MICRO WAVE NEWS

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INSIDE...

NY State Power Lines Report: ELF Risks Gain National Attention

The New York State Power Lines Project's scientific advisory panel has accepted and endorsed the findings of the Savitz study, noting that they add "to the credibility of the [Wertheimer-Leeper] hypothesis that exposure to extremely low frequency [ELF] magnetic fields might be a cause of childhood cancer."

In its final report, the panel distanced itself from endorsing a "causal relationship" between power line magnetic fields and cancer, however – arguing that it is "still no more than a hypothesis," albeit a "stronger" one now. If a causal relationship does exist, the panel estimated that "10-15% of all childhood cancer cases are attributable to magnetic fields."

While bemoaning the absence of a mechanism to explain the action of the magnetic fields, the panel underlined how small the implicated fields are: "One might be exposed to such fields almost anywhere in the environment."

Overall, the panel concluded that the 16 funded studies indicated a "variety of effects" not "previously appreciated" and that, "Several areas of potential concern for public health have been identified." One particular result that has sparked special interest is Dr. Kurt Salzinger's experimental finding of long-term behavioral effects from pre- and post-natal exposure to ELF fields (see p.6). The panel singled out this effect, calling it "dramatic," and said that it is in specific need of replication.

(continued on p.7)

Congress To Hold Hearings

The House Subcommittee on Water and Power Resources plans to hold hearings on the potential health risks associated with exposure to power line electromagnetic fields when Congress reconvenes in the fall. The subcommittee is chaired by George Miller, Democrat of California.

The hearings are prompted by the New York State report, a subcommittee aide told *Microwave News*. She added that Congressman Miller – who also chairs the Select Committee on Children, Youth and Families – is particularly concerned about the potential cancer threat to children.

The hearings were tentatively scheduled for mid-September. At press time, no decision had been reached on who will be invited to testify.

HIGHLIGHTS

The Talk of BEMS

The action started early at this year's Bioelectromagnetics Society (BEMS) conference.* In his introductory remarks at the opening session, Dr. Ross Adey digressed to lash out at Drs. Ken Foster and Bill Guy for their "flight of fancy" in ignoring all but thermal effects in their article on microwaves in *Scientific American* (see *MWN*, November/December 1986): "We have a responsibility, individually and collectively as a society, to communicate athermal effects to society and lawmakers," Adey said, noting the irony that the next four speakers would address the detection of weak electromagnetic fields for navigation and orientation.

Moments later, John Mitchell, Dr. Dave Erwin and Dr. Jonathan Kiel, all of the U.S. Air Force walked out of the ballroom, together with Foster, Dr. Eleanor Adair of the John B. Pierce Foundation and Dr. John Bergeron of GE. Foster refused to talk about his protest. Others were more forthcoming: "It went beyond the privilege of chairing a session," Erwin told *Microwave News*. For his part, Bergeron said he was "responding personally to something that was totally inappropriate."

Few in the audience were without an opinion. Many thought that Adey had chosen the wrong time to pick a fight, but Dr. Steve Baumann of Northrop Services, Inc., expressed a view shared by many when he said that he thought Adey's remarks were "particularly appropriate," because *Scientific American* is perceived as the arbiter of "what is valid in science."

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Henry Kues of the Johns Hopkins University Applied Physics Lab and Jack Monahan of the Food and Drug Administration presented startling new evidence of damage to the corneal endothelial layer of a monkey's eye caused by microwaves acting alone and in combination with drugs (see *MWN*, September/October 1986). The lesions on the surface of the cornea – a crater-marked landscape – are clearly visible in Kues and Monahan's photographs, leading them to suggest that this effect could be used as a diagnostic technique for acute overexposure to microwaves.

Kues and Monahan stressed that you have to look for the lesions. "I asked an ophthalmologist to examine some exposed and control eyes of live monkeys and, after a slit-lamp examination, he pronounced them normal," Kues said during a break at the meeting. "He was amazed when I showed him the lesions. He could not believe he had missed them."

