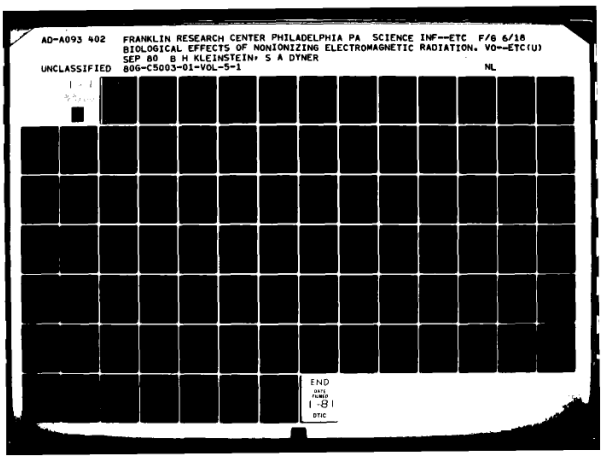
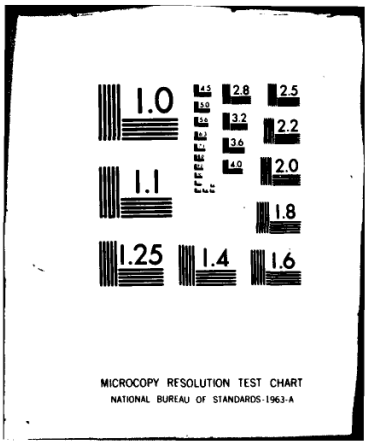

AD-A093 402
FRANKLIN RESEARCH CENTER PHILADELPHIA PA SCIENCE INF--ETC F/6 6/18
BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. VO--ETC(U)
SEP 80 B H KLEINSTEIN, S A DYMER
UNCLASSIFIED
806-C5003-01-VOL-5-1
NL
END
DATE FILMED
1-81
DTIC


1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A093402

LEVEL II

A086468

Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME V
NUMBER 1
SEPTEMBER, 1980

A DIGEST OF CURRENT LITERATURE

A Quarterly Publication Produced for
National Telecommunications and Information Administration

DTIC ELECT DEC 24 19

A

FILE COPY

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION

A Digest of Current Literature

A Quarterly Publication Produced for
National Telecommunications and Information Administration

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

Bruce H. Kleinstein, Ph.D., J.D., Project Manager

Sheryl A. Dyner, Managing Editor

"The views and conclusions contained in this documentation are those

BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

September, 1980 Volume V, Number 1

TABLE OF CONTENTS

Preface..... v

Abbreviations and Acronyms..... vii

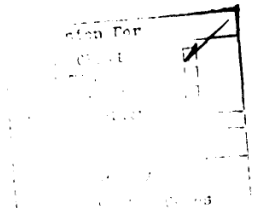
News Items..... 1

Meetings and Conferences..... 7

Current Research..... 9

Current Literature..... 15

Authors of Current Literature Index..... 79



PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by the Franklin Research Center, Science Information Services Organization, under contract to and funded by the National Telecommunications and Information Administration (NTIA).

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

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

ABBREVIATIONS AND ACRONYMS

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

μ - micro--

COMBINED MICROWAVE-HYPERTHERMIA TECHNIQUE USED TO TREAT CANCER PATIENTS

A technique that uses microwaves to induce hyperthermia is being used with good results in cancer patients at the Henry Ford Hospital in Detroit, MI. According to Dr. Haim Bicher, head of the division of radiology and physics and a staff radiotherapist, to date 65% of 121 tumors that have been treated over the last 2 yr have shown total tumor regression. The hyperthermia is delivered in one of two ways--with an intracavitary antenna for regional hyperthermia (e.g., for the neck, mediastinum, and pelvis regions) or with applicators for external tumors. The patients are given a total of eight hyperthermia treatments over a 4-wk period. Each microwave treatment consists of hyperthermia to 117 F for 1.5 hr, 2x/wk; the last four treatments are immediately preceeded by x-ray irradiation (1,600 rads) as an adjuvant therapy. The best results have been observed in patients with melanoma, lymphoma, and recurrent breast cancer on the chest wall. Skin squamous cell carcinoma, metastasizing from a lung tumor, and basal cell carcinoma have also been treated. The failures have occurred mainly with sarcomas. Dr. Bicher noted that a particular advantage of hyperthermia "is that this is the only modality used to treat cancer that does not induce cancer."

Oncology Times 2(3): 17; 1980.

HYPERTHERMIA FOR CANCER TREATMENT

The use of hyperthermia for the treatment of cancer is being studied in a number of institutions across the country. Researchers may use a variety of techniques to produce hyperthermia including radio waves, microwaves, ultrasound, and water or hot wax baths. As an experimental therapy still under investigation, hyperthermia is never used as a first line of treatment for cancer; surgery, chemotherapy, radiation, and possibly immunotherapy, are the recognized primary modalities. Since 1975, Drs. Jae Ho Kim and Eric Hahn have been doing clinical work at the Memorial Sloan-Kettering Cancer Center in New York, NY using radio frequency waves to induce hyperthermia (see Current Literature 6327, 6491). About 100 patients have been treated, most of whom, according to Dr. Kim, have been "in the more advanced stage of cancer and who have already had conventional treatment." Their treatment regimen consists of a dose of radio waves followed immediately by radiation therapy, 2x/wk for 8-10 sessions. This treatment is now being used with some success on breast cancer patients, but Dr. Kim warns that "It's too early to say if these results are permanent." Dr. F. Kristian Storm, Dr. Donald Morton, Dr. Robert Elliott, and William Harrison have been using microwaves to induce hyperthermia. They developed a large cylinder or magnetrode that, according to Dr. Storm, provides "deep internal heating to any depth with no injury to normal tissue." The patients received ten 30- to 60-min treatments during a 2-wk period. Dr. Storm adds that when chemotherapy or radiotherapy is combined with hyperthermia, the results are "dramatic." At the Roswell Park Memorial Hospital in Buffalo, NY, microwaves are being used to create hyperthermic temperatures in tumors. Dr. Richard Johnson, a radiation oncologist, and Henry Kowal, a former Air Force engineer, have treated more than 100 patients at the hospital since 1975 (see Current Literature 6430, 6477, 6515, 6673). The treatment at frequencies of 915 MHz to 434 MHz usually consists of ionizing radiation (300-400 rads) followed by 30-90 min of microwaves (to produce temperatures of 42-42.5 C), 2x/wk. To date, results from the various hyperthermic techniques have ranged from temporary remission to "no response." Dr. Storm states that he knows "of no patient who's been 'cured' by hyperthermia," but, he adds, "in a few of his patients, survival was clearly enhanced." Most hyperthermia clinicians seem to agree with Dr. Storm, who says that "At present, hyperthermia is nothing more than an investigational therapy," but "we think that once it's understood, it may well be a fifth form of treatment for cancer."

New York Times 129(44531, Section 6): 96, 98, 100, 102, 108; March 1980.

PROFESSOR RECEIVES GRANT TO CONTINUE STUDIES OF MICROWAVE EFFECTS ON CANCER CELLS

Professor E. H. Grant of the Physics Department of Queen Elizabeth College in London, England has received a grant for 1980 of 11,728 pounds from the British Cancer Research Campaign for continued research into the effect of microwave energy on cance cells. Two aspects of microwave hyperthermia--localized heating and accurate temperature measurement--are being studied. A miniature applicator within a hypodermic needle has been designed and two more applicators are proposed to boost the energy dissipated by the cancer tissue. The initia experiments were performed with 2.45 GHz, but the effects of varying the microwave signal frequency to obtain optimum heating will also be studied. Hospital trials may be conducted later this year or early in 1981.

Microwaves 19(5): 68; 198

DR. DURNEY RECEIVES RESEARCH AWARD

The University of Utah presented a Distinguished

Research and Professor of Bioengineering, received the award for his pioneering research into the medical effects of microwave radiation. The award was presented at the June 1980 graduation exercises.

Utah Bioengineering Newsletter
p. 1, Spring 1980.

STUDY SHOWS NO BIRTH DEFECTS IN RATS DUE TO NONTHERMAL MICROWAVES

Following a decade of extensive laboratory research on microwave bioeffects, Dr. Ronald P. Jensh, Ph.D. (Department of Anatomy, Thomas Jefferson University, Philadelphia, PA 19107) has found no physical or behavioral birth defects due to nonthermal microwaves. Dr. Jensh's research included one study performed on a grant by the EPA on the teratologic potential of microwaves at 915 and 2,450 MHz (see Current Literature 6258) and another study performed for the General Telephone and Electronics Corporation on the effects of a carrier frequency at 6,000 MHz. According to Dr. Jensh, associate professor of anatomy and radiology at the College of Allied Health Sciences, their "studies indicate that microwave ovens can be one of the safest appliances you can have in your kitchen," and the ovens will not harm anyone who uses them correctly. During the course of Dr. Jensh's study for the EPA, rats were exposed to microwaves 8 hr/day for 16 days during a 3-wk gestation period. The postnatal effects of prenatal exposure were studied and rats and their offspring were dissected to determine if any tissue damage occurred. Both the mothers and fetuses were healthy. When mothers were bred more than once to determine if microwave exposure affected future offspring, "Neither the first nor the second generation offspring was deformed," says Dr. Jensh. To observe subtle behavioral defects, five tests of the offsprings' ability to learn and memorize simple tasks were conducted, as well as six tests of the rats' reflexes. No abnormalities were detected.

Allied Health Rev Rea Wkly (11): 9-10; 1980.

AMENDMENT TO MICROWAVE OVEN STANDARD FOR MEASUREMENT AND TESTING IS PROPOSED

The FDA has proposed to amend the performance standard for microwave ovens to delete the error limit and effective aperture requirements for instruments used for compliance measurement of leakage radiation from microwave ovens. The proposal would provide, as part of the manufacturer's testing program for microwave ovens, that periodic reports

evaluations of the characteristics and methods
calibration of many microwave survey instrumen
have indicated that it is possible that a comm
cially available instrument may produce readin
of oven leakage that are in error by more than
The proposed alternate compliance policy would
into account the technical limitations associa
with the measurement of microwave radiation.
BRH will have the responsibility to review tes
programs by which the manufacturers certify th
ovens. Under the proposal, manufacturers may
any instrument with uncertainties greater than
db in their compliance testing programs provid
that the uncertainties are taken into account
that the BRH concurs with the manufacturer's s
limit of uncertainty. The FDA has determined
this proposal would not compromise microwave o
safety. The FDA has also proposed that the co
cept "equivalent plane-wave power density" be
stituted in the existing standard for "power d
sity" (performance standard 21 CFR, sections
1030.10 [c]1 and [c]3i) and that a definition
of "equivalent plane-wave power density" (as
"the square of the root-mean-square electric
field strength divided by the impedance of
free space [377 ohms])" be added to improve th
standard's technical accuracy. The proposed am
ments are designed to reflect the actual compli
test situations for microwave ovens. No change
the permissible leakage levels is to be made.
further information contact Joseph Wang, BRH (H
460), FDA, HEW, 5600 Fishers Lane, Rockville, M
20857 or (301)-443-3426.

Fed Regist 45(87): 29307-29308; 1

NATURAL RESOURCES DEFENSE COUNCIL UNSATISFIED WITH NIOSH CRITERIA DOCUMENT ON NONIONIZING RADIATION

The Natural Resources Defense Council (NRDC; 10 East 78th Street, New York City, NY) criticized the November draft of a NIOSH criteria d
ment on nonionizing radiation. The environmen
group felt that the draft paid too little atte
to low-level radiation effects. The NRDC also
quested that a modified version of the draft b
leased as an "interim" working draft, and that
modified version recommend that OSHA adopt a "
exposure standard of 1 mW/cm^2 for frequencies
tween 0.3 MHz and 300 GHz and drop the "comple
frequency dependency" in the proposed standard
NRDC letter to Anthony Robbins, NIOSH Director
charged that the November draft paid too much
tention to the thermal effects of radiation an
offered "no explanation of why the proposed st
dard would adequately protect worker health."

Occup Saf Health Rep 9(31): 724-725;

IEC RELEASES INTERIM REPORT ON WORLDWIDE RADIATION STANDARDS

interim report, Publication No. 657, that summarizes the present limits and attitudes towards nonionizing hazards that have been adopted by a number of countries, the IEC, and other international agencies. The report emphasizes that there is still no worldwide consensus on what levels of nonionizing radio frequency radiation constitute a hazard to man and calls for further work at the national level. The origin of some of the differences between the national standards are reviewed and discussed. Some preliminary conclusions are drawn. It is suggested that when considering standards for maximum allowable levels of nonionizing radiation, it is important to distinguish between personnel safety limits and equipment specifications. The study suggests, that if there was worldwide agreement on personnel exposure limits, then there would be no great difficulty in deriving appropriate specification limits for the various classes of equipment.

Microwaves 19(4): 30; 1980.

DETAILED RESEARCH PROGRAM ON BIOLOGIC EFFECTS OF HIGH-VOLTAGE POWER LINES REQUESTED BY THE NEW YORK PUBLIC SERVICE COMMISSION

Following an extensive public hearing on the health and safety effects of high-voltage power lines, negotiations have been concluded for the initiation of a "detailed" research program on the biologic effects of the lines' 60-Hz electric and magnetic fields. The 5-million dollar program will be designed and administered jointly by three New York state agencies: Public Service Commission, Department of Health, and the Power Authority. Requests for proposals for research efforts are expected to be issued around January 1981. The aim of the program will be to determine as precisely as possible what health risks might be suffered by people who live and work along a high-voltage right-of-way. Negotiations on the research program follow a 3-yr Public Commission hearing on the Authority's 765-KV line, which stretches 155 miles from the Quebec border to Utica, NY. After evaluating the evidence presented at the hearing, the Commission decided that the fields did constitute a health risk and ordered the Authority to expand its right-of-way by 100 feet and forbade operation of the line until the Authority promised to contribute 2% of its construction costs to a research program. The authority contested the order in court, and began operating the line, despite opposition by residents who had opposed the line's construction. In court, the Commission's original decision on the biologic effects was upheld, but the order for the Power Authority to fund a research program was overturned. Following the court's decision, the Commission filed an appeal to a higher court on the latter decision. The present negotiations are apparently the result of the Power Authority's failure to answer the appeal. Although the details are not finalized, the research program may consist of both laboratory and epidemiologic by a panel of independent scientific experts. If the Commission determines after the research is complete that human exposure limits to 60-Hz electromagnetic fields should be even stricter, it will have the authority to impose regulations enforcing these limits, not only on 765-KV lines but on smaller ones as well.

Bull At Sci 36(4): 28-30; 1980.

FIRST CALL FOR PAPERS FOR 1981 IEEE/MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM ANNOUNCED

The Institute for Electrical and Electronics Engineers (IEEE)/Microwave Theory and Techniques Society (MTT-S) has announed the first call for papers for their 1981 International Microwave Symposium to be held June 15-17 in Los Angeles, CA. The theme for the 1981 Symposium is "Around the World with Microwaves." The Symposium will be held jointly with the IEEE Antennas and Propagation Symposium that will meet June 17-19. Papers describing original work, which have never been published or presented, are solicited. Papers concerned with new techniques, devices, systems, applications, and bioeffects will be considered. Authors should submit both a 35-word abstract and a 500-1,000 word summary (up to 6 illustrations) explaining their contribution, its originality, and relative importance. Abstracts and summaries (5 copies) should be received by Dr. Don Parker, TPC 1981 MTT-S Symposium, Hughes Aircraft Co., Building 268/Mail Station A54, Canoga Park, CA 91304 by January 15, 1981.

IEEE/MTT-S Announcement.

MAGNETIC ORIENTATION IN BIOLOGY DISCUSSED AT THE 18th INTERNATIONAL INTERMAG CONFERENCE

The 18th International Intermagnetics Conference was held April 21-24, 1980 in Boston, MA. Session 25 of the Conference was concerned with magnetic orientation in organisms. Four papers were presented that summarized recent work on the ability of organisms to sense the earth's magnetic field and use it for orientation and migration. A. J. Kalmijm reviewed electroreception in sharks and skates and magnetotaxis based on ferromagnetic alignment in bacteria. R. P. Blakemore and C. Denham comprehensively reviewed bacterial magnetotaxis. Blakemore discussed his expedition to New Zealand where south-swimming magnetotactic bacteria were found, and Denham presented magnetic data on whole cells and cellular components that identified magnetosome as the site for the biomagnetic compass of these cells. For the third presentation, C. Walcott reviewed the evidence that suggests that pigeons use the earth's magnetic field in their homing behavior. The evidence suggests that pigeons may use their magnetic sense(s) both as a compass and as a map, and it was suggested that magnetite

fourth presentation on magnetic orientation in biology was J. L. Kirschvink's review of evidence concerning the honey bees' sensitivity to the earth's magnetic field. Magnetite has also been detected in the abdomens of bees.

IEEE Magnetics Society Newsletter 16(1): 3; 1980.

BATTELLE LAB STUDYING THE EFFECTS OF MICROWAVES AND TRANQUILIZERS

A two-part study is being conducted at Battelle's Pacific Northwest Laboratory to determine if microwaves enhance the effect of tranquilizers and if they have any affect on learning. According to Dr. Richard Lovely, a senior research scientist at Battelle's Biology Department, "Recent studies using laboratory rodents suggest that microwaves may intensify the effects of chlorodiazepoxide, one of the most widely prescribed tranquilizers in the country. Other preliminary findings suggest that microwave exposure has an adverse effect on the brain's ability to memorize complex or sequential tasks." Battelle's study is specifically investigating the higher levels of microwave radiation (as opposed to lower levels emitted from microwave ovens, etc.) and the workers who may be exposed to them.

Ind Res Dev 22(6): 39; 1980.

RESEARCH SUGGESTS POSSIBLE NONTHERMAL EFFECTS FROM LOW-LEVEL MICROWAVE EXPOSURE IN ANIMALS

Research conducted at the John B. Pierce Foundation, New Haven, CT and the University of Rochester, Rochester, NY has suggested that low levels of microwave radiation may produce interference with the body's mechanism for regulating internal temperatures. At the Pierce Foundation, squirrel monkeys trained to regulate their cage temperature lowered the temperature after 10 min of exposure to 2.45-GHz continuous-wave (CW) radiation of incident power density 6-8 mW/cm^2. Their body temperatures, however, did not change until the power density was 22 mW/cm^2. Similar results were reported at the University of Rochester for experiments with rats. Another study at Pierce demonstrated measurable tail vein dilation in irradiated (2.45-GHz CW radiation at 10 mW/cm^2) monkeys without any change in the deep body temperature. Experiments conducted at the Naval Medical Research Institute in Bethesda, MD have demonstrated that the stimulating effect of dexadrine amphetamine in rats increases greatly at sible changes in the body regulatory mechanism caused by drug and radiation combination, but terest in studying the longer term effects of doses of microwave radiation is growing. A program is scheduled at the University of Washing to study the behavior of rats exposed to micro radiation over a period of years.

Electronics 53(7): 46;

ELECTROTHERAPY USED TO STIMULATE BONE GROWTH

Dr. C. Andrew L. Bassett, professor of orthope surgery at Columbia University's College of Ph cians and Surgeons, New York, has developed a invasive system for stimulating bone growth. technique involves a 10-V pulse generator that drives current through externally mounted, "O" shaped wire coils, setting up an electromagnet field of 2 G between the coils over the nonuni site. Bassett's device, which has received pr market approval by the FDA, sells for about $2 The device, which has been used in more than l patients, has an 80% success rate for healing union fractures in adults. It can be used to fractures all over the body, although the majo of cases involved the tibia. Aside from its c advantage--noninvasiveness--the device is also able to precisely deliver current to area of t nonunion. The precision, and subsequent bone ing, depends on the accurate placement of the ternal coils. "The placement of the coils mus be done under x-ray control...," says Dr. Bass and adds that "... the orthopedic surgeon is a solutely critical in this whole business." He agrees that electrical bone growth stimulation not and probably will never replace bone graft as a method for treating some cases, e.g., syn ovial pseudoarthroses, serious infections, and gaps greater than one-half the bone diameter; ever, an advantage of Bassett's electrotherapy technique is that it appears to work well in c bination with bone grafting surgery.

JAMA 243(14). 1402-1403;

ELECTROMAGNETIC DEVICE DETERMINES DEGREE OF SKIN BURN

A device that uses electromagnetic fields (wav length 0.7-1.1 cm) at current density of 100 μ to analyze the degree of human skin thermal da was patented. The degree of burn is determine comparing the characteristics of healthy and d aged skin after irradiation with an electromag field. The reflected signal power is measured

ELECTROMAGNETIC TREATMENT FOR NECK BONE CARTILAGE IS DESIGNED

A method for the application of decimeter electromagnetic waves followed by sinusoidally modulated currents for the treatment of neck osteochondrosis has been designed. The electromagnetic waves are applied for 8-10 min and followed within 5-10 min by the sinusoid currents, frequency 80-100 Hz and current intensity 10-50 mA.

Sov Invent Illust C09(Su-P3): 6; 1980.

