sclerotic process (gross), the extent of invasion of the media by foam cells (microscopic) and the cholesterol content of the aorta wall. The effect of frequencies between 10^5 and 10^9 Hz will be tested as will the effect of a range of field strengths between 0.5 and 50 V/meter. To test the hypothesis that radio frequency irradiation causes arterial wall injury we will study the microscopic anatomy of the irradiated aortic wall in the absence of hypercholesterolemia. We will also study the effects of radio frequency irradiation on blood pressure and serum cholesterol concentration. (9/73-8/74).

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., Natl. Heart & Lung Inst.

0035 RADIOFREQUENCY CORDOTOMY OF THE LUMBOSACRAL CORD FOR RELIEF OF SPASTICITY IN MAN. Katz, M. R. (Temple U. Grad. Sch., Philadelphia, Pa. 19122).

The object of this project is to test the hypothesis that radiofrequency (RF) cordotomy is an effective method of treatment for spasticity of spinal cord origin in man. RF cordotomy of the lumbosacral cord will be induced in each of 3 patients with complete physiological and clinical transection of the spinal cord. Subjects will present severe clinical spasticity of the flexors of the hip, adductor of the hip, and flexor of the knee. (7/72-6/73).

SUPPORTING AGENCY:HEW, Soc. & Rehabil. Serv., Off. Res. Demons. & Trng., Res. & Trng. Ctr. Div.

0036 QUANTITATIVE EFFECTS OF ELECTROMAGNETIC ENERGY ON HUMAN TISSUES. Guy, A. W. (U. Washington Sch. Med., Seattle, Washington 98105).

This study is designed to illuminate areas in which more quantitative information is required to establish realistic safety standards in regard to effects of electromagnetic fields on biological tissues and systems. Animals and human volunteers are exposed to selected sources of electromagnetic energy and electromagnetic field patterns are established quantitatively as a function of frequency, source configuration and source location. Effects on the central nervous systems and other factors such as genetic and behavioral patterns are quantified by engineering and medical technology. The results are as follows: (1) Exposure of cat's head to 918 MHz microwave irradiation increased brain temperature and thus altered central nervous system responses. Recordings from the thalamic area indicate that changes occur only if the exposure level is thermally significant. (2) Fluid filled glass electrodes of ionic concentration other than Ringer's solution (e.g. 4μ), when irradiated with electromagnetic energy, produced artifacts as data. Insulated metal electrodes also yielded unorthodox responses. (3) Filters have been developed to eliminate artifacts in recordings from the brain. (4) Electromagnetic field and heating patterns and absorption of energy have been determined for exposure of the brain and the total body in both humans and animals. (5) Dosimetry instrumentation has been developed to measure fields actually induced in tissues. (7/72-6/73)

SUPPORTING AGENCY:HEW, Soc. & Rehabil. Serv., Off. Res. Demon. & Trng., Res. & Trng. Ctr. Div.

0037 NAVY ENVIRONMENT: EFFECTS ON BIOLOGICAL SYSTEMS DUE TO MICROWAVE IRRADIATION. Durney, C. H.; Lords, J. L. (Univ. Utah, Sch. Engineering, Salt Lake City 84112).

This research investigates the possible damage caused by exposure to low-power microwave radiation. The response of isolated turtle hearts and *in situ* dog hearts will be studied. In addition, development of a nonperturbing temperature probe based on fiber optics illuminating system and a liquid crystal detecting system will be undertaken. Hearts from freshly killed turtles are placed in Ringer's solution and a record of physical and electrical activity taken until stabilization occurs. Microwave power is then delivered to the heart and the activities of the heart recorded. Microscopic studies will then reveal microstructural defects. A waveguide catheter system small enough to be passed into the venous or arterial circulatory system of the dog will be designed. This allows *in situ* irradiation of the interior of the dog heart both acutely and chronically. Temperature sensitive liquid crystals are to be used in conjunction with a fiber optic illuminator-display to possibly develop a nonperturbing probe for temperature measurement in biological media in the presence of a microwave field. (7/73-6/74)

SUPPORTING AGENCY:Off. Naval Res., Dept. of Defense

0038 EFFECT OF MICROWAVE RADIATION ON NERVOUS ACTIVITIES. Kritikos, H. N.; Takashima, S. (Univ. Pennsylvania, Sch. Engineer., Philadelphia 19104).

This research examines the effects of low dose microwave radiation on nervous activities of invertebrates. These effects can be extrapolated to mammals with a considerable degree of assurance. The non-thermal effects of low dose radiation on the central nervous system of mammals has been debated by investigators for many years with considerable divergence of opinion. Nervous activities are based on intricate neuron networks that can be disturbed by even low dose microwave radiation. Experiments have resulted in evidence of symptomatic disorders in human subjects. With low dose irradiation, changes in behavioral patterns such as irritability, headache and memory difficulties have been observed. This research will aid in understanding the complex relationships that exist in this area. (8/73-7/74)

SUPPORTING AGENCY:NSF, Div. Engineer.