Kues and Monahan found that pulsed microwaves can cause changes at an SAR of 2.6 W/Kg. But if the eye is first treated with drugs used in glaucoma therapy, the threshold is reduced to less than 1.3 W/Kg. Surprisingly, they have found the same action with two different drugs – timolol maleate and pilocarpine – that act in opposite ways to relieve the intraocular pressure associated with glaucoma. They were quick to point out that some two million Americans take these glaucoma drugs on a regular basis.

The mechanism of interaction is not yet clear, but Kues and Monahan have shown that the blood barrier in the eye leaks following radiation exposure. They speculated that transferrin, a catalyst for the formation of superoxides, may be passing through the barrier and causing the damage to the corneal endothelial layer.

The next step, Kues and Monahan said, is to look at the effects of microwaves on the blood barrier in the brain. They plan to begin those experiments soon.

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In the past, speakers from the floor were likely to ask whether temperature changes had been measured following radiation exposure or SARs had been calculated. This year, there were many more questions as to whether researchers had measured the local geomagnetic field.

Dr. Abe Liboff of Oakland University and Dr. Bruce McLeod of Montana State University, along with Dr. Carl Blackman of the Environmental Protection Agency, are largely responsible for this new trend. In Portland, Liboff and McLeod reviewed three sets of experimental data – on rats, diatoms and lymphocytes – which agreed with their *a priori* predictions based on their cyclotron resonance model.

Cyclotron resonances have come a long way as a predictor of bioelectromagnetic interactions, yet many of the early arguments against them still need answers. As Dr. Charles Polk of the University of Rhode Island explained, complications arise due to both collisions among particles and the "smearing out" of the resonances as the target moves in the magnetic field.

Skepticism still abounds. Nevertheless, few took issue with Liboff and McLeod when they said that the data "suggest very strongly that we are on the right path."

Dr. Carl Durney of the University of Utah also scored a success with his new model of the movement of a charged particle in combined DC and AC magnetic fields. The model is extremely simple, but it does, under the right conditions, predict both frequency and amplitude windows, similar to those found by Adey and Blackman in their work on calcium efflux.

*The *9th Annual Meeting of the Bioelectromagnetics Society* (BEMS) was held June 21-25 in Portland, OR.

PMFs Again Linked to Abnormal Pregnancies in Mice

New experimental data from Sweden support last year's finding that VDT-type radiation can upset fetal development in mice. Professor Gunnar Walinder and coworkers at the Swedish University of Agricultural Sciences in Uppsala have found a significant increase in fetal deaths and resorptions (fetal losses) among pregnant mice exposed to weak pulsed magnetic fields (PMFs), as compared to controls. The offspring of the exposed mice also had a higher incidence of malformations, though this finding is not statistically significant.

Last year, a group headed by Professor Bernhard Tribukait of the Department of Medical Radiobiology at the prestigious Karolinska Institute in Stockholm reported a significant increase in external malformations among mice exposed to VDT-type radiation (see *MWN*, March/April and May/June 1986).

The different results from the Uppsala and Karolinska studies may be due to the fact that the experiments used different strains of mice and different lengths of exposure: "They are not contradictory," Tribukait told *Microwave News* from his lab in Stockholm. "In general, it is the same effect." He added, "It is rather clear that the [PMF] effect is real."

Walinder, who heads the Radiobiological Oncology Unit at the agricultural university, agrees that the PMFs have an effect on the mice embryos, but does not think that the two sets of results are "consistent." In a telephone interview from Uppsala, Walinder hypothesized that the PMF exposures may cause increased fetal implantations and that these added fetuses are not surviving: "We are seeing a very early effect that makes animals more susceptible to implantation. Embryos that are normally rejected by the mice were accepted."

The Uppsala team exposed "CBA/s" mice to sawtooth PMFs for the first 19 days of pregnancy, after which the mice were killed; the Karolinska group exposed "C3H" mice for the first 14 days of pregnancy – these mice were killed on the 19th day.*

In the Uppsala study, there were increases in fetal death (2.3% v. 0.98%) and resorptions (10.67% v. 5.55%) among exposed mice, compared to unexposed controls, as well as a non-significant rise in malformations (see table on p.4). In the Karolinska study, there was a significant increase in serious malformations (1.9% v. 0.2%), but not in fetal deaths or resorptions.

