gators that microwave exposure increases the resistance of animals to x-irradiation and reduces their mortality. (8 references)

0318 CHANGES OF PERIPHERAL BLOOD PARAMETERS IN GUINEA PIGS CAUSED BY EXPOSURE TO AN ELECTROMAGNETIC FIELD IN THE THREE-CENTIMETRE RANGE. *(Ukr.)* Kartsovnik, S. A. (Odessa Agric. Inst., USSR) and V. R. Faitelberg-Blank. *Dopovidi Akad. Nauk Ukrainsk. RSR (Ser B)* (8):736-741, 1974.

Changes in the white blood picture were studied in 25 male guinea pigs which were exposed to superhigh frequency (SHF) electromagnetic radiation in the 3-cm range at intensities of 25-500 $\mu W/cm^2$ for 10 min/day over a 30-day period. Controls consisted of 7 guinea pigs exposed to noise from the generator, the field of which was not turned on. Periodic increases occurred in the white blood cells (WBC) of guinea pigs exposed to intensities of 25 and 50 $\mu W/cm^2$, while the WBC decreased in animals exposed to 200 and 500 $\mu W/cm^2$. Exposure to SHF radiation significantly increased the lymphocyte count at intensities of 50 and 500 $\mu W/cm^2$ with a corresponding decrease in the number of neutrophils. At an intensity of 200 $\mu W/cm^2$, periods of lympyocytosis were produced while some animals had a tendency to lymphopenia. Although no change occurred in the total number of monocytes, the number of old, inactive monocytes increased, indicating that the activity of the monocyte system was suppressed. This suppression increased with the intensity of SHF radiation. Qualitative changes produced in leukocytes by an intensity of 50 $\mu W/cm^2$ included anisocytosis of the hypersegmented macroforms and nuclear polymorphism in the monocytes. Exposure to 500 $\mu W/cm^2$ for 30 days significantly reduced the osmotic resistance of leukocytes. Exposure to SHF radiation probably resulted in the development of an osmotically less stable generation. (7 references)

0319 THE BIOLOGICAL EFFECTS OF RADAR WAVES. *(E.)* Boiteau, H. (no affil.) *Rev. Corps Sante Armees* 1(5):637-652, 1960.

In the late 1940s investigations in man and animals showed no pathological effects of radar waves on the human organism, but these results were obtained with low-power emitters. There are now radars with radiation as high as 0.01 W/cm^2 150 meters from the antenna in the beam axis. Animal studies in the U. S. have shown that ultra-short waves (e.g., 2500 and 10,000 megacycles) have indisputable biological effects on organs that are most sensitive to hyperthermia (eyes, testicles, nerve centers). The severity of the histological lesions varies as a function of the energy density received by the organ. To determine the effect of ultra-short waves on man, Lockheed Aircraft Corporation conducted a 2-yr survey of 226 employees working on active radars (peak power slightly in excess of 1 Mw) for up to 4 hr/day. Length of such exposure was 3-4 yr in some cases and 13 yr in 1. The percentages of acute of chronic afflictions in the exposed group were comparable to those found in 88 nonexposed controls. Radar workers had an abnormally high proportion of ocular difficulties, but these appeared unrelated to their exposure. Subjective symptoms were modest on the whole. Some employees (25%) noted a sensation of heat in the face, neck, or hands while working near an antenna emitting in the S band; others complained of fatigue, headaches, and pain inside the eyeballs. For man, the energy density tolerable without risk for a prolonged period has been empirically fixed at 0.01 W/cm^2. If exposure is of short duration, a much higher flux can be tolerated (3 W/cm^2 for 1 min). It is not clear whether ultra-short waves act on tissues by a simple release of heat or have a specific activity that is added to the effects of hyperthermia. The latter possibility is supported by animal experiments showing that ultra-short waves and infrared radiation have the same clinical manifestations but that the critical temperature is lower for radar radiation than for infrared. In the absence of precise knowledge of the activity of radar waves in man, care must be taken to protect workers from very high-power emitters (4 Mw at peak). (22 references)

0320 VARIATIONS OF NERVE EXCITABILITY AND CONDUCTION UNDER THE INFLUENCE OF MICROWAVES. *(Fr.)* Deficis, A. (U. E. R. des Sciences Pharmaceutiques, Toulouse, France), A. Delfour, J. C. Dumas and S. Laurens. *Experientia* 30(11):1276-1277, 1974.

