val between impulsed of 10 sec. The first group of rats was exposed to 72 ka/m (900 oersteds) for 3 hr/day (15 sessions) and the second group to 24 ka/m (300 oersteds) for 1.5 hr/day for 1, 3, and 6 months. Histochemical examinations of the livers of these animals after exposure to the impulse magnetic field showed a marked decrease in the activities of succinate, isocitrate, and malate dehydrogenases in animals belonging to the first group. A decrease was also noted in the activity of glutamate dehydrogenase, an enzyme which takes part in the synthesis of various amino acids and in the reaction in which NH_4^+ is bound to ketoacids in detoxification. In the second group of rats similar changes occurred in the activities of these enzymes along with necrobiosis and damage to the mitochondrial membrane. Decreases in succinate dehydrogenase activity persisted in some cells even 2 months after exposure to radiation had been discontinued. (9 references)

0049 CHANGES IN THE CARDIOVASCULAR SYSTEM DUE TO CHRONIC EXPOSURE TO AN ULTRAHIGH FREQUENCY FIELD. *(Rus.)* Muratov, V. I. (No affiliation) and A. P. Turaeva. *Voen Med Zh* (1):22-24, 1972.

Cardiovascular examinations were performed before and after measured physical exercise on 25 men, aged 21-39 yr, who had serviced a superhigh frequency (SHF) generator for 2-17 yr. This generator produced waves in the centimeter range with frequencies of 3000-30,000 MHz and power flux denisities of 40-310 μwatts/cm^2. The exposure time for these subjects averaged 3.5 hr/day. On the basis of the results obtained, subjects were classified into three categories. All findings were within normal limits, both before and after exercise, in 11 subjects. The second group consisted of seven subjects with a tendency toward hypertension. Consistent increases in the mean hemodynamic pressure were noted at rest and after exercise. The diastolic pressure was within normal limits, but the systolic pressure ranged from 132 to 150 mm Hg; no significant changes occurred after exercise. The minute volume was increased and the peripheral resistance decreased in all of these subjects. Mild hypodynamia at rest was observed in the systolic phase. This was manifested in a lengthening of the stress phase, a decrease in the intrasystolic index, and an increase in the myocardial stress index. These parameters improved after excercise. The rate at which pulse waves were propagated at rest was within normal limits, but the ratio of pulse wave propagation through vessels of the muscular type to the rate through the elastic type (S_M/S_E) increased after exercise. The third group consisted of seven normotensive subjects whose hemodynamic parameters improved after exercise. No relationship was found between the duration of exposure to SHF radiation and changes in the hemodynamic parameters. No significant changes in the ECG were found in any of the subjects. Cardiovascular changes observed in some subjects chronically exposed to to UHF radiation are considered to be a form of neurovegetative dystonia. Since no relationship was found between the duration of exposure and changes in hemodynamic parameters, other factors may play a role in the development of disorders in neurohumoral regulatory mechanisms in workers exposed to SHF radiation. (9 references)

0050 EXPERIENCE WITH MICROWAVE TREATMENT OF DISEASES OF THE ORGANS OF LOCOMOTION. *(Rus.)* Getman, E. G. (1st Munic. Hosp., Nikopol', USSR). *Klin Khir* (8):82-84, 1972.

Outpatient microwave therapy was used to treat 193 patients (58 men and 135 women) with acute (9 cases), subacute (70), and chronic (114) diseases of the joints and muscles. These consisted of 52 with dystrophic arthritis, 51 with scapulohumeral periarthritis, 34 with calcaneal bursitis, 23 with humeral epicondylitis, 13 with periarthritis of the knee joint, eight with traumatic arthritis, and 12 with myositis. Power outputs ranged from 6-15 watts, and exposure times from 8 to 12 min/day; in most cases the time was increased by 2 min after four to six sessions. The number of sessions varied from six to fifteen. Microwave therapy was combined with therapeutic gymnastics in 18 cases and with massage in 14. In 12 cases microwave therapy was administered alternately (every other day) with other physical methods (paraffin applications, ultrasound, etc.). Drug therapy and bandaging to immobilize the joints were employed on patients with acute forms, and some patients received nerve blocks with procaine and hydrocortisone. Microwave therapy had a beneficial effect in 165 cases (85.5%) and had no effect in 28 (14.5%). The best results were obtained with 87 patients who received 12-15 sessions of microwave therapy: a beneficial effect was observed in 92% while 8% showed no improvement. Follow-up examinations, performed on 141 patients, revealed that 54 had recovered completely, for all practical purposes, 1-3 weeks after therapy was discontinued. (No references)

0051 EFFECT OF A SUPERHIGH FREQUENCY FIELD ON THE PHYSICAL TRAINABILITY OF EXPERIMENTAL ANIMALS. *(Rus.)* Gusarov, D. V. (No affiliation). *Voen Med Zh* (3):61-66, 1971.

Male albino mice, with 1.5 g weights attached to the base of their tails, were exposed to microwave radiation in plexiglas cages which were rotated 36° every 10 min to insure uniform irradiation. After the mice had been trained to swim, exposure to microwaves (wave length 12.6 cm, power flux density 10 mW/cm^2 for 2 hr every other day) significantly reduced their swimming times until after 15 sessions, irradiated mice were only swimming for half as long as nonirradiated controls. This effect was even more pronounced if mice were exposed to the same dose of radiation before they were trained to swim: the swimming time of untrained irradiated mice decreased progressively with time until they were swimming only one-fifth as long as nonirradiated controls after 14 training sessions. In more highly trained mice microwave exposure had less effect. The unfavorable effect of microwave irradiation on training also depended upon the intensity and dose of radiation, the presence of other unfavorable factors, and the time which had elapsed since the last exposure to microwaves. While irradiation with a power flux density of 1 mW/cm^2 had no effect on the next day's

swimming, use of a power flux density of 10 mW/cm^2 reduced the swimming time for the next six training sessions. If trained mice were forced to swim in water colder than usual, no difference was found between the swimming times of mice irradiated once and nonirradiated controls. However, if mice were exposed to ten sessions of radiation, there was a significant decrease in the swimming time of irradiated mice. Although the swimming times of nonirradiated controls returned to their original level during the next training session, those of mice irradiated with 1 and 10 mW/cm^2 did not return to initial values until the fourth and seventh sessions, resp. after the test with cold water. These findings suggest that microwave exposure makes it more difficult for the mice to select the optimal variant of motor activity. (7 references)

0052 EFFECT OF MICROWAVES ON THE REACTIONS OF THE WHITE BLOOD CELLS SYSTEM. *(E.)* Baranski, S. (Inst. Biostructure, Med. Acad., Warsaw, Poland). *Acta Physiol Pol* 23(4):685-695, 1972.

Guinea pigs were irradiated for 3 hr daily over a period of 3 months with microwaves of pulse modulation or constant modulation at a power density of 3.5 mW/cm^2. Their peripheral blood, bone marrow, lymph node, and spleen cells were then examined in terms of mitotic index, maturation curves, and incorporation of ^{3}H-thymidine. No changes in the granulocytic blood system were found in the irradiated animals. However, the cells in the lymphocytic system showed mitotic disturbances (an increase in the mitotic index), increased ^{3}H-thymidine incorporation, and nuclear structure changes. These changes indicated a stimulation of lymphopoiesis. The changes in the peripheral blood correlated with changes in the structure of the spleen and lymph nodes.

0053 MICROWAVE OVENS AND THEIR PUBLIC HEALTH SIGNIFICANCE. *(E.)* Elder, R. L. (Public Health Service, Bureau Radiol. Health, Rockville, Md.) and W. E. Gundaker. *J Milk Food Technol* 34(9): 444-446, 1971.

