determination. Comparisons were made with conventional techniques using a thermal oven at 103 C for 1 hr. The microwave oven provided comparable results in 1/4 to 1/5 of the time required by the thermal oven. The drying time required to reach a constant weight tended to decrease with increase in the operating power of the microwave oven for power settings below 1400 watts. Below 1000 watts, 15 min was required to obtain a constant weight of low-level solids samples, and the time increased with increase in amount of suspended solids on the filter. Above 1400 watts, a nearly constant time for constant weight was observed for suspended solids from 5-88 mg. At 1400 watts, 13 min was required to reach constant weight. Statistical analysis indicated that microwave dried samples reached a higher constant weight than did samples dried in the thermal oven. (2 references)

0156 THERMAL DENATURATION OF DNA EXPOSED TO 2450 MHz CW MICROWAVE RADIATION. *(E.)* Hambrick, P. E. (Natl. Inst. Environ. Hlth., Research Triangle Park, N.C.). *Radiat Res* 56:400-404, 1973.

Thermal denaturation curves of DNA formaldehyde and sodium citrate buffer solutions exposed to 2450 MHz continuous wave microwave radiation for 16 hr were compared with control curves. Both control and exposed solutions were maintained at 37 C. No differences in the curves could be detected for an absorbed power density of 94 mW/cm^2. In another experiment, DNA in formaldehyde solution was exposed for 1 hr at 40-50 C and therefore at higher power levels. Even with a power absorption of 225 mW/cm^2, there were no differences between control and exposed solutions. (19 references)

0157 INSECT-CONTROL STUDIES WITH MICROWAVES AND OTHER RADIOFREQUENCY ENERGY. *(E.)* Nelson, S. O. (U. Nebraska, Lincoln). *Bull Entomol Soc Amer* 19(3):157-163, 1973.

Control of insects infesting grain, wood, food, and other stored products can be achieved through radio-frequency (RF) dielectric heating. Such heating offers an advantage over more conventional types if the insects can be heated selectively, i.e., if they absorb energy at a higher rate than their host material and can thus be raised rapidly to lethal temperatures without damaging the host material. General principles and findings relating to insect control by RF treatment are reviewed, and the practical aspects of RF processing are discussed. Mortality and physiological injury data are presented for several stored-grain insect species. At present, immediate application of RF energy for insect control is questionable from an economic standpoint; however, cost factors could change with time and developing technology. To best exploit selective heating advantages, data on the frequency dependence and temperature dependence of the dielectric properties of insects and their host materials are needed. (41 references)

0158 COLOUR-THERMOGRAPHY: A POWERFUL TECHNIQUE IN THE EVALUATION OF MICROWAVE FIELD RADIATION PATTERNS IN BIOLOGICAL SYSTEMS. ITS USE AS A MICROWAVE ENERGY DENSITY MONITOR. *(E.)* Bigu del Blanco, J. (Dept. Anat., Queen's U., Kingston, Canada), C. Romero Sierra and J. A. Tanner. *Proc Microwave Power Symp*, May 29-31, 1974, p A3-3/1-A3-3/4.

Infrared scanning (color-thermography) was used for power density measurements at X-band frequencies (7-10 GHz). Experiments were conducted in an anechoic chamber in the presence and absence of animals or plant vegetation. Dramatic changes in radiation patterns occurred in the presence of a biosystem and were attributed to the large disturbance introduced by the system on the imposed electromagnetic field. Color-thermography enabled simultaneous visualization of radiation patterns over large areas of interest, and made it possible to establish the diffraction and scattering properties of the specimens. In some cases, resonance absorption was observed and in all cases multipath wave formation was established. These results emphasize the limited validity of free-space power density measurements as indicators of biological and behavioral hazards of microwave radiation. (1 reference)

0159 MICROWAVE HEARING: EVIDENCE OF THERMOACOUSTIC STIMULATION OF THE HUMAN AUDITORY SYSTEM BY PULSED MICROWAVES. *(E.)* Foster, K. R. (Natl. Naval Med. Ctr., Bethesda, Md.) and E. D. Finch. *Science* 185(4147):256-258, 1974.

In water, a 2450 MHz radiation pulse at the threshold for microwave "hearing" in humans produced pressure transients of approximately 90 dB re 0.0002 $dyne/cm^2$ peak amplitude within the 200 Hz-20 KHz frequency band audible by bone conduction. This peak pressure level is adequate to explain the "clicks" heard by persons exposed to identical radiation. (12 references)

0160 NONIONIZING RADIATION HAZARDS. *(E.)* Schwan, H. P. (Moore Sch. Electr. Eng., U. Pennsylvania, Philadelphia). *J Franklin Inst* 296(6):485-497, 1973.

The physical and engineering-oriented approach to the biological effects of microwaves carried out at the Moore School for over 20 yr is largely responsible for the Western standard of 10 mW/cm^2. Various phases of this research include determination of the electrical characteristics of body tissues; determination of microwave and membrane characteristics; studies of a variety of electromechanical phenomena which can be evoked by radio frequency fields; investigations of the mode of propagation of microwaves into man and animals, including absorption and reflectance characteristics and radar cross-section of man. The accepted standard for safe exposure derives from the relationship between incident power and power absorbed by man, and the absence of any known dangerous nonthermal mechanism. Flux data indicate that exposure standards can be drastically relaxed below 30 or 100 MHz. (28 references)

0161 THE EFFECT OF MICROWAVES ON THE TOBACCO BEETLE. *(E.)* Laszlo, T. S. (Philip

Morris U.S.A. Res. Ctr., Richmond, Va.) and W. K. Stephens. *Proc Microwave Power Symp*, May 29-31, 1974, p B3-4/1-B3-4/5

Specimens of all four life stages of the tobacco beetle, *Lasioderma Serricorne*, were embedded in cut tobacco and exposed to identical microwave treatment at 2450 MHz. Specimens were removed from the tobacco bed immediately after exposure or left in the tobacco for 2 or 16 hr. With identical exposure the death ratio increased with storage time in the still hot tobacco. The mortality is attributed entirely to thermal effects of microwaves. Theoretical considerations suggest that malformations observed by other investigators after microwave treatment are also due to heating. Microwave energy is many orders of magnitude less than chemical bond energies. Thus microwave radiation cannot break chemical bonds, and the formation of new chemical compounds from existing ones in biological systems exposed to microwaves has a very low probability. (No references)

0162 HUMAN PERCEPTION OF MODERATE STRENGTH LOW FREQUENCY MAGNETIC FIELDS. *(E.)* Schmitt, O. H. (Biophys. Group, U. Minnesota, Minneapolis) and R. D. Tucker. *Proc IEEE 1973 Electromagnetic Compatibility Symp*, June 1973, p 65-70.

If humans cannot perceive even subliminally that they have been immersed in or removed from a 60 Hz magnetic field of a few gauss strength, it becomes improbable that weak magnetic fields have deleterious effects. With whole body immersion in a large Helmholtz coil field, some few individuals demonstrate perception scores absolutely impossible by chance. With acoustically quiet sources and with better and better isolation from auxiliary nonmagnetic clues, fewer and fewer individuals show significant perception and none develop the very high scores found for sensitive subjects in the open coil system. Perception scores may approach negligibility with an accoustically sealed isolation cabinet now being tested. (No references)

0163 POTENTIAL INSECT CONTROL APPLICATIONS FOR MICROWAVES. *(E.)* Nelson, S. O. (Agric. Res. Service, U. Nebraska, Lincoln). *Proc Eur Microwave Power Symp (Belgium)*, Vol. 2, 1974, C.14.5, p 1-4.