The effects on speed of conduction, rheobase, and chronaxie of the sciatic nerve of the frog was studied as a function of the frequency of microwave irradiation. A preliminary test showed that the thermal effect of microwaves did not affect speed of conduction. Across a frequency range from 1 to 9 GHz, there was a marked decrease in speed of conduction between 2.5 and 9 GHz, with a maximum effect at 5 to 6 GHz, where the diminution was 8 to 10%. There was no appreciable effect on the chronaxie and rheobase. A systematic frequency study is suggested to obtain more specific biological effects of microwaves. (6 references)

PREPRINTS

0321 DO MICROWAVES ALTER NERVOUS SYSTEM STRUCTURE? *(E.)* Albert, E. N. (Sch. Med. Hlth. Sci., George Washington Univ., Washington, D.C.) and M. DeSantis.

Exposure of adult Chinese hamsters to microwaves of 2450 MHz frequency and at power densities of 25 mW/cm^2 for 1-22 days or 50 mW/cm^2 for 30 min to 24 hr resulted in severe structural alterations of neuronal cytoplasm in the hypothalamus and subthalamus. At the light microscopic level, the neuron cell bodies of the hypothalamus and subthalamus showed vacuolization and chromatolysis. Electron microscopy revealed that the neurons were devoid of polyribosomes and rough endoplasmic reticulum. In addition, myelin figures and swollen membranous structures were frequently observed in the dendrites of the hypothalamic neurophile. Application of the Fink-Heimer technique suggested that some axonal degeneration occurred after microwave irradiation. There was no evidence of gliosis, hemorrhage, or perivascular edema in the irradiated animals; however, vascular stasis or congestion was seen in some animals. No changes occurred in cell bodies of hippocampal pyramidal neurons, Purkinje cells of the cerebellum, mesencephalic nucleus of the trigeminal nerve, motor neurons of the spinal cord ventral horn, or cell bodies of the thalamic relay nuclei. It is not clear whether the electromagnetic radiation itself or tissue heating, due to radiation energy absorption, was responsible for the effects on the hypothalamus and subthalamus. (13 references)

0322 LONG WAVELENGTH ANALYSIS OF PLANE WAVE IRRADIATION OF A PROLATE SPHEROID MODEL OF MAN. *(E.)* Durney, C. H. (Dept. Electr. Eng., Univ. Utah, Salt Lake City), C. C. Johnson and H. Massoudi.

Electromagnetic field perturbation techniques were applied to obtain the first-order internal electric fields and absorbed power for planewave irradiation of a prolate spheroid model of man when the wavelength is long compared to the dimensions of the spheroid. Power calculations based on the results show a striking change in absorbed power with a change in orientation of the spheroid in the incident fields. In a given radiation field, the absorbed power varies with the size of the absorbing body. The derived expressions for absorbed power density and absorbed total power should be useful in studies of radiation hazards to man. (11 references)

0323 RATE EFFECTS IN ISOLATED TURTLE HEARTS INDUCED BY MICROWAVE IRRADIATION. *(E.)* Tinney, C. E. (Univ. Utah, Salt Lake City), J. L. Lords and C. H. Durney.

Experiments were conducted to test the hypothesis that excitation of nerve remnants, or direct transmitter release, contributed to the bradycardia observed at low power levels of microwave irradiation (960 MHz, continuous wave, 2-10 mW/cm^3 absorbed power). First, the action of the parasympathetic system of isolated turtle hearts was blocked by addition of atropine to Ringer's solution, and 8 mW/cm^3 absorbed power was applied. Second, the sympathetic system was blocked by addition of propranolol hydrochloride (β blocker) to the Ringer's solution and similar power applied. Atropine allowed the microwave neural effect to stimulate the symphathetic system only, thus causing tachycardia rather than bradycardia. Propranolol hydrochloride allowed the parasympathetic system to cause even greater bradycardia than that noted when only microwaves were applied. The results confirm that microwaves can cause neural transmitter release effects. At 100 mW total applied power (8 mW/cm^3 absorbed power), the temperature rise within the heart was about 0.02 C. This indicates that the neural effect of microwaves is dominant at lower power levels in contrast to generalized heating effect of higher power levels. (No references)

0324 EFFECT OF LOW INTENSITY MICROWAVES ON ISOLATED NEURONS. *(E.)* Wachtel, H. (Dept. Biomed. Eng., Duke Univ., Durham, N.C.) and R. Seaman.

Changes in the electrical activity of individual neurons from *Aplysia* ganglion were recorded before, during, and after exposure of the ganglion to microwaves at 1.5 and 2.45 GHz. In addition to monitoring incident and reflected microwave power levels, ganglionic temperature was recorded. Pronounced changes in the firing patterns of pacemaker neurons with regular beating rhythms and those with regular bursting rhythms occurred at absorbed microwave power levels below what human brain cells would be exposed to at the accepted safety level of 10 mW/cc. In large part, these effects are attributable to slight ganglionic warming, but effects are found that are not accompanied by, or not reproduced by, ganglionic warming. No significant differences were detected in the effects of pulsed or continuous wave radiation at the two frequencies used. (11 references)

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CURRENT RESEARCH

SOURCES:Smithsonian Science Information Exchange

0071 DEVELOPMENT OF MICROWAVE INSTRUMENTATION. Wyatt, R. H.; Joines, W. T. (Environ. Biophysics Branch, Duke Univ., Durham, N. C.).