DISINFECTION OF EGGS BY AN ELECTROMAGNETIC FIELD

A method for disinfecting eggs in a high-frequency electromagnetic field has been designed. The technique employs an amplitude modulated electromagnetic field with a carrier frequency of 1.0-1.2 x 10^9 Hz and an electrical field strength of 200-250 V/cm or a modulated field with a frequency of 1.0-1.5 x 10^7 Hz and a field strength of 150-200 V/cm. Treatment with the modulated field is periodic; the duty factor is 10-100 and the interval is 0.1-1 sec. The total treatment takes 1-4 hr. For example, the temperatures of hens' eggs that have been placed between the flat electrodes of the electromagnetic field source are increased over 8 min to 52.4 C at the shells' surface and 43.0 C inside the eggs. The eggs remain at this temperature for 2.5 hr. The temperatures at the shell and within the egg are controlled by heat resistors to an accuracy of 0.01 C. The characteristics of the field and shape of the voltage curve are controlled by an oscillograph, pulse voltmeter, and multimeter. Biologic tests demonstrate that contaminating microflora were absent after treatment, while the embryos continued to develop and grow. This technique increases the effectiveness and reduces the time necessary for egg disinfection.

Sov Invent Illust B47(SU-D): 5; 1980.

39th ERMAC MEETING HELD

The 39th meeting of the Electromagnetic Radiation Management Advisory Council (ERMAC) was held August 26-27, 1980 in Washington, DC. The meeting, sponsored by the NTIA, was basically concerned with two topics--the biologic implications resulting from the Soviet irradiation of the U.S. Embassy in Moscow and the scientific basis for microwave and other radio frequency radiation standards. The session concerned with the microwave irradiation of the U.S. Embassy included presentations and discussions on the analysis of the microwave environment, its biologic implications, and report strategy and contents. The sessions concerned with the scientific basis for standards included presentations and discussions on the specific absorption rate concept, physical and mathematical modeling, selection and scaling of key experiments to humans, modeling and selection of data, and the possible mechanisms for the observed effects. Copies of the minutes of the meeting will be available from NTIA.

ERMAC 39th Meeting--Revised Agenda.

ITEMS FROM THE COMMERCE BUSINESS DAILY

□ THEORETICAL RESEARCH STUDY TO DETERMINE THE EFFECTS OF HIGH POWER MICROWAVE RADIATION ON MATERIALS.

The Office of Naval Research, 800 N. Quincy St., Arlington, VA 22217 is negotiating with the Scientific Research Center, 1640 Fifth St., Santa Monica, CA 90401 for the above study. (June 2, 1980)

BIOELECTROMAGNETICS SOCIETY SECOND ANNUAL MEETING

Date: September 14-18, 1980
Place: San Antonio, TX: El Tropicano Hotel
Sponsor: Bioelectromagnetics Society
Requests for Information: Bioelectromagnetics Society, P.O. Box 3651, Arlington, VA 22203
Content: Topics will cover the interaction of electromagnetic energy and acoustic energy with biologic systems, including behavioral, physiologic, neurologic, endocrine, developmental, genetic, and cellular and ultrastructural effects. Also included are the dielectric properties of biologic materials, electric field effects, exposure systems, dosimetry, diagnostic and therapeutic applications, interactive mechanisms, instrumentation, hyperthermia, and field perturbations

INTERNATIONAL CONFERENCE ON ELECTROMAGNETIC COMPATIBILITY

Date: September 16-18, 1980
Place: Southampton, England: University Southampton
Sponsor: Institution Electronic and Radio Engineers, Institution Electronical Engineers, Institute Electrical and Electronics Engineers, Institute Marine Engineers, Institute Quality Assurance, Royal Aeronautic Society
Requests for Information: Conference Registrar, Institution Electronic and Radio Engineers. 99 Gower St., London WC1E 6AZ, England

Selected Bibliography of Papers to be Presented:

AN EM ENVIRONMENT FOR AIRCRAFT--PREDICTION OF FIELD STRENGTH NEAR HF TRANSMITTERS. P. J. Frank, J. M. Thomson

ESTIMATING BULK SURFACE CURRENT OF FAT CYLINDERS DUE TO AN EMP. J. Bishop

INVESTIGATION OF SOME RF RADIATION HAZARD METERS. I. Langlet

RF INTERFERENCE GENERATED BY A THYRISTOR CONTROLLED HAND-HELD DRILL MOTOR. J. K. Hall, M. W. Quelch

FIFTH INTERNATIONAL WROCLAW SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

Date: September 17-19, 1980
Place: Wroclaw, Poland: Wroclaw Technical University
Sponsor: Association Polish Engineers, Wroclaw Technical University, Institute Telecommunications, Polish Academy Sciences, International Union Radio Science (URSI), International Electrotechnical Commission (IEC)
Requests for Information: W. Moron, Symposium

Selected Bibliography of Papers to be Presented:

MICROWAVE ON-LINE MOISTURE CONTENT MONITORING IN LOW-HYDRATED ORGANIC MATERIALS. S. Kulinski, K. Zielkowski, J. Madziar, A. Kraszewski

POSSIBILITIES OF MICROWAVE HEATING. S. Lefeuvre

MICROWAVE THERMOGRAPHY--THE MODELLING OF PROBES. AN APPROACH TOWARD THERMAL PATTERN ROCOGNITION. D. D. N'Guyen, M. Robillard, M. Chive, Y. Leroy, J. Audet, Ch. Pichot, J. Ch. Bolomey

NUMERICAL SIMULATION AND MODELS FOR MICROCOAXIAL STROBES, APPLICATION TO "IN VIVO" MEASUREMENTS OF DIELECTRIC PARAMETERS OF BIOLOGICAL MEDIA IN THE MICROWAVE BAND 1-12 GHz. F. Bliot, A. Castelain, B. Dujardin

MICROWAVE HEATING OF REALISTIC CYLINDRICAL MODELS OF HUMAN LIMBS. H. Tosun, I. Karayilan

33rd ANNUAL CONFERENCE ON ENGINEERING IN MEDICINE AND BIOLOGY

Date: September 30-October 3, 1980
Place: Washington, DC: Washington Hilton Hotel
Sponsor: Alliance for Engineering in Medicine and Biology, Institute Electrical and Electronics Engineers (IEEE) Engineering in Medicine and Biology Society
Requests for Information: Alliance for Engineering in Medicine and Biology, 4405 East-West Highway, Washington, DC 20014

Selected Bibliography of Papers to be Presented:

SHORT COURSE 1--RADIOFREQUENCY AND MICROWAVE THERMOTHERAPY IN THE TREATMENT OF CANCER. A. Y. Cheung, D. R. Justesen, M. Salcman, G. N. Samaras, R. M. Scott, M. A. Stuchly, S. S. Stuchly

UTILITY ELF ELECTRIC FIELD MEASURES FOR BIOPHYSICAL STUDIES. O. H. Schmitt, R. D. Tucker, J. E. Holte

NONINVASIVE ANKLE BLOOD PRESSURE MEASUREMENTS. S. X. Salles-Cunha, N. Wynn, D. Vincent, K. D. Vollrath, H. D. Itskovitz

UNDERWATER ELECTRIC FIELDS CONTROL MOVEMENTS OF MIGRATORY FISH. R. B. Northrop

HAZARDS OF ELECTROSURGICAL DEVICES--SOME CASE REPORTS. F. S. Osman, D. L. Johnson

A MICROWAVE DEVICE FOR ARTERIAL WALL MOTION ANALYSIS. S. S. Stuchly, A. Smith, M. Goldberg, A. Thansandote, A. Menard

A VARIABLE FREQUENCY MICROWAVE SYSTEM FOR HYPERTHERMIA. D. E. Cunningham, R. A. Frey, D. E. Velkley

MEASUREMENTS OF MAGNETIC FIELD OF ISOLATED NERVES. J. P. Wikswo

MEDICAL COMPUTED TOMOGRAPHY USING MICRO-

1980 IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

Date: October 7-9, 1980
Place: Baltimore, MD: Baltimore Hilton Hotel, 101 West Fayette St.
Sponsor: Institute Electronics and Electrical Engineers
Requests for Information: IEEE EMC '80 Symposium, P.O. Box 1711, Annapolis, MD 21404

Selected Bibliography of Papers to be Presented:

RF AND MICROWAVE EMISSIONS FROM A VIDEO DISPLAY TERMINAL, COLOR TV RECEIVER, AND A MONOCHROME TV RECEIVER. A. A. Smith

ANALYSIS OF AIRBORNE RF MEASUREMENTS FROM USA URBAN AREAS. R. E. Taylor, J. Hill

NEW AND KNOWN METHODS OF THE APPLICATION OF TRANSFORMS TO QUASIPERIODIC BIOMEDICAL SIGNALS. B. Meffert, D. Schubert, T. Lazarus, R. Poll

MOBILE DATA COMMUNICATION RELEVANT TO SAFETY. G. H. Schildt

A SYSTEM PERFORMANCE CRITERION FOR COMPARING ELECTROMAGNETIC ENVIRONMENTAL EFFECTS. M. L. Van Blaricum, A. R. Hunt

A PRACTICAL APPROACH TO ESTABLISH EFFECTIVE GROUNDING FOR PERSONNEL PROTECTION. C. C. Kleronomos, E. C. Cantwell

AN EMC TEST PROCEDURE FOR AN ELECTROENCEPHALOGRAPHY (EEG) USING HUMAN SUBJECTS AND SIMULATED *PATIENTS*. *P. S. Ruggera*

FIFTH INTERNATIONAL CONFERENCE ON INFRARED AND MILLIMETER WAVES

Date: December 8-12, 1980
Place: Wurzburg, West Germany
Sponsor: Institute Electrical and Electronics Engineers (IEEE)/Microwave Theory and Techniques Society
Requests for Information: K. J. Button, MIT National Magnetic Laboratory, Cambridge, MA 02139
Content: Sessions will cover the biologic effects of electromagnetic radiation

FOURTH INTERNATIONAL ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM

Date: March 10-12, 1981
Place: Zurich, Switzerland: Federal Institute Technology
Sponsor: Association Swiss Electrotechnicians
Requests for Information: Dr. T. Dvorak, ETH Zentrum-KT, 8092 Zurich, Switzerland
Content: Topics will cover the protection of the electromagnetic environment and will include the social and economical impact of electromagnetic EMC of communications, electric power, and automotion; EMC hazards to vital safety systems; compatibility of medical electronics; biologic effect of radio frequency energy; and shielding and absorptive materials

19th INTERNATIONAL MAGNETICS CONFERENCE

Date: May 12-15, 1981
Place: Grenoble, France
Sponsor: Magnetics Society/Institute Electrical a Electronics Engineers, Societe Francaise de Physiq Societe des Electroniciens et des Radioelectricien
Requests for Information: James M. Lommel, Genera Chairman, General Electric Company, Corporate R&D, P.O. Box 8, Schenectady, NY 12301
Content: Topics will cover new developments in applied magnetics and related magnetic phonemena, including magnetics in the life sciences

1981 IEEE/MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM

Date: June 15-17, 1981
Place: Los Angeles, CA: Bonaventure Hotel
Sponsor: Institute Electrical and Electronics Engineers (IEEE)/Microwave Theory and Techniques Societ (MTT-S)
Requests for Information: Al Clavin, Chairman, Hughes Aircraft Co., Building 268/A-55, Canoga Park CA 91304
Content: Topics will include microwave techniques, devices, systems, applications, and bioeffects

TENTH L. H. GRAY CONFERENCE

Date: July 13-16, 1981
Place: Oxford, England
Sponsor: Institute Cancer Research
Requests for Information: Dr. R. C. Hill, Institute Cancer Research, Royal Marsden Hospital, Sutton, Surrey, England
Content: The biology and biophysics of radio frequency, microwave, and ultrasonic radiation wil be reviewed, particularly with respect to their potential therapeutic value

URSI 20th GENERAL ASSEMBLY

Date: August 10-19, 1981
Place: Washington, DC: Hyatt Regency Hotel, 400 New Jersey Ave., NW
Sponsor: International Union Radio Science (URSI)
Requests for Information: Mr. R. Y. Dow, National Academy Sciences, 2101 Constitution Ave., NW, Washington, DC 20418
Content: Topics will cover the branches of radio science including electromagnetic metrology, such as radio standards, and interactions between electromagnetic radiation and biologic systems. A 2-day series on interactions of electromagnetic waves with biologic systems will include a) two traditional summary and review sessions on the

0618 IMPLANTABLE MICROWAVE APPLICATORS. Taylor, L. S. (Dept. Electrical Engineering, Sch. Engineering, Univ. Maryland, College Park Campus, College Park, MD 20742).

Small implantable applicators in the form of hypodermic needles are being developed that can be inserted into tissue or into miniature flexible radiating cables that can then be inserted into body cavities. The potentials and characteristics of modified sleeve and collinear array radiators, magnetic radiators, and cylindrical and coaxial waveguide radiators are being evaluated and compared. (funding period 11/79-4/82)

Supporting Agency:NSF, Directorate for Engineering and Applied Science, Div. Electrical Computer and Systems Engineering

0619 MICROWAVE-INDUCED MECHANICAL RESONANCES IN BIOLOGICAL SYSTEMS. Olsen, R. G.; Grissett, J. D. (Medical Sciences Dept., Naval Aerospace Medical Res. Lab., Navy, U.S. Dept. Defense, Pensacola, FL 32508).

The effects of pulsed or modulated microwave energy on biologic systems will be studied, with regards to the mechanical waves produced thermoelastically by the irradiation. The microwave-induced mechanical waves will be evaluated empirically in man. In addition, the impact of any of the observed effects on the relative hazard potential of various types of Navy transmitting systems will be assessed. Pulsed and amplitude modulated microwave energy from 1 to 10 GHz will be beamed at brain, bone, and muscle models that have been instrumented with sensitive transducers to record the excitation of vibrational modes. The observed mechanical waves produced in the models will be compared to theoretical predictions of resonant frequencies, and attempts will be made to stimulate the mechanical vibrations within the samples by modulating or pulsing the microwave energy at the observed resonant frequencies. The microwave carrier frequency and intensity will be chosen for each model to produce an electromagnetic absorption of sufficient magnitude and optimal spatial pattern to elicit a vigorous thermoelastic response. (funding period 10/78-9/81)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. and Development Command, Natl. Naval Medical Center

Lab., Univ. California, Berkeley Campus, Berkeley, CA 94720).

The possible effects of the stationary and alternating magnetic and electric fields produced by controlled thermonuclear reactors, high-voltage transmission lines, magnetic energy storage systems, and magnetohydrodynamic systems are being investigated. Data will be analyzed from an epidemiologic study of 2,000 sclentists and technicians who have been exposed to high fields for substantial cumulative exposures. (funding period 0/79-n/a)

Supporting Agency:U.S. Dept. Energy, Office Health and Environmental Res.

0621 BIOLOGICAL EFFECTS OF HIGH MAGNETIC FIELDS. Tenforde, T. S. (Lawrence Berkeley Lab., Univ. California, Berkeley Campus, Berkeley, CA 94720).

Biomagnetic effects are being investigated to provide quantitative baseline data for the establishment of exposure guidelines for workers in energy-related technologies that utilize stationary and pulsed direct current (dc) fields. Magnetic field effects are being evaluated from physiologic measurements in small mammals, including body temperature, cardiac activity, respiration, blood and urine composition, hormones, hematopoiesis, tissue pathology, and neurobehavioral parameters. Biomagnetic effects in potentially sensitive neural and visual tissues are being assessed by electrophysiologic techniques. Development of organisms in strong fields is being studied with model insect and plant systems. After fabrication of a suitable large-volume magnet, functional studies will be carried out on the visual, cardiovascular, respiratory, and nervous systems of exposed individuals. These studies will provide a comprehensive assessment under well-controlled experimental conditions of biomagnetic effects in mammalian systems. This data will be directly relevant to the establishment of occupational exposure guidelines at fusion reactor facilities, magnetohydrodynamic systems, magnetic energy storage systems, isotope separation facilities, cyclotrons and bubble chambers, and technologies that involve induction-type devices such as induction welding. (funding period n/a)

Supporting Agency:U.S. Dept. Energy, Office Health and Environmental Res.

TEM. Smith, A.; Jedrejczak, W. W. (Sch. Medicine, Georgetown Univ., 3800 Reservoir Rd., NW, Washington, DC 20007).

The effect of microwaves on the immune system will be investigated in inbred mice strains. Microwave exposures will be carried out in a recently constructed waveguide facility. The first study will attempt to repeat some previous research in which an increase was found in the proportion of lymphoid cells bearing a receptor for complement (CR+) in the spleen. In addition, the establishment of the threshold for this phenomenon will be attempted. Kinetic studies will be carried out to determine the most appropriate latent time for assay following the microwave exposure. Finally, the effects of multiple, subthreshold exposures will be studied to determine if such exposures are cumulative. (funding period 3/78-n/a)

Supporting Agency:U.S. Dept. Defense: Navy, Office Naval Res.

0623 EFFECTS OF RADIOFREQUENCY RADIATION (RFR) ON BIOLOGIC MEMBRANES. Dowben, R. M.; Matthews, L. (Dept. Pathology, Sch. Medicine, Baylor Coll. Medicine, 1200 Moursund Ave., Houston, TX 77025).

Unique, state-of-the-art experimental techniques will be used to evaluate membrane structure and function in rodents after whole-body exposure to pulsed radio frequency radiation. The following parameters will be studied: 1) membrane protein composition as analyzed by two-dimensional polyacrylamide gel electrophoresis using novel detergents; 2) membrane fluidity, lateral mobility of membrane proteins, and transmembrane potential as measured by unique fluorescent probes and a one-of-a-kind time-correlated laser fluorimeter; and 3) membrane ultrastructure as revealed by cross-sectional and scanning electron microscopy. (funding period 10/79-4/81)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks Air Force Base

0624 AN INVESTIGATION OF THE MECHANISM OF MICROWAVE-INDUCED CHANGES IN MEMBRANE

The interaction mechanisms responsible for lo level microwave-induced changes in membrane p meability of the blood-brain barrier will be vestigated, with particular attention paid to role of modulation and temperature. Radioiso methods will be employed to monitor the membr transport properties of mammalian cells expos to microwave radiation. Studies will be carr out systematically to determine the exact dep ence of any observed permeability changes on lation and temperature. To further elucidate interaction mechanisms responsible for any ob permeability changes, dynamic measurements wi used to monitor structural changes that occur the biologic membrane and its environment dur a single microwave pulse. These data will be ful in identifying the mechanism of interacti the microwave field with the biologic membran The transport data taken together with the dy measurements should identify thresholds for a observed effects. (funding period 10/77-9/82)

Supporting Agency:U.S. Dept. Defense: Navy, N Medical Res. and Development Command, Natl. N Medical Center

0625 ELECTROMAGNETIC FIELD EFFECTS ON TH CELL MEMBRANE. Marron, M. T.; Good E. M.; Greenebaum, B. (Dept. Chemistry, Sch. ence and Society, Univ. Wisconsin, Parkside C Kenosha, WI 53140).

The mechanism by which extremely low frequenc electromagnetic fields (ELF EMF) affect livin organisms will be identified and characterize Initially the hypothesis that the cell membra is altered by interaction with ELF EMF will b studied. Using an organism that has been pre ously shown to be affected by ELF EMF, *Physar polycephalum*, the following topics will be in tigated: (a) the transport of Ca ions and gl across the cell membrane by measuring the inf and efflux of Ca ions and the rate of glucose take (Experiments have been designed to isola the membrane-dependent component of transport the component due to intracellular processes. the electrical properties of the cell membran measuring changes in both membrane surface an membrane potential; and (c) electric and magn field components that will be applied individ and measurements (a) and (b) will be repeated dividual field components have been observed produce similar effects in *Physarum*; these ex periments will determine whether the effects similar at the membrane level. (funding peri 1/80-12/80)

0626 THERMAL AND NONTHERMAL EFFECTS OF MICROWAVE RADIATION. Wissler, E. H.; Diller, K. R.; Itosh, T. (Dept. Chemical Engineering, Sch. Engineering, Univ. Texas, Austin Campus, 200 W. 21st St., Austin TX 78712).

The thermal response of humans to whole-body irradiation and the changes in cellular and endothelial membrane permeability after microwave irradiation will be evaluated quantitatively in a two-part study. A comprehensive mathematical model for computing specific absorption rates and transient-state temperature profiles for irradiation under various conditions will be developed in the first part of the study. Factors that will be evaluated using this model include frequency and polarization of the incident field; subject's size, exercise, and clothing; and environmental conditions. For the second phase of the study, new and innovative experimental techniques of stopped-flow spectrophotometry, computerized microscopic densitometry, and digital velocity correlation will be applied to the analysis of transient and steady state alterations of tissue transport function. Specific studies will be conducted to characterize the biologic response to microwave irradiation according to: 1) the permeability of human erythrocytes and cultured cells to water and solutes, 2) the extravasation and interstitial diffusion of plasma macromolecules in the microvascular bed, and 3) the in vivo velocity of blood flow in the microcirculation. (funding period 4/80-3/81)

Supporting Agency:U.S. Dept. Health and Human Services, PHS, NIH, Natl. Inst. General Medical Sciences

0627 BIOELECTRIC PHENOMENA CONTROLLING BONE GROWTH. Bassett, C. A.; Pawluk, R. J.; Chokshi, H. R.; Doty, S. B.; Moran, D. (Dept. Orthopedic Surgery, Coll. Physicians and Surgeons, Columbia Univ., 630 W. 168th St., New York, NY 10032).