"One possible explanation is that the malformed animals might have been killed during the longer exposure period," Tribukait suggested. Similarly, Dr. Kjell Hansson Mild of the Swedish National Board of Occupational Safety and Health in Umea reasoned, "The extra days of exposure may be causing the extra deaths." Most of the dead malformed fetuses in the Uppsala study had multiple malformations. In a related study, Mild and Dr. Ingrid Nordenson of Umea University have found genetic effects due to PMFs (see box on left).

The Uppsala mice study used the same type of radiation as that used in the Karolinska study: a 20 kHz sawtooth magnetic field with an intensity of 15 microtesla. The pulse had a rise time of 45 microseconds (μsec) and a fall time of 5 μsec. The shape and frequency of the pulses were designed to mimic emissions from video display terminals (VDTs).

In contrast to the active research program in Sweden, most U.S. experts have largely ignored the Karolinska results and continue to dismiss the risks associated with VDT radiation. No U.S. labs are attempting to repeat the mice experiment, largely due to the dearth of research funds.

At the Food and Drug Administration (FDA), scientists are watching the VDT studies and their "implications for public health," according to Roger Schneider, the associate director for science at the FDA's Center for Devices and Radiological Health in Rockville, MD. The FDA, which has the authority to regulate VDT radiation

PMFs: Chromosomal Changes

Dr. Ingrid Nordenson of the Department of Medical Genetics at Sweden's Umea University and Dr. Kjell Hansson Mild of the Swedish National Board of Occupational Safety and Health in Umea have found preliminary indications that VDT-type PMFs can cause genetic effects in exposed tissue samples.

In a poster paper presented at the Bioelectromagnetics Society meeting in Portland, OR, in June, Nordenson and Mild wrote that human amniotic cells exposed to 20 kHz sawtooth magnetic fields with intensities of up to 16 μT (peak-to-peak) for three days showed "significant increases in the frequency of aberrations in exposed cells compared to controls." Similar effects were seen among cells exposed to 30 μT sinusoidal 50 Hz fields for three days.

Nordenson and Mild noted that there was considerable inter-experimental variation in the results and that the "implications for human health were unclear." The work will expand: They plan to investigate PMF-induced oncogene expression and to study tissue samples from the Karolinska and Uppsala mice exposed to PMFs.

*The Uppsala and Karolinska teams used different systems to number the days in their experiments. Each lasted a total of 19 days. The Karolinska group called the first day, "day 0," and the last day, "day 18."

EFFECTS OF PMFs ON MICE: Uppsala Experimental Results

	PMF-Exposed	*Controls*
No. of female mice	245	173
No. of pregnant females	211 (86.1%)	154 (89.0%)
No. of non-pregnant females	34 (13.88%)	19 (10.98%)
No. of implantations	1,753	1,190
No. of resorptions	187 (10.67%)	66 (5.55%)
No. of live fetuses	1,530 (97.7%)	1,113 (99.0%)
No. of dead fetuses	36 (2.3%)	11 (0.98%)
Weight of live fetuses (gram)	0.957 ±0.003	0.947 ±0.003
Length of live fetuses (mm)	19.58 ±0.03	19.51 ±0.03
No. of Live Malformed Fetuses	16 (1.05%)	8 (0.72%)
No. of Malformations	21	13
No. of Dead Malformed Fetuses	5 (13.89%)	2 (18.18%)
No. of Malformations	13	2

emissions, has only a small research program on the biological effects of non-ionizing electromagnetic fields. Schneider noted that, "The FDA cannot afford to study VDTs separately from microwave ovens, diathermy or other types of electronic products."

Dr. Przemyslaw Czerski, also of the FDA, expressed a keen interest in the Swedish experiments and told *Microwave News* that reciprocal visits between agency scientists and the Swedish researchers are desirable and are being explored.

A number of scientists at the Environmental Protection Agency (EPA) are also monitoring the new developments, even though the agency is no longer doing any research on non-ionizing radiation. Dr. Ezra Berman, an EPA teratologist, commented that, "Although this [new] experiment shows early death while the previous one showed malformations, the interesting thing is they both show effects. That similarity should be examined further."