Theoretical and experimental data on insect control by application of microwaves and lower frequency radiofrequency (RF) energy are presented. The most promising experimental results have been obtained when the energy absorption rate in the insects is high compared with that in the host material. Under these conditions, the insects can be disabled or killed by selective or differential dielectric heating. Many insects that infest grain, cereal products, and wood can be controlled by short exposures to RF fields that do not damage the host material. The resulting host temperatures necessary for insect control are 40-70, depending on the host, the insect species, the developmental stage, and the nature of the RF treatment. Studies of the frequency dependence of the dielectric properties of insects and host media suggest that better selective heating of insects can be obtained by increasing the frequency during exposure. (11 references)

0164 MICROWAVE RADIATION. *(E.)* Sells, S. B. (Inst. Behavioral Res., Texas Christian U., Fort Worth), M. J. Duke, and N. Findikyan. *Stress Reviews Radiation* (Texas Christ. U., Ft. Worth), Contract Nonr 3436 (00), Aug. 1966, p 15-33.

Microwaves affect man adversely in at least four ways: by raising tissue temperature to intolerable levels and causing cellular damage or death; by emanation of x-rays from microwave equipment; by molecular absorption in tissues; and directly, as heat or in some other manner, setting off stress reactions. Variables of biological importance are frequency, wavelength, and power in watts. Much of the present radar equipment operates at frequencies that are largely reflected or absorbed in the first few millimeters of body tissue. However, microwave effects vary with the tissues affected. Vascularized tissues, provided with a blood supply, can absorb more radiation than nonvascularized tissues, such as the lens of the eye. Local tissue exposure, particularly of the eyes, may be more important in relation to microwave radiation than whole-body exposure. The calculated tolerance to whole-body exposure (.143 large cal/min, equivalent to 0.1 kW/m^2) provides a large safety factor under ordinary circumstances, although allowance must be made for high air temperature, high humidity, and other conditions conductive to raising body temperature. No case of verified injury to radar personnel was found in a study of 335 persons exposed over a 14-yr period. Nevertheless, the potential hazard of new equipment should be monitored. As voltages rise, shielding becomes more difficult due to the more intense x-radiation produced, which, uncontrolled, could be more hazardous than the microwave radiation itself. (32 references)

0165 CYTOGENETICS, CHEMICAL DOSIMETRY SECTION, AND ANIMAL CARE SECTION. *(E.)* Eastern Environ. Radiat. Lab. (Montgomery, Ala.). *Annual Report*, Jan.-Dec. 1970, p 26-37.

One of several microwave radiation projects was a study of the cytogenetic effects of 2450 MHz radiation on kidney, lung, and thyroid tissue of Chinese hamsters given a 2-min exposure at a power density of 200 mW/cm^2. Preliminary results from cultured cells indicate a significantly higher percentage of aberrations in irradiated hamsters (6-10%) than in controls (1%). Temperature rises measured in samples of distilled water and agar solution irradiated in a microwave oven (frequency 2450 MHz) showed that placement of the sample to be exposed is critical for relatively consistent exposures in chemical dosimetry studies. Experiments conducted in a calibrated microwave radiation facility showed no direct functional relation between optical rotation changes in a sucrose-polyvinyl-pyrrolidone-glycerin mixture and absorbed microwave energy. In other experiments, enzymes (sucrase, peroxidase, aldolase, alpha amylase, alcohol dehydrogenase, and catalase) were exposed to high power density levels in a microwave oven and to lower

power density levels (200 mW/cm^2) in an anechoic chamber. Comparison with enzymes heated in an oil bath provided no indication that the enzymes studied are sensitive to microwave radiation. Microwave radiation did not affect the viscosity of several polymers tested nor the stability of 2-diphenyl-1-picryl-hydrazyl. The Chinese hamster colony for experimental studies has increased to approximately 4000 animals. (4 references)

0166 POLAROID MICROWAVE LEAKAGE MEASUREMENT, HAZARD EVALUATION OF MARINE RADAR ON PLEASURE CRAFT, FLUORESCENT LIGHT BULBS AS MICROWAVE OVEN INTERLOCKS, PRODUCT TESTING. *(E.)* Eastern Environmental Radiation Laboratory (Montgomery, Alabama). *Annual Report*, Jan.-Dec. 1970, p 49-52.

An investigation of the use of Polaroid film for measurement of leakage radiation from microwave ovens confirmed that Polaroid Type 58 color film provides visual indication of microwave fields with power densities greater than 5 mW/cm^2, the value set by PL 90-602 for microwave ovens following purchase by the consumer. Localized heating resulting from microwave exposure at 5 cm from the oven door caused a selective increase in film development rate in these areas. This increase resulted in a darkening of the film in the heated areas and formation of an image corresponding to the intensity of the electromagnetic field. Theoretical power density calculations for marine radar units used on small pleasure craft indicated that average power densities in excess of 10 mW/cm^2 may exist near the antenna (the curremt USASI standard for exposure times $\geq$ 6 min). The feasibility of using fluorescent light bulbs as microwave oven interlocks was also investigated, using the property of the bulbs' ignition in a microwave field. Results show that the bulbs do not have a uniform ignition level and would require critical individual spacing to ignite at a predetermined leakage level. In support of a national survey, approximately 200 microwave oven owners in Alabama, Georgia, Texas and Tennessee were surveyed. Owners of ovens leaking slightly above the industry design standard of 10 mW/cm were advised to discontinue use of their ovens pending repair. (No references)

0167 MICROWAVE RADIATION. *(E.)* Roth, E. M. (Lovelace Fdn., Albuquerque, N.M.). *Compedium Human Responses Aerspace Environment*, Vol. 1, Sect. 1-6, 1968, p 1/1-1/26.

Microwave penetration of tissue is discussed as a function of frequency (100-30,000 MHz). Thermal factors in microwave absorption are reviewed together with available data on microthermal and nonthermal effects. Total body, nervous system, ocular, and testicular effects of microwaves have been observed in animals. Dogs continuously exposed to 3000 MHz develop cataracts if the eye temperature reaches at least 45 C, but much lower temperature elevations in excess of 1 C are associated with testicular damage. These represent animal data most pertinent to man. U.S. and Soviet retrospective studies of radar workers are reviewed, and U.S. and Soviet limits of safe exposure are compared. A value of 0.01 watt/cm^2 absorbed energy appears tolerable for long-time total body exposure and 0.1 watt hr/cm^2 tolerable for short exposures. Possible tolerance levels for specific frequencies are 0.03 watt/cm for below 500 MHz, 0.01 watt/cm^2 for 1000-3000 MHz, and 0.2 watt/cm for frequencies in excess of 3000 MHz. The potential value of the microwave cross-section of man in operations such as search and rescue is noted. Animal data on the synergism between microwave and ionizing radiation are briefly summarized. (85 references)

0168 MICROWAVE REFLECTION, DIFFRACTION AND TRANSMISSION BY MAN: A PILOT STUDY. *(E.)* Reno, V. R. (Naval Aerospace Med. Res. Lab., Pensacola, Fla.) and D. E. Beischer. *Naval Aerospace Med Res Lab Report* No. 1183, June 11, 1973, 9p.