There are currently 90 to 130 thousand microwave ovens being used in homes and commercial establishments and the number of units sold in the United States is expected to increase greatly in the next 2 to 3 years. Microwave ovens may have detrimental thermal and nonthermal (field) effects on living organisms. According to the Department of Health, Education, and Welfare performance standard, units manufactured after October 6, 1971 leakage will be limited to 5 mW/cm^2 throughout the life of the oven. Recent field surveys have found that approximately 20 to 33% of all microwave ovens surveyed emit microwave leakage in excess of 10 mW/cm^2. Proper maintenance on the part of the owner and improved servicing, including a microwave emission measurement, seem to be significant factors in maintaining control over excessive leakage. In particular, since any object which accumulates on the door seal of the oven can allow leakage to increase, basic sanitation is vital to microwave oven safety. Other problems which will indicate the potential for unnecessary leakage include a loose door (indicating excessive hinge wear), an interlocking door, and a malfunctioning cooking indication light. State and local health workers are urged to take an active part in convincing owners to implement proper maintenance procedures and to practice good sanitation.

0054 COMPARATIVE ASPECTS OF RADIOFREQUENCY AND MICROWAVE BIOMEDICAL RESEARCH. *(E.)* Michaelson, S. M. (Sch. Med. Dent., U. Rochester, N.Y.) and H. P. Schwan. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 330-332.

Physical "scaling" and comparative biomedical aspects of size, metabolism, and thermal tolerance are discussed as criteria for selecting experimental animals to assess biologic effects and potential hazards to man from exposure to microwaves. From a spectrum of species, basic information on the comparative reaction of biologic systems can be acquired which in turn can be used to elucidate mechanisms of action. For the study of physiologic function, a common parameter such as metabolic rate, body weight, or body surface could be utilized to provide an index of extrapolation among species. A combination of biomedical parameters should permit assessment of changes in basic physiological functions, differentiation of normal and pathophysiological states, differentiation of specific and nonspecific reactions, and differentiation of defensive-adaptional or compensatory changes, which show self-regulatory properties, from pathological manifestations.

0055 AN RF DECOUPLED ELECTRODE FOR MEASUREMENT OF BRAIN TEMPERATURE DURING MICROWAVE EXPOSURE. *(E.)* Larsen, L. E. (Walter Reed Army Inst. Res., Washington, D.C.), R. A. Moore, and J. Acevedo. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 262-264.

A thermistor probe mount combining microcircuitry, current limiting, series resistance, and thermal isolation enables measurement of temperature to a resolution of 0.1 C in the anterior hypothalamic/preoptic area of the brain of subject animals in the presence of continuous RF radiation. The mount and all its connections did not alter absorption in a 3 cm hemisphere filled with dielectric approximating brain at 918 and 2450 MHz. Comparative thermograms for other temperature probes showed an altered pattern of power absorption.

0056 PERTURBATIONS OF THE MICROWAVE FIELD BY EXPERIMENTAL ANIMAL AND APPARATUS IN BIOLOGICAL RESEARCH. *(E.)* Carpenter, R. L. (Northeastern Radiol. Hlth. Lab., Winchester, Mass.), E. S. Ferri, and G. J. Hagan. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 196-197.

Availability of reliable radiation survey meters has simplified measurement of power density at given points in the near- or far-fields. However, field perturba-

tion by the test animal or ancillary equipment, even if made of material with a low dielectric constant, is a problem in biological research on microwave effects. The effect of Plexiglas (dielectric constant 2.7-3.2 at 10^6 Hz) on the radiation field was tested in the far zone in an anechoic chamber. Radiation source was a Raytheon Model PGM-100 generator (2.45 GHz frequency, 800 watts maximal output). Depending on their placement, perturbation by Plexiglas sheets greatly increased or decreased the initial free field power density of 100 mW/cm^2. The greater their thickness, the more pronounced was the effect. Power density was 152 mW/cm^2 when a single 1/4 in. sheet was placed 1/4 wavelength from the probe compared with 24 mW/cm^2 when the distance was 1 wavelength. The highest reading (192 mW/cm^2) resulted with two sheets, one on each side of the probe, at the 1/4 wavelength distance. With each sheet at the 1 wavelength distance, the reading was the lowest (16 mW/cm^2). Uniform power contours were plotted for the radiation field before and after insertion of animals, Plexiglas cylinders, or irregular forms. The resulting perturbations were extensive, complex, and unpredictable.

0057 ACCURATE MEASUREMENT OF MICROWAVE FIELDS FOR MEDICAL AND BIOLOGICAL APPLICATIONS. *(E.)* Toler, J. C. (Georgia Inst. Technol., Atlanta). *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1972, p 2B3/1-2B3/2.

Microwave fields are used increasingly in medical and biological research. Yet measurement of these fields in shielded enclosures or anechoic chambers often results in unreliable, nonrepeatable, and inaccurate data. In the case of shielded enclosures, data errors can be attributed to standing waves generated by multipath propogation due to reflections from the enclosure walls, floor, and ceiling. A hooded antenna technique has proved highly successful in alleviating these problems. In the case of anechoic chambers, materials and devices commonly used in the test configuration (e.g. Plexiglas containers, interconnecting wires, instrumentation etc.) are readily capable of perturbing the exposure environment and causing erroneous data. An optical measurement technique that has reduced error to acceptable levels is presented.

0058 THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC WAVES AND THEIR RELATIONSHIP TO PENDING CANADIAN REGULATIONS. *(E.)* Ghosh, S. K. (Radiat. Prot. Div., Dept. Natl. Hlth. Welfare, Ottawa, Canada) and A. M. Muc. *Proc Microwave Power Sym* (Inst. Microwave Power, Canada) May 1972, p 25-28.

Growing public concern over the increasing number and power of sources of electromagnetic radiation has been reflected in legislation in several countries. In Canada, the Radiation Emitting Devices Act was enacted in May 1970. Radiation leakage limits relevant to specific classes of devices are set in regulations under the provisions of this Act. Microwave ovens, whether domestic, commercial, or industrial, must be designed so that the leakage level at a distance of 5 cm from any point on the external level is less than 1.0 mW/cm^2. Other regulations now under study will deal with microwave blood warmers and diathermy units. That biological systems and materials respond to electromagnetic radiation exposure is well established, but many published studies given insufficient information on the essential parameters of exposure conditions and radiation characteristics. The conflicting and often imprecise data renders the job of specifying regulatory standards extremely difficult.

0059 INSECT-CONTROL POSSIBILITIES OF ELECTROMAGNETIC ENERGY. *(E.)* Nelson, S. O. (U.S. Dept. Agriculture, Agricultural Res. Service, Lincoln, Neb.). *Cereal Sci Today* 17(12):377-378, 387, 1972.

Three regions of the electromagnetic spectrum (the infrared-, gamma-, and radiofrequency (RF)-radiation regions) have been identified as offering potential means for controlling insect species of concern in the baking and milling industries. Numerous insect control studies have been conducted in the RF dielectric-heating range, and some studies have been conducted at microwave frequencies. Materials such as grain can be exposed to high-frequency electric fields between electrodes coupled to RF electronic power oscillators; at microwave frequencies, such materials are exposed to the energy in microwave oven enclosures or waveguide applicators. Stored-grain insects can be controlled by exposures which do not damage grain, but only at costs several times higher than those of chemical control methods. The insects can be heated selectively if their dielectric properties bear the proper relationship to those of the grain. A high insect-to-grain dielectric-loss-factor ratio is desired, with an insect-to-grain dielectric-constant ratio also being preferable. The most efficient insect control can probably be achieved in the frequency range between 10 and 100 MHz. Some evidence indicates that factors other than heating may be involved in the effects of RF fields on biological materials, suggesting possibilities for the development of more efficient RF insect-control methods.

0060 MICROWAVE DISOIMETRY. *(E.)* Vetter, R. J. (Bionucleonics Dept., Purdue U., West Lafayette, Ind.), P. L. Ziemer and D. Puntenney. *Res/Dev* 24(4):22-26, 1974.

The biological effects of microwaves are largely due to heating or hypothermia, although there is some evidence that nonthermal effects of a neurological and psychological nature may be produced by relatively low level radiation. Specific organs such as the eyes and testes are particularly susceptible to the effects of microwaves. At the present time, there is no microwave field measuring device that is small enough to be placed *in toto* in a free field without causing significant perturbation of the field. Nor is there a small device which integrates the microwave energy incident upon a test object or animal. A new dosimeter is described which is designed to integrate the energy density during

microwave irradiation and to monitor the microwave exposure of personnel working around microwave producing equipment. The dosimeter is small, relatively inexpensive, and passive (i.e., powered by the microwave field); it integrates the microwave energy through the use of a coulometer. The dosimeter could be used for several frequencies and, in practice, will integrate power density over time yielding energy density.

