

Biological Effects Electromagnetic Radiation II(1), March 1975

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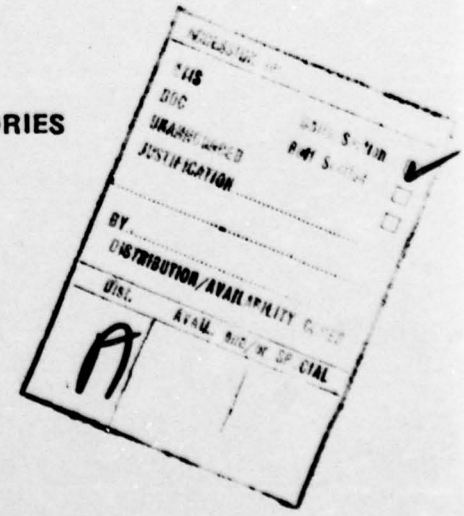
Literature Selected and Abstracted
by

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

Science Information Services

Biomedical Section

Bruce H. Kleinstein, Ph.D., Technical Editor



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

(used in this issue)

- A -

A - ampere (also amp)
ac - alternating current
AMP - adenosine monophosphate
ANSI - American National Standards Institute
ATP - adenosine triphosphate

- B -

BRH - Bureau of Radiological Health
BSI - British Standards Institute

- C -

c - cyclic
C - Centigrade
CL - Current Literature
cm - centimeter
CNS - central nervous system
cps - cycles per second
CR - Current Research
CW - continuous wave

- D -

dB - decibel
dc - direct current
DNA - deoxyribonucleic acid
DOD - Department of Defense

- E -

ECG - electrocardiogram
EEG - electroencephalogram
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
ES - electrostatic
ESF - electrostatic field

- F -

f - frequency
FDA - Food and Drug Administration
FM - frequency modulation

- G -

g - gram
GHz - gigahertz
GMP - guanosine monophosphate

- H -

HEW, DHEW - Dept. of Health, Education and Welfare
HF - high frequency
HFC - high frequency current
H-field - magnetic field
hr - hour
Hz - hertz

- I -

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 -

J - joule
JPRS - Joint Publication Research Service

- K -

kg - kilogram
kHz - kilohertz
km - kilometer
kV - kilovolt
kW - kilowatt

- L -

l - liter
LF - low frequency

- M -

m - meter
mA - milliampere
mc - megacycle
mEq - milliequivalent
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
mon - month
mW - milliwatt
Mw - megawatt
MW - microwave
mV - millivolt

- N -

NBS - National Bureau of Standards
NIH - National Institutes of Health
NIR - nonionizing radiation
nm - nanometer
NMR - nuclear magnetic resonance
nsec - nanosecond
NSF - National Science Foundation
NIOSH - National Institute for Occupational Health and Safety
NTIS - National Technical Information Service

- O -

ONR - Office of Naval Research

ABBREVIATIONS AND ACRONYMS (continued)

- P -

P - pulsed
PFD - power flux density
PHA - phytohemogglutinin
PHS - Public Health Service

- R -

r - Roentgen
rad - radiation absorbed dose
RBC - red blood cell
RF - radiofrequency
RMF - rotating magnetic field
RNA - ribonucleic acid
rpm - revolutions per minute

- S -

s.c. - subcutaneous
sec - second
SHF - super high frequency

- U -

U - units
UHF - ultra high frequency
USAFSAM - U.S. Air Force School of Aviation Medicine
USDA - U.S. Dep. of Agriculture
UV - ultraviolet

- V -

V - volt
VA - Veterans Administration
VLF - very low frequency

- W -

W - watt
Wb - unit of measurement of magnetic flux
WBC - white blood cell
WG - waveguide
WHO - World Health Organization
wt - weight
wk - week

Symbols

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

NEWS ITEMS

INTERNATIONAL SYMPOSIUM ON BIOLOGIC EFFECTS, WARSAW, POLAND, 1973

Abstracts of the Proceedings of the International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, which was held in Warsaw, Poland, October 15-18, 1973, are included in the Current Literature section of this issue of *Biological Effects of Electromagnetic Radiation Digest* (CL 0404 through CL 0450). The proceedings were published last year by Polish Medical Publishers, and the full-text articles from the book have been used for the abstracts presented here. Dr. Sol M. Michaelson's contribution "Thermal Effects of Single and Repeated Exposures to Microwaves--A Review," was included in Volume I, issue 2, of the *Digest*, as CL 0087, and is not repeated. Dr. Michaelson's evaluation of the symposium has been included instead, and appears as CL 0451.

EMC SYMPOSIUM, MONTREUX, 1975

The EMC Symposium being held in Montreux, Switzerland, May 20-22, 1975, is considered to be the "first" of its kind in Europe. The aim of the event is to promote interdisciplinary contacts and exchange of information on problems which may be described as "protection of the EM environment." The conference will treat problems of the interaction of EM energy with electronic and biological systems, the immunity of electronic systems to interference, as well as their compatibility with the EM environment.

The Symposium is held under the auspices of the Director-General of the Swiss PTT. Cosponsors are the URSI, IEEE, SAE, CISPR, the Association of Polish Electrical Engineers, and the Convention of the Societies of Electrical Engineers of Western Europe. The keynote address, opening day, May 20, by Professor R. M. Showers, University of Pennsylvania, is entitled "Electromagnetic Compatibility Comes of Age." The 36 papers presented that day will include those in a session on "EMC and the Hospital." On Thursday, the 22nd, 44 papers will be delivered. Among the sessions is one on the "Biological Aspects of EMC."

The largest number of contributions on all topics comes from the United States, followed by Poland, Germany, Switzerland and England. Papers were also contributed from Japan, Australia, India, USSR, Czechoslovakia, the Scandinavian countries, the Netherlands, Austria, Italy, France, Bulgaria and Canada. The full text of the 118 papers and 15 summaries will be made available in a 550-page report, *Electromagnetic Compatibility 1975*. Papers presented on biological effects of EM radiation will be abstracted in a later issue of the *Digest*.

For further information contact: Mr. T. Dvorak, ETH-HF, Sternwartstrasse 7, 8006 Zurich, Switzerland. Phone (Zurich) 32 62 11, Ext. 2790.

MICROWAVE OVEN LEAKAGE DETECTOR

A device that provides a fast measurement of EM leakage fields from MW ovens is now available from REL Equipment & Components, Croft House, Bancroft, U.K.

Known as Apollo XI, the hand-held RF monitor is designed to indicate the recommended safe limits of RF radiation specified by HEW and BSI. The unit monitors the 2425 to 2475 MHz frequency band. It is calibrated with a direct reading scale from 0 to 10 mW/cm^2, with a cardinal point at 5 mW/cm^2 indicating the exposure and emission standards. Accuracy is said to be ± 1 dB for planewaves of all polarization. A 9 V battery powers the monitor. *Electrical Review*, 196(6):203, 1975.

JOINT RESEARCH EFFORT

Recently, 24 monkey phantoms and one human phantom were transported under the supervision of Dr. Curtis Johnson from the University of Utah, Salt Lake City, to Brooks Air Force Base, Texas. The phantoms will be evaluated in the School of Aerospace Medicine's EM irradiation chambers. The preliminary tests, also in collaboration with Dr. Arthur Guy and associates, University of Washington, were conducted in preparation for more extensive tests during April. *Utah Bioengineering Newsletter*, March-April, 1975.

ITEMS FROM THE COMMERCE BUSINESS DAILY

- COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY POWER.

The R&D Contracts Division, Brooks Air Force Base, Texas, has contracted with the University of Utah, Salt Lake City, for the above study. (January 22, 1975)

- ANALYZING AND PREPARING THE AVAILABLE WORLD LITERATURE ON THE BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION.

Negotiations are being conducted between the Contracting Branch, U. S. Army Medical R&D Command, and Mead Technology Laboratories, Dayton, Ohio. (See CR 0103, this issue, for a brief description of the project.) (February 12, 1975)

- MICROWAVE EFFECTS STUDIES.

The Office of Naval Research, Arlington, Virginia, has contracted with the University of Washington, Seattle, for the above study. (March 28, 1975)

- EFFECTS OF HIGH LEVEL EXPOSURE TO MICROWAVE RADIATION.

The Food and Drug Administration proposes to negotiate a contract with the American Health Foundation for the above study. (March 31, 1975)

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

The Food and Drug Administration proposes to negotiate a continuation and expansion of ongoing work with

Randomline, Inc., Willow Grove, Pennsylvania. (March 31, 1975)

IMPI REPORTS...

The World Health Organization (WHO) has designated the Bureau of Radiological Health as the WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation, for the next three years. The Center is to assist WHO in estimating present levels and trends of human exposure from nonionizing radiation; promoting the establishment of instrumentation calibration and reference services in various countries; establishing internationally acceptable nomenclature, definitions, and dosimetry methods; training public health personnel; establishing nonionizing radiation control programs; and stimulating research. It is expected that the Bureau's new assignment will greatly aid in the exchange of scientific information on radiation biology between the United States and other countries.

At a public meeting in December, in Rockville, Maryland, the need for a MW oven standards amendment was debated. It was proposed that the standard be amended to prevent the sale of ovens in which the concealed interlock is clearly visible and readily susceptible to defeat. The amendment also would clarify the test criteria for assuring that the insertion of an object into the oven while the door is closed does not cause microwave leakage in excess of the limit set. The Bureau of Standards will announce its decision soon after the first of the year.

An information exchange program related to the regulation of radiation-producing electronic products was formalized last week between FDA's Bureau of Radiological Health and the Canadian Department of National Health and Welfare's Health Protection Branch. The program will provide a mechanism for communicating information and experience in conducting national compliance programs.

IMPI Newsletter 3(1), 1975

USNC/URSI SERIES ON BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION ANNOUNCED

The United States National Committee of the International Union of Radio Science (USNC/URSI) has announced that its 1975 meeting, October 20-23, 1975, at the University of Colorado, Boulder, will include the following topics:

General Effects of Electromagnetic Fields
Behavioral, Neural and CNS Effects
Cellular and Biochemical Effects
Quantification and Measurements
Medical and Biological Applications

Sessions will be organized by the Program Committee for the Bio-Effects Series, which includes: A. W. Guy, C. C. Johnson and S. W. Rosenthal. The deadline for abstracts in this Series is July 1. Abstracts and inquiries should be directed to:

Prof. A. W. Guy
Dept. of Rehabilitation Medicine, RJ-30
University Hospital
Seattle, Washington 98105
(206) 543-1071

A call for papers, which includes detailed abstract information, has been mailed. Talks are limited to 20 minutes; abstracts should be 200 to 245 words, submitted with two copies. An abstract form is included in the back of this issue of the *Digest*.

Papers presented in this Series will appear in a special issue of *Radio Science*, early in 1976.

MEETINGS AND CONFERENCES

****** 46TH ANNUAL SCIENTIFIC MEETING, AEROSPACE MEDICAL ASSOCIATION**

Date: April 28 - May 1, 1975
Place: San Francisco, California
Sponsor: Aerospace Medical Association
Requests for Information: Dr. M. H. Goodwin, Exec. Vice President, Aerospace Medical Association, Washington National Airport, Washington, D. C. 20001

Selected Bibliography of Papers to be Presented:

MEDICAL SURVEY OF PERSONNEL OCCUPATIONALLY EXPOSED TO NONIONIZING ELECTROMAGNETIC RADIATION. W. C. Milrow (Naval Surf. Weapons Cent., Dahlgren, Va.)

****** 1975 INTERNATIONAL MICROWAVE SYMPOSIUM**

Date: May 12-14, 1975
Place: Palo Alto, California
Sponsor: San Francisco Chapter MTT-S
Requests for Information: 1975 IEEE G-MTT International Microwave Symposium, Rickeys Hyatt House, 4219 El Camino Real, Palo Alto, California 94306, (415) 493-8000

Selected Bibliography of Papers to be Presented:

RESONANT ELECTROMAGNETIC POWER DEPOSITION IN MAN AND ANIMALS. O. P. Gandhi (Electr. Eng. Dep., Univ. Utah, Salt Lake City).

NONINVASIVE MICROWAVE MEASUREMENT OF RESPIRATION. J. C. Lin (Electr. Eng. Dep., Wayne Univ., Detroit, Mich.).

COMPLEX PERMITTIVITY AND PENETRATION DEPTH OF CERTAIN BIOLOGICAL TISSUE BETWEEN 40 AND 90 GHz J. Edrich (Univ. Denver, Colo.) and P. C. Hardee.

DIELECTRIC MEASUREMENTS FOR THE DESIGN OF A PHANTOM EYE. M. R. Foster (Mass. Inst. Tech., Cambridge) and W. B. Westphal.

EFFECT OF MICROWAVE FIELDS ON RABBIT VAGUS NERVES AND SUPERIOR CERVICAL GANGLIA. C. K. Chou (Univ. Washington, Seattle) and A. W. Guy.

MICROWAVE IRRADIATION DESIGN USING DIELECTRIC LENSES. H. S. Ho (HEW, Rockville, Md.), G. J. Hagan, and M. R. Foster.

A NONPERTURBING LIQUID CRYSTAL FIBEROPTIC MICROWAVE POWER PROBE. O. P. Gandhi (Electr. Eng. Dep., Univ. Utah, Salt Lake City) and T. C. Rozzell.

FIBEROPTIC MICROPROBES FOR MICROWAVE ELECTROMAGNETIC FIELDS MEASUREMENT. A. Deficis (Lab. du D.E.R.M.O., O.N.E.R.A.-C.E.R.T., Toulouse, France).

****** SYMPOSIUM & TECHNICAL EXHIBITION ON ELECTROMAGNETIC COMPATIBILITY**

Date: May 20-22, 1975
Place: Montreux, Switzerland
Cosponsors: International Union of Radio Science, Prof. Group on EMC of the Inst. of Electrical and Electronic Engineers, Comm. AE-4 on EMC of the Soc. of Automotive Engineers.
Requests for Information: T. Dvorak, Secretary General, ETH-HF, 7 Sternwartstrasse, 8006 Zurich, Switzerland.

Selected Bibliography of Papers to be Presented:

SOME EMC PROBLEMS IN HOSPITALS. A. Kirkeby (Birch & Krogboe, Virum, Denmark).

ELECTROMAGNETIC ENVIRONMENTS IN MAJOR MEDICAL FACILITIES. J. C. Toler (Georgia Inst. Tech., Atlanta, Ga.).

A COST EFFECTIVE METHOD FOR ASSESSING ELECTROMAGNETIC PERFORMANCE OF DEMAND PACEMAKERS. J. J. Crenca (Atlantic Res. Corp., Alexandria, Va.).

ENERGY DENSITY: A PROPOSED PARAMETER FOR ASSESSING ELECTROMAGNETIC PERFORMANCE OF DEMAND PACEMAKERS. J. C. Toler (Georgia Inst. Tech., Atlanta, Ga.).

ELECTROMAGNETIC ENVIRONMENT TO PACEMAKERS IN TERMS OF MODULATION FREQUENCY AND FIELD STRENGTH. R. Schlentz (Medtronics Corp., Minneapolis, Minn.).

QUANTIFICATION OF HAZARDOUS RF FIELDS. H. Korniewicz (Centralny Instytut Ochrony Pracy, Warsaw, Poland).

MICROWAVE POLLUTION OF THE ENVIRONMENT AND THE ECOLOGICAL PROBLEM. J. Bigu del Blanco (Queen's Univ., Kingston, Canada) and C. Romero-Sierra.

MICROWAVE POWER DENSITY MEASUREMENT IN THE PRESENCE OF BIOLOGICAL SPECIMENS. J. Bigu del Blanco (Queen's Univ., Kingston, Canada) and J. A. Tanner.

EFFECTS OF PULSE MODULATED MICROWAVE ENERGY ON ISOLATED FROG HEART. R. Chapman (Univ. Illinois, Urbana) and C. Cain.

•••• 10TH ANNUAL MICROWAVE POWER SYMPOSIUM

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

Selected Bibliography of Papers to be Presented:

MICROWAVE HEATING OF MALIGNANT MOUSE TUMORS AND TISSUE EQUIVALENT PHANTOM SYSTEMS. J. E. Robinson (Univ Maryland Sch. Med., Baltimore), D. McCulloch and E. A Edelsack.

ENERGY DEPOSITION IN HOMOGENEOUS AND MULTILAYER TISSUE SPHERES AND EFFECT OF CIRCULATION. H. P. Schwan (Dep. Bioeng., Univ. Pennsylvania, Philadelphia) and H. N. Kritikos.

COLOUR THERMOGRAPHY AND MICROWAVE RADIOMETRY: THEIR APPLICATION TO BIOLOGICAL SYSTEMS UNDER MICROWAVE RADIATION EXPOSURE. J. Bigu del Blanco (Anat. Dep., Queen's Univ. Kingston, Ontario) and C. Romero-Sierra.

MICROWAVES IN TUMOR THERAPY. F. Dietzel (Cent. Radiol., Justus Liebig Univ., Giessen, W. Germany).

ELECTROMAGNETIC THAWING OF FROZEN GRANULOCYTES. C. P. Burns (Georgia Inst. Tech., Atlanta) E. C. Burdette and V. P. Popovic.

FAST FIXATION OF BRAIN IN VIVO BY HIGH INTENSITY MICROWAVE IRRADIATION FOR NEUROCHEMICAL STUDIES. S. H. Butcher (Dep. Pharmacol., Univ. California, Los Angeles), L. L. Butcher, M. S. Harms and D. J. Jenden.

A NEW TECHNIQUE FOR MEASURING POWER DEPOSITION PATTERNS IN PHANTOMS EXPOSED TO EM FIELDS OF ARBITRARY POLARIZATION--EXAMPLE, THE MICROWAVE OVEN. A. W. Guy (Bioelectromagnetics Res. Lab., Univ. Washington Sch. Med., Seattle), M. D. Webb and J. A. McDougall.

BIOLOGICAL ALTERATIONS OBSERVED UNDER MICROWAVE IRRADIATION. A. Deficis (Lab. D.E.R.M.O., O.N.E.R.A.-C.E.R.T., Toulouse, France), J. S. Dumas, S. Laurens.

LOW LEVEL MICROWAVE EFFECTS ON THE TOTAL IRON BINDING CAPACITY OF PREGNANT RATS. W. D. Travers (Dep. Bi nucleonics, Purdue Univ., W. Lafayette, Ind.) and R. J Vetter.

EFFECT OF MICROWAVE FIELDS ON MUSCLE CONTRACTION. C-K. Chou (Bioelectromagnetics Res. Lab., Univ. Washington Sch. Med., Seattle) and A. W. Guy.

CONDITIONED TASTE AVERSIONS IN THE RAT INDUCED BY A SINGLE EXPOSURE TO MICROWAVES. R. H. Lovely (Bioelectromagnetics Res. Lab., Univ. Washington Sch. Med., Seattle) and A. W. Guy.

NEUROENDOCRINE AND CARDIODYNAMIC RESPONSE OF THE DOG SUBJECTED TO CRANIAL EXPOSURE TO 2450 MHz MICROWAVES. S-T. Lu (Univ. Rochester Sch. Med. Dent.), J. Jones, S. Pettit, N. Lebda and S. Michaelson.

THE GENERATION OF ACOUSTIC SIGNALS IN MATERIALS IRRADIATED WITH MICROWAVE PULSES--A THEORETICAL ANALYSIS. D. Borth (Dep. Electr. Eng., Univ. Illinois, Urbana) and C. Cain.

STRIPLINE TECHNIQUES IN THE STUDY OF MICROWAVE BIOLOGICAL EFFECTS ON ISOLATED NEURAL PREPARATIONS. R. L. Seaman (Dep. Biomed. Eng., Duke Univ., Durham, N. C.), H. Wachtel and W. T. Joines.

THE OCULAR LENS AND CATARACT. S. M. Michaelson (Univ. Rochester Sch. Med. Dent., N.Y.) and S. W. Magin.

ELECTRON MICROSCOPIC EVALUATION OF THE LENSES OF RABBITS EXPOSED TO LONGTERM 2450 MHz CONTINUOUS MICROWAVE ENERGY AT 10 MW/CM^2. R. J. Williams (Duke Univ. Eye Cent., Durham, N.C.), A. McKee, E. D. Finch and D. W. Fulk.

A MODEL FOR THERMAL CATARACTOGENESIS. M. R. Foster (Div. Biol. Effects, Bur. Radiol. Hlth, Winchester, Mass.).

BIOLOGICAL EFFECTS OF LOCALLY APPLIED MICROWAVES ON THE THYROID GLAND OF DOGS. R. L. Magin (Univ. Rochester Sch. Med. Dent., N.Y.), S-T. Lu and S. M.. Michaelson.

EFFECTS OF RF FIELDS ON NERVOUS ACTIVITIES. H. Kritikos (Dep. Bioeng., Univ. Pennsylvania, Philadelphia) S. Katashima and H. P. Schwan.

LOW LEVEL MICROWAVE INTERACTION WITH ISOLATED MAMMALIAN HEARTS. R. G. Olsen (Dep. Electr. Eng., Univ. Utah, Salt Lake City), C. H. Durney, J. L. Lords and C. C. Johnson.

LIGHT AND ELECTRON MICROSCOPIC OBSERVATIONS ON HAMSTERS AFTER MICROWAVE IRRADIATION. E. N. Albert (George Washington Univ. Med. Cent., Washington, D.C.).

MICROWAVE SPECIFIC EFFECTS ON BEER YEAST. B. Thourel (O.N.E.R.A.-C.E.R.T., Toulouse, France), A. Priou and C. Auge.

STUDIES ON MICROWAVE LEAKAGE SUPPRESSION OF MAGNETRONS. A. Harada (Hitachi, Ltd., Mobara, Chiba, Japan), I. Ohara, and T. Oguro.

MICROWAVE DOSIMETRY. M. Piotrowski (Mil. Inst. Hyg. Epidemiol., Sawsaw, Poland) and K. Dzieciolowski.

OCULAR EFFECTS OF 35 AND 107 GHZ CW MICROWAVES. L. Birenbaum (Res. Assoc. Polytech. Inst. New York, Brooklyn), I. T. Kaplan, W. Metlay, S. W. Rosenthal, and M. M. Zaret.

**** 1975 JOINT INTERNATIONAL IEEE/AP-S SYMPOSIUM & USNC/URSI MEETING

Date: June 2-4 (IEEE); June 3-5 (URSI), 1975
Place: Urbana-Champaign, Illinois
Sponsors: Institute of Electrical and Electronics Engineers and U.S. National Committee of the International Scientific Radio Union.
Requests for Information: Department of Electrical Engineering, University of Illinois, Urbana, Illinois 61801 (217) 333-1200

Selected Bibliography of Papers to be Presented:

SCATTERING FROM FINITE BIOLOGICAL AND METALLIC CYLINDERS. D. Livesay (Michigan State Univ., East Lansing), B. S. Guru and K. M. Chen.

ELIPTICALLY POLARIZED EM FIELD INDUCED IN A BIOLOGICAL TISSUE BY A PLANE EM WAVE. K. M. Chen (Michigan State Univ., East Lansing) and D. Livesay.

DEVELOPMENT OF ELECTROMAGNETIC MODELING MATERIALS FOR X-BAND DOSIMETRY STUDIES. A. Y. Cheun (Univ. Maryland, College Park), D. W. Koopman, J. D. Saffer and M. L. Swicord.

INVERSE SCATTERING SOLUTIONS BY LEAST SQUARES. H. E. Bussey (NBS, Boulder, Colo.).

A FINITE ELEMENT METHOD FOR CALCULATING ELECTROMAGNETIC FIELDS IN COMPLEX GEOMETRIES. R. B. Kellogg (Univ. Maryland, College Park) and S. Neuder.

HEATING PATTERNS OF ENCLOSED AND DIRECT CONTACT MICROWAVE DIATHERMY APPLICATORS. G. Kantor (Bur. Radiol. Hlth., Rockville, Md.), M. L. Swicord and M. Blair.

INDUCED CURRENTS IN BIOLOGICAL MEDIA WITH IMPLANTED METALLIC CONDUCTORS. D. P. Syquist (Michigan State Univ., East Lansing) and K. M. Chen.

CALIBRATION OF MINIATURE MICROWAVE ELECTRIC FIELD DETECTOR FOR IMPLANTATION MEASUREMENT WITHIN BIOLOGICAL TISSUES. A. Y. Chung (Univ. Maryland, College Park).

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A NUMERICAL STUDY OF MICROWAVE DOSE DISTRIBUTION IN THE HUMAN HEAD. S. M. Neuder (Bur. Radiol. Hlth., Rockville, Md.) and R. B. Kellogg.

THE MICROWAVE HEARING EFFECT--A THEORETICAL ANALYSIS. C. Cain (Univ. Illinois, Urbana-Champaign) and D. Borth.

ELECTROMAGNETIC TRANSIENT PROPAGATION IN MODELS OF MAN. J. C. Lin (Wayne State Univ., Detroit, Mich.) and C-L Wu.

**** 5TH EUROPEAN MICROWAVE CONFERENCE

Date: September 1-4, 1975
Place: Hamburg, W. Germany
Sponsors: VDE, in cooperation with the Convention of National Societies of Electrical Engineers of Western Europe, IEEE, International Microwave Power Institute, German National Committee of URSI, and Microwave Exhibitions & Publishers, Ltd.
Requests for Information: Dr. H. J. Schmitt, Conference Chairman, Philips Forschungslaboratorium, Vogt Koellnstrasse 30, D2 Hamburg 54, W. Germany.

Selected Bibliography of Papers to be Presented:

MICROWAVE BIOEFFECTS: CURRENT STATUS AND CONCEPTS. P. Czerski (Dep. Hum. Genet., Natl. Res. Inst. Mother Child, Wawsaw, Poland) and S. Szmigielski.

MICROWAVE ABSORPTION OF LIVING HUMAN SKIN BETWEEN 8 AND 96 GHz. J. Edrich (Univ. Denver, Colo.).

THE IMPORTANCE OF BOUND WATER STUDIES IN THE DETERMINATION OF ENERGY ABSORPTION BY BIOLOGICAL TISSUE. E. H. Grant (Queen Elizabeth College, London, U.K.), R. J. Sheppard and G. P. South.

A SYSTEM FOR QUANTITATIVE CHRONIC EXPOSURE OF A POPULATION OF RODENTS TO UHF FIELDS. A. W. Guy (Univ. Washington Sch. Med., Seattle) and R. H. Lovely.

MEASUREMENT OF TEMPERATURE AND MICROWAVE POWER USING LIQUID CRYSTAL/OPTIC FIBER PROBES. T. C. Rozzell (ONR, Arlington, Va.).

A POCKET-SIZED MONITOR OF DANGEROUS MICROWAVE POWER LEVELS. R. Agarwal (Univ. Newcastle-upon-Tyne, U.K.), S. Hannah, H. Hartnagel and J. T. Kennair.

USE OF DIELECTRIC MICROPROBES FOR ELECTROMAGNETIC FIELDS MEASUREMENT. A. Deficis (O.N.E.R.A.-C.E.R.T., Toulouse, France).

**** 1975 USNC/URSI-IEEE MEETING

Date: October 20-23, 1975
Place: Boulder, Colorado
Sponsor: U.S. National Committee of the International Union of Radio Science (USNC/URSI).
Requests for Information: Prof. A. W. Guy, Dept. of Rehabilitation Medicine, RJ-30, Univ. Hosp., Seattle, Washington 98105.

BOOK NOTES

Biological Effects Electromagnetic Radiation II(1), March 1975

ULTRAHIGH FREQUENCY RADIATION AND HEALTH SAFETY

by

B. A. MININ

The main principles of protecting personnel from occupational exposure to EM radiation in the UHF range are presented in this book, which is designed for use by engineers, technicians, hygienists and safety engineering experts. The information is intended for use in making calculations and measurements of antenna fields and internal radiation emission of operating communication, broadcasting, radar, and radionavigational facilities. Research data on the biological effects of UHF radiowaves are cited. The theoretical and practical aspects of radiation standards are reviewed and UHF and x-ray radiation protection measures are outlined. A 200-item bibliography of international publications is included.

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Sovetskoie Radiao Publishers: Moskow, 1974, 352p. In Russian.

ELF AND VLF ELECTROMAGNETIC FIELD EFFECTS

Edited by Michael A. Persinger
Laurentian University, Ontario

Offering exciting new research on EM signals whose frequencies overlap with time-varying processes in living organisms, this book presents data indicating significant effects of ELF fields on human and other life form activities. It distinguishes between the detection and effect of ELF signals, and examines the physical parameters of ELF-VLF EM fields and their penetrability, shielding properties, and behavioral and biological effects. This volume will be of interest to biophysicists, biochemists, environmental scientists, public health workers, and others concerned with exposure to EM radiation.

Contents

Plenum Publishing Corporation: New York. 1974, 316p

0325 BIOMEDICAL ASPECTS OF NONIONIZING RADIATION. *(E.)* Milroy, W. C. (Naval Weapons Lab., Dahlgren, Va.). *Proc. Symp. Biomed. Aspects Nonionizing Radiat.*, July 1973. Naval Weapons Lab. Rep. TR-3110, NTIS: AD-780 222, March 1974, 75p.

The proceedings of a one-day Symposium on Biomedical Aspects of Nonionizing Radiation held on July 10, 1973, at the Naval Weapons Laboratory, Dahlgren, Virginia, in conjunction with the opening and dedication of the new Biomedical Research Laboratory, are presented in this report. It includes six invited papers presented at the Symposium by leading authorities in the fields of bio-engineering, comparative biology, human exposure factors, high power pulses, and EMP bioeffects; and an overview of the Naval Weapons Laboratory efforts so far in their study of the possible biological effects and health hazards of EM radiation. (See CL 0326 through CL 0331, and CL 0170, Volume I, No. 2, for abstracts of these presentations.) (No references)

0326 WHERE ARE WE AND WHERE ARE WE GOING? *(E.)* Tyler, P. E. (Naval Weapons Lab., Dahlgren, Va.). *Biomedical Aspects of Nonionizing Radiation*, Naval Weapons Lab. Rep. TR-3110, NTIS: AD-780 222, March 1974, pp. 1-4.