0039 MIXED RF/IONIZING RADIATION EFFECTS. Krupp, J. H. (U.S. Air Force, Sch. Aerospace Med., San Antonio, Texas 78235).

The effect of combination ionizing and nonionizing radio frequency (RF) fields will be investigated in experimental animals. The animals will be housed in a climate controlled, low dose rate facility which will allow exposure to any desired continuous dose rate between 100 millirad and 20 rad per day, either alone or simultaneously with radio frequencies ranging from 40-400 MHz and 1-3.5 GHz. This facility can be used to test such parameters as performance capabilities on trained tasks, hematological and biochemical variations and organ function tests. Because air crew and other personnel will be exposed to combination ionizing and nonionizing RF fields in operations involving high altitude, nuclear propulsion and isotope power sources, subclinical injury and long term delayed effects of RF fields must be evaluated. The findings of this study will be correlated with available human data, including the Oak Ridge Facility, in an attempt to make realistic extrapolations to humans. (7/73-6/74)

SUPPORTING AGENCY:USAF Sch. Aerospace Med., Dept. of Defense

0040 COMBINED STRESS STUDIES IN HF BAND FIELDS. Cupello, J. M. (USAF, Sch. Aerospace Med., Brooks AFB, San Antonio, Texas 78235).

The objective of this effort is to evaluate biological responses under combined temperature and radio frequency (RF) radiation stress. Plexiglas environmental chambers will be designed and constructed for experimental animals undergoing RF radiation exposure. These chambers will permit control of temperature and relative humidity. The effects of heat stress on the animal during RF radiation exposure, which overburdens the heat dissipation mechanism, will give an indication of effect of combined stress in RF fields. Monitoring of the chamber's input and output temperature and relative humidity will allow quantitation of the amount of heat generated which is due to RF radiation. Larger chambers will be constructed at a later date to perform this same study on *rhesus* monkeys. Results will be applied to exposure standards for Air Force personnel. (7/73-6/74)

SUPPORTING AGENCY:USAF Sch. Aerospace Med., Brooks AFB

0041 BIOLOGICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS. Skidmore, W.; Brunhart, G. (Armed Forces Radiobiol. Res. Inst., Bethesda, Maryland 20014).

The objective of this research is to determine biological hazards associated with long term exposure to electromagnetic pulsed fields (EMP). Sixty male leukemia-prone mice (AKR-J), 20 mammary tumor-prone female Sprague-Dawley rats and 150 male rats to be serially sacrificed for bioassay data will be exposed continously (23 hr/day) in an EMP field for approx 1 yr. An equal number of animals will serve as controls. The exposure will consist of 1 pulse/second with a peak field intensity up to 500 KV/M and a mixed frequency component up to 100 MHz. Data will be evaluated to determine if any abnormal biological effects such as an increased incidence and rate of neoplasms, changes in hematological parameters, increased chromosomal aberrations, etc., occurred during the exposure period. Results will be applied to potential occupational hazards associated with long term exposures to electromagnetic pulsed fields. (7/73-6/74).

SUPPORTING AGENCY:Armed Forces Radiobiol. Res. Inst.

0042 CYTOGENETIC EFFECTS OF MICROWAVE RADIATION ON CHINESE HAMSTERS (VARIABLE POWER DENSITY). Everts, J. M. (Natl. Environ. Res. Center, Durham, N.C. 27711).

The contract for this project was renewed for 7/73-6/74. Please refer to abstract #0033, page 35 in Volume 1, Issue 1 of the *Biological Effects of Electromagnetic Radiation Digest* for a project description.

SUPPORTING AGENCY:EPA, Off. Res. and Dev.

0043 EMP EFFECTS ON CARDIAC PACEMAKER. Brunhart, G. (Armed Forces Radiobiol. Res. Inst., Bethesda, Maryland 20014).

This study will seek to determine (1) the physiological effects of EMP interference on electronic cardiac pacemaker wearers and (2) the physical effects on the pacemaker circuits and components. A literature search will be conducted. Both a hypothesized model and mathematical analysis will be used to predict effects. Bench testing and *in vivo* testing will be carried out to verify the model. At each stage of testing, the model will be modified as necessary. (7/73-6/74)

SUPPORTING AGENCY:Armed Forces Radiobiol. Res. Inst.

0044 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Univ. Washington, Med. Rehabil. Res. Tr. Ctr., Seattle 98105).

Test animals are exposed to selected sources of electromagnetic energy to quantify observable effects and biological changes. The electromagnetic field patterns, both in and near the tissue structures, are quantitatively established as a function of frequency, source of configuration and source location. Progress in the project is as follows: (1) Power absorption patterns have been measured in cat brains, rat bodies, and rabbit heads and eyes. Physiological changes were noted in the tactile and auditory systems of cats. Equivalent changes were noted when a cat's head was heated using a non-microwave heating-heat exchanger. Radiation changes can be counteracted by cooling the affected tissues. (2) Cataracts were produced by microwaves near the posterior pole of the rabbit eye lens at microwave power levels producing temperatures at 42 C. (3) Non-

thermal levels of pulsed microwaves were noted to produce auditory sensations in humans at pulse energy densities of 20-40 Microfarads/cm^2. Experiments on cats show that the microwave pulses stimulate the auditory system via the inner ear. (4) The electrical characteristics of isolated peripheral nerves of frogs and cats under controlled temperature conditions did not change under radiation power levels as high as 4 watts/cm^2 as long as the temperature was kept constant. Data from this research indicate that microwaves may be used to transmit energy safely through tissue from the outside to power implanted microsize nerve stimulators. Implanted packages as small as a cubic millimeter appear to be feasible for nerve stimulation to block pain or activate denervated muscles. The project hopes to provide realistic guidelines for safety standards related to human exposure to electromagnetic radiation. (7/73-6/74)

SUPPORTING AGENCY:HEW, Soc. Rehabil. Serv., Off. Res. Demons. Trng., Res. Trng. Ctr. Div.

0045 CYTOGENETIC EFFECTS OF MICROWAVE RADIATION ON TISSUE CULTURE. Everts, J. M. (Natl. Environ, Res. Ctr., Durham, N. C. 27711).