0061 DETERMINATION OF THE PROPERTIES OF THE BOUND WATER IN BIOLOGICAL SAMPLES BY MICROWAVE METHODS. *(E.)* Almassy, G. (TKI, Budapest, Hungary) and M. B. S. Misik. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 1B3/1-1B3/2.

Microwave measurements give direct information about the structure of "bound" water of the living cell. For the measurment of the microwave dielectric parameters of biological samples, cavity resonator techniques are suitable. Dielectric parameters are deduced from measurements of resonate frequency and Q-factor of the cavity resonator. Measurements performed on frog nerves show that interaction between albumens and water has a considerable bearing on dielectric parameters. The dielectric decrements depend to a great extent on temperature.

0062 BRADYCARDIA IN ISOLATED HEARTS INDUCED BY MICROWAVE IRRADIATION. *(E.)* Lords, J. L. (U. Utah, Salt Lake City), C. H. Durney, A. Borg, and C. Tinney. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 335-336.

Continuous 960 MHz irradiation (estimated 5 mW absorbed) of isolated poikilothermic hearts in Ringer's solution caused bradycardia, in contrast to the tachycardia usually produced by generalized heating. The effect occurred only over the range 100-200 mW total power. The bradycardia suggests that specific heating took place at one of several tissue interfaces within the heart, particularly at the myelin-muscle interface involving the remnants of the cut nerves enervating the myocardium. The interface responded by initiating firing in the nerves of the parasympathetic system, the result being a decrease in heart rate.

0063 THE PACEMAKER PATIENT AND THE ELECTROMAGNETIC ENVIRONMENT. *(E.)* Smyth, N. P. D. (George Washington U. Sch. Med., Washington, D.C.), V. Parsonnet, D. J. W. Escher and S. Furman. *J Am Med Assoc* 227(12):1412, 1974.

To cope with the ability of the inhibitory-demand pacemaker to sense electromagnetic interference (EMI) other than the intrinsic myocardial potentials, manufacturers have made improvements in the shielding, filtration, and discrimination of the circuitry of the units. However, as protection against EMI increased, so did the strength and variety of the EMI sources (e.g., leaky microwave ovens). Despite these EMI sources, there are very few documented cases of EMI affecting implanted pacemakers. The action of environmental EMI on the patient with an implanted demand pacemaker does not at this time constitute an important clinical problem. While the pacemaker manufacturer must continue to improve his product's resistance to EMI, the product must not lose clinically important sensitivity and versatility. Government agencies can control EMI emissions where feasible (e.g. microwave ovens) and impose geographic limitations where this is not feasible (e.g., powerful sources of radar).

0064 MICROWAVE OVEN INTERFERENCE WITH CARDIAC PACEMAKERS. *(E.)* Rustan, P. L. (Aerospace Med. Div., Brooks Air Force Base, Texas), W. D. Hurt and J. C. Mitchell. *Med Instrumentation* 7(3):185-188, 1973.

ECG tracings were made on 9 anesthetized dogs with atrioventricular blocks induced by injection of 10% buffered formalin and implanted demand cardiac pacemakers before and during exposure to microwaves (2450 mHz) at a distance of 370 cm from the sending horn. Power was continuously increased until inhibition or a change in rate occurred. Bench tests were performed under the same conditions on 10 implanted demand and synchronous pacemakers. Complete inhibition was observed on 4 of the 9 implanted pacemakers at thresholds of about 8 $\mu W/cm^2$. All nonimplanted pacemakers were inhibited by radiation, and 3 of the 10 showed inhibition at the lowest detectable level (0.8 $\mu W/cm^2$), indicating that complete inhibition might have occurred at a lower level. There were significant differences in susceptibility threshold levels among identical devices. Shielded models had a much higher threshold level than unshielded models. In dogs bradycardia and tachycardia were observed at various power density levels. This test shows potentially hazardous electromagnetic interference (EMI) can occur below 10 $\mu W/cm^2$. The effect of EMI was qualitatively the same on implanted and nonimplanted pacemakers, suggesting that each model has a typical response versus power density curve. (9 references)

0065 CLINICAL, MORPHOLOGICAL AND BIOCHEMICAL CHANGES IN EXPERIMENTAL MICROWAVE-INDUCED CATARACT. *(Rus.)* Grechushkina, V. A. (Helmholtz Sci. Res. Inst., Moscow, USSR). *Oftalmol Zh* 27: 226-228, 1972.

The effects of exposure to moderately intense ultrahigh frequency radiation (output power 60 watts, slit 9 cm, wavelength 12.6 cm, frequency 2375 MHz, diameter of the emitter 9 cm, 10-14 sessions of 15 min exposure each) were studied on 28 Chinchilla rabbits weighing 2-3.5 kg. These doses of radiation are comparable to those used clinically as moderate therapeutic doses in ophthalmologic practice. The left eye of each rabbit was exposed, while the right eye served as a control. Microwave-induced cataracts developed in 23 of these 28 rabbits. The lens became cloudy immediately after the course of radiation exposure in ten of the younger rabbits and within 3-7 days after radiation exposure in 13 of the adult

animals. Microwave-induced cataracts were located in the posterior cortical layers in the horizontal suture. They were round or semicircular in shape and regressed in eight of the ten rabbits which were observed for 2-3 months. The remaining five rabbits were sacrificed immediately after radiation exposure to determine if any biochemical changes had occurred in the lens. In these rabbits the ascorbic acid content of the lens had decreased, but ascorbic acid contents were normal in the aqueous humor. No changes had occurred in dehydroascorbic acid contents. There was a significant decrease in the sulfhydryl group content in the soluble protein of the lens, but no change occurred in the content of total soluble protein. The decrease in the ascorbic acid and sulfhydryl group contents occurred simultaneously, suggesting that biochemical changes precede the development of microwave-induced cataracts. In the ten rabbits which had already developed cataracts, more pronounced decreases were observed in the ascorbic acid and sulfhydryl group content in the lens than in rabbits which had not yet developed cataracts. The ascorbic acid content had also decreased in the aqueous humor, as had the content of total soluble protein in the lens. Studies of seven rabbits in which microwave-induced cataracts had regressed revealed that all of these biochemical changes are reversible. Because these microwave-induced cataracts regress spontaneously and heat is not a very important factor with the moderate doses used here, the specific action of microwaves may play a role in the mechanism which results in cataract formation. (19 references)

0066 EFFECT OF INDUCTOTHERMY ON HEART FUNCTION IN PATIENTS WITH SYSTEMIC SCLERODERMA. *(Rus.)* Maiorova, I. S. (Ctr. Inst. Balneol. Physiother., Moscow, USSR). *Vopr Kurorotol Fizioter Lech Fiz Kult* 37:448-450, 1972.

Of 91 patients with systemic scleroderma and cardiac involvement, 45 had cardiosclerosis, 34 had myocardosis, and 12 had involvement of the heart valves. Clinical signs consisted of cardiac dilatation, dullness of the heart tones, a systolic murmur, and accentuation of tone II over the pulmonary artery. ECG findings included changes in the T wave (45 cases), low potentials of the main waves (30 cases), conduction disorders (31 cases), and changes in rhythm (23 cases). In combination with therapeutic gymnastics and massage, inductothermy was administered with an inductor cable, two coils of which were wrapped around the patient's body at the T_{10}-L_4 level and an anode current of 140-180 milliamps was applied for 10-15 min. Treatments were given 4 times a week (total of 12-16 sessions). This therapy reduced pain in the chest in 56% and alleviated dyspnea and made tachycardia disappear in 1/2 of the patients. ECG tracing showed improvements in conduction in 5 and normalization of rhythm in 12 patients. Analysis of the phase structure of systoles in the left ventricle showed improvement in myocardial contractility and increased efficiency of the systole in 29 cases; a decrease in compensatory ability due to deterioration in myocardial contractility in 34 patients; and a decrease in the efficinecy of the systole due to changes in the phase structure of systoles in the left ventricle in 28 patients. (5 references)

0067 SCREENING FOR CATARACTS. *(E.)* McAfee, R. D. (Univ. Sch. Med., New Orleans, La.), L. L. Cazenavette and M. G. Holland. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 3B2/1.