A major portion of the scientific community has shunned the area of nonionizing radiation, primarily because of the lack of a unifying theory which could explain the reported biological effects of electromagnetic radiation. This attitude is changing with the greater willingness of medicine to accept empiral facts without absolute knowledge of the mechanisms of action. Questions in the area of biological effects of nonionizing radiation will eventually be answered through a multidisciplinary approach involving both medica and engineering experts. With its truly interdisciplinary team, the Naval Weapons Laboratory has the opportunity to explore solutions to three major problems in nonionizing radiation: the frequency dependence problem, the effects of long-term exposure to relatively low levels, and the problems of pulsed *versus* continuous radiations. (No references)

0327 SOME GUIDELINES FOR THE DEVELOPMENT OF EM RADIATION STANDARDS. *(E.)* Schwan, H. P. (Moore Sch. Electr. Eng., Univ. Pennsylvania, Philadelphia). *Biomedical Aspects of Nonionizing Radiation*, Naval Weapons Lab. Rep. TR-3110, NTIS: AD-780 222, March 1974, pp. 5-8.

Biophysical studies undertaken with Naval support indicate no direct (nonthermal) effect of microwaves on biosystems at the molecular and cellular level. However, field forces may become significant at the macroscopic level and could be responsible for the phenomenon of "hearing" pulsed waves. Bioengineering research has shown that: (a) penetration of microwaves in body tissues is highly frequency sensitive and decreases from about 1 in. at RF frequencies to less than 1 mm above 10 GHz; (b) man absorbs the incident energy; and (c) for an exposure not in excess of 10 mW/cm^2 external flux, cerebral circulation effectively eliminates the danger of excessive temperature elevation. No detrimental effects have been reported for therapeutic partial body irradiation at 1000 mW/cm^2. Above 100 mW/cm^2 deleterious effects have been observed in animal whole body exposures. Between 1-100 mW/cm^2 a variety of subtle and not necessarily detrimental effects take place, including the threshold of thermal perception and the "RF hearing" phenomena. The U.S. standard of 10 mW/cm^2 corresponds to a current density inside body tissue of 3 $milliamp/cm^2$. The threshold current density is not strongly frequency dependent and could be used as a yardstick for the development of subsidiary standards. Such standards might include exposure to very low frequency and static electrical fields, contact of one part of the body with a high potential (e.g., high voltage line workers), MW, and low frequency and RF standards in terms of magnetic and electrical field parameters. (No references)

0328 COMPARATIVE BIOLOGY IN ASSESSMENT OF ELECTROMAGNETIC BIOEFFECTS. *(E.)* Michaelson, S. M. (Dep. Radiat. Biol. Biophys., Univ. Rochester, N.Y.). *Biomedical Aspects of Nonionizing Radiation*, Naval Weapons Lab. Rep. TR-3110, NTIS: AD-780 222, March 1974, pp. 17-26.

The problem of animal selection for experiments on electromagnetic bioeffects is discussed. Extrapolation of animal data on hot spots to man is complicated by the fact that various animal species differ in brain size and in distribution of brain circulation relative to the circle of Willis. To interpret rabbit experiments related to cataractogenesis, it is important that thermal gradients in the rabbit eye be taken into consideration. The biologist must remember that animal species also differ in eye volume, dimensions, and location of the eye in the head. Thus, the scope of cataractogenesis research must be expanded to include species other than the rabbit. In the major area of thermal conversion, the inherent thermal regulatory capacity of the animal must be considered: the rat and the rabbit are poor thermal regulators, whereas the dog is a very good and man a very efficient thermal regulator. One of the constant factors among species is the relationship of body surface area. Basal metabolic rate or heat production is definitely related to body weight or surface area, in a linear relationship among various species. This relationship may permit the development of interspecies comparisons and extrapolation factors for man. (No references)

0329 HIGH POWER PULSE TRANSMITTERS. *(E.)* Rose, M. F. (Naval Weapons Lab., Dahlgren, Va.). *Biomedical Aspects of Nonionizing Radiation*, Naval Weapons Lab. Rep. TR-3110, NTIS: AD-780 222, March 1974, pp. 38-49.

Two classes of experimental short pulse, high power, discrete frequency transmitters are described which

represent the state of the art in attainable power levels. Their applications include atmospheric mapping, EM testing, and short pulse radar. Personnel working near the devices could be exposed to power levels and pulse shapes for which biological studies have not been done. The first class includes a Herzian quarter-wave cavity that is dc charged from an external source. When the voltage across the spark gap reaches a predetermined level, the gap arcs and produces a standing wave inside the cavity. An alternate cavity device is a travitron with a series of spark switches located along the axis. A fast rising pulse propogating in the cavity is chopped by switch action and can be radiated from a horn antenna. The Hertzian quarter-wave device operates at 50 Mw at 50 MHz and the travitron at 20 Mw. Another device, a Landnecker ring, is composed of 100 coupled resonant circuits that can discharge in phase. It has several oscillatory modes, each containing a fractionated portion of the total energy. In the open literature, the highest recorded power for this device is 17 Mw at 70 MHz. The second class of transmitters comprises beam plasma devices. One beam interacts with a magnetic field in the drift space to produce microwave radiation at several frequencies simultaneously. Power levels of 30-50 Mw are produced at a number of radiofrequencies for each pulse. (6 references)

0330 CONTINUOUS EXPOSURE OF RODENTS TO 10^8 PULSES OF ELECTROMAGNETIC RADIATION. *(E.)*

Baum, S. J. (Armed Forces Radiobiol. Res. Inst., Bethesda, Md.), W. D. Skidmore and M. E. Ekstrom. *Biomedical Aspects of Nonionizing Radiation,* Naval Weapons Lab. Rep. TR-3110, NTIS: AD-780 222, March 1974, pp. 50-69.

Experiments were conducted to test the hypothesis that rapid rise and fall of electric fields would adversely affect vital ionic and electrochemical processes at the molecular level in biological systems. Rodents were continuously exposed for 38 wk to 10^8 pulses from an EMP generator which provides 5 pulses/sec with a peak electric field intensity of 447 kV/m, a 5 nsec rise time, and 550 nsec 1/e fall time. Irradiated Sprague-Dawley male rats did not differ significantly from their unexposed controls with respect to the number and production of bone marrow cells, the incidence of chromosome aberrations in mitotic bone marrow cells, and the concentration of circulating neutrophils, lymphocytes, and erythrocytes. Circulating reticulocyte concentration was greater in the irradiated animals and platelet concentration was consistently lower beyond the 6th wk of irradiation; however, both counts remained within acceptable levels. No mammary tumors were observed in experimental female Sprague-Dawley rats or in their nonirradiated controls. Leukemia did not occur earlier in leukemia-prone AKR/J male mice exposed to EMP, nor was the incidence of leukemia higher in this group than in control mice. The data, obtained from animals at 1 yr of age, do not indicate an acute biological hazard to rodents from EMP exposures. The possible occurrence of late effects and malignancies will be determined during the second half of life of the experimental rodents. (14 references)

0331 BIOMEDICAL ASPECTS OF NONIONIZING RADIATION: AN OVERVIEW OF THE NWL EFFORT. *(E.)*

Diachenko, J. A. (Naval Weapons Lab., Med. Res. Team, Dahlgren, Va.), R. L. Ellis, L. Lawton, W. C. Milroy, T. C. O'Grady and E. T. Prince. *Biomedical Aspects of Nonionizing Radiation,* Naval Weapons Lab. Rep. TR 3110, NTIS: AD-780 222, March, 1974, pp. 70-74.

The Medical Research Team was established at the Naval Weapons Laboratory in 1972 to study the possible bioeffects and health hazards of EM radiation. This biomedical research effort is multidisciplinary, covering engineering and electronic instrumentation, medical surveillance, biological research, and psychological research. The projects planned in each of these areas are reviewed. A group of 100 occupationally exposed personnel will be examined annually to provide a comparative basis for detecting cumulative long-term effects of EM radiation. Parameters to be evaluated are hematology, blood chemistry, urinalysis, electrocardiogram, electroencephalogram, and psychological testing. Biomedical research projects include: (1) longterm studies on the effects of chronic exposures to microwave radiation, both radar-type pulse modulation and high-energy frequency specific pulse modulation; and (2) investigations of the mechanisms of action on nonionizing radiation of biological studies. The parameters investigated in (1) will include blood chemistries; body weight; fertility; death; tissue enzyme levels and hormone levels; metabolism and behavioral parameters. Short-range studies will determine the effects of EM radiation on cell cycle timing and cell division in plants, and also genetic aberrations. In the psychological research, human and animal subjects will be tested for consistency of timing in operant conditioning tasks. Additionally, human "micro-tremor" will be studied to determine EM radiation effects on the CNS. (No references)

0332 THE BIOLOGICAL EFFECT OF MICROWAVES. *(Ger.)*

Röhl, D. (Sect. Cardiol. Angiol., Univ. Ulm, Germany). *Dtsch. Med. Wochenschr.* 100(1):26-29, 1975.

The direct and indirect biological effects of microwave radiation emitted by radio and TV broadcasting stations, radar transmitters, as well as MW ovens and diathermic apparatuses are reviewed. MW radiation, absorbed by the organism at rates ranging from 20 to 80% as a function of frequency, the type of the tissue exposed, and of perfusion, may cause cataract and oligospermia following irradiation of the eyes and testes, respectively. The biological tolerance limit for whole-body irradiation has been set at a radiation density of 10 mW/cm^2, while a lower limit of 10 $\mu W/cm^2$ has been proposed by East European scientists who observed fatigability, irritability, and lability of the pulse and blood pressure in radar technicians exposed to radiation densities below 10 mW/cm^2. Apart from its thermal effect, MW radiation

causes orientation of blood corpuscles and proteins, thereby bringing about a disruption of hydrogen bonds in, and denaturation of, proteins, as well as changes in enzyme activities. As MW radiation interferes with the function of pacemakers in cardiac patients at intensities well below 10 mW/cm^2, such patients should avoid high-frequency radiation sources. The susceptibility of pacemakers can be reduced by efficient encapsulation and electrode input filtration. Diathermic apparatuses and MW ovens, generating radiation densities of 1 and 1-5 mW/cm^2, respectively, are not hazardous for healthy patients. Notwithstanding, prolonged exposure of the eyes and testes should be avoided, and the diathermic therapy of patients with pacemakers is indicated only in special cases. (25 references)

0333 DESTRUCTION OF *Escherichia coli* AND *Salmonella typhimurium* IN MICROWAVE-COOKED SOUPS. *(E.)* Culkin, K. A. (Dep. Microbiol., Pennsylvania State Univ., University Park) and Y. C. Fung. *J. Milk Food Technol.* 38(1):8-15, 1975.

Single serving (20 ml) portions of tomato soup, vegetable soup, and broth inoculated with *Escherichia coli* or *Salmonella typhimurium* at about 10^7 organisms/ml were exposed to 915 MHz microwaves. Bacterial destruction was studied in relation to the time of MW exposure and the temperature achieved during the exposure. Temperatures at various positions in the soup samples, indicated by color changes in temperature-sensitive paper strips, were recorded immediately after exposures; aliquots were taken from the same regions for standard plate count determination of survivors. For any given exposure time, the middle region of soup samples had the warmest temperature and the top region the coolest. In terms of exposure time, organisms at the top had the lowest survival, those in the middle had intermediate values, and those in the bottom had the greatest survival. In terms of temperature, organisms in the top region declined to given levels of survival at temperatures lower than those required to reduce organisms in the middle and bottom regions to the same given levels. These results suggest the heat generated during the MW exposure was not in itself adequate to account for the destruction of the bacteria. (16 references)

0334 IMPACT OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON SOIL ARTHROPODS. ONGOING STUDIES AT THE PROJECT SANGUINE WISCONSIN TEST FACILITY, 1973. *(E.)* Greenberg, B. (Dep. Biol. Sci., Univ. Illinois, Chicago) and N. Ash. *Res. Rep.*, NTIS: AD A001 924, 1973, 35p.

Study of the long-term impact of Sanguine EM fields on soil arthropod population was continued in the summer of 1973, with population analyses of nine test and six control plots. Of the nine test plots, one has been monitored for 5 yr, three have been studied for 3 yr, and five for 2 yr. The Sanguine Wisconsin Test Facility antennae operate at or near a frequency of 45 or 75 Hz; experiments have involved both CW and modulated operation. Comparisons of test and control populations of mites and Collembola included statistical treatment of within-yr and between-yr numbers, predator proportions, Cryptostigmata:Collembola ratios, and Cryptostigmata:Mesostigmata ratios. In 1973, there were no significant differences in the proportions of predators (Mesostigmata, Prostigmata) in seven of nine test and control comparisons for the entire summer and on a monthly basis. In 73% of the test plots and in 63% of the control plots, there was also no significant shift in proportions of predators between 1972 and 1973. Prostigmates and mesostigmates had similar densities in paired test and control plots, as they did in 1971 and 1972. The ratios Cryptostigmata:Collembola (the numerically dominant arthropod groups) approximated the 1969 pretreatment ratios. Three-yr summer population curves are generally synchronous. These observations indicate that Sanguine EM fields have had no demonstrable effect on the arthropod populations under study. (5 references)

0335 OXYGEN CONSUMPTION IN FOUR SPECIES OF INVERTEBRATES AND A VERTEBRATE NATURALLY EXPOSED TO SANGUINE ELECTROMAGNETIC FIELDS. *(E.)* Greenberg, B. (Dep. Biol. Sci., Univ. Illinois, Chicago). *Res. Rep.*, Contract No. N00039-73-C-0030. NTIS: AD A001 925, 1973, 11p.

The oxygen consumption and the respiratory quotient (RQ) of five species of animals collected adjacent to the Sanguine antenna (operated with 300 amperes at 45 and 75 Hz) during summer, 1973, were tested. The species were wood louse, *Oniscus asellus;* earthworms, *Lumbricus terrestris* and *L. rubellus;* slug, *Arion* sp.; and redbacked salamander, *Plethodon cinereus cinereus.* Controls were collected on the same day, 6-13 miles from the nearest Sanguine antenna, and both exposed and control groups were tested simultaneously. There were no significant differences in O_2 consumption or RQ between any test and control group of animals. (12 references)

0336 LOW FREQUENCY ELECTRIC FIELD INDUCED CHANGES IN THE SHAPE AND MOTILITY OF AMOEBAS. *(E.)* Friend, A. W., Jr. (U.S. Naval Med. Res. Inst., Bethesda, Md.), E. D. Finch and H. P. Schwan. *Science* 187:357-359, 1975.

Perpendicular and parallel elongation of the giant amoeba *Chaos chaos (Chaos carolinensis)* were observed in alternating electric fields over the frequency range 1 Hz to 10 MHz. The elongation characteristics vary with frequency in the following ways: (a) between 1-100 Hz, pseudopodia extend perpendicular to the field but complete alignment never occurs; (b) between 100 Hz and 1 kHz, parallel pseudopodia withdraw and perpendicular pseudopodia extend to the extreme of the field; (c) between 1-100 kHz, *Chaos* loses its pseudopodia and becomes approximately elliptical perpendicular to the field; and (d) above 100 kHz, *Chaos* remains elliptical but deforms with its long axis parallel to the field. Field strengths less than 10 V/cm produce these effects at frequencies be-

low 1 kHz. Above 1 kHz the required field strength steadily increases; at 100 kHz it may exceed 200 V/cm. These results are consistent with a simple dielectric force mechanism. (29 references)

0337 THE LEVELS OF LABILE INTERMEDIARY METABOLITES IN MOUSE BRAIN FOLLOWING TISSUE FIXATION WITH MICROWAVE IRRADIATION. *(E.)* Medina, M. A. (Univ. Texas Hlth. Sci. Cent., San Antonio), D. J. Jones, W. B. Stavinoha and D. H. Ross. *J. Neurochem.* 24(2):223-227, 1975.

The levels of several labile glycolytic and organic phosphate metabolites in male Sprague-Dawley mouse brain were determined following rapid inactivation with 2450 MHz MW irradiation. The ATP levels in mouse brain following a 0.25 sec exposure in a 6 kW MW oven was 2.415 $\pm$ 0.061 µM/g wet wt. Whole brain levels of ATP and seven other labile intermediary metabolites in samples irradiated for 0.4 sec were comparable to those obtained by freeze-blowing or whole-body immersion in liquid N_2. Analysis of these same metabolites in four regional areas of irradiated brains did not reveal any anoxic changes between superficial and deeper brain areas. MW irradiation did not produce any significant changes in brain water or protein content. Unlike freeze-blowing or whole-body immersion, MW irradiation has the advantage of producing irreversible inactivation of enzymes. Furthermore, the MW technique is the only method that preserves the structural integrity of the brain, making regional analysis possible. (20 references)

0338 ELECTROMAGNETIC POWER DEPOSITION IN MAN EXPOSED TO HIGH-FREQUENCY FIELDS AND THE ASSOCIATED THERMAL AND PHYSIOLOGIC CONSEQUENCES. *(E.)* Guy, A. W. (Dep. Rehabil. Med., Univ. Washington, Seattle), C. C. Johnson, J. C. Lin, A. F. Emery and K. K. Kraning. *USAF Sch. Aerospace Med. Rep.* SAM-TR-73-13, 1973, 67p.

The induced fields and the associated power deposition in man exposed to HF EM fields were investigated theoretically with spherical models. The induced fields inside the model exposed to planewave or near fields can be described by a combination of quasi-static electric and quasi-static magnetic solutions. For field impedances less than 1200π the magnetic-field induced absorption predominates; thus, H fields must be measured to estimate the hazards due to HF exposure. For a 70-kg spherical model of man, the theory indicates that the time-average power absorption/unit volume is less than 2.5 X 10^{-3} mW/cc for each mW/cm^2 incident at 20 MHz and below. This suggests that the thermal safe exposure levels for the HF band are many orders of magnitude in excess of the 10 mW/cm^2 level recommended by the Department of Defense or the American National Standards Institute. A spherical mathematical model of heat transfer and thermal regulation was used to simulate a steady-state temperature distribution in a nude man, resting in an environment of 28 C and 50% relative humidity, and subjected to 100 W total power deposition. This would correspond to incident HF power density of 590 mW/cm^2 at 20 MHz. Results indicate that a steady-state thermal condition was achieved in 100-120 min of exposure with a resulting core temperature elevation of 2.1 Celsius. While temperature regulation in a normal subject would remain efficient and stable, this stability would undoubtedly be gained at some physiologic cost, such as skin blood flow accompanied by increased heart rate, cardiac output, and diversion of blood flow from splanchnic areas. It is shown that 3450 and 900 mW/cm^2 of incident 20-MHz power levels are required to produce heat stress index = 100 for man at rest and work, resp., in an environment whose globe temperature is 25 C, 50% relative humidity, and 15 millibars. (41 references)

0339 HIGH FREQUENCY ELECTROMAGNETIC WAVE POWER, DEPOSITION IN MAN. *(E.)* Johnson, C. C. (Dep. Biophys. Bioeng., Univ. Utah, Salt Lake City), C. H. Durney and H. Massoudi. *USAF Sch. Aerospace Med. Rep.*, Contract No. F41609-73-C-002, April, 1974, 26p.

Approximate Mie equations were applied to muscle sphere representations of man and experimental animals. Dose rate data, valid only in the HF to UHF bands, show that small animals absorb considerably less power/unit volume or mass than man. For an incident planewave field power density of 1 mW/cm^2, man absorbs an average power density of approximately 10^{-3} at 10 MHz, whereas a monkey absorbs an average power density of approximately 10^{-4}. Thus, a monkey will require an incident power density of about 10 mW/cm^2 to receive the same average absorbed power density as man will at 1 mW/cm^2. Similar results are obtained for peak absorbed power density. For the same average absorbed power density, a dog will require two to three times more incident power density than man; a mouse may require about 50 times more incident power density. Power deposition of planewave irradiation in anisotropic tissue was calculated for simple two- and five-layer models. The calculations show a striking difference in power absorption with polarization at low frequencies, the difference disappearing at higher frequencies. (No references)

0340 HIGH FREQUENCY ELECTROMAGNETIC FIELDS IN PHANTOM MODELS OF MAN AND MEASURED ELECTRICAL PROPERTIES OF TISSUE MATERIALS. *(E.)* Guy, A. W. (Univ. Washington Sch. Med., Seattle), M. D. Webb, A. F. Emery, R. H. Willard and J. C. Lin. *USAF Sch. Aerospace Med. Rep.*, No. 3, Contract F41609-73-C-0002, July 1974, 82p.

A thermographic technique was used to quantify power absorption due to HF field exposure in biological tissues with regular geometries corresponding to spheres or ellipsoids or in irregular geometries corresponding to man. A dual-mode resonant cavity operating at 144 MHz produced the necessary rapid temperature rise in scale model (1/5 or less) phantom tissues to allow thermographic measurement of the absorption patterns. Measurements in free body phantom models of man indicate that peak power ab-

sorption densities can exceed those produced in equivalent volume spheres by as much as three orders of magnitude for electric field exposures and a factor of up to six for magnetic field exposures. The electric field perpendicular to the transverse plane produces maximum absorption in the neck and in areas such as the ankles and the knees where transverse cross-sections are small. The magnetic field perpendicular to the frontal plane induces eddy currents that attain high values at the periphery of the torso; peak values occur in the region near the axilla and the perineum where there are sharp angles in the tissue. The power absorption density increases with the square of the frequency for exposure to either electric or magnetic fields, and also the square of the dimensions for magnetic field exposure. Absorption measurements under a given set of conditions at one frequency can be used to predict the results for all HF frequencies and sizes of bodies with the same geometric shape. Study of electric properties in dog and cat tissues showed that anistropy was small in the HF range; for frequencies below HF, the orientation dependence of electrical conductivity can reach 5:1, with the higher values occurring along the direction of fiber orientation. (10 references)

0341 A RADIOFREQUENCY RADIATION EXPOSURE APPARATUS. *(E.)* Mitchell, J. (USAF Sch. Aerospace Med., Brooks Air Force Base, Tex.). *USAF Sch. Aerospace Med. Rep.* SAM-TR-70-43, July 1970, 8p.

A RF radiation exposure apparatus has been developed and placed into operation at the USAF School of Aerospace Medicine. The rectangular coaxial device has dimensions of 4 3/4 ft by 9 1/2 ft by 30 ft, with a 6-ft-wide center conductor. It is powered by a 50-kwp transmitter and operates in a pulsed mode at frequencies of 10.5, 19.27, and 2.6 MHz. Up to 12 animals *(Macaca mulatta)* can be exposed simultaneously to uniform fields ranging in power density from 0.05-0.2 W/cm^2. The instrumentation system, consisting of portable E- and H-field probes and fixed E-field probes, was developed and calibrated by the National Bureau of Standards. Details of the system design, checkout, and operation are presented. The experimental data to be obtained with this exposure apparatus should provide new guidelines for personnel exposure criteria for many of the new-generation radar systems and comparable communication systems. (6 references)

0342 INTERACTION OF ELECTROMAGNETIC FIELDS WITH MAN AND EXPERIMENTAL ANIMALS. *(E.)* Frazer, J. W. (USAF Sch. Aerospace Med., Brooks Air Force Base, Tex.). *USAF Sch. Aerospace Med. Rep.*, 1974, 23p.

An EM near-field synthesizer was developed which is capable of forming either E or H fields. Investigations with the synthesizer showed that H field coupling is predominant at HF bands and that this yields nonuniform power deposition in several experimental models. Exposure of a sectioned and rejoined rat to 19 MHz fields at 35 A/m resulted in considerable heating around the edge of the animal, including both head and tail; the core remained relatively much cooler. The power distribution pattern was in agreement with a theoretical prediction of a toroidal heating pattern. A scaled model of man, filled with a mixture matching the dielectric constant and conductivity of muscle at 147 MHz, was exposed to relatively pure H fields and relatively pure E fields. After exposure to the H field, the model showed edge heating expected from toroidal eddy currents. With exposure to an E field, there was apparent heating wherever there was an apparent current constriction. Exposure to an admixture of the two fields caused a major redistribution of power deposition although the pattern was still predominantly that expected from an H field. The appearance of eddy currents and nonuniformity of power deposition calls into question the concept that the thermal consequences of power deposition in man are an addition to metabolic heat production. While the biological response to the observed power distributions remains problematical, orientational effects of high-molecular weight dipoles are possible in high fields. Moreover, loss of divalent metals has been observed in liver and brain tissues; such a loss probably signals wide disruption of many metabolic reactions. (15 references)

0343 NEUROCHEMICAL ALTERATIONS IN SPECIFIC BRAIN AREAS IN RODENTS EXPOSED TO HIGH INTENSITY FIELDS. *(E.)* Stavinoha, W. B. (Univ. Texas Med. Sch., San Antonio), M. A. Medina and A. P. Deam. *Air Force Contract Rep.*, Contract F41609-73-C-008, 1974, 45p.

Male Sprague-Dawley rats were exposed to a high-frequency radio transmitted (33 kW at 26.6 megacycles with 3.3 W/cm^2), and the effect of this irradiation on brain biochemistry was studied using MW radiation to inactivate tissue enzymes. The results are difficult to interpret. There were no significant differences between experimental and control rats in brain area concentrations of nicotinamide adenine dinucleotide, reduced nicotinamide adenine dinucleotide phosphate, nicotinamide adenine dinucleotide phosphate, or reduced nicotinamide adenine dinucleotide phosphate. There was also no extensive alteration in adenine nucleotide levels in the brain areas of irradiated rats compared with controls. ATP was decreased in the medulla pons and midbrain of the irradiated animals, while AMP was increased in the cortex and medulla pons of these animals. Turnover rates of serotonin and norepinephrine were not significantly different between the two groups. The cholinergic system of the medullary area showed changes after irradiation. The cholinesterase activity increased, the cholineacetyltransferase activity decreased, and acetylcholine concentration decreased. The MW oven used for enzyme inactivation operated at 2450 MHz with a 1500 W, DX-206 magnetron. An improved MW oven for the sacrifice of small laboratory animals operates at the same frequency with a YJ 1191 Amperex magnetron tube. It is now being tested at an output of 5-6 kW. (33 references)

0344 EFFECTS OF ELECTROMAGNETIC INTERFERENCE (2450 MHz) ON CARDIAC PACEMAKERS. *(E.)* Hurt, W. D. (USAF Sch. Aerospace Med., Brooks Air Force Base, Tex.). *USAF Sch. Aerospace Med. Rep.* SAM-TR-73-40, Dec. 1973, 16p.

Tests were performed to determine the effects of 2450 MHz RF radiation on implantable cardiac pacemakers from various manufacturers. Of the 25 units tested, 11 were implanted in dogs and 14 were tested in air (freefield). The fields included continuous wave, sine wave half-wave rectified, and square-wave modulated signals. Most of the pacemakers exhibited some EM radiation interference under certain test conditions. At pulse repetition frequencies less than approximately 30 pulses/sec, the most sensitive pacemakers cut off at 2 V/m in free-field tests and at approximately 16 V/m when implanted. This 16 V/m corresponds to approximately 11 $\mu W/cm^2$ average power density from a MW oven, a not uncommonly high level. (5 references)

0345 MEASURED EFFECTS OF SQUARE-WAVE MODULATED RF FIELDS (450 AND 3100 MHz) ON CARDIAC PACEMAKERS. *(E.)* Hurt, W. D. (USAF Sch. Aerospace Med., Brooks Air Force Base, Tex.), J. C. Mitchell and T. O. Steiner. *USAF Sch. Aerospace Med. Rep.* SAM-TR-74-51, Dec. 1974, 35p.

Twenty-four cardiac pacemaker models from 10 manufacturers were tested in square-wave modulated 450 MHz and 3100 MHz RF radiation fields. The 450 MHz fields were circularly polarized with electric field levels up to 292 V/m; pulse-width range was 1 µsec to 1 msec at 2-50 pulses/sec. The 3100 MHz fields were vertically polarized with levels up to 320 V/m for a pulse-width range of 10-120 sec at 7-400 pulses/sec. Both free-field and simulated-implant configurations were investigated. Test results indicate an improvement in the EMI characteristics of the more recent pacemaker models. Shielding factors of approximately 3 (10 dB) at 450 MHz and approximately 5 (14 dB) at 3100 MHz can be expected for EMI thresholds from the free-field to the implanted situation. At 450 MHz, three models were not affected at 200 V/m in the simulated-implant tests; three other models demonstrated no serious effects at 200 V/m for pulse repetition rates greater than 10 pulses/sec. All other pacemakers were significantly affected at electric field values below 200 V/m and pulse repetition rates greater than 10 pulses/sec. At 3100 MHz and 120 µsec pulse width, none of the pacemakers were seriously affected at 200 V/m in the simulated-implant tests. (21 references)

0346 EMC DESIGN EFFECTIVENESS IN ELECTRONIC MEDICAL PROSTHETIC DEVICES. *(E.)* Mitchell, J. C. (USAF Sch. Aerospace Med., Brooks Air Force Base, Tex.), W. D. Hurt and T. D. Steiner. *Presented Int. Conf. Environ. Toxicity, Fundam. Appl. Aspects Nonionizing Radiat.*, Rochester, N. Y. June 6, 1974.