The contract for this project was renewed for 7/73-6/74. Please refer to abstract #0026, page 34, in Volume 1, Issue 1 of *Biological Effects of Electromagnetic Radiation Digest* for a project description.

SUPPORTING AGENCY:EPA, Off. Res. and Dev.

0046 NAVY ENVIRONMENT: MUTAGENIC EFFECTS DUE TO MICROWAVE RADIATION GENERATED BY NAVAL OPERATION. Varma, M. M.; Joshi, S. R. (Howard Univ., Sch. Engineering, Washington D. C. 2001).

This research will evaluate the mutagenicity of microwaves as a function of frequency, exposure time and power level. The testes of male mice will be irradiated. To avoid struggling during restraint, the mice will be anesthetized with phenobarbital. After each exposure the males will be mated with three unexposed virgin females for five days. The females will be replaced weekly for a total of eight consecutive weeks. Mated females, as evidenced by the presence of a vaginal plug will be dissected on the thirteenth day of the pregnancy and the total number of implants, viable implants, and early and late foetal deaths will be recorded. The results will be compared with concurrent control groups. Adverse genetic effects will be studied by observation of the F_1, F_2 and F_3 progeny of exposed male mice. (7/73-6/74)

SUPPORTING AGENCY:Off. Naval Res., Dept. of Defense

0047 RADIO FREQUENCY HEAT FOR CANCER THERAPY. Edwards, W. S.; Doss, J. D.; Weiss, G. K.; Key, C. (Univ. New Mexico, Sch. MEd., Albuquerque 87106).

Recent reports from several investigators suggest that malignant cells are as much as twice as susceptible to heat as corresponding normal cells. Clinical trials in the last twenty years have demonstrated that superficial tumors do respond to heat, but its usefulness could not be thoroughly explored because there was no way to localize heat to volumes of tissue beneath the skin or mucous membranes. Radiofrequency current offers such an opportunity. Preliminary experiments have shown that a standard sarcoma transplanted to mice can be made to disappear without damage to the overlying skin using heat generated by radiofrequency current and these tumors have not recurred in a six month period of follow-up. We plan to explore this further to determine very carefully the dose response curve of this tumor by varying the temperature and time of exposure. We will then determine the dose response curve of normal skin, mucous membrane and many other organs and tissues. We have developed an animal tumor referral system that will allow us to test the effectiveness of radiofrequency current on many spontaneous malignancies in dogs, cats and mice and to facilitate the development of radiofrequency electrodes for internal as well as external therapy. The combination of surgical removal of the bulk of tumors, then treatment of the residual with radiofrequency heat will also be tested. (1/74-12/74)

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., Natl. Cancer Inst.

0048 EFFECTS OF MICROWAVE RADIATION ON GROWTH AND DEVELOPMENT OF EMBRYO CELL SYSTEMS. Barnes, F. S.; Gamow, E. (Univ. Colorado, Sch. Engineer., Boulder 80302).

Irradiated chick embryos will be observed and assayed in order to detect growth cycle related deviations which may exhibit some degree of latency. A microwave system will be designed and constructed for the irradiation of the embryos such that the energy field incident on the test specimen is known and reproducible. Exposures will be made at varying times of development, with emphasis on critical periods of organ system differentiation. Microscopic examination will be made as indicated on embryos dying prematurely, and routinely on selected embryo systems. Of particular interest would be areas of tissue containing those highly specialized cells which are determinants for vital organ structures, e.g. neural crest cells and cardiovascular precursors. Cell cycle studies will be used to evaluate the existence of microwave resistant or sensitive phases in cellular metabolism. Standard biophysical techniques will be employed in cell culture production and evaluation. Exposures at various phases of cell growth will be utilized to assay the possible nonthermal effects of RF radiation on cell growth kinetics. Data will be used to establish safety criteria and operational procedures for Air Force personnel. (7/73-6/74)

SUPPORTING AGENCY:USAF Sch. Aerospace Med., Brooks AFB

0049 SCIENTIFIC AND TECHNICAL PROGRAMS FOR

MONITORING OF ENVIRONMENTAL RADIATION LEVELS AND INVESTIGATION OF BIOLOGICAL EFFECTS. Sharp, J. C. (U.S. Army Reed Inst. Res., Washington D. C.).

The contract for this project, formerly headed by H. M. Grove, was renewed for 7/73-6/74. Please refer to abstract #0028, page 34 in Volume 1, Issue 1 of the *Biological Effects of Electromagnetic Radiation Digest* for a project description.

SUPPORTING AGENCY:EPA, Off. Res. and Dev.

0050 INVESTIGATION OF RADIO FREQUENCY AND MICROWAVE RADIATION INDUSTRY. Conover, D. (HEW Publ. Hlth Serv., Cincinnati, Ohio 45202).

Current OSHA Regulations include occupational exposure limits for RF/Microwave radiation over the frequency range from 10 MHz to 100 GHz. Instrumentation is not available for detecting hazardous exposure levels for non-ionizing radiation with frequencies below 300 MHz. Little is known about the biological effects of RF/Microwave radiation on humans at assigned industrial, scientific and medical (ISM) frequencies of 13, 27, and 40 MHz; however, industrial uses of these frequencies are rapidly increasing. Consequently a survey of application of 13, 27 and 40 MHz radiation in industry is planned to determine the potential limits for occupational exposure and to identify health and safety problems experienced as a result of these uses. Efforts will also be made to develop a monitoring instrument for use over the 10 MHz to 300 MHz frequency range. (7/73 - 6/74)

SUPPORTING AGENCY:HEW, Publ. Hlth Serv., Natl. Inst. Occupational Saf. Hlth.