A shadow-graph is described which allows a subject to view his own eye for opacities. The device has been tested at an eye clinic, and the results of its use by cataract patients who have drawn their own opacities are compared with follow-up by photo-slit lamp examinations. In an ongoing survey, the shadow-graph is being used for cataract screening of veterans who have been exposed to microwave radiation as a result of a specific service-connected job such as radar repairman or an aircraft handler on aircraft carrier flight decks.

0068 METHOD OF MEASUREMENT OF RADIO FREQUENCY INTERFERENCE FROM MICROWAVE OVENS. *(E.)* MacLachlan, A. S. (Ministry Posts Telecommunications, London, England). *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 5B3/1-5B3/2.

Microwave ovens are a potential source of interference to radio services over the whole range of frequencies up to 7000 MHz. Because an oven forms an imperfect screen, some of the radio-frequency energy produced escapes by conduction along the main lead or by radiation through imperfect door seals and ventilation slots. In Europe measurements of interference at 0.15-30 MHz are made with a quasi-peak RF voltmeter at the main terminals. Radiated interference can also be measured using an RF voltmeter. The measurements are usually made using a magnetic loop aerial in the range up to 30 MHz, a dipole aerial for 30-1000 MHz, and a small-aperture horn aerial above 1000 MHz.

0069 ADVANCES IN CHOKE DESIGN FOR MICROWAVE OVEN DOOR SEALS. *(E.)* Osepchuk, J. M. (Raytheon Res. Div., Waltham, Mass.), J. E. Simpson, and R. A. Foerstner. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 5B4/1-5B4/11.

By introducing periodic or quasi-periodic loading in the door seal region, new slotted choke designs for microwave oven door seals confine modes exciting choke resonance to TEM and inhibit transverse mode propogation. The new designs yield maximum leakage values at 2.0" below 0.10 mW/cm^2 fairly consistently. Leakage distribution curves for 15 microwave ovens with the slotted choke show a mean of 0.0537 mW/cm^2 with only a few units above 0.10 mW/cm^2. Field data show little increase in leakage over a 1-2 yr period.

0070 INTERLOCK SYSTEMS FOR MICROWAVE OVENS. *(E.)* Prucha, R. V. (General Electric Co., Louisville, Ky.). *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 5B21/

J5B2/2.

A number of interlock systems found in household microwave ovens in the United States are reviewed and a description of methods is presented. Design objectives are discussed and the relative merits of various approaches are illustrated using the method of "fault tree analysis." Simple interlock systems have been replaced by redundant systems to guard against component failures, latched systems to ensure that power is removed before the door seal is disturbed, and concealment schemes to ensure that the interlock system is not defeated deliberately or accidentally. More sophistication may be required. There have been instances where simple redundancy did not guard against common mode kinds of induced failure. Systems must be studied for freedom from common mode failure. In addition, the concept of an interlock monitoring function is being advanced. This concept is also related to a disablement function which renders apparatus incapable of generating microwave energy until it has been tended by a service specialist, if the monitor detects a malfunction.

0071 THE COMBINED EFFECT OF A SUPERHIGH-FREQUENCY FIELD AND AN UNFAVORABLE MICROCLIMATE ON THE BODY. *(Rus.)* Zhuravlev, V. A. (No affiliation). *Voen Med Zh* (3):64-67, 1973.

Experiments were performed on young female rats which were exposed to microwaves in the 10-cm range (5 milliwatts/cm^2) for 1 hr/day and then were placed in an incubator at 40°C and a relative humidity of 22-25%, were exposed to the same unfavorable microclimate but were not irradiated, or were neither irradiated nor exposed to heat. After 60 days these females were mated with normal males to study the effect of these conditions on their reproductive function. Exposure to heat and microwaves increased the RBC, WBC, and hemoglobin content of the blood, whereas heat alone tended only to increase the RBC. The specific gravity of the blood remained essentially unchanged in both groups. The viscosity of the blood and blood catalase activities decreased in both treated groups, but the decrease was more pronounced in rats exposed to both microwaves and heat. While exposure to heat alone had no effect on the percentage of rats producing progeny (87.5%) or on the mean number of offspring per liter (8.9), only 50% of the females exposed to heat and microwaves produced offspring and the mean number of offspring per litter was 6.5. While controls gave birth to more females than males, the sex ratio was reversed for rats exposed to microwaves and heat and for those exposed to heat alone. Autopsies revealed that weight coefficients for the liver and spleen were significantly lower than control values in rats exposed to both microwaves and heat. Histological examinations of the myocardium showed that homogenized and fragmented muscle fibers and small subepicardial hemorrhages were present in rats exposed to microwaves and heat, while rats subjected to heat alone had signs of circulatory disorders (congestion, stromal edema, etc.). Chronic venous congestion was more pronounced in livers and spleens from rats exposed to microwaves and heat. (No references)

0072 CHANGE IN THE NUMBER OF TOTAL SULFHYDRYL GROUPS IN THE BLOOD OF SUBJECTS WHO COME INTO CONTACT WITH GENERATORS OF SUPERHIGH-FREQUENCY RADIATION. *(Rus.)* Kolesnik, F. A. (No affiliation) and N. A. Komogortseva. *Voen Med Zh* (3):63-64, 1973.

Amperometric titrations with 0.001 M silver nitrate solutions were used to determine the concentration of -SH groups in the blood of subjects who come into contact with generators of superhigh-frequency (SHF) radiation and of controls. All subjects were 20-40 yr old, and those exposed to SHF radiation had been employed in their positions for 1-10 yr. The mean concentration of -SH groups was 920 µM/100 ml in controls, 698 µM/100 ml in those exposed for 1-2 yr, and 768 µM/100 ml in those exposed for 2-10 yr. Since exposure to SHF radiation significantly decreases blood -SH group concentrations, this test can be used to diagnose the initial stages of disorders caused by SHF radiation. Administration of cysteamine (0.4-1.2 g) significantly increased blood -SH group levels in both controls and workers exposed to SHF radiation, while administration of ascorbic acid (0.5 g) had no effect on blood -SH group levels. It is recommended that cysteamine be used prophylactically in subjects exposed to SHF radiation. (No references).

0073 ANALYSIS OF REPORTED PHYSIOLOGIC EFFECTS OF MICROWAVE RADIATION. *(E.)* McLees, B. D. (Naval Med. Res. Inst., Bethesda, Md.) and E. D. Finch. *Advances Biol Med Phys* 14:163-223, 1973.

The interaction between electromagnetic waves and tissue is described with emphasis placed on the water content of the tissue. Techniques used to measure the dose of microwave radiation are considered, and temperature changes induced by whole-body, partial-body, and experimental human exposure to microwaves are reviewed. In thermal doses microwave exposure consistently produces changes in the WBC. Changes in the RBC suggest that microwaves induce mild hemolysis, but the data are not conclusive. Changes in reticulocyte counts and isotope kinetics have been variable, and insufficient evidence has been obtained to indicate that microwave exposure causes hemolysis or bone marrow depression. Microwave irradiation has decreased blood volume and produced changes in serum protein, venous CO_2, and chloride levels, but the last two changes cannot be explained until serum electrolytes, arterial blood gases, and pH are investigated. Exposure of rabbits to microwave radiation until a critical temperature had been reached affected production of antibodies to sheep RBC, but investigations at lower power levels are needed to gain insight into the nature of these antibody changes. The effects of microwaves on the endocrine system, particularly the testes, are reviewed, and brief consideration is given to possible mutagenic effects. Systems for inducing cataracts with microwaves are discussed, relationships between cataract formation and intraocular temperature and power

density are reviewed, and metabolic changes occurring in the eye during microwave irradiation are considered. Although most American and Western European investigators believe data on low-level nonthermal effects of microwave radiation are not valid, a wide variety of such effects are reported in the Eastern European literature. Most of these effects involve the CNS and do not appear to depend upon the frequency of the radiation but on the peak power density. (80 references).