Twenty-one cardiac pacemaker models, exposed in free-field and simulated implant configurations, were tested for their response to pulsed 450 MHz and 3100 MHz radiation. An adverse effect was defined as a pacemaker rate which falls below 50 beats/min or exceeds 120 beats/min as a direct result of RF radiation interference. The implanted adverse effects thresholds at 450 MHz ranged from 8 V/m to > 292 V/m, with new models showing marked improvement in their relative interference thresholds. Very few effects were noted at 3100 MHz since the implanted adverse effects thresholds were all greater than 200 V/m, with only four of the 21 pacemaker types significantly affected at 320 V/m. Decreasing the pulse width raised the adverse effects threshold for some pacemakers. Some of the pacemakers tested reverted to their interference rejection mode (fixed rate) at any pulse repetition rate above 5 pulses/sec, while others would not revert at rates as high as 40 pulses/sec. Free-field to implant attenuation factors were approximately 3 at 450 MHz and approximately 5 at 3100 MHz. Continuing effort by the manufacturers should ultimately resolve most of the potential EMI problems of pacemakers. (17 references)

0347 RESEARCH ON BIOLOGICAL EFFECTS OF VLF 3AND ELECTROMAGNETIC RADIATION. *(E.)* Bollinger, J. N. (Southwest Res. Inst., San Antonio, Tex.), R. L. Lawson and W. C. Dole. *USAF Sch. Aerospace Med. Rep.* SAM-TR-74-52, Nov. 1974, 131p.

Growth, reproduction, metabolism, and pathological studies were performed on C3H/He mice exposed to very high field intensities of very low frequency (VLF) EM radiation. Two field intensities were used at a frequency of 25 kHz: E = 15,000 V/m, H = 7.5 A/m for full power exposure and E = 10,600 V/m, H = 5.3 A/m for one-half power exposures. Mice were exposed 1 hr/day, 5 days/wk (total of 50 hr) for the growth, reproduction, and metabolism studies and 10-100 hr for the pathological studies. Exposure of dams and neonates to the high intensity VLF fields had no statistically detectable effect on the growth, reproductive ability, and metabolism of the neonates or the growth of their subsequent offspring. Hematology evaluations (hematocrit and hemoglobin determinations, red and white blood cell counts, and white cell differential analysis) also revealed no detectable VLF exposure effects. Similarly, analysis of major organ weights and histopathological study of the major organs (including inner ear and eye) showed no effects atrributable to VLF radiation. Mammary tumor development was not observed in C3H/He mice up to age 90 days. Cytological analysis revealed no obvious VLF effects on the number or architecture of the bone-marrow chromosomes. The only apparent effect of VLF radiation was significantly increased ^{3}H-thymidine uptake in lymphocyte cultures from exposed mice. This finding suggested an increased immune response, but screening for major parasites indicated no difference in incidence between experimental animals and controls. (21 references)

0348 ELECTROMAGNETIC FIELDS AND THE BRAIN. *(E.)* Kholodov, Y. A. (Inst. Higher Nerv. Act., USSR Acad. Sci., Moskow). *Impact Sci. Soc.* 24(4):291-297, 1974.

With radio waves a normal part of the environment, the question of how EMF with a longer wavelength than infrared rays affect organisms has become extremely important. The author deals with questions connected with the influence on the CNS of radio waves, low-frequency EMF, and electrical and magnetic fields, all of which are penetrative and subsensory. From the biological point of view, EMF may be divided into 4 groups: natural EMF, with external and internal subgroups; and artificial EMF, with weak and strong subgroups. External natural fields come from space, geophysical processes and living beings. Internal natural fields are found in systems of the organism, cells, intracell formation, and biomolecules. Artificial EMFs of the weak type are generated by screening and the establishment of antifields. Strong artificial fields are created by various technical generators. Oscillations of natural EMF of cosmic or geophysical origin are believed to affect human behavior, the formation of the CNS in the prenatal period, and aggravate cardiovascular diseases. Natural EMFs also assist living beings to orient themselves in space. Only in fish have electrical generators and receivers been detected, but biological EMF are suspected of playing a role in the regulation of living being's activity by the ephaptic transfer of information to the CNS. Little is known about the influence of weak EMF on the activity of the brain; studies with astronauts detected no serious deviations. Weak fields do influence the visual cortex in man and direction-finding by means of the geomagnetic field in birds, fishes and insects. The questions surrounding weak EMF are difficult to research because of their multidisciplinary requirements. The therapeutic approach to their study focuses on the CNS and its role in increasing resistance; EMF can have a healing effect through their influence on the CNS. It has been suggested that when external EMF are weak or strong in comparison to natural fields, they may influence an organism (including the nervous system) through changes in the internal biological field. Consequently, electrical and magnetic fields serve as experimental instruments for obtaining information about basic phenomena. The role of internal EMF in the CNS has not yet been sufficiently studied. The use of external fields as an instrument of study may prove important. (12 references)

0349 WHAT HAPPENS WHEN RADIO WAVES PENETRATE THE HUMAN SKIN. *(E.)* Paharich, A. (87 Hawkes Ave., Ossining, N. Y.). *Impact Sci. Soc.* 24(4):353-357, 1974.

The phenomenon of penetration of skin by radio waves is described. Risk occurs only with high-power bursts of radio waves from lightning, high-tension power lines, and military radar. To determine precisely the effects of radio penetration of skin, a transdermal instrument (TD-100) was developed which applies radio waves directly to the skin through radio wave-energized plates. The instrument operates at 7-30 kHz and can be amplitude-modulated by human speech. The transmitted voice signal is not heard by a human subject when the plates are stationary on the skin, but it is clearly heard as the plates move over the skin. This effect is due to the stretching of protein keratin molecules in the skin; when the keratin is stretched in the presence of amplitude-modulated carrier waves, the substance becomes a detector of radio waves. Following a course of TD-100 electrotherapy, a significant percentage of children with nerve deafness were able to hear, discriminate, and understand speech sounds by means of a hearing aid sending radio waves to the brain as a speech signal. TD-100 therapy has also benefited patients suffering from dizziness because of Meniere's syndrome, accelerated bone healing in cases of fracture, improved short-term memory loss due to senility, and controlled blood clotting by slowing coagulation. The corona discharge phenomenon was observed by placing insulated, radio-energized plates across the human body. At a carrier amplitude modulation of 50 kHz and audio frequency of 1 kHz, the body radiates waves from about 1 kHz to the light-wave frequencies. (15 references)

0350 A VERSATILE TEMPERATURE CONTROLLED EXPOSURE CHAMBER FOR MICROWAVE BIOEFFECTS RESEARCH *(E.)* Ali, J. S. (Exp. Biol. Lab., Natl. Environ. Res. Cent., Research Triangle Park, N.C.). *IEEE Trans. Biomed. Eng.* 22(1):76-77, 1975.

A versatile temperature-controlled microwave exposure chamber has been designed especially for use in microwave bioeffects research. The device uses a thermoelectric heat pump to cool the air in the chamber below ambient and a resistive heater for above ambient operations. A unique feature of the exposure chamber is that the radiating antenna can be placed inside the chamber for millimeter wave experiments and outside the chamber for lower microwave frequency exposures. In a normal laboratory environment, chamber temperatures can be controlled over the 18 to 42 C range to within ± 0.1 C. (5 references)

0351 MICROWAVE PROPERTIES OF FRESH MAMMALIAN BRAIN TISSUES AT BODY TEMPERATURE. *(E.)* Lin, J. C. (Dep. Electr. Eng., Wayne State Univ., Detroit, Mich.). *IEEE Trans. Biomed. Eng.* 22(1):74-76, 1975.

The complex dielectric constant of human, primate, canine, ovine, and swine brain tissues at 37 C was measured in the *S* band using a slotted waveguide section. The *in vitro* measurements indicate that mammalian brains exhibit very little dispersion within the frequency range 2.25-395 GHz. The dielectric constant was found between 30-35 and the conductivity varied from 1.1-3.1 mho/m. (7 references)

0352 MICROWAVE INDUCED TEMPERATURE RISES IN RABBIT EYES IN CATARACT RESEARCH. *(E.)* Emery, A. F. (Univ. Washington, Seattle), P. Kramar, A. W. Guy and J. C. Lin. *J. Heat Transfer* Feb. 1975, 123-128.

Microwave power deposition patterns and temperature distributions were measured for rabbit eyes exposed to 2450 MHz radiation at 5 cm from the cross-over point to the corneal surface. The absorbed power peaked midway between the lens and the retinal surface with maximum absorption of 0.92 W/Kg per 1 mW/cm^2 incident power. Retrolental and orbit temperatures were measured at irradiation levels of 100, 200, and 300 mW/cm^2. Measured transient temperatures, summarized in figures, were in good agreement with values predicted by a model assuming a correlation between intraocular temperatures and rate of arterial blood flow. Animal eyes were examined with a slit-lamp ophthalmoscope to determine the minimum exposure times necessary to produce posterior lens opacity (cataracts), and these times were correlated with the temperature calculations. The data suggest that a critical temperature for cataracts may be of the order of 43 C; for power levels below 150 mW/cm^2, the required exposure time is greater than 100 min. When body temperature was maintained at a temperature low enough to ensure that maximum eye temperature never reached 40 C, hypothermic rats did not develop cataracts after exposure to microwaves. Numerical tests of the present 10 mW/cm^2 standard showed that the maximum temperature in eyes of rabbits exposed to 2450 MHz was well below the suspected cataractogenic temperature. (25 references)

0353 AN EVALUATION OF SELECTED SATELLITE COMMUNICATION SYSTEMS AS SOURCES OF ENVIRONMENTAL MICROWAVE RADIATION. *(E.)* Hankin, N. N. (Electromagnetic Radiat. Anal. Branch, EPA, Silver Spring, Md.) *EPA Rep.* 520/2-74-008, 1974, 64p.

Selected satellite communication (SATCOM) systems were evaluated analytically and, for some of these systems, through measurement of the MW radiation power densities generated by them. The evaluation was directed toward assessing the radiation exposure hazards which exist for specific systems and generally for SATCOM systems as a class of high-power nonionizing radiation source. This paper includes determinations of anticipated maximum power density levels as functions of distance from the source, a description of the analytical method used, and the results of measurements of the power densities produced by certain SATCOM systems. Also included is a discussion of potential hazard analysis and its uses in identifying systems which may constitute environmental hazards. Some systems, if operated improperly, can create thermally hazardous situations due to the large on-axis power densities that can be produced at great distances from the antennas. Models exist which predict, under ideal conditions, maximum on-axis near-field power density, and appear to be applicable in defining the intermediate and far-field zones and on-axis power density as a function of distance from the system. A selected power density threshold can be the basis for the potential hazard evaluation, but a realistic evaluation of bioeffects hazards will include the frequency dependence of the effects, the expose time, and the characteristic and distribution of the exposed population. (5 references)

0354 SIMULTANEOUS APPLICATION OF PULSED HIGH FREQUENCY CURRENTS AND GAMMA-RAYS TO CULTURED MELANOMA CELLS. *(E.)* Häkkinen, A.-M. (Univ. Central Hosp., Helsinki, Finland), K. Blomqvist, E. Spring and E. Valtonen. *Strahlentherapie* 149(2): 205-207, 1975.

Cells differentiated from a human metastasizing melanoma were irradiated simultaneously with pulsed HF EM currents (27.12 MHz, 400-600 pulses/sec, pulse duration 65 μsec, average power 25-38 W) and gamma radiation from a Co-60 source. Simultaneous pulse HF fields and gamma radiation acted in a way resembling a cell-protecting mechanism, enhancing the number of surviving cells by about 15% as compared with survival after pure Co-60 gamma radiation treatment. Irradiation with pure HF currents resulted in increasing cell death for a period up to 4 min; subsequently, cell survival seemed to be independent of time. The number of cells survived, as compared with controls, was approximately 80%, at a distance of 6.5 cm from the symmetry axis, perpendicular to the plane of the radiating element. These experiments suggest that the use of simultaneous high-frequency currents as radiosensitizers with ionizing radiation has no practical value. (4 references)

0355 BIOLOGICAL EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS. *(E.)* Gordon, Z. V., Ed., (Inst. Ind. Hyg. Occup. Dis., Moscow, USSR). Translated from Russian. *Joint Publ. Res. Serv.* NTIS: JPRS 63321, Oct. 1974, 262p.

This book, the fourth of such collections, reports the work done between 1968 and 1972 by the Laboratory of Radiofrequency Electromagnetic Waves, of the Academy of Medical Sciences, USSR. Originally published in Moscow in 1973, it has been translated by JPRS and has unlimited availability through NTIS. The report contains 32 articles which include results of hygienic standards at USSR industrial sites, and data on in-depth studies of the mechanisms of action of EM fields. The latter include the effects of varied frequencies, intensities, type (CW or pulsed), and combined effects with x-rays, of EM radiation on the CNS and peripheral blood and blood systems; cellular and neurophysiological responses; and reproduction, testicular microstructure and embryotropic results. A 238-item bibliography is included.

0356 NEW RESULTS OF INVESTIGATIONS ON THE PROBLEMS OF WORK HYGIENE AND THE BIOLOGICAL EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC WAVES. *(E.)* Gordon, Z. V. (Inst. Ind. Hyg. Occup. Dis., Moscow, USSR). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 2-14.

Results are presented of hygienic, clinical, and experimental investigations, including biophysical studies, conducted over the last 5 yr on work hygiene and bioeffects of radiowaves. Due consideration was given to the combined effects of SHF radiation and soft x-rays, SHF and heat, intermittent irradiation, protection of personnel at radio and television stations, as well as to the pathogenic effects of radiowaves. A new trend in the investigations was the study of the dynamics of irradiation of workers employed in handling MW emitters. Both clinical and experimental studies support the contention that the biological effect of radiofrequencies is due in large part to disturbances in regulatory processes. Particularly pertinent data were obtained on the biological effects, including threshold effects, of very low intensity MWs (up to 150 $\mu W/cm^2$). Earlier maximum permissible levels for exposure to electromagnetic fields are being reconsidered. The standards presently in force are shown. (No references)

0357 MAJOR TRENDS IN THE SCIENTIFIC ORGANIZATION OF WORK AT RADIO AND TELEVISION STATIONS. *(E.)* Fukalova, P. P. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 15-24.

Hygienic and physiologic investigations at radio and TV stations pointed to the need for instituting effective protection against radiation and for more effective working conditions. These requirements have been met by extensive technical reorganization and by implementation of protective measures based on the principles of the scientific organization of labor. Protective measures have included substitution of new equipment for old transmitters as well as improved shielding and rational layout of old transmitters. (No references)

0358 HYGIENIC EVALUATION OF WORKING CONDITIONS INVOLVING RADIOWAVE EMITTERS ON THE BASIS OF DYNAMIC STUDIES ON THE NATURE OF RADIATION DURING A WORK SHIFT. *(E.)* Markov, V. V. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 25-31.

Dynamic investigations were made of the nature of irradiation of operators of SHF equipment during the work-shift period. The studies consisted of two parts: measurement of the power flux density at the place of work, and time course studies of the operations performed by workers during adjustments, operation, and testing of a complete radar transmitting assembly of a radar station. The results showed that this occupational group is usually exposed to intermittent radiation which is characterized by alternating periods of radiation and intervals without radiation, and a random variation in the forces and temporal parameters. The resultant data were treated by the mathematical theory for random processes. (No references)

0359 METHODS FOR THE INVESTIGATION OF RADIATION FIELD DISTRIBUTION OF RADAR STATIONS AT CIVIL AVIATION AIRPORTS. *(E.)* Khramova, N. D. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 32-37.

Methods have been developed for measuring the power flux density (PFD) of SHF radiation emitted by radar stations at civil aviation airports. Analysis of PFD levels measured at individual airports from 1968-1970 made it possible to standardize and generalize the various emission conditions. Thus, the results can be used in planning new airports and in determining the proper site for the scanning radar station. For practical purposes, zones of discontinuity between the radar station and various objects can be planned without conducting actual instrumentation studies. (No references)

0360 REGIONAL LOCATION OF METEOROLOGICAL RADAR STATIONS. *(E.)* Khramova, N. D. (no affil.), V. I. Tomoshin, V. I. Belov and V. A. Miroyedov. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 38-45.

Instrumental measurements were conducted to obtain quantitative information on the intensity of SHF radiation emitted by antennas of meteorological radar stations (MRS). The relationship between the power flux density of the MRS electromagnetic field and distance was determined for different heights at maximum emission. Results show that the operation and repair of MRS presents the danger of irradiation for both service personnel and the general population. To decrease the zone of radiation, the MRS should be placed on scaffolds at a height of 10-16 m. (No references)

0361 DISTRIBUTION OF ULTRASHORT WAVE FIELDS IN THE VICINITIES OF URBAN TELEVISION CENTERS. *(E.)* Khramova, N. D. (no affil.), V. A. Miroyedov and V. V. Yur'yev. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 46-53.

Electromagnetic field intensities were measured in residential areas around television centers in six Soviet cities. Good agreement was obtained between calculated and measured data. At a distance of 250-750 meters from a television center, the intensity of the electromagnetic field does not exceed 1 V/m. This value is in accord with the maximum permissible level for ultrashort wave radiation. (No references)

0362 THE CLINIC, PATHOGENESIS, TREATMENT, AND OUTCOME OF RADIOWAVE SICKNESS. *(E.)* Sadchikova, M. N. (no affil.) and K. V. Glotova. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 54-62.

Many years of clinical observation indicate that prolonged work under conditions of exposure to SHF electromagnetic fields of significant intensities (up to several mW/cm^2) may lead to the development of radiowave sickness. Three essential syndromes of this disease have been identified: the asthenic syndrome, the astheno-vegetative syndrome with vascular dysfunction, and the hypothalamic syndrome. Studies on the mechanism of the neurovascular impairment have revealed the significant role of the deep structures of the brain, including the hypothalamic regions. Dysfunction of the hypothalamic-hypophyseal-adrenal cortical system may be highly important in the pathogenic mechanisms responsible for development of clinical symptoms of radiowave sickness. Based on results obtained with 152 patients, essential principles have been formulated to cover drug therapy and late results of treatment. (No references)

0363 STATE OF THE BLOOD SYSTEM UNDER THE INFLUENCE OF SHF FIELDS OF VARIOUS INTENSITIES AND IN RADIOWAVE SICKNESS. *(E.)* Sokolov, V. V. (no affil.), I. A. Gribova, N. A. Chulina, M. N. Gorizontova and M. N. Sadchikova. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 63-71.

Hematologic studies were performed on 131 persons occupationally exposed to SHF electromagnetic fields of high intensity. A sequence of changes was noted in the blood system which initially consisted of stimulation of hemopoiesis with the development of moderate leukocytosis, erythrocytosis, and reticulocytosis. With increased duration of exposure and development of symptoms of radiowave sickness, the stimulatory response was replaced by cytopenic reactions of which the most frequent were leukopenia and thrombocytopenia. Changes in bone marrow hemopoiesis, characterized by an increase in the number of erythronormoblasts, had the distinct character of a compensatory regeneration. In patients with radiowave sickness there was also a tendency for cells in a state of division to increase. While in controls 5.42 ± 0.40 cells out of a thousand nucleated cells were dividing; in the individuals studied mitosis increased to 7.67 ± 0.59 ($p < 0.05$). Proliferation occurred because of intense division of erythroid cells; granulocyte division changes were small. (No references)

0364 GLUCOCORTICOID FUNCTION OF THE ADRENALS IN RADIOWAVE SICKNESS. *(E.)* Dumkin, V. N. (no affil.) and S. P. Korenevskaya. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 72-74.

Corticosteroid excretion in 20 patients with moderate or pronounced manifestations of radiowave sickness was studied by fractionation of urinary extracts by silica gel thin-layer chromatography. Results were compared with those obtained for 10 healthy controls. Total hormone and tetrahydrocortisone and cortisone excretion was reduced in the patients; tetrahydro-17-hydroxy-11-deoxycorticosterone (THS) was slightly increased. Changes in the average value of the hydrocortisone/cortisone ratio in the patient group indicated disturbances in the mechanism responsible for transformation of cortisol into cortisone. Administration of adrenalin hydrochloride (0.3 ml of a 1% solution, s.c.) resulted in even more pronounced changes in THS levels, the hydrocortisone and cortisone fractions, and the hydrocortisone/cortisone ratio. Similar changes in the glucocorticoid function of the adrenal glands were previously detected in patients with toxic diencephalopathies resulting from chronic intoxication with neurotrophic poisons. Changes in glucocorticoid metabolism in patients with radiowave sickness are apparently related to damage of the deep structures of the brain which are responsible for regulating the activity of the hypophysis-adrenal cortex systen (No references)

0365 ELECTROGRAPHIC DATA ON THE EFFECTS OF VERY WEAK MICROWAVES AT THE LEVEL OF THE MIDBRAIN RETICULAR FORMATION-HYPOTHALAMUS-CEREBRAL CORTEX LEVEL. *(E.)* Bychkov, M. S. (no affil.) and I. S. Dronov. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 75-86.

Acute experiments on rabbits exposed to low intensity (up to 100 $\mu W/cm^2$) MWs yielded data on parallel changes in the background electrical activity of the cerebral cortex, the reticular formation of the brain stem, and the posterior hypothalamus. The changes were characteristic of certain intersystemic changes in the brain, and indicated the important role of the subcortical-brain stem structures in the mechanism by which MWs elicit their biological effects in the CNS. Separate long-term experiments were conducted on the interaction between the anterior and the posterior regions of the hypothalamus. In addition to a more pronounced response in the posterior hypothalamus at a given stage of chronic radiation, interaction was characterized by a phasic development of the response to MWs. During the initial stages, the response was expressed very strongly in the form of a generalized deactivation; subsequently, the response became highly attenuated and, at the end, took the form of generalized activation. (No references)

0366 ELECTROENCEPHALOGRAPHIC CHANGES UNDER THE INFLUENCE OF LOW INTENSITY CHRONIC MICROWAVE IRRADIATIONS. *(E.)* Bychkov, M. S. (no affil.), V. V. Markov and V. M. Rychkov. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 87-94.

To elucidate the effects of chronic (2 month) intermittent MW radiation (λ = 10 cm, pulse generated) on EEGs, 12 rabbits were exposed as follows: 150 $\mu W/cm^2$

for 8 min, 10 min rest period; 60 μW/cm^2 for 8 min, 240 μW/cm^2 for 6 min, 34 min rest period; 320 μW/cm^2 for 12 min, 60 μW/cm^2 for 8 min, 14 min rest period; 60 μW/cm^2 for 8 min; 150 μW/cm^2 for 8 min. Total time of irradiation was 1 hr. In a parallel 2-month experiment, 12 rabbits were subjected to continuous MW irradiation (153 μW/cm^2 for 1 hr). The incident energy, as well as the total exposure period, was equal in both studies. Control experiments were conducted on eight rabbits. Both radiation regimes induced distinct, though limited, changes in spontaneous electrical activity, with somewhat greater changes evident in the intermittent radiation group after 10 exposures. More pronounced effects were seen in studies on the reactivity to sub-stress functional stimuli in the form of prolonged (2 min) combined stimulation with light flashes and intermittent sound, with the intensity and the frequency of both stimuli being altered in contrasting directions. Earlier experiments on 110 intact rabbits had revealed two types of transient response to MW stimulation: desynchronization (Type A) and synchronization (Type B). Subtypes of these two responses, representing deviations from optimal and suboptimal regimes of automatic regulation, were observed in a relatively large number of animals in the present study. The major difference between the two radiation regimes was that recovery of spontaneous electrical activity and recovery of automatic regulation were more delayed in animals exposed to intermittent radiation. (No references)

0367 THE EFFECTS OF CONTINUOUS AND INTERMITTENT MICROWAVE RADIATION ON WEIGHT AND ARTERIAL PRESSURE DYNAMICS OF ANIMALS IN CHRONIC EXPERIMENTS. *(E.)* Markov, V. V. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 95-103.

The effects of chronic continuous and intermittent MW radiation of nonthermal intensities on weight dynamics and arterial pressure (AP) were investigated in white rats. The incident energy and the duration of exposure were equal in both studies. A significant lag in weight gain became apparent by the 4th month in animals exposed to intermittent irradiation in comparison with animals subjected to continuous irradiation. This lag was retained not only during the period of irradiation, but also during the recovery period. Changes in AP under both radiation regimes were phasic in nature. The initial phase consisted of elevated AP at the end of the 4th week, while the second phase consisted of a persistent decrease. After termination of radiation (recovery phase), AP gradually increased over a 1.5-month period until close to initial values were obtained. During the initial period of AP changes, the hypertensive effect was more significant in animals exposed to continuous radiation. During the second phase (the major phase in terms of duration), the hypotensive effect was more pronounced in animals exposed to intermittent radiation. (No references)

0368 THE EFFECTS OF CONTINUOUS AND INTERMITTENT RADIATION ON THE FUNCTIONAL STATE OF THE HYPOTHALAMIC-HYPOPHYSIS-ADRENAL CORTEX SYSTEM. *(E.)* Kitsovskaya, I. A. (no affil.) and E. I. Polukhina. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 104-108.

Intermittent and continuous exposure to MWs was virtually without effect on the functional state of the hypothalamus-hypophysis-adrenal cortex system in animals. Retention of the glucocorticoid function of the adrenals was evidenced by a > 50% decrease in eosinophil numbers following administration of adrenocorticotropic hormone (10 U) and 1% epinephrine (0.5 mg/kg), and after a strong sound stimulus (70 dB). Controls showed less reactivity to the sound stimulus, confirming that radiation (intermittent or continuous) was a strong stress factor. The weight of the adrenal glands tended to increase in continuously exposed animals subjected to heat and cold stresses. This may indicate some type of threshold for changes in the functional state of the adrenal glands. (No references)

0369 THE EFFECTS OF INTERMITTENT AND CONTINUOUS RADIATION ON THE FUNCTIONAL STATE OF THE ADRENAL MEDULLA. *(E.)* Kitsovskaya, I. A. (no affil.) and E. I. Polukhina. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 109-112.

Studies on epinephrine and norepinephrine levels in the adrenal glands were conducted on animals exposed to two regimes of intermittent and continuous MW irradiation. The first intermittent regime consisted of two alternating densities (250 and 100 μW/cm^2) and two durations of exposure (1 hr and 15 min); the continuous regime was 2 mW/cm^2 for 30 min. Catecholamine concentrations were measured after 2, 6, and 12 months of irradiation. In the second regime, the maximum intensity of intermittent radiation was 320 μW/cm^2 and the minimum was 60 μW/cm^2; the intensity of continuous radiation was 153 μW/cm^2. Catecholamine levels were determined weekly during 1 month of irradiation. Results of the first experiments showed no significant deviations from normal in the concentrations of epinephrine and norepinephrine. Increases in epinephrine (under both continuous and intermittent radiation) and in norepinephrine (continuous radiation) approached statistical significance only in animals irradiated for 6 months in the presence of a cold stress. Exposure to intermittent and continuous radiation for 1 month did not alter the function of the adrenal medulla; a tendency toward an increased norepinephrine content was observed only in individual cases. (No references)

0370 CERTAIN DATA ON THE BIOLOGICAL EFFECTS OF CONTINUOUS AND INTERMITTENT MICROWAVE RADIATION. *(E.)* Demokidova, N. K. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 113-119.

Male and female white rats were exposed to continu-

ous or intermittent MW (λ = 10 cm) irradiation for up to 5 months. The intensity of the continuous exposure was 153 $\mu W/cm^2$ for 1 hr; intensities of the 2-hr intermittent exposures were 60-320 $\mu W/cm^2$, with the periods of irradiation interrupted by three intervals of 10-34 min. Both continuous and intermittent MW radiation produced significant changes in the weight of such endocrine glands as the hypophysis, the thyroid, and the adrenals. After 4-5 months of continuous exposure, metabolic indices and the weight of the endocrine glands did not differ from the respective control values. After intermittent radiation for 4-5 months, significant changes were apparent in urinary potassium levels and in the weight of the hypophysis (these factors were increased in females and decreased in males). (No references)

0371 THE EFFECTS OF INTERMITTENT AND CONTINUOUS IRRADIATION ON CHANGES IN THE SECRETORY FUNCTION OF THE HYPOTHALAMUS AND CERTAIN ENDOCRINE GLANDS. *(E.)* Tolgskaya, M. S. (no affil.), Z. V. Gordon, V. V. Markov and R. S. Vorontsov. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 120-125.

Comparative morphological studies were conducted on the biological effects of intermittent and continuous irradiation of white rats with microwaves of nonthermal intensities. Studies at the level of the different structures of the hypothalamus-hypophysis-adrenal cortex system revealed reversible changes indicative of exhaustion of the secretory activity of the anterior nuclei of the hypothalamus and of the neurohypophysis. This exhaustion was accompanied by a decrease in blood pressure and a decrease in RNA, DNA, and lipid concentration in the adrenal cortex. Recovery of secretory activity of the hypothalamic nuclei proceeded more slowly and was less complete in the animals subjected to intermittent radiation. (No references)

0372 ON SETTING HYGIENIC STANDARDS FOR THE COMBINATION OF SHF AND X-RAYS. *(E.)* Nikonova, K. V. (no affil.), and I. P. Sokolova. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 126-130.

Results are presented of experimental studies on the nature of the bioeffects elicited by combined exposure of animals to 10-cm MWs and soft E_{eff} = 13.5 kev x-rays. The experiments, conducted with different SHF power flux densities (40, 10, and 1 mW/cm^2) and doses of x-rays (2500, 250, and 25 r) demonstrated that the nature of the response to combined irradiation depends on the intensity of the factors involved. Synergism prevails when the combination consists of high intensity SHF and x-rays; in such a situation, the primary factor responsible for the clinical picture is the soft x-rays. Combined low intensity SHF and soft x-rays elicited different biological effects than those evoked by high intensity radiation. No distinct amplification of the biological effect was evident in comparison with instances in which SHF and x-rays are employed separately. Some effects were due to SHF and others to the x-rays. SHF effects at 1 mW/cm^2 included changes in weight dynamics, blood, immunobiologic reactivity, and morphological changes. For situations where SHF and soft factors are combined, 1 mW/cm^2 cannot be recommended as the maximum permissible limit for SHF; the safety factor is inadequate. (No references)

0373 THE EFFECTS OF COMBINED EXPOSURE TO SHF ELECTROMAGNETIC FIELDS AND SOFT X-RAYS ON THE PERIPHERAL BLOOD. *(E.)* Sokolova, I. P. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 131-138.