The microwave energy reflected, diffracted, and transmitted by man was measured as part of an ongoing investigation of the biological effects of low intensity microwave radiation on man. Energy density patterns were determined in proximity to human participants introduced into horizontally or vertically polarized microwave fields of low intensity (<50 μW/cm^2) at 1 GHz. In both cases the radiation formed a standing wave in space on the illuminated side and a pronounced shadow on the opposite side. Differences in interference patterns were related to polarization of the incident wave. The most apparent of these occurred in the diffraction patterns seen in the shadow areas. These observations place restrictions on the proximity of several subjects exposed at the same time to a microwave field for observations of biological effects. Similar considerations extend to the location of experimental apparatus adjacent to the subject. (3 references)

0169 USE OF MICROWAVE AND LOWER FREQUENCY RF ENERGY FOR IMPROVING ALFALFA SEED GERMINATION. *(E.)* Nelson, S. O. (U.S. Dept. Agric., U. Nebraska, Lincoln) and L. E. Stetson. *Proc Microwave Power Symp (Wis)*, May 29-31, 1974, p PS 1-1/2 to PS 1-1/4.

Brief exposures of samples from many different alfalfa seed lots to 39 MHz electric fields consistently increased germination by decreasing the percentage of hard seeds. Comparison tests on fewer seed lots showed no real differences between the effectiveness of treatments at 5, 10 and 39 MHz, or between treatments at 39 MHz and treatments at 2450 MHz in the microwave range. Germination of most seed lots was increased from the 40-60% range to the 80-90% range by radiofrequency treatment. Effectiveness of treatment in lowering hard-seed content increased with decreasing moisture content. (No references)

0170 MICROWAVE REFLECTION, DIFFRACTION AND TRANSMISSION STUDIES IN MAN. *(E.)* Reno, V. R. (Naval Aerospace Med. Res. Lab., Pensacola, Fla.). *Naval Aerospace Med Res Lab Report* No. 1199, Feb. 1974, 42p.

A series of studies of the energy distribution in proximity to man during microwave illumination is in

progress. The studies indicate several concepts of importance for investigations of the bioeffects of nonionizing radiation. A pronounced diffraction field is generated in space in proximity to man during illumination by microwave energy at 1 or 4 GHz (maximum intensity of incident field at either frequency, approximately 0.7 nJ/m^3). The characteristics of the field are dependent on the complex relationships between the frequency and polarization of the radiation and geometry and dielectric properties of man. Definite standing waves are formed on the illuminated side of man and pronounced areas of shadow appear on the opposite side. Considerable energy is also present in the field alongside man, if the electric vector of the incidence wave is parallel to the long axis of man. If the wave is polarized horizontally relative to man, this energy is redistributed so the amount present at the lateral aspects is much reduced. A considerable amount of the energy incident on man was reflected under all conditions tested. The information obtained is immediately applicable to hazard evaluations and the design of bioeffect investigations. A significant benefit of the approach is the potential for development of a noninvasive method for estimating the energy absorbed by man from a microwave field. (15 references)

0171 INSECT-CONTROL POSSIBILITIES USING MICROWAVES AND LOWER FREQUENCY RF ENERGY. *(E.)* Nelson, S. O. *1974 IEEE S-MTT Int Microwave Symp Digest Technical Papers (Ga)*, June 12-14, 1974, p 27-29.

Principles applicable to controlling stored-product insects with radiofrequency (RF) energy and general findings of research on this topic are reviewed. Many insects infesting grain, cereal products, and wood products can be controlled by short exposures to RF fields without damage to the host material. Resulting temperatures in the host material necessary for insect control are generally between 40-70 C, depending on the host, the insect species, and the nature of the RF treatment. Differences have also been found in the susceptibility of different development stages within the same species. Data on the frequency dependence of the dielectric constant and dielectric loss factor of insects and grain indicate that efficiency of RF treatment can be improved by increasing the frequency during exposure to more nearly follow the maximum insect-to-grain loss factor ratio as the treatment progresses. With improvement of efficiency, RF insect-control methods may become economically practical. (9 references)

0172 DIELECTRIC PROPERTIES OF AGRICULTURAL PRODUCTS. *(E.)* Nelson, S. O. (U.S. Dept. Agric., U. Nebraska, Lincoln). *Proc 1973 Microwave Power Symp (England)*, Sept. 11-13, 1973, p 6B/1 to 6B1/2.

The dielectric properties of materials are important in understanding the interaction of electromagnetic energy and materials. Considering agricultural products, possible uses for microwave and lower frequency radio frequency energy include both high and low-power applications. High-power uses might include heating, drying, sterilization, or insect control processes. Low-power applications include measurement or monitoring processes and noncontacting or nondestructive testing for quality measurement or control. Dielectric properties of agricultural materials vary widely and are dependent on many factors, including frequency, temperature, moisture content, and density. (No references)

0173 INTERACTION OF MICROWAVE AND RF ENERGY ON BIOLOGICAL MATERIAL. *(E.)* Sher, L. D. (Moore Sch. Electr. Eng., U. Pennsylvania, Philadelphia). *Electronic Product Radiation and the Health Physicist*, Oct. 1970, p 432-461, NTIS: PB-195 772.

Microwave hazards are greater under near field than far field radiation conditions. Unlike the far field, the near field has a complex radiation pattern that is closely dependent on the nature of the radiating source and its immediate environment. The extent of the near field is proportional to the directivity of the source. An electric field and a magnetic field coexist in the propagating microwave radiation. Magnetic interactions with biological material are very weak, but the electric field can lead to a marked heat development in biological tissue. Theoretical and model-system studies indicate that a man absorbs all radiation incident on his geometric cross section. His capacity for self-protection is limited to frequencies (above 10,000 MHz) at which the thermal input is sensed via cutaneous thermal receptors. Because currently available dosimetry is ineffective in the near field, it has not been possible to determine significant effects on tissues of microwave heating at levels considered to be safe. Protection from undue thermal effects, as offered by the U.S. Radiation Protection Guide, insures automatic protection against any possible nonthermal effects whose biological significance is unknown. Mechanisms for nonthermal effects other than field-induced force effects have not been demonstrated. (No references)

0174 ACETYLCHOLINE AND CHOLINE LEVELS IN THE RAT CORPUS STRIATUM AFTER MICROWAVE IRRADIATION. *(E.)* Butcher, S. G. (U. California Sch. Med., Los Angeles) and L. L. Butcher. *Proc West Pharmacol Soc* 17:37-39, 1974.

A comparison was made between levels of acetylcholine (ACh) and choline (CH) in Sprague-Dawley rat striata after decapitation and after rapid enzyme inactivation by a microwave fixation system. In the 3-min interval between decapitation and brain dissection, ACh levels decreased by 54.4 nmoles/g and Ch levels increased by 100 nmoles/g. These rapidly occurring changes were prevented by microwave irradiation at 6000 J (5kW for 1.2 sec). Parallel histochemical experiments showed virtually complete loss of acetylcholinesterase and NADH-diaphorase activities in the caudate-putamen nucleus after irradiation. (5 references)

0175 RADIATION HAZARDS FROM THERAPEUTIC MICROWAVE DIATHERMY. *(E.)* Vawter, S. M. (Am. Med. Assoc., Chicago, Ill.). *JAMA* 228(9):1170, 1974.