EPA's Dr. Carl Blackman is interested in exploring the possible effects of variations in the earth's magnetic field – these may provide clues to explain the differences in the observed experimental results, he suggested.

Berman is coordinating an international project to explore the effects of PMFs on chick embryos – a finding first reported by Dr. Jocelyne Leal of the Centro Ramon y Cajal Hospital in Madrid, Spain (see *MWN*, March 1983 and January/ February 1986). Preliminary results from the six participating labs – including Mild's and Leal's – are expected by the end of the year.

Walinder, Tribukait and Mild all agree that the PMF experiments must continue. "We cannot stop at this stage," Mild said. Walinder concurred, noting that he is "not convinced" that the effect is well understood. Plans for new studies are already underway. In his next experiment, Walinder will expose mice beginning on the fourth or fifth day of pregnancy to test his hypothesis concerning the effect on the frequency of implantation. He will also look for brain damage among the fetuses – which he called a more sensitive indicator of an effect.

Tribukait intends to run his next experiment at higher frequencies – at 40 kHz and, possibly, at 60 kHz. In addition, he would like to repeat his original study using the same strain of mice used by the Uppsala group. Walinder said that he is reluctant to use the Karolinska mice due to the risk of infection. On the other hand, Tribukait said that he is not worried about infections because the strains can be isolated from each other.

Tribukait is in the process of preparing a paper, which he intends to submit to the *International Journal of Radiation Biology*. Walinder wants to complete his next set of experiments before publishing his results.

The results of the Uppsala study were released in Sweden in June without fanfare; they have received little attention in the Swedish press.

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DNA MW Absorption Contested

Researchers at two independent labs in England and Sweden have failed to replicate experiments showing that aqueous solutions of DNA can absorb microwaves in the 1-10 GHz frequency band. Professor Edward Grant and coworkers at King's College, London, and Drs. B. Gestblom and E. Noreland of Uppsala University were unable to document any resonances or "any form of enhanced absorption." The new results appear in the July 9 issue of *Nature* (*328*, pp.145-146, 1987).

The absorption of microwaves by DNA was predicted by the theoretical work of Drs. Earl Prohofsky and Lonnie Van Zandt of Purdue University in West Lafayette, IN, and was first shown experimentally by Drs. Glenn Edwards and Chris Davis of the University of Maryland in College Park, Dr. Jeffrey Saffer of the National Cancer Institute in Bethesda, MD, and Dr. Mays Swicord of the Food and Drug Administration in Rockville, MD.

In a series of telephone interviews, U.S. researchers suggested two possible explanations for the lack of experimental agreement: variations in the DNA samples and/or differences in the sensitivity of the measurement techniques.

Edwards, who is now at Vanderbilt University in Nashville, TN, noted that, "Grant's paper failed to report the quality of the DNA sample or the ability of his technique to resolve small differences in dielectric properties."

Davis also remains confident that the microwave effect is real: "We have been trying to generate artifactual data to explain away our results, but we cannot." He said that producing the DNA samples is "not trivial," adding that the disagreement in experimental results may be due to "some subtleties in the samples."

Speaking from London, Grant stressed that his DNA "was prepared in exactly the same way" as the Maryland group's DNA. In fact, he said, a biochemist had gone to the U.S. to learn the technique.

The European researchers used time domain spectroscopy with pulsed radiation, while the Americans used a frequency domain technique with continuous wave microwaves. Grant argued that the two methods were identical and that the DNA samples "should not react differently" to the two types of radiation. As added proof, he pointed out that the Swedish group had also taken some frequency domain measurements and that these agreed with their time domain results. Grant said that these data were not included in the *Nature* paper, but would be cited in a future publication, now in preparation.

There will soon be added support for the negative results from Europe. Dr. Ken Foster of the University of Pennsylvania in Philadelphia – working with Dr. Michael Gealt of Drexel University, also in Philadelphia, and with Dr. Benjamin Epstein of the David Sarnoff Labs in Princeton, NJ – has failed to detect any DNA resonances, using the same measurement technique as Edwards did, but he did succeed in generating artifactual resonances. Foster told *Microwave News* that the magnitude of Edwards's resonances was much smaller than the errors specified by the manufacturer of the probe. "It's like trying to weigh an airmail letter with a bathroom scale," he said. These new results will appear in the September issue of the *Biophysical Journal*.