To investigate the mechanism of electromagnetic field effects on bone formation, the interaction between pulsing electromagnetic fields and cellular responses is being investigated, particularly as they relate to growth, cell differentiation and/or specialization, synthesis of macromolecules, and transfer of ions across the plasma membrane. Tissue culture, experimental surgery, and histochemical, biochemical, and ultrastructural analyses are being employed in a coordinated, multidisciplinary approach. Results will have not only scientific importance in defining the physiologic selectivity of electromagnetic fields with specific pulse characteristics, but will aid in increasing

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Arthritis, Metabolism, and Digestive Diseases

0628 MICROWAVE DIELECTRIC PROPERTIES OF TUMOR TISSUE. Foster, K. R.; Schwan, H. P. (Dept. Bioengineering, Sch. Engineering and Applied Sciences, Univ. Pennsylvania, 4001 Spruce St., Philadelphia, PA 19104).

The dielectric properties of various normal and tumor tissues and of cell suspensions will be measured using a coaxial line technique and microwave network analyzer. Measurements will be made in the 0.1- to 18-GHz frequency range, including the frequencies most useful for electromagnetic induction of hyperthermia. Tissues studied will include surgically excised tumors from live dogs, normal tissues from freshly killed dogs, lymphoma and ascites cell suspensions, and mouse spleen tissue. The net water content of each sample will also be measured. Dielectric data from these soft tissues will be interpreted using the Maxwell moisture theory and compared to the known properties of pure water in this frequency range to yield (a) the apparent amount of "bound" water and (b) the rotational mobility of the major fraction of water in normal and tumor tissues. This analysis will be useful for the determination of the dielectric properties of soft tissue from a single measurement of the net water content of the tissue and for the comparison of the physical properties of water in normal and tumor tissues. (funding period 7/79-6/81)

Supporting Agency:U.S. Dept. Health and Human Services, PHS, NIH, NCI

0629 MICROWAVE-INDUCED HYPERTHERMIA FOR DEEP-SEATED TUMORS. Douple, E. B.; Strohbehn, J. W.; Walsh, J. E.; Bartrum, R. J.; Roberts, D. W.; Saunders, R. L. (Dept. Medicine, Sch. Medicine, Dartmouth Coll., P.O. Box 833, Hanover, NH 03755).

An invasive irradiation system that uses microwaves in the gigahertz range to achieve local hyperthermi will be developed for the treatment of deep-seated cancers. The system will be adapted for percutaneous insertion and surgical implantation to produce appropriate hyperthermia in difficult to heat, deep-seated tumors in humans. Microwaves will be delivered directly to the tumor site through transmission lines and antenna structures. Antenna probes with diameters <1 mm will be employed.

many of the problems associated with the delivery of heat to deep-seated tumors will be circumvented. The heat distributions produced by the improved system in tissue phantoms, tumors, and normal tissues of animals and humans will be predicted theoretically and measured experimentally. The therapeutic efficacy of the proposed system will be evaluated by studying the hyperthermia effects alone and in combination with ionizing radiation and chemotherapy on animal tumors and in pilot clinical studies. In addition, the effect of local hyperthermia on blood flow and the uptake of chemotherapeutic drugs in tumors and in normal tissues will be examined. Tumors will include transplantable mouse mammary adenocarcinoma (MTG-B), chemically-induced tumors in the rat, and spontaneous brain tumors in dogs. The effects of the treatment on tumor cell viability will be assessed using the TD_{50} and tumor latency assays as well as histologic evaluation. Tumor growth, median tissue culture dose, and host life span will also be studied as indicators of therapeutic effectiveness, and normal tissue response will be carefully observed in heated animals. Clinical tumors will include brain tumors and other tumors such as pancreas and prostate cancer. (funding period 3/80-2/81).

Supporting Agency:U.S. Dept. Health and Human Services, PHS, NIH, NCI

0630 EFFECTS OF MICROWAVE RADIATION ON THE BEHAVIORAL DEVELOPMENT OF LEARNING PROCESSES: ACUTE AND CHRONIC EXPOSURES ON ANIMALS. Schrot, J. F.; Thomas, J. R. (Behavioral Sciences Dept., Naval Medical Res. Inst., Navy, U.S. Dept. Defense, Bethesda, MD 20014).

The effects of microwave radiation on the acquisition of behavior by rats will be studied. Initial studies will be concerned with establishing the threshold range of power densities that alter the learning process. Additional studies will focus on the long-term effects of chronic exposure. Operant conditioning techniques are used to develop a baseline of repeated acquisition of behavioral chains in rats. The schedule requires the animal to learn a different four-member response chain each session, which results in the daily generation of an individual learning curve. The baseline is used to assess the effects of low-level (near 10 mW/cm^2) microwave fields. Initial emphasis is on establishing threshold radiation values producing behavioral change. Subsequent studies will focus on long-term chronic exposures with effective radiation parameters. With this method-

Supporting Agency:U.S. Dept. Defense: Navy, Nava
Medical Res. and Development Command, Natl. Nava
Medical Center

Funding Period Modifications:

0631 BOSE-EINSTEIN CONDENSATION IN BIOLOGICA
SYSTEMS. Wu, T. (Dept. Physics, Sch.
Arts and Sciences, State Univ. New York, Bingham
Campus, Vestal Parkway, Binghamton, NY 13901).

Funding period extended to 2/81. See Current Re
search 0506 for description of this project.

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

0632 INTERACTION OF ELECTROMAGNETIC FIELD W
BIOLOGICAL SYSTEMS. Chen, K. (Dept.
Electrical Engineering and Systems Science, Sch.
Engineering, Michigan State Univ., Engineering
Building, East Lansing, MI 48824).

Funding period extended to 7/79. See Current Re
search 0267 for description of this project.

Supporting Agency:NSF, Directorate for Engineeri
and Applied Science

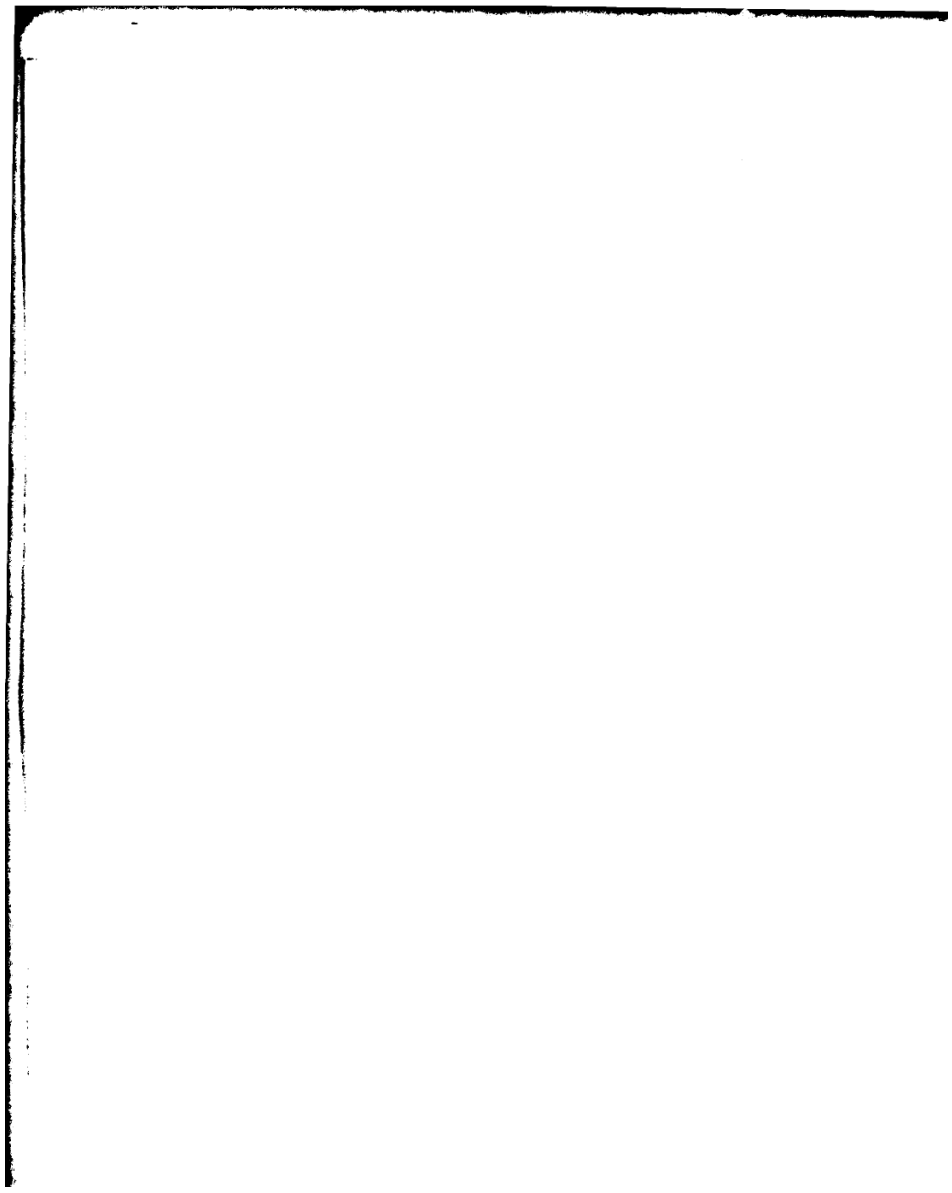
0633 LOW LEVEL MICROWAVE RADIATION EFFECTS (
BEHAVIOR. Thomas, J. R.; Schrot, J. E.
(Behavioral Sciences Dept., Naval Medical Res.
Inst., Navy, U.S. Dept. Defense, Bethesda, MD 20(

Funding period extended to 10/81. See Current Re
search 0492 for description of this project.

0634 REMOTE STIMULATION BY RADIO-FREQUENCY TRANSMISSION. Glenn, W. W.; Gee, J. B.; Allison, T.; Goff, W. R.; Lange, R. C.; Manuelidis, E. E.; Schachter, E. N. (Dept. Surgery, Sch. Medicine, Yale Univ., 333 Cedar St., New Haven, CT 06510).

Funding period extended to 12/80. See Current Research 0458 for description of this project.

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



6675 ELECTROMAGNETIC PROPERTIES OF BIOLOGICAL SOLUTIONS.--I. GENERAL CONSIDERATIONS AND PRESENTATION OF AN IMPROVED SYSTEM FOR MICROWAVE SPECTROSCOPY OF SMALL BIOLOGICAL SAMPLES. *(Eng.)* Bianco, B. (Laboratorio per i Circuiti Elettronici, Consiglio Nazionale delle Ricerche, 16145 Genoa, Italy); Drago, G. P.; Marchesi, M.; Martini, C.; Mela, G. S.; Ridella, S. *Boll Soc Ital Biol Sper* 55(22): 2322-2328; 1979 (25 refs).

A microwave spectroscopic method for measuring the complex permittivity of small samples of biologic liquids is described and some preliminary results are presented. The liquid under test is placed in a sample holder that acts as an infinite circular waveguide. Since the penetration depth of the electromagnetic field into the sample is very small (about 1.4 mm), a small amount of liquid (<1 ml) is sufficient to make accurate measurements. The measurement system is a Hewlett-Packard 8542A automatic network analyzer, controlled by an HP 2116C computer. Measurements made in the 100- to 2,000-MHz frequency range (in steps of 50 MHz) with liquids of known permittivity (sodium chloride solution, ethanol, and albumin) indicated that the precision of the method is normal for the real part of the complex permittivity and is good for the imaginary part of the complex permittivity.

6676 ELECTROMAGNETIC PROPERTIES OF BIOLOGICAL SOLUTIONS.--II. METHODOLOGICAL CONSIDERATIONS ON MICROWAVE SPECTROSCOPY OF HUMAN SERA. *(Eng.)* Bianco, B. (Laboratorio per i Circuiti Elettronici, Consiglio Nazionale delle Ricerche, 16145 Genoa, Italy); Drago, G. P.; Marchesi, M.; Martini, C.; Mela, G. S.; Ridella, S. *Boll Soc Ital Biol Sper* 55(22): 2329-2333; 1979 (1 ref).

Complex permittivity measurements were made for 20 sera of healthy young men. The measurements were made at 39 frequencies over the range of 100-2,000 MHz in 50-MHz steps. A linear regression was constructed for the serum conductivity versus the square of the frequency for all of the 39 frequencies, and the results were found to be in good agreement with theoretical predictions.

6677 ELECTROMAGNETIC PROPERTIES OF BIOLOGICAL SOLUTIONS.--III. DIFFERENCES BETWEEN SERA OF NORMAL YOUNG MEN AND CHILDREN. *(Eng.)* Bianco, B. (Laboratorio per i Circuiti Elettronici, Consiglio Nazionale delle Ricerche, 16145 Genoa, Italy); Drago, G. P.; Intra, E.; Marchesi, M.; Martini, C.; Mela, G. S.; Ridella, S. *Boll* sera obtained from 15 children (1- to 6-yr old) to determine if complex permittivity is similar for healthy individuals. Complex permittivity measurements were obtained for all sera in the frequency range of 100-2,000 MHz at 50-MHz steps. Serum conductivity (SC) was obtained for all frequencies, and a regression was made versus the square of the frequency (f) to obtain the following relationship: $SC = a + bf$, where a and b are assumed as characteristics of the electromagnetic properties of the sample. For all subjects, the regression $SC = a + bf$ showed a very high significance (lowest correlation coefficient: $r = 0.99$) and the percent standard deviation of the a and b parameters was less than 5.5%. Although the protein, albumin, and gammaglobulin contents of the sera did not differ significantly between children and adults, the parameter "a" was significantly lower in children ($p = 0.017$) than in adults. Thus, the electromagnetic properties of sera expressed by the "a" parameter seem to depend not only on serum protein content but also on some other factor related to the age of the subject. Since the "a" parameter heavily depends on the direct current conductivity of the sera, the above factor could be related to the salt percentage of the sera.

6678 THE BIOLOGICAL EFFECTS OF MICROWAVE RADIATION--A REVIEW. *(Eng.)* Cornelius, W. A. (Health and Safety Section, Australian Radiation Lab., Melbourne, Australia) [Report No. ARL/TR002] 23 pp., 1978 (58 refs).

A review of the biologic effects of microwave radiation in animals and man is presented. Most experiments conducted on the bioeffects of microwaves have employed a limited range of microwave frequencies, pulse repetition rates, and power levels, and the only interaction mechanism proven to be biologically significant is the thermal effect. Problems associated with microwave dosimetry in biologic experiments make the evaluation of the observed biologic effects difficult; examples include nonuniform power absorption ("hot spots") perturbation of the microwave field, and resonance conditions. The effect of microwave irradiation on animals is difficult to extrapolate from one species to another. Microwave-induced cataracts are well documented in animal experiments; for the rabbit eye the cataractogenic microwave irradiance at 2,450 MHz for a single acute 100-min exposure is about 150 mW/cm^2, which is equivalent to 138 W/kg peak absorption immediately behind the lens. This effect, which appears to be due to heating, occurs at an intra-ocular temperature of about 43 C for a single acute exposure. Computer modeling indicates that the temperature rise expected in the human eye would be similar to that for the rabbit for an

relationship was not found for loss of visual acuity or cataract production. Eastern European countries have reported reversible effects such as headache, nausea, insomnia, tiredness, irritability, cardiac pain, loss of appetite, memory difficulties, decreased libido, changes in heart rate and blood chemistry, and alterations in electroencephalograms and electrocardiograms, and in thyroid and adrenal output at chronic exposure levels below 10 mW/cm². However, due to defects in study design, these reports have been largely discounted by western researchers. Altered behavioral responses in animals at apparently microthermal or nonthermal microwave doses appear to be due to thermal hot spots in view of the frequencies used in relation to the size of the animal. Teratogenic effects due to microwaves have also been demonstrated in animals, and these effects are evidently direct thermal effects.

6679 LONG-WAVELENGTH ANALYSIS OF NEAR-FIELD IRRADIATION OF PROLATE SPHEROIDAL MODELS OF MAN AND ANIMALS. *(Eng.)* Massoudi, H. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112), Durney, C. H., Iskander, M. F. *Electron Lett* 16(3): 99-100; 1980 (6 refs).

A long wavelength analysis was derived for spheroidal and ellipsoidal models of man and some test animals that showed a strong dependence of electromagnetic (EM) energy absorption on orientation of the body. This analysis was applied to calculate the average specific absorption rate (SAR) in spheroids irradiated by EM near fields, when the long wavelength approximation is given, and when the spatial variation of the EM field is not "too rapid." The incident electric field and the incident magnetic fields, as well as the average SAR, were derived for an EM plane wave that was incidental on a lossy dielectric prolate spheroid along its Z-axis. The analysis gave an excellent approximation for the average SAR in a prolate spheroidal model of man as a function of dipole location.

6680 DETERMINATION OF A THERMAL EQUIVALENT OF MILLIMETER MICROWAVES IN LIVING CELLS. *(Eng.)* Dardalhon, M. (Institut Curie, 26, rue d'Ulm, 75005 Paris, France), Averbeck, D., Berteaud, A. J. *J Microwave Power* 14(4): 307-312; 1979 (10 refs).

Diploid strain D5 *Saccharomyces cerevisiae* cells were irradiated at frequencies of 70.5 and 73 GHz on millipore filter discs placed on agar plates in open petri dishes to determine if microwaves can affect to genetic insult, was used to study the effects of both temperature (conventional heating at 30, 37, 42, 47, and 52 C) and microwave irradiation on cell survival, induction of mitotic recombination, and induction of cytoplasmic "petite" mutations. No evidence of altered survival, impaired function, or structural injury was seen at either frequency, even at power densities as high as 60 mW/cm² (duration of exposure ≤3 hr). Conventional heating had no deleterious effects until temperatures of specimens exceeded 50 C. When two haploid strains of yeast of opposite mating type were compared with respect to temperature and microwave treatment for zygote formation, the ratio of zygotes formed in treated samples over that of control samples was observed to be a function of increasing power density and increasing temperature. The effect of conventional heating at 30 or 37 C on zygote formation was greater than the effect of 70.5-GHz microwave irradiation at a power density of 60 mW/cm². Elevation of temperature due to microwave treatment at 60 mW/cm² and 2 mm distance was estimated to be 3 C. Thus, the results of these experiments indicate that microwaves do not induce lesions and genetic effects in cellular DNA.

6681 PRELIMINARY STUDIES: FAR-FIELD MICROWAVE DOSIMETRIC MEASUREMENTS OF A FULL-SCALE MODEL OF MAN. *(Eng.)* Olsen, R. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). *J Microwave Power* 14(4): 383-388; 1979 (10 refs).

Measurements of microwave heating were made in a 75-kg, full-size, upright human model composed of electrically simulated muscle that was placed in the far-zone of a standard gain horn inside an absorber-lined chamber. The material of the model was closely matched to human muscle in terms of permittivity and conductivity at the frequency of irradiation. Pulsed 1.29-GHz (L-band) microwaves (3-μsec pulse duration, 310 pulses/sec repetition rate) from a military radar transmitter resulted in an average power density of 6-14 mW/cm² at the location of the model. Microwave heating at the front surface was measured at nine locations on the phantom. Measurements at several depths within the phantom were also made at a central location to assess the depth of penetration of the microwave energy. The above measurements permitted a calculation of the approximate whole-body average specific absorption rate (SAR) when the model's long axis was parallel to the electric field vector. For a normalized power density of 1 mW/cm² at a frequency of 1.29 GHz, the whole-body average SAR was 0.031 W/kg, which agrees well with the predicted value of 0.03 W/kg based on absorption in prolate spheroidal models of man.

TION OF MICROWAVES. *(Eng.)* Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, RJ-30, Sch. Medicine, Univ. Washington, Seattle, WA 98195); Galambos, R. *J Microwave Power* 14(4): 321-326; 1979 (9 refs).

The contribution of the ossicles (middle ear bones) and external ear bones to auditory perception of microwaves was evaluated by the brain-stem evoked response (BER) method in guinea pigs (500-750 g). The animals were placed upside down with the head inserted inside a circular microwave exposure system, and the amplitude and latency of BERs were recorded as guinea pigs were stimulated at various intensities by acoustic pulses coupled to the auditory canal or via bone conduction and by 918-MHz microwave pulses (10 μsec pulse duration, 30 pulses/sec repetition rate). Blocking of the external ear, middle ear damping, and middle ear destruction produced little change in the BERs that were elicited by microwave pulses. The results indicated that the middle ear is not critical for auditory perception of microwaves and that the mechanisms involved in this perception are similar to those responsible for hearing by bone conduction. Also, since no response to microwave or to acoustic stimulation was recorded when the cochlea was destroyed, it is clear that microwave hearing requires activation of the cochlea. Conduction of pressure waves through the bones of the calvarium appears to be the mechanism responsible for perception of pulsed microwaves.

6683 CARBON-LOADED TEFLON ELECTRODES FOR CHRONIC EEG RECORDINGS IN MICROWAVE RESEARCH. *(Eng.)* Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, RJ-30, Sch. Medicine, Univ. Washington, Seattle, WA 98195); Guy, A. W. *J Microwave Power* 14(4): 399-404; 1979 (15 refs).