Microwave diathermy at 900 or 2450 MHz is similar to the radiation produced by microwave ovens. Because the primary effect of microwaves on the body is to produce heat, an overdose could result in a burn, internally or externally. The temperature increase in the body due to microwave exposure depends on (1) the specific area exposed and the efficiency of heat elimination from that area, (2) the intensity of the microwave field, (3) duration of exposure, (4) wavelength, and (5) thickness of skin and subcutaneous tissue. The lens of the eye is considered the organ most sensitive to microwave exposure, and cataracts may be produced at levels above 100 mW/cm^2. Data on long-term, low-level exposure to the lens are inadequate to determine if a cumulative effect exists. (2 references).

0176 ANALYSIS OF CENTRAL NERVOUS SYSTEM INVOLVEMENT IN THE MICROWAVE AUDITORY EFFECT. *(E.)* Taylor, E. M. (U. Washington Sch. Med., Seattle) and B. T. Ashleman. *Brain Res* 74(2):201-208, 1974.

Nine cats were prepared for the recording of potentials in three brain sites evoked by acoustic stimuli (square wave pulses 10 μsec in duration with a repetition rate of 1 pulse/sec) and microwave stimuli (pulses of 2450 MHz energy). Loci in which potentials were observed were the eighth cranial nerve, medial geniculate nucleus, and primary auditory cortex. The effect of cochlear disablement on these potentials was evaluated. Potentials at all sites were abolished by cochlear damage. There were no differences between acoustic and microwave stimuli in this regard. The data support the contention that the microwave auditory effect is mediated at the periphery as are the effects of conventional acoustic stimuli. (9 references)

0177 PSYCHOPHYSIOLOGICAL EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS: A REVIEW. *(E.)* Persinger, M. A. (Dept. Psychol., Laurentia U., Sudbury, Canada), H. W. Ludwig, and K.-P. Ossenkopp. *Perceptual Motor Skills* 36:1131-1159, 1973.

Extremely low-frequency (ELF) electromagnetic field waves, defined as occupying the frequency band from .01-100 Hz, are associated with geomagnetic disturbances, weather perturbations, electrical appliance discharges, and possibly seismic movements. ELF electromagnetic phenomena have been recorded as sinusoidal-like wave forms or as ELF pulses of short duration from higher frequency waves (10-100 kHz). Although natural ELF electrical component intensities range from less than 1 mV/m to slightly more than 1 V/m with magnetic components less than a μgauss and calculated power densities of 10^{-8} $watts/m^2$, these waves can propagate long distances without appreciable attenuation and penetrate housing structures. Theoretical calculations show that energy available from ELF phenomena can contribute to neuro-energetic functioning and protein-lipid activity. Correlational and experimental data indicate that ELF fields can influence reaction time, timing behavior, ambulatory behavior, oxygen uptake, endocrine changes, cardiovascular functions, and precipitation-clotting times of colloids. Possible mechanisms of ELF-organismic interactions are discussed. Correlational studies between ELF and life processes could be helpful as sources of stimulation for experimental design. This can be accomplished by increasing the number of stations measuring ELF waves and very low-frequency (3-30 kHz) carriers on a national and international scale. (136 references)

0178 FINAL ENGINEERING REPORT: RF RADIATION HAZARD DETECTION AND WARNING DEVICES: PHASE I AND II. *(E.)* Bissett-Berman Corp., Santa Monica, Calif. *Bureau of Ships Report* Contract No. NObsr 87467, Project No. SF 013 01 017, June 30, 1964, 80p NTIS: AD604900

Recognition that physiological damage caused by microwave radiation is a function of exposure time as well as power density level required the development of a radiofrequency (RF) radiation integrator. Two integrating power density meters have been developed for protecting personnel against high-power radar and other electromagnetic radiation emitting systems. The first instrument accumulates incident electromagnetic energy over a 30-sec interval and reads out the total value on a counter. The second instrument is a portable, battery-operated RF integration detector which accumulates incident electromagnetic energy of a 30-sec interval and actuates first, second, or third level visible and audible alarms when total energies exceed 0.3, 0.6, and 3.0 J/cm^2, resp. Both instruments utilize the E-CELL as the integrating device; in this new electrolytic component, transfer of a platable material between electrodes is proportional to the incident energy. The 30-sec integration period conforms to current Bureau of Ships requirements and can be changed to accommodate integration periods of from 1 sec to many hr. The E-CELL integration technique offers other instrumentation possibilities: a lower cost RF radiation integrator which would read out and alarm only when a hazardous condition exists; the integration of ionizing radiation for a personal alarm dosimeter; and the integration of various inputs such as solar intensity, wind, current velocity, or the operational hours of electronic devices. (No references)

Biological Effects Electromagnetic Radiation I(1), June 1974 and I(2), September 1974

CURRENT RESEARCH

SOURCES:Smithsonian Science Information Exchange

0001 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R.; Levinson, D. M. (U. Kansas Sch. Med., Kansas City, Kanasas 66101).

Sensory thresholds of response to microwave energy will be assessed in animals. Rats, guinea pigs and squirrel monkeys will be exposed, in multi-mode cavities, to microwave energy at 915 and 2450 MHz. During exposure, the animals will be observed to determine the effect of carrier frequency modulation on sensory thresholds and to evaluate the gross anatomical locus of detection. Following selected irradiation experiments (duration and power density variables) on fetuses, infants and adults, examinations will be made on adult animals for (1) learning ability and retention of simple and complex tasks, and (2) visually-evoked, and electocortical respnses. Ancillary studies will evaluate the interaction between endogensouly triggered hyperthermia, which is produced by "phychological" stress, and irradiation. (6/73-5/74)

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

0002 EPIDEMIOLOGICAL FIELD STUDY OF ATHERMAL NONIONIZING EXTREMELY LOW FREQUENCY (ELF) ELECTROMAGNETIC RADIATION EFFECTS. Krumpe, P. E. (U.S. Navy, Med. Res. Unit. #4, Waukegan, Illinois 60088).

The object of this study is to provide complete accurate clinical and epidemiological base lines on the health of technicians exposed to ELF radiation at Sanguine Test Facility, Clam Lake, Wisconsin. The health status of Sanguine "test subjects" who continue to be exposed to ELF radiation will be evaluated by complete annual examinations. Any changes in the health status of these subjects will be recorded in the form of a "problem oriented" medical record. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Naval Med. Res. Inst.

0003 PERSONNEL EXPOSURE CRITERIA FOR OPERATIONAL RADIOFREQUENCY RADIATION ENVIRONMENTS. Bonney, C. H. (USAF Sch. Aerospace Med., San Antonio, Texas 78235).