0051 GENETIC EFFECTS OF MICROWAVE RADIATION ON CHINESE HAMSTERS. Everts, J. M. (Natl. Environ. Ctr., Durham, N. C. 27711).

The contract for this project was renewed for 7/73-6/74. Please refer to abstract #0014, page 31, in Volume 1, Issue 1 of *The Biological Effects of Electromagnetic Radiation Digest* for a project description.

SUPPORTING AGENCY:EPA, Off. Res. and Dev.

0052 DEVELOP AND VALIDATE EQUATIONS TO ALLOW EXTRAPOLATION OF RF ANIMAL DATA TO MAN FOR HAZARD ASSESSMENT PURPOSES. Guy, A. W. (Univ. Washington, Sch. Med., Seattle 98105).

The purpose of this effort is to develop mathematical models of the interaction of electromagnetic fields with man. These equations are necessary because of the increased recent concern about electromagnetic pollution of the environment and possible deleterious effects on humans. Accurate prediction of power deposition and distribution coupled with thermal flux equations are necessary elements for formulating AF safety criteria. Known tissue conductivities, dielectrics and loss tangents will be used to model electromagnetic interactions with a two-meter 70 kg normal man. Thermal flux equations will be utilized to determine rates of heat flux away from sites of dielectric discontinuity and predict temperature changes of those sites. The gross core temperature change can be determined, in principle, by integrating heat flux from such sites and comparing it with normal heat loss mechanisms. Considerable difficulties are introduced by the lack of formal conformation of man or other animals. Such departures from regular ellipsoidal objects introduces great difficulty in finding general solutions for appropriate field equations, and will probably necessitate a semi-empirical approach to some partial solutions. For this reason, elementary circuit analysis, heat flux and circulatory dynamics within published state-of-the-art are the purpose of this effort. A later effort, based on equations developed here, will be undertaken to refine frequency domain interactions and field vector interactions. (7/73-6/74)

SUPPORTING AGENCY:USAF Sch. Aerospace Med., Brooks AFB

0053 NAVY ENVIRONMENT: X-RAY MICROWAVE RADIATION INTERACTION WITH MUSCLE CELLS. APPLICATION TO PROTECTION AND TREATMENT. Portela, A.; Perex, J. C. (Consejo Nac. De Inv. Cien. Tec., Buenos Aires, Argentina).

The contract for this project was renewed for 7/73-6/74. Please refer to abstract #0024, page 33 in Volume 1, Issue 1 of the *Biological effects of Electromagnetic Radiation Digest* for a project description.

SUPPORTING AGENCY:Off. Naval Res., Arlington, Virginia

0054 BIOLOGICALLY IMPORTANT RF POWER ABSORPTION MEASUREMENTS FOR SAFETY CRITERIA. Howell, W. A. (Block Engineering Inc., Cambridge, Massachusetts 02139).

Molecular level perturbations caused by radiofrequency (RF) fields will be measured. Genetic or long term effects of RF radiation, if any exist, must ultimately affect at least one of the large molecular species important in cell function. Consequently, the effects of RF fields on large molecular species in a water solution will be studied. Only a water solution, whose constituent subunit (nucleotides or amino acids) is well-documented and which can be obtained in highly pure form will be used. These substances including pure RNA-ase, pure virus RNA, nucleotides, amino acids, and poly amino acids are to be dissolved in aqueous buffers and subjected to RAMAN determination of group vibrational amplitudes during application of RF fields and programmed temperature changes. Any effects of RF fields should be revealed in resonant line broadening and in alteration of polarization dependence or resonant absorption. Frequencies will range from 3 to 100 MHz with electric field equivalent to 3 KV/meter. Data will be used to formulate hazard criteria and safety

standards. (7/73-6/74)

SUPPORTING AGENCY:USAF Sch. Aerospace Med., Brooks AFB, Texas

0055 STUDY OF BRAIN METABOLISM THROUGH MICROWAVE HEATING. Stavinoha, W. B.; Medina, M. A. (Univ. Texas, Sch. Med., San Antonio, Texas 78229).

Microwave radiation will be used to accomplish brain enzyme inactivation times of 1.5 seconds in the rat and 0.3 seconds in the mouse. Using this technique, studies of intermediary metabolism, cyclic nucleotide and the cholinergic system in whole brain and brain areas will be carried out. The effect of morphine will then be studied in this system. Further works will be done to decrease the microwave exposure time and to adapt the system to sacrifice unrestrained rats.

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

0056 STUDY OF GENETIC EFFECTS OF MICROWAVE RADIATIONS. Hungate, F. P.; Felix, W. D.; Hunt, E. L. (Battelle Mem. Inst., Richland, Washington 99352).

A sensitive method of evaluating the dose absorbed during exposures to 2450 microwaves has been established by measuring light emission from a suspension of luminescent bacteria stabilized in a nondividing form. Mutation frequencies are measured in these bacteria subsequent to exposure by the method of auxotroph reversion. This exposure system will be used to study forward mutation among the genes controlling light emission by identifying the frequency of colonies on plates which emit light at 23 C but not at 37 C. Since cell division and mutation are related, an exposure procedure will be developed in which light emission can be followed in growing cells during microwave exposures. This will enable one to evaluate mutation in dividing cells and also to chronically expose cells to lower dose rates over longer time periods. To make the data more representative of diverse species, other microorganisms whose genetics have been more extensively studied will be exposed under conditions identical to those used with the luminescent organisms and the mutation frequencies will be evaluated. A continuous wave source is sought for attachment to the exposure chamber. If one is obtained, mutation frequencies produced by continuous as well as pulsed sources will be compared. The same techniques of measuring absorbed dose will be utilized for both. (2/74-1/75)

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv., FDA, Bur. Foods

0057 BIOLOGICAL EFFECTS OF VLF BAND ELECTROMAGNETIC RADIATIONS. Birgel, S. H. (SW Res. Inst., 8500 Culebra Rd., San Antonio, Texas 78228).