The proposed work of this contract is threefold: (1) Study the electrical dipole model of the neural membrane and its implications, and determine the unknown parameters in the interaction of the dipole model with microwave radiation; (2) Develop microwave instrumentation and methods to investigate microwave-neuron interactions over the 0.2 to 3.0 GHz frequency band; (3) Develop the instrumentation and dosimetry of a more accurate method of determining the microwave power absorbed by a neuron.

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., NIH, Natl. Inst. Environ. Hlth. Sci.

0072 EFFECTS OF MICROWAVE RADIATION ON THE NEURAL RESPONSE. McRee, D. S. (Environ. Biophysics Branch, Duke Univ., Durham, N. C.).

The objective of this project is to determine the effects of microwave radiation on the functioning of the central nervous system when exposed to CW and modulated microwave radiation in the frequency range of 1-10 GHz. Isolated neurons and surviving spinal cords of decerebrated cats will be exposed. The effects of the radiation on action potentials, conduction velocities, and firing patterns will be observed.

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., NIH, Natl. Inst. Environ. Hlth. Sci.

0073 INVESTIGATION OF NON-THERMAL MICROWAVE RADIATION EFFECTS ON NEUROLOGICAL FUNCTIONING. Wyatt, R. H.; Somjen, G.; McRee, D. I. (Environ. Biophysics Branch, Duke Univ., Durham, N. C.).

The project objective is to conduct an investigation into the non-thermal effects of microwave radiation on neurological functioning. More specifically, recent efforts have been aimed at investigating the effects of microwave radiation on spinal reflex function in the cat. The lower lumbar spinal cord was exposed, and the ventral roots of L7 and S1 segments were cut at their exit from the vertebral canal. Pulses of 0.05 msec were used to stimulate the sciatic nerve, and the response at the ventral root was recorded for both irradiated and non-irradiated controls. Microwave radiation at 2450 MHz with power levels from 2 to 10 mW/cm^2 was used. Only preliminary, pilot results have been obtained.

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., NIH, Natl. Inst. Environ Hlth. Sci.

0074 EFFECTS OF 2450 MHZ MICROWAVE RADIATION ON BIOLOGICAL MATERIAL AT CELLULAR AND MACROMOLECULAR LEVEL. Hamrick, P. E.; Zinkl, J.; Staples, R. (Environ. Biophysics Branch, Duke Univ., Durham, N. C.).

The objectives of this project are to determine the effects of 2450 MHz microwave radiation on biological material at the cellular and macromolecular level and relate the amount of microwave energy absorbed to the effect. Various cellular and macromolecular systems will be tested by exposure to microwaves under carefully controlled temperature and dose conditions. Parameters such as viability, cell membrane permeability and denaturation will be used as indicators of microwave effects.

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., NIH, Natl. Inst. Environ. Hlth Sci.

0075 EFFECTS OF 2450 MHZ CW MICROWAVE RADIATION ON THE EMBRYONIC DEVELOPMENT OF JAPANESE QUAIL. Hamrick, P. E.; McRee, D. I.; Zinkl, J.; Thaxton, P. (Environ. Biophysics Branch, Duke Univ. Durham, N. C.).

The objective of this project is to determine the effects of 2450 MHz CW microwave radiation on the embryological development of Japanese quail. Fertilized quail eggs will be exposed to 2450 MHz microwave radiation under carefully controlled temperature and dose conditions. Parameters such as percent hatching, gross deformities, and blood values will be used as indications of microwave effects.

SUPPORTING AGENCY:HEW, Publ. Hlth Serv., NIH, Natl. Inst. Environ. Hlth. Sci.

0076 VARIABLE FREQUENCY MICROWAVE EXPOSURE SYSTEM. McRee, D. I. (Environ. Biophysics Branch, Duke Univ., Durham, N. C.).

The objective of this project is to design, build and calibrate a variable frequency microwave exposure system for biological material. A field uniformity at the specimen of 90 percent over a 4 inch diameter circle, a continuous frequency variation in the range of 1 to 10 GHz, and a power level range at the specimen of 0.010 to 10 mW/cm2 are specified for the desired system. The electromagnetic radiation produced by the system can be either continuous wave fields or modulated fields.

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., NIH, Natl. Inst. Environ. Hlth. Sci.