An attempt will be made to establish appropriate exposure criteria for operational radiofrequency radiation environments. Current exposure guidelines do not apply to many operational situations. Data are needed for site selection and layout, shielding requirements and operational maintenance procedures for such systems as the over-the-horizon (OTH) radar for conus defense. A series of exploratory tests will be conducted to establish power absorption/energy deposition parameters as a function of frequency, field intensity, sample configuration, and environmental stress. Initial studies will be conducted in the HF range at 10.5, 19.27 or 26.6 MHz with 50 KWP pulse transmitter. These studies will include measurement of resulting temperature changes in representative boundary interface models and evaluation of the RF radiation-induced effect on the growth rate in mice. Subsequent studies will be conducted using the new 40 KW (An/FRT-6B) continuous wave transmitter. Results will be used as a biomedical data base for the establishment of normal and emergency exposure limits for specific operational situations. (7/72-6/73)

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

0004 EFFECTS OF HF BAND ELECTROMAGNETIC FIELDS ON THE CENTRAL NERVOUS SYSTEM: PERMISSIBLE EXPOSURE CRITERIA. Stavinoha, W. B. (U. Texas Sch. Med., Pharm., San Antonio, Texas 78229).

The effects of electromagnetic fields on the turnover rates and energy metabolism of neurotransmitter substances will be studied. While present safety criteria for nonionizing radiation are based on thermal effects studies of varying frequencies (300-300,000 MHz), thermal effects information is limited for lower Air Force frequencies. In addition, energy transfer mechanisms and their possible long term effects require definition and evaluation. Data acquired will be used to establish human exposure criteria and contribute to the establishment of hazard levels in RF fields. Methods for 100 mg tissue sample assay of neurotransmitter (acetylcholine, deoxphenylalanine, gamma-amino butyrate) have been perfected and calibrated. Brain tissue (cortex and hypothalamus) from animals exposed to 3 HF fields at 3 power levels will be examined for neurotransmitter turnover rates. Labeled precursors and new rapid enzyme inactivation techniques will be used. The turnover of major energy stores will be determined for adenosine triphosphate (ATP), diphosphate (ADP) and monophosphate (AMP). The structurally determined sequences in mitochondria will also be studied. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, USAF Sch. Aerospace Med. Res.

0005 EFFECTS OF LOW FREQUENCY ALTERNATING CURRENT FIELDS ON BIOLOGICAL SYSTEMS. Straub, K. D. (U.S. Navy, Crew Systems Department, Warminister, Pa. 18974).

The effects of low frequency alternating current (1 Hz - 10 KHz) on various well defined cellular parameters will be determined in order to provide a

basis for the estimation of the possible effects of these low frequency fields on personnel and the environment, particularly the fields generated by Project Sanguine, Omega and very low frequency (VLF) communication and navigation transmitters. Various well-defined cellular and tissue preparations will be subjected to a.c. fields of varying frequency and strength. Parameters such as ionic potential, oxygen consumption, metabolic levels and enzyme activity will be monitored and the effects of a.c. fields determined on the basis of changes in these parameters. These effects can then be used to design experiments which involve exposure of the whole body.

SUPPORTING AGENCY:Department of Defense, Naval Bur. Med. Surg.

0006 PERFORMANCE IN NON-HUMAN PRIMATES AS INFLUENCED BY LOW FREQUENCY ELECTROMAGNETIC FIELDS. Delorge, J. O.; Grissett, J. D. (U.S. Navy, Aerospace Med. Res. Lab., Pensacola, Florida 32512).

The influence of low intensity, low frequency electromagnetic fields on *Macaca mulatta* will be analyzed for possible relevance to human behavior under similar influences. In addition, the possible function of fields as stimuli for arousal will be investigated. Specific tasks, found to produce behavioral sensitivities to electromagnetic fields in humans and animals, will be taught to rhesus monkeys through the use of operant conditioning techniques. Presented successively, the tasks assess an organism's reaction to temporal stimuli, auditory signal, and the immediate memory of visual stimuli. When a consistent performance of the three tasks has been established, the monkey will be subjected to an extremely low frequency (ELF) electric field and further data collected. The field will later be removed and the original conditions reinstituted to observe the behavioral recovery of the animal to pre-exposure levels. A similar procedure will be followed with an ELF, low-intensity magnetic field and a combined electric and magnetic field utilizing the same exposure values. The second phase of the experiment will focus on the reaction time task as an indication of electromagnetic field stimuli. Results will be applied to behavioral research in ELF communication systems. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Naval Aerospace Med. Res. Inst.

0007 PARENTAL RADIATION EXPOSURE AND DOWN'S SYNDROME, WITH PARTICULAR ATTENTION TO IONIZING RADIATION AND RADAR. Cohen, B. (Johns Hopkins U. Sch. Med., Baltimore, Maryland 21205).

This project proposes to study the genetic and chromosomal effects of microwave radiation specifically in relation to Down's syndrome (mongolism). This project is in direct support of the project to define the military medical problems associated with exposure to microwave hazards and is relevant to the mission of the Army medical department in maintaining military forces in the field. Children with a diagnosis of Down's syndrome will be selected. Medical records of parents will be examined and the parents interviewed. Particular emphasis will be placed on previous history of radiation exposure to determine if any aberrations in chromosomes are noted. Differences between controls and experimental subjects will be examined for any discernible differences and/or abnormalities. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Army Med. Res. & Develop., Internal Med. Res. Div.

0008 QUANTITATIVE EFFECTS OF EM ENERGY ON HUMAN TISSUES. Guy, A. W.; Lehmann, J. F.; Lin, J. C.; Taylor, E. M. (U. Washington Sch. Med., Seattle Washington 98105).

The biological effects of electromagnetic energy will be quantifiably assessed. Engineering studies involving theoretical prediction and experimental verification of energy distribution as a function of exposure parameters in phantom models and animal tissue, will be applied to the evaluation of biological effects data and the design of relevant experiments. In particular, evaluation of energy distribution around diathermy and optimization of designs for the safety of the patient and operator will take place. Present low level thermal effects of EM radiation on CNS-evoked responses will be expanded to include investigation of somatic and autonomic consequences. Blood pressure, heart rate, respiration and other bodily functions will be monitored during exposure. Techniques of recording and sequential system ablation will be employed in the observation of auditory response to pulsed electromagnetic energy. Cat spinal cord preparations will be used in detailing EM energy effects in discrete aggregates of CNS elements. The vagus nerve of the cat will be differentially radiated in a chronic preparation and effects on heart rate and blood pressure noted. For the assessment of conduction and junction phenomena in terms of absorbed energy, amphibian and mammalian peripheral nerves and neuromuscular junctions will be illuminated in temperature controlled chambers. Single cells from rabbit dorsal root ganglia will also be illuminated with EM energy during intracellular potential recording to assess single element effects. Biological and engineering data will be extrapolated to the human exposure problem (6/73-5/74)

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

0009 VISION HAZARDS TO AIRCREW PERFORMANCE. Welch, A. J. (U. Texas Sch. Engineer., Austin, Texas 78712).

Successful performance of aircrew duties requires detail vision. Accidental photocoagulation of small areas of the retina may degrade work quality and

result in loss of life or loss of USAF equipment. Minimum changes in vision which alter job performance must be determined for safety of personnel working with high energy density light sources. These threshold determinations must be obtained using standard medical and optometric tests, and related to electrophysiological changes. Since permanent eye damage is a distinct possibility, and experimental surgical preparation is necessary, rhesus monkeys must be used as subjects. The data will be extrapolated to human vision conditions. First, surgical preparation of six rhesus monkeys will be accomplished to obtain baseline vision-related electrical activity of the brain recordings. Photo evoked potentials will be obtained under baseline conditions as well as a measure of vision capability using standard clinical optometric tests of detail vision. Second, lesions will be placed in the fovea varying spot size, and a corresponding visual field defect 'map' will be obtained. Third, visual acuity will be obtained to determine functional vision capability changes from baseline conditions. Data will be reported for the energy source, density, duration, and wavelength, which altered electrophysiological and functional vision changes. (7/72-6/73)

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

0010 HISTOPATHOLOGICAL EXAMINATIONS OF EYES EXPOSED TO VARIOUS WAVELENGTH ELECTROMAGNETIC RADIATIONS. Vassiliadis, A. (Stanford Res. Inst., Menlo Park, California 94025).

