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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Male and female white rats were exposed to continu-

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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