Carbon-loaded Teflon electrodes with a conductivity close to that of tissue were implanted in cortical and subcortical locations of rabbits for periods of 4-6 mo to determine their usefulness for making chronic electroencephalogram (EEG) recordings during microwave irradiation. Two types of carbon-loaded Teflon were used. One was a fine carbon-loaded Teflon wire (0.25 by 0.3 mm cross- section) with a conductivity of 4 S/m that was used as a conductive lead and as a subcortical electrode. The other type, with a conductivity of 1 S/m, was machined into 2-56 or 4-40 screws that were used for cortical recordings. One rabbit was implanted both with conventional metal and with carbon-loaded Teflon electrodes. Three rabbits were implanted with carbon-loaded Teflon electrodes only, and two other rabbits with metal electrodes only. When a 60-Hz filter was used in conjunc- recordings were made during acute exposure of two rabbits to 2.450-MHz microwave radiation directed to the right eye at an incident power density of 100 mW/cm^2 (specific absorption rate in the hypothalamus of about 25 W/kg), there was no obvious radio frequency interference picked up by the carbon-loaded Teflon electrodes. Histologic examination showed good tissue compatibility for the carbon-loaded Teflon electrodes. The results indicate that carbon-loaded Teflon electrodes can be implanted chronically to record the EEG in animals during the course of microwave radiation.

6684 MINIATURE ANECHOIC CHAMBER FOR CHRONIC EXPOSURE OF SMALL ANIMALS TO PLANE-WAVE MICROWAVE FIELDS. *(Eng.)* Guy, A. W. (Bioelectromagnetics Res. Lab. Dept. Rehabilitation Medicine, RJ-30, Sch. Medicine, Univ. Washington, Seattle, WA 98195). *J Microwave Power* 14(4): 327-338; 1979 (4 refs).

A system of miniature anechoic chambers that can be used at frequencies of 2.450 MHz and higher for chronically exposing several small animals to plane-wave microwave fields is described. The system, which occupies a floor area of only 73 by 73 cm, consists of a combination of tapered and rectangular sections lined with Model AN-77 absorber material on the sides and thicker SPY-12 pyramidal absorber material on the bottom. The system allows for the simultaneous exposure of eight experimental animals, while eight sham-exposed controls are simultaneously maintained in the same environment. During actual and sham exposures, each animal is contained in a separate plastic cage that is electrically isolated from the other cages. Each animal is exposed to fields under simulated free-space conditions. Tests showed that although the plastic cage containing the animal within the exposure chamber causes field perturbance, specific absorption rate (SAR) patterns within exposed cadavers or models show very little modification. Each animal can be supplied with food and water by a system designed to eliminate severe perturbations of the field and of SAR patterns in the animals. Each chamber is mounted on casters that allow easy transport when the horn antenna assembly is removed. Experimental measurements indicated that at 1 W of input power, radiation at a power density of 169 $\mu W/cm^2$ was obtained at the position normally occupied by the animal. At an incident power density of 1 mW/cm^2, peak SAR values as high as 0.84 W/kg were produced in a prolate spheroidal model of the rat. SARs as high as 2.21 W/kg were produced in the rat cadaver.

TROMAGNETIC ENERGY. *(Eng.)* Ho, H. S. (FDA, BRH, 5600 Fishers Lane, Rockville, MD 20857). *Health Phys* 37(6): 743-750; 1979 (22 refs).

Varying the source frequency, aperture size and shape, and field distribution was theoretically examined in relation to designing aperture sources that deliver deep penetration of nonionizing electromagnetic energy into different sizes of spherical tissue-equivalent bodies. Fifteen source frequencies ranging from 10 MHz to 10 GHz were used. Three types of sources were used: plane wave; "Cap" aperture, a circular aperture shaped like a polar cap in contact with the irradiated sphere; and "Belt" aperture, a loop source that wraps around the irradiated sphere. Four different sizes and three different aperture field distributions of each aperture were used. Twelve sizes of the tissue-equivalent sphere were used with radii ranging from 0.5 to 10.0 cm. For each size of the sphere, four cases were considered: a single-layered muscle sphere and three triple-layered spheres with muscle, fat, and skin layers (1.0-mm thick). The thickness of the fat layer of the three triple-layered spheres was 10, 20, and 30% of the radius of the muscle sphere, respectively. The calculated results indicated that for each souce frequency, the size of the aperature source equaling $\pi/4$ yields the lowest energy penetration factor (quotient of dose rate at the sphere center by the maximum dose rate at the surface of all tissue layers of the sphere). The results indicated a strong resonance type of dependence on source frequency for deep electromagnetic energy penetration. This resonance frequency decreased with increased sphere size. The energy penetration was also a strong function of aperture size. With optimum design, the aperture sources could produce deeper energy penetration characteristics than those obtained with plane wave sources. The optimum energy penetration into smaller size spheres (<5.0 cm radius) was much greater than that for larger size spheres. In general, optimum deep energy penetration characteristics of triple-layered spheres were not as good as those of single-layered spheres.

6686 CURRENT PROBLEMS OF RADIOBIOLOGY OF RADIO FREQUENCY ELECTROMAGNETIC RADIATION. *(Rus.)* Akoev, I. G. (Inst. Biophysics, USSR Acad. Sciences, Pushchino, USSR). *Radicbiologiia* 20(1): 3-8; 1980 (14 refs).

Recent studies on and current problems associated with the radiobiology of radio frequency electromagnetic radiation are reviewed. Previous studies have demonstrated that most changes induced by radio frequency radiation are reversible, and morphologic changes are rare and slight. However, radiation has been demonstrated as has a cumul tion of effects from repeated exposures to ineffectiv small doses. Partial synergism of radio frequenc radiation in the centimeter range and infrared radi tion has also been observed experimentally. Little known on the selectivity of the radiation effect on di ferent organs. Electromagnetic radiation has bee shown to have a direct or thermal effect and an i direct effect, which is manifested by such symptom as neurosis, asthenia, and cardiovascular function changes, especially during exposure to low-intensi radiation. The organism as a whole is assumed to b more sensitive to electromagnetic radiation tha isolated organs and cells. Thus, the sensitivity higher in vivo than in vitro.

6687 ELECTRIC CURRENT AND HIGH FRE QUENCY WAVE HEATING PROCESSES *(Fre.)* Dutreix, J. (Institut Gustave-Roussy, 16 bis avenue Paul-Vaillant-Couturier, 94800 Villejui France); Convert, G.; Cosset, J. M.; Damia, E Dufour, J.; Salama, M. *J Radiol* 60(11): 669-673; 197 (11 refs).

Recent studies on the therapeutic possibilities c capacitive, radiative, and inductive diathermy ar reviewed. One study involved the use of inductiv diathermy with a frequency of 27 MHz to treat ski melanoma. The depth of penetration into muscula tissue decreased with increasing frequency fro 14.1 cm at 25 MHz to 1.7 cm at 3,000 MHz. A simila decrease was also observed in fatty tissue, from 15 cm at 25 MHz to 7.5 cm at 3,000 MHz. Intracavitary an interstitial diathermy is possible with the use of in planted antennas operating at such frequencies a 0.5 or 80 MHz.

6688 THERAPEUTIC APPLICATION OF CONS TANT AND LOW-FREQUENC MAGNETIC FIELDS (LITERATURE REVIEW). *(Rus* Bogoliubov, V. M. (Central Inst. Balneology an Physiotherapy, Moscow, USSR); Skurikhina, L. A *Vopr Kurortol Fizioter Lech Fiz Kul't* (2): 65-72, 197 (58 refs).

Clinical and experimental reports on the therapeuti uses and effectiveness of constant and low frequency magnetic fields are reviewed. Often com bined with other conventional therapeutic methods magnetic field therapy has been found to produc favorable results in such diseases as asthen neurosis, arterial aneurysms, neuritis of inflam matory and ischemic etiology, lumbrosacra radiculitis, phantom pain, ischemic heart disease

premenstrual disorders, and chronic diseases of the uterus), fractures, psoriatic polyarthritis, and burns. Considerable palliative effect has been observed in many cases. No therapeutic effect has been observed with patients with rheumatoid arthritis. Experiments with erythrocytes have demonstrated increased storage stability due to magnetization.

6689 STATE OF THE ART AND PROSPECTS FOR THE USE OF RADIO FREQUENCY AND MICROWAVE HYPERTHERMIA. *(Fre.)* Gautherie, M. (Lab. Biomedical Thermology, Faculty of Medicine, French Natl. Inst. for Health and Medical Res., Universite de Strasbourg, 11, rue Humann, 67085 Strasbourg cedex, France Caisse Nationale de l'Assurance Maladie des Travailleurs Salaries). *J Radiol* 60(11): 685-689; 1979 (3 refs).

Recent achievements and prospects for the use of radio frequency hyperthermia in cancer therapy are reviewed. The therapeutic use of hyperthermia is based on the fact that cell death occurs above a certain temperature (above 42 C for mammalian cells). The frequencies that have been tested to date include 13, 27, 434, and 2,450 MHz. The biologic studies on cell cultures and experimental animals should be extended to include the mechanism of action of radio frequency at the cellular level. Various technological problems are discussed, such as irradiation frequency, applicators, and dosimetry (e.g., noninterfering probes, microwave radiometry). Other topics to be considered when evaluating the prospects of microwave hyperthermia for cancer therapy include: synergism between radio frequency hyperthermia and ionizing radiation or drugs, the long-term effects of radio frequency and heat on healthy tissues, the enhancement of tumor growth and lymphogenic dissemination of tumor cells, and the specific, nonthermal effects of radio frequency radiation.

6690 MECHANISM OF ACTION AND THERAPEUTIC APPLICATION OF SINE-MODULATED CURRENTS. *(Rus.)* Iasnogorodskii, V. G. (Central Inst. Balneology Physiotherapy, Moscow, USSR). *Vopr Kurortol Fizioter Lech Fiz Kul't* (2): 5-13; 1979 (93 refs).

The action mechanism and possible therapeutic applications of sine-modulated currents (SMC) are reviewed. Studies have demonstrated that SMC have an analgesic effect; they have been shown to increase the blood circulation, perfusion, and trophism of tissues. SMC have also been shown to normalize the sympathetic function of the adrenals in experimental atherosclerosis and in clinical cervical

6691 MUSCLE BLOOD FLOW CHANGES IN RESPONSE TO 915 MHz DIATHERMY WITH SURFACE COOLING AS MEASURED BY Xe^{133} CLEARANCE. *(Eng.)* Sekins, K. M. (Dept. Mechanical Engineering, FU-10, Univ. Hosp., Sch. Medicine, Univ. Washington, Seattle, WA 98105); Dundore, D.; Emery, A. F.; Lehmann, J. F.; McGrath, P. W.; Nelp, W. B. *Arch Phys Med Rehabil* 62(3): 105-113; 1980 (20 refs).

Muscle blood flow (MBF) response of the human anterior thigh to treatment with a 915-MHz, direct-contact microwave applicator with simultaneous air-cooling (5.0 ± 0.5 C at 60 m³/min) was measured by ^{133}Xe (0.1 ml in isotonic saline) clearance. Forty-four anterior thigh MBF studies were performed in 13 volunteers (11 men and 2 women, all 30 yr old) in 25 separate sessions. All subjects had <1 cm of subcutaneous anterior thigh fat. ^{133}Xe clearance was measured at depths of either 1.5 or 3.0 cm from skin surface. Prior to treatment, resting blood flow (RBF) imaging demonstrated a uniform pretreatment perfusion field with a measured mean RBF value of 1.8 ± 1.1 and 2.06 ± 1.03 ml/min/100 g at 1.5 and 3.0 cm, respectively; adjusting the RBF values for correlations with direct flow measurements found in the literature resulted in a RBF value of 2.6 ml/min/100 g. The maximum MBF measured in response to heating with simultaneous surface cooling was 32.35 ml/min/100 g (mean, 27.23); this figure was in fair agreement with the reported maximum perfusion rate of 35-40 ml/min/100 g for skeletal muscle. To further investigate the thermoregulatory mechanisms involved with diathermy and simultaneous surface cooling, the indirect effect on the perfusion of one thigh caused by treating its counterpart was briefly studied. Results of this experiment demonstrated that 1) the effect of surface cooling a limb to depress the perfusion of its counterpart dominates that of heating one thigh to elevate blood flow in its counterpart and 2) contralateral responses to cooling diminish with depth. The results with this diathermy technique with simultaneous surface cooling demonstrate the "focusing" of perfusion and temperature into the muscle bed, thus providing therapeutic deep-heating effects while maintaining safe superficial temperatures.

6692 MICROWAVES AND HEALING OF BONE FRACTURES. *(Ger.)* Babayan, R. (Abteilung fur Allgemeinchirurgie, Chirurgische Universitatsklinik und Poliklinik, Martinistrasse 52, D-2000 Hamburg 20, W. Germany); Hahn, W.; Bensien, H. *Med Welt* 30(34): 1224-1226; 1979 (14 refs).

Osteotomy of the tibia was performed in 50 4- to 5-mo-old rabbits. The fractures were set and then ir-

and the tensile strength of the fractured bone was determined. Both the irradiated and nonirradiated bones refractured at the site of the primary fracture. The mean value of the tensile strength of the tibia was 6.7 kp in the controls and 7.9 kp in the irradiated animals on day 14 after osteotomy; the difference was not statistically significant. On day 16, the mean tensile strength was 7.4 kp in the controls and 9.7 kg in the irradiated animals, a statistically significant difference. These findings demonstrate that high-frequency irradiation accelerates the healing of bone fractures.

6693 FRACTURE HEALING IN RATS EXPOSED TO EXTREMELY LOW-FREQUENCY ELECTRIC FIELDS. *(Eng.)* Marino, A. A. (VA Hosp., Irving Ave. and Univ. Place, Syracuse, NY 13210); Cullen, J. M.; Reichmanis, M.; Becker, R. O. *Clin Orthop Relat Res* (145): 239-244; 1979 (10 refs).

The effects of full-body exposure to a 5,000 V/m electric field (1,590 V at 60 Hz) on bone healing were investigated in 27-day-old male Sprague-Dawley rats following a standardized fibular osteotomy (SFO). Both experimental and control rats (same living conditions except for the absence of the 60-Hz field) were sacrificed at 14 days postfracture. The fractures of rats exposed to 5,000 V/m electric field exhibited a distinctly altered histologic appearance compared with that of control rats. In the field-exposed rats, the new bone had much thinner trabeculae, most with cartilaginous cores, than in control rats. Large blocks of cartilage were evident throughout the callus. In some instances, a cartilage plate, exhibiting typical epiphyseal plate organization, was seen at the union site in the region of the uniting callus. New compact bone was strictly limited to the anchoring callus and was never extensively developed. After 2 wk of field exposure, fractures exhibited less new bone formation, and correspondingly more cartilage, than did control fractures. The mean healing index for the field-exposed rats was significantly less ($p<0.001$) than that for control rats. It is concluded that bone healing in field-exposed rats was adversely affected probably because of a systemic stress interaction. The early stress response is catabolic in nature; it includes labile protein breakdown and concomitant negative nitrogen balance. Under these conditions, bone collagen synthesis may be impaired and healing time lengthened accordingly. Since this effect occurred at much lower power levels than are presently used in electrical osteogenesis, the therapeutic evaluation of electricity-promoted bone healing must consider both local and systemic effects and the local manifestations of systemic effects.

Haas, W. G. (Orthopedic Res. Lab., Facu Medicine, Univ. Calgary, Calgary 44, Alber Canada); Lazarovici, M. A.; Morrison, D. M. *Clin O thop Relat Res* (145): 245-251; 1979 (26 refs).

The effects of noninvasive exposure to relative strong, low-frequency magnetic fields on the heali of freshly created osteotomies of the rabbit radi were investigated using a solid core electromagn energized by a square wave unidirectional curre The magnetic field was pulsed transversely acro the osteotomy site of the radius while the animal w confined to a restraining device for 6 hr/day, days/wk. In one experiment, the influence of d ferent pulse frequencies (0.1, 1, or 4 Hz) w evaluated in 51 adult rabbits (2-4 kg), with the peri of stimulation being kept constant at 2 wk; 18 non radiated rabbits served as controls. In a seco study, pulse frequency was kept constant at 1 H and the exposure period for nine animals was eith 3 or 4 wk; nine nonirradiated animals served as co trols. A definite healing effect was observed in cor parison with nonexposed control animals when magnetic field of 250 G, pulsed at either 0.1 or 1 H was applied to the recently created osteotomy of th rabbit radius. This was especially noticeable animals exposed to the 1-Hz pulse frequency; after wk of exposure (60 hr) at this frequency, th histologic and radiologic scores in experiment animals were approximately double those of the co trol animals. However, the initially accelerated hea ing effect observed after 2 wk of magnetic fie stimulation was not maintained after 3 wk. After 4 w of exposure (120 hr), the degree of healing in e perimental animals was still more advanced than controls, but the difference in the histologic ar radiologic scores was less pronounced. It appeare that although the initiation of the healing proces was accelerated, the period of time required for sol union was not significantly reduced. Also, none the osteotomies, even after 4 wk of stimulation, wer judged to be completely healed on a histologic bas (i.e., bone formation in all 4 sectors). In view of thes findings, this form of treatment is not recommende for clinical use in the treatment of recent fractures long bones.

6695 AN INVASIVE MICROWAVE ANTENN FOR LOCALLY-INDUCED HYPERTHE MIA FOR CANCER THERAPY. *(Eng.)* Strohbehn, W. (Thayer Sch. Engineering, Dartmouth Coll Hanover, NH 03755); Bowers, E. D.; Walsh, J. E.; Dou ple, E. B. *J Microwave Power* 14(4): 339-350; 1979 (1 refs).

An invasive microwave system that uses hypodermi

critical design parameters were identified. Absorbed power was measured in saline, in tissue equivalent phantoms, and in tumors (mouse mammary adenocarcinomas implanted in the flanks of C3H/HeJ mice) in live and dead mice. The results suggest that this system will produce significant heating in small tumors. However, the resulting thermal distributions are not sufficient for clinical applications, where a heating volume with a diameter of 2-4 cm is required. Using a 3-W, 1-GHz oscillator, temperature increases of more than 18 C were achieved in tumors of live mice in less than 10 min. Temperature profiles measured in mouse tumors indicated that this system produced significant and sufficient heating of tumor material at a 5-mm distance from the antenna. A several degree variation in tumor temperature was noted because of the large temperature rise needed to bring the anesthetized mouse from a low core temperature up to therapeutic levels of 44.5 C. It is anticipated that human tumor temperatures would be raised from 37.5 to 44-45 C and that the predicted gradient between the antenna and a distance 5 mm away would be much less. However, to have clinical relevance, antenna designs must be found that will produce flatter temperature distributions over larger volumes. Agreement between theoretical calculations and measured temperatures for the microwave antenna was quite good. The theoretical calculations predicted that there may be a small advantage in using a frequency of 3 GHz in animal tumors of about 1 cm in diameter. The microwave antenna system provides a heat distribution that is superior to that obtained using a resistance heater of similar dimensions. Future modifications of the antenna design will require measurements of absorbed power and temperature distributions in vivo or in very carefully constructed phantoms.

6696 PULSE-CYTOPHOTOMETRIC STUDIES ON EXPERIMENTAL BRAIN TUMORS UNDER THE EFFECT OF CHEMOTHERAPEUTIC AGENTS, MICROWAVE IRRADIATION, AND HYPERTHERMIA. *(Jpn.)* Shitara, N. (Dept. Neurosurgery, Univ. Tokyo Hosp., Bunkyo-ku, Tokyo 113, Japan); Kohno, T.; Nagamune, A.; Takakura, K.; Sano, K. *Neruol Med Chir (Tokyo)* 18(3): 199-207; 1978 (20 refs).

To determine the best method to achieve optimal brain tumor cell synchronization as a pretreatment for radiotherapy, the results of treating cultured experimental glioma C6 strain rat tumors with various chemotherapeutic agents, hyperthermia (40 C), or microwave irradiation were analyzed. The cultured cells were exposed at the day 3 log phase stage of culture to the agents, hyperthermia, or microwaves. cells. The quantitative distribution of cell cycle phases produced by microwave irradiation after 72 hr was 42.8% (G_1 phase), 28.4% (S phase), and 28.8% (G_2 + M phase), and after 24 hr was 60.4%, 18.5%, and 21.1%, respectively. Hyperthermia for 72 and 24 hr caused cell cycle distributions in the G_1, S, or G_2 + M phase as follows: 44.1% and 46.8%, 18.7% and 32.3%, or 37.2% and 20.9%, respectively. Of the methods tested, it is suggested that the preferred pretreatment for cell synchronization for radiotherapy is the combined use of vinca alkaloids (vincristine) and nitrosourea derivatives (ACNU).

6697 ELECTROMAGNETIC HYPERTHERMIA AND ITS EFFECT ON MALIGNANT TUMORS. *(Cze.)* Pokorny, J. (Ustave radiotechniky a elektroniky CSAV, Prague, Czechoslovakia). *Cas Lek Cesk* 118(30): 929-933; 1979 (14 refs).