The objective of this project is to determine the observable effects of very low frequency (VLF) radiation on growth, reproduction, tumorigenesis, lymphocyte division, gross biochemistry or pathology of mice. Since existing safe level determinations (10 MW/cm^2), used for the entire nonionizing portion of electromagnetic (EM) spectrum, are based on very high microwave frequency studies they do not reflect the extremely low biological power absorption associated with low and VLF radiation. A well-documented (C^3H) strain of mice will be obtained as pregnant dams. The litters will be divided and the total number controlled such that litter mates will serve as nonradiated controls. Throughout life a daily radiation schedule (minimum 1 hr/day) will be followed. Radiation fields are to be produced in a coil-capacitor arrangement allowing development of 15 KV/meter fields. A variety of models in addition to the liver animals will be observed with thermography and temperature detectors. Animals will donate lymphocytes for culturing; examination will be made for chromosomal abnormalities, growth curve changes, food and water consumption, and urinary output throughout the experiment. Radiated animals are to be bred and the offspring examined for any abnormalities, including growth. All animals are to be screened for pathological changes during the course of the experiment. Data will be used to formulate operational safety criteria. (7/73-6/74)

SUPPORTING AGENCY:USAF Sch. Aerospace Med., Brooks AFB, Texas

0058 NAVY ENVIRONMENT: NON-THERMAL HAZARDS OF EXPOSURE TO RADIO FREQUENCY AND MICROWAVE FIELDS. Mickey, G. H. (New England Inst. Inc., Ridgefield, Conn. 06877).

The contract for this project was renewed for 7/73-7/74. Please refer to abstract #0012, page 31 in Volume 1, Issue 1 of the *Biological Effects of Electromagnetic Radiation Digest* for a project description.

SUPPORTING AGENCY:Off. Naval Res.

0059 THE EFFECTS OF EXTREMELY LOW FREQUENCY (ELF) RADIATION ON MAN. Beischer, D. E.; Grissett, J. D. (U.S. Navy, Aerospace Med. Res. Lab., Pensacola, Florida 32512).

Possible biological effects of extremely low frequency radiation (ELF) will be investigated. Controlled systematic laboratory exposure tests will progress in stages using a frequency below 100 Hz: (1) short-term exposure of lower primates and then human volunteers and (2) several months of ELF radiation exposure. In each case physiological and psychological tests will be used to measure metabolic effects, autonomic nervous system responses and central nervous system performance. The results of the project will provide an urgently needed database which the Navy can employ in establishing safe operational standards. (7/73-6/74)

SUPPORTING AGENCY:Dept. Defense, Navy

0060 EFFECTS OF MICROWAVES ON CNS, LIVER AND HEART. Albert, E. N. (George Washington Univ. Sch. Med., Washington D.C. 20037).

The purpose of this project is to investigate the ultrastructural effects of 2450 MHz microwaves on the central nervous system, heart and liver of Chinese hamsters. The animals will receive whole body irradiation at various power densities. They will then be sacrificed and prepared for morphological observations. Total synthesis and utilization of ATP and protein per gram of tissue will be measured in control and experimental animals. (10/73-9/74)

SUPPORTING AGENCY:HEW, Publ. Hlth. Serv.

0061 MICROWAVE DOSE-RESPONSE RELATIONS ON TWO BEHAVIORAL TASKS. Galloway, W. D. (Bur. Radiol. Hlth., Rockville, Maryland 20852).

The objective of this project was to determine if microwave irradiation at 2450 MHz continuous wave of a rhesus monkey head would produce a behavioral change and if this change was dose related. Two rhesus monkeys were trained on a repeated acquisition task for 39 days at which time an irradiation series was initiated. Irradiation was performed in the experimental chamber via a helmet facility immediately prior to the behavioral test session. Integral dose rates of 10, 15, 20 and 25 W were administered randomly at least twice during the 100-day irradiation series. Duration of irradiation was two minutes or until convulsion began. Two sets of reinforcements schedules were tested under similar irradiation conditions. Under FR, reinforcement occurred after every 4th correct response, while under VR it occurred on the average for every 4th correct response. Results showed that under VR conditions, irradiations at 25 W consistently produced deficits in performance. Irradiation at lower power levels produced smaller deficits in performance in the early part of the session. The effects on FR performance were less dramatic. Performance following irradiation fell within the range of normal performance except during the first 10 trials after 25 W. (Duration of contract not known.)

SUPPORTING AGENCY:DHEW, FDA, BRH, NSS

0062 MICROWAVE RADIATION EFFECTS ON SIMPLE DISCRIMINATION AND GENERALIZED TASKS. Galloway, W. D. (Bur. Radiol. Hlth., Rockville, Maryland 20852).

The objective of this project was to investigate the effects of microwave radiation using a 2450 MHz continuous wave diathermy type applicator on the performance of a simple discrimination and generalization task. Four rhesus monkeys were trained on a VI-DRO schedule until baseline responding was reached. This schedule was maintained over a nine month period during which approximately 2-minute doses of irradiation at 5, 10, 15 and 20 watts were delivered twice each prior to a normal session. Following this series of random irradiation, two generalization tests were given, one with 10 watts and the other without radiation. T-tests for differences between control day vs experimental (radiation) day showed no significant results for VI-DRO schedule. Generalization data showed a significant radiation effect, but this interference is unreliable as there is evidence of an important dependence on the response to radiation in the animal being tested. (Duration of contract not known.)