0074 CHANGES IN INTRALEUKOCYTE PEROXIDASES IN INTRAARTICULAR EXUDATES AFTER IRRADIATION WITH RADAR MICROWAVES. *(It.)* Santolini, B. M. (San Giorgio Inst. Orthopedics, Genoa, Italy), P. L. Nai Fovino and L. Rossoni. *Minerva Ortopedica* 22:459-462, 1971.

The technique of Stato and Sekija was used to determine peroxidase activity in WBC of intraarticular exudates from 12 patients with rheumatoid arthritis. Samples were exposed to radar microwaves *in vitro* immediately after they were obtained. Exudates from 6 patients were exposed to microwaves for 5, 15, or 30 min with the power held constant at 150 watts, while those from the remaining 6 patients were irradiated for 10 min at powers of 50, 100, and 150 watts. The peroxidase activity in WBC decreased only in exudates irradiated at 150 watts for 30 min. No changes were observed in any of the other samples exposed for shorter periods. These findings confirm that radar therapy has a beneficial local effect in rheumatic inflammation when it is used in the proper doses. (26 references)

0075 MORPHOLOGICAL STUDIES OF THE COAGULATION EFFECTS OF 8-mm MICROWAVES IN THE RABBIT EYE. *(Ger.)* Lommatzsch, P. (Ophthalmol. Clin., Humboldt U., Berlin, Germany), B. D. Bohne, W. D. Ulrich and R. Kuhn. *Albrecht von Graefes Arch Klin Ophthalmol* 187:201-214, 1973.

Ophthalmoscopic and histological examinations were performed on rabbits after irradiation with pulsed (duration ca. 80 nanosec) microwaves (wavelength 8.15 mm) from a generator equipped with a hollow adaptor designed to fit the curvature of the eye. The emergent power ranged from 0.1-2.5 watts, and exposure times were 30 and 60 sec. By measuring the increase in temperature occurring during irradiation in a water phantom, it was demonstrated that coagulation produced by 8-mm microwaves can be accounted for by thermal effects. Because of the rapid decrease in temperature as the distance between the eye and the generator was increased, a relatively large increase in temperature was obtained primarily in the outer layer of the sclera. Histological findings resembled those previously observed with high-frequency diathermy. Scleral fibers were swollen, and there was proliferation of the surrounding connective tissue at higher powers. Clearly defined chorioretinal scars formed at lower powers, suggesting that 8-mm microwaves might be used for surgical correction of detached retinas. (28 references)

0076 SUSCEPTIBILITY OF CARDIAC PACEMAKERS TO RADAR INTERFERENCE. *(E.)* Rohl, D. (U. Ulm, W. Germany), H. M. Laun, M. E. T. Hauber, H. Voigt and M. Staunch. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 4B1/1-4B1/2.

The susceptibility of 16 cardiac pacemakers to radar interference was investigated. All pacemakers showed signs of interference at effective pulse power densities between 25 $\mu W/cm^2$ and 6250 $\mu W/cm^2$. Metal-shielded and unshielded pacemakers were equally sensitive in air because the interfering radiation was received through the electrode in both types. Pace-makers implanted in dogs and patients were disturbed in the vicinity of a high-power radar station. To reduce interference susceptibility, a very sensitive unshielded pacemaker was modified by metal-shielding and a low-pass filter at the electrode. Thereafter it was insensitive to effective pulse power densities of > 12 W/cm^2 when tested under worst-case conditions in air.

0077 MECHANISM INVOLVED IN THE BIOLOGICAL ACTION OF ULTRASOUND AND SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELDS IN THE 3-CENTIMETER RANGE. *(E.)* Sivorinovskii, G. A. (Ctr. Inst. Balneother. Physical Ther., Moscow, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* 38:222-227, 1973.

Oxidative phosphorylation was studied in rat liver and kidney mitochondria before and after irradiation of the abdomen with pulsed (2700 impulses/sec) microwaves (power densities of 25, 50, and 100 microwatts/cm^2) for 10 min. A single exposure to 25 microwatts/cm^2 had no effect on oxygen consumption and respiratory control in rat liver mitochondria but did decrease the effectiveness of phosphorylation somewhat. In kidney mitochondria respiratory activity decreased slightly, respiratory control increased, and the effectiveness of phosphorylation remained unchanged. Ten exposures to this power density of microwave radiation increased the rate of oxygen consumption and respiratory control in kidney mitochondria. A single exposure to 50 microwatts/cm^2 decreased phosphorylating activity in liver mitochondria but had no effect on that in kidney mitochondria. Ten exposures to this power-density of microwave radiation increased respiratory control in both liver and kidney mitochondria. A single exposure to 100 microwatts/cm^2 increased oxygen consumption and decreased the effectiveness of phosphorylation in rat liver mitochondria and increased respiratory control but had no appreciable effect on phosphorylation in kidney mitochondria. The rates of oxidative phosphorylation approached normal values in both liver and kidney mitochondria when rats received 10 exposures at this power density. No correlation was found between blood sugar levels and the functional activity of mitochondria when rats were repeatedly exposed to 100 microwatts/cm^2 radiation. Since repeated exposure to microwaves in the 3-cm range had less effect than a single exposure on oxidative phosphorylation in liver mitochondria, it is suggested that some of the enzymes involved in this process adapt to microwave exposure. (19 references)

0078 GASTROINTESTINAL FUNCTION IN WORKERS EXPOSED TO THE EFFECTS OF ELECTROMAGNETIC FIELDS IN THE ULTRAHIGH FREQUENCY RANGE. *(Rus.)* Kleiner, A. A. (Inst. Industrial Hyg. Occupational Dis. Khar'khov, USSR). *Gig Tr Prof Zabol* (2):15-18, 1974.

Gastrointestinal function was investigated in 72 workers in radio and television centers who had been exposed to 5-10 times the maximum permissible levels of electromagnetic radiation in the meter range (UHF). Of these workers, 69% were men and 62% were less than 40 yr old. The duration of exposure was less than 5 yr in 16 cases, between 5 and 10 yr in 27, and more than 10 yr in 29. Occupationally related functional disturbances of the nervous and cardiovascular systems were diagnosed in 69%. Controls consisted of 43 normal subjects who had never been exposed to occupational hazards. Among the radio and television workers clinical symptoms of gastrointestinal disease (epigastric pain, postprandial discomfort, nausea, heartburn, decreased appetite, belching, and evacuatory disorders) tended to increase in frequency with increasing occupational exposure to UHF radiation. Although no disorders were observed in basal gastric acid or protein secretion or in the volume of gastric juice secreted, response to mechanical or chemical stimulation was reduced in the majority of cases. Although clinical diagnosis of chronic gastritis had been established in 12 subjects (16.6), stomach biopsies from 17 workers showed that 5 had only superficial gastritis and 11 had normal findings. Almost all of the 5 patients with gastritis had been exposed to UHF for more than 10 yr. The amplitude of gastric contractions was reduced in 41.2%. Pancreatic enzyme secretion recovered slowly after stimulation with 30 ml of 0.5% hydrochloric acid. Blood levels of Atoxyl-resistant lipase and trypsin were significantly increased and blood amylase levels increased after double glucose loading. Although none of the workers had symptoms of liver disease, liver function tests showed that 1/2 had disorders in protein secretion, 58% had disorders of carbohydrate metabolism, and 33% had impairment of hepatic detoxification. The Meltzer-Lyon test was positive in 1/5 of the workers and bile concentrations of bile acids tended to be low while bile cholesterol levels were higher than in the control group. Disorders in bile synthesis were most pronounced among workers who had more than 10 yr exposure to UHF radiation. (12 references).

0079 BIOLOGICAL EFFECTS AND EXPOSURE STANDARDS FOR NON-IONIZING ELECTROMAGNETIC ENERGIES. *(E.)* Michaelson, S. M. (U. Rochester Sch. Med., N.Y.). *3rd Int. Congress of Int. Radiation Protection Assn. (Washington, D. C.)* September 9-14, 1973.