Experimental results concerning the use of microwave hyperthermia to kill malignant human tumor cells are reviewed. In experiments with mice with sarcoma 180, exposure to electromagnetic radiation (frequency ranging from 0.01 to 10 GHz), at a temperature of 44.2 C for a 30-min period, resulted in irreversible damage to cancer cells (95%). Irreversible damage to cells in vitro was judged by the amount of DL-glyceraldehyde or oxygen accepted by the cells from the environment. At 45.2 C healthy cells were damaged. At temperatures <42 C, the effect of heat was negligible even with long-lasting exposure. The results of other studies with humans have indicated that the temperatures required to kill malignant and healthy cells are different, i.e., 45.3 and 46.2 C, respectively. Other studies have demonstrated that hyperthermia is lethal for most types of tumor cells, except for peripheral cells, which are less sensitive to heat and maintain their biologic activity, thereby propagating the tumor. Cells of various cancers differ in their sensitivity to heat, i.e., temperatures ≥44 C are lethal for human stomach cells, while temperatures ≥46 C result in death for human skin melanoma cells. The experimental results to date are inadequate to fully assess the potential usefulness of hyperthermia for treating human malignancies.

6698 ELECTROTHERAPY OF COMMON CERVICODYNIA WITH OR WITHOUT RADICULALGIA. *(Fre.)* Teyssandier, M. J. (Service de Rhumatologie, CHU, Nice, France). *Cinesiol* 18(72): 81-86; 1979 (7 refs).

Electrotherapy of common cervicodynia with or without radiculalgia is discussed. Electrotherapy is

metals, should not be exposed. Low-frequency radiation (no dosage information specified) is indicated for analgesic purposes. Modulated and nonmodulated low-frequency currents are recommended for the treatment of acute cervicodynia. Centimeter and decimeter waves have in-depth analgesic, thermal, and vasodilating effects. Meter waves are contraindicated because of their potent thermal effect. Long-pulse currents are of great value in the treatment of cervicobrachial neuralgia causing paresis.

6699 THERAPEUTIC EFFECT OF CENTIMETER PULSED WAVES IN PATIENTS WITH OSTEOARTHROSIS DEFORMANS. *(Rus.)* Grigor'eva, V. D. (Central Inst. Balneology Physiotherapy, Moscow, USSR). *Vopr Kurortol Fizioter Lech Fiz Kul't* (2): 36-40; 1979 (8 refs).

The therapeutic effect of pulsed wave irradiation in the centimeter range (PWI) was studied in 90 patients (59 women and 31 men, aged <40 to >60 yr) with osteoarthrosis deformans. Stage I was diagnosed in 19 patients, stage II in 58, and stage III in 13. The length of the disease was 1-25 yr. The pulse frequency was 70 or 700 Hz, the power output was 0.8 W, and the duration of the treatment was 5-7 min/day or every other day for 12-18 sessions. A favorable effect of the treatment (alleviation of arthralgia, disappearance of exudation in secondary synovitis, and improvement of the function of the joints) was observed after the first 4-6 sessions. Improvement continued until the end of treatment. Alleviation of leukocytosis, reduction of blood hexose level in the patients with secondary synovitis, and normalization of the glycoprotein and lipid levels were also observed. Blood pressure, which had been increased, normalized during treatment. There was no epicardial pain, nor were there any significant electrocardiogram changes. The results demonstrated that the treatment had a general analgesic and antiinflammatory effect. The therapeutic effect was greatest at 70 Hz and it was comparable to that observed in control patients treated with a permanent magnetic field (20-40 W).

6700 LOW-FREQUENCY VARIABLE MAGNETIC FIELD FOR THE TREATMENT OF PATIENTS WITH RHEUMATOID ARTHRITIS OF THE KNEE JOINTS. *(Rus.)* Silin, L. L. (Dept. Traumatology, Orthopedics, and Military Field Surgery, I. M. Sechenov First Moscow Medical Inst., Moscow, USSR); Brovkin, S. V.; Gorfinkel', I. L.; Vinogradov, E. V. *Vopr Kurortol Fizioter Lech Fiz Kul't* (2): 41-43; 1979 (3 refs).

repeated at 5-day intervals for up to 30 sessions). Th duration of the disease was 5-23 yr. Primary ar secondary rheumatoid arthritis were diagnosed in and 35 cases, respectively. Twenty-one patien were in stage II and 43 were in stage III. Thirty-thre patients in stages II and III without pronounce secondary synovitis received magnetotherapy on (group 1); the other 31 patients (group 2) in stages and III with pronounced secondary synovitis receive intra-articular hydrocortisone injections (25 m before sessions 1 and 8; their magnetotherapy co sisted of 15-20 sessions. The control group consiste of 40 patients with pronounced secondary synovit who were treated with hydrocortisone only. Inflan mation and nocturnal pain disappeared during or in mediately after the magnetotherapy in most patien in group 1. The nocturnal pain and inflammatio disappeared in 25 patients in group 2; 4 patient achieved considerable improvement. Th therapeutic effects were similar in the two group but they appeared sooner in group 2 than in group The total necessary hydrocortisone dose wa smaller in group 2 than in the controls. Forty-eigh patients were followed up for 6-24 mo; positiv therapeutic effects continued in 24 cases; 19 patient had periodic exacerbations; and 5 cases showed n improvement.

6701 ELECTROSTIMULATION WITH SIN MODULATED CURRENTS IN THE COM PLEX TREATMENT OF PATIENTS WITH DISEASE OF THE SPINAL CORD ASSOCIATED WITH SPASTI AND MIXED PARESES. *(Rus.)* Bagel', G. E. (Dep Physiotherapy, Belorussian Postgraduate Medica Inst., Minsk, USSR). *Vopr Kurortol Fizioter Lech F Kul't* (2): 32-36; 1979 (9 refs).

Electrostimulation with modulated sine currents wa performed in the complex treatment of 50 patients (3 men and 15 women) with spastic paraplegia (5 cases spastic paraparesis (27), or mixed paraparesis (18 The duration of the disease was up to 3 mo in 1 cases, up to 6 mo in 10, up to 6-12 mo in 10, and >1 mo in 17. Pronounced spasticity was observed in 1 cases, moderate spasticity was observed in 25, an mild spasticity was observed in 11. The antagonist of the spastic muscles were stimulated in the pa tients with spastic paraparesis and the peronea nerves and long peroneal muscles were additionall stimulated in the patients with mixed paresis. Cor tact electrodes were placed in the electromoto points and the muscle-tendon junctions. Th modulating frequency was 150 Hz for cases of pro nounced spasticity and 30-100 Hz for cases of mil and moderate spasticity and mixed paresis. Th modulation factor was 50-75%, the current intensit was 30-40 mA, and the duration of the pulse plus

effect was best when the electrostimulation was administered within 1-12 mo; good results were also obtained, however, when the patients were treated during the later phase of the recovery period (1-3 yr). Early treatment (1-3 mo from the onset of the disease) prevented the aggravation of spasticity.

6702 COMPLEX CONSERVATIVE THERAPY OF ACUTE PANCREATITIS WITH THE USE OF PERMANENT MAGNETIC FIELDS. *(Rus.)* Val'ter, E. O. (Dept. Clinical Surgery, Izhevsk Medical Inst., Izhevsk, USSR). *Sov Med* (2): 34-38; 1980 (13 refs).

Experience with the use of permanent electromagnetic fields for the treatment of acute pancreatitis in 25 dogs and 109 patients (22 men and 87 women) is reported. Pancreatitis was induced in 25 dogs by introducing bile into the pancreatic tissue. Twenty dogs were treated with an electromagnetic field by applying two radiation sources (magnetophores, 360 Oe each) for 10-20 days; 5 untreated dogs served as controls. The mortality was 6/20 in the experimental group and 5/5 in the control group. Compared with the controls, the experimental animals showed a more rapid normalization of the trypsin, trypsin inhibitor, and amylase levels. In the clinical trials, 80 patients with acute pancreatitis and 29 with cholecystopancreatitis received electromagnetic treatment by wearing two magnetophores (360 Oe each, gradient 41 Oe/mm) continuously for a few hours or up to 2-3 wk, depending on the seriousness of the clinical picture and the therapeutic effect in connection with the standard conservative treatment. The magnetophores were placed on the anatomic projections of the pancreas on the abdomen and back. The urine diastase level returned to normal in 4-5 days and the blood amylase and trypsin levels normalized in 6-10 days, but the trypsin inhibitor level remained elevated for 20 days. Improvement was seen in 14 patients within the first 5 days of complex treatment, on day 10 in 17, on days 14-15 in 17, on days 15-20 in 35, and after 20 days in 2. The therapeutic results were more favorable than those reported for an untreated control group (results not available). These findings suggest that the magnetic field acts not only on the trophic connections between the active sites of the skin and the internal organs, but also directly on the pancreas, thus potentiating the effects of drugs.

6703 VERY LOW FREQUENCY AND SMALL INTENSITY ELECTROMAGNETIC AND MAGNETIC FIELDS AS AN OECOLOGICAL FACTOR. *(Eng.)* Achkasova, Iu. N. (Crimean Medical Inst., bul. Lenina 5/7, Simferopol, USSR); Pyatkin, K. D.;

tromagnetic fields (EMF) and magnetic fields (MF) on the biologic properties of several strains of bacteria (*Staphylococcus aureus, Bacillus anthracoides, Klebsiella pneumoniae, Escherchia coli, Salmonella typhimurium*, and *Shigella sonnei*) were examined. The bacteria were exposed to EMF and MF either for 4 hr/day or repeatedly for 8 hr/day (20-30 passages). EMFs of 0.1 Hz and 0.4 V/m, 0.5 Hz and 0.4 V/m, 1.0 Hz and 0.4 V/m, and 1-20 kHz and 4 mV/m stimulated the rate of cellular proliferation, increased bacterial enzyme activity, produced no change in the type of nutrition, and increased resistance to antibiotics. An EMF of 0.5 Hz and 100 V/m inhibited the rate of proliferation and enzyme activity, produced unstable auxotrophs, and increased resistance to antibiotics. An MF of 0.1 Hz and 0.5 gamma inhibited the rate of proliferation, resulted in maltose-negative enzyme activity, produced auxotrophs, and increased resistance to antibiotics. MFs of 0.6 Hz and 1 gamma, 0.5 Hz and 16 gamma, 0.5 Hz and 30 gamma, 0.5 Hz and 46 gamma, and 0.5 Hz and 92 gamma inhibited the rate of proliferation and enzyme activity and produced auxotrophs. MFs of 0.6 Hz and 1 gamma, 0.5 Hz and 46 gamma, and 0.5 Hz and 92 gamma increased resistance to antibiotics, while MFs of 0.5 Hz and 16 gamma and 0.5 Hz and 30 gamma decreased resistance to antibiotics. A single exposure to both EMF and MF changed the rate of bacterial proliferation; however, the rate returned to normal when the exposure was discontinued. Resistance to antibiotics and the development of auxotrophs were observed after long-term exposure. Considerable scatter of results was observed in all experiments. A study of the fluctuations of natural MFs during the experimental period revealed that the growth of bacteria in a control group was greatly influenced by magnetic storms. Thus, it is necessary to take into consideration perturbations of the geomagnetic field when studying the effects of very low frequency and intensity MFs and EMFs on bacteria.

6704 EXPERIMENTAL EFFECTS OF COMBINED EXPOSURE TO INFRASOUND AND ULTRA-HIGH FREQUENCY ELECTROMAGNETIC FIELDS. *(Rus.)* Gabovich, R. D. (Kiev Medical Inst., Kiev, USSR); Shutenko, O. I.; Koziarin, I. P.; Shvaiko, I. I. *Gig Sanit* (10): 12-14; 1979 (6 refs).

The physiologic effects of exposure to infrasonic waves (8 Hz, 110 dB, 2 hr/day for 10 consecutive wk), an ultra-high frequency electromagnetic field (100 $\mu W/cm^2$, 2.375 ± MHz, 2 hr/day for 10 consecutive wk), and their simultaneous application were studied in 160 male albino rats (initial body wt, 130 ± 5 g). The animals were divided into four equal groups: group 1 received no treatment, group 2 received elec-

observed in all groups 2 wk after exposure, but it was significant in group 4 only ($p<0.05$). Performance capacity (as measured by a swimming test) was significantly reduced ($p<0.05$) only in group 4 by the end of the experiment. The summation threshold index, reduced in group after 2 wk, was significantly increased after 6 wk in groups 3 (16.9 ± 0.69) and 4 (18.1 ± 0.65) compared to the controls (14.5 ± 0.36). The latent period for unconditioned reflexes was reduced in group 4 compared with controls after the first 2 wk; it was significantly increased in all three exposed groups at 6 wk, but it remained significantly increased until the end of the experiment in group 4 only (60.2 ± 2.5 msec). The duration of hexobarbitol-induced sleep was significantly prolonged in all three exposed groups after the second experimental week, but it remained increased until the end of the experiment in group 4 only. Blood cholinesterase activity was significantly reduced in the three exposed groups at 2 wk, but no difference was observed at the end of the experiment. Oxygen consumption was reduced in group 2 only (by 7.7%) at the end of the experiment. After an initial stimulation, the thyroid function was depressed in the exposed groups at the termination of the experiment; radioiodine uptake was 33% in group 2, 28.7% in group 3, and 25.4% in group 4 versus 36.9% in the controls. These findings demonstrate a synergistic effect for the combined exposure to infrasonic waves and ultra-high frequency electromagnetic waves.

6705 NEW STEP IN THE HYGIENIC SUPERVISION OF THE USE OF ELECTROMAGNETIC RADIATION SOURCES IN MOSCOW. *(Rus.)* Appenianskiii, A. I. (Public Health Epidemiology Station, Moscow, USSR); Gordon, Z. V.; Tsessarskii, A. V. *Gig Tr Prof Zabol* (10): 49-51; 1979 (7 refs).

Reports describing the hygienic inspection of work places and workers exposed to electromagnetic radiation in Moscow are reviewed. Three hundred thousand measurements of radiation levels were performed during the period 1968-1978. The maximum allowable radiation levels (not specified) were exceeded in 29-37% of all cases. Exposure to electromagnetic fields was reported to impair the resistance of exposed workers to other harmful environmental factors (e.g., infections) and to increase the incidence of some diseases, such as ischemic heart disease. The hygienic inspection will be extended to all frequencies of nonionizing radiation and radiation levels will also be measured in the general hygienic evaluation at the design stage and du testing.

6706 NEW VDE REGULATIONS F MICROWAVE OVENS. *(Ger.)* Schroth (No affiliation given). *Electrotech Z* 100(20): 1 1102; 1979 (4 refs).

New Association of German Electrical Engine (VDE) regulations for microwave ovens presented. Warning labels are required on microwave ovens only if the radiation intensity ceeds 5 mW/cm² when one of the covers is remo (e.g., for repair). The leakage radiation intensity m not exceed 5 mW/cm² during attempts to open *door with all but the principal safety interlocks ou* order. The maximum permissible leakage for both tact and repaired microwave ovens is 5 mW/cm².

6707 A REVIEW OF SELECTED BIOLOGIC EFFECTS AND DOSIMETRIC DA USEFUL FOR DEVELOPMENT OF RADIOFREQUI CY SAFETY STANDARDS FOR HUMAN EXPOSUI *(Eng.)* Tell, R. A. (Office Radiation Programs, El P.O. Box 18416, Las Vegas, NV 89114); Harlen, F *Microwave Power* 14(4): 405-424; 1979 (88 refs).

Bases for developing radio frequency (RF) exposi standards, which can be related to the thermoge properties of electromagnetic fields, are present In addition, selected biologic effects, includ dosimetric data, that are pertinent to the devel ment of the standards are reviewed. On the basis available bioeffects data, the following conclusic seem reasonably supportable. When an animal thermally loaded to approximately its basal metabc rate (BMR) value, noticeable signs of heat stre become evident. Clearly discernible elevations rectal temperature in laboratory animals can occu thermal loads as low as 20-30% of the BMR. Althou numerous behavioral and endocrine effects as w as heart and respiration rate changes are observec specific absorption rates below the equivalent of animal's BMR, there is little evidence that the observed effects are anything but manifestations normal physiologic responses to mild thermal stre When RF induced thermal loads exceed about tw the BMR in small laboratory animals, the therm

pulsed electromagnetic fields are any more hazardous than an equivalent average power continuous wave field. Based on the analogy of thermal-stress standards that have been developed for hot industrial environments, limits on increases of body temperature are proposed as criteria for limiting exposure to RF fields, i.e., occupational exposures involving deep heating of the whole body should not increase core temperature in excess of 1 C. However, since energy deposition from exposure to some RF fields is likely to be nonuniform and may be high in tissues that are not adapted to high rates of absorption or dissipation of thermalizing energy, means are needed to adjust focal thermal loading against the whole-body averages. A limit on core temperature is inadequate when focal elevations of temperature are close to the limits for protein denaturation; this may occur even though the core temperature may rise less than 1 C. On the basis of available data, it is concluded that the safe value for continuous exposure to 10 mW/cm² appears to provide an adequate margin of safety for both occupational and environmental exposure for frequencies above about 1 GHz. This limit may be too high (perhaps by an order of magnitude) for some frequencies below 1 GHz where body resonances cause a significant increase in energy deposition and where local temperature rises occur. It is also concluded that tbe present averaging period of 0.1 hr seems unjustifiably short.

6708 RISKS OF MICROWAVES AND RADIO WAVES FOR HUMANS. *(Ger.)* Bernhardt, J. (Institut fur Radiologie, Universitat Erlangen, Krankenhausstrasse 12, 8520 Erlangen, W. Germany). *Dtsch Med Wochenschr* 104(50): 1757-1761; 1979 (32 refs).

Studies of the effects of microwaves and radio waves on the human body are reviewed. On a molecular level, the electromagnetic field causes the motion and partial rotation of polar molecules, which leads to the development of heat due to frictional losses. Thermal denaturation of macromolecules occurs only in fields of extremely high intensity. Nonthermal effect (excitation of nerve and muscle cells) may occur at frequencies below 30 kHz and at sufficiently high field intensity. Microwaves and radio waves with frequencies above 30 MHz generate heat in exposed tissues. The penetration of such waves is 0.1-100 mm. At power densities >100 mW/cm², the eye is the critical organ, and irradiation may cause cataracts. The recommended maximum permissible power density for exposure exceeding 0.1 hr is 10 mW/cm² or 200 V/m and 0.5 A/m. Whole-body effects may be manifested above 30-100 mW/cm². The recommend-

Their penetration depth may exceed 100 mm. In the frequency range of 3-30 MHz, the recommended maximum permissible field parameters are 1.5 kV/m and 4 A/m for long-term exposure exceeding 0.1 hr. In the range of 10 kHz-3 MHz, the recommended maximum permissible field parameters are 3 kV/m and 8 A/m for long-term exposure (>0.1 hr).

6709 ACUTE MICROWAVE IRRADIATION: REPORT OF A CASE TREATED RECENTLY AT BEGIN HOSPITAL. *(Fre.)* Delahaye, R. P. (Clinique de Rheumatologie, Hopital Begin, Saint Mande, France); Doury, P.; Conrad, J.; Metges, P. J.; Pattin, S. *Med Aeronaut Spat* 18(72): 293-296; 1979 (4 refs).

A 36-yr-old technician was exposed to whole-body microwaves for about 20 min while repairing radar equipment. The power density was estimated to be 10 mW/cm²; the wavelength was 1.3 cm; the pulse length was 0.5 μsec; and the pulse frequency was 4,000 Hz. The exposure produced a sensation of heat, especially in the hands, and dorsolumbar pains, which prompted the technician to leave the exposed area. The patient was unable to move for several hours. Primary treatment consisted of bed rest and treatment with analgesics. The patient was in good condition 3 days after the exposure, but nausea without emesis persisted for a few weeks. Thorough, comprehensive clinical examinations, performed a few weeks after exposure, failed to reveal any abnormal changes. The ophthalmologic and neurologic findings were normal.

6710 TIME PARAMETERS IN MICROWAVE IRRADIATION (ABSTRACT). *(Eng.)* Davydov, B. I. (No affiliation given); Antipov, V. V.; Tikhonchuk, V. S. *Eng Mon Index* 18(1): 418, 1980 (19 refs).

The time characteristics of injury and recovery after microwave irradiation were anlyzed from experiments on 3,080 mice and 604 rats. The processes resulting from exposure to microwave and ionizing radiation were subjected to a formal comparative analysis. The analysis indicated a similarity between the effects of exposure to microwave and ionizing radiation.

THE ADRENAL CORTEX FUNCTION IN CHILDREN WITH BRONCHIAL ASTHMA. *(Rus.)* Stepanova, L. T. (Moscow Inst. Pediatrics and Pediatric Surgery, Russian SFSR Ministry Public Health, Moscow, USSR); Gromova, V. N.; Titov, G. N.; Terfilova, E. V.; Iudaeva, N. I.; Strekalovskaia, N. N. *Vopr Kurortol Fizioter Lech Fiz Kul't* (2): 26-31; 1979 (10 refs).