Studies with 10 mW/cm^2 and 50 r/week x-ray irradiation showed that a combination of these two factors evoked a much more pronounced leukopenia than did either factor when employed alone. In subsequent long-term experiments, white rats were exposed to 1 mW/cm^2 SHF for 1 hr/day and 25 r/week x-ray radiation, alone or in combination. Combined radiation or MW radiation alone led to a decrease in leukocyte counts that became evident at 2.5-3.5 months and persisted until the end of the experiments (6-9 months). In both groups, the decrease in the number of leukocytes was due to a decrease in the absolute number of lymphocytes. Exposure to combined radiation or to MWs alone also produced a significant decrease in erythrocyte counts after 2.5-4.5 months and a significant increase in reticulocyte counts after 3.5 months. In general, animals exposed to x-rays alone exhibited a moderate decrease in erythrocytes followed by an early return to normal levels. Leukocyte and reticulocyte counts in animals exposed to x-rays alone did not differ significantly from control values. (No references)

0374 THE EFFECTS OF COMBINED EXPOSURE TO MICROWAVES AND SOFT X-RAYS ON IMMUNOBIOLOGICAL REACTIVITY OF ANIMALS. *(E.)* Sokolova, I. P. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 139-143.

Exposure of white rats to a combination of super high frequency fields (1 mW/cm^2 for 1 hr/day) and soft x-rays (25 r/week) for 6 1/2 months resulted in a decrease in the ingestive and digestive functions of neutrophils, and a decrease in the bacteriocidal activity of plasma. These immunobiological changes were analogous to, and no more pronounced than, those seen when either of the physical factors was employed alone. (No references)

0375 PATHOANATOMICAL CHARACTERIZATION OF CHANGES INDUCED IN EXPERIMENTAL ANIMALS BY COMBINED IRRADIATION WITH MICROWAVES AND X-RAYS. *(E.)* Tolgskaya, M. S. (no affil.), K. V. Nikonova and R. S. Vorontsov. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 144-152.

Studies on the morphological changes in organs and tissue of white rats and mice exposed to a combination of SHF and soft x-ray radiation showed that the nature and the extent of the changes correspond to those seen when either physical factor is employed alone. The effects of x-rays predominate when high-intensity combined radiation is used; at low intensities, the histologic picture of the organs and tissues has features characteristic of both factors. Results are presented for three series of investigations conducted with different intensities of irradiation: (1) single 250 r x-ray exposure combined with 10 mW/cm^2 SHF for 2 weeks; (2) long-term exposure to a combination of SHF and x-rays at 10mW/cm^2 and 50 r/week, resp.; and (3) chronic daily 1-hr exposure to 1 mW/cm^2 SHF in combination with x-ray exposure of 25 r/week. (No references)

0376 EXPERIMENTAL STUDIES ON THE BIOLOGICAL EFFECTS EVOKED BY COMBINED EXPOSURE TO MICROWAVES AND HIGH AIR TEMPERATURE. *(E.)* Nikonova, K. V. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 153-162.

Acute and chronic experiments were conducted on white mice and rats to determine the biological effects of exposure to both SHF electromagnetic fields and heat. SHF intensities and air temperatures were 10-90 mW/cm^2 and 38-40 C, resp. The combination of SHF and high air temperatures exerted a more potent biological effect in terms of a number of indices (body temperature, physical endurance, weight dynamics, and arterial pressure) than did either factor employed alone. The combined exposure also had a more pronounced effect on conditioned reflex activity of mice and on the bioelectrical activity of rabbit brain. All 18 mice exposed to 80 mW/cm^2 SHF at 40 C died within 17-41 min. Subsequent experiments at 60 mW/cm^2 and 40 C indicated that time of death coincided with a rapid rise in body temperature. (No references)

0377 RESULTS OF EXPERIMENTAL STUDIES ON ELECTROMAGNETIC IRRADIATION WITH LOW INTENSITY USW, SW, AND MW. *(E.)* Fukalova, P. P. (no affil.), M. S. Bychkova, M. S. Tolgskaya, I. A. Kitsovskaya, A. P. Volkova, and N. K. Demokidova. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 163-167.

Threshold values were established for the biological effects of ultrashort waves (USW), short waves (SW), and medium waves (MW) in laboratory experiments on white mice, rats, and rabbits. The values are based on analysis of the quantitative relationship between the biological effects and the incident energy. USW bands (69.7, 155, and 191 MHz) at intensities of 10-12 V/m induced insignificant short-term changes in blood pressure, immunobiological reactivity, EEG, and morphology; similar changes were not seen at intensities of 2.5 or 5 V/m. Studies on the effects of SW (14.88 MHz) and MW (500 kHz) bands were conducted with intensities of 70 and 600 V/m, resp. Exposure to 70 V/m SW for 8 months did not affect physical endurance, blood pressure, vascular permeability, or the threshold of neuromuscular excitability. Moderate and mostly short-term effects of SW were lag in weight gain, changes in the hypophysis-adrenal system, insignificant decrease in natural immunity, moderate morphological changes, and EEG changes. MW did not evidence a biological effect in terms of most of the parameters investigated. *These results were* used in setting hygienic standards. (No references)

0378 CHANGES IN CERTAIN PROTECTIVE REACTIONS OF AN ORGANISM UNDER THE INFLUENCE OF SW IN EXPERIMENTAL AND INDUSTRIAL CONDITIONS. *(E.)* Volkova, A. P. (no affil.) and P. P. Fukalova. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 168-174.

Outbred white rats exposed over a 10-month period to short wave (SW) electromagnetic radiation (14.99 MHz) at an intensity of *2250* V/m for 1 hr, or *100* V/m for 4 hr, showed a change in natural immunity which was more pronounced when the higher intensity was used. The phagocytic activity of neutrophils decreased by 56% in animals exposed to 2250 V/m compared with 25% for animals subjected to the lower intensity radiation. Recovery of phagocytic activity did not occur in either group. Plasma bacteriocidal activity decreased by 11% following high-intensity irradiation, while activity after low-intensity radiation was the same as the control value. The course of an inflammatory reaction, induced by administration of *E. coli* beneath the aponeurosis of the foot, also was more pronounced in rats exposed to the more intense radiation. Four days after infection, the degree of the inflammatory reaction was 6.6 ± 0.5 units in animals exposed to 2250 V/min, 5.0 ± 0.01 in animals exposed to 100 V/m, and 4.0 ± 0.3 in controls. At the end of 2 wk, the corresponding values were 1.2 ± 0.02, 0.5 ± 0.001, and 0.2 ± 0.01. Inhibition of natural immunity (e.g., 2-fold inhibition of phagocytic activity and 4-fold increase in autoflora counts in the mouth cavity) was also observed among engineers and technicians at radio centers where intensity of irradiation exceeded the maximum permissible level (up to 20 V/m). Changes in natural immunity did not occur in a group of 69 men at stations where irradiation levels did not exceed maximum permissible levels. (No references)

0379 CERTAIN PRINCIPLES GOVERNING THE EFFECTS OF MICROWAVES ON K^+ AND Na^+ TRANSPORT IN HUMAN ERYTHROCYTES. *(E.)* Shtemler, V. M. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 175-187.

Microwave irradiation of human erythrocyte suspensions affected the rate at which K^+ and Na^+ were transported into the erythrocytes. Transport rates were studied in relation to the frequency, intensity, and duration of exposure, and in terms of recovery dynamics following termination of irradiation. At fixed intensities, the relationship between changes in the rate of transport and time was the sum of a linear component and an autoregulatory component, the latter arising under conditions of over-regulation with amplitude attenuation. The product of the first component is equal to the absorbed dose and its effects are microthermal; the second component is responsible for protecting the cell against damaging influences. After 30 min of irradiation (2340 MHz and 50 mW/cm^2 intensity), complete recovery occurred in about 90 min. Longer exposure at the same intensity evoked disruption in autoregulation and recovery did not occur. Apparently changes in the rate of electrolyte transport are due to partial destruction of the erythrocyte membrane which leads to its decreased resistance. Relatively weak and short-term exposures evoke reversible changes in the membrane structure, while more powerful and prolonged exposures elicit irreversible damage. (No references)

0380 THE EFFECTS OF MICROWAVES ON ACTOMYOSIN ATPase ACTIVITY. *(E.)* Shtemler, V. M. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 188-194.

In vitro experiments demonstrated a significant but variable decrease in adenosine triphosphatase (ATPase) activity of actomyosin of rabbit muscle under the influence of MW irradiation (250 MHz). Irradiation of an enzyme-substrate mixture of actomyosin-ATP did not induce significant changes in ATPase activity, indicating that ATP was bound to the active center of the actomyosin molecule and thereby preserved its specific conformation. Thus, the effects of an EM field are due to its influence on the activity center of ATPase activity in the actomyosin molecule. The nature of the variation of ATPase activity in actomyosin solutions is discussed in relation to the involvement of intermolecular water in this process. (No references)

0381 THE DEPENDENCE OF THE TEMPERATURE RESPONSE TO MICROWAVE IRRADIATION ON THE INITIAL FUNCTIONAL STATE OF THE CNS. *(E.)* Lobanova, Ye. A. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 195-200.

Temperature response to microwave irradiation (10 cm and 40 mW/cm^2 intensity) for 30 min was investigated in white rats with initial changes in the functional state of the CNS induced by prior s.c. administration of neurotropic agents. Chlorpromazine (5 mg/kg) and acetylcholine (60 mg/kg) decreased the hyperthermic effect of MWs and shortened the period of temperature recovery, while epinephrine (1 mg/kg) and atropine (10 mg/kg) had the opposite effects. Under the thermogenic conditions of MW irradiation, the tone of the sympathetic branch of the autonomic nervous system predominates. (No references)

0382 INVESTIGATIONS ON THE SUSCEPTIBILITY OF ANIMALS TO MICROWAVE (MW) IRRADIATION FOLLOWING TREATMENT WITH PHARMACOLOGIC AGENTS. *(E.)* Lobanova, Ye. A. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 201-204.

Studies were conducted on the sensitivity of white rats to MW irradiation (14 mW/cm^2 for 2 hr) before or after the administration of 15 pharmacologic agents. The clinical picture induced by MW irradiation was that of a state of excitement which was replaced by a state of depression subsequent to a 1.2 ± 0.2 C rise in body temperature. After depression set in, hyperemia was evident and rectal temperature increased by 4.5 ± 0.2 C. Death followed convulsive twitches of the head and extremities. Only the sedatives chloral hydrate (200 mg/kg) and sodium barbital (200 mg/kg) and the antidepressant bemegride (7.5 mg/kg) decreased susceptibility to MW irradiation, as indicated by increased survival times. Under irradiation, survival times with chloral hydrate and sodium barbital were 101 ± 4' and 97 ± 11', resp., compared with control survival time of 71 ± 4'. Five of 12 rats treated with bemegride survived for 110 ± 6' in contrast to the control survival time of 81 ± 11'. Caffeine (100 mg/kg), a cerebral cortex stimulant, and pentylenetetrazol (60 mg/kg), a subcortical stimulant like bemegride, increased the susceptibility of animals to MWs. Susceptibility to MWs was also increased by substances which inhibit or stimulate adrenoresponsive structures in the brain (chlorpromazine, 5-10 mg/kg; epinephrine, 0.2-0.5 mg/kg; ephedrine, 40 mg/kg) and by substances which inhibit or stimulate cholinoreactive structures (atropine, 10-29 mg/kg; acetylcholine, 60 mg/kg; nicotine, 3 mg/kg). Stimulation of serotonin responsive structures by serotonin (10 mg/kg) and mexamine (10 mg/kg) prior to irradiation did not influence susceptibility to MWs, while indopan (20 mg/kg), a monoamine oxidase inhibitor, significantly increased susceptibility. Stimulation of the adrenals by exogenous adrenocorticotropic hormone (3 U) did not alter susceptibility of rats to subsequent MW irradiation. The basis for the positive effects of chloral hydrate, sodium barbital, and bemegride has not yet been determined. (No references)

0383 PRINCIPLES OF NEUROPHYSIOLOGICAL INVESTIGATIONS OF MICROWAVE BIOEFFECTS AND CHANGES IN ELEMENTARY EXCITABLE STRUCTURES ON EXPOSURE TO VERY LOW INTENSITY IRRADIATION. *(E.)* Bychkov, M. S. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 205-213.

Studies were conducted on the methodologic limitations of electrographic studies of EM fields, which are due to the appearance of artifacts resulting from SHF-induced currents. Results are presented of electrophysiological studies on frog-nerve muscle preparations irradiated at 5 $\mu W/cm^2$ power flux density for 5 min. The data demonstrate a change in the membrane potential, threshold of excitability, latent and refractory periods, rate of conduction, amplitudes of the action potentials of muscle fibers, synpatic delays at the myoneural junction, and impulse activity of individual neurons in the nerve ganglia of the medicinal leech. Differences in inhibition of neuronal activity in isolated and non-isolated ganglia are described. (No references)

0384 THE PROBLEM OF GLIO-NEURONAL RELATIONSHIP IN THE RAT CEREBRAL CORTEX DURING LONG-TERM EXPOSURE TO MICROWAVES. *(E.)* Kazbekov, I. M. (no affil.) and Ye. A. Lobanova. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 214-220.

Cytometric studies were conducted on the glio-neuronal relationship in the brain cortex of rats exposed to 10 cm MWs at an intensity of 10 mW/cm^2 for 60 min/day over a 6-month period. Despite relatively weak (but significant) changes in the dimensions of the cytoplasm and the nuclei of neurons, the numbers of perineural gliocytes in the irradiated animals increased several-fold in comparison with controls. The greater reactivity of the neuroglia can be regarded as a protective reaction against the MWs which themselves did not elicit changes in the neurons. (No references)

0385 STUDIES ON THE REPRODUCTION AND TESTICULAR MICROSTRUCTURE OF MICE EXPOSED TO MICROWAVES. *(E.)* Bereznitskaya, A. N. (no affil.) and I. M. Kazbekov. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 221-229.

White outbred male mice were exposed to microwaves (λ = 10 cm) of subthermal intensity (10 mW/cm^2), 2 hrs/day, either prenatally, for 5 months during the postnatal period, or pre- and postnatally. Studies of reproductive function in the irradiated animals revealed poorly delineated changes which were reflected in a decrease in the number of progeny of healthy females mated with the males, and an increase in the number of defective offspring. The most pronounced changes were noted in mice exposed to MWs both pre- and postnatally. Studies of the microstructure of the testes of exposed mice showed an increased number of seminiferous tubules with desquamated germinal epithelium, formation of giant cells, and decreased weight coefficient of the testes. Again, the changes were most marked in mice exposed to MWs both during embryonic development and in the postnatal period. (No references)

0386 EMBRYOTROPIC EFFECTS OF MICROWAVES. *(E.)* Bereznitskaya, A. N. (no affil.) and T. Z. Rysina. *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 230-236.

Female white mice were exposed to microwaves (λ = 10 cm, 10 mW/cm^2 power flux density) for 2 hr/day from the 1st to the 15th day of pregnancy. The average number of living fetuses in the irradiated females was 6.95 ± 0.13 compared with 7.9 ± 0.08 in controls. Preimplantation death of zygotes reached 13.06 ± 2.39% in the experimental animals and 5.0 ± 1.6% in the controls; postimplantation mortality of the embryos was, resp., 15 ± 2.76% and 6.47 ± 1.99%. In the control group, postnatal mortality was 15.4 ± 2.83%; 36.7 ± 5.5% of the irradiated mice did not survive to the 21st day. The high postnatal mortality in the irradiated mice corresponded to the greater number of weak and debilitated offspring. Developmental anomalies were more frequent (56.16 ± 3.89% versus 37.06 ± 4.48%) in embryos exposed to MWs. In the exposed embryos, an increase in the ventricles of the brain (hydrocephaly) and general underdevelopment of the embryo (small size, absence of eyelids, underdevelopment of the external ear) accounted for 45.8% of the development anomalies. These anomalies were completely absent in the controls. Irradiated mice also showed impairment in excitability of the CNS. These results point to the potential embryotropic danger of MWs. (No references)

0387 THE EFFECTS OF RADIOWAVES ON THE GROWTH OF ANIMALS. *(E.)* Demokidova, N. K. (no affil.). *Biological Effects of Radiofrequency Electromagnetic Fields.* Z. V. Gordon (ed.) NTIS: JPRS 63321, 1974, pp. 237-242.

The effects of UHF and HF bands on indices reflecting the state of the growth function of the adrenohypophysis were investigated. Irradiation of adult rats with UHF (69.7 MHz, 12 V/m, 1 hr/day, for 1.5 months) resulted in an increase in body weight and a significant increase in the weight of the hypophysis. However, histologic study of the adrenohypophysis revealed no difference in the number of acidophilic cells between the irradiated and control rats. Serum alkaline phosphatase activity and the width of the tibial cartilage were decreased, suggesting activation of the adrenal cortex. Irradiation of infant mice at 48 V/m, but not at 5 or 12 V/m, for 4 hr/day for 1.5 months produced a significant decrease in the weight of the thyroid gland and a significant increase in the weight of the adrenal gland. The size of the tibial cartilage tended to decrease in all experiments, but body weight did not change. Ex-

posure of 2- to 8-month-old mice to the HF band (14.88 MHz, 70 V/m, 0.185 A/m) led to a significant increase in body weight and significant decreases in the weight of the adrenal and thyroid glands, diuresis, and urinary levels of total nitrogen and chlorides. Body length of irradiated animals did not differ from that of controls. The data indicate that radiowaves do not stimulate the growth of rats; the increase in body weight of young rats exposed to microwaves in the presence of water, chloride, and nitrogen retention is apparently due to a depression of metabolism which is mediated via the endocrine system. (No references)

0388 A REVIEW OF MICROWAVE RADIATION HAZARDS AND SAFETY STANDARDS. *(E.)* Lindsay, I. R. (Inst. Naval Med., Alverstoke, U. K.). *Ann. Occup. Hyg.* 17(3/4):315-320, 1975.

Available data relating to MW hazards are frequently uncertain, contradictory, or inapplicable. The current United Kingdom and U.S. safety standard of 10 mW/cm^2 assumes that the only biological effects of microwave radiation are thermal in nature, and that thermal effects do not occur below 100 mW/cm^2. The Soviet maximum permissible exposure is 0.01 mW/cm^2 for a working day; it can be raised to 1 mW/cm^2 for a 20-min exposure. This standard is based, to a great extent, on psychological and neurasthenic responses in exposed personnel which have not been observed elsewhere. Differences in the evaluation criteria used in the East and the West should be resolved in the interest of international agreement. Adequate and operable standards should be developed from careful and intelligent evaluation of information obtained from animal experiments and surveys of occupationally exposed individuals. (16 references)

0389 DEVELOPMENT OF ELECTRIC AND MAGNETIC NEAR-FIELD PROBES. *(E.)* Greene, F. M. (Electromagnetics Div., NBS, Boulder, Colo.). *NBS Tech. Note* 658, 1975, 47p.

The development and design of small electric and magnetic near-field probes for measuring hazard-level fields up to 20,000 V/m and 100 A/m, resp., are described. The probes, originally designed for use at 10-30 MHz, consist of short dipole antennas (which measure the electric field components) and small, single-turn, balanced loop antennas (which measure the magnetic field components). They are intended for use in radiation-exposure programs to determine the effects of hazard-level, nonionizing, EM fields on living tissue, electro-explosive devices, and volatile fuels. To extend the application of the probes to frequencies above 30 MHz, a detailed analysis was made of several types of measurement errors likely to be encountered. The principal errors result from a variation with frequency in: (1) the effective length and impedance of the dipoles, and (2) the electric-dipole response and partial resonance of the loops. Corresponding corrections are given for each type of error as a function of the operating frequency from 10-1000 MHz and as a function of the physical and electrical sizes of the probes. As a result of the analysis, the dipoles can be used for measurements at frequencies up to 750 MHz, and the loops to 75 MHz with an estimated uncertainty of 0.5 dB. Applying recommended corrections will provide a substantial further increase in the usable frequency range. (14 references)

0390 DEVELOPMENT OF MAGNETIC NEAR-FIELD PROBES. *(E.)* Greene, F. M. (Electromagnetics Div., NBS, Boulder, Colo.). *HEW Publ.* No. (NIOSH) 75-127, 1975, 28p.

The Nonionizing Radiation Exposure Standard (June 2, 1974) includes EM radiation from 10 MHz to 100 GHz. The relationship between the electric and magnetic fields is completely ambiguous for EM fields within the RF region between 10-300 MHz. Thus, the electric and magnetic fields must be measured separately to characterize adequately the total occupational exposure from EM fields at 10-300 MHz. In the absence of commercially produced survey instruments, the Physical Agents Branch of NBS has developed two portable magnetic-field-strength probes for use in assessing occupational exposure from industrial RF power sources. These probes consist of small, single-turn, balanced loop antennas 10 cm and 3.16 cm in diameter. Their measuring range varies with frequency but averages 0.5-5.0 and 5.0-50 A/m, resp. The probes are specifically calibrated for use within the ISM bands at 13.56, 27.12, and 40.68 MHz but can be used at any frequency from 10-40 MHz. The probes accurately measure magnetic near-fields which exist within a few centimeters of an RF radiation source. They will be used by NIOSH in its program to determine the bioeffects of hazard-level, nonionizing EM fields on human beings. (3 references)

0391 EFFECTS OF MICROWAVES: LOCAL "HOT SPOT" HEATING BY MICROWAVES. *(E.)* Schwan, H. P. (Univ. Pennsylvania, Philadelphia). *ONR Rep.* Contract N00014-67-A-0216-0015, NTIS: AD/A-001 558, 1975, 9p.

Studies of MW effects on biological systems showed that hot spots are possible at frequencies of 0.3-10 GHz. The spots may occur either from resonances of the total exposed body section or from the focusing of MWs by the curved surface of the exposed body segment. While hot spots of considerable intensity can be evoked in small brain structures (e.g., cats), they are weaker in the human brain. Cerebral blood flow prevents strong local temperature elevations; for a brain structure typical for man, local internal temperature elevations resulting from an external MW flux of 10 mW/cm^2 are only a fraction of a degree C. Nonthermal effects of alternating electrical fields include pearl chain formation, cellular orientation phenomena, and shape changes. These effects are not produced more effectively by pulsed fields than by a continuous one of the same average power. In amoebae, the threshold field strength for

direct mechanical effects was 1 V/cm or less. A direct action of MWs is improbable at the microscopic and molecular level, but a direct mechanical effect becomes substantial at the macroscopic level. A nearly frequency-independent current density of approximately 2 or 3 mA/cm^2 could be established as a standard not to be exceeded in any tissue. This standard would provide a rationale for standards for MWs, RF fields, magnetic fields, and inhomogeneous fields. Standards of safe exposure for RF fields can be orders of magnitude higher than the 10 mW/cm^2 in existence for MWs. (No references)

0392 EFFECTS OF EXPOSURE TO PULSED MICROWAVES (RADAR) ON CENTRAL NERVOUS SYSTEM EXCITABILITY IN LABORATORY ANIMALS. *(E.)* Hunt, E. L. (Biol. Dep., Battelle Pacific Northwest Lab., Richland, Wash.), R. D. Phillips and N. W. King. *ONR Final Rep.* Contract N0014-70-C-0197, NTIS: AD786753, Oct. 10, 1974, 62p.

A MW bioeffects project was designed to develop reliable exposure methods and dose estimation procedures for animal studies on the potential effects on CNS excitability. A resonating cavity exposure chamber, powered by a 2.45 GHz magnetron, was developed and provided accurate control of the integral energy delivered multilaterally to the animal. A high-performance anechoic chamber, powered by a 2.88 GHz radar transmitter, pulsed with high peak power, provided planewave irradiation. For use in both systems, a biodosimetry method based on latency for MW-induced seizures was developed for indexing exposure levels, validating biophysical dosimetry measurements, and investigating effects of field geometry. Acoustically primed SJL/J mice were tested for decreased CNS excitability, as reflected in audiogenic seizures. Seizures developed in all sham-irradiated mice and all mice irradiated at 20 mW/g for 30 min; the form of the seizures differed, however. Eleven of the 12 controls showed full tonic-clonic seizures, whereas only six of the irradiated mice exhibited this reaction, the remaining six showing a mild "wild running" form of seizure. Exploratory activity in Wistar rats decreased for several hr following a 30-min irradiation at 6.3 mW/g. The response is probably related to autonomic regulatory adjustments initiated by the irradiation. (56 references)

0393 BIOLOGICAL EFFECTS OF MICROWAVES ON THE HYPOTHALAMIC/PITUITARY/THYRODIX AXIS. *(E.)* Magin, R. L. (Univ. Rochester Sch. Med. Dent., N. Y.) and S. M. Michaelson. *Univ. Rochester At. Energ. Proj. Rep.* No. UR 3490-440, 1974, 4p.

Microwave-induced neuroendocrine effects have recently been reported. A specific part of the neuroendocrine system, the hypothalamic-hypophysial-thyroid (HHT) axis, has indicated a sensitivity to pertubation following MW irradiation. Mechanisms proposed to explain the observed changes in thyroid functions have included direct CNS, thermal, or nonthermal stimulation; alteration of internal temperature gradients within the brain or other parts of the body; and peripheral nerve stimulation. However, the exposure conditions are either not known, as in the cases of thyroid dysfunction in humans reported in the USSR, or consisted of whole body irradiation, as in most animal experiments. Thus, the focus of action of microwaves on a particular point in the HHT axis cannot be specified. (No references)

0394 THERMOGENETIC AND CARDIODYNAMIC REGULATION IN DOGS CRANIALLY EXPOSED TO 2450 MHz (CW) MICROWAVES. *(E.)* Lu, S. T. (Univ. Rochester Sch. Med. Dent., N. Y.), R. Bogardus, J. Cohen, J. Jones, E. Kinnen and S. Michaelson. *Univ. Rochester At. Energ. Proj. Rep.* No. UR-3490-441, 1974, 7p.

Cardiovascular and neuroendocrine function was studied in pentobarbital-anesthetized dogs cranially exposed to 2450 MHz (CW) MWs. Cranial exposure for 1 hr to power densities from 20 to 100 mW/cm^2 resulted in a slowing or reversal of the cooling process and an alteration of internal thermal gradients that were dependent on both power density and ambient temperature. Hyperthermia could be achieved only at >50 mW/cm^2 and a supraneutral ambient temperature. A paradoxical increased rate of skin cooling was found after the beginning of an 80 mW/cm^2 exposure; shivering occurred only at higher power densities and persisted in spite of the reversal of cooling at these densities. Heart rate change and the rate of change of isovolumic intraventricular pressure showed a correlation with body temperature. Pulmonary and renal circulation increased during irradiation, but both pulmonary and systemic blood pressure appeared to be refractory. Instead of the positive chronotropic action observed with barbiturate anesthesia, a negative chronotropic effect of microwaves on the heart was observed when morphine sulfate was used as a preanesthetic agent. Compared with skin, rectal, and jugular temperatures, tympanic tempature showed the best and widest correlation with circulatory parameters; it was also the most sensitive indicator of thermal changes. The results suggest that MWs induce alteration in the "set-point" for thermal regulation. (No references)

0395 SENSATION AND PERCEPTION OF MICROWAVE ENERGY. *(E.)* Michaelson, S. M. (Univ. Rochester Sch. Med. Dent., N. Y.). *Univ. Rochester At. Energ. Proj. Rep.* No. UR-3490-550, 1974, 12p.

Sensing or perception of MW/RF energy is accomplished through various mechanisms. In mammals, the main phenomena of sensation or perception are those of thermal sensation and, in selected cases, audition. Thermal sensation is accomplished by stimulation of thermosensitive nerve endings in the skin. Although some investigators believe that "hearing" or audition is evidence of direct nerve stimulation, the most recent data show this phenomenon to be due to electromechanically induced vibrations in tissue and normal reception in the cochlea of the ear. Threshold data are presented for the warmth sensation induced by MWs and for the auditory perception of MW energy. (49 references)

0396 BIOLOGICAL EFFECTS OF MICROWAVE RADIATION ON THE TESTES OF SWISS MICE. *(E.)* Varma, M. M. (Bio-Environ. Eng. Sci. Res. Lab., Howard Univ., Washington, D. C.) and E. A. Traboulay. *ONR Rep.* Contract N0014-73-A-0346 Rep., 1974, 10p.

The biological effects of MW radiation on testicular tissue of 55- to 65-day-old Swiss mice was studied at 1.7 and 3.0 GHz. The power density and exposure time varied. At 1.7 GHz and a power density of 10 mW/cm^2 for 100-min exposures, severe changes in morphology were observed. The number of cells in the seminiferous tubules was reduced and the tubules showed sloughing of degenerating germinal cells in the lumen, which appeared as a coagulated mass of fused spermatids. At the same frequency, exposure to 50 mW/cm^2 for 30-40 min altered spermiogenesis: the lumens were empty with complete disintegration of spermatids, sertoli cells, and the connective tissue which surrounds the seminiferous tubules. Injuries at 3.0 GHz were minimal. (12 references)

0397 PROBLEMS OF PROTECTION AGAINST NONIONIZING RADIATION. *(Fr.)* Jammet, H. (Dep. Prot., At. Energ. Comm., Fontenay-aux-Roses, France). *Proc. Int. Cong. Int. Radia. Prot. Assoc.*, Washington, D. C., Sept. 9-10, 1973, 26p.