Nonionizing radiant energies at certain frequencies, intensities, and durations of exposure can produce biological effects which may be beneficial as well as harmful. For the general population and those persons exposed or with potential exposure to these energies, personnel exposure guidelines and product emission standards have been promulgated for some of these energies. Personnel protection guides or exposure standards are usually those established by the American National Standards Institute, American Conference of Government Industrial Hygienists, or Department of Defense. Some industrial organizations have standards of their own which may be modifications of the national standards. Legislation for personnel exposure and product emission levels for nonionizing radiation are covered under the Occupational Safety and Health Act of 1970 and the Radiation Control for Health and Safety Act of 1968, resp. It is important that a distinction be made between product emission standards and personnel exposure standards and how they relate to potential injury. Realistic assessment of the biomedical effects of these radiant energies is essential so that the worker or general public will not be unduly exposed, nor research, development, and beneficial utilization of these energies be hampered or restricted. There are areas of disagreement between Eastern European and Western investigators on the effects of radio frequency and microwaves. USSR and Eastern European standards are based on vague "asthesia" syndromes reported by individuals who work with microwave/radio frequency energies. These effects have not been demonstrated by Western researchers. (55 references)

0080 LENTICULAR AND RETINAL CHANGES SECONDARY TO MICROWAVE EXPOSURE. *(E.)* Aurell, E. (Dept. Ophthalmol., U. Gothenburg, Sweden) and B. Tengroth. *Acta Ophthalmol (Kbh)* 51(6):764-771, 1973.

Eye examinations were carried out on 98 employees in an electronic industry developing radar equipment. Of this number 68 subjects had been exposed to microwaves for a certain period or were still working in the field; the remaining 30 had no known exposure. The number of exposed subjects with lens opacities was high, even in age groups under 41 yr. Retinal lesions were also frequent in the exposed group but were found in only 1 employee in the control group. Dividing the exposed group into testing personnel and laboratory personnel revealed a significantly higher concentration of lens and retinal lesions in the former. This concentration in a certain exposed group suggests that the recommended maximum permissible exposure of 10 mW/cm^2 is probably sufficient and that the lesions were due to leakages from equipment or carelessness on the part of testing personnel. In two cases the lesions resulted in a decrease in vision. Damage to the retina suggests that similar changes might appear in other nervous tissue after exposure to microwaves. (41 references)

0081 DO YOU HEAR WHAT I HEAR? *(E.)* Hindin, H. J. (no affil.). *Microwaves* 13(2):9, 1974.

Experiments conducted by Allan H. Frey and Rodman Messenger, Jr. of Randomline, Inc., Willow Grove, PA are described. Field tests with radar have indicated that humans perceive low-power, pulse-modulated energy in the 0.3-3 GHz band. In radio-frequency anechoic chamber experiments, subjects with normal hearing were trained to estimate the perceived loud-

ness of the buzz heard at 1.245 GHz. A randomized order of peak power, average power, pulse width, and pulse repetition rates were used. The results show that once a minimum pulse width is achieved, perceived loudness is a function of peak power only. When pulse width is held constant and average power varied, the sounds perceived vary in timbre and pitch. The threshold for perception in the radio-frequency chamber was a peak power of about 80 mW/cm^2. The mechanism of detection of microwave energy by humans is not known but may involve interaction of microwave, electromagnetic and neural fields. (No references)

0082 HAZARDS-RESEARCH COORDINATION. *(E.)* Anonymous. (no affil.). *Microwave J* 17(3):32, 1974.

Intensification of research on microwave radiation health effects, with improved communication among world scientists, may result from the first International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, held October 15-18, 1973 in Jadwisin, Poland. A major discrepancy to be resolved between Western and Eastern scientists concerns microwave power levels at which health effects may be expected. Because of differences in findings, maximum occupational exposure levels in the United States are as much as 1000 times the levels permitted in Russia and Eastern Europe. Following the presentation of 40 papers on microwave radiation subjects, the Symposium recommended (1) the promotion of international coordination of research on the biologic effects of microwave radiation; (2) development of a nonionizing radiation program by an international health agency; (3) establishment of internationally acceptable nomenclature and definitions of physical quantities and units, and standardization of measurement techniques and dosimetry; (4) use of operational definitions of microwave intensity ranges to achieve a more uniform approach to the discussion of mechanisms underlying biological effects; and (5) furtherance of biologic, medical, epidemiologic, and bio-physical studies to improve understanding of the interaction of microwave radiation with biologic systems. (No references)

0083 BIOLOGICAL EFFECTS IN RODENTS EXPOSED TO 10^8 PULSES OF ELECTROMAGNETIC RADIATION. *(E.)* Skidmore, W. D. (Armed Forces Radiobiol. Inst., Bethesda, Md.) and S. J. Baum. *Health Phys* 26(5):391-398, 1974.

Sprague-Dawley rats and AKR/J mice were exposed for 38 weeks to 10^8 electromagnetic pulses (EMP) at 5 pulses/sec and a peak electric field intensity of 447 kV/m. Reticulocyte count in exposed rats were often significantly greater than that of non-irradiated animals. However, there were no concomitant differences in peripheral erythrocyte counts between the two groups, nor did radioactive iron incorporation indicate increased cellular production in the irradiated group. While platelet counts in exposed rats were about 10% below those in the nonexposed group, the two groups did not differ in number of circulating leukocytes or bone marrow cellularity. Analysis of chromosomes from bone marrow cells showed no detectable increases of aberration in EMP-exposed rats; chemical analysis of blood and histological studies indicate no effect of EMP. Rat fetuses showed no abnormalities, and no mammary tumors were observed in exposed rats. Exposure to EMP did not induce an early onset of spontaneous leukemia in male AKR/J mice, nor was the fraction of leukemic mice greater in the exposed group (9/42) than in the nonirradiated group (11/24). Exposure of rodents under conditions in excess of that encountered by humans who handle EMP facilities indicated no apparent acute injuries. (17 references)

0084 MICROWAVE IRRADIATION SACRIFICE: APPLICATION IN NEUROCHEMICAL RESEARCH. *(E.)* Schmidt, D. E. (Tennessee Neuropsychiatr. Inst., Nashville), M. J. Schmidt, F. A. Robinson and L. K. Wilson. *Proc Int Microwave Symp* June 1973, p 326-327.

Temperatures, inactivation rates of adenyl cyclase, phosphodiesterase, cholinesterase, and levels of acetylcholine and cyclic AMP were measured in rat brain following microwave sacrifice. Temperatures of 70-80 C were reached in 15-20 sec in a 200-250 g rat. Inactivation of enzyme systems was rapid and simultaneous throughout the brain. Acetylcholine, choline, and cyclic AMP values were interpreted as approaching true *in vivo* brain levels. It is concluded that microwave irradiation sacrifice reduces presacrifice and sacrifice stress in animals as compared with decapitation and/or freezing. Design and construction of a more powerful focused microwave system should reduce inactivation time to under 1 sec and further reduce or eliminate stress. Such a system will allow the most accurate determination of true *in vivo* levels and turnover rates of heat stable neurotransmitters to date. (5 references)

0085 POSSIBILITIES FOR CONTROLLING STORED-GRAIN INSECTS WITH RF ENERGY. *(E.)* Nelson, S. O. (Agric. Eng., Univ. Nebraska, Lincoln). *Proc Microwave Power Symp* May:201-202, 1972.

Studies of the effects of radiofrequency and microwave energy on insects are reviewed. The influence of physical and entomological factors is summarized on the basis of experimental evidence. Physical factors discussed include frequency, field intensity, modulation, exposure time, dielectric properties of insects and grain, moisture content and other characteristics of the host medium. Entomological factors include insect species, developmental stage, age, nature of injury and effects on reproduction when insects are exposed to high-frequency fields. The frequency dependence of the relative dielectric constant and loss factor is illustrated as determined by measurements on bulk insects and bulk grain samples throughout the range 250 Hz to 12.2 GHz. Data are presented on relationships between sample density and dielectric properties for hard red winter wheat and adult rice weevils, and estimates are given for dielectric properties of wheat kernels and individual insects at about 10 GHz. Estimates of relative field intensity are obtained

modeling insects as spherical objects in an infinite medium. Analyses indicate that the range 5-100 MHz offers the best possibility for insect control through selective or differential dielectric heating. (No references)

0086 THE ENVIRONMENTAL IMPACT OF MICROWAVE SYSTEMS IN THE 70'S. *(E.)* Jansky, D. M. (Off. Telecommun. Policy, Exec. Off. President, Washington, D.C.). *Proc Int Microwave Symp* June 1973, p. 184-185.