Studies are underway to determine the medical effects of electromagnetic and particulate radiation. Exposures to AF operational radar frequencies, lasers and nuclear weapons environments will be studied. Findings will be used to establish medical safety criteria for hazard assessment of AF operational system/environments. This effort will provide detailed histopathological examination of about 150 primate eyes. Changes in both retina and lens will be precisely located, evaluated and interpreted. Animals will be exposed to various radiations. At prescribed times, enucleations will be performed and the eyes sent for histopathological examinations. Information from the examinations will be correlated with other data to produce exposure criteria necessary for utilization of aerospace environments contaminated with radiation. (7/72-6/73).

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

0011 ANALYSIS AND PREPARATION OF THE AVAILABLE WORLD LITERATURE ON THE BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. Lindberg, R. (Mead Technology Laboratories, Dayton, Ohio 45432).

Selected literature on the biological effects of nonionizing electromagnetic radiation will be entered into a computerized file in full text and in a manner to provide rapid review and retrieval. (7/73-6/74)

SUPPORTING AGENCY:Department of Defense, Army Med. Res. & Develop.

0012 NAVY ENVIRONMENT: NON-THERMAL HAZARDS OF EXPOSURE TO RADIO FREQUENCY AND MICROWAVE FIELDS. Mickey, G. H. (New England Institute Inc., Ridgefield, Conn. 06877).

The possibility exists that shipboard radar exposure may induce genetic damage in naval personnel. This research project explores the incidence of genetic anomalies after exposure to radar frequency microwaves. Microwave treatments in the X and K bands at 15 to 40 MHz are administered to Chinese hamster cells *in vitro* (lymphocytes and lung cells in culture) and to whole Chinese hamsters for subsequent removal and study of bone marrow cells, lymphocytes, and germ cells, using double blind coded preparations. The total number of chromosome breaks are scored and compared with chromosome breaks in controls, and a dose-response curve constructed. In another approach, genetic effects of microwaves on germ cells of male rats will be determined. Pregnant female rats which have been mated with microwave irradiated males will be autopsied on the 14th day of pregnancy and scored as to incidence of early fetal and pre-implantation deaths. (7/72-6/73).

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

0013 RESEARCH INITIATION - EFFECTS OF RADIATION ON BIOLOGICAL SYSTEMS. Cain, C. A. (U. Illinois Grad. Sch., Urbana, Illinois 61801).

The purpose of this research is to determine if RF radiation can affect functioning biological systems by non-thermal mechanisms. The effects of pulse modulated RF energy on heart and brain function in the cat will be studied. (3/73-8/74).

SUPPORTING AGENCY:NSF, Div. Engineering

0014 GENETIC EFFECTS OF MICROWAVE RADIATION ON CHINESE HAMSTERS. Everts, J. M. (U.S. EPA, Natl. Environ. Res. Ctr., Durham, North Carolina 27711).

Sexually mature male and female Chinese hamsters are irradiated with microwave radiation (2450 MHz) at a power density of 200 mW/cm^2 for two minutes. The animals are then bred and the litters observed for variation from the norm of the colony. Blood leukocyte cultures are prepared from the offspring which reach weaning age and the cells are scored for chromosome anomalies. This study is designed to give an indication of the presence or absence of

gross genetic effects elicited by microwave radiation. (8/71-1/73).

SUPPORTING AGENCY:EPA, Off. Res. & Develop.

0015 EFFECTS OF ELECTROMAGNETIC FIELDS ON GENETIC PHENOMENA. Braver, G. (U. Oklahoma Sch. Arts, Norman, Oklahoma 75069).

The investigators propose to examine the biological effects of various configurations of electromagnetic fields at levels which are below the range where thermal effects are evident. They will study the biological indices provided by mutations, specifically sex-linked lethals, recombinations and nondisjunction of the X-chromosome in *Drosophila melanogaster*. (7/72-6/73)

SUPPORTING AGENCY:EPA, Off. Res. & Develop.

0016 BIOCHEMICAL MEASURES OF MICROWAVE INDUCED STRESS. Schwarz, H. P. (Philadelphia Gen. Hosp., Philadelphia, Pa. 19104).

Plasma samples from human subjects under various conditions of stress and from animals irradiated with nonionizing radiation under various frequencies will be analysed for phospholipid distribution to correlate changes with the intensities and duration of the stress. Two-dimensional thin layer paper chromatography of deacelyted phospholipids will be used to separate the individual phospholipids extracted from plasma. Quantitation will be achieved by colormetric determination. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Naval Air Develop. Ctr., Crew Systems Dept.

0017 IONIZING AND NON-IONIZING RADIATION BIOLOGY. Appleby, A. (Rutgers State U., Agricultural Exp. Sta., New Brunswick, New Jersey 08903).

The effect of chronic low level microwave exposures on the mammalian anterior lens as they relate to cataract formation at various age levels will be evaluated. Fundamental data relevant to the understanding of the chemical and biological processes involved in the interaction of radiations with organisms will be gathered; such data being directed towards the development of practical means to inhibit, neutralize or reverse the biological damage caused by radiation. The mitotic index of chosen mammalian species will be measured using a tritiated thymidine-autoradiography technique of different age groups after various exposure periods, followed by the observation of cataract producing doses. The relative radiation sensitivity of experimental animals (e.g. rats) with or without treatment by radiated gas will be determined by standard procedures. The objects of the study are to calibrate a 2450 MHz microwave oven as a specimen irradiator and determine subsequently the effects of microwaves on thyroid function in the mouse. Calibration by colorimetry was carried out successfully. Preliminary results on the test animals showed no significant changes in thyroid function following single or multiple exposures at various power levels. (7/73-6/74).

SUPPORTING AGENCY:New Jersey State Government

0018 *BRACON*, AN ASSAY FOR GENETIC EFFECTS OF MICROWAVES. Valcovic, L. R. (Auburn U., Agricultural Exp. Sta., Auburn, Alabama 26830).

An assay for possible genetic and physiological effects of 2450 MHz radiations using the parasitic wasp, *Bracon hebetor* will be carried out. Mature sperm and all stages of oogenesis will be surveyed for mutational effects, particularly dominant and recessive lethal mutations. Two experiments have been completed since the beginning of the grant period. In the first, female wasps were exposed to 2450 MHz microwaves for 30, 60, and 90 minutes. Analysis indicates that these exposures did not cause any significant changes in fecundity, fertility, or life span. Adult males were exposed to the same levels of radiation in the second experiment. The biological parameters studied were dominant and recessive lethals and sperm inactivation. This experiment also failed to detect any significant damage with these levels of irradiation. The power density in the exposure area for both experiments was 200 mW/cm^2. (7/72-6/73).