The physical properties, uses, possible occupational and non-occupational exposures, and the biological and physiological effects and health hazards of nonionizing radiation are reviewed. Microwaves produce heat in the irradiated organism by exciting certain vibration and rotation levels in atoms. The nonthermal effects of MW radiation on the body are of secondary importance. The MW-generated temperature increment of the body is a function of the energy content of the absorbed MWs, of the heat conduction capacity, and heat transfer capacity of the irradiated tissue. MWs absorbed by the body produce local hyperthermia or even burns, and are most dangerous for tissues with low degree of vascularization, such as the crystalline lens, which becomes opacified after a certain exposure time. Fatigability, somnolence, or insomnia; headache, sensorial disorders, emotional instability; increased neuromuscular excitability, anorexia, nausea, disorders of the cardiac rhythm; vagotonic crises, changes in lipothymic status, adrenal insufficiency, thyroidal hyperfunction; as well as ionic, electrophoretic and cytological changes of the blood, such as, anemia, lymphopenia, and polynucleosis were demonstrated in subjects exposed to low-intensity MW radiation. Broadcast waves are too weak to produce any biological effect in the organism even during occupational exposure. While there are no criteria for a maximum allowable radiation dose, and there has been no uniform standard established, the maximum allowable dose is usually set at 10 mW/cm^2 for relatively prolonged occupational exposure, and at 1 mW/cm^2 for continuous exposure. Certain countries, such as the USSR, have adopted limits ranging from 1 to 0.01 mW/cm^2, depending on the exposure time, on the basis of the nonthermal, functional effect of MW radiation. The development of closed systems with minimized radiation leak, the designation of no-access safety zones around high-power, open radiation sources, and minimization of the number of persons occupationally exposed to radiation are the most important measures in radiation protection. Goggles and protective clothing may be necessary in special cases for individual protection. (No references)

0398 TEST PROCEDURES FOR MEASUREMENT OF THE LEVEL OF RF ENERGY FROM VARIOUS DEVICES. *(E.)* *Fed. Commun. Comm. Rep.* No. FCC/OCE T74-01, NTIS: PB-236 994, 1970-1974, 22p.

Procedures used by the Federal Communication Commission's Laboratory in type approval testing of devices emitting RF energy are presented. The procedures cover: (1) wireless microphones operating in the 88-108 MHz band and auditory training transmitters operating in the 72-76 MHz band; (2) microwave ovens; (3) Class I TV devices; and (4) a radio control for a door opener. Manufacturers are urged to employ these procedures to increase their likelihood of receiving a grant for type approval. The procedures should also be used to test subsequent production of a type approved device to assure that all such devices continue to comply with the applicable regulations. (No references)

0399 AN EXAMINATION OF REGENERATING HEPATIC TISSUE SUBJECTED TO RADIO FREQUENCY IRRADIATION. *(E.)* McLees, B. D. (U.S. Naval Med. Res. Inst., Bethesda, Md.), E. D. Finch and M. L. Albright. *J. Appl. Physiol.* 32(1):78-85, 1972.

The effects of both pulsed and CW irradiation on mitotic activity and chromosomal aberrations in regenerating liver of partially hepatectomized Sprague-Dawley rats were investigated. Power absorption by the animals was 1.2-1.3 mW/g, or slightly below the threshold required for a rise in body temperature. Peak mitotic activity occurred 32-36 hr after partial hepatectomy. In both the CW and pulsed experiments, there was no significant difference between sham-irradiated and experimental animals in mitotic index values or percent of mitotic aberrations. The aberrations occurred primarily in the anaphase and telophase stages of cell divisions; the most common forms were bridging and fragmentation. No evidence for cellular damage at the histologic or ultrastructural level was found. In particular, there was no evidence of hepatocyte swelling, erythrocyte accumulation, or swelling of mitochondria from liver and kidney. The relationship of these results to similar studies in the literature and to radiation safety requirements is discussed. The exposure levels used in this study may represent the upper limit to which humans can be safely exposed. (44 references)

0400 RISKS AND DAMAGES DUE TO OCCUPATIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS. *(It.)* Molteni, G. (Luigi Devote Clin. Occup. Dis., Univ. Milan, Italy). *Med Lavoro* 65(1-2):25-29, 1974.

Biological effects of, and health hazards due to, occupational exposure to MW radiation are reviewed. MW radiation exerts mainly thermal effect on the organism, and its biological thermal effect is essentially determined by the rate of absorption and the depth of penetration of EM waves. The absorption rate is a function of the water content of the body and the dielectric constant of the tissues. The depth of penetration is directly correlated with the presence of adipose tissue. The quantity of the heat absorbed is a function of the heat dispersion capacity of the body. The sensitivity of the organs is determined by the water content, the presence of adipose tissue, the degree of vascularization of the tissues, as well as of the mitotic index and of the degree of cell differentiation. Crystalline lenses, having a low degree of vascularization, and low heat dissipation capacity, as well as the testes and the nerve tissues, especially the hypothalamus, are the most sensitive organs with respect to MW radiation. MW-induced hyperthermia of the testes results in a reduction of the androgen production by the interstitial tissue. Hyperthermia of the hypothalamus may also result in a reduced androgen production due to hypofunction of the hypothalamus with resulting reduction of the gonadotropin production. The nonthermal effects of EM radiation include the demodulating effect, and the EM and molecular effects, the latter of which are of little significance for the human body. EM waves are able to orient electrically charged particles over 15 microns in diameter, and to exert a catalytic effect on certain chemical and enzymatic reactions within a narrow frequency band. EM waves were found to modify the amplitude and frequency of EEG and ECG waves. (6 references)

0401 INFLUENCE OF LOW-INTENSITY MICROWAVES ON THE ACID-BASE BALANCE IN EXPERIMENTAL ANIMALS. *(Rus.)* Shaposhnikov, Yu. G. (Dep. Surg., Cent. Inst. Postgrad. Train. Phys., Moscow, USSR) and I. F. Yares'ko. *Eksp. Khir. Anesteziol.* (6):60-61, 1974.

Guinea pigs were exposed to low-intensity MW radiation (5 mW/cm^2, wavelength 12.6 cm) 1 hr daily for 4 months to study the effect of such radiation exposure on the acid-base balance of the organism. The low-intensity radiation caused a persistent, strongly compensated shift in the acid-base balance, which manifested itself in a reduction of the carbon dioxide partial pressure in the plasma (37 ± 1.03 mm mercury), and of the total carbon dioxide level (22.6 ± 0.7 mEq/l), while the pH value was within the physiological range with 7.39. The significant decrease in the plasma carbon dioxide concentration was a result of hyperventilation, which is a specific adaptive reaction of the irradiated animals to low-intensity radiation. The tendency toward metabolic acidosis in the treated animals represents a compensatory factor in response to the reduced plasma carbon dioxide level. (6 references)

0402 VARIABLE FREQUENCY EXPOSURE SYSTEM FOR SMALL BIOLOGICAL SPECIMENS. *(E.)* McRee, D. (Natl. Inst. Environ. Hlth. Sci., Research Triangle Park, N. C.), P. Walsh, and R. Mathew. *Rev. Sci. Instrum.*, 46(3):253-256, 1975.

A variable frequency system referred to as the log-periodic-parabolic reflector system for exposure of small biological specimens has been developed. This system provides continuous wave and modulated EM radiation from 1-10 GHz with a variable power density from 0-20 mW/cm^2. The field at 61 cm from the irradiator assembly has a uniformity of ±10% over a 6 cm circle. The variable frequency sources are sweep oscillators with octave bands of 1-2, 2-4, 4-8, and 8-12.4 GHz which produce at least a 20 mW output throughout the entire frequency range. The function generator (range 0.0005 Hz to 5 MHz) and pen modulator provide the capability of pulse, square wave, sine wave, triangle wave or ramp function modulation. The forward and reflected power can be monitored at any given frequency and the system can be adjusted to provide maximum irradiated power. The MW field produced at the specimen location 61 cm from the illuminator enclosure is a planewave type field with a horizontal electrical field and vertical magnetic field. The shape of the MW field profiles may be changed by changing the antenna-to-reflector distance. The disadvantages of the system are its small uniform field size and power density availability at the specimen location. The primary advantages are (1) a wide range of frequencies with adequate power densities can be obtained economically; and (2) the planewave field is achieved at small distances from the illuminator permitting the entire system to be placed in a relatively small area. (12 references)

0403 BLOOD PROTEINS IN PERSONS EXPOSED LONGTERM TO 300 kHZ-300 MHz ELECTROMAGNETIC RADIATION. *(Pol.)* Pazderová, J. (Fac. Gen. Med., Charles Univ., Prague, Czechoslovakia), J. Pícková and V. Bryndová. *Pracov. Lék.* 26(8):292-295, 1974.

The total blood serum protein and protein spectrum were examined in 153 technicians at television (TV) broadcasting stations, shortwave (SW) and medium-wave (MW) radio stations. The mean period of exposure at the individual transmitters amounts to 10, 14, and 17 years; the mean intensity of the EMF was 4.9, 15.6, and 7.0 V/m. All the individual values and also the mean blood proteins and their fractions were within the physiologic limits in the entire group. Comparison with a control group of 100 members disclosed the following differences in the mean values at 5% level of significance: Decrease of the albumin-globulin quotient in persons exposed to MW, conditional on the decrease of albumins and increase of alpha 1 and beta globulins. Decrease of beta globulins in persons exposed to SW, and decrease of gamma globulins in those exposed to TV. The total blood proteins were higher in the latter two groups. The deviations, determined statistically, can be considered to be an expression of the reaction by organisms to longterm EM radiation of low intensity, but they are too negligible to be considered pathological. (17 references)

SOURCE: Proceedings of the International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, Warsaw, Poland, October 15-18, 1973.

0404 WHO CONCERN AND ACTIVITIES RELATED TO HEALTH IMPLICATIONS OF MICROWAVE RADIATION. *(E.)* Dieterich, B. H. (Div. Environ. Hlth, WHO, Geneva, Switzerland). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. xii-xiii.

The International Symposium on Biologic Effects and Health Hazards of Microwave Radiation was organized within the framework of the problems which man has had to face in terms of his physical environment, both old environmental hazards and new ones brought about by the progress of science and technology. WHO is concerned about the health implications of the growing use of devices producing nonionizing radiation. A need for national and international public health programs reflecting the rapid technical development of these devices is apparent. Internationally agreed criteria and standards of exposure are needed. The review and evaluation of existing knowledge made by this Symposium will aid WHO in suggesting priorities and reviewing long-term programs on MW radiation. This Symposium is regarded as a step forward in the joint effort undertaken by scientists in various countries and WHO to bring together scientific achievements in different parts of the world and to establish recommendations which should ultimately lead to the control of potential radiation hazards. (No references)

0405 U. S. PUBLIC HEALTH SERVICE CONCERN AND ACTIVITIES RELATED TO HEALTH IMPLICATIONS OF MICROWAVE RADIATION. *(E.)* Villforth, J. C. (Bur. Radiol. Hlth., HEW). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. xiii-xvi.

Man is exposed to increasing numbers of devices emitting RF and MW radiation. The manufacturing processes have far exceeded the development of instruments to detect radiation and biological research to determine somatic or genetic risks. The Bureau of Radiological Health of the U. S. Public Health Service is required by law to conduct research into the health effects of electronic products radiation and to establish and enforce standards of performance for electronic products that will assure that the public health and safety are protected. In addition, the EPA has general authority to develop guides and recommendations and the Occupational Safety and Health Administration is charged with protection of workers from occupational insults, including MWs. Some activities of the Bureau of Radiological Health include: (1) study of effects of MW ovens as they are the most immediate public health problem in the United States, (2) epidemiologic studies, (3) pathologic studies, (4) metabolic studies, (5) genetic studies, and (6) dosimetric studies. Technical problems indicate a general hardware problem associated with nonionizing radiation investigations. These force the Bureau into R & D activities to produce necessary product evaluation information from which dosimetry systems can be developed to assess deleterious biological effects of exposure to radiation. (No references)

0406 RAPID WARMING FROM HYPOTHERMIA BY MICROWAVES. *(E.)* Baillie, H. D. (Crumpsall Hosp., Manchester, U.K.). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 15-21.

A microwave (MW) method for producing rapid warming from hypothermia in rats was developed to investigate the physiological responses to rapid warming, and perhaps contribute to research on the nonthermal effects of MWs. Wistar rats weighing 200-250 g, under general anesthesia, were used. Overheating of extremities was prevented by converting the animal's body to a uniform geometric shape by immersing it in a water jacket during exposure. Twelve control rats were cooled to 18 C and warmed to normal body temperature using water spray. All other rats were cooled by water spray and warmed by MWs in a 3 m x 1 m x 1 m cavity energized at 2.5 GHz by three water cooled magnetrons rated at 1.5 kW, giving the cavity a dielectric heating power of 4.5 kW, under optimal conditions. The frequency of the MWs corresponded to a freespace wavelength of 12.4 cm when measured with a coaxial wavemeter. Three groups of 12 rats each were warmed from 18 C to 38 C at power settings of 1/3, 2/3, and full power; for 60, 40, and 20 sec, resp. Control rats all survived; the mean cooling time was 20 min and the mean warming time 30 min. Three deaths occurred in rats warmed at full power, and two among those warmed at 2/3 power. All rats warmed at 1/3 power survived, indicating that warming rate of 20 C in 60 sec is the safe limit of MW warming under experimental conditions. During 3-mon observation period all survivors behaved normally, and offspring were apparently normal. The surface area of a 216 g rat was estimated to be 225 cm^2. While it was impossible to measure the field strength of the MWs used in these experiments in terms of mW/cm^2, it is suggested that the nonreflected part of the field incident on the animal had a power density functionally equivalent to 1100 mW/cm^2, based on the estimated surface area. (5 references)

0407 MAIN DIRECTIONS AND RESULTS OF RESEARCH CONDUCTED IN THE USSR ON THE BIOLOGIC EFFECTS OF MICROWAVES. *(E.)* Gordon, Z. V. (Labor Order Red Banner Inst. Sci. Res. Ind. Hyg. Occup. Dis., USSR Acad. Med. Sci., Moscow), A. V. Roscin and M. S. Byckov. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 22-35.

Research programs in the USSR use three approaches; i.e., hygienic, clinical, and experimental studies, to investigate the biological effects of a whole range of radiofrequencies, and particularly of MWs. Hygienic studies in factories have demonstrated the pronounced intermittent character of the MW irradiation regime to which workers are exposed; experimental studies have shown that intermittent radiation results in more pronounced biologic effects than steady irradiation under conditions of equal strength and time parameters. Based on long-term (20 yr) observations of exposed workers, the biologic effects of MW irradiation become more se-

vere with increasing duration of work accompanied by irradiation at low intensities (less than 1 mW/cm^2). Early USSR experimental studies on MW bioeffects were concerned with high intensities and were limited to establishing minimal lethal doses, thermal action, and effects such as cataract formation and changes in blood pressure. Subsequent studies have focused on changes in functions (general indicators, nervous system, cardiovascular system, biochemical changes, reproductive function, and nonspecific reactivity) in animals irradiated with MWs of nonthermogenic intensity. Statistically significant results of these experiments are summarized in a table showing, for each investigated function, radiation intensity, type of experiment, duration of each irradiation, animal species, and character of the changes. The results show the MW radiation (intensity, 10 mW/cm^2), when acting for long time periods, constitutes a pathogenic factor (morphologic lesions in the nervous system, changes in reproductive function, and some borderline conditions; e.g., lowered endurance, lag in weight gain). Irradiation at a lower intensity (1 mW/cm^2) is also medically significant according to a number of indicators; even at intensities as low as 250-500 $\mu W/cm^2$, certain biologic effects occur, including definite pathologic effects on reproductive functions. Investigations of the primary mechanisms of the biological action of MWs are also discussed. (32 references)

0408 PHARMACOLOGIC EFFECTS OF A PULSED MICROWAVE FIELD. *(E.)* Servantie, B. (Mil. Hosp. Postgrad. Stud., Sainte Anne, Toulon-Naval, France), C. Bertharion, R. Joly, A. M. Servantie, J. Etienne, P. Dreyfus and P. Escoubet. *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 36-45.

The effects of prolonged MW exposure on laboratory animals were studied using albino CD-1 mice of the Charles River strain. To look for biologic effects other than thermal, low mean power densities were used. The field effect on sensitivity to pentetrazol was studied by exposing the mice to MWs for 8, 15, 20, 27, and 36 days. At the end of this period 50 mg/kg pentetrazol was administered i.p. to each mouse and the time interval between injection and beginning of the convulsive fit was measured. Mortality was determined at the end. All irradiated mice except the 8-day group differed significantly from the control population. After 15 days, exposure delays appearance of the fit, but for longer exposures the onset of the fit is hastened. The differences in mortality between exposed animals and controls appears after 15 days and increases for longer exposures. Studies performed using curare-like drugs resulted in a hypothesis of the way a MW field acts. The experiments were performed on intact animals using Gallamin or suxamethonium; on *in situ* neuromuscular preparations using Pancuronium; and on isolated neuromuscular preparations consisting of removed left-half diaphragms and left phrenic nerve in baths containing decamethonium, suxamethonium, tubocurarin, and diallylnoxiferin, after 10-15 days of irradiation. It was found that preparations from irradiated animals are paralyzed less and recover sooner than those from normal rats. This experiment led the authors to localize the action of the MW field to the level of the neuromuscular synapse with the field modifying the enzymatic mechanism by a decrease in the quantity of enzyme or a modification of the enzyme itself. They conclude that the MW field creates a decrease in the binding energy between the drug molecule and enzyme molecule, explaining the difference in susceptibility between normal and irradiated animals. (3 references)

0409 MICROWAVE IRRADIATION AND ENDOCRINE FUNCTIONS. *(E.)* Mikolajczyk, H. J. (Inst. Occup. Med., Lódź, Poland). *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 46-51.

The literature on MW radiation and endrocrinological changes is reviewed. Since the question of whether there is general or selective reactivity of the endocrine system in an organism exposed to MWs has not been answered, the effect of MWs on endocrine function should be studied with carefully controlled investigations and experimental procedures for the following reasons: electromagnetic energy is transformed into heat within living tissues and may therefore affect pituitary-thyroid functions; it may be an environmental stress factor regulated by the pituitary-adrenocortical system; the heating may affect the pituitary-gonadal system; and MW radiation may modify activation of acetylcholine and adrenaline. (19 references)

0410 BIOLOGIC EFFECTS OF RADIATION IN THE 30-300 MHz RANGE. *(E.)* Kalada, T. V. (Inst. Ind. Hyg. Occup. Dis., Leningrad, USSR), P. P. Fukalova and N. N. Goncarova. *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 52-57.

Clinical observation of a large group of workers exposed to UHF EM radiation (40-200 MHz) for more than 5 yr indicates that systematic, prolonged exposure leads to disturbances in neurovegetative regulatory functions (52%), often expressed in vegeto-asthenic and neurasthenic syndromes (14%); circulatory pathology, including hypertension, mycardiodystrophy, cardiosclerosis (24%); changes in the gastrointestinal tract (chronic gastritis 12%, ulcers 2%); and impairment of oxygenation of heart muscle (42 out of 50 patients with negative histories). Levels of loosely protein-bound cholesterol and total cholesterol were elevated, and the ratio of phospholipids lowered. Lowered osmotic resistance of leukocytes and lowered phagocytic reaction were more frequent than in controls. Changes in threshold of heat perception, reflex responses to stimuli, and hypertension were also observed. The intensity of these disturbances was related to the length of occupational exposure, indicating causal and perhaps cumulative effects. A clearcut relationship between reaction and intensity of exposure was also found. Phasic changes

in the neurovegetative and circulatory systems were observed, indicating adaptive responses. These responses are regarded as transient states with the potential for becoming pathologic since repeated irradiation led to serious functional disturbances. The influence of thermogenic and athermal levels of EM fields on CNS, EEG conditioned reflexes, hemodynamics, biochemical and immunobiologic function, and the morphologic picture of animals (unspecified) was also evaluated in acute and chronic experiments (5-8 mon irradiation). Results indicate a definite dependence of biologic effects on the length of irradiation and the intensity, frequency and components of the EM field. The studies establish general biologic trends in the reactions of organisms, elucidate some aspects of pathogenesis of functional deviations, and indicate their cumulative character. (17 references)

0411 THE CHARACTERISTICS OF BIOLOGIC EFFECTS OF MICROWAVES COMBINED WITH THE ACTION OF SOFT X-RAY IRRADIATION AND HEAT. *(E.)* Nikonova, K. V. (Labor Order Red Banner Inst. Sci. Res. Ind. Hyg. Occup. Dis., USSR Acad. Med. Sci., Moscow) and I. P. Sokolova. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 58-66.

The biologic effects of combined 10 cm MWs and x-ray irradiation with E_{ef} = 13 x 5 keV were studied in mice. Following exposure to a single dose of 2500 r x-rays and 15-min daily irradiations with 40 mW/cm^2 MWs for 6 weeks, mice developed radiation sickness manifest by changes in body weight, low leukocyte count in peripheral blood, progressive skin lesions, and decreased weight of the testes. The testicular lesions were more severe, death rate higher, loss of body weight more marked, skin lesions occurred earlier and were more evident, and decline in peripheral blood leukocytes was more pronounced than resulted from x-rays or MWs applied singly. Studies of the effects of the combined action of 1 mW/cm^2 for 1 hr/day and 24 r/week revealed that the role of MWs becomes more conspicuous with a change to low intensities. Changes in weight and in peripheral blood (decreased leukocyte and erythrocyte counts and increased reticulocyte numbers) were analagous to those accompanying isolated MW irradiation. Also related to the action of MWs was a marked hyperplasia of reticuloendothelial elements in the liver and spleen, of lymphoid elements in the lungs, and of microglia in the brain; manifestations of irritation of the receptor apparatus; and a decrease in ribonucleoproteins of the epidermis. X-ray irradiation determined the lowered weight of the testicles and increased vascular permeability. Immunologic functions (phagocytic and digestive functions of neutrophils, bactericidal properties of plasma) over a 6-mon period revealed changes attributable to either MWs or x-rays with intensity indistinguishable from those resulting from exposure to either factor alone. Studies of the combined action of MWs and high air temperature clearly evidence synergism. Significant changes in arterial pressure of animals so exposed emphasize the need for study of the regulatory and adaptive systems of organisms. (17 references)

0412 INFLUENCE OF MICROWAVE RADIATION ON THE HEMATOPOIETIC SYSTEM. *(E.)* Czerski, P. (Natl. Res. Inst. Mother Child, Warsaw, Poland), E. Paprocka-Słonka, M. Siekierzyński and A. Stolarska. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 67-74.

Results of investigations of MW effects in the lymphocytic and red cell systems are reported. In the first series of experiments, 3 groups of rabbits were exposed to 2950 MHz pulsed (1200 MHz, 1 μsec) or CW MWs at 3 mW/cm^2, 2 hr/day for a total of 74 or 158 hr; a 4th group served as controls. After irradiation, ^{59}Fe citrate-labeled blood samples were withdrawn from all groups for hematologic and radioactivity determinations. Calculations of ferrokinetic indices demonstrated significant differences. The 74-hr exposure to pulsed MWs induced much more pronounced effects than did CW MWs of the same duration; the differences were highly significant. In contrast, 158-hr exposure to CW MWs induced effects similar to those of pulsed MWs of half that duration. The second series of experiments concerned the effects of MW exposure of guinea pigs at various times of the day on the circadian rhythm of bone marrow cells. No marked differences were seen in the circadian rhythm of recognizable precursors of granulocytes and erythroblasts. In cells belonging to the stem cell category (early erythroblasts, myeloblasts, hemopoietic stem cells, and probably lymphocytes), a distinct change in amplitude and phase of the circadian rhythm of cellular divisions was noted in animals irradiated in the morning or evening, as compared with one another and controls. Syngeneic mice were subjected to a single MW exposure (a.m. or p.m.) and examined for 3 days beginning 24 hr after exposure. Results indicated that MWs induce a disturbance in the amplitude and phase of the mitotic rhythm of cells of the stem cell category. The reaction of the lymphocytic system was quantitated by determining the serum hemagglutin level and the number of antibody producing cells in lymph node homogenates of mice irradiated for 6 or 12 weeks and immunized with sheep RBC. Significant differences between controls and irradiated groups indicated that MW exposure affected the lymphocytic systems of immunocompetent cells. (14 references)

0413 HARMFUL EFFECTS OF MICROWAVE RADIATION ON THE BONE MARROW. *(E.)* Yagi, K. (Dep. Intern. Med., Tokyo Med. Coll., Japan), R. Ueyama, S. Kurohane, N. Hiramine, H. Ito and S. Umehara. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 75-88.

The possibility that MW radiation might result in aplastic bone marrow was investigated by irradiating young white male rabbits with a 2450 MHz (12 cm) continuous MW generator. Irradiation sessions (power density 1.3 mW/cm^2) lasted 30 min, repeated 5 times/day for 7 consecutive days. Histologic and macroscopic changes in the irradiated bone marrow, changes in body weight, tissue temperature, and peripheral blood were examined over a 6-week period. Macroscopically, the color of the bone marrow changed from red to yellowish red in the first 3 weeks, and then to gray in the last 2 weeks of the observation period. In the first 3-4

days, plasma-like substances (exudate) developed around bone marrow fat cells and in the center of the parenchyma. Over the next 3 days, the exudate increased gradually in the parenchyma and surrounding fat cells; and completely filled the sinuses. A marked increase in the exudate was accompanied by the disappearance of fat cells in week 2, marked destruction and decrease of the parenchymal cells starting at week 3, and distinct sinus wall thickening and plasmatastis in the sinus in weeks 5-6. Fat cells reappeared during week 4, but the destruction of the parenchyma cells continued. Complete aplastic bone marrow was seen in 5 of 7 cases in the 5th week, and in 6 of 9 in the 6th week. Fibrosis, present in the 3rd week, was not observed in bone marrow obtained in weeks 5-6. Histochemical studies indicated that the exudate contained neutral and acid mucopolysaccharides, apparently derived from the serum due to an inflammation of the bone marrow. The average decrement of body weight in the exposed animals was 0.4 kg. Femoral tissue temperature rose to 39 C within the first 5 min of irradiation and maintained a level of 42 C during the next 30 min. Peripheral blood changes included a marked decrease in small lymphocytes at the end of irradiation and a 900% increase in large lymphocytes. Animals treated with hydrocortisone (4 mg/kg/day for 6 weeks) did not develop aplastic bone marrow. The results demonstrate that MWs can have a harmful effect on bone marrow and suggest that aplastic anemia may be caused by inflammation of the bone marrow rather than by stem cell failure. (12 references)

0414 EFFECTS OF MICROWAVES ON THE CELL METABOLISM OF THE RETICULO-HISTOCYTIC SYSTEM. *(E.)* Miro, L. (Lab. Biol. Phys., Fac. Med. Montpellier, Nimes, France), R. Loubière and A. Pfister. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 89-97.

Long-term exposure to low levels of MW radiation is known to produce subjective and objective disorders in humans. To find the source of these disorders, mice, rats, and rabbits were exposed to 450 hr of continuous MW irradiation at 7 mW/cm^2 mean power density. No modification of their behavior or appearance was noted. Autopsy revealed no macroscopic or microscopic alterations of their organs, but a hyperplasia of the spleen and liver was noted, indicating possible stimulation of the reticulohistocytic system. A systematic study of the liver, spleen, and thymus cell metabolism of 40 male Swiss mice exposed to MWs was undertaken. The mice were paired and divided into 2 groups: the experimental group was continuously exposed to MW radiation for 145 hr while the control group was kept under the same conditions in another room. No difference in behavior between control and experimental animals was noted and weight curves showed no modification. After exposure all animals were injected i.p. with a methionine ^{35}S solution in a dose of 2.5 $\mu Ci/g$. Fifteen hr after injection, the mice were decapitated and an autopsy was performed. For the germinative centers and lymphoid zone of the spleen, liver, and thymus there was a highly significant ($p < 0.001$) increase in the rate of incorporation of tagged amino acid in the experimental group. This increased radioactivity is in conformity with a real increase in protein synthesis by hepatic, thymic, and splenic cells and is not a simple slowing down of the protein metabolism rate. Thus, continuous exposure of mice to MW radiation for 160 hr induced a great increase in protein synthesis in the liver, thymus and spleen. Further experiments are necessary to confirm or invalidate this effect on the reticulohistocytic system. (No references)

0415 ARE MICROWAVES TERATOGENIC? *(E.)* Rugh, R. (Bur. Radiol. Hlth., U.S. Pub. Hlth. Serv., Rockville, Md.), E. I. Ginns, H. S. Ho and W. M. Leach. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 98-107.

Pregnant CF_1 white mice were exposed for 15 min on gestation day 8.5 to a constant exposure rate of 2450 MHz radiation (forward power of 7.37 W). A waveguide apparatus was used so that the integral dose rate to the animals could be determined under stable controlled environmental temperature (25 C) and relative humidity (50%). Most pregnancies were terminated at 18 days to determine the teratogenic effect of MWs on whole litters. Doses to pregnancies that yielded 100% normal offspring ranged from 2.4-7.8 cal/g, with the frequency of normal litters decreasing with an increase in average dose; doses that yielded 100% abnormal offspring were observed beginning at 5.8 cal/g. Microwave-induced teratogenesis was seen among litters exposed to average doses in the 2-8 cal/g range. The teratogenic effects detectable by direct observation included gross hemorrhage, exencephaly, stunting, fetal resorptions, and fetal death. The possibility of subtle and microscopically observable effects, in addition to gross anomalies, is suggested. The results indicate a linear relation exists between the MW dose and fetal effects; there was no evidence of a threshold effect. The variability of the incidence of anomalies within litters indicates that cause and effect relations are not well enough established and understood to permit prediction of MW effects either in the mouse or in other species. (6 references)

0416 THE USE OF CONDITIONED REFLEXES TO STUDY MICROWAVE EFFECTS ON THE CENTRAL NERVOUS SYSTEM. *(E.)* Lobanova, E. A. (Labor Order Red Banner Inst. Sci. Res. Ind. Hyg. Occup. Dis., USSR Acad. Med. Sci., Moscow). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 109-118.