Users of Government and non-Government microwave systems are documented together with the types of services they perform and the magnitude of powers employed. Projected advances in microwave technology during the 1970's include a new spectrum for space services and integrated circuit microwave components which will permit the development of inexpensive equipment, applicable to a number of different systems. These advances will have two major environmental impacts, one of which is electromagnetic compatibility and the other biological. Existing communication-electronic equipment may be susceptible to functional modification by the radio energy of new communication-electronic systems. Therefore, the introduction of new systems increasingly demands prior proof of electromagnetic capability. Considerable research has been undertaken to ascertain the potential biological impact of radio energy. Boundary conditions that will be protective of health, while permitting the functioning of telecommunication systems, are discussed. (No references)

0087 THERMAL EFFECTS OF SINGLE AND REPEATED EXPOSURES TO MICROWAVES - A REVIEW. *(E.)* Michaelson, S. M. (U. Rochester Sch. Med., N.Y.). *Proc Int Symp Biologic Effects Health Hazards of Microwave Radiation (Poland)* October 15-18, 1973, Report No. UR-3490-317.

Although few studies of repeated exposures to microwaves are available, there are some that show interesting relationships in respect to threshold phenomena and physiologic adaptation. Threshold response is noted in rabbits exposed to 2.45, 5.40, 8.23 and 10.05 GHz localized to the eye at power density/time durations sufficient to result in opacities. Adaptive reactions have been noted in the dog, rabbit, and cat. For example, repeated whole-body exposure to 2.88 GHz and 1285 MHz pulsed microwaves at power densities from 20-165 mW/cm^2, 1-6 hr/day for 2-4 weeks, showed thermal adaption or acclimatization as reflected by diminished temperature response as the exposures continued. Rats repeatedly exposed to 2.45 GHz pulsed reveal adaptive reaction of functional changes. Acetylcholine levels in the blood of rabbits and functional changes such as arterial pressure alterations in rabbits also show the phenomenon of adaptation as a result of repeated exposures to thermogenic levels of microwaves. These studies are of interest not only from the viewpoint of microwave biologic effects and health implications, but also as a means of examining some fundamental aspects of thermoregulation, acclimatization or adaption, and interrelated cardiovascular, biochemical, and neuroendocrine functions. (84 references)

0088 A PROPOSAL FOR A MICROWAVE RADIATION WARNING SIGN. Ghosh, S. K. (Radiation Protection Bureau, Hazards Control. Div., Health Welfare Canada, Ottawa), A. M. Muc, D. W. Lecuyer and M. P. Diotte. *Health Phys* 26(4):360-361, 1974.

One way to reduce exposure to microwave radiation would involve the posting of warning signs which would be specific to microwave radiation hazards and would indicate the hazard both qualitatively and quantitatively. Based on the concept used by the Canadian Department of Consumer and Corporate Affairs, a system of three such signs is proposed. A triangular sign indicating CAUTION MICROWAVES would indicate the presence of microwave fields which are sufficiently low (less than 1 mW/cm^2) to allow UNLIMITED OCCUPANCY under normal conditions. A diamond-shaped sign indicating WARNING MICROWAVES would indicate areas in which the power density exceeds 1 mW/cm^2 and within which LIMITED OCCUPANCY would be allowed. An octagonal sign indicating DANGER MICROWAVES would indicate areas in which the power density exceeds 25 mW/cm^2, or DENIED OCCUPANCY zones. For microwave devices, the CAUTION sign would indicate a device whose normal use requires care, while the WARNING sign would indicate devices which could cause injury and the DANGER sign would indicate devices which could cause death. (2 references)

0089 THE MICROWAVE OVEN SAFETY DEBATE. De Vore, R. T. (Bureau Radiological Health) and A. Van de Griek. *FDA Consumer* p. 25-26, Apr. 1973.

In April 1973, the Consumer Union announced that it could not recommend any of the home model microwave ovens now on the market, largely because they leak detectable radiation. However, since all electronic devices generating almost all types of electromagnetic radiation leak some detectable radiation, the Bureau of Radiological Health, which maintains that the microwave ovens manufactured today are safe for home use, states that the most feasible approach to electronic radiation protection is to require that electronic radiation emissions be kept well below the lowest levels known to cause biological effects. The Federal microwave oven standard sets a maximum emission standard within such limits. While this standard allows for some deterioration of the oven during its useful life, properly cared for ovens may undergo little change in radiation control capabilities as the result of use. The Consumer Union unfavorably compares the FDA standard for microwave oven emissions with the Russian standard for microwave exposure of an individual. The maximum allowable emission level at the source and the actual exposure received are not the same, however, and the FDA standard is actually more stringent than the Russian requirement. The microwave oven standard is continually reviewed and, when warranted, improved by the Bureau of Radiological Health. (No references)

0090 RADIO-FREQUENCY ENERGY: A HAZARD TO WORKERS? *(E.)* Odland, L. T. (Radiol. Hlth. Lab., Wright-Patterson Air Force Base, Ohio), V. T. Penikas, and R. B. Graham. *Ind Med Surg*

July/August:23-26, 1973.

A statistical summary of results of ophthalmological examinations conducted on individuals whose occupations provided a potential for exposure to the radiofrequency portion of the electromagnetic spectrum is presented. Studies were conducted on 697 individuals (320 controls) during the period December 1970 to April 1972. Criteria for selection of participants were that the individual be primarily engaged in the operation or maintenance of radar equipment. The main criterion in the selection of controls was that the individual was not and had not been engaged in any duties that permitted an actual or potential opportunity for repeated exposure at the occupational level to electromagnetic radiation other than that of background and visible light. The data considered relevant to the purposes of the study were: age, family history, and three indices of lens changes; opacities, vacuoles, and posterior subcapsular irridescence (PSCI). In the control group, 33 of 320 had no recordable lens changes in either eye as compared with 40 of 377 in the study group. In the control group; 89 individuals had positive family histories (siblings, parents, or grandparents) of diabetes mellitus, nontraumatic cataract, glaucoma, and/or grossly defective vision as compared with 99 in the study group. Both groups were well matched for age with the mean age for both groups being 35. Frequency of lens changes between the two groups were similar with PSCI the most frequently observed change. The only notable difference in the study was that in controls 17% had positive family histories and lens changes as opposed to 29% in the study group. No conclusions were reached with respect to this difference since there was no record of actual exposure for each individual in the study group. To judge the significance of the occupational hazard of electromagnetic radiation more accurately, it will be necessary to correlate medical findings from long-term observations of workers exposed to electromagnetic radiation with the extent of exposure. (9 references)

0091 DETERMINATION OF ENERGY ABSORPTION OF MICROWAVE RADIATION USING THE COOLING CURVE TECHNIQUE. *(E.)* McRee, D. I. (Natl. Inst. Environ. Health Sci., Research Triangle Park, N.C.). *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 4B5/1-4B5/3.

Cooling time-temperature profiles of a simulated biological specimen in a test tube were measured after the 2450 MHz microwave field was terminated. From these cooling curves, the loss and absorption coefficients were determined. Using these coefficients, the time-temperature profiles and energy absorption during exposure can be mathematically calculated. A comparison of the calculated time-temperature profiles and the measured time-temperature profiles is presented. The cooling curve technique has usefulness in biological effects studies. The amount of energy absorbed or dose to the specimen can be determined without having a detector in the specimen during irradiation. The calculated time-temperature profiles allow the investigator to treat control specimens to the same time-temperature conditions. Thus, nonthermal or specific effects of microwave irradiation can be evaluated. (No references)

0092 DETERMINATION OF THE ABSORPTION OF MICROWAVE RADIATION BY A BIOLOGICAL SPECIMEN IN A 2450 MHz MICROWAVE FIELD. *(E.)* McRee, D. I. (Natl. Inst. Environ. Hlth. Sci., Research Triangle Park, N.C.). *Health Phys* 26(5):385-390, 1974.