Edwards countered that it is easy to generate false resonances. "However, if the system is correctly calibrated," he said, "such artifacts will not occur."

For his part, Van Zandt maintains that the enhanced absorption is predicted by his theoretical work. "Maybe Glenn Edwards did not see it," he said, "but according to my calculations, there is a good chance he did."

The research is continuing on both sides of the Atlantic. Grant said that his next set of experiments will be run at lower frequencies – in the kHz range. These studies will be carried out in collaboration with Professor M. Mandel of the University of Leiden in Holland. Mandel, a physical chemist, is an expert on the dielectric properties of DNA. In addition, Grant said that he will run the experiment with frozen DNA.

In a month, Davis's group will start a new series of experiments using fresh DNA samples and a new measurement system. Edwards is also continuing his studies.

As the arguments about whether DNA in solution can absorb microwave energy continue, Saffer, who is now at the Jackson Laboratory in Bar Harbor, ME, is investigating what he calls the "biological significance" of these resonances under a recent $343,000 contract with the Office of Naval Research (ONR).

In preliminary experiments, Saffer has already shown that irradiation with 2-4 GHz microwaves can cause enhanced gene expression of plasmid DNA in *E. coli*. He admits that he is not certain that the radiation affects the DNA – it may change RNA translation – but he is sure that he is not observing a thermal effect because heat causes a decrease in expression.

Interestingly, much of the U.S. work on DNA absorption is being supported by the U.S. Navy, through ONR, while the English and Swedish work is being paid for by the U.S. Air Force.

See also L.L. Van Zandt, "Resonant Microwave Absorption by Dissolved DNA," *Physical Review Letters, 57*, pp.2085-2087, October 20, 1986; John Maddox, "Physicists About To Hi-Jack DNA?," *Nature, 324*, p.11, November 6, 1986; J.W. Powell et al. (including Edwards and F. Kremer), "Investigation of Far-Infrared Vibrational Modes in Polynucleotides," *Physical Review A, 35*, pp.3929-3939, May 1, 1987; Maxim Frank-Kamenetskii, "Physicists Retreat Again," *Nature, 328*, p.108, July 9, 1987; and *MWN*, May and November 1984, March and June 1985 and May/June 1987.

ANSI Too High? A Thermal View

Many people – citing non-thermal effects of radiofrequency and microwave (RF/MW) radiation – have argued that the widely used American National Standards Institute (ANSI) safety standard is too lax. Now, Dr. Christopher Gordon of the Environmental Protection Agency (EPA) makes the same case but only on the basis of thermal effects.

Writing in the most recent issue of *Bioelectromagnetics* (*8*, pp.111-118, 1987), Gordon argues that human health protection standards are incorrectly derived from animal data – by simply extrapolating to a larger weight. Gordon believes that RF/MW thermal effects should be scaled on the basis of whole-body surface area not whole-body mass, because the ability of mammals to dissipate heat decreases with increasing mass but is independent of surface area. According to his calculations, the ANSI standard of 0.4 W/Kg would translate into 0.06 W/Kg, an exposure level of approximately 150 $\mu W/cm^2$, if keyed to surface area rather than body mass.

Gordon's coworkers at the EPA's Health Effects Research Lab in Research Triangle Park, NC, have found that the threshold for thermal effects should be 1 W/Kg (see *MWN*, January/February 1984). In its draft criteria document on RF/MW radiation, the National Institute for Occupational Safety and Health (NIOSH) proposed a 2 W/Kg threshold (see *MWN*, July/August 1985). Using ANSI's safety factor of ten and scaling by surface area, the EPA and NIOSH standards would be 0.015 and 0.03 W/Kg, respectively, the equivalent of 38 and 75 $\mu W/cm^2$.

"I expect there will be a lot of discussion of Gordon's paper in the bioelectromagnetics community," predicts EPA's Dr. Joe Elder, who edited the agency's 1984 review of RF/MW bioeffects.

EPA's non-ionizing radiation research program has been closed down; Gordon is now doing research on toxic chemicals (see *MWN*, September/October 1986).