The effects of centimeter waves and of inductothermy on the function of the adrenal cortex was studied in 150 children aged 5-15 yr with bronchial asthma of allergic-infectious etiology (70% of the children) or of allergic etiology only (30%). Severe asthma was diagnosed in 20 patients and moderate asthma was diagnosed in 130. Group 1 consisted of 79 children subjected to centimeter wave irradiation (frequency not given; 2 W for those in the 5-7 yr bracket, 4 W for those in the 7-10 yr bracket, and 6-8 W for those in the 11-15 yr bracket) for 10 min every day or every other day, totaling 8-10 courses. Group 2 included 36 children aged 5-8 yr who received contact inductothermy (UHF, output 30 W) for 10 min every day or every other day, totaling 10-12 courses. Thirty-five children served as controls. In addition, the children also received a regulated diet, vitamins, hormones (13 cases), and specific desensitization (19 cases). In children with moderate asthma in group 1, the serum cortisol and corticosterone levels were 10.1 μg% and 9.8 μg%, respectively, before treatment and 12.9 μg% ($p<0.002$) and 6.9 μg% ($p<0.001$), respectively, after treatment. In group 2, the levels were 8.8 μg% and 11 μg%, respectively, before treatment and 9.9 μg% and 8.9 μg% ($p<0.05$), respectively, after treatment. The respective serum levels for controls were 9.8 μg% and 8.7 μg% before treatment and 8.7 μg% and 8.2 μg% after treatment. The C21 corticosteroid level and the 17-oxycorticosteroid/17-deoxycorticosteroid ratio increased significantly after treatment in group 1. Along with the activation of corticosteroid biosynthesis, the hepatic metabolism of these hormones was also increased. Similar changes were seen in group 2. In the children with the most severe form of asthma, who had been on long-term hormone treatment, treatment with centimeter waves and inductothermy was ineffective; the treatment caused a further deterioration of the adrenal cortex function. The therapeutic effect was better in children aged 5-8 yr in group 1 than in group 2. The findings indicate that centimeter wave irradiation and inductothermy have a pronounced clinical effect, i.e., normalization of the adrenal cortex function in children with moderate cases of bronchial asthma. This treatment is not indicated for patients with severe bronchial asthma.

affiliation given.); Dyshlovoi, V. D.; Kachura, V. Vybornyi, V. P. *Elektron Obrab Mater* (6): 64-71; 19 (9 refs).

The general principles and the physical aspects the biologic effect of industrial frequency (50 H electromagnetic fields are described. In addition, t results of in vitro experiments of the effects of ele tromagnetic fields (50 and 150 kV/m) on hum peripheral lymphocytes and embryonal fibrobla like cells are presented. Exposure to the ele tromagnetic field caused disturbances in the grow and development of the cultures; ultrastructu changes in the chromatin in the nuclei, nucleoli, a cytoplasmic organelles; and a reduction in mitotic a tivity. The passage of the cells in the phase of deo ribonucleic acid synthesis within the mitotic cy was slowed, the duration of the S phase was prolor ed, and ribonucleic acid and protein syntheses we inhibited. These experimental data give indire evidence of the direct effect of industrial frequen electromagnetic fields on cells.

6713 **CHANGES IN THE BIOLOGIC ACTIVI OF CERTAIN RABBIT BRAIN STRU TURES UNDER THE EFFECT OF MICROWAVE** *(Rus.)* Ershova, L. K. (Inst. General Municip Hygiene, Kiev, USSR); Rudnev, M. I. *Fiziol Zh* 25(132-138; 1979 (18 refs).

The effects of microwave irradiation (2,375 ± 50 H energy flux density of 1, 5, 10, 50, and 500 μW/cr length of exposure, 7 hr/day for 3 mo) on the bioele tric activity of various brain structures (poster hypothalamic nucleus, central median thalar nucleus, and sensory-motor and visual cortice were studied in 36 male chinchilla rabbits (bo wt 2.7-3.5 kg). The animals were irradiated by t distance method in anechoic chambers. Exposure 1 and 5 μW/cm² caused insignificant changes in t biopotentials, while exposure to 10-500 μW/cm² cau ed considerable changes in the bioelectric activity the cortical and subcortical structures. Two weeks exposure to 10 μW/cm² microwaves caused a 19.7 increase in the alpha-rhythm index of the senso motor cortex and a 43.2% increase for the visual c tex. The amplitude also increased--by 53.4% in t sensory-motor cortex and by 75.8% in the visual c tex. These changes appeared slightly later in t subcortical structures. The bioelectric process were inhibited by 500 μW/cm² during the init period. The findings indicate that microwave irrad tion with >10 μW/cm² causes an increased excitab

6714 CALCIUM AND MAGNESIUM LEVELS IN RAT TISSUES UNDER THE EFFECTS OF INDUSTRIAL-FREQUENCY ELECTROMAGNETIC FIELDS. *(Rus.)* Dyshlovoi, V. D. (A. A. Bogomolets Medical Inst., Kiev, USSR); Radlovskaia, Z. T.; Arkhipchuk, V. D.; Kachura, V. S. *Gig Tr Prof Zabol* (2): 46-47; 1980 (no refs).

The effect of exposure to an electromagnetic field (50 kV/m, 50 Hz, for 5 hr) on the calcium and magnesium levels in the liver, thymus, kidneys, brain, hip muscles, tongue, testicles, prostate, heart, lungs, stomach, spleen, large and small intestines, and adrenals was studied in seven male Wistar rats (body wt 180- 220 g). Seven untreated animals served as controls. The animals were decapitated immediately after exposure. The calcium levels were significantly reduced in the liver (1,781 versus a control value of 3,534 μg/g dry tissue wt, $p<0.001$) and thymus (2,863 versus 5,202 μg/g, $p<0.01$), and were significantly increased in the kidneys (3,016 *versus* 1,376 μg/g, $p<0.05$), brain (3,347 versus 1,367 μg/g, $p<0.001$), hip muscles (2,905 *versus* 693 μg/g, $p<0.001$), tongue (2,831 versus 916 μg/g, $p<0.01$), testicles (4,945 versus 1,526 μg/g, $p<0.01$), and prostate (2,157 versus 1,053 μg/g, $p<0.001$). The magnesium levels were significantly reduced in the liver (1,223 versus 1,565 μg/g, $p<0.001$) and thymus (1,484 versus 2,381 μg/g, $p<0.01$), and were significantly increased in the brain (1,362 versus 901 μg/g, $p<0.001$), hip muscles (1,731 versus 1,321 μg/g, $p<0.05$), tongue (1,266 versus 818 μg/g, $p<0.01$), testicles (2,042 versus 1,426 μg/g, $p<0.05$), and prostate (974 versus 721 μg/g, $p<0.01$).

6715 SIGNIFICANCE OF BLOOD LIPID AND ELECTROLYTE DISTURBANCES IN THE DEVELOPMENT OF SOME REACTIONS TO MICROWAVES. *(Rus.)* Sadchikova, M. N. (Inst. Industrial Hygiene Occupational Diseases, USSR Acad. Medical Sciences, Moscow, USSR); Kharlamova, S. F.; Shatskaia, N. N.; Kuznetsova, N. V. *Gig Tr Prof Zabol* (2): 38-39; 1980 (6 refs).

Physiologic and biochemical changes were studied in 50 men (aged 32-50 yr, average age 42 yr) who were occupationally exposed to low-intensity microwave radiation for several years (5-15 yr, average 13 yr). The field intensity reached several hundred μW/cm² and the daily exposure did not exceed 2-3 hr. Seventy-nine men, not exposed to electromagnetic fields, served as controls. Dermatographia, hyperhidrosis, labile pulse and a tendency for hypertension, cardialgia, and changes in conduction were seen in the exposed group (no corresponding the blood chloride level ranged from 274 to 380 mg% in 67.6% of the exposed workers (compared with 393 mg% as the lower limit of the normal range) and the intracellular sodium level was 31.9 mg% (average value). Compared with the controls, the serum triglyceride, β-lipoprotein, cholesterol, and phospholipid levels were increased significantly in the exposed workers. The changes were most marked in the triglyceride and β-lipoprotein levels, the triglyceride level ranged from 157 to 259 mg% in 63.6% of the cases (compared with 151 mg% as the upper limit of the normal range) and the β-lipoprotein level ranged from 783 to 1,659 mg% in 50.2% of the exposed workers. These findings indicate that long-term exposure to low-intensity electromagnetic fields causes changes in the blood electrolytes and serum lipids.

6716 EFFECT OF ELECTROMAGNETIC RADIATION AT 2.45 GHz FREQUENCY ON DBA2 MICE: EFFECT ON SERUM TRIGLYCERIDES AND β-LIPOPROTEINS. *(Fre.)* Laurens, S. (Departement d'Etudes et de Recherches en Microondes, Centre d'Etudes et de Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Roux, G. *Arch Sci* 32(2): 181-187; 1979 (14 refs).

The effect of exposure to electromagnetic fields of different intensities at a fixed frequency (2.45 GHz) for 63 hr on the serum triglycerides and β-lipoproteins was studied in purebred DBA2 mice. The field instensity was 1.2 mW/cm² in group A (72 animals), 3 mW/cm² in group B (36 animals), 5 mW/cm² in group C (72 animals), 8.4 mW/cm² in group D (48 animals), 10.2 mW/cm² in group E (48 animals), 12 mW/cm² in group F (84 animals), and 15 mW/cm² in group G (48 animals). Nonirradiated animals served as the controls. Irradiation caused a nonlinear increase in the serum triglyceride levels. The increase was observed as follows: A, B > C, D, E > G > F; the level was increased by 46% in group F. The β-lipoprotein level showed a nearly linear increase with increasing field intensity, exceeding 40% at 15 mW/cm². There were no significant changes in the cholesterol level. The changes in in the triglyceride and β-lipoprotein levels produced observable results at intensities greater than 3 mW/cm².

6717 DYNAMICS OF THE IMPULSE ACTIVITY OF NEURONS OF THE POSTERIOR LOBE OF THE HYPOTHALAMUS UNDER THE EFFECT OF MICROWAVES. *(Rus.)* Faitel'berg-Blank, V. B. (Dept.

The effect of an electromagnetic field (wavelength 12.6 cm, field intensity 0.5 or 5 mW/cm², length of exposure 10 min) on the impulse activity of 128 nerve cells of the mamillary bodies of the hypothalamus was studied in 18 male chinchilla rabbits (body wt 2-3 kg). The vibrator was oriented parallel to the body axis at a distance corresponding to 4 wavelengths from the head of the animal. Depending on the type of background activity, 68% of the cells generated irregular solitary action potentials (type 1), 11% generated action potentials clustered in discharges (type 2), and 21% generated solitary and clustered action potentials (type 3). An electromagnetic field of 0.5 mW/cm² caused an increase in the discharge frequency of the nerve cells. The highest percent (80%) of excited neurons was recorded during 4 min of exposure. Before exposure, the discharge frequency of the majority of the cells was 1-7 impulses/sec, increasing to 8-14 impulses/sec during irradiation. The highest percent (22%) of inhibited cells occurred during 10 min of exposure. The impulse activity of the cells returned to the background level 4 min after exposure. Under the effect of 5 mW/cm², there was a considerable decrease in the percent of cells responding with increased peak frequency. The percent of excited neurons was highest (62%) during 3 min of exposure, and the percent of inhibited cells was highest (36%) during 5 and 10 min of exposure. The impulse activity returned to normal levels 4-5 min after exposure. Four percent of the cells showed increased frequency of the action potentials, while a decrease was seen in 5% in the nonexposed controls.

6718 EFFECT OF UHF ELECTRICAL FIELDS ON SPERMATOGENESIS. *(Rus.)* Danilova, I. N. (Central Inst. Dermatology Venereal Diseases, Central Inst. Balneology Physiotherapy, Moscow, USSR); Skurikhina, L. A.; Skuratovich' A. A.; Alvazian, A. A. *Vopr Kurortol Fizioter Lech Fiz Kul't* (2): 16-19; 1979 (11 refs).

The effects of therapeutic and experimental ultrahigh frequency (UHF) irradiation on spermatogenesis were studied in men and in rabbits, respectively. The therapeutic experiment involved UHF irradiation (40 W, 8-10 min/day, 3-10 sessions) of the testicles of 38 men (aged 21-50+ yr) with epididymitis (28 cases of acute epididymitis and 10 nonacute; 10/38 cases of gonorrheal etiology). The ejaculate was examined in 19 patients 3-6 mo after treatment and in 11 patients 5 yr after treatment. No pathologic changes were observed and the numbers of motile spermatozoa were normal. Analysis of the catamnestic data showed no children in the families of six patients; no data were available on one patient. The findings indicate of the irradiated organs were examined 1, 5, 10, an 30 days after treatment. Activation of spe matogenesis was observed 1 day after treatment. N histologic changes were observed after 5 days, an spermatogenesis returned to normal within 10 day of treatment.

6719 ELECTROMAGNETIC FIELD AN PSYCHOBIOLOGIC INFORMATIOI *(Cze.)* Grunner, O. (Rehabilitacni oddeleni, Nemoc nice s poliklinikou OUNZ, Havlickova 294, 790 0 Jesenik, Czechoslovakia). *Cas Lek Cesk* 118(40/41 1221-1226; 1979 (34 refs).

Clinical and experimental studies on th psychobiologic effects of electromagnetic fields ar reviewed. The human body is able to receive elec tromagnetic signs in the range of several tens to hur dreds gamma (1 gamma=10⁻⁵ G). The organism is als able to emit information-carrying electromagneti signals. The application of a homogeneous elec tromagnetic field (0.72 or 96 G, pulse length 66 msec frequency 12 Hz) to the head for 1 hr was observed t alleviate migraine headaches. The response to th electromagnetic treatment was manifested in a no malization of the electrogram of the fingertips.

6720 EFFECT OF A CONSTANT MAGNETI FIELD ON ELABORATION OF COND TIONED REFLEXES OF MICE IN LOWLANDS AN HIGHLANDS. *(Rus.)* Ryskanov, T. (Kirghiz Medical In st., Frunze, USSR); Abdullina, Z. M. *Zh Vyssh Ner Deiat* 29(2): 410-412; 1979 (9 refs).

The effect of a constant magnetic field of varyin strengths (2,000 Oe, gradient 20 Oe/cm; 200 Oe, gra dient 25 Oe/cm; and 20 Oe, gradient 1 Oe/cm, 2 hr day for 10 consecutive days) on the elaboration of th conditioned escape reflex was studied in albin mice. The animals were placed in a T-shape labyrinth and the effects of previous exposure to th magnetic field were investigated under flatland an highland conditions (3,200 m above sea level). Th development of the conditioned reflex was inhibite at all intensities under flatland conditions; the inhib tion was most pronounced at 2,000 Oe. In the grou exposed to 20 Oe, inhibition of the conditione escape reflex was not observed until the 6th day, in dicating a summation effect. Under highland cond tions at 20 Oe, inhibition of the escape reaction wa observed only after the first 5 days. Under highlan

have similar effects on the elaboration of conditioned reflexes, their effects are antagonistic when occurring simultaneously.

6721 PHYSIOLOGICAL AND BEHAVIORAL EFFECTS OF CHRONIC EXPOSURE TO 2450-MHz MICROWAVES. *(Eng.)* D'Andrea, J. A. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Gandhi, O. P.; Lords, J. L.; Durney, C. H.; Johnson, C. C.; Astle, L. *J Microwave Power* 14(4): 351-362; 1979 (25 refs).

Long-Evans male adult rats (350-375 g) were exposed for 16 wk to 2,450-MHz continuous wave microwaves at an average power density of 5 mW/cm² (dose rate, 1.23 ± 0.25 mW/g) to assess the physiologic and behavioral effects of chronic microwave exposure. The electric field was parallel to the long axis of the holding cage and to that of the rat, resulting in maximal absorption of radiant microwave energy. The animals were exposed for 8 hr/day, 5 days/wk, for a total of 640 hr in a monopole-above-ground radiation chamber while housed in Plexiglas holding cages. Daily measures of body mass and of food and water intake indicated no statistically significant effects of microwave irradiation. Biweekly stabilimetric tests immediately after exposure revealed a significant depression of behavioral activity in 15 microwave-exposed rats as compared with 15 sham-exposed animals. Measures of locomotor activity based on revolutions of a running wheel, which were obtained during 12-hr periods between each 8-hr exposure, showed no significant effect of microwave irradiation. However, the overall mean number of wheel revolutions for microwave-exposed rats was approximately 30% greater than that for sham-exposed rats during the study. This may reflect attempts by the microwave-exposed animal to recover the loss of the increased metabolic load while not under exposure. Blood samples taken after 2, 6, 10, and 14 wk of microwave exposure indicated slight alterations of sulfhydryl groups and of red and white blood cell counts. Measurement of the mass of the adrenals, heart, and liver at the end of the 16-wk exposure period as well as measurement of 17-ketosteroids in the urine at 1, 5, 9, and 12 wk of exposure revealed no indications of stress.

6722 MICROWAVE IRRADIATION AND AMBIENT TEMPERATURE INTERACT TO ALTER RAT BEHAVIOR FOLLOWING OVERNIGHT EXPOSURE. *(Eng.)* Gage, M. I. (Neurotoxicology Div., MD-74, Health Effects Res. Lab., EPA, Research Triangle Park, NC 27711). *J Microwave Power* 14(4): hooded rats (235 days old, 315-365 g) by measuring operant behavior after termination of overnight exposures. Each of 12 naive rats was trained to insert its head into a food cup for food pellets on a random-interval schedule of reinforcement. After performance stabilized, the rats were assorted into three groups of four animals each. Groups were matched for response rates. The rats were exposed in an electrically anechoic chamber under far-field conditions in groups of four animals each for 15.5 hr to continuous wave 2,450-MHz microwaves once every 6 nights. Each group was exposed to a given power density of 5, 10, or 15 mW/cm² for three times at an ambient temperature of 22 C, then three times at 28 C, and then once more at 22 C. The relative humidity was 50% during all exposures. Rats were sham irradiated the night before each microwave exposure. Behavior was tested daily after termination of microwave irradiation or after sham exposure. Exposure to microwaves at 22 C did not alter the rate or duration of responding behavior. However, behavior following 10- or 15-mW/cm² exposure at 28 C showed a marked decrement in overall performance, increased occurrence of long pauses between bursts of responding, and decreased numbers of reinforcers received by the animals. The results are interpreted as a transient debilitation of behavior that is produced by the interaction of a mild elevation of ambient temperature and microwave irradiation.

6723 PSYCHOSES IN RADIO WAVE DISEASE. *(Rus.)* Chudnovskii, V. S. (Dept. Psychiatry, Kazan' Medical Inst, Kazan', USSR). *Sov Med* (8): 111-115; 1979 (8 refs).

The case reports of three men with psychoses that developed during stages II and III of radio wave disease are presented. The three men were exposed occupationally to high-energy super-high frequency radio waves in the centimeter and 10-cm range for 10-19 yr. One patient was also exposed to ultrasound for the last 4 yr. Exposure was especially intense (10-12 hr/day) immediately before the onset of the radio wave disease. Weakness, fatigability, epicardia pain, palpitation, headache, sleeplessness, and irritability were the first symptoms. Neurosis, autonomic vascular dystonia, and thoracic radiculitis were diagnosed. Moderate disorders of the oculomotor innervation, nystagmus, tendon hyper-reflexia, reduced cerebral circulation or venous stasis, and retinal angiopathy were also found. The psychoses developed on a background of severe asthenia and were characterized by delirious disorders. The first psychotic attack developed abruptly in one patient in stage II radio wave disease. Emotional stability, hyperesthesia, asthenic syndrome, and hallucinations were diagnosed. The psychotic episode lasted

explosiveness, slight impairment of memory, and self-criticism. One patient suddenly developed a paranoid syndrome. The follow-up of the patients (2-7 yr) disclosed no signs characteristic of schizophrenia. The treatment of psychoses in radio wave disease is unspecific and is determined by the cardinal psychopathologic syndrome and by the somatic disorders.

6724 MICROWAVE PHOTOCONDUCTIVITY IN PLANT LEAVES. *(Rus.)* Deriabkin, V. N. (Moscow Physical Technical Inst., Moscow, USSR); Kireev, V. B.; Spachkov, M. P.; Trukhan, E. M. *Biofizika* 24(16): 1026-1029; 1979 (10 refs).

The superhigh frequency (SHF) photoconductivity of pea and *Tradescantia* leaves illuminated at 0.5-100 MW/cm^2 was studied at 10 and 1 GHz by measuring microwave photo-induced dielectric loss signals. All signals at both frequencies were linearly dependent on the white light intensity. The signal obtained for the fresh leaves at 10 GHz had a biphasic course with the major portion being negative at 20 C. Negative photoconductivity was found after heating above 50 C. A positive signal component appeared when the leaves were stored in darkness for approximately 30 min before illumination, and the entire signal was positive when the leaves were dried before the measurement. At 1 GHz, both the fresh and dried leaves gave similar positive signals, and moderate heating had no effect on the shape of the signal. Heating the leaves at 100 C for 10 min reduced the signal amplitude. It is suggested that the positive segment of the biphasic signal obtained for fresh leaves may be associated with conformational and charge changes of the photosynthesizing apparatus and with the photoconductivity. Heating of the leaf causes changes in the tissue electrolyte composition; as the contribution of the heating of the water diminishes, the positive signal appears more clearly.

6725 MICROWAVE TECHNIQUES IN FOOD PROCESSING. *(Ger.)* Reuter, H. (Institut fur Verfahrenstechnik, Bundesanstalt fur Milchforschung, Kiel, W. Germany). *Gordian* 80(1757): 44-50; 1980 (10 refs).

The general physical and biologic effects of microwaves and the use of microwave techniques for food processing are reviewed. The thermal effect of microwave radiation on the human body causes an increase in the body temperature only beyond a certain limit, depending on the environmental temperature, heat dissipation, and the surface irradiated. Exposed organs with high water content

6726 EFFECT OF SOME FACTORS OF PRE EMERGENCE ELECTRICAL TREATMEN OF SPRING WHEAT SEEDS ON CROP YIELD AND O THE NUTRIENT UPTAKE DURING DIFFEREN PHASES OF ONTOGENESIS. *(Rus.)* Izakov, F. Ia. (N affiliation given); Blonskaia, A. P.; Okulova, V. A *Elektron Obrab Mater* (6): 59-64; 1979 (6 refs).

The effect of electrical treatment of spring whea seeds under varying conditions on the crop yield an nutrient uptake of wheat plants seeds was studied The seeds were treated in a constant coron discharge field (5 kV/cm, voltage 50 kV, distance bet ween electrodes 10 cm, duration of treatment 5 sec and plants grown from untreated seeds served a controls. The electrical treatment was carried ou either in a vacuum or in open air, in which cas ionization was possible. The crop yield was 2.41 kg/hectare for the controls, 2.940 kg/hectare for th group treated in air, and 2.840 kg/hectare for th group treated in a vacuum. Both electrical treatment increased the nitrogen, phosphorus, and potassiu levels in the plants at different stages of on togenesis, but seed treatment in air had a more pro nounced effect than did treatment in a vacuum. A the stage of milky ripeness, the nitrogen level wa 126.2% of the control after treatment in air and 118.7% after treatment in a vacuum. The phosphorus level were 105.1% and 115.5%, and the potassium level were 103.5% and 103.5%, respectively. When th electrical treatment was carried out in a nitrogen o an oxygen atmosphere, crop yield was 3.210 kg/hec tare and 2.780 kg/hectare, respectively, versus 2.41 kg/hectare for the controls. At the stage of milk ripeness, nitrogen, phosphorus, and potassiu levels were 152.5%, 173.5%, and 109.5% of the contro values, respectively, for a nitrogen atmosphere an 118.7%, 89%, and 100%, respectively, for an oxyge atmosphere. When the grounded electrode was in sulated with a coveyer belt, polyethylene, fiberglass or polyvinyl chloride during the electrical treatment the crop yields were 3.120, 2.950, 3.140, and 3.33 kg/hectare, respectively, versus 3.160 kg/hectare without insulation and 2.760 kg/hectare in the ab solute control. For the insulated electrode ex periments, the nitrogen levels in plants at the stage of milky ripeness were 118.7%, 118.7%, 100%, an 170%, respectively, while the phosphorus level were 108%, 89%, 94.8%, and 105.1% and the potassium levels were 109.5%, 109.5%, 100%, an 109.5%, respectively.

6727 USES OF ELECTROMAGNETIC WAVES IN FOOD TECHNOLOGY AND AGRICULTURE. *(Fre.)* Thourel, M. (Departemen d'Etudes et de Recherches en Microondes, Centre d'Etudes et de Recherches de Toulouse (ONERA)

microwaves can be used to dry, dehydrate, cook, bake, bleach, pasteurize and sterilize food products; to kill soil weed seeds; and to kill parasites in soil and food products. Results of one experiment demonstrate that microwave treatment at 2,450 MHz (to produce temperatures of 52 C) was effective for killing fungi and retarding the fermentation of must. Treatment at 27.12 MHz was effective in the destruction of insects in cereals and flour. The advantages of microwaves for the above uses, e.g., savings in energy, space, time, and manpower, are equalized by the relatively high cost of microwaves. The author predicts, however, that a reduction in cost will evolve over the next several years.

6728 CHANGES IN THE ELECTRICAL CONDUCTIVITY OF THE WHITE AND YOLK OF HENS' EGGS DURING THE EARLY STAGE OF INCUBATION UNDER THE EFFECT OF MAGNETIC FIELDS. *(Rus.)* Borodaikevich, D. T. (No affiliation given); Khananaev, L. I. *Biol Nauki* (4): 34-38; 1979 (10 refs).

The effect of a 60-min preincubation exposure to magnetic fields of various strengths on the electrical conductivity of the albumen and yolk of 534 eggs from White Leghorn hens was studied. The conductivity was measured from 12 to 96 hr of incubation at 500, 2,000, and 5,000 Hz. The eggs were transferred into the incubator 1-2 min after treatment. The field intensity was 50, 100, and 200 Oe in all experiments. Some eggs were exposed to a constant magnetic field (CMF, parameters not given), others to an alternating magnetic field (AMF, 50 Hz), and others to a pulsed magnetic field (PMF, pulse length, 220 msec, interval between pulses 20 sec). PMF and AMF increased the electrical conductivity of the albumen and yolk, while CMF decreased the conductivity compared with the untreated controls. PMF and AMF may accelerate the ion exchange, thereby increasing the electrical conductivity. The reduction of the conductivity due to CMF exposure may result from an inhibition of the ion exchange.

6729 THE EFFECTS OF LOW INTENSITY, EXTRA-LOW FREQUENCY ELECTROMAGNETIC FIELDS ON TIME PERCEPTION AND THE ELECTROENCEPHALOGRAM (ABSTRACT). *(Eng.)* Kercher, M. M. (Baylor Univ., Houston, TX 77025). *Diss Abstr Int B* 40(8): 3997-B; 1980 (no refs).

The effects of imposed electromagnetic fields on human behavior was investigated, with emphasis on the difference between field effects of various frequencies. Sixty male college students (aged 18-26 yr) were exposed to electric fields of four different frequencies in a time production method, and an electroencephalogram (EEG) served as dependent measures. Subjects made 15 estimates of intervals of 5 and 9 sec in each field condition. Statistically significant differences were demonstrated between the field and no-field condition at 7 Hz; field estimates were shorter than no-field estimates. The differences were in the same direction at 14 Hz, but were not statistically reliable. There were no differences between field and no-field estimates at 10 Hz or 20 Hz. These results were explained in terms of the relationship of the experimental frequencies to the basic alpha frequency of 10 Hz. The frequencies that were not coincident with the alpha frequency, 7 Hz and 14 Hz, tended to have the predicted effect of shortening time estimates, though this effect was only significant for the 7-Hz field. The smaller effect at 14 Hz may have been due to a higher threshold for the higher frequency. The EEG was monitored constantly during the time estimations, but only that portion of the record that coincided with the actual time estimates was utilized to compute the percent of time alpha was present. For a given interval the alpha over 30 μV was underlined and divided by the total length of the interval, yielding a percent of alpha for that interval. Analysis revealed no differences in the percent of alpha present in field versus no-field conditions for any of the experimental frequencies. It was felt that the lack of difference in the EEG between field and no-field conditions might reflect the inability of the particular method of EEG analysis utilized to tap any subtle field effects rather than a true state of no difference.

6730 AVIAN ORIENTATION AND NAVIGATION. *(Eng.)* Schmidt-Koenig, K. (Duke Univ., Durham, NC). (New York: Academic Press) pp. 29-152; 1979 (399 refs).

Laboratory and field experiments on avian orientation and navigation are reviewed, including the use of the earth's magnetic field as a compass. It appears that birds do not use the polarity of the magnetic field, but rather seem to evaluate the inclination of the field lines to the vertical. Avian magnetoreception also appears to be adaptable to different intensity ranges. As birds react to magnetic storms, which are small variations of the geomagnetic field, e.g., from 0.460 Oe to 0.465 Oe, the avian magnetic compass appears to be sensitive to changes of at least 0.005 Oe. Young pigeons seem to calibrate their sun compass by a learning process on the basis of their magnetic compass. Pigeons possibly also use the geomagnetic field for navigational information. Theoretical models of the physiologic mechanism of magnetoreception, such as utilizing the Hall effect in several different ways, have been suggested but never documented.

TO MICROWAVE IRRADIATION DURING METAMORPHOSIS. *(Eng.)* Green, D. R. (M.Sc. Dissertation, Washington Univ., MO 63130). A thesis presented to the Sever Institute of Technology of Washington University: 156 pp.; 1978 (34 refs).

The effect of microwave irradiation during metamorphosis of 2,214 pupae of the darkling beetle (*Tenebrio moliton* on teratogenesis and survival was studied. A 2-hr irradiation of 1-day-old *Tenebrio molitor* pupae at a frequency of 9.00 GHz in an X-band waveguide increased the incidence of developmental abnormalities in resulting adults without correspondingly increasing pupal mortality at incident power levels below 160 mW. This was not observed when pupae were conventionally heated to the same temperatures experienced during irradiation. Pupae showing evidence of disease or trauma prior to irradiation ("nonideal pupae") exhibited the microwave effects to a greater extent than normal pupae ("ideal pupae"). The incidence of microwave related abnormalities and deaths did not appear to increase monotonically in the 40- to 160-mW incident power range, as it did outside this range. Microwave effects decreased in the vicinity of 80 mW, corresponding to a maximum temperature during irradiation of about 28 C for ideal pupae and 32 C for nonideal pupae. Significant evidence of microwave effects was not observed at ambient relative humidities above 35%, suggesting that pupal dessication is involved in the increased incidence of abnormalities for specimens irradiated as pupae. Although pupal mass following 2 hr of irradiation at 80 mW was within ±1% of the original mass, such a small change in water content may be responsible for the above observations. It is also possible that incompletely reversible changes in the permeability of the pupal cuticle may promote water loss at low ambient humidities following irradiation.

6732 THE BIOLOGICAL EFFECTS OF RADIO-FREQUENCY AND MICROWAVE RADIATION. *(Eng.)* Assenheim, H. M. (Associate Committee on Scientific Criteria for Environmental Quality, Environmental Secretariat, Natl. Res. Council Canada, Ottawa, Canada K1A OR6); Hill, D. A.; Preston, E.; Cairnie, A. B. [available through National Research Council Canada (NRCC/CNRC), Ottawa, K1A OR6, Canada, NRCC No. 16448]: 245 pp.; 1979 (299 refs).

Studies on the physical and biologic effects of radio frequency and microwave radiation are reviewed, as well as the applications of radio frequency and microwave radiation, dosimetry, and criteria for personnel exposure standards. Many of the low-level effects thermal effects may occur. East European and So scientists claim that an asthenovegetative syndrc (e.g., nausea, headache, fatigue) occurs in power density range because of effects on the r vous system; at this level, the changes are gener reversible. At power densities greater than mW/cm², distinct thermal effects occur with dis bances of the circulatory system and the tl moregulatory mechanism. In the 15-20 mW/ range, the onset of various syndromes occ depending on which organs are chronically expos Hypotension, fatigue, and changes in el troencephalograms and electrocardiograms h been noted. At power densities of greater thar mW/cm², the onset of a hypothalamic syndrome even radiation shock occurs according to East scientists. The following effects are generally cepted by Western scientists: an increase in b temperature with the possibility of heat damage the testis and some internal organs at power d sities of 20-100 mW/cm² (corneal damage occur frequencies above 35 GHz); induced fever at po densities >100 mW/cm²; and cataracts at power d sities >150 mW/cm² if the eyes are irradiated at quencies between about 2 GHz to over 10 GHz longer than 1 hr. With regard to sources of radio quency and microwave radiation, nondirectio broadcast stations, although considerably lo powered than many other sources, may prove to the greatest potential hazard to man.

6733 PHYSICAL PLASMA IN BIOLOGIC SOLIDS: A POSSIBLE MECHANISM F RESONANT INTERACTIONS BETWEEN LOW INT SITY MICROWAVES AND BIOLOGICAL SYSTE *(Eng.)* Zon, J. R. (Dept. Theoretical Biology, Cath Univ. Lublin, Lublin 20-950, Poland). *Physiol Ch Phys* 11(6): 501-506; 1979 (38 refs).

Resonant effects of microwaves in biologic syste are discussed in relation to the hypothesis that so state plasma occurs in organic semiconducto Observed semiconductor properties of biolo material in vitro indicate possible involvement semiconduction in biologic processes. Also, sir solid-state plasma occurs in inorganic semic ductors, it is hypothesized that solid-state plas similarly occurs in organic semiconductors. If c tinual plasma excitation does characterize biolo materials, then it is suggested that the resonant sorption and the positive biologic effects microwaves (e.g., reduction of radiation damage a increase in survival ability) could be explained as t ing due to the supply of quanta of energy capable sustaining the integrating plasma oscillations in t biologic system. On the other hand, the harmful

6734 RECOMMENDED PERMISSIBLE LEVELS FOR EXPOSURE TO MICROWAVE AND RADIOFREQUENCY RADIATION (10 MHz TO 300 GHz)--A PROPOSAL. *(Eng.)* Cornelius, W. A. (Australian Radiation Lab., Melbourne, Australia); Viglione, G. [Report No. ARL/TR009]: 25 pp.; 1979 (23 refs).

Maximum permissible levels for exposure to radio frequency and microwave radiation (10 MHz to 300 GHz) are proposed. The proposed levels are calculated from a "worst case" analysis of electromagnetic energy absorption based on thermal hazard considerations, and they include a significant safety factor. For whole-body exposure to continuous wave (CW) or pulsed (P) electromagnetic radiation (EMR) in the 10-MHz to 300-GHz frequency range, except as provided for some near field exposure (NFE) conditions, the maximum permitted time integrated exposure averaged over any 1-hr period is defined as "L" mW-hr/cm², where L has the following values for different frequency (f) ranges: $L=5.4 - 0.365f + 0.0064f^2$ for $10<f\leq30$ MHz; $L=0.2$ for $30<f\leq130$ MHz; $L=0.2 + 0.00128 (f - 130)$ for $130<f\leq600$ MHz; $L=0.8 + 0.00029 (f - 600)$ for $600<f\leq3,000$ MHz; and $L=1.5$ for $3,000<f\leq300,00$ MHz. For whole-body exposure to CW or P EMR in the 10- MHz to 300-GHz range for periods of less than 1 hr, except as provided for some NFE conditions, the maximum permitted irradiance (I) averaged over any 1-sec period is 4 L mW/cm²; the peak pulse irradiance must not exceed 1,000 mW/cm². The time integrated exposure must not exceed L multiplied by the square root of the time interval T (expressed in hr) in mW-hr/cm² for any T less than 1 hr. Under certain NFE conditions, greater irradiance levels than those specified above may be tolerated. For whole-body exposure to CW or P EMR in the range of 10 MHz to 300 GHz, except as provided for certain NFE conditions, the maximum permissible field strengths are as follows: electric field strength (V/m) must not exceed the square root of I multiplied by 3,770, where I is expressed in mW/cm²; the magnetic field strength (A/m) must not exceed the square root of I divided by 37.7, where I is expressed in mW/cm². The derivation of the above limits does not include blood flow cooling effects; exposure limits derived from accurate blood flow cooling models may allow higher exposures.

6735 BIOHAZARDS OF MICROWAVE BEAMS FROM PROPOSED SATELLITE SOLAR POWER STATIONS. *(Eng.)* Gandhi, O. P. (Dept. Electrical Engineering and Bioengineering, Univ. Utah, Salt Lake City, UT 84112). *Based on a presentation at the Conference on Health Implications of New Energy Technologies held April 4-7, 1979 in Park City, Utah.* 22 pp.; 1979 (15 refs).

fects is reviewed. The SSPS is designed to convert incident solar energy to direct current (DC) power, which is then converted to microwave energy for beaming to a receiving antenna site on the ground. The microwave energy incident upon the receiving antenna (rectenna) elements is then converted back into DC power. The proposed SSPS microwave transmitting system is designed to operate at a frequency of 2,450 MHz, and the ground level microwave power density on the beam axis is estimated to be 25.2 mW/cm². In case of a failure of the phase control system, the peak intensity of the beam will drop to 0.003 mW/cm². Priority areas of research on the possible microwave bioeffects of the SSPS, as identified by the United States Department of Energy, include the following: response of airborne biota; immunologic/hematologic studies; teratogenic effects; perturbations in behavior resulting from the interaction of drugs with SSPS microwave radiation; central nervous system effects; quantification of the absorbed dose in man and animals for unipath and multipath exposure conditions characteristic of rectenna sites; and quantification of thresholds for microwave-induced febrile convulsions, microwave-induced work stoppage, and sensory detection.

6736 ELECTROMAGNETIC FIELDS AND RELATIVE SAR PATTERNS IN BILAYERED BIOLOGICAL TISSUE EXPOSED TO A CIRCULAR APERTURE APPLICATOR. *(Eng.)* Tsiang, H. K. (Ph.D. Dissertation, Dept. Electrical Engineering, Univ. Washington, Seattle, WA 98195). [available through Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 7917654]: 185 pp.; 1979 (30 refs).

The specific power absorption rate (SAR) in human tissues exposed to a direct-contact or an indirect-contact microwave diathermy applicator was theoretically investigated using dielectric simulated fat-muscle tissue. A circular aperture source with a TE_{11} mode field distribution was assumed for the applicator in the theoretical formulation. The frequencies used were 750, 918.8, and 2,450 MHz, and the aperture size varied from 7 to 16 cm in diameter. The theoretical study was based on a Fourier-Bessel integral representation technique, and a Gauss-Legendre quadrature integration technique was used in the numeric computations. Limited thermographic experiments demonstrated the validity of the theory that accurately predicted the experimental results within a reasonable limit. It was found that the fat to muscle SAR ratio decreases with increasing diameter of the applicator aperture up to approximately 1 wavelength (lambda) as measured in the fat (f). A dampened cosine variation of SAR ratio as a function of aperture radius ranging from 0.5 lambda f to 3 lambda f occurs when the applicator is in direct contact with tissue. Although there is a slight in-

aperture size on SAR patterns are similar to those observed for direct contact applicators. It is concluded that an indirect contact applicator of 1 lambda f with a TE_{11} mode source distribution should be used to achieve optimally deep and selective heating in muscle tissue.

6737 BIOLOGICAL EFFECTS OF HIGH STRENGTH ELECTRIC FIELDS ON SMALL LABORATORY ANIMALS. *(Eng.)* Phillips, R. D. (Battelle Pacific Northwest Lab., Richland, WA 99352); Anderson, L. E.; Kaune, W. T. [available through National Technical Information Service, Springfield, VA 22161, Document No. DOE/TIC-10084]: 349 pp.; 1979 (12 refs).

An interim report on the biologic effects of 60-Hz electric fields on small laboratory animals is presented. The biologic parameters that are being studied include: hematology, serum chemistry, immunolgy, pathology, metabolic status and growth, bone growth, endocrinology, cardiovascular function, neurophysiology, development, and behavior. Exposure of rats and mice to 60-Hz vertical electric fields at a field strength of 100 kV/m for up to 120 days (~20.5 hr/day) resulted in few statistically significant and reproducible effects. Consistent, replicated effects were observed in experiments measuring synaptic excitability. Serum levels of corticosterone and testosterone appeared to be reduced in exposed animals, and significant reproducible effects were documented in several behavioral tests. The results of several experiments showed trends that suggested the possibility of decreased in vivo cell-mediated immunity and alteration in several hematologic parameters, e.g., higher white blood cell levels in mice exposed from conception to 77 days of age and higher red blood cell parameters in the 3rd generation of exposed mice. Studies are in progress to determine if the observed effects are transitory or permanent and to establish the relationship between the observed effects and the intensity/duration of exposure.

6738 HUMAN RESPONSES TO POWER-FREQUENCY EXPOSURES. *(Eng.)* Michaelson, S. M. (Sch. Medicine and Dentistry, Univ. Rochester, Rochester, NY 14627). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp., pp. 1-29; 1979 (42 refs).

sion lines are reviewed. Most recent labora animal studies are unsuitable for extrapolatio man due to insufficiencies in the study design. M research on possible health effects in man h been clinical studies of longitudinal or cross-scti design or isolated studies on human volunte Systemic studies to determine the possible eff of electric fields on linemen have been conducte the United States and Canada. Isolated occupati studies have been reported in Canada, Spain, the United Kingdom. Reports from Russia Eastern Europe are based on surveys performe substation personnel. Studies on small number humans have originated in the U.S., Germany, Sweden. In North America there are currently m than 200,000 circuit miles of overhead transmis lines rated at 138 kV or higher of which 14,000 m constitute 500 kV. There are also several thousa of miles of 765-kV lines that have been opera since 1969. Typical values of maximum vertical e tric fields at 4 feet above ground level under extre ly high voltage transmission lines range from 5 kV/m. There is no evidence of harm to human animals from these high voltage lines. Aside from cidental contact electrocution, no occupati disease or deviation of general morbidity patte has been reliably reported among high volt workers. Subjective sensations such as indu voltage microshocks on ground contact do occu workers exposed to high voltage field gradients. corona discharge from the sharp extremities of body can occur in high voltage laboratory wor exposed to extremely high field gradients; howe these effects have not adversely affected hea Although it has been suggested that electric fi may act as stressors, electric fields of up to 20 k have been demonstrated to induce no detecta stress response. There are also no indication electrolyte shifts or metabolic disorders caused electric fields acting on humans. It is concluded electric fields of up to 20 kV/m and magnetic field up to 240 A/m, individually or in combination, do present any persistent threat to health.

6739 THE HUMAN CONSIDERATIONS BIOEFFECTS OF ELECTRIC FIEL *(Eng.)* Mehn, W. H. (Medical Sch., Northwest Univ., Evanston, IL 60201). *In: Biological Effects of tremely Low Frequency Electromagnetic Fields. ceedings of the Eighteenth Annual Hanford Sciences Symposium at held October 16-18, 197 Richland, Washington.* [available through Natio Technical Information Service, Springfield, VA 22 Document No. CONF-781016]: 593 pp., pp. 21 1979 (50 refs).