SUPPORTING AGENCY:Alabama State Government

0019 EFFECTS OF MICROWAVE RADIATION ON NAVAL PERSONNEL. Beischer, D. E.; Reno, V. R. (U.S. Navy, Aerospace Med. Res. Lab., Pensacola, Florida 32512).

Exposure of naval personnel to microwave radiation is an acute problem. Even low doses are likely to reduce the efficiency of personnel in vital duty positions. The maximum safe exposure level presently endorsed by all branches of the armed forces (10 mW/cm^2) is based on extrapolation from animal experiments and does not take into account duration of exposure or frequency of radiation. The great uncertainty in setting safe limits is best illustrated by the wide gap between the U.S. and Soviet limits, with the U.S. limit higher by a factor of 1000 than the Soviet level. Present and future use by the Navy of microwave radiation of increasingly higher power in a wide band of frequencies makes it mandatory to establish safe levels of exposure using the results of well controlled laboratory exposure of human subjects as a guide line. Human volunteers will be exposed to microwave radiation in the 1 to 12.4 GHz range, and the physiological and psychological effects observed. Exposure time and maximum power

density will be increased gradually, starting from the Soviet levels and approaching but not surpassing the intensity level considered at present to be safe in the U.S. Objective test methods will be used to detect possible neurological decrements (aesthenic syndrome), sleepiness in daytime, fatigue, reduced memory and inability to make decisions. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Naval Aerospace Med. Res. Lab.

0020 SIMULATION OF OTH RADAR HF RADIATION FIELDS. Hurt, W. D.; Hardy, K. A. (USAF, Sch. Aerospace Med., San Antonio, Texas 78235).

The primary objective of this project is to develop and implement a system and technique for exposing biological samples to HF band radiofrequency (RF) electromagnetic radiation fields. This system will be used to better define personnel exposure criteria for priority operational RF radiation environmental situations. Current exposure guidelines, as presented in AFM 161-7, may not be appropriate for HF bands (3-30 MHz). Initial efforts will be directed to the installation and operational checkout of an AN/FRT-6B transmitter. The RF exposure enclosure currently being used in support of the engineering services project for ESD will be modified to accommodate the AN/FRT-6B transmitter. (7/72-6/73)

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

0021 THE EFFECTS OF MICROWAVE RADIATION ON THE BRAIN MECHANISM REGULATING METABOLISM AND BODY TEMPERATURE. Squires, R. D. (U.S. Navy, Crew Systems Department, Warminister, Pennsylvania 18974).

The object of this project is to assess the effects of microwave radiation on the central nervous system in order to aid the establishment of maximum exposure standards for aircrews. A new metabolic chamber will be used to measure the metabolic responses of test animals in terms of oxygen consumption and brain colonic temperatures, while they are being subjected to microwave radiation confined to their heads. The radiation intensity levels will be in accordance with those experienced by aircrewmen exposed to microwave (radar) radiation. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Naval Bureau of Med. Surg.

0022 CRITICAL REVIEW: BIOLOGICAL EFFECTS OF MICROWAVE IRRADIATION. Baranski, S. (Coord. Comm. Pol. Amer. Collab., Warsaw, Poland).

The use of microwave generators in industry, radionavigation, radio-communication, radio-location and research will be reviewed and the possible hazards for personnel employed within the compass of irradiation will be identified. The physical characteristics of microwave exposure and methods, for application to the prevention of health hazards stemming from continued exposures to microwave irradiation, will also be identified. A monograph (approx. 350 p) will be published for international use in research to reduce the effects of microwave irradiation and improve methods of treatment. The monograph will include supporting tabulations and photographs. (7/72-6/73)

SUPPORTING AGENCY:HEW, Publ. Hlth. Service, Natl. Inst. Hlth., Fogarty Internatl. Ctr.

0023 NAVY ENVIRONMENT: PHYSIOLOGICAL, PATHOLOGICAL AND BEHAVIORAL EFFECTS OF MICROWAVE RADIATION. Hunt, E. L.; Phillips, R. D. (Battelle Mem. Inst., Pacific NW Labs., Richland, Washington 99352).

This investigation is part of a Navy program to evaluate the potential hazards of microwave radiation to Navy personnel. Young pathogen-free rats will be exposed to microwave irradiations under two sets of conditions. Rats will be exposed in the Fraunhofer range of a horn in an anechoic chamber which provides a unilateral exposure to a well-defined field, but which has the drawback that absorbed energy cannot be measured. As a complementary procedure, rats will be exposed in a multilateral resonating cavity in which the field is shifting and complex. However, energy absorbed by the animal can be (indirectly) measured. Radiation effects will be assessed through observation of excitability of the central nervous system as manifested by the decrease in threshold response to electrically induced convulsions. Other response parameters may be included. A Navy S-band (and later an X-band) radar source will be used to provide an average field intensity of 50 mW/cm^2 in both types of exposure. (7/72-6/73)

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

0024 NAVY ENVIRONMENT: X-RAY AND MICROWAVE RADIATION INTERACTION WITH MUSCLE CELLS. APPLICATION TO PROTECTION AND TREATMENT. Portela, A.; Perez, J. C. (Consejo NAC, De Inv. Clien. Tec. Buenos Aires, Argentina).

This research seeks to identify and characterize in cellular and subcellular structures the critical membrane systems, organelles and biochemical mechanisms which are affected by the absorption of ionizing (X-rays) and nonionizing (microwaves) radiation likely to exist in the environment of naval personnel. Efforts will be made to develop specific agents to prevent or counteract undesirable effects of these radiations. The area and nature of radiation damage at the cellular and subcellular level is being investigated *in vivo* and *in vitro*, using skeletal muscles of frogs and

rats, with special micro techniques developed by the principal investigator. Changes in ion transport, conductance, and incorporation of physiologically important chemicals are analyzed. The insight gained into the mechanisms of damage to the membranes and cells then serves as a guide to the design, selection, and testing of possible therapeutic and prophylactic agents. (7/72-6/73).

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

0025 NAVY ENVIRONMENT: BIOLOGICAL EFFECTS OF MICROWAVES AND ELECTRIC FIELDS. Schwan, H. P.; Kirtikos, H. (U. Pennsylvania, Sch. Electrical Engineer., Philadelphia, Pa. 19104).

The possible hazards of present microwave exposure limits will be investigated with respect to the safety of naval radar operations. Experiments are designed to investigate two hypotheses: (1) that microwave-induced hot spots in the brain and other parts of the body emit frequencies resonant with microwaves or (2) that the conductivity of human tissues is high enough to dampen such resonances. Pertinent field equations will be applied to models with dielectric properties similar to the human brain. Extensive calculations will be made by computer. (7/72-6/73)

SUPPORTING AGENCY:Department of Defense, Off. Naval Research

0026 CYTOGENETIC EFFECTS OF MICROWAVE RADIATION ON TISSUE CULTURE. Everts, J. M. (U.S. EPA, Natl. Environ. Res. Ctr., Durham, North Carolina 27711).

Cultured cells will be irradiated with 2450 MHz microwave radiation for varying time intervals and varying power densities. Power density will range from 200 mW/cm^2 to 15 mW/cm^2. Chromosome analysis will follow the irradiation procedure at appropriate time intervals. This data will provide information regarding variations in percentage of chromosome aberration associated with time and power density variations. (9/1/72-1/1/74).

SUPPORTING AGENCY:EPA, Off. Res. & Develop.