SUPPORTING AGENCY:DHEW, FDA, BRH, NSS

0063 BEHAVIORAL SUPPRESSION BY 383 MHz RADIATION. Cunitz, R. J.; Galloway, W. D.; Berman, C. M. (Bur. Radiol. Hlth., Rockville, Maryland 20852).

The objective of this study was to determine whether microwave radiation via 383 MHz resonant cavity, affected performance on a four-choice, forced choice serial reaction task. Two rhesus monkeys were irradiated for 1 hr immediately before and during performance on the task which then lasted a maximum of 2 hr. Integral dose rates of 0.001 through 17.5 W were delivered to the head. No effects were observed below a critical dose level (≈23 W/kg) derived from integral dose rate and body mass. Above this level, behavioral suppression occurred, i.e., correct response rate was profoundly altered. The effect was completely reversible and repeatable in one of the subjects; the other subject did not recover completely and was sacrificed for histological examination which revealed no gross or microscopic damage. The nature of the effect suggests a neurochemical rather than a direct electrical or mechanical basis for the results. (Duration of contract not known.)

SUPPORTING AGENCY:DHEW, FDA, BRH, NSS

0064 PERSONNEL TECHNOLOGY: THE EFFECTS OF IONIZED AIR AND RADIO ENERGY UPON THE PERFORMANCE OF NAVAL PERSONNEL. *(E.)* Frey, A. H. (Randomline Inc., Willow Grove, Pennsylvania 19090).

This work is concerned with the effects of exposure to radio frequency energy and ionized air on the neutral activity and behavior of naval personnel. Work planned for the coming year includes (1) further work with air ions emphasizing the mechanisms of effect on behavior and brain chemistry; in particular, the effect of positively charged ions and (2) extention of work in motivational effects of RF energy possibly using fluorescence techniques to study neural changes and relate them to behavioral changes. (7/73-6/74)

SUPPORTING AGENCY:US Department of Defense, Navy

0065 BIOPSYCHOLOGICAL STUDY OF MICROWAVE

IRRADIATION. *(E.)* Justesen, D. R. (Univ. Kansas, Sch. Med., Kansas City 66101).

The following description records the observations of this project to date. Murine subjects were irradiated in a modulated 2450 MHz microwave field. It was observed that dosing rates of energy just above the threshold of sensory detection (2 mW/g) or 5 times greater (10 mW/g) were associated with rises in colonic temperature which paralleled temperatures engendered by near threshold (and 2 times greater) electrical shocks to the feet. Radiation and footshock, taken in combination, were additive with respect to the amplitude of the evoked thermal response. Anesthetized animals exhibited little thermal reaction to either class of stimulation. The evoked thermal response thus shares with the electroencephalogram (EEG) the capability of indexing emotional arousal and central nervous system reactivity to "novel" stimuli. (6/74-5/75)

SUPPORTING AGENCY:USD HEW, PHS, FDA, BRH

0066 BIOLOGICAL EFFECTS OF AIR FORCE TRANSMITTER NEAR FIELDS. *(E.)* Stavinoha, W. B.; Medina, M. A. (Univ. Texas. Sch. Med., San Antonio, 78229).

The independent and synergistic effects of high frequency band (3-30 MHz) magnetic and electric field vectors will be studied and assessed in a variety of biological systems using the United States Air Force "near-field" radiation simulator. A large variety of mammalian systems are to be exposed in the simulator and studied to detect any possible alterations in (1) growth and reproduction, (2) central nervous system (neurotransmitter turnover, brain nucleotide levels, brain cyclic AMP assay), (3) endocrine status (corticosteroid assays depending on experimental animal, water balance, VMA, norepinephrine and epinephrine analysis), (4) hematology in Primates and (5) liver and renal functions. In selected animals specific examination of the heart will be undertaken. Such information is required to establish personnel exposure criteria in close proximity to Air Force High Power Radiofrequency radiation emitters operating in the frequency range of approx. 3-500 MHz. (7/73-6/74)

SUPPORTING AGENCY:US Department of Defense, Air Force

0067 PERSONNEL TECHNOLOGY: OCEAN ENGINEERING AND BIOMEDICAL RESEARCH. *(E.)* Wheeler, E. J. (Wheeler Industries, Inc., Washington, D.C. 20036).

The objective of this work is to provide technical assistance with Navy biomedical programs related to electromagnetic radiation and deep submergence. A "Deep Submergence Biomedical Workshop" will be held in addition to meetings on the biomedical effects of electromagnetic radiation. New and existing Navy programs will be reviewed utilizing information gained from the workshops and meetings and recommendations for program changes will be made. (7/73-6/74)

SUPPORTING AGENCY:US Department of Defense, Navy

0068 QUANTITATIVE EFFECTS OF EM ENERGY ON HUMAN TISSUE. *(E.)* Guy, A. W.; Lehman, J. F.; Lin, J. C.; Taylor, E. M.; Emery, S. F. (Univ. Washington, Sch. Med., Seattle 98105).