The effect of MWs on the function of higher compartments of the CNS was investigated in a series of experiments on rabbits and rats. Experiments were first performed on rabbits irradiated 4 months with cm MWs at an intensity of 10 mW/cm^2 for 60 min/day; following irradiation conditioned motor-food

reflexes were studied for 2 months. The action of MWs during the first month of irradiation led to an inhibition of conditioned reflexes, as apparent from a prolongation of the latent period of the reflexes to positive signals and, in a number of cases, even the lack of conditioned reflexes. These changes were found more frequently in the first half of the stereotype, preceding application of the differentiating signal. The active inhibition was somewhat intensified. The shifts in neurodynamics were preserved during the 2nd and 3rd mon of exposure. In the course of the 4th mon, all indicators of conditioned reflex activity underwent marked changes. Following termination of radiation, normalization of conditioned reflexes took place only after 2 mon. Outbred nonstock rats exposed to the same radiation regime became lethargic after their first exposure. Early MW-induced effects on conditioned motor-food reflexes consisted of a significant increase in latent periods, frequent lack of reflexes to positive conditioning stimuli and sight of food, the presence of phase phenomena, deepening of differential inhibition, and a resultant pronounced inhibition. Inbred K-M rats, which have more excitable CNS, appeared more resistant than outbred rats to the action of MWs; however, starvation led to a deterioration of conditioned reflexes in the inbred rats, and slightly facilitated the activity in the outbred rats. Chronic irradiation of rats with pulsed 10 cm waves of 10 mV/cm^2 intensity induced pronounced changes in reflexes; the same waves at 1 mV/cm^2 intensity did not. Irradiation for 15-min at 10 mW/cm^2 did not significantly influence CNS excitability, while 1 mW/cm^2 irradiation for 15 min somewhat increased it. Further studies revealed that the expression of CNS changes depended on the level of food motivation. Changes in conditioned reflexes indicates functional changes in the higher compartments of the CNS; the possible mechanisms of these functional changes are discussed. (26 references)

0417 PHARMACOLOGIC ANALYSIS OF MICROWAVE EFFECTS ON THE CENTRAL NERVOUS SYSTEM IN EXPERIMENTAL ANIMALS. Barański, S. (Mil. Inst. Aviat. Med., Warsaw, Poland) and Z. Edelwejn. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 119-127.

The effects of chronic exposure to nonthermal levels of MWs on the activity of the CNS of experimental animals were analyzed. During the studies drugs stimulating or inhibiting the function of the CNS at different levels were used. Male, 1-yr old rabbits weighing 3.0 kg were divided into 3 groups of 15 and administered i.v. chloropromazine (4 mg/kg), 1% solution penetracole (3 mg/kg), and an aqueous solution of phenobarbitone (40 mg/kg), resp. Unirradiated controls received the same treatment as experimental animals which had previously been exposed to chronic irradiation of pulse-modulated 10 cm MWs at power density 7 mW/cm^2 for 3 hr per day for a total of approximately 200 hr. EEG recordings of the motor, sensory and visual cortex regions were made after irradiation and after the administration of drugs; the evoked potential of the visual cortex was also investigated by retinal stimulation by a flash of light 700 lux density and 1 c/s frequency, emitted by a stroboscope. The effects of irradiation were detected in all EEG parameters, with a high degree of desynchronization of the EEG pattern. Chloropromazine produced EEG synchronization in both irradiated and control animals; pentetrazole produced rapid onset in irradiated animals; and desynchronization of EEG was marked after phenobarbitone. All main components of evoked visual potentials were also markedly changed by irradiation. Desynchronization of EEG pattern was probably due to activation of the ascending part of the mesencephalic reticular formation. The differences in evoked visual cortical potentials were dependent, partially, on the functional state of afferent systems transmitting specific or nonspecific impulses. (17 references)

0418 A QUANTITATIVE ELECTROENCEPHALOGRAPHIC STUDY OF THE ACUTE EFFECTS OF X-BAND MICROWAVES IN RABBITS. *(E.)* Goldstein, L. (Dep. Psychiatr., Rutgers Med. Sch., Piscataway, N. J.) and Z. Sisko. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 128-133.

Adult male New Zealand rabbits equipped with intracranial electrodes above the sensory-motor cortex, and trained to sit quietly in an anechoic chamber, were exposed 5 min to MW radiation at 9.3 GHz, with power densities varying from 0.7 to 4.8 mW/cm^2, CW. Radiation was beamed at the heads, with the antenna 45 cm away. The rabbits were pretreated with a sedative dose (4mg/kg in a 0.1 ml/kg volume, i.v.) of pentobarbital in order to create conditions permitting the detection and measurement of EEG, and the behavioral manifestations of arousal and hyperarousal. Although there were no behavior and/or EEG changes during exposure, in a number of experiments, following a latent period of 3 to 12 min, sudden arousal occurred which lasted on the average 3 min, with desynchronization of EEG activity and clearcut behavioral excitation, observed through remote control TV monitors. In most cases, 2 or 3 successive periods of arousal occurred interspersed with reversals of electrical activity and behavior to sedation activity. In most experiments, the alternation of periods of arousal and sedation was separated by intervals of 3 to 10 min. Duration of arousal was related to power density, 240 ± 75 sec for 1.44 mW/cm^2, and 768 ± 78 sec for 2.88 mW/cm^2 (9 experiments in each case, total exposure time 5 min). In a few cases there was a constant waxing and waning of both EEG and behavior between sedation and arousal. Alternation of periods of arousal and sedation has been previously described following acute administration of stable free-radical compounds. It is possible that MW exposure produces or enhances the formation of free-radicals from naturally occurring compounds in the brain. The effects did not occur when the relative ambient humidity was above 40%, perhaps because transmission of waves was impaired in rabbits whose long hairs are known to absorb water. (2 references)

0419 PSYCHOGENIC STRESSORS ARE POTENT MEDIATORS OF THE THERMAL RESPONSE TO MICROWAVE IRRADIATION. *(E.)* Justesen, D. R. (VA Hosp., Kansas

City, Mo.), D. M. Levinson, and L. R. Justesen. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 134-140.

A quantitative measure of the ability of small mammals to detect MW energy at low rms-density is studied using Evoked Thermocolonic Response (ET_cR), a parameter experimentally developed by the authors. This response is an elevation of colonic temperature as a reaction to various stimuli. The female albino Sprague-Dawley rat was used to compare ET_cR's evoked by peripheral sensory perception and by MW radiation. A study was made to determine whether small doses of MW energy and a mildly adversive stimulus (faradic stimulation of the feet) would evoke comparable ET_cR's and be additive in nature. 2.45 GHz magnetron-generated MW energy was injected into a cavity holding the rats. Measurements were made at 0, 360, and 1800 mJ/g total E doses, with faradic currents of 0, 50, and 60 μA-rms applied to the feet. Both irradiation and foot shock were found to be reliable triggers of the ET_cR. There was no interaction between the two, but simply an additive effect with respect to magnitude of the ET_cR. A second study was done using rats treated with sodium pentobarbital (35mg/kg i.p.), a hypnotic, resulting in little or no ET_cR, demonstrating that the quickening of nervous activity leading to a rise in core temperature will not occur without the perception of an alien stimulus. (10 references)

0420 SOME EFFECTS OF VARIOUS PULSED FIELDS ON ANIMALS WITH AUDIOGENIC EPILEPSY. *(E.)* Stverak, I. (Inst. Aviat. Med., Prague, Czechoslovakia), K. Marha and G. Pafkova. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 141-144.

The significantly greater biological effectiveness of PW as compared to CW at equal frequency and average power density raises the question of whether the greater effect is caused by the actual modulation of the EM field in normally used sources. To investigate the problem, the effects of a pulsed EM field were compared with the effects of a pulsed ES field, the interfering influence of the high-frequency carrier component being excluded. Forty rats with congenital audiogenic epilepsy were used in both situations (24 were irradiated, 16 served as controls). In order to create the types of pulsed energy required, generators were developed and the values of the field carefully calculated so that in both cases the amount of effective energy was equal. The characteristics of generators of ES pulses were approximately: pulse width 10 μsec, amplitude 800 V, pulse repetition 762.2 Hz. The generator of pulsed EM waves emitted waves at 2850 MHz, pulse duration 2.7 μsec and repetition frequencies 357 Hz. At the place of exposure the average power density amounted to 30 mW/cm^2. Irradiation occurred over a period of 10 weeks. Indicators of the effect of both pulsed fields were changes in sensibility; i.e., the length of the latency period and the sensitivity to the stimulus releasing the onset of convulsions. Homogeneity of biologic material was ascertained by using one-half of each animal litter and the control group, and excepting irradiation, handling in the same way as the experimental group. Change in the onset of the cramp reaction was studied not only in animals directly irradiated, but also in the first and second filial generation. Results obtained from the pulsed ES field showed that irradiation led to prolongation of the interval from the beginning of sound stimulation to the onset of seizures. A higher number of null reactions also occurred. In all cases of EM radiation the mean time preceding the onset of seizures was longer in irradiated than in control animals; the null reaction occurring in approximately 70% of the irradiated group and 20% of controls. Results obtained at the 6th week were significant at the 5% level; the remaining differences were statistically insignificant. The next stage of the study will examine the effects of CW fields. (4 references)

0421 INTERACTION OF ELECTROMAGNETIC FIELDS AND LIVING SYSTEMS. *(E.)* Romero-Sierra, C. (Dep. Anat., Queen's Univ., Kingston, Canada), J. A. Tanner and J. Bigu del Blanco. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 145-151.

Basic phenomena underlying electromagnetic (EM) interaction with living systems are reviewed, and a conceptual viewpoint of the emerging laws that govern such interactions is presented. Past experimental findings on interaction effects are summarized, and the extremely complex wave and nonwave effects are diagrammed. Microwave (MW) field intensity ranges corresponding to identifiable biological effects are: nonthermal, 1 μW-100 μW; thermal, nonheating, 100 μW-10 mW; and heating, 10 mW and above. Thermal, nonheating effects are identified with changes in temperature and heat balance not attributable to the direct conversion of MW energy to heat in tissue. Irradiation intensities below 100 $\mu W/cm^2$ are considered nonthermal for both pulsed and continuous waves. At a power level of 10 mW/cm^2, the energy transformed into heat in the body is roughly equal to the heat loss per square centimeter of body surface. On this basis, power levels between 100 μW and 10 mW are nonheating although thermal mechanisms may be involved. The interaction between EM fields and living systems is dependent on the characteristics of the radiation, the environment, and the biological receptors. In light of the strong EM interaction between glial and neuronal cells, the emerging laws of interaction between EM fields and organisms appear to be: (1) EM fields imposed on a living system modify the EM interaction that exists between glial and neuronal cells inside a nervous structure; (2) To predict the consequences of interaction, all the parameters (radiation, environment, biological receptors) must be quantified and integrated; (3) EM fields trigger a set of interactive biophysical phenomena; and (4) The unstable sequence of events thus triggered may be stabilized at the level of the cell, tissue, organ or organism affected. It is noted that a period of captivity introduces a discontinuity in birds' spatial and temporal perception of the minute gradients in temperature, humidity and EM field, creat-

ing disorientation when released. The same concept can be applied to other migratory species such as fish. (49 references)

0422 PRINCIPLES OF INTERACTION OF MICROWAVE FIELDS AT THE CELLULAR AND MOLECULAR LEVEL. *(E.)* Schwan, H. P. (Dep. Bioeng., Univ. Pennsylvania, Philadelphia). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 152-159.

The present state of knowledge of the electrical properties of tissues and other biological systems is summarized. Three relaxation regions α, β, γ of the dielectric constant exist at low, medium, and very high frequencies. Inhomogeneous structure is responsible for β-dispersion and permanent dipole rotation for γ- and β tail-dispersion; α-dispersion is least clarified but involves both counter ion relaxation and electrophoretic relaxation. The characteristic frequencies vary from one biological object to another. Thus, blood cells display a weak α-dispersion centered around 2 kHz, while muscle displays a very strong one near 0.1 kHz. The β-dispersion of blood is near 3 MHz, that of muscle tissue is near 0.1 MHz. Dispersion characteristics of certain biologic materials are tabulated, including electrolytes, biologic macromolecules, amino acids, proteins, nucleic acids, protein-free cells, and charged and excited membranes. Unresolved problems include the origin of β-dispersion; the application of the theory of counter ion relaxation to macromolecules and cells; protein, amino acid, and nucleic acid data *versus* concentration; and the origin of α-dispersion in membranes. The electric data available to date do not support the concept that MWs may induce resonance effects which might cause irreversible damage. In addition, there is no evidence of the existence of nonthermal effects at the molecular or cellular level. While electric properties provide insight into the mode of interaction of alternating fields, they cannot readily reveal the mechanic effects that may be imparted. Forces evoked by alternating fields (field-evoked forces, dielectrophoresis, electromechanical effects) deserve consideration; they may be responsible for the phenomenon of "hearing" pulsed fields and, hence, some of the behavioral effects reported in the 1-10 mW/cm^2 range. (8 references)

0423 INTERACTION BETWEEN MICROWAVE AND MILLIMETER-WAVE ELECTROMAGNETIC FIELDS AND BIOLOGIC SYSTEMS: MOLECULAR MECHANISMS. *(E.)* Illinger, K. H. (Dep. Chem., Tufts Univ., Medford, Mass.). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 160-172.

The interaction between EM radiation and the molecular components of biologic systems is analyzed to delimit the possible coupling mechanisms with EMF which may lead to an alteration of the energetics and/or dynamics of the molecular system. Subjects treated include the quasilattice vibration mechanism of MW absorption in poly-(α-benzyl-L-glutamate) (PBLG) and dielectric saturation in PBLG and other biopolymer systems in MW fields. Appendices contain a theoretical analysis of the time-evolution of the energy of a molecule in the presence of collisional perturbation by other molecules and of perturbation by an EM field; a discussion of the natural background of nonionizing radiation in the biosphere; a description of molecular dynamics in the presence of EM field perturbation; a brief summary of RF and MW absorption in biopolymers; and a short review of field-stimulated proton shift in the hydrogen bonds of biopolymers. The natural EM background in the biosphere at MW- and RF-frequencies is orders of magnitude below the power levels associated with technological and/or scientific applications. In contrast, the natural background of VLF, ELF, and zero-frequency (static) fields in the biosphere is one of the same order of magnitude as certain technical applications. Irreversible effects arising from the perturbation of rotational diffusion in biological fluids by external EMF in the RF and centimeter-wave region, at normal *in vivo* temperatures, have a low probability at field strength below saturation levels. The existence of quasilattice vibrations in extended biopolymeric structures (e.g., the alpha-helix) indicates the possibility of damped resonant interactions between millimeter-wave and far-infrared EMF and biologic systems. Irreversible saturation effects in biological fluids are expected only at (static) field strengths of the order of kV/cm in the helix-coil transitions of certain biopolymers and in micelle-random-Zwitterion transitions. Proton shifts induced by MW EMF, and hence *possible associated genetic-code alterations*, are improbable for systems such as DNA. (56 references)

0424 EFFECTS OF MICROWAVE IRRADIATION IN VITRO ON CELL MEMBRANE PERMEABILITY. *(E.)* Barański, S. (Mil. Inst. Aviat. Med., Warsaw, Poland), S. Szmigielski and J. Moneta. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 173-177.

Erythrocytes were isolated from heparinized (50 I.U./ml) rabbit venous blood, saline washed, and suspended in clean saline containing no potassium, to form a 10% suspension. They were then exposed to continuous EM waves of 10 cm at 1, 5 and 10 mW/cm^2 power densities for 15, 30, 60, 120 and 180 min. No increase in temperature was observed. The erythrocytes were centrifuged and the concentration of potassium and hemoglobin in the supernatants measured. Osmotic resistance of the cells was also determined. Rabbit granulocytes isolated from the peritoneal cavity 8 hr after infusion of 0.5% glycogen and suspended in heparinized saline were also exposed to continued 10-cm waves at 1 or 5 mW/cm^2 for 15, 30 and 60 min. The granulocytes were stained with 0.1% nigrosin and observation of cell viability was made using a phase-contrast microscope. After centrifugation of the remaining suspensions at 15,000 rpm at 4 C for 20 min the activities of acid and alkaline phosphatase, catalase and lysozyme were determined in the supernatants using biochemical techniques. Irradiation at 1 mW/cm^2 for 15 and 30 min resulted

in an efflux of potassium from the erythrocytes. Increased permeability of membranes to hemoglobin appeared at 60 min, and total hemolysis and lowered osmotic resistance appeared at 120 and 180 min of irradiation. A marked increase in the percentage of dead granulocytes was observed after irradiation at 5 mW/cm^2. After 60-min irradiation at this power density 80% of the granulocytes showed diffuse staining. In suspensions irradiated at 1 mW/cm^2 only 20% were stained, the last figure being close to the value observed in controls. Injury of isolated rabbit granulocytes was observed after 20 min of irradiation, measured by the activity of acid phosphatase and lysozyme in the supernatants. Activity of alkaline phosphatase and catalase was seen only after 120 and 180 min. Marked morphological changes were also observed in stained cells under phase-contrast microscopy after the two longest periods of irradiation. (18 references)

0425 ASSESSING MICROWAVES AS A HAZARD TO THE EYE--PROGRESS AND PROBLEMS. *(E.)* Carpenter, R. L. (Bur. Radiol. Hlth., Winchester, Mass.), E. S. Ferri and G. J. Hagan. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 178-185.

At any given output of a particular MW source, the minimal single exposure period required to induce opacity formation of the lenses of the eye can be determined. These minimal exposure periods yield a curve showing time and power thresholds for induction of lens opacities by single irradiations of the eye. This curve is also useful for identifying specific time and power combinations which constitute subthreshold exposures. Experiments which tested the effect of subthreshold exposures repeated at regular intervals demonstrated that irradiation which apparently does not damage the lens when experienced only once may cause lasting damage when repeated daily or weekly. Non-anesthesized New Zealand white rabbits were irradiated 2 inches from a dipole antenna at 2.45 GHz, CW, one hr a day for 20 days. This was defined as chronic irradiation and the lowest power level which would consistently cause development of lens opacities was sought. Opacities developed in 4/10 experiments at 100-110 mW/cm^2, but an increase to 120 mW/cm^2 resulted in opacities in 8/10 rabbits. One hr exposure at this level was found to be subthreshold in 7 experiments. Tests were also performed to study how the MW field is perturbed by the body of a rabbit. In a free field condition the power distribution in a planewave resembled concentric circles of decreasing power density. The rabbit was placed with its right eye in the center of the field and the resulting planewave distribution became a haphazard pattern of irregular zones of differing power densities. The power density at the position of the eye was reduced about 40%. Many other factors disturb the field, leading to the conclusion that power density should be reported only as a measurement in the field where the experiment is to be conducted in the absence of all perturbing factors including the experimental animals. (27 references)

0426 EXPERIMENTAL MICROWAVE OCULAR EFFECTS. *(E.)* Appleton, B. (Walter Reed Army Med. Cent., Washington, D. C.). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 186-188.

Albino rabbits were exposed to MW radiation of the eyes under varying experimental conditions including number and duration of exposures, wavelength, power level, duty cycle, and head only *vs* whole body exposures. Similar experiments using dogs were also started. If the front or one side of the rabbit was irradiated, the lethal power level was between 25 mW/cm^2 and 50 mW/cm^2, but if the body was shielded or if only the head was exposed, the threshold for ocular damage was around 300 mW/cm^2, giving little support to the hypothesis that repeated subthreshold exposures cause significant cumulative damage. Exposure to power levels one order of magnitude below cataractogenic levels was an extremely noxious stimulus causing the animal to struggle violently to remove itself from the field. In experiments using dogs, similarity with respect to MW ocular effect between the two experimental models was indicated. (No references)

0427 THE EFFECTS OF MICROWAVES ON HUMAN LYMPHOCYTE CULTURES. *(E.)* Stodolnik-Barańska, W. (Inst. Biostruct., Med. Acad. Warsaw, Poland). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 189-195.

The effects of exposure to MW radiation on human lymphocytes cultured *in vitro* with and without addition of phytohemagglutinin (PHA) was studied. Lymphocyte cultures were exposed in a thermostatic (37 C) chamber at 7 mW/cm^2 or 20 mW/cm^2 to 2950 MHz pulsed MWs. At 20 mW/cm^2, MW exposure induced changes in the mitotic index which depended on exposure time: at 10 and 15 min exposures slight differences were noticed compared to controls; after 20 and 40 min exposure, significant differences were seen. Similar results were obtained at 7 mW/cm^2 after 3-4 hr. Exposure also induced changes in numbers and structures of chromosomes, the degree of change depending on duration of exposure. The most usual finding was changes in chromosomal morphology suggesting changes in spiralization. Irradiation of lymphocytes without PHA addition induced the appearance of blastoid forms and macrophage-like cells. The results suggest that MWs may have mutagenic effects, and also indicate that exposure may induce changes in interphasic nuclei. MWs are the only agents known to be capable of inducing lymphoblastoid transformations. This phenomenon could be used to investigate the mechanism operative in blastic transformation of lymphocytes. (13 references)

0428 MICROWAVE THAWING OF CELLS AND ORGANS. Voss, W. A. G. (Surg. Med. Res. Inst. Univ. Alberta, Canada). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 196-201.

Microwaves may provide a method of controlling the rate and uniformity of heating deep-frozen materials such as might be developed for recovery of human organs from storage banks. Large MW insults at 2450 MHz have been applied to deep-frozen adult kidneys, fetal mouse hearts and tissue culture cells causing controlled temperature changes at rates up to 500 C/min from -196 C to 23 ± 12 C. Two resonant MW systems of 10 and 17 cubic inches, similar in design to conventional MW ovens, were used for heating a number of biological samples, ranging in volumes from 2 to 100 ml. The methods used and results obtained are presented. The electrical activity of fetal mouse hearts taken from 17-19 day-old embryos and recovered from -196 C by MW heating survived in a high percentage of cases. Electrical activity was observed for up to 35 days after implantation of these hearts in the ear of syngeneic adult mice. MW heating at 2450 MHz seems to give rise to faster resumption of electrical activity and a higher survival rate compared to conventional water bath heating. Tissue culture cells also withstood rapid thawing in a resonant MW system operating at very high, near breakdown, field strengths. Uniform MW thawing of adult canine kidneys was obtained at rates between 100 and 300 C/min. Although subsequent functional success was not achieved with the kidneys, areas of viable tissue with vascular integrity were observed. (12 references)

0429 QUANTITATION OF INDUCED ELECTROMAGNETIC FIELD PATTERNS IN TISSUE AND ASSOCIATED BIOLOGIC EFFECTS. *(E.)* Guy, A. W. (Univ. Washington Sch. Med., Seattle). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, pp. 203-216, 1974.

A quantitative description of EMF within tissues and an understanding of the relation between these fields and the thermodynamics of the biologic system are desirable in formulating exposure standards. U.S. safety guides that allow a maximum human exposure level of 10 mW/cm^2 incident power are partially based on limiting the average absorbed power density to the average resting value of the metabolic rate. Safety guides, however, cannot be specified in terms of absorbed power density; they are more conveniently expressed in terms of an incident PFD expressed in units of mW/cm^2 or, for the case of stationary or quasi-stationary fields, in terms of electric field strength E, in V/m, or magnetic field strength H, in A/m. Nevertheless, none of these field quantities measured exterior to a subject can be classified as hazardous, nonhazardous, thermal, or nonthermal without sufficient knowledge of exposure conditions, frequency, subject size, and subject geometry to determine the actual absorbed power density in the subject. Both thermal effects and pearl-chain formation, which depends on a sustained force across internal tissue or cell interfaces, are related to average power absorption and not to the peak absorbed power from modulated or pulsed EMF. The relation between frequency, body size, and absorbed power can be understood by considering spherical tissue layers exposed to a plane EM wave. From 1 MHz to 20 MHz, absorption varies as the square of the frequency, due primarily to the magnetically induced fields. In this range, the maximum power absorption density is 10^{-5} to 10^{-2} W/kg per mW/cm^2 incident power. From 100 to 1000 MHz, internal reflections are significant for a man-size sphere and the average absorption attains a maximum of 2×10^{-2} W/kg per mW/cm^2 incident power at 200 MHz, which remains relatively constant with frequency up to 10 GHz. The maximum absorption density increases with frequency above 1000 MHz, approaching that produced by nonpenetrating radiation. Thermograms are presented which clearly show hot spots in a phantom cat brain exposed to a 918 MHz aperture source and the unpredictable absorption peaks that occur in the body and tail of a phantom rat exposed to the same frequency. An experimental protocol is outlined to eliminate misinterpreting highly localized thermal effects as nonthermal or low-level effects. (12 references)

0430 SOME RECENT DEVELOPMENTS IN THE CHARACTERIZATION AND MEASUREMENT OF HAZARDOUS ELECTROMAGNETIC FIELDS. *(E.)* Bowman, R. R. (Electromagnetic Div., NBS, Boulder, Colo.), *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 217-227.

The magnitude of power density [S] is often not a meaningful measure of the intensity of complicated EMF and is a poor index of potential hazards even in the MW band. In contrast, the electric field strength, defined as the Hermitian magnitude [E] of the field, is a meaningful measure of the strengths of fields having reactive near-field components, multipath components, and arbitrary polarization. Three recently developed instruments for measuring [E] in complicated fields are discussed with respect to their capabilities and limitations for measurement of either fields external to subjects or fields unperturbed by subjects. Tabulated characteristics include frequency range (GHz) for ± 1 dB response for single planewaves, upper frequency (GHz) limit for spatial resolution of complicated fields, and field levels measurable (given in terms of [E] and equivalent planewave [S]). The first instrument is a broadband, isotropic sensor based on a Golay cell. The sensor consists of a pair of thin-walled air-filled spheres connected by tubes to a sensitive differential pressure transducer. The field-sensing sphere is coated with a high-resistivity film; the noncoated sphere provides compensation for changes in ambient temperature or pressure. The sensor will have an essentially constant response (average of $[E]^2$) for single planewave fields with wavelengths either long or short compared with the field-sensing sphere. The sensor can withstand fields of 1 W/cm^2 average level; the peak density overload is not known. A second type of broadband, isotropic field sensor consists of three orthogonal dipoles with diode detectors connected between the arms of the dipoles. The readout of the instrument is calibrated to display $1/4\ \varepsilon[E]^2$. For wavelengths up to two or three times the length (8 mm) of the dipoles, the probe can be calibrated to measure single planewave fields or to provide some sort of average reading for multipath fields; the instrument will not accurately measure multifrequency fields. Another isotropic, wideband field sensor comprises three orthogonal lossy elements made from thin-

film thermocouples. Outputs from the elements are summed to provide a signal proportional to $[E]^2$; the instrument can be calibrated to read in units of mW/cm^2. (10 references)

0431 METHODS OF CALIBRATING MICROWAVE HAZARD METERS. *(E.)* Baird, R. C. (Electromagnetics Div., NBS, Boulder, Colo.). *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 228-236.

Existing calibration methods for MW hazard meters require that a known field intensity be established through measurement, calculation, or a combination of both. The device under test is placed in the "standard" field and the meter indication is compared with the known field value. Three different approaches to producing the "standard" calibrating field are described: the free-space standard method, guided wave methods, and the standard probe method. The basic concepts, advantages and limitations, and attainable accuracies of each method are reviewed. The free-space standard field method can be used for calibrating antennas as well as power meters. NBS uses standard gain horns above 2.6 GHz to establish 10 mW/cm^2 fields to an accuracy of $\pm$ 0.5 dB, including multipath effects. Below 2.6 GHz an open-ended waveguide is used as the radiating element. Present accuracy down to 0.9 GHz is $\pm$ 0.6 dB; transmitter powers of 35 W or less are required to produce a 10 mW/cm^2 field. Guided wave methods require considerably less power and space but are useful only for frequencies below 1 or 2 GHz, since the device being calibrated must be small compared to the guide dimension. One waveguide system operates at 400-600 MHz with an estimated uncertainty in the field intensity of $\pm$ 12%; another operates at 2450 MHz with an accuracy to within $\pm$ 6-7%. The standard probe method is the simplest and may prove to be the best method of calibrating hazard meters for general use. An accurately calibrated probe is used as a "transfer standard"; i.e., the probe determines the field intensity over a particular region in space (or in a guided system) produced by an arbitrary transmitting antenna. The probe to be calibrated is then placed in the same location in the field and the meter reading compared with the known value of the field. Dipole-diode type probes may ultimately serve as such a transfer standard. (21 references)

0432 METHODS OF MICROWAVE FIELD QUANTIFICATION FOR BIOLOGIC STUDIES. *(E.)* Smith, R. B. (Sch. Electr. Electron. Eng., Univ. Bradford, U.K.). *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 237-239.