0027 NAVY ENVIRONMENT: EVALUATION OF THE SAFETY EXPOSURE LIMITS OF RADAR USED BY NAVAL PERSONNEL. Hunt, E. L.; Phillips, R. D. (Battelle Mem. Inst., Pacific NW Labs., Richland, Washington 99352).

Naval personnel exposed to the powerful electromagnetic radiation of radar on shipboard may possibly suffer deleterious nervous effects, which are not immediately apparent, as a result of long-term exposure. This research is designed to test for possible ill effects of chronic low-level microwave exposure. Physiological and behavioral effects of single, repeated and long-duration exposures to microwaves of various wavelengths are being studied in rats. Studies of the central nervous system reactivity will ascertain whether decrements occur in sensory function, physical performance, temperature regulation, metabolic capacity and response to environment after exposure to microwaves. Specifically, rats will be monitored for temperature and observed for velocity and endurance in a 20 foot swim test. Ability to maintain normal temperature under cold stress (-17 C) and alertness in a vigilance task will also serve as criteria of physiological detriment from microwave exposure. (7/72-6/73)

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

0028 SCIENTIFIC AND TECHNICAL PROGRAMS FOR MONITORING OF ENVIRONMENTAL RADIATION LEVELS AND INVESTIGATION OF BIOLOGICAL EFFECTS. Grove, H. M. (U.S. Army, Walter Reed Army Inst. Res., Washington, D.C. 20012).

The agreement provides for cooperative scientific and technical programs for monitoring environmental radiation levels - radiofrequency and microwave energy, developing any special instruments required, and investigating biological effects of nonionizing electromagnetic radiation. (7/72-6/73).

SUPPORTING AGENCY:EPA, Off. Res. & Develop.

0029 NAVY ENVIRONMENT: QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Guy, A. W.; Piroska, K. (Washington U., Sch. Med., St. Louis, Mo. 63110).

The conditions and mechanisms of cataract production by microwave irradiation will be ascertained and the results will be quantitatively extrapolated to human exposure problems. This research will involve a theoretical determination of the relation between the internal absorption characteristics of the animal and human eye and the microwave frequency and aperture size. An investigation will also be made into thresholds of eye damage caused by continuous and pulsed microwaves during acute and chronic exposure to frequencies between 200 MHz and 10 GHz. Recording temperature change in the tissue by means of thermographic and thermocouple techniques will improve dosimetry. Rabbits and monkeys will be used. Induced temperature rise and post-exposure cooling will be carefully monitored with hollow glass micropipettes placed in the eye so that thermocouples can be readily placed for temperature measurement. Electromagnetic field patterns, both in and near the tissue structures, will be quantitatively established as a function of frequency and source location. Acute exposures will be performed at radiation levels rang-

ing from 10 to 500 mW/cm^2. Pre-irradiation examinations will be made by slit-lamp biomicroscopy. Histological examinations will be performed on animals with significant ocular changes. (7/72-6/73)

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

0030 A PRELIMINARY SURVEY OF VETERANS WHO MAY HAVE BEEN EXPOSED TO CATARACT PRODUCING RADIATION. McAfee, R. D.; Cazenavette, L. L.; Holland, M. G. (U.S. VA Hosp., New Orleans, Louisiana 70140).

A shadow graph device which allows an individual to see opacities within the lens of his eye (or in the cornea) has been developed at this laboratory. It is an improved version of an old device known as a cataract viewer. This device is being mailed to a select population of veterans (with their approval) who may have been at risk from exposure to x- and microwave radiation. They are requested to draw what they see. If they see opacities in what should be clear field, follow-up examinations of these individuals will be made. Thus the shadow graph device is an inexpensive means for screening a population who may have been exposed to ionizing and microwave radiation, specifically individuals who have not worked with or on electronic equipment, will be included in the study. (7/72-6/73).

SUPPORTING AGENCY:Veterans Administration

0031 BEHAVIORAL AND EEG EFFECTS OF MICROWAVES. Cunitz, R. J.; Cornog, J. R. (U.S. Dept. Commerce, Natl. Bur. Stds., Washington D. C. 20234).

Two monkeys were exposed to radiation levels varying from 0.1 to 10,000 milliwatts absorbed power in a 400 MHz reasonant cavity. They performed a four-choice serial reaction task, changes in their EEG rhythms were monitored and they were observed during exposure to the microwave source. Contrary to expectations, no change occurred in the level of arousal. The dosimetry technique employed permits a relatively accurate measurement of absorbed power and is less dependent on wavelength and body size than the usual field strength determination. Results from this study will be used to evaluate the effects of low level exposure and to establish human exposure standards. The experimental phase of the project has been completed (June 1973) and data analysis and report presentation are underway.

SUPPORTING AGENCY:EPA, Off. Res. & Develop.

0032 NAVY ENVIRONMENT: NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS DUE TO MICROWAVE IRRADIATION. Guy, A. W.; Lin, J. C. (Washington U., Sch. Med., St. Louis, Mo. 63110).

To provide a better understanding of microwave irradiation hazards and a scientific basis for safety standards, it is proposed that biological effects of continuous and pulsed microwaves be studied quantitatively. In addition, frequency and intensity factors will be investigated by controlled exposure of animals. The following research will be undertaken: (1) theoretical investigation of energy distribution in humans and animals after microwave radiation exposure; (2) thermographic determinations of temperature distribution in animals and phantom models; (3) observation of behavioral changes using operant conditioning techniques; (4) establishment of microwave influence on neurophysiological characteristics by using gross and single cell recordings of CNS-evoked responses. In the first phase of the work, a study will be made of the effects produced on recording electrodes which differ in composition and size. Results will be compared using fluid-filled electrodes of different ionic concentrations (4μ vs Ringer's solution) to pinpoint any effects caused by ions driven out of the recording electrode to the vicinity of the cell. Fluid-filled electrodes will also be used to study the effects of microwaves on thalamic responses to sound stimulation. Heat distribution in the brain will be correlated with changes in response; thermographic studies will be performed on small animals and phantom spheres. The behavioral effects of direct microwave stimulation will be studied on cats, monkeys, mice and rats. (7/72-6/73).

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

0033 CYTOGENETIC EFFECTS OF MICROWAVE RADIATION ON CHINESE HAMSTERS (VARIABLE POWER DESTINY). Everts, J. M. (U.S. EPA, Natl. Environ. Res. Ctr., Durham, North Carolina 27711).

Chinese hamsters will be irradiated with 2450 MHz microwave radiation at accurately specifiable free field power densities for a predetermined time interval. The incident power density will vary from 200 mW/cm^2 to 15 mW/cm^2. Animals will be sacrificed and appropriate tissues cultured for chromosome analysis. This data will provide information regarding variations in percentage of chromosome aberrations associated with power density. (6/1/72-6/30/73).

SUPPORTING AGENCY:EPA, Off. Res. & Develop.

0034 ATHEROSCLEROSIS AND RADIO FREQUENCY IRRADIATION. Sparks, H. V. (U. Michigan Sch. Med., Ann Arbor, Michigan 48104).

The effect of radio frequency irradiation on the development of atherosclerosis in rabbits, rats, and squirrel monkeys will be studied. All animals will be fed an atherogenic diet and one group of animals will be irradiated while others serve as controls. After several months the animals will be sacrificed and their aortas will be analyzed for the extent of intimal involvement in the athero-