ELF NEWS

Long-Term ELF Behavioral Effect

Adult rats previously exposed to 60 Hz electric and magnetic fields in the womb and for the first few days of life responded to behavioral conditioning significantly more slowly than unexposed controls, according to Professor Kurt Salzinger of Polytechnic University in Brooklyn, NY. This is a "lasting effect that cannot be ignored," Salzinger told *Microwave News*.

Salzinger and coworkers exposed pregnant rats to 60 Hz, 30 kV/m electric and 1 G magnetic fields for their entire gestation period; the offspring were then exposed for the first eight days of life. When they were 90 days old, the male offspring were extensively trained on a random-interval reinforcement schedule and their responses were measured. The study was sponsored by the New York State Power Lines Project.

A key finding is that the rats' delayed responses were observed long after their exposure to ELF fields and after a good deal of conditioning. Indeed, in his report, Salzinger points out that "the effect might not have been found if we had been content to look only for immediate effects." The response rate of the exposed rats decreased up to 20%, as compared to controls.

In a telephone interview, Salzinger said that the effect was "robust" and "permanent," but that it was not yet clear whether the disability developed over time or after training. "We want to do more studies in which we train the rats earlier in order to separate out these two possibilities," he added.

Salzinger drew an analogy between the rats' behavioral defect and dyslexia, a reading disability. "You can only tell there is a problem when children start learning to read, and then you need a sensitive test," he said. Similarly, the rats' disability only became apparent when they were adults. Salzinger's final report notes that none of the exposed rats showed any differences in physical appearance, in activity level, in weight or in incidence of disease.

Salzinger and his collaborators – including Leo Birenbaum, Dr. Steven Freimark, Dr. Malcolm McCullough and Donald Phillips – also exposed rats to fields of 10 kV/m and 0.33 G and compared them to others exposed to 30 kV/m and 1 G. The less-exposed group showed less of an effect, but the difference was not statistically significant.

Like most of the other New York State researchers, Salzinger has been unable to raise any funds since the New York power line money ran out. "I've just about given up trying," he said. Salzinger, who is with the Department of Social Sciences at Polytechnic University, is a past president of the New York Academy of Sciences.

EPRI Funds Two New Occupational Studies

The Electric Power Research Institute (EPRI) has funded two new projects: (1) a feasibility study for a large-scale epidemiological survey of the risk of leukemia, particularly acute non-lymphocytic leukemia (ANLL), and primary brain cancer among utility workers exposed to electric and magnetic fields; and (2) an assessment of occupational exposures to power line fields.

In July, Dr. David Savitz of the University of North Carolina in Chapel Hill and J. Michael Silva of Enertech Consultants, Inc., in Sunnyvale, CA, began examining utilities for a suitable population for a case-control epidemiological study. By the time this first phase is completed in December 1988, Savitz and Silva will have both identified a utility to participate in the study and developed a tentative system to classify exposures by job title.

Savitz will also run a pilot mortality follow-up study of approximately 3,000 workers to ensure that enough cancer cases will be generated in the full-scale study. And Silva will measure both occupational and non-occupational electromagnetic exposures.

The proposed study will be designed to detect a relative risk of 2.0 for ANLL and primary brain cancers.

Dr. Joseph Bowman of the University of Southern California in Los Angeles is the principal investigator on the second study, which will test the validity of occupational titles as surrogates for actual measurement of electric and magnetic fields. Bowman is already collaborating with Dr. John Peters on an epidemiological study to test the Wertheimer-Leeper finding of a link between childhood leukemia and ELF fields (see *MWN*, November/ December 1986).

The exposure assessments will be based primarily on data from portable dosimeters. EPRI has specified the use of the dosimeter developed by IREQ, the research arm of Hydro-Quebec (see *MWN*, September/October 1986). Bowman will also collect data on other potential chemical and physical contaminants.

In a related development, Dr. Charles Rafferty, who has been filling in for Dr. Tom Rozzell at the Office of Naval Research, has joined EPRI as a project manager in the non-ionizing radiation sub-program.