Interdisciplinary theoretical and experimental investigations are proposed to further advance the current knowledge of electromagnetic (EM) interaction with the human body. Of particular interest are (1) the quantitative effects of EM energy on the neural, circulatory and respiratory physiology, (2) the mechanisms of interaction, (3) the absorption of EM energy by humans and animals as a function of body size and source frequency, (4) the thermal significance and/or consequences of total or partial body exposure to EM radiation, and (5) the establishment of safety guidelines for patient and health care personnel during therapeutic usage of EM devices. The emphasis of these studies is on the accurate determination of dose-effect observations and quantitative extrapolations of animal experimentation to human exposure. (6/74-5/75)

SUPPORTING AGENCY:US DHEW, PHS, FDA, BRH

0069 CARDIAC OUTPUT MEASUREMENT BY MEANS OF RF ATTENUATION MEASUREMENT. *(E.)* Frazer, J. W. (US Air Force Sch. Aerospace Med., San Antonio, Texas 78235).

The objective of this effort is to develop a microwave attenuation measurement capable of detecting changes in cardiac output in adverse Air Force environments without disturbing the subject. Cardiac/heart output determinations are necessary to acquire physiological data on which to base safe exposure criteria for Air Force operational environments. Present means of cardiac output measurement in high acceleration or radiation environments depend on vascular intervention with subsequent laboratory analysis of blood or respiratory gases. Alternatively, the subjects are exposed to appreciable doses of ionizing radiation for chest fluoroscopy with subsequent film development and analysis. Scanned frequency RF measurements of the chest will be followed by interferometry at selected wavelengths. (7/73-6/74)

SUPPORTING AGENCY:US Department of Defense, Air Force

0070 EFFECTS OF SEROTONIN-INHIBITING DRUGS ON THE PERFORMANCE OF ANIMALS UNDERGOING RADIO FREQUENCY (RF) IRRADIATION. Galloway, W. D. (Bur. Radio. Hlth., Rockville, Maryland 20852).

Previous research has suggested that decreases in behavioral output resulting from 383 MHz radio frequency radiation may be due to alterations in brain levels of certain neurohumors. This hypothesis is investigated by examining the effects of parachlorophenylalanine and fenfluramine at various dosages on the performance of RF irradiated monkeys. The behavioral baseline

is a four-choice, forced choice serial reaction task. (Duration of contract not known.)

SUPPORTING AGENCY:DHEW, FDA, BRH, XSB, NSS

SOURCES:Author, Principal Investigator, or Other

Ashwood-Smith, M. J., Acting Chairman, Department of Biology, University of Victoria, Faculty of Arts and Sciences, P.O. Box 1700, Victoria, B.C., Canada V8W 2Y2 (604)477-6911, Local 737.

"Preservation Studies at Low Temperature of Cells and Organs with Special Reference to the Effects of Pluronics and Microwave Thawing" (Research Grant). The usefulness of microwave thawing in studies on the freeze preservation of cells, tissue and organs will be investigated.

Cohen, B. H., Professor, Department of Epidemiology, John Hopkins University, School of Hygiene and Public Health, 615 North Wolfe Street, Baltimore, Maryland 21205 (301)955-3977.

Current research activities in biological effects of nonionizing electromagnetic radiation (microwave and radio frequency radiation) include (1) completion of analysis of data on microwave exposure of fathers of a group of children with Down's syndrome and matched controls and (2) ancillary study of screening of blood samples from fathers with a history of microwave exposure and matched unexposed controls to determine whether there are any discernable differences in chromosome abnormalities.

Fanslow, G. E., Associate Professor, Electrical Engineering and Engineering Research Institute, Iowa State University, 122 Coover Hall, Ames, Iowa 50010 (515)294-6576.

Proposals for funding are being prepared to cover work in the soil, the effects on eggs treated to sub-ovicidal pulses and possible side effects on other organisms.

Foster, K. R., Biophysicist, Naval Medical Research Institute, Biophysics Division, National Naval Medical Center, Bethesda, Maryland 20014 (301) 295-0372.

Present research activities are related to the "microwave hearing" effect. Results indicate that this effect arises from the perception, by bone conduction, of thermally generated sound transients in the subject's head.

Houk, W. M., LCDR MC USN, Naval Aerospace Medical Research Laboratory, Biomedical Sciences Division, Pensacola, Florida 32512 (904)452-2556, Ext. 2557.

Detailed investigations are being made into metabolic, thermoregulatory and neuroendocrine responses of small mammals (rodents) to microwave radiation exposure. All responses are related to time and intensity of exposure. Particular emphasis is being placed on field pattern description in the presence of the experimental animal, and in relating energy incident to energy absorbed. After the end-points have been derived, attempts will be made to elicit mechanisms of biological response by simultaneously raising or lowering environmental temperature while irradiating the animals and studying the responses produced.

Mickey, G. H., Senior Scientist and Dean of Graduate School, The New England Institute, Cytogenetics, 90 Grove Street, P.O. Box 308, Ridgefield, Conn. 06877 (203)438-6591.

"Non-Thermal Hazards of Exposure to Radiofrequency and Microwave Fields" (Research Contract). Objectives of this project are (1) to determine the tolerance limits of exposure to radiofrequency and microwave fields; the amount of exposure mammals (including man) may withstand with no appreciable injury, (2) to study the physical parameters involved in determining these limits-such factors as frequency, average power, peak power, pulse rates, integrated exposure time, recovery time between exposures, and biological characteristics of the test species including their relation to man.

Nelson, S. O., Research Leader, U.S. Department of Agriculture, Agricultural Research Service, Room 5, Agricultural Engineering, University of Nebraska, Lincoln, Nebraska 68503 (402)472-2945; (402)475-3616, FTS

The use of radiofrequency and microwave energy for the control of stored-grain insect species and treatment of seeds to improve germination is being studied. Measurements are being made of the dielectric properties of insects and grain over a wide range of frequencies (audiofrequencies through X band and K band). While observed effects on insects appear to be mainly of thermal origin, possible nonthermal biological effects are of interest because confirmed athermal effects detrimental to insects would be of value in improving the effectiveness of insect-control treatments.