Research into the bioeffects of microwave radiation requires accurate measurements of fields and doses to the specimen to provide information of value for determining safe exposure levels. A technique is presented for determining the energy absorbed by a biological specimen in a laboratory situation. Time-temperature profiles for 5 ml of distilled water were measured using a thermistor tested for its insensitivity to the 2450 MHz continuous wave microwave field. The time-temperature profiles are accurately described by a mathematical equation derived from absorption and loss coefficients at a single known power density. After obtaining the mathematical model for a particular experimental situation, the model can be used to determine the time-temperature profile for any power density level. While primarily applicable to *in vitro* studies where the biological specimen is small and relatively homogeneous, the technique could be extended to specific tissues in animal systems where small probes are implanted. (7 references)

0093 FUNCTIONAL AND MORPHOLOGICAL STUDIES OF THE THYROID GLAND IN ANIMALS EXPOSED TO MICROWAVE IRRADIATION. *(E.)* Baranski, S. (Military, Inst. Aviation Med., Warsaw, Poland), K. Ostrowski and W. Stodolnik-Baranska. *Acta Physiol Pol* 23(6): 1029-1039, 1972.

Functional and morphological changes in the thyroid gland and in ultrastructure of secretory cells were studied in 20 adult rabbits irradiated 3 hr/day for 4 months with microwaves of pulsed modulation (wavelength 10 cm, power density 5 mW/cm^2). Chronic irradiation, at a dose not causing an elevation of total and local temperature, induced a 100% increase in the indexes of conversion and protein-bound ^{131}Iodine, which indicates increased secretion of thyroid hormone. Increases in ^{131}I incorporation into the thyroid gland (50%), the differential absorptive ratio (70%), and radioactivity of dry thyroid mass (70%) were related to increased production of hormone in the thyroid, as confirmed by autoradiographic studies. In histological sections, thyroid follicles were covered by high cuboidal epithelium. No mitotic figures were observed. Electron microscopy revealed an increased number of cytozomes, enlargement of the Golgi apparatus, and endoplasmic reticulum. These studies confirm the possibility of extrathermic action of microwaves and cumulation of doses of radiation through a long period of time. (17 references)

0094 EFFECT OF AN ELECTROMAGNETIC FIELD IN THE METER RANGE ON THE NERVOUS SYSTEM OF ANIMALS ON THE BASIS OF PHYSIOLOGICAL AND BIOCHEMICAL STUDIES. *(Rus.)* Goncharova, N. N. (Inst.

Industrial Hyg. Occupational Dis., Khar'kov, USSR) and L. I. Mishchenko. *Gig Tr Prof Zabol* (7):22-25, 1973.

Changes in defensive conditional reflexes and biochemical changes in the brain were studied in rats exposed for 4 months to nonthermal magnetic and electrical fields in the meter range. Rats were divided into 5 groups and were exposed to electrical fields with intensities of 800 and 200 volts/m and magnetic fields with intensities of 2 and 1 amps/m, resp. The remaining group consisted of nonexposed controls. Exposure to electrical and magnetic fields increased the latent period of conditional reflexes. This increase reached a maximum after 4-6 wk of exposure. The latent time then decreased but was still significantly longer than in controls after 4 months. Summation threshold values also tended to increase with exposure to 800 volts/m and 2 amps/m. This increase reached a maximum after 8-12 wk of exposure. The extent of the increase depended upon the intensity of the field. When exposure was discontinued, both the latent period and summation threshold values returned to normal. Exposure to an electrical field at an intensity of 800 volts/m decreased the glycogen content of the brain but had no effect on its glucose content; increases in lactate and pyruvate occurred in the brain and blood. Exposure to a magnetic field increased the glycogen content of the brain by 21% but had no effect on other parameters of carbohydrate metabolism. Thus, exposure to an electrical field apparently stimulates glycolysis and interferes with oxidation of carbohydrates while exposure to a magnetic field inhibits carbohydrate metabolism. During exposure to an electrical field with an intensity of 800 volts/m the preformed ammonia content of the brain increased by an average of 37.5%; decreases were noted in the other groups. In a number of cases these metabolic disorders persisted for several weeks after discontinuation of exposure. Although no change was produced in the total acetylcholine content of the brain by exposure to electrical (800 volts/m) or magnetic (1 amp/m) fields, changes did occur in the distribution of acetylcholine fractions in the former group. Bound acetylcholine decreased by 84% while the free or loosely bound fraction increased by 134%. Acetylcholinesterase activity decreased in all groups except the one exposed to a magnetic field with an intensity of 1 amp/m. These findings suggest that binding of acetylcholine with lipoprotein is impaired and its synthesis may be inhibited. The decrease in acetylcholinesterase activity is apparently secondary to the decrease in its substrate. (6 references)

0095 RATE EFFECTS IN ISOLATED HEARTS INDUCED BY MICROWAVE IRRADIATION. *(E.)* Lords, J. L. (Microwave Device Physical Electronics Lab., U. Utah, Salt Lake City), C. H. Durney, A. M. Borg and C. E. Tinney. *IEEE Trans Microwave Theory Tech* MTT-21(12):834-836, 1973.

Continuous wave 960-MHz microwave irradiation of isolated turtle hearts in Ringer's solution produced bradycardia rather than the tachycardia usually induced by generalized heating. The effect occurred over the range of 50 to 200 mW total input power, with the greatest decrease in heart rate occurring at 100 mW. This corresponds to an estimated 3 mW absorbed by the heart. It is hypothesized that the microwave power stimulated the nerve remnants and/or the *boutons terminaux* causing the release of transmitter which induced the decrease in heart rate. (2 references)

0096 POWER DEPOSITION IN A SPHERICAL MODEL OF MAN EXPOSED TO 1-20 MHz ELECTROMAGNETIC FIELDS. *(E.)* Lin, J. C. (Univ. Washington Sch. Med., Seattle), A. W. Guy and C. C. Johnson. *IEEE Trans Microwave Theory Tech* MTT-21(21):791-797, 1973.

The induced fields and the associated power deposition in man exposed to high frequency (HF) electromagnetic fields were investigated theoretically using spherical models. The induced electric fields inside the model exposed to plane wave or near fields can be described adequately by a combination of quasistatic electric and magnetic induction solutions. For field impedances less than 1200$\pi\Omega$, the magnetically induced energy absorption predominates. Therefore, *H* fields must be measured to obtain any estimate of the hazards due to HF exposure. For a 70-kg model of man exposed to a plane wave field, the theory indicates that the time-average power absorption/unit volume is less than 2.5×10^{-3} mW/g for each milliwatt/square centimeter 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 for the microwave region. (12 references)

0097 I. ISOTROPIC ELECTRIC FIELD PROBES FOR COMPLICATED FIELDS. *(E.)* Bowman, R. R. (Natl. Bur. Standards, Boulder, Colo.). *Digest of Papers Joint US Army/Georgia Inst Technol Microwave Dosimetry Workshop* 1-2 June, 1972, p 53-55.

A field sensor for complicated electric fields is completely independent of its orientation in the field despite any combination of reactive near-field components, multipath components, and arbitrary polarization. The sensor consists of three electrically short, orthogonal, dipole-diode antennas that separately sense the corresponding orthogonal components of the electric portions of the electromagnetic field. The three detected signals are transmitted away from the sensor by conductors of such high resistance that they are essentially transparent to the electromagnetic field. Preamplifiers buffer these signals which are then summed in a scaling amplifier with three nonlinear inputs. The composite signal provided is proportional to the electric field energy density at the position of the sensor. Practical probes utilizing this sensor are within 1 dB of isotropic. Electromagnetic hazard meters with greater than 40 dB dynamic ranges and wide frequency ranges have been developed from these probes. (no references)

0098 STUDIES OF RF BIOLOGICAL HAZARDS FROM HIGH POWER TRANSMITTERS OPERATING IN THE