NY Power Lines Project Report *(continued from p.1)*

The release of the New York panel report generated headlines in newspapers all over the world, focusing attention on the health risks associated with living next to power lines. The report has been in great demand; 600 copies have already been distributed and another 500 have been printed. A month after the report was issued, Dr. David Carpenter of the New York Department of Health, who served as the executive secretary of the panel, said that he was still getting five to ten calls a day from reporters. Congress plans to hold hearings in September (see box on p.1).

The panel avoided suggesting how wide right-of-ways should be next to power lines, but did recommend a "major research effort" to reduce exposures to magnetic fields associated with power delivery. Calling more research on the biological effects of electromagnetic fields "very important," the panel specifically suggested a search for thresholds for magnetic field effects and further extensive studies on the potential cancer link (see pp.8-10 for the full text of the panel's summary and recommendations).

In contrast to the current situation in which essentially all funds for ELF bioeffects research come from the Department of Energy (DOE) and from the Electric Power Research Institute (EPRI), the panel advocated that research be "administered by an agency, preferably federal, which is credible by virtue of being clearly independent of partisan influence." Carpenter told *Microwave News* that the intent of this recommendation was not to end DOE and EPRI support but to encourage others to join the research effort. Carpenter singled out the National Institutes of Health (NIH) as one agency that should participate.

The panel issued its report in July – six years after it was constituted to spend $5 million to investigate ELF health effects, eight years after Dr. Nancy Wertheimer and Ed Leeper published their epidemiological study first linking magnetic fields to childhood cancer and 14 years after applications were filed to build 765 kV power lines in NY state, touching off a controversy that led to the project. Dr. David Savitz of the University of North Carolina in Chapel Hill first announced his study results last November (see *MWN*, November/December 1986).

Many of the key findings of the NY studies have already been reported. These include:

- The proliferation of human tumor cells exposed to ELF fields (see *MWN*, April and September 1984 and July/ August 1986). These results, by Drs. Wendell Winters and Jerry Phillips, were not replicated by Dr. Maimon Cohen in a follow-up study also funded by the project, after the Winters-Phillips results were publicized. A dispute is brewing over whether Cohen followed the same experimental procedures. (This will be addressed in a future issue.)
- Dramatic behavioral effects in rats exposed to weak ELF fields in a static field less than that of the earth's, demon-

NY Power Lines Project Reports

Prasanta K. Basu, *Biological Effects of Extremely Low Frequency Electric and Magnetic Fields on the Ocular Tissues: An In Vitro Study*, 112 pp., $28.00.

Arland L. Carsten, *Mutagenicity and Toxicity of Electric and Magnetic Fields*, 196 pp., $49.50.

Maimon M. Cohen, *In Vitro Genetic Effects of Electromagnetic Fields*, 100 pp., $25.00.

Maimon M. Cohen, *The Effects of Low-Level Electromagnetic Fields on Cloning of Two Human Cancer Cell Lines (Colo 205 and Colo 320)*, 34 pp., $8.50.

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Charles Graham and Harvey D. Cohen, *Influence of 60 Hz Fields on Human Behavior Physiology Biochemistry*, 102 pp., $25.50.

Ross Gundersen, Ben Greenebaum and Eugene Goodman, *Effects of 60 Hz Electromagnetic Fields on Calcium Efflux and Neurotransmitter Release*, 46 pp., $11.50.

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Kurt Salzinger, *Behavioral Effects of ELF*, 137 pp., $34.00.

David A. Savitz, *Childhood Cancer and Electromagnetic Field Exposure*, 178 pp., $45.00.

Richard G. Stevens, *Epidemiological Studies of Cancer and Residential Exposure to Electromagnetic Fields* (50 pp.), and William T. Kaune, *Residential Magnetic and Electric Fields Measured over 24-H Period* (109 pp.), 159 pp., $40.00.

Frank M. Sulzman and David E. Murrish, *Effects of Electromagnetic Fields on Primate Circadian Rhythms*, 65 pp., $16.25.

John R. Thomas and John Schrot, *Investigation of Potential Behavioral Effects of Exposure to 60 Hz Electromagnetic Fields*, 75 pp., $18.75.

Wendell D. Winters, *Biological Functions of Immunologically Reactive Human and Canine Cells Influenced by In Vitro Exposure to 60 Hz Electric and Magnetic Fields*, 105 pp., $26.25.