0077 MICROWAVE EXPOSURE SYSTEM AND MICROWAVE DOSIMETRY. McRee, D. I.; Walsh, P. J. (Environ. Biophysics Branch, Duke Univ., Durham, N.C.).

The objectives of this project are to develop a microwave exposure system for biological material which has a well-defined, uniform field characteristic, to study the mechanisms of interaction of microwave radiation with matter, and to develop dosimetric relationships for energy absorption. Techniques using thermistors, liquid crystal probes, infrared microscope and other type detectors will be evaluated as they become available.

SUPPORTING AGENCY:HEW, Publ. Hlth Serv., NIH, Natl. Inst. Environ. Hlth. Sci.

0078 EFFECT OF MICROWAVE RADIATION ON AUDITORY SYSTEM. Konishi, T.; McRee, D. I.; Hamrick, P. E.; Cook, R. O. (Environ. Biophysics Branch, Duke Univ., Durham, N. C.).

Anesthetized guinea pigs are exposed to modulated microwaves of frequencies from 1 to 10 GHz. The cochlear microphonics and whole-nerve action potentials are measured during exposure to microwaves. The stimulus-response relationships will be tested. The possible mode of microwave-induced auditory responses will be explored.

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., NIH, Natl. Inst. Environ. Hlth. Sci.

0079 DEVELOPMENT OF HIGH POWER MICROWAVE FOCUSED OVEN. Guidotti, A.; Hawkins, R. A.; Cheney, D. L.; Trabucchi, M.; Doteuchi, M.; Wang, C. (Lab. Preclinical Plasmacolog., St. Eliz. Hosp., Washington, D.C.),

A high power microwave oven was developed to study the effect of drugs on the concentrations of various label substrate in brain nuclei of small laboratory animals. With this method the brain of mice can be fixed in 0.5 sec and that of rats in 2 sec - cAMP, cGMP, choline, GABA, acetylcholine and intermediate metabolites concentrations were comparable to those found after freezing and blowing technique. The device is now being modified to inactivate instantaneously the enzyme in the spinal cord of rats and in the brain of cats and rabbits.

SUPPORTING AGENCY:HEW, Pub. Hlth. Serv., Natl. Inst. Mental Hlth.

0080 BEHAVIORAL AND BIOLOGICAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. Gandhi, O. P.; Johnson, C. C. (Sch. Eng., Univ. Utah, Salt Lake City).

The objective of this research is to determine behavioral and biological effects of resonant electromagnetic power absorption in rats in order to develop understanding which may lead to projection of effects in humans and the development of realistic and scientifically based exposure criteria for military personnel. A parallel - plate wave guide is used to generate plane waves for exposure of experimental animals oriented along the E, H, + K, axes. Frequency will be established based on the frequency of peak absorption. Frequencies of 0.5, 0.75, 1.0, 1.25 and 1.5 times this resonant frequency will also be used.

SUPPORTING AGENCY:MDRDC, Med. Res. Dev. Command, U.S. Dept. Defense, Army.

0081 UHF BAND RADIOFREQUENCY RADIATION FOR CARDIAC PACEMAKER ELECTROMAGNETIC INTERFERENCE. Toler, J. C. (Georgia Inst. Tech., Atlanta).

To provide research support and use of Georgia Tech radiofrequency (RF) radiation facilities to generate and apply UHF band fields at two nominal frequencies (450 MHZ and 3100 MHZ) for USAFSAM studies of the effects of RF radiation on 'new generation' cardiac pacemakers. The contractor will set up and calibrate nominal 450 MHZ and 3100 MHZ radiation fields having an intensity of at least 200 volts per meter. Contractor will assist USAFSAM personnel in the evaluation of human phantoms and in the conduct of cardiac pacemaker electromagnetic radiation interference tests.

SUPPORTING AGENCY:U.S. Dept. Defense, Air Force.

0082 NONTHERMAL EFFECTS OF MICROWAVE RADIATION ON THE GROWTH, DEVELOPMENT AND BEHAVIOR OF BIOLOGICAL SYSTEMS. Barnes, F. S.; Gamon, E. I. (Sch. Eng., Univ. Colorado, Boulder).

Previous work by the contractor has indicated that significant alterations occur in developing embryos when exposed to microwave radiation for periods of less than that necessary to induce thermal effects. Further investigation of this phenomenon is desired in order to ascertain the effect of stage of embryonal development, frequency and time exposure, and the interrelationships thereof. Validation of these results could have a major impact on the setting of standards for safe exposure to microwave fields under conditions of high pulse powers. Embryos of the zebra fish (*Brachydanio rerio*) will be exposed to microwave pulses of varying intensity and duration to clearly delineate the thresholds of damage for these parameters. Additional exposures will be done to assay the effect of various initial embryo temperatures, as well as varying stages of

embryological development. Theoretical considerations for nonthermal damage will be undertaken, utilizing data from previous experiments in order to develop a mathematical and physical model to explain and predict nonthermal effects.

SUPPORTING AGENCY:U.S. Dept. Defense, Air Force.

0083 OCULAR PATHOLOGY FROM ELECTROMAGNETIC RADIATIONS. Fine, B. S.; Hirsch, S. E.; Tso, Mo (Univ. Assoc. Res. Educ., Bethesda, Md.).

With development, in recent years, of a wide variety of sources of powerful electromagnetic radiations, some of which are, in addition, coherent (i.e., masers and lasers) the potential for accidental injury to the eye grows. The principal investigator and his colleagues propose to evaluate the sequence of morphologic events produced in ocular tissues by such devices in both the visible and invisible portions of the spectrum. Current methods of light and electron microscopy will be applied to these studies. The project consists of two parts: (1) An evaluation of two important regions of the invisible spectrum using (a) an ultraviolet laser to determine effects on cornea, lens, and possibly the retina in short (days, weeks) and medium terms (months to a year) experiments; (b) microwave radiations to determine mainly the effects on the lens in short, medium, and long term (i.e., years) experiments. (2) An evaluation of damage to the primate fovea by coherent visible light using a continuous (CW) laser (Argon). The proposed studies are of great clinical importance in evaluating the potential for accidental injury and determination of standards of safety.

SUPPORTING AGENCY:HEW, Pub. Hlth. Serv., Food & Drug Adm.

0084 IRRADIATION OF BIOLOGICAL PRODUCTS. Bickert, W. G. (Agri. Exp. Sta., Michigan State Univ., East Lansing).

Radiation is to be applied to biological products, particularly in the areas of disinfestation of grains, improvement of germination, water intake rate of seeds, and the effects of radiation noted from the standpoint of the basic compounds of the treated products. Sources provide energy from the ultraviolet to the infrared portion of the electromagnetic spectrum. Studies have been initiated to determine effects of various wavelengths of electromagnetic radiation on different stages of cereal leaf beetle development. Sugar beets irradiated with high energy electrons and gamma rays showed approximately the same quality deterioration during storage as control beets. This work will be continued with emphasis on the chemical and physiological changes caused by irradiation.

SUPPORTING AGENCY:Michigan State Government.

0085 NON-IONIZING ELECTROMAGNETIC RADIATION HAZARDS. Bowman, R. R. (Natl. Bur. Stand., Boulder, Colo.).

This project will develop instrumentation, measurement techniques, and calibration services required for effective measurement and control of hazardous non-ionizing radiation and for understanding the interactions of such radiation with biological systems. A new miniature E-field sensor has been developed and three versions (high, low, and medium power) of a simplified and improved EM hazard meter designed and partially constructed. Equipment to provide limited calibration and evaluation facilities for EM hazard meters above 1GHz is also in progress. A study of a HF near-field synthesizer indicates such a device is feasible and development is proceeding. This on-going project is the Dept. of Commerce portion of the 5-year national program recommended by ERMAC.

SUPPORTING AGENCY: U. S. Dept. Commerce, Natl. Bur. Stand.

0086 A PRELIMINARY SURVEY OF VETERANS WHO MAY HAVE BEEN EXPOSED TO CATARACT PRODUCING RADIATION. McAfee, R. D.; Cazenavette, L. L.; Holland, M. G. (VA Hosp., New Orleans, La. 70140).

See CR 0030, I(1), for description of this project. (Renewed 7/73 to 6/74).

SUPPORTING AGENCY:U. S. Veterans Administration

0087 A RADAR INVESTIGATION OF THE EFFECTS OF NAVAL COMMUNICATIONS SYSTEM ON FREE FLYING MIGRANT BIRDS. Williams, T. (Dept. Biol., State Univ. New York, Buffalo 14214).

The objective of this study is to evaluate the possible effect of the electromagnetic fields of the Sanguine antenna on the behavior of free flying birds which migrate over the Wisconsin Test Facility. A small, low power radar, mounted in an Econoline van, will be located at several locations within and near the Test Facility during the fall and spring migration periods. Each observation period will last approximately 2 weeks. The paths of migrating birds will be observed with the radar during alternating periods of radiating and inactive modes of the Sanguine transmitter to determine if the headings and flying patterns of the birds will be altered when the transmitter is operating. Times of observation will be selected to include both songbird and water fowl migrations. (9/74-8/75)

SUPPORTING AGENCY:Naval Electronics Systems Command

0088 LIQUID CRYSTAL FIBEROPTIC PROBES FOR MEASURING TEMPERATURE AND MICROWAVE FIELDS IN BIOLOGICAL MATERIALS. Johnson, C. C. (Dept. Biophysics Bioeng., Univ. Utah, Salt Lake City 84112).

As a large user of microwave power, the Navy is concerned with its biological effects, especially on humans. The objective of this project is to conduct research and development of nonperturbing, dielectric probes for measuring temperature and microwave fields in biological materials used in microwave hazards research. Liquid crystals and optic fibers are being used to fabricate probes for measurement. The optimum liquid crystal mixtures will be determined as will be the response and sensitivity as a function of time. The optimum tip design will be studied and 8 to 10 prototype temperature units will be fabricated for evaluation by other investigators. The feasibility of a liquid crystal/optic fiber power probe (LCOFPP) using spherical shells of a resistive material (carbon) will be determined. (3/75 - 2/76).

SUPPORTING AGENCY:Office Naval Research.

0089 INFLUENCE OF ELECTROMAGNETIC FIELDS GENERATED BY NAVAL COMMUNICATIONS SYSTEMS ON GROWTH, DEVELOPMENT AND BEHAVIOR IN DOMESTIC BIRDS. Durfee, W. K. (Coll. Resource Dev., Univ. Rhode Island, Kingston 02881).

This project is part of a Navy program to investigate the possible effects of extremely low frequency electromagnetic radiation on living organisms. This research continuation will seek to determine if modulated 75 Hz electric and magnetic fields will have effects upon growth, development and behavior in the domestic fowl *Gallus domesticus*. Growth and development of the chick embryo is studied by exposing the growing eggs in a specially modified incubator. Observations will be made on hatchability, embryonic abnormalities, growth rates and CO_2 production. Chicks will continue to be exposed after hatching and growth rate, behavior, feeding efficiency and learning/memory consolidation will be observed. (7/74 - 6/75).

SUPPORTING AGENCY:Naval Electronics Systems Command.

0090 RESPONSE OF PLANT AND SOIL MICROORGANISMS TO ELECTROMAGNETIC FIELDS GENERATED BY NAVAL COMMUNICATIONS SYSTEMS. Gardner, W. R. (Dept. Soil Sci., Univ. Wisconsin, Madison 53706).

The purpose of the research is to determine whether ELF electric fields have any effect on metabolic activity of plants and soil micro-organisms. Microorganisms were chosen from representative soil saprophytic and pathogenic bacteria and fungi in the Northern Wisconsin area. Initial emphasis was placed on evaluation of the effect of electric fields on solute transport and metabolic activity using a radiotracer-enzyme kinetic approach to determine transport constants, uptake velocities and turnover times and rates for solutes such as sugars and amino acids being assimilated through active transport processes by microbial cells in aqueous solutions. Single plants were grown in the desired growth media under conditions of controlled temperature, light, relative humidity and CO_2 concentration. The soil water potential and soil aeration was controlled and measured. The relation between the transpiration flux to water through the plant and the water potential drop across the plant were determined for a range of environmental conditions. Stomatal resistance and the components of the leaf water potential were measured periodically. Where effects upon photosynthesis are indicated, these effects will be confirmed by direct measurements of net CO_2 assimilation. Particular attention will be paid to systems which are poorly aerated as well as to relatively dry soil systems. (4/73 - 3/74).

SUPPORTING AGENCY:Naval Electronics Systems Command.

0091 A PHYSIOLOGICAL AND BIOCHEMICAL STUDY OF THE EFFECTS OF ELECTROMAGNETIC FIELDS GENERATED BY NAVAL COMMUNICATIONS SYSTEMS ON Physarum polycephalum. Goodman, E. M. (Univ. Wisconsin, Kenosha 53140).

This project is part of a Navy program to investigate the possible effect of extremely low frequency (ELF) electromagnetic radiation on living organisms--both plant and animals. This research is designed to examine the possible effects of ELF electromagnetic radiation (both short and long term exposure) on growth and development of the slime mold *Physarum polycephalum*. Three simulators will be set up to expose the *Physarum*. The first will be a continuation of present studies at 75 Hz, 2 G and 0.7 V/m. ATP concentrations will also be studied in this simulator. The second simulator will operate at 75 Hz with modulation and with 60 Hz CW superimposed. The third simulator paradigm will be decided upon in consulation with the scientific officer and the Sanguine Division. In all cases, the critical indicators in *Physarum* will be: (1) time to mitosis, (2) reproductive differentiation, (3) protoplasmic streaming period. (7/74 - 6/75).

SUPPORTING AGENCY:Naval Electronics Systems Command.

0092 BIOLOGICAL EFFECTS FROM ELETROMAGNETIC FIELDS GENERATED BY NAVAL COMMUNICATIONS SYSTEMS. Holberg, F. (Dept. Pathol., Univ. Minnesota, Minneapolis 55455).

This research will evaluate possible effects of extremely low frequency (ELF) fields on circadian and other biological rhythms in organisms such as silk tree, flour beetle, mouse and rat. Effects on susceptibility to drugs and life span will also be studied. Body core temperature of rodents will be monitored by implanted sensors. Leaf closing rhythms in silk tree will be studied using whole plants as well as excised pairs and stems. Flour beetles will be exposed to ELF then given varying doses of insecticide and susceptibility compared with controls. O_2 consumption vs ELF exposure will be studied. Rodents will be exposed to ELF then given barbiturates to study variation in susceptibility. Long-term effects on aging and development of the mouse will also be studied. (12/73 - 11/74).

SUPPORTING AGENCY:Office Naval Research.

0093 AN EVALUATION OF POSSIBLE EFFECTS OF 60 HZ AND 75 HZ ELECTRIC FIELDS ON NEUROPHYSIOLOGY AND BEHAVIOR OF MONKEYS. Medici, R. G. (Brain Res. Inst., Univ. California, Los Angeles 90024).

This project is part of a Navy program to investigate the possible effects of extremely low frequency electromagnetic fields on living organisms. This research seeks to evaluate the possible effects of 60 and 75 Hz (modulated) electric fields on neurophysiology and behavior in monkeys. In this study monkeys are surgically implanted with cortical and subcortical EEG electrodes. After recovery, the monkeys are trained to perform a fixed-interval, limited hold lever pressing task. Once they attain a high, stable performance level they are put through several 4-day experiments in which they are exposed to electric fields of either 0, 1, 10 or 57 V/m. Frequency conditions will be 75 Hz modulated alone and with a 60 Hz component. EEG will be monitored as well as changes in performance levels and interresponse times. In addition, calcium efflux will be studied in neonatal chick brains exposed to the modulated fields. (7/74 - 6/75).

SUPPORTING AGENCY:Naval Electronics Systems Command.

0094 QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Kramar, P. O. (Dept. Ophthamol., Univ. Washington, Seattle 98195).

The production of opacity and damage in the eye by exposure to microwave radiation can occur. The exact conditions under which the effect occurs are yet to be established. Consequently, there is a great deal of controversy concerning the safe level of human exposure to microwave radiation. The increased use of high power microwave equipment by the Navy and other Armed Services, as well as the general population, demands well-planned and expertly executed theoretical and experimental investigations. The proposed on-going research [see CR 0029, I(1)] is designed to: (1) ascertain the conditions and mechanisms of cataract production by microwave irradiation; (2) extrapolate quantitatively the animal results to human exposures. This will involve a theoretical determination of the internal absorption characteristics of animal and human eyes as related to source frequency and aperture size; a laboratory investigation of the threshold of eye damage by CW and pulsed microwaves during acute and chronic exposure for frequencies ranging from 915 MHz to 2.5 GHz; and improved dosimetry through the use of thermographic and thermocouple recordings of temperature changes in the tissue. In the coming period, a cataractogenic threshold will be established in the rhesus monkey for 2450 MHz. A computer model based on the power absorption patterns found in the monkey will be developed. This should enable extrapolations to the human. Rabbits will be exposed to a 2450 MHz slot applicator and power absorption patterns will be established. Rabbit lenses which have been exposed to threshold and subthreshold levels will be studied by electronmicroscopy. Rabbits will also be exposed continuously to low levels (i.e., 20 mW/cm^2) in the far field at 2450 MHz. In addition to periodic eye examinations, the basic blood picture and coagulation parameters will be monitored. Finally, rabbits under general hyperthermia (hot water) will be studied in an attempt to determine if a temperature rise equivalent to that obtained by a cataractogenic dose of microwaves is capable of producing cataracts. (12/74 - 11/75).

SUPPORTING AGENCY:Office Naval Research.

0095 NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS DUE TO MICROWAVE IRRADIATION. Guy, A. W. (Dept. Rehab. Med., Univ. Washington, Seattle 98195).

See CR 0032, I(1), for a complete description of the on-going project. This phase involves: (1) a study of the effects of microwaves on the central nervous system with particular attention to the spinal cord using a segment of cord exposed in live cats; (2) the use of combined physiological and behavioral methods in primates, cats and rats. Primary emphasis will be on the interaction of microwave energy and the auditory system. Attempts will be made to determine the threshold of perception of audible microwave pulses. Information on mechanisms for this phenomenon will be sought using sequential ablation of structures of the auditory system of the cat. (12/74 - 11/75).

SUPPORTING AGENCY:Office Naval Research.

0096 THE EFFECTS OF IONIZED AIR AND RADIO ENERGY UPON THE PERFORMANCE OF NAVAL PERSONNEL. Frey, A. H. (Randomline, Inc., Huntingdon Valley, Pa. 19006).