Studies on the biologic effects of electric fields f

term effects attributable to induced currents on plants, animals, or humans, including those persons who work daily in the vicinity of energized high voltage lines. Soviet studies performed in 1966, 1968, and 1969 noted that workers servicing power transmission lines of 110 and 500 kV at open-air distribution and switching systems frequently complained of headache, heart pain, irritability, fatigue, apathy, sleeplessness, sleepiness, memory and attention-span disturbances, impairment of sexual potency, and various other disturbances primarily neurologic in nature. Functional disorders of the nervous and cardiovascular systems were also seen along with various disturbances of vegetative functions. These effects occurred only when the intensity of the electric field exceeded 5 kV/m, with the degree of the effect depending on the field intensity and exposure duration. More recent Soviet studies (1977) of human volunteers under natural conditions exposed to 330- and 750-kV overhead power lines have not shown any statistically significant changes in central nervous system functional condition, work ability, electrocardiogram, and numerous metabolic indices for exposure to a 5 kV/m electric field (2-hr exposure/day for 6 days) or a 12 kV/m electric field (30-min exposures, 3x/day, for 6 days). However, individuals exposed to fields of 15-16 kV/m (30-min exposures, 3x/day, for 6 days) complained of headache, fatigue, and irritability. An epidemiologic study to be conducted as part of a U.S.-Russia agreement in the fields of extra-high voltage and ultrahigh voltage transmission is described. It is concluded that at present, there is no known mechanism of action by which power frequency electric fields associated with power transmission can produce effects on living organisms.

6740 EVALUATION OF RESPONSES OF ELECTRICAL UTILITY COMPANIES TO ELECTROMAGNETIC RADIATION QUESTIONNAIRE. *(Eng.)* Holt, G. L. (Industrial Hygiene Branch, Tennessee Valley Authority, Muscle Shoals, AL). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 38-41; 1979 (no refs).

A questionnaire was mailed to over 600 electrical utility companies in the United States and Canada during the spring of 1978 to determine the extent of employee complaints concerning health problems associated with working in or near the electromagnetic fields generated by electrical transmission lines and switchyards. Of 226 responses received, only about 2% indicated that complaints had 11% used shielded buckets. For voltages of 500 kV and greater, 39% used conductive suits and 17% used shielded buckets. The survey also uncovered the fact that live-line maintenance is being conducted on 735-kV transmission lines.

6741 ENVIRONMENTAL EFFECTS OF 765-kV TRANSMISSION LINES. *(Eng.)* Scott-Walton, B. (Center for Resource and Environmental Systems Studies, SRI International, Menlo Park, CA); Clark, K.; Holt, B.; Jones, D. C.; Kaplan, S.; Krebs, J.; Polson, P.; Shepherd, R.; Young, J. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 42-54; 1979 (3 refs).

Testimony given before the New York State Public Service Commission on the potential environmental and biologic effects of 765-kV overhead alternating-current transmission lines is reviewed. The testimony focused on the potential effects of audible noise, potential biologic effects of electromagnetic fields, potential for electric shock, effects on cardiac pacemakers, and potential effects of ozone produced by corona discharge. Although the fields generated by these lines are not strong enough to cause tissue heating, some witnesses described claims of increased serum triglycerides, accelerated bone fracture healing, altered psychomotor reaction times, synchronization of circadian rhythms, malaise, neurasthenia, and encephalogram changes in humans and primates. However, many of the experiments citing such effects involved electric and/or magnetic fields with strengths much greater than or with frequencies much different from ground-level fields under 765-kV lines. Some experts claimed that no biologic effects exist as a result of these fields. Witnesses agreed that adults will occasionally be startled by currents and sparks when they touch a large vehicle under or near 765-kV lines. The effects of such currents on children remain unresolved, but it is possible that currents beneath 765-kV lines might under rare circumstances approach the respiratory arrest current for children. Fields under 765-kV transmission lines may affect some cardiac pacemakers, although the testimony cited no cases of transmission line interference.

6742 ELECTRIC AND MAGNETIC FIELDS AS CONSIDERATIONS IN ENVIRONMENTAL STUDIES OF TRANSMISSION LINES. *(Eng.)* Lee, J. M. (Bonneville Power Admin., Portland, OR).

Richland, Washington. [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.: pp. 55-73; 1979 (44 refs).

The electrical and physical properties of a transmission line environment are described and the possible biologic effects of transmission line electric (E) and magnetic (H) fields on plants and animals are reviewed. The E and H fields of existing extremely high voltage transmission lines and the E field from a Bonneville Power Administration 1,200-kV prototype line appear to be too weak to cause adverse effects to low growing vegetation; however, trees that grow very close to transmission line conductors may be damaged by the corona caused by high electric field intensities. Transmission line E fields should have no adverse effects on soil invertebrates, owing in part to the low field intensities resulting from shielding effects of vegetation. Evidence from laboratory and environmental studies indicates that transmission line E fields can affect honeybees and possibly other insects. However, other studies report negative results. The strengths of E and H fields in water beneath transmission lines may be, as shown by laboratory studies, near the level of perception by some fish species. Although birds show an avoidance for perching on energized transmission conductors, they regularly nest and produce young in transmission towers with no apparent ill effects from E or H fields. Laboratory and environmental studies indicate that some birds can perceive low-level E fields; however, it seems unlikely that transmission line fields interfere with bird navigation or orientation. In most situations, small mammals on a transmission line right-of-way are exposed to negligible E field strengths because of shielding effects of vegetation. Environmental studies indicate that E and H fields do not result in adverse behavioral effects in large mammals. In comparison with documented effects of transmission line construction and maintenance activities that can be severe and result in direct mortality to plants and animals, the effects of E and H fields appear insignificant on the basis of environmental research to date.

6743 EFFECTS OF HIGH-VOLTAGE TRANSMISSION LINES ON HONEYBEES. *(Eng.)* Greenberg, B. (Bioconcern, Chicago, IL); Kunich, J. C.; Bindokas, V. P. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.: pp. 74-84; 1979 (11 refs).

strengths at 1 m height were 6.6-7.1 kV/m. Within t hive bodies, electric fields were 0.6-4.5 kV/m in t nonmetal hives and 1.1-8.3 kV/m in metal-containi hives. With wire mesh shields in place, the elect fields in the hives were reduced to about 10 V/ which was equal to the ambient condition in a cont area, 400 m away. The magnetic field under t transmission line averaged 4.4 x 10 ' G for the verti component and 7.1 x 10 ' G for the horizontal comp nent. At the control site, the magnetic fields we one order of magnitude lower. Queen and brood pr duction, hive wt, body wt of individual workers, hive temperature, honey moisture content, pr polization of hive entrances, aggression, winter su vival, hemocyte numbers, and blood proteins we among the parameters investigated. Bees in u shielded hives underneath the line were affected several ways, with the effects being more p nounced in metal-containing hives, e.g., hive wt g was almost zero ($p<0.005$) owing to a near absence honey; a lowered moisture content of honey (0.0 $p<0.05$); bees weighed less ($p<0.01$); hive entranc were excessively but not completely propolize there were fewer pupae ($p<0.01$) but normal numbe of eggs, larvae, and queen cells; and all hives fail to survive the winter. In metal-free, unshielded hive hive wt gain, bee wt, honey moisture content, a the numbers of eggs, larvae, pupae, and queen ce were all normal. Abnormal features in these hiv were propolization of hive entrances (at a slower ra and lesser extent than in metal-containing hives), a gressive clusters of bees at lower-front hive corne poor overwintering survival (78% mortality vers 14% in shielded counterparts underneath the li versus 9% for control hives), and a possibly high hemocyte count.

6744 EXPOSURE OF PERSONNEL TO ELE TRIC FIELDS IN SWEDISH EXTRA-HIG VOLTAGE SUBSTATIONS: FIELD STRENGTH AN DOSE MEASUREMENTS. *(Eng.)* Lovstrand, K. (High-Voltage Res. Inst., Uppsala Univ., Uppsa Sweden); Lundquist, S.; Bergstrom, S.; Birke, E *Biological Effects of Extremely Low Frequency Ele tromagnetic Fields. Proceedings of the Eighteer Annual Hanford Life Sciences Symposium held C tober 16-18, 1978 in Richland, Washington.* [availab through National Technical Information Servic Springfield, VA 22161, Document No. CONF-78101 593 pp.; pp. 85-92; 1979 (4 refs).

Field strength and dose measurements were ma at various locations in Swedish extra-high voltag substations where personnel were exposed to 50-H electric fields to determine the cumulative biolog effect of exposure. An instrument was designed th permitted continuous recording of the electric fie

testing of insulator elements. Electric field strengths were mapped with a dipole-type field strength meter. Dosimeter measurements frequently showed that the dose was much lower than expected when personnel were working on the ground. This can be explained by the fact that work on the ground is performed on disconnected and grounded equipment or alongside shielding equipment frames where the local field strength is low. During routine inspections, which largely include moving across open areas between various components, the dosimeter readings agreed well with the dose estimated on the basis of field strength mapping. Work conducted on top of circuit breakers close to hot phases gave high exposure values; e.g., the accumulative exposure values (expressed as a percent of total exposure time) for electric field strengths of 10-15 kV/m and greater than 15 kV/m were 21 and 10%, respectively. Making inspection rounds and remaining in the substations when doing maintenance work often gave higher exposures than when working on disconnected and grounded components. Thus, people doing general maintenance work can be exposed to comparatively high fields.

6745 MONITORING OF PERSONNEL EXPOSED TO A 60-Hz ELECTRIC FIELD. *(Eng.)* Deno, D. W. (General Electric Co., Pittsfield, MA). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 93-108; 1979 (3 refs).

Two electric field exposure monitors, constructed to measure the time integral of the unperturbed electric field, were used to determine the exposure of personnel in high voltage installations to 60-Hz electric fields. The monitors were based on the principle that the current induced in a person is proportional to the unperturbed electric field and on the fact that the surface current density about the upper part of the body is suitably proportional to the unperturbed electric field to use as a measure. One monitor was used for hard-hat mounting above the visor, while a second more complicated device, which switches with logic the integration of the electric field into three categories of electric field intensity (0-5, 5-10, and >10 kV/m), was mounted with an armband. Accuracy of the monitors was limited by the local electric field stability about the measuring surface. Instability of the local electric field was dominated by hair, clothing, moisture, and individual body shape. A nominal accuracy of approximately ±10% was achieved in practical tests for outdoor conditions. Values of individual exposure for people in high voltage installations were measured and were found to be

6746 60-Hz ELECTRIC FIELD PARAMETERS ASSOCIATED WITH THE PERTURBATION OF A EUKARYOTIC SYSTEM. *(Eng.)* Miller, M. W. (Dept. Radiation Biology, Sch. Medicine and Dentistry, Univ. Rochester, Rochester, NY 14627), Carstensen, E. L.; Kaufman, G. E.; Robertson, D. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 109-116; 1979 (5 refs).

Roots of *Pisum sativum* (garden pea) were exposed for 7 days to 60-Hz electric fields ranging from 70 to 430 V/m in an aqueous medium whose conductivity was approximately 0.07 S/m to quantify the electric field parameters associated with the perturbation of a eukaryotic system. Corresponding current densities in the exposure medium associated with these field strengths ranged from 0.5 to 3.0 mA/cm^2. Root growth rate was examined for a random selection of seedlings assigned to one of two groups (exposed or control) that were concomitantly grown in the same tank where the growth medium was continuously circulated. Temperature in the exposure medium was held constant at 19 ± 1 C. Exposure to 60-Hz fields greater than 290 V/m caused a reproducible reduction in the rate of root growth. The data pointed to a threshold for the effect at approximately 2 mA/cm^2 or 290 V/m. The maximum reduction in root growth rate (relative to controls, $p<0.01$) occurred at the highest electric field strength of 430 V/m on the 1st and 2nd day after exposure. Comparable fields could not be obtained by exposure of the medium through air because the required fields would exceed the dielectric strength of air. Under conditions in which growth inhibition occurs, it is estimated that induced 60-Hz cell membrane potentials would be about 5 mV.

6747 EFFECTS OF EXTREMELY LOW FREQUENCY FIELDS ON SLIME MOLD: STUDIES OF ELECTRIC, MAGNETIC, AND COMBINED FIELDS, CHROMOSOME NUMBERS, AND OTHER TESTS. *(Eng.)* Greenebaum, B. (Div. Science, Univ. Wisconsin-Parkside, Kenosha, WI, 53141); Goodman, E. M.; Marron, M. T. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016] 593 pp.; pp. 117-131; 1979 (14 refs).

Lengthening of the mitotic cycle and depression of the respiration rate after exposure of the slime mold *Physarum polycephalum* to 75-Hz continuous wave

to either the electric field (0.7 V/m) or the magnetic field (2 G) independently or after exposure to both fields at 20% of the original strength. Exposure of the slime mold to modulated fields (minimum-shift keying modulation) at three different levels (0.7 V/m and 2.0 G, 0.14 V/m and 0.4 G, and 0.035 V/m and 0.1 G) produced roughly the same magnitude of lengthening of the mitotic cycle, even though the field levels varied by a factor of 20. This suggests the absence of a strong dose-response relationship. A similarity of the changes in the mitotic cycle length between the modulated and CW experiments suggests that the mechanism of action may not depend critically on the waveform producing the change. In general, respiration rate data supported the mitotic cycle data. Indirect measurements of chromosome numbers indicated that any difference in such numbers induced by exposure to the electric and magnetic fields was less than 6% ($p<0.05$) in this polyploid organism.

6748 FIRING-PATTERN CHANGES AND TRANSMEMBRANE CURRENTS PRODUCED BY EXTREMELY LOW FREQUENCY FIELDS IN PACEMAKER NEURONS. *(Eng.)* Wachtel, H. (Dept. Biomedical Engineering, Duke Univ., Durham, NC). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 132-146; 1979 (13 refs).

The minimum current densities of an extremely low frequency (ELF) field needed to perturb the firing of pacemaker neurons from the abdominal ganglion of the marine mollusc *Aplysia* were measured as a function of frequency and direction. These measurements were compared with the values of intracellularly injected currents needed to produce the same effect to examine ELF field effects in terms of the transmembrane currents that they are likely to produce in nerve cells. The threshold for firing pattern disturbance was measured for frequencies ranging from 0.1 to 1,000 Hz. Between 0.8 and 1.0 Hz, a one-for-one synchrony between firing rate and the injected current, in response to intracellular current, was achieved with very weak current strengths (down to 0.6 nA). The firing rate changes observed in neurons in response to extracellular field currents generally followed the same pattern with respect to frequency as they responded to intracellular current. The minimum thresholds for ELF values near the ambient firing rate, leading to one-for-one synchrony, for field currents (at 0.55 Hz) was 2.0 $\mu A/cm^2$. In the case of the field current, the threshold was highly dependent on the direction of the current with respect to the neuron orientation. The transmembrane current density calculated from estimates of

6749 THE ROLE OF CELL SURFA POLARIZATION IN BIOLOGICAL FECTS OF EXTREMELY LOW FREQUENCY FIEL *(Eng.)* Sheppard, A. R. (J. L. Pettis Memorial Medical Center, Loma Linda, CA 92357); Adey, W *In: Biological Effects of Extremely Low Frequ Electromagnetic Fields. Proceedings of the E teenth Annual Hanford Life Sciences Sympos held October 16-18, 1978 in Richland, Washing* [available through National Technical Informa Service, Springfield, VA 22161, Document No. CC 781016]: 593 pp.; pp. 147-158; 1979 (30 refs).

A counterion polarization model was applied to sider the polarization of long, thin neural proces such as dendrites of brain tissue in extremely frequency electromagnetic fields parallel or per dicular to the long axis of the neural process. degree of polarization depends on orientation of incident field with respect to the length of the drite or axon, radius of the cylindrical surface, mobility, and temperature. The effect of the pola tion on the dynamics of weakly bound ions sugg ways in which certain ions may have greatly redu momenta and thus participate in quantum beha (such as tunneling), which, under normal cumstances, is not possible for such massive tities. The analysis leads to the possibility nonclassical behavior by protons or other ions c provide amplification mechanisms of the type s observed only in the electron gas or Bose gas of biologic physical systems.

6750 THE DESIGN OF EXPOSURE SYST FOR STUDYING THE BIOLOGICAL FECTS OF 60-Hz ELECTRIC FIELDS ON SM PLANTS AND ANIMALS. *(Eng.)* Poznaniak, D (Westinghouse Electric Corporation, Pittsb [East], PA); Johnson, J. G.; McKee, G. W.; Grave B. *In: Biological Effects of Extremely Low Freque Electromagnetic Fields. Proceedings of the E teenth Annual Hanford Life Sciences Sympos held October 16-18, 1978 in Richland, Washing* [available through National Technical Informa Service, Springfield, VA 22161, Document No. CO 781016]: 593 pp.; pp. 159-171; 1979 (9 refs).

Design considerations involved in constructing posure systems, which simulate the electrostatic vironment of extra-high voltage (EHV) transmis lines, for studying the effects of 60-Hz electric fi on small plants and animals are discussed. typical electrostatic environment of transmis was determined by analytic studies and verifica through field measurements. Near ground level EHV electrostatic field is predominantly vertica orientation, and such conditions are easily simul by using a simple parallel-plate exposure systen

of up to 80 kV/m (e.g., an approximate safety factor of 5), housing within environmentally controlled chambers, multileveled design for simultaneous multiple-exposure areas, and sufficient electrode (grid) spacing (0.5-1.0 m) such that the experimental subjects do not unrealistically enhance the initially undisturbed uniform electric field. These design considerations hold for small plants and animals that do not exceed 12-25 cm in height. To ensure carefully controlled dosimetry, steps such as individual caging and ceiling restraints should be implemented. However, if a fundamental objective of the study is the determination of effects on the subject regardless of their classification as primary (i.e., direct electric field) or secondary (i.e., piloerection) effects, then natural living conditions should be permitted. Controlled laboratory studies of the biologic effects of 60-Hz electric fields on small plants and animals are being conducted with the latter design approach. The validity of the experimental results, however, is dependent on the accuracy with which the experimental exposure system simulates a transmission lin electric field.

6751 PREDICTION OF DAMAGE SEVERITY ON PLANTS DUE TO 60-Hz HIGH-INTENSITY ELECTRIC FIELDS. *(Eng.)* Johnson, J. G. (Westinghouse Electric Corporation, Pittsburgh [East], PA); Poznaniak, D. T.; McKee, G. W. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 172-183; 1979 (11 refs).

Laboratory studies involving the exposure of 85 species of small plants to 60-Hz high-intensity electric fields indicated that plant tissue damage severity is dependent on leaf tip geometry and morphology. Fleshy, rounded, or blunt plant parts showed no damage in 50-kV/m fields, whereas plant parts with a pointed shape exhibited minor damage at field intensities of 20-22 kV/m. Tissue damage was limited to the aerial portions of the leaf tip. The rate of tissue damage development decreased with time such that total tissue damage achieved a finite limit. This limit was directly proportional to electric field intensity. Tissue damage had the same electric field inception level as visible corona discharges about the damaged parts. Using Peek's law for partial electric breakdown in nonuniform fields, a technique for predicting the extent of tissue damage on a given species was developed. This prediction method uses data on the enhancement of the electric field at the tip of the plant as a means for calculating the corona-inception level for the plant. Experimental data for more than 20 specimens of five small plants (corn, for calculating levels of corona inception and damage inception in uniform electric fields was demonstrated. The method can be used with reasonable accuracy only if single plants are considered. Further work is needed to confirm the plausibility of the method, especially for large, tall plants.

6752 BIOLOGICAL EFFECTS OF 60-Hz ALTERNATING-CURRENT FIELDS: A CHESHIRE CAT PHENOMENON? *(Eng.)* Graves, H. B. (Dept. Biology, Pennsylvania State Univ., Univ. Park, PA); Long, P. D.; Poznaniak, D. T. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016] 593 pp.; pp. 184-197; 1979 (7 refs).

Short-term (0-120 min) and long-term (6 wk) exposures of male CD-1 mice to 60-Hz alternating current fields of 0, 25, or 50 kV/m revealed only random patterns of difference in blood cell composition changes. The parameters that were studied included red and white blood cell (WBC) count, packed cell volume, hemoglobin concentration, and differential WBC count. The differences observed in the long-term studies included an elevated WBC count and a statistically significant increase in lymphocyte numbers in the 50-kV/m group. No significant effects on WBC and lymphocytes were observed in the short-term studies. Behavioral studies with domestic pigeons exposed for 15-sec periods to a 60-Hz field (21 kV/m at the center of the head region) demonstrated a significant ($p \lesssim 0.001$) suppression in peck rates when the electric field was turned on. Decreased pecking responses were not observed in three pigeons tested under field-on, shielded conditions. Thus, short-term behavioral responses indicative of awareness of very high intensity fields were demonstrated.

6753 EXPOSURE AND DATA-COLLECTION FACILITIES FOR CIRCADIAN STUDIES OF ELECTRIC FIELD EFFECTS UPON BEHAVIOR, THERMOREGULATION, AND METABOLISM IN SMALL RODENTS. *(Eng.)* Ehret, C. F. (Div. Biological and Medical Res., Argonne Natl. Lab., Argonne, IL); Sacher, G. A.; Langsdorf, A.; Lewis, R. N. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016] 593 pp.; pp. 198-224; 1979 (12 refs).