Priorities placed on establishing standards for safe exposure of personnel working in the vicinity of high-power radiofrequency sources have created new emphasis on the development of instrumentation for monitoring microwave (MW) power density. This report describes a monitoring bolometer, developed at the Univ. of Surrey, based on the classical gas thermometer. Two thin-walled silica spheres are placed in a radome coated to reflect infrared radiation and transparent to microwave radiation. The spheres are air-filled and connected by narrow-diameter tube to a capacitive differential-pressure transducer. One sphere is coated with resistive films and absorbs MW energy. The other is not coated and provides ambient temperature compensation. The pressure difference due to the absorption of energy by the resistive film and subsequent heating of air in the coated cylinder is converted into a change in capacitance at the pressure transducer. A special transformer ratio bridge converts the capacitance change into an out-of-balance voltage which is linearly related to temperature rise in the coated sphere and thus to the power absorbed. The final temperature of the coated sphere is dependent on the heat loss mechanisms within the radome. The thermal time constant was found to be dependent on the silica substrate and was about 8 sec for 63% of the final temperature. The use of an electronic differentiation circuit reduced the effective time constant of the instrument to less than one second. A major part of the research was devoted to measuring the frequency-dependent absorption coefficient of the coated spheres, which was found to be a function of sphere diameter and surface resistivity. (2 references)

0433 RADIATION HAZARDS FROM MICROWAVE SOURCES WITH MOBILE ANTENNAS: CERTAIN TECHNICAL PROBLEMS. *(E.)* Frank, Z. (Inst. Aviat. Med., Prague, Czechoslovakia). *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 240-242.

In considering hygienic conditions in a given locality MW sources, such as radar installations whose main function is to emit energy into the environment, should be observed. The general practice is to measure the intensity of the irradiated field; however, real conditions during field measurements of MW intensity differ significantly from those of calibrating standards and anechoic chambers. It is therefore necessary to determine the maximum intensity values considering radiation emitted simultaneously from all independent sources. In order to compute data for hygienic evaluation, one must use an orderly sequence of theoretical analysis, real measurements, analysis of the existing situation, and of all factors influencing the distribution of power density from the equipment used. The derived formulae may then be used to predict hygienic conditions for new installations. (6 references)

0434 RESONANCE METHOD FOR THE DETERMINATION OF THE COMPLEX DIELECTRIC CONSTANT OF BIOLOGIC MATERIALS IN THE MICROWAVE BAND. *(E.)* Piotrowski, M. (Mil. Inst. Hyg. Epidemiol., Warsaw, Poland). *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 243-253.

The problem of measuring the complex dielectric constant of biologic materials in EM fields was solved by the resonance method. The examined substance was

placed in a cuvette, the dimensions of which were smaller than the inner dimensions of the measuring cavity. Losses in the wall of the cuvette and its geometry were taken into consideration. The electrodynamic aspect of the task was reduced to the solution of the internal electrodynamic problem for the case of an isotropic medium described by a continuous function of dielectric permittivity of a nonhermitian symmetry. The metrologic aspect was based on experimental determinations of the resonance frequency and the Q factor of the resonator with and without a sample, and establishing interrelations linking these quantities with certain physical parameters of the resonator and the examined material. An original solution to the problem of selfvibrations of the resonator was obtained using Galerkin's method. An analytical procedure and the use of quasi-H_{onp} modes are needed for the dielectric measurement of lossy samples concentrically placed in the resonator and cuvettes, and not completely filling the cavity. There are no restrictions on size or on the material parameters of the tested substances (for isotropic media with magnetic permeability equal to vacuum permeability $\mu_o = 1$). These characteristics allow the choice of convenient samples and ensure obtaining the selected sensitivity for predicted values of ε_2 and ε_1 The most critical parameter is the inside diameter of the cuvette. Procedures for determining the permittivity ε_2' and ε_2'' from f (ε', ε'') and Qd (ε', ε'') can be carried out separately. Measurements of the dielectric constants of a number of substances including distilled water, γ-globulin, and human blood (Na tartrate) were carried out in a resonator tuneable to the X band with a field distribution H_{011}. In the range of measured values $\varepsilon_2' = (40 + 60)$ and $\varepsilon_2'' = (20 + 35)$, the error does not exceed 0.5%. The full error in determining ε_2' and ε_2'' (5 + 10)% is mainly due to the measuring technique used. (14 references)

0435 MICROWAVE REFLECTION AND DIFFRACTION BY MAN. Beischer, D. E. (Naval Aerospace Med. Res. Lab., Pensacola, Fla.) and V. R. Reno. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 254-259.

Valuable information for evaluating the biological effects of MW radiation may be gained from measurements of reflected, scattered and transmitted radiation. MW field perturbations were measured in immediate proximity to an illuminated human subject in an indoor range to assure close environmental control. A 4.8 m parabolic reflector was used to collimate a beam illuminating an experimental stage (3.6 m x 3 m x 2.4 m). Power measurements were taken by an NBS isotropic sensor in which three orthogonal dipoles are combined to measure the power density. The studies were conducted at 1 and 3 GHz CW, at power densities of not more than 50 $\mu W/cm^2$ in vertically and horizontally polarized fields. The interference patterns of a human being show a standing wave on the illuminated side and a pronounced shadow on the opposite side. Both the spatial standing wave and the radial diffraction field around man resemble the field perturbations demonstrated theoretically and experimentally around a conducting circular cylinder. A comparison between diffraction patterns around a cylinder and a conducting mannequin allow for estimating the significance of the shape of the subject. The studies indicate that power measurements made in the vicinity of man may be subject to wide errors if standing waves and shadows are not taken into consideration; the design and positioning of personnel MW dosimeters should be influenced by these facts. It is also apparent that one man can considerably modify the MW field incident on his neighbor, an important consideration in multiple exposure of men and animals. Reflection and transmission measurements will permit a new approach to the estimation of absorbed energy in different-sized parts of the human body. (2 references)

0436 CLINICAL MANIFESTATIONS OF REACTIONS TO MICROWAVE IRRADIATION IN VARIOUS OCCUPATIONAL GROUPS *(E.)* Sadcikova, M. N. (USSR Acad. Med. Sci., Moscow. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 261-267.

Microwave or radiowave sickness has been identified as a distinct occupational disease following prolonged work involving exposure to MWs. Changes take place in the function of the nervous, cardiovascular, and other systems leading to a characteristic complex of symptoms. The health status of 2 groups of workers involved with radio equipment emitting radiation in the MW range was observed and compared to controls. The first group was exposed to a power density of up to a few mW/cm^2 while the second group was exposed to a much lower intensity. Both groups significantly differed from controls in frequency of such complaints as heaviness of the head, drowsiness during the day, tiredness, irritability, anxiety, light sleep at night, and partial loss of memory. In both groups the frequency of asthenic and autonomic vascular disturbances of a hyperreactive character (expressed dermographism, hyperhidrosis, arterial hypertension) related to age and employment depended directly on the duration of professional contact. It was found that a complex of symptoms corresponding to MW sickness was diagnosed only in those patients of the first group who began work under very unfavorable conditions. Microwave sickness was characterized by various autonomic vascular disturbances with crises of cerebral and coronary vascular insufficiency and asthenic symptoms. Three stages (initial, moderately advanced, and advanced) in the development of the illness were distinguished with asthenic, astheno-autonomic with vascular dysfunction of hypertonic type, and hypothalmic clinical syndromes. Of those patients suffering from MW sickness, despite repeated therapeutic courses and temporary withdrawal from work, upon returning to previous working conditions symptoms increased in severity. Cessation of work involving irradiation frequently resulted in stabilization of the processes or recovery if withdrawal took place in the initial stage of the illness. (24 references)

0437 NEUROLOGIC FINDINGS IN PERSONS EXPOSED TO MICROWAVES. *(E.)* Klimková-Deutschová, E. (Neurol. Clin., Charles Univ., Prague, Czechoslo-

vakia). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 268-272.

Data on 352 persons occupationally exposed to nonionizing radiation from 29 places of work were analyzed with respect to clinical, biochemical and bioelectric signs, age, and the characteristics of the exposure to EM radiation. Symptoms such as headache, fatigue and excitability were found most frequently in workers exposed to radiation in the cm waveband. Age had no significant relationship to symptomatology. There were slight disturbances in enzyme function including a slight increase in fasting blood sugar. Fatigue, paralleled by a reduction in vigilance and pathological changes in the EEG, was found to be localized in the mesodiencephalic region. This activity was found particularly in persons exposed to high levels of radiation from a pulsed field. These analyses concentrated on fine regulatory mechanisms which are disturbed before organic changes can occur. This determination is important for the application of preventive measures such as excluding from work involving nonionizing radiation persons liable to paroxysmal activity of the CNS and certain people with pseudoneurasthenic syndrome or motor system disturbances. (No references)

0438 A STUDY OF THE HEALTH STATUS OF MICROWAVE WORKERS. *(E.)* Siekierzyński, M. (Inst. Postgrad. Stud., Mil. Med. Acad., Warsaw, Poland). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 273-280.

The health status of 841 men (ages 20-45 yrs) who were occupationally exposed to irradiation with pulsed MWs of various frequencies was studied. The men were divided into two groups according to exposure levels: those exposed during working hours at power densities above 2 W/m^2 and those exposed at power densities below 2 W/m^2. They were divided into subgroups based on age and duration of employment and were examined for eye changes, functional disturbances, and all other causes for unfitness for work taken together. No statistically significant correlation was found between parameters examined and duration of employment in the two groups, while there was an obvious existing correlation between some parameters and age. Thus within the groups as well as between groups of persons occupationally exposed to various power densities of MW radiation, no correlation is indicated between degree of exposure or duration of employment and incidence of analyzed health disturbances. (2 references)

0439 BLOOD PROTEINS IN PERSONNEL OF TELEVISION AND RADIO TRANSMITTING STATIONS. *(E.)* Pazderová, J. (Res. Inst. Telecommun., Prague, Czechoslovakia), J. Picková, and V. Bryndová. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 281-288.

Previous studies have indicated that no changes in health status due to EM radiation have been observed except modification of the blood protein ratio. These investigations were repeated on radio and TV technicians who have worked at least 5 years in their profession. The levels of blood proteins and their fractions were within physiologic limits, but statistically significant differences were found between mean values for the exposed *vs* control groups. Total protein level was higher in people operating medium wave transmitters. The albumino-globulin quotient decreased in radio technicians, and gamma-globulin decreased in TV technicians. The findings confirmed previously reported data on evidence of blood protein changes, but differs from previous reports in that no evidence of gamma-globulin elevation was found. No pathologic findings were revealed, and the mean differences between exposed and control groups are considered to be a general response of the organism to the stress of EM radiation. (9 references).

0440 THE BIOLOGIC ACTION AND HYGIENIC SIGNIFICANCE OF ELECTROMAGNETIC FIELDS OF SUPERHIGH AND ULTRAHIGH FREQUENCIES IN DENSELY POPULATED AREAS. *(E.)* Dumanskij, J. D. (A. N. Marzeev Kiev Sci. Res. Inst. Gen. Public Hyg., USSR) and M. G. Šandala. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 289-293.

Hygienists have begun studying the effect of UHF and SHF energy in densely inhabited areas. At the sites of TV, radar, radioastronomy and radiometerology sources, the intensity of electromagnetic energy is much higher than the earth's background and penetrates buildings located in the vicinity. Twenty-eight rabbits and 128 white rats were used in investigations of biologic effects for the UHF range and 100 white rats and 32 rabbits were used in the SHF range. The animals were irradiated for 8-12 hr daily for 120 days. Turning on the EM field elicited changes in the CNS as the animals appeared excited. Certain periodic changes appeared in the conditioned reflex activities of the animals; this was connected with development of inhibitions related to impairment of nervous reactivity and leading to pathologic stagnation and inertia. Previously observed changes in bioelectric activity of the brain cortex were confirmed. EM fields impaired biochemical mechanisms which ensure the normal course of nervous processes; resulted in increased weight of the adrenals, reduction in their ascorbic acid content, and increased secretion of ketosteroids in the urine; and increased the ability of the thyroid gland to concentrate radioactive iodine. Electromagnetic energy caused changes in the composition of the blood including decrease in leukocytes, eosinophils, reticulocytes, erythrocytes and hemoglobin. An increase in the RNA and DNA contents of spleen and liver was induced. Thus, prolonged exposure of low intensity EM energy in the UHF and SHF ranges resulted in appreciable changes in the general status of the organism, conditioned reflex activity, bioelectric activity

of the brain cortex, various biochemical parameters, blood composition and morphologic structures of tissues and organs of the exposed animals. The biologically active intensities were 0.06-10 $\mu W/cm^2$ for UHF and 5-20 $\mu W/cm^2$ for SHF ranges. (No references)

0441 SELECTED CASES OF MICROWAVE CATARACT IN MAN ASSOCIATED WITH CONCOMITANT ANNOTATED PATHOLOGIES. *(E.)* Zaret, M. M. (Zaret Foundation, Inc., Scarsdale, N.Y.). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 294-301.

The term microwave cataract is defined, its pathogenic evolution described, and the differential diagnostic features distinguishing it from all other types of cataract are presented. The role of microwaves as a secondary, contributory or synergistic factor is not discussed. Six case histories, selected from more than 50 cases, are presented. Each case having exhibited characteristic posterior capsular opacification following a known exposure to microwaves, and an absence of other demonstrable cataractogenic etiology, is considered as having primary microwave cataractogenic etiology. Histories and ophthalmologic findings depict acute, subacute or chronic forms of microwave cataract. The covert nature of usual exposures, characteristic latency, slow evolution and subsequent insidious onset of symptoms are discussed. Concomitant ophthalmologic and generalized pathological findings are described and compared to similar findings reported in the scientific literature as being related to microwave exposure. The additional ophthalmological findings consist of: (1) hydrops of the lens, keratoconjunctivitis, iridocyclitis and chorioretinitis, which can develop immediately following irradiation; (2) keratopathy, glaucoma, synchiae,, retinal degeneration, melanomata and capsule exfoliation, which can develop later; and (3) after long periods of latency, corneal endothelial dystrophy and lenticular nuclear sclerosis, which are indicative of premature aging. Non-ophthalmological findings observed in this group include mental illness; cardiac, vascular, hormonal and arthritic disease; testicular malignancy and a rare, bizarre CNS degeneration in a child fathered by one of the patients. The protean nature of microwaves and its potential contributory role as a pathogenic agent are discussed. (No references)

0442 RETINAL CHANGES IN MICROWAVE WORKERS. *(E.)* Tengroth, B. (Dep. Ophthalmol., Univ. Gothenburg, Sweden) and E. Aurell. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 302-305.

Retinal changes in people occupationally exposed to MWs have not been reported in the literature. However, in an electronic industry working with radar equipment, during periodic checking on the eyes of personnel the frequency of significant lens opacities in a group of younger workers and retinal lesions in the paramacular and macular regions had been noted. An epidemiologic study on 98 workers in a similar industry was performed to determine the significance of these findings. Sixty-eight workers had been exposed to MWs for a length of time; they were divided by type of exposure into persons testing radar equipment and measuring MW radiation from different klystrons and persons from experimental laboratories. Thirty persons also exposed were used as controls. All personnel were examined by eye specialists to determine refraction and visual acuity, to study the optic media by corneal microscope and slit lamp in comple mydriasis, and to study the retina by ophthalmoscope. The number of lens opacities even at younger ages was high among exposed workers. Retinal lesions were also of high frequency. Dividing the exposed personnel by task indicated a concentration of lens and retinal lesions among testing personnel. This group is more apt to be exposed to higher power levels, indicating that maximum permanent exposure (MPE) of 10 mW/cm^2 may be too high. Similar retinal lesions have been observed in subsequent studies done in Poland, confirming these preliminary observations. Further experimental and theoretical work needs to be done to determine whether such lesions are due to nonthermal effects. (7 references)

0443 ASSESSMENT OF LENS TRANSLUCENCY IN JUVENILES, MICROWAVE WORKERS AND AGE-MATCHED GROUPS. *(E.)* Zydecki, S. (Inst. Postgrad. Stud., Mil. Med. Acad., Warsaw, Poland). *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 306-308.

Differing criteria used for lens translucency have led to controversy on the effects of occupational exposure to MW radiation on the eye. The reported study examined 3000 individuals of both sexes, divided into 3 groups of 1000 each. Group A was further divided into 2 subgroups. A_1 contained 542 people exposed directly to MW radiation ranging between 0.1 mW/cm^2 and 1 mW/cm^2, approximately. During short periods of time the mean power density to which this group was exposed could reach up to 6 mW/cm^2. Group A_2 was made up of 458 individuals exposed to MWs at 0.01 mW/cm^2 or less. Both groups were exposed on the average 4 hr per day, the history of occupational exposure ranging from 1 to 15 yr. Group B comprised 1000 age-matched individuals not exposed to MWs; Group C included young people aged 5-17 yr. Groups B and C served as controls for Groups A_1 and A_2. Lens translucency was assessed using a 5-grade scale. Detailed analysis indicated that a close correlation exists between age and the grade of lens translucency, and that the frequency of inborn defects may be about 0.7%. Statistically significant differences in the frequency of various grades of lens translucency existed between Group A, B, and C; as were the differences between subgroups A_1 and A_2. Analysis demonstrated that duration of occupational exposure did not play a decisive role. Decrease in lens translucency depended upon power density levels. However long-term exposure to low doses (below cataractogenic levels) may tend to accelerate the normal aging process. (No references)

0444 MICROWAVES - A TOOL IN MEDICAL AND BIOLOGIC RESEARCH. *(E.)* Grant, E. H. (Phys. Dep., Queen Elizabeth Coll., London, U. K.). *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 309-316.

The degree of interaction of MWs with biologic tissue may be determined if the amount of energy which is reflected and the amount absorbed is known. This can be determined theoretically from the angle of incidence and the complex permittivity. The complex permittivity may be rigorously determined and it should be possible to construct a data base for the electrical properties of body tissues. In the MW region the electrical properties of water dominate those of all other biologic molecules present. The structure of this water immediately surrounding the biologic macromolecules is "bound" or "modified" and has different electrical properties than "pure" water. Once these electrical parameters are known they may be used in medical and biologic research such as the investigation of hyperbetalipoproteinemia, treatment of cancer and evaluation of the size and shape of biologic molecules in an aqueous environment. (28 references)

Summaries of Discussions, Session Reports and Recommendations

0445 SESSION A. GENERAL EFFECTS OF MICROWAVE RADIATION. *(E.)* Z. V. Gordon, T. V. Kalada, M. L. Shore and H. P. Schwan. *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 317-320.

Several papers during this session were devoted to the biologic effects of higher intensities of MW radiation. The majority were concerned with the biologic effects at intensities so low that thermal effects can be excluded. In these latter investigations the possibility exists that microthermal effects and nonthermal effects which are unclear at the present time might have occurred being responsible for the biologic changes observed. During the general discussion it was suggested that energy density flux levels of MW fields be divided into three ranges: (a) high intensities of 10 mW/cm^2 upwards (region of thermal effects); (b) the range of subtle effects from about 1-20 mW/cm^2 (possible effects of a microscopic or macroscopic nature); (c) intensities below 1 mW/cm^2 (region of nonthermal effects). The boundaries indicated are dependent on numerous variable factors such as animal size, threshold of warmth sensation, frequency, pulsing, etc. The intermediate range calls attention to the need for additional research on subtle effects and clarification of the underlying mechanisms. The following recommendations specific to the subject of this session were agreed upon: (1) More biophysical investigations are needed on mechanisms of MW interaction with complex microscopic and submicroscopic systems (e.g., intermolecular mechanisms). Special attention should be made in determining the absorbed energy dose and its spatial distribution. (2) Threshold values at which biologic effects are induced should be determined. Combined effects of MW and other environmental factors and the effects induced at various MW frequency bands should be studied. (3) Biologic, medical and biophysical effects in the entire RF range should be conducted, with particular attention to their dependence on the physical characteristics of the EM field. (4) Cumulative effects, delayed effects, differential radiation sensitivity, effects related to cellular transformation, and carefully controlled human epidemologic studies are areas requiring further research.

0446 SESSION B. INFLUENCE OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM AND BEHAVIOR. *(E.)* W. R. Adey, E. A. Lobanová, A. V. Roščin and W. A. G. Voss. *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 321-323.

Discussions in this session emphasized difficulties in evaluating subtle physiological and behavioral effects during and following MW exposure in mammals. For example, natural factors such as growth and aging must be considered in long range tests, autonomic nervous reactions resembling field-induced changes must be ruled out, and difficulties involved with using inappropriate metal instrumentation must be solved. The question of thresholds for thermal effects within the crania with and without potential distortions of the EM field following implantation of inappropriate metal electrodes was repeatedly raised. There was much interest in problems of instrumentation in CNS studies, as recording of temperature during or immediately following irradiation of the brain would be important. Justesen presented his "evoked colonic temperature" to obviate the need for recording directly in the CNS, but this was not accepted by Soviet participants. In studying the effects of pulsed fields, Stverak, Marha, and Pavkova emphasized the significance of the envelope of the carrier wave in seizure induction, as these envelopes are potent in modifying conditioned reflexes and EEG rhythms. Romero-Sierra proposed schemes of tissue-interaction with MW fields. The data presented are important for setting up safe exposure limits to MW radiation. The session recommended that further investigation of MW effects on the nervous system should include: (1) investigation of the influence of MW exposure on behavior and conditioned reflex functions using various exposure regimes; (2) electrophysiologic investigations carried out during the exposure period; (3) investigations of effects of MWs on CNS metabolism; and (4) investigation of morphologic changes in the CNS following MW exposure.

0447 SESSION C. EFFECTS OF MICROWAVE RADIATION AT THE CELLULAR AND MOLECULAR LEVEL. *(E.)* E. H. Grant, K. H. Illinger, B. Servantie and S. Szmigielski. *Biologic Effects and Health Hazards of Microwave Radiation,* Polish Med. Publishers: Poland, 1974, pp. 324-326.

The size dependence of the pearl-chain effect was discussed. Inconsistencies between reported findings

and the currently accepted model for predicting the dielectric behavior of membranes, the Hodgkin-Huxley model, may be due to the possibility that effects at the level of biologic systems may not be predictable on the basis of the behavior of isolated molecular systems. The question of the energy difference between conformational states of biopolymers was raised; the effects of the shape and nature of experimental containers and depth of liquid on the actual field in studies of MW irradiation of biologic preparations were discussed; and the question of the existence of cumulative effects in cataractogenesis was discussed at some length. The problem of runaway heating in the MW heating of frozen tissues was also mentioned. The principal conclusions drawn from the six papers presented were set forth. Summing up the session, multidisciplinary research by a team of investigators comprising at least a doctor, biophysicist or physicist, and electrical engineer was strongly recommended.

0448 SESSION D. MEASUREMENTS OF MICROWAVE RADIATION. *(E.)* R. C. Baird, P. Czerski, A. W. Guy and M. Piotrowski. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 327-329.

Understanding of the biologic effects observed in specimens exposed to EM fields requires a complete quantitative description of the fields inside and outside the test subject. These fields are a complex function of the types of sources and the shape and size of the exposed subject. External fields have been specified in terms of power density, but the electric field or square of the electric field are more reliable indicators of possible biologic effects. Accurate instrument calibration is necessary for safety reasons and to provide interlaboratory comparisons of experimental results. Three approaches to calibration, all of which can be reasonably accurate, were discussed: the free-space standard field method, guided wave methods, and the standard probe or transfer standard method. Internal fields and power absorption may be directly measured *in vivo* by implanted electromagnetically transparent probes, though accurate and reliable probes still need to be developed. The problem of perielectrode energy observed in brain tissue was discussed as, in general, any time a sharp metal object is put in contact with tissue, field enhancement results at the point of contact. Diffraction patterns produced when a human subject is exposed to a MW field of 1-3 GHz were described, showing that the field is strongly perturbed by the subject. A simplified method for determining radiation hazards associated with radar antennas employing assumed radiation patterns based on selective measurements was described. The need for complete data on dielectric properties of biologic substances was discussed. The session made the following recommendations: (1) accurate internal dosimeters are needed; (2) standard methods for quantifying fields and detecting biologic signals should be established; (3) standardized exposure techniques should exist between laboratories; (4) researchers should describe all pertinent experimental conditions; (5) the development of magnetic field sensors should be promoted; (6) more complete information on EM and thermodynamic properties of biologic materials are needed; and (7) an interdisciplinary group should be established to translate and disseminate documents pertaining to biologic and engineering aspects of research on biologic effects of EM radiation.

0449 SESSION E. OCCUPATIONAL EXPOSURE AND PUBLIC HEALTH ASPECTS OF MICROWAVE RADIATION. *(E.)* Z. Edelwejn, R. L. Elder, E. Klimková-Deutschová and B. Tengroth. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 330-331.

The difficulties of rigidly controlled long-term clinical and epidemiologic studies were discussed. Environmental factors such as ambient temperature and exposure to x-rays, the lack of serious cardiovascular disturbances due to MW exposure, the fact that clinical findings in the case of longterm or overexposure are referable to the nervous systems, and "MW neurosis" were mentioned. Inclusive discussion concerned MW lens and eye injury. Biologic effects and health hazards to the general population and the methodological difficulties of large population research studies in the working environment were also discussed. The clinical studies presented led to recommendations for studies dealing with: suitable preventive measures for persons occupationally exposed to MW and for the general population, epidemiologic comparative and dynamic studies, and refinement of tests of motor system function as a diagnostic tool. Examination of the retina in all ophthalmologic examinations was also recommended.

0450 SESSION F. PRESENTATION AND DISCUSSION OF SESSION REPORTS, CONCLUSIONS (INCLUDING FUTURE RESEARCH NEEDS) AND RECOMMENDATIONS. *(E.)*

J. C. Gallagher, K. V. Nikonova, E. Shalmon and C. Susskind. *Biologic Effects and Health Hazards of Microwave Radiation*, Polish Med. Publishers: Poland, 1974, pp. 332-335.

A single paper was presented on the use of microwaves as tools in biological research. Bound water in tissues was discussed. The second part of the session was devoted to session reports and recommendations, which included: (1) There should be continued international exchange of information, improved translation services, exchange visits, and closer international collaboration. (2) A program concerned with nonionizing radiation should be developed by an international health agency. (3) Internationally acceptable nomenclature and definitions and standardisation of measurement techniques should be established. (4) Microwave intensities should be divided into three approximate ranges as suggested in Session A. (5) New electrode systems and integrated electrodeignal amplifying systems should be developed. (6) Further studies are needed to improve understanding of interaction of MW radiation with biologic systems in the following areas: cumu-

lative and delayed effects; low-intensity effects; determination of possible threshold values; combined effects of radiation and other environmental factors; investigation of differential radiation sensitivity; effects related to cellular transformation; effects at the molecular level; and determination of absorbed energy dose and its spatial distribution. Similar investigations in the RF range were emphasized.

0451 EVALUATION OF THE INTERNATIONAL SYMPOSIUM ON BIOLOGICAL EFFECTS AND HEALTH HAZARDS OF MICROWAVE RADIATION - WARSAW, POLAND, 15-18 OCTOBER, 1973. *(E.)* Michaelson, S. M. (Univ. Rochester Sch. Med. Dent., N.Y.). *Univ. Rochester At. Energ. Proj. Rept.* No. UR-3420-457, 1973, 28p.

Following the 1973 Warsaw International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, the World Health Organization's (WHO) Regional Office for Europe convened a group of experts to review the results of the symposium and to advise the Office on future plans for evaluation of the public health risks from MW radiation. Papers evaluated by the Group are summarized under the headings: Measurement of Electromagnetic Fields; Survey of Biological Effects, including Cellular and Molecular Effects, Thermal Effects, Cataracts; Central Nervous System Interactions; Occupational and Public Health Aspects; and Microwaves as a Tool in Medical and Biological Research. Recommendations for further action in some of these areas are presented along with a list of recommendations relating to the international exchange of data on the bioeffects of MWs and to other areas in which additional information is needed. The Group emphasizes that measurement of MW fields is complicated and still in a developmental state. A clear understanding of bioeffects in man, animals, and biological specimens exposed to EMF requires a complete quantitative description of the field both inside and outside the test subject. Accordingly, the Group recommends development of accurate internal dosimeters; increased efforts to quantify internal fields; and establishment of standard methods of quantifying internal and external fields and of detecting biological signals. The Group suggested the convening of a small working group of specialists to discuss and evaluate available instruments for measuring complex MW fields, and to provide a standardized description of their selection and use, including calibration and intercomparison of calibration. Further, the Group suggests convening a working group to discuss instrumentation for *in vivo* and *in vitro* measurements of MW fields in biological objects. Additionally, the Group suggests that available literature on the biological effects of MWs be analyzed by a small working group for evidence or rejection of threshold phenomena; if the data do not permit a definitive evaluation, recommendations should be made for appropriate biological investigations. In the area of epidemiologic studies, a working group should be convened to identify appropriate groups and risk and to determine study procedures. Carefully controlled epidemiologic studies are required to determine the biophysical mechanisms of microwave interaction with complex systems such as cellular and subcellular structures. The convening of working groups is also recommended to evaluate the compatibility between MW radiation and medical electronic equipment and to determine the risk from certain types of diathermy equipment. Other actions urged by the Group include a symposium on MW biophysics, biology, and potential health hazards; standardization of nomenclature used in discussing the effects of exposure to MW/RF energies; promotion of interaction between physical engineering and biological scientists; evaluation of ambient EM fields by a consultant and later, if a serious increase occurs, by a working group; a survey to establish consistency of product performance standards for MW-emitting devices with personal exposure standards; and a training program for health physicists and public health officials responsible for evaluating MW and RF radiation. (No references)

PREPRINTS

0452 A THEORETICAL ESTIMATION OF TISSUE ANISOTROPY EFFECTS ON ELECTROMAGNETIC POWER DEPOSITION -- 0.1 TO 100 MHz. *(E.)* Johnson, C. C. (Dep. Biophys. Bioeng., Univ. Utah, Salt Lake City) and C. H. Durney.

Muscle anisotropy has been demonstrated at ECG frequencies (below 100 Hz) by closing a battery-activated circuit for 0.1 sec to simulate the QRS complex. Greater than 15:1 changes in conductivity were measured as current flow was applied parallel to and then perpendicular to the direction of human skeletal muscle fibers. EM power deposition was studied theoretically by correlating the ECG anisotropy conductivity data with Schwan's data describing conductivity and permittivity variations with frequency in terms of a relaxation phenomenon associated with cell wall polarization. With E-fields perpendicular to the muscle fiber area, an estimate of σ variation with frequency was inferred. For E parallel to the fibers, no cell-wall polarization effects were assumed and thus no change in σ and ε in the range 0.1 MHz to less than 100 MHz. Expressions were derived for absorbed power distribution in a plane layered medium and for the case of a planewave in air striking an air-fat interface and then a fat-anisotropic muscle interface. With these expressions, variation in power deposited in muscle tissue can be calculated as a function of polarization, fat thickness, and frequency. (4 references)

0453 RAMAN SPECTROSCOPY OF MOLECULAR SPECIES DURING EXPOSURE TO 100 MHz RADIO FREQUENCY FIELDS. *(E.)* Klainer, S. M. (Block Eng., Inc., Cambridge, Mass.) and J. W. Frazer.

A Raman spectrometer with an argon ion laser was used to observe the effects of 100 MHz RF fields on glycine, ATP, *Escherichia coli* tRNA, and chymotrypsin molecules. No perturbations of glycine or ATP spectra were found in carefully stirred solutions where thermal gradients were avoided. *E. coli* tRNA, conversely, lost several of the peaks associated with intramolecular hydrogen bonding that appear in the region 800 cm^{-1} to 2000 cm^{-1}. The most pronounced loss was in the adenine-guanosine cross bonding; this effect was produced with a power feed of 8 W, corresponding to a field of about 400 V/cm. At input powers of 3 W ($\sim$150 V/cm) and 4 W ($\sim$200 V/cm), chymotrypsin showed a progressive loss of several prominent peaks in the 209 cm^{-1} to 600 cm^{-1} region. When power was increased to 5 W, the entire solution became very turbid. These results suggest that alterations in the Raman spectra may show effects of applied fields on the tertiary structure of large molecules in addition to providing information usually contained in dielectric dispersion spectra. (5 references)

0454 ELECTROMAGNETIC POWER ABSORPTION IN ANISOTROPIC TISSUE MEDIA. *(E.)* Johnson, C. C. (Dep. Biophys. Bioeng., Univ. Utah, Salt Lake City), C. H. Durney and H. Massoudi.

Strong dielectric constant anisotropy exists in muscle tissue at the lower MW frequencies. Based on a model derived from tissue measurements at 0.001-100 MHz, an analysis is carried out for single and multiple tissue layers. The model assumes an idealized anisotropic tissue medium consisting of infinitely long, perfectly parallel muscle fibers generating relaxation effects only where there are E field components perpendicular to the fibers. Calculated effects of tissue anisotropy on MW fields and power absorption in tissues at two frequencies are presented. The effect of polarization on power absorption is significant at 0.01 MHz but not at 100 MHz. Further research on anisotropic effects must involve models more representative of human- or animal-sized bodies. (3 references)

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0100 EFFECTS OF ELECTROMAGNETIC FIELDS ON GENETIC PHENOMENA. Braver, G. (Dep. Zool., Univ. Oklahoma, Norman).

See CR 0015, Volume I(1), for description of this research. (Renewed 7/73-6/74)

SUPPORTING AGENCY:EPA, Off. Res. Dev.

0101 TREATMENT OF TRICEP'S SURAE CONTRACTURES. Lehmann, J. F. (Univ. Washington Sch. Med., Seattle).

The objective of this study is to develop a more efficient nonsurgical method of combating equinus deformity that occurs as a result of gastrocneumius and soleus contractures. Loading--with and without diathermy--is added at a prescribed rate with simultaneous readout of the strain produced. The gain was approximately one degree of dorsiflexion per day at the ankle in patients with recent (as opposed to long standing) contractures, in patients with lower motor neuron disease, and in young muscular dystrophy patients. Patients with upper motor neuron lesions immediately gained full range of motion, but it is uncertain whether true contractures or muscle tone problems were present in these cases. Optimal conditions for selectively heating the calf musculature have been developed by using a specially designed microwave applicator, but investigations are still preliminary. (7/72-6/73)

SUPPORTING AGENCY:HEW, Soc. Rehab. Serv.

0102 INVESTIGATION OF OCULAR EFFECTS OF CHRONIC EXPOSURE OF PRIMATES TO MICROWAVE RADIATION AT 2.45 GHz. Polson, P. (Stanford Res. Inst., Menlo Park, Calif.).

The objective of the initial phase of this study will be the design, development, calibration, and testing of exposure cavities. The cavities developed will be utilized to study MW effects to determine safe exposures for military personnel. The exposure cage will be designed as a "stirred," multimode resonant cavity so that animals will constitute virtually the entire power absorption load within the cavity. It will be designed so that animals will have free movement with capabilities to control and monitor ambient temperature and humidity, and to view and feed exposed animals. (7/74-6/75)

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

0103 ANALYSIS AND PREPARATION OF AVAILABLE WORLD LITERATURE ON BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. Lindberg, R.; Larrimore, J. (Technol. Labs., Mead Corp., Dayton, Ohio).

Literature selected and included in the *Biological Effects of Electromagnetic Radiation Digest* produced by the Science Information Services Department of the Franklin Institute Research Laboratories, under another contract with the Army, will be entered into a computerized file in full text and in a manner to provide rapid review and retrieval. (7/74-6/75)

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

0104 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Med. Rehab. Res. Train. Cent., Univ. Washington, Seattle).

A renewal of the contract reported in CR 0044, Volume I (2), is being conducted to advance the existing knowledge on the quantitative effects of electromagnetic radiation on the human body and to provide realistic guidelines for safety standards of human exposure. The progress and findings of this on-going project include: (1) The minimum cataractogenic threshold in the eyes of a rabbit exposed to EM energy was determined. (2) The threshold for human auditory perception of incident MW pulses was found to correspond to a specific pulse energy density regardless of average or peak power. (3) Calculated peak pressures induced in mammalian tissues by the incident electric field energy were found to be above the cone-conduction threshold. (4) The behavior of the spinal cord exposed to high level microwaves indicates that this CNS structure is subject to functional alteration by the impingement of radiation. (7/74-6/75)

Supporting Agency:HEW, Soc. Rehab. Serv.

0105 OCULAR EFFECTS OF MICROWAVE RADIATION. Carpenter, R. L. (Northeast Radiol. Hlth. Lab, Winchester, Mass.).

The objective of the research is to determine the threshold conditions for the production of microwave induced cataracts and to characterize these cataracts uniquely. The effect of frequency, dose regimen and pulsing on the threshold for cataract formation in rabbits will be investigated. Biochemical and histopathological examinations of microwave irradiated lenses will be performed in order to determine if microwave induced cataracts differ in any characterizable manner from cataracts of other etiologies. (7/74-6/75)

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

0106 THE EFFECTS OF MICROWAVE RADIATION ON THE CENTRAL NERVOUS SYSTEM. Albert, E. N. (George Washington Univ. Sch. Med., Washington, D.C.).

The project will investigate, using light and electron microscopy, the existence of morphological alterations in animals exposed to microwave irradiation. Chinese hamsters are being irradiated with microwaves at 12.5 cm and power levels of 10, 25, and 50 mW/cm^2. Brain nuclei will be examined for radiation-induced changes using both light and electron microscopy. Special emphasis will be placed on the mitochondria, nucleolus, rough endoplasmic reticulum, golgi apparatus, and lysosomes. (7/74-6/75)

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

0107 INVESTIGATION OF BIOMOLECULAR FUNCTIONS BY MICROWAVE RADIATION. Eisenbud, M.; Rabinowitz, J. R. ((New York Univ. Sch. Med., New York City).

Work is being conducted to describe the mechanisms by which the absorption of microwave energy can interfere with the function of the absorbing biological molecule; and to attempt experimentally to demonstrate these mechanisms in biological systems and identify the specific biomolecules involved. Tranquilized rabbits will be irradiated at 2450 MHz to determine the cause of the decrease in ascorbic acid concentration of the lens. Irradiated and control lenses will be cultured in a media containing C^{14} ascorbic acid, then C^{14} activity of the lenses determined after removal from the media. If it is transport that is affected, and the element changed is in the transport system of the lens, then the study will determine if ascorbic acid transport is stereo-specific in the lens. Research will also aim at determining if microwave irradiation increases the concentration of acetylcholine when an animal is irradiated at 2450 MHZ using a power density of 40 mW/cm^2, and if the hydrolysis of acetylcholine by acetylcholine esterase is affected by irradiation. (7/74-6/75)

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

0108 NAVY ENVIRONMENT: MUTAGENIC EFFECTS DUE TO MICROWAVE RADIATION GENERATED BY NAVAL OPERATIONS. Varma, M. M.; Joshi, S. R. (Sch. Eng., Howard Univ., Washington, D.C.).

See CR 0046, Volume I (2), for description of this research. (Renewed 7/74-6/75)

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

0109 NAVY ENVIRONMENT: EFFECTS ON BIOLOGICAL SYSTEMS DUE TO MICROWAVE IRRADIATION. Durney, C. H.; Lords, J. L. (Sch. Engr., Univ. Utah, Salt Lake City).

This research continues study of the response of isolated turtle and rat hearts to low power MW radiation. Hearts from freshly killed turtles are placed in Ringers solution and a record of physical and electrical activity is taken until stabilization occurs. Microwave power is then delivered to the heart and the activities of the heart recorded. Chemical stimulants and depressants are added to determine which of the two parts of the autonomic nervous system are most affected by the microwave field. The microwave field parameters will be varied and mammalian (rat) hearts will also be studied. See CR 0037, Volume I (2), for earlier work in this project. (Renewed 7/74-6/75)

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

0000 PERSONNEL TECHNOLOGY: OCEAN ENGINEERING AND BIOMEDICAL RESEARCH. Wheeler, E. J. (Wheeler Industries, Inc., Washington, D.C.).

See CR 0067, Volume I (2), for description of this research. (Renewed 7/74-6/75)

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

0111 NAVY ENVIRONMENT: QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Guy, A. W.; Piroska, D. (Univ. Washington Sch. Med., Seattle).

See CR 0029, Volume I (1), for description of this research. (Renewed 7/74-6/75)

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

0112 INFLUENCES OF VERY WEAK EXTRA-PHOTIC ELECTROMAGNETIC FIELDS. Brown, F. A. (Dep. Biol. Sci., Northwestern Univ., Evanston, Ill.).

Systematic variations in living systems in constancy of obvious environmental factors are reported to include such phenomena as geographic directional preference, spontaneous activity and standard metabolism, seed germination and growth, response to light, and gas and water uptake by seeds. Correlations with weather parameters, with solar activity and geomagnetic changes, with major geophysical periodicities, and between organisms simultaneously investigated at separated sites have been described. These, together with recent experimental demonstrations of an apparently highly specialized organismic responsiveness to diverse parameters of the extremely weak geoelectromagnetic fields, suggest the organismic variations reflect responsiveness to their varying ambient subtle physical fields and the fields have roles for biological clocks and orientation. Recent discoveries of organismic in-

teractions through biologically generated electromagnetic fields and discovery of plus and minus response states now emphasize further potential significances of the phenomenon. Objectives of this investigation include further searches for subtle geophysical influences for selected plants, invertebrates, and vertebrates and include such processes as directional preferences, light responses, spontaneous activity, growth rates, and water uptake by seeds. Common denominators will be sought, experimental manipulation and regulation of the phenomenon will be attempted, and efforts made toward disclosure of effective atmospheric parameters. (11/74-10/75)

Supporting Agency:U.S. Natl. Sci. Found., Div. Biol. Med. Sci.

0113 NAVY ENVIRONMENT: NONTHERMAL HAZARDS OF EXPOSURE TO RADIOFREQUENCY AND MICROWAVE FIELDS. Mickey, G. H. (New England Inst., Ridgefield, Conn.).

These experiments test for chromosome damage or malformation in live animals and cultured cells following microwave treatment in the X and K bands and radio frequency (RF) exposure between 15 and 40 MHz. Cytologic assays are being carried out to determine chromosome aberrations in cultures of Chinese hamster lung cells and lymphocytes irradiated *in vitro* and in bone marrow cells, cells of the testes, and lymphocytes irradiated *in vivo*. Studies will be done using *Drosophila* to determine if RF and microwaves at the above frequencies will have genetic effects as evidenced by nondisjunction, chromosome abnormalities and mutations. See CR 0012, Volume I (1), for further information on this research. (Renewed 7/74-6/75)

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

0114 EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION ON SUBCELLULAR PREPARATIONS. Straub, K. D. (Univ. Arkansas Sch. Med., Little Rock).

The project will explore the effect of ELF and microwave radiations on the subcellular preparations responsible for active transport and oxidative phosphorylation. The work involves exposing microsomal cell membrane and (Na+ and K+) ATPase from several sources (ox brain, rat brain, gar olfactory nerves, and invertebrate peripheral neurons) to both ELF-ULF (10 Hz - 30 kHz), VHF-UHF (30-300 MHz) and microwave radiation (1-12 GHz) in especially constructed cells. Measurement of the various parameters of this membrane preparation will be made including K_m and V_{max} for Na+, K+, and Mg^{++} and ATP, ouabain sensitivity and lipase activation. Fluorescent probes of membrane structures will be used to assess the extent of change in membrane conformation. Simultaneously rat liver and rat brain mitochondria will be exposed to these frequencies using the same exposure cells. The O_2 consumption, ADP/O ratios, state 3-4 transition, control ratios, swelling and shrinking, and state of electron carriers will be measured. (7/74-6/75)

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

0115 A PRELIMINARY SURVEY OF VETERANS WHO MAY HAVE BEEN EXPOSED TO CATARACT PRODUCING RADIATION. McAfee, R. D.; Cazenavette, L. L.; Holland, M. G.; Robinett, C. D. (Tulane Univ., New Orleans, La.).

A pilot program was reported in CR 0030, Volume I (1). The National Academy of Sciences, National Research Council, Medical Followup Agency, is cooperating in enlarging the original pilot study to a full scale investigation of electronic technicians who may have been exposed to microwave radiation (as well as controls). It will be their task to obtain the names and addresses of selected groups of veterans to whom the shadowgraph device will be mailed. Medical Followup people will also participate in the statistical interpretation of the data obtained. (Renewed 7/74-6/75)

Supporting Agency:U.S. Vet. Adm.

0116 SEQUENTIAL CHEMOTHERAPY AND HYPERTHERMIA IN THE TREATMENT OF EXPERIMENTAL GLIOMAS. Sutton, C. H.; Popoff, N.; Carroll, F. B. (Neurosurg. Sect., VA Hosp., Miami, Fla.).

In order to explore the antineoplastic effects of moderate hyperthermia alone and as an adjuvant in the chemotherapy of malignant gliomas of the brain, a method, employing MW radiation at 2,450 MHz, has been devised for heating rat brain, murine gliomas and cell cultures. The gliomas can be implanted either intracranially or subcutaneously. Lipid crystal was used to map the MW field. It was possible to heat both normal and neoplastic tissues uniformly and reproducibly at sublethal dosages. In one series of experiments, mice with bilateral flank implants of experimental glioma were subjected to MW heating of one implant at increasing increments of temperature and time from 37 C to 45 C. Tumor blood flow, as measured with intratumoral 133 Xenon clearance, increased in normothermic mice with implant heating up to 42 C for decreasing periods of time, followed by a rapid diminution in flow. Histochemical studies on heated implants showed that the secondary rapid decrease in blood flow was produced by vessel coagulation secondary to excessive heating. Increased flow had resulted from vascular dilatation. In hypothermic mice, increased tumor blood flow persisted for prolonged periods. This temperature gradient may serve to achieve greater concentrations of intravenous agent in gliomas. When rat brain was heated selectively, the blood-brain barrier, as studied with horseradish peroxidase, was resistant to MW radiation at lower dosages, but could be disrupted by excessive heating. Systemic hypothermia increased its tolerance. The barrier was disrupted in the white matter of

cerebellum before that in cerebrum. Studies have been initiated to determine the cell cycle kinetics of both lines of hyperthermia and individual antineoplastic agents. Studies of the uptake of these agents with isotopic labels in heated and unheated implants is also in progress. (7/74-6/75)

Supporting Agency:U.S. Vet. Adm.

0117 BIOLOGICAL EFFECTS AND HAZARDS OF MICROWAVE RADIATION. Sharp, J. C.; Grove, H. M. (Walter Reed Army Inst. Res., Washington, D.C.).

Research has been undertaken to establish meaningful criteria to delimit human operations in an EM environment and to determine maximum combat effectiveness at minimum personnel risk from the environment. The study will delineate the interaction of RF and MW radiation 100 MHz to 100 GHz with biological systems, survey and evaluate all known methods and techniques of MW dosimetry and develop improved techniques and instrumentation where appropriate and necessary. Each major organ system and biological process will be investigated where there is reason to believe microwave effects may occur at reasonable power intensities. Where indicated, the military significance of the effects and the measures necessary to obviate them will be determined. A data bank of the world literature on the biological effects and hazards of EM radiation is to be established and maintained. Initial scientific efforts will use evaluative methods from experimental psychology, electrophysiology and neurochemistry. Exposure parameters will be chosen for relevance to army radiating equipment and operational requirements. (7/74-6/75)

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

0118 PERSONNEL EXPOSURE CRITERIA FOR OPERATIONAL RADIOFREQUENCY RADIATION ENVIRONMENTS. Frazer, J. W.; Gass, A. H. (Sch. Aerospace Med., Brooks Air Force Base, San Antonio, Tex.).

The primary objective is to establish appropriate personnel exposure criteria for operational RF radiation environments. Current exposure guidelines are not adequate for many operational situations. The results of this work will be used as the biomedical data base to establish both normal and emergency exposure limits for specific operational situations. These data are needed to support site selections and site layout and to establish shielding requirements and operational maintenance procedures for systems such as the Over-The-Horizon (OTH) radar for CONUS defense. A series of exploratory tests will be conducted to establish power absorption/energy deposition parameters as a function of frequency, field intensity, sample configuration, and environmental stress. Initial studies will be conducted at HF band frequencies of 10.5, 19.27, or 26.6 MHz using a 50 kW pulse transmitter. These studies will include irradiation and measurement of resulting temperature changes in sensing implants, and evaluation of the RF radiation induced effect on the growth rate in mice. Subsequent studies will be conducted using the new 40 kW (AN/FRT-6B) CW transmitter. (7/74-6/75)

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

0119 MIXED RF/IONIZING RADIATION EFFECTS. Krupp, J. H.; Barnes, D. J. (Sch. Aerospace Med., Brooks Air Force Base, San Antonio, Tex.).

See CR 0039, Volume I (2), for description of this research. (Renewal 7/74-6/75)

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

0120 RADIOFREQUENCY RADIATION INTERFERENCE (RFI) OF MEDICAL PROSTHETIC DEVICES. Mitchell, J. C.; Hart, W. D. (Sch. Aerospace Med., Brooks Air Force Base, San Antonio, Tex.).

This research is being conducted to develop test data on the interaction of Air Force RF radiation emitters and medical prosthetic devices. The initial objective is to assess manufacturers' progress in developing cardiac pacemakers to operate properly in pulsed RF fields of 200 volts per meter. The overall purpose of this R & D effort is to resolve the potential hazard to cardiac pacemaker users in the vicinity of RF radiation emitters. A state-of-the-art test sample of cardiac pacemakers including approximately 20 types made by 10 different manufacturers will be tested to a variety of RF radiation sources. Tests will be conducted in both "free-field" and "simulated-implant" configurations, in the laboratory, and at radar and communication sites remote from Brooks AFB. Test plans include studies using the AWACS radar, AN/FPS-24 and 35 research radar, AN/MPS-T1 ECM threat simulators, AN/FRT-49 ground to air telemetry system, and a Loran system. The AN/FPS-85 and an AN/TPS-44 may also be studied. (7/74-6/75)

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

0121 RADIOFREQUENCY EFFECTS ON BIOCHEMICAL SYSTEMS IN THE CENTRAL NERVOUS SYSTEM. Merritt, J. H.; Frazer, J. W. (Sch. Aerospace Med., Brooks Air Force Base, San Antonio, Tex.).

The USAF has an on-going R & D effort to evaluate the biological effects of RF radiation associated with planned or operational radar systems. This effort will evaluate "near field" exposures representative of those associated with the 414L OTH radar system. Data will be applied to USAF safety criteria for this and other systems. The study will evaluate the effects of RF radiation on those biochemical events subserving and associated with neural impulse transmissions in the central nervous system. Simultaneous estimations of 5-hydroxyindole-

acetic acid, homovanillic acid, norepinephrine, dopamine, and 5-hydroxytryptamine will be made in discrete brain areas of rats exposed to RF fields. Preliminary studies of the effect of a defined electrical stimulus and hyperthermia on the levels of these transmitters will be made. After preliminary data have been obtained, the effect of "far field" conditions (19 MHz) at both CW and pulsed modes on the neurotransmitters will be determined. The same studies will be done using animals exposed on the SAM "near-field" simulator. (7/74-6/75)

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

0122 IMPACT OF RF BIOEFFECTS ON AF OPERATIONS. Mitchell, J. C. (Sch. Aerospace Med., Brooks Air Force Base, San Antonio, Tex.).

Specific Air Force systems RF emission and bioeffects studies will be conducted and a state-of-technology data base maintained to support environmental impact positions and operational RF safety criteria for future and ongoing systems such as AN/FPS-85, AWACS, 487L, 414L, Pave-paws, and Seeksail. RF radiation effects data applicable to AF RF safety criteria and systems' operations will be compiled as background information. Systems' studies will be undertaken in accordance with mission direction. The RF biomedical data base generated under this effort will be used in support of the AF petition for a change in OSHA standards, Title 29, CFR 1910.97 and in the revision of AFM 161-7. Initial state-of-the-art data will be obtained through a multi-agency contract with the Franklin Institute to provide a quarterly *Biological Effects of Electromagnetic Radiation Digest*.

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

0123 EFFECTS OF LOW FREQUENCY A-C FIELDS ON BIOLOGICAL SYSTEMS. McKinney, H. E. (U.S. Navy, Crew Syst. Dep., Warminster, Pa.).

CR 0103, this issue, describes this project. H. E. McKinney replaces K. D. Straub as principal investigator during this contract period. (Renewed 7/74-6/75)

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

0124 BIOCHEMICAL MEASURES OF MICROWAVE INDUCED STRESS. Polis, B. D.; Cope, F. (U.S. Navy, Crew Syst. Dep., Warminster, Pa.).

The stress induced by microwave radiation using chemical and physiological changes to determine possible health hazards will be measured. The direct relation of the rise in plasma phospholipids to stress of various kinds has been established by the biochemistry laboratory of NAVAIRDEVCEN. Phospholipid changes have been correlated with CNS excitation caused by injection of free radical structures discovered at NAVAIRDEVCEN. The levels of MW power which cause biochemical and EEG indication of stress will be investigated. Alteration with frequency, pulse light, duty cycle will also be studied. From the results, information will become available to establish safety standards. (7/74-6/75)

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

0125 EFFECTS OF MICROWAVE IRRADIATION ON EMBRYONIC BRAIN TISSUE. Rioch, D. M. (Inst. Behav. Res., Silver Spring, Md.).

Preliminary studies have indicated that moderate to low level exposure to microwaves causes increasing mitotic activity of primordial neuroblasts. A study will be made of those effects and their implications on brain development and behavior factors of rats so exposed. The Army is a major developer and user of ground located devices using MW beams. The effects on man or animals accidentally irradiated are of considerable concern. Adequate knowledge will allow establishment of improved safety criteria and avoid establishment of excessive restrictions on their use by other governmental agencies. Phase I of the project will study neuroanatomic alterations during fetal and subsequent development. Gestational stage, exposure mode (cavity vs free space), and variations in MW parameters (frequencies, power densities, exposure rates) will be included. Phases II and III will depend on the success of Phase I. Phase II will study behavioral consequences of alterations found in Phase I, the biophysical properties operative, and the nature of mechanisms causing alterations. The objectives of Phase III are to provide a detailed description of neuroanatomical alterations in the developing brain resulting from fetal brain MW insult. An operational explanation of the biophysical parameter important to the alterations will be developed and the behavioral and physiological effects of brains so altered "in utero" will be assessed. (7/74-6/75)

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

Biological Effects Electromagnetic Radiation II(1), March 1975

TECHNICAL NOTES

PRELIMINARY INVESTIGATION OF THE RF EXPOSURE OF CLINICAL PERSONNEL USING 13.56 MHz DIATHERMY EQUIPMENT

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Introduction

Constant vigilance is maintained throughout the USAF laboratories to minimize personnel radiofrequency (RF) radiation exposures. In response to a recent question concerning potential hazards with the use and control of RF diathermy machines, a survey was performed on two Birtcher Model 800 diathermy units (13.56 MHz) at Wilford Hall Medical Center, Lackland AFB, Texas.

Procedure

The survey was performed with NBS built and calibrated E-field (dipole) and H-field (loop) probes and a Narda Model 8310 electromagnetic radiation monitor with a Model 8321 broad-band isotropic probe. The first survey (Birtcher Model 800, Serial #B115E7201) was performed with the patient reclined on a treatment table with the applicator in the region of the knees. Three orthogonal readings were made with the NBS dipole and these readings converted to incident power density. Three orthogonal readings were also made with the H-field probe and these readings converted to incident power density. The field measurements were applied as follows:

Incident Power Density in mW/cm^2 =

$$\frac{E_1{}^2 + E_2{}^2 + E_3{}^2}{3770}$$

Where E is in V/m

Incident Power Density in mW/cm^2 =

$$37.7(H_1{}^2 + H_2{}^2 + H_3{}^2)$$

Where H is in A/m

A second series of measurements was made using the Birtcher Model 800, Serial #3108E7664 with another patient seated in a chair and the applicator on the left arm. The 10 mW/cm^2 isodose lines were located using the E-field probes.

Results

For 13.56 MHz CW the NBS dipole and Narda instrument agree within 10%. It should be cautioned that if the Narda probe is used in a pulsed field in this frequency range, large errors can result; the instrument being designed for 0.3 to 18 GHz operation. The E-field devices indicated the 10 mW/cm^2 isodose line extended from 2 to 3 feet from the applicator for either exposure geometry. Treatment tables were approximately 5 feet apart and survey of adjacent treatment tables indicated the field to be less than 1 mW/cm^2. The incident power in the area where the therapist stood to tune the diathermy was less than 1 mW/cm^2 and the therapist was only in the immediate area for 2-3 minutes during the treatment. H-field measurements made at several locations indicated a field strength which was about a factor of 2 higher than would be indicated by the E-field measurements, that is E/H = 200. For the second exposure geometry the loop was inserted between the applicator and the patient's arm, and the field density was determined to be 3770 mW/cm^2. Although the measurement in this geometry is of questionable absolute accuracy, it does indicate the magnitude of the power density and the patient reported only a slight sensation of heating in the treated area. For the second exposure, measurements above the patient's head indicated fields which were less than 1 mW/cm^2.

Conclusions

Extremely high fields are generated near the applicator of these specific devices; however, the untreated areas of the patient, as well as the surrounding area occupied by the therapist and other patients, are well below 10 mW/cm^2. The patients reported little if any sensation of heating for 20 minute treatments. The results of these measurements show no exposure problem for the therapist or patients in this specific clinical situation. Several other AF diathermy clinics will be surveyed to cover the other diathermy frequencies and ascertain if any potential personnel hazards exist.

LETTERS TO THE EDITOR

Biological Effects Electromagnetic Radiation II(1), March 1975

Extending the Parameters of the Digest

Dear Sir: I have received your letter regarding informal exchange program in biological effects of non-ionizing EM radiation. I have also received a letter from Dr. Kleinstein of the Franklin Institute which is apparently relevant to the same topic.

I am very interested in this field and am pleased to see that an informal exchange is being set up. I note from Dr. Kleinstein's letter that the electrical EM parameters are to be microwave and RF's; all of our work is in static or low frequency fields, and I would have nothing to contribute to the present bibliography. I suggest that you consider extending the scope of the parameters to include this additional area; we have found certain specific effects and there are collaborative reports in the literature in this area.

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Ed.'s Note: A special section or special report could be devoted to static and low frequency fields in an issue later this year. Those interested should complete the General Information form, or suggest other sources of work in this area.

Low-level High Frequency Current Flows

Dear Sir: I would be most interested in receiving your current awareness bulletin on the biological effects of non-ionizing radiation, since I am involved with several committees of the NFPA and IEEE in this area.

Could I suggest a subject for early discussion? The effects on infants (or neo-natal animals) of the application of low-level high frequency currents for long periods of time. Low-level would be 10 to 500 microamperes. We are usually concerned with currents flowing through the body rather than radiation fields. Frequency range is 10 KHz to 10MHz. Duration is one hour to one week.

While this is probably not your area of prime concern, it is a significant problem in patient monitoring. If there is nothing much in the literature about it now, perhaps it could go out as a question.

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Ed.'s Note: Send suggested sources or references directly to Dr. Aronow or the digest

Gordon Conference of EM Radiation Suggested

Dear Sir: I was most pleased to learn from your letter of July 1, of the Science Information Services effort to produce a current awareness bulletin on the biological effects of non-ionizing electromagnetic radiation. I am currently doing research in this area, as you may know, and would like to be on your mailing list and assist you in any way possible.

It occurred to me that your quarterly publication might serve as a vehicle to present the idea of organizing a Gordon Research Conference on the Biological Effects of Non-Ionizing Electromagnetic Radiation. The readers of your bulletin would appear to be the individuals who would benefit from such a meeting and if the idea is presented I feel it might serve as the impetus leading to the organization of a much needed meeting of this type. I hope you will consider this further and contact me if it appears feasible to pursue.

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Ed.'s Note: The digest is exploring this possibility; reader's comments would be appreciated.

AUTHOR INDEX

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