See CR 0064, I(2), for a complete description of this research. Work planned for the coming year includes: (1) continuation and extension of work exploring changes in the permeability of the brain after exposure to pulsed rf energy, (2) extension of work on behavioral effects of pulsed rf energy and (3) continuation of work on electrical space charge and its bearing on habitability of enclosed spaces. (1/74 - 12/75).

SUPPORTING AGENCY:Office Naval Research.

0097 EFFECTS ON BIOLOGICAL SYSTEMS DUE TO MICROWAVE IRRADIATION. Durney, C. H. (Dept. Electr. Eng., Univ. Utah, Salt Lake City 84112).

See CR 0037, I(2), for description of this research. (Renewed 3/75 -2/76).

SUPPORTING AGENCY:Office Naval Research.

0098 X-RAY AND MICROWAVE RADIATION INTERACTION WITH MUSCLE CELLS; APPLICATION TO PROTECTION AND TREATMENT. Portela, A. (Inst. Biophysics Res., Buenos Aires, Argentina).

See CR 0025, I(1), for description of this research. (Renewed 9/74 - 8/75).

SUPPORTING AGENCY:Office Naval Research.

0099 EVALUATION OF THE SAFETY EXPOSURE LIMITS OF RADAR USED BY NAVAL PERSONNEL. Hunt, E. L. (Battelle Mem. Inst., Richland, Wash. 99352).

See CR 0027, I(1) for further information of this research. Current studies will be limited to behavioral and neurophysiological investigations for the detection and characterization of effects that might be produced by short term exposure to pulsed microwaves at low power levels, 10 mW/cm^2 or less average power, or following chronic exposures to pulsed microwaves at low average levels. Discrimination performances will be tested using operant conditioning procedures. One test will look for a disturbance in the level of performance following exposure. Another will look for disturbances in the learning of a simple discrimination task. Research will continue attempts to verify the avoidance by rats of the pulsed microwave field. Finally, susceptibility to sound-induced seizures will be studied in sensitive and insensitive mice following exposure to pulsed microwaves in a series of daily 3-hr exposures. (Renewed 7/74 - 6/75).

SUPPORTING AGENCY:Naval Medical Res. Dev. Command.

SOURCES:Author, Principal Investigator, or Other

Schmitt, Otto H., Biophysics Group, University of Minnesota, Minneapolis, Minnesota 55455 (612) 373-3345.

Studies of human perception of moderate strength 60 Hz magnetic fields are being continued. After eliminating subliminal clues, there no longer is any striking evidence indicating that humans can perceive moderate strength low frequency magnetic fields, either uniform or gradient. Presently computer-assisted learning experiments are being employed in an attempt to "teach" subjects to recognize the presence of a field. The preliminary data from these experiments do not suggest any earnable magnetic perception ability, but do strongly confirm the ability to learn to perceive previously sub-threshold levels of vibration or sound.

Schwan, Herman P., Professor, Department of Bioengineering, University of Pennsylvania, Philadelphia, Pennsylvania 19174 (215) 594-8533.

"Electric and Acoustic Properties of Biological Material" (Research Grant). Research on the electrical and acoustic properties of biological particles. Present and future emphasis will be on: (a) the behavior of electrodes used for impedance measurements and excitation purposes in physiology and cardiology (pacemakers) in frequency and time domain, with particular emphasis on their nonlinear characteristics; (b) electrical characteristics of macromolecules and water bound to their surface; (c) electrical characteristics of biological and artificial cells and membranes as related to their structure and function; (d) acoustic properties of tissues and biological macromolecules and the reasons why specific absorption varies so considerably from one type to another. The scattering of ultrasound by cells and its contribution to apparent absorption; (e) field induced force effects, particularly alternating field induced forces acting on biological cells and of signficance from either a hazard point of view or with a potential for new biological research techniques.

Stavinoha, William B., Department of Pharmacology, University of Texas Health Science Center, San Antonio, Texas 78284 (512) 696-6416.

In addition to research reported earlier [see CR 0055, I(2)], the following studies are in progress: (1) Research and Reports on Biological Effects of AF Transmitter Near Field (Research Contract); (2) Labile Metabolites, Transmitters in the Heart Cycle (Research Contract); (3) Use of Microwave Radiations for the Study of Brain Neurochemistry (Research Grant).

Takashima, Shiro, Associate Professor, Department of Bioengineering, University of Pennsylvania, Philadelphia, Pensylvania 19174 (215) 594-8537.

The triggering of nerve impulses by use of radiofrequency fields is being investigated. So far, it has been found that continuous ac field has a cut-off frequency about 15-20 KHz. The use of pulsed a.c. waves extends the cut-off to much higher frequencies. (Research Grant)

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