Varma, M. M., Professor and Director, Bio-Environmental Engineering and Sciences, Howard Univ., School of Engineering, 2300 Sixth Street, N.W., Washington D.C. 20059 (202)636-6574.

Toxicology studies were performed by exposing the testes of anesthetized 56 day old male mice, at 1.7 and 3.00 GHz, the power densities were 10 mW/cm^2 and 50 mW/cm^2, for each frequency. The exposure time varied from 5 min to 180 min. Mating studies based upon toxicology studies are being conducted at LD_{50}, LD_{10}. Each male is mated with 3 unexposed virgin females for one week; the females are replaced each week for 6 consecutive weeks. All females are autopsied on Day 13, and scored for pregnancy and the total number of implants (comprised of living implants and late fetal deaths); the latter appearing as small black decidumata. Results are compared with concurrent control groups.

Osaka, A., Chief of Second Internal Medicine, Sapporo Hosp., North 1st, West 9th, Hokkaido, Japan, 060, 261-2281.

Current research activities involve the effect of microwave radiation on malignant tumors. Malignant tumors induced on rats by injection of methyl-cholanthren were exposed to microwave radiation. As an example, a mass about 4 cm in diameter was cured completely by one exposure to radiation, the coagulated necrotic tumor tissue falling off afterwards.

Oscar, K. T., Senior Physicist, Army Mobility Equipment Research and Development Center, Military Technology Department, Fort Belvoir, Virginia 22060 (703)664-5606, 664-5740.

Current research seeks to identify specific physiological or behavioral responses caused by microwaves and to get dose response data on them as a function of frequency, dose (power density, time) and animal specie. Approximately 90% of this effort is contracted out. A small in-house effort is being carried out on the phenomena of RF sound.

Phillips, R. D., Research Associate, Battelle, Pacific Northwest Laboratory, Biology Department, P.O. Box 999, Richland, Washington 99352 (509)946-2269.

Present studies are concerned with the behavioral and physiological effects of pulsed microwaves.

Rabinowitz, J., Associate Research Scientist, New York University Medical Center, Institute of Environmental Medicine, 550 First Ave., New York, New York 10016 (212)679-3200, Ext. 5247.

The mechanisms for the basic interactions between microwave radiation and biological molecules, along with possible functional implications, have been considered. Specific systems are being investigated where biological changes induced by microwave radiation suggest possible functional changes on the molecular level. The systems are: (1) uptake of ascorbic acid by the rabbit lens; (2) uptake of known actively transported compounds in rabbit lens; (3) activity of acetylcholinesterase; (4) cation transport in red blood cells.

Milroy, W. C., Head, Biomedical Research Team, Naval Weapons Laboratory, Weapons Safety Division, USNWL, Biomedical Research Team, Code ESR, Dahlgren, Virginia 22448, (703)663-7139.

The Special Effects Biomedical Research Department is concerned with the health and safety of personnel exposed to nonionizing electromagnetic radiation, particularly high peak power pulse systems. Our research includes a medical surveillance program and animal experimentation. Current research is being done on reproduction and longevity, hepatic enzymes, hematology, and behavioral factors. Programs which are being initiated include cell cycle timing, biorhythms, and neurochemical and neuroelectrical activity.

Mitchell, J. C., Chief, Radiation Physics Branch, USAF School of Aerospace Medicine, Radiobiology Division, Brooks AFB, San Antonio, Texas 78235 (512)536-3582.

The Radiobiology Division (RA) of the USAF School of Aerospace Medicine is the AF office of primary responsibility for all microwave and radiofrequency radiation bioeffects research. The school has unique HF band (3-30 MHz) exposure and measuring capabilities including a large (nominal 2x3x10 meter) coaxial waveguide for uniform "far-field" exposures and a "near-field" radiation simulator for studying E- and H-field bioeffects. A complete series of E- and H-field measuring probes and a differential power absorption measuring system, all designed and calibrated by the National Bureau of Standards, are routinely used in the School's bioeffects studies. The School's RF facilities also includes a 40-400 MHz exposure strip line, an anechoic chamber and both MCL and Cober generators to cover the frequency range from 30 MHz to 14 GHz. The in-house RF research includes studies of rodent growth rate, water metabolism in rodents, gross oxygen uptake, subcellular distribution of divalent metals, lymphocyte division, neurotransmitter turnover in the brain, and thermal distribution. The School's RF contract program includes studies of the effects of VLF band radiation, electric and magnetic effects of HF band fields on isolated macromolecules, biological effects of high amplitude pulsed fields, thermal distribution of absorbed power in man models, and frequency dependence of power absorption.

Mittler, S., Professor of Biological Sciences, Northern Illinois University, Department of Biological Sciences, DeKalb, Illinois 60115 (815)753-1884.

Experiments are being conducted on the mutagenic effects, if any, of 146 MHz and 29 MHz on Drosophila. Future research plans involve studying the effects of 2450 MHz on homing behavior in pigeons.

Wachtel, H., Associate Professor, Duke University, Departments of Biomedical Engineering and Physiology, Durham, North Carolina 27706 (919) 684-6185.

The immediate effects of microwaves on individual nerve cells are being investigated. In some cases changes are seen in firing rhythms resulting from absorbed powers less than 10 mW/cc which seem to be thermally nonreproducible. Some form of current detection mechanisms is implied by the results. Future interest lies in looking at long term exposure effects (> 1 month) on both neuronal activity and organism behavior.

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