Jonathan R. Wolpaw, Richard F. Seegal, Robert I. Dowman and Saty Satya-Murti, *Chronic Effects of 60 Hz Electric and Magnetic Fields on Primate Central Nervous System Function*, 165 pp., $41.25.

A complete set of reports costs $419.00. Order from: Charlene McAuliffe, New York State Power Lines Project, Wadsworth Labs, E-297, Empire State Plaza, Albany, NY 12201, (518) 474-7888.

strated by Drs. Abe Liboff and John Thomas (see *MWN*, November 1984).

- Changes in the concentration of neurotransmitter-related metabolites in the cerebrospinal fluid of exposed monkeys, as shown by Drs. Jon Wolpaw and Richard Seegal (see *MWN*, November/December 1985).
- The lack of a positive association between acute non-lymphocytic leukemia and adult exposure to ELF fields at home (see *MWN*, November/December 1986).

Members of the scientific advisory panel who wrote the report were: Drs. Anders Ahlbom (Sweden's National Institute of Environmental Medicine), Ernest Albert (George Washington University Medical Center), Antony Fraser-Smith (Stanford University), Alan Grodzinsky (MIT), Michael Marron (Office of Naval Research), Alice Martin (Northwestern University Medical School), Michael Persinger (Laurentian University), Michael Shelanski (Columbia-Presbyterian Medical Center), Chairman, and Edward Wolpow (Harvard Medical School).

Single copies of the panel's report, *Biological Effects of Power Line Fields*, are available at no charge – while supplies last – from Dr. David Carpenter, School of Public Health Sciences, Wadsworth Labs – E297, Empire State Plaza, Albany, NY 12201, (518) 474-7888. For a list of the individual contractor reports, see the list to the left.

NY State Power Lines Project Summary & Recommendations

SUMMARY

In this section we focus on effects that have been found in the New York-funded projects and which seem worthy of further consideration because of their possible implications for human health.

A. Magnetic Fields

It is clear from the results of the studies sponsored by the Project, as well as from many other recent studies, that both 60 Hz electric and magnetic fields can affect certain biological systems. Magnetic field effects were found in a number of the projects in this program. However, the mechanisms responsible for these effects are unknown. Many effects have been observed at magnetic flux densities in the neighborhood of 100 μT (1 G) or greater. These levels are similar in magnitude to the maximum magnetic flux density directly beneath power transmission lines. Lower magnetic flux density thresholds for most observed field effects have not been determined.

The epidemiological studies raise the possibility that magnetic flux densities one one-thousandth of those shown to have effects in laboratory studies may be a health concern. For several reasons, including the fact that a causal relationship between weak magnetic fields and cancer has not been established and that methodological uncertainties associated with quantifying magnetic field exposure levels exist, we cannot offer a recommendation based on the epidemiological studies. Except for

houses close to power transmission lines, the major sources of magnetic fields in homes are the ground return currents from distribution systems and fields in the immediate proximity of appliances.

B. Neurobiology and Behavior

At the onset of this project there was serious question as to whether there were demonstrable neurobiological or behavioral effects of exposure to electrical and/or magnetic fields. Data accumulated by our contractors as well as a rapidly building literature on retinal magnetoreceptors in birds and mammals leave little doubt that such effects can be observed in well designed experiments.

In contrast, our knowledge of the mechanisms by which these effects are mediated has not advanced significantly. One hypothesis is that several of these effects are mediated via endogenous opioids. However, no data have been obtained to either support or deny this hypothesis. Other effects could be mediated or modulated by changes in the levels or intracellular localization of ionic calcium. The alterations in miniature end plate potential frequency by magnetic fields could be due to small changes in internal ionic calcium. Efflux of calcium from multicellular nervous system preparations reported by other laboratories reflects effects on extracellular calcium, and the physiologic relevance of this calcium store is unknown.

The reliable and specific effects of brief exposures to 60 Hz magnetic fields within a decreased geomagnetic background deserve further attention. Interactions between 60 Hz magnetic fields and the intensity and direction of the static background fields have been suspected by many authors and may be an important source of the variability in occurrence of magnetic field effects. The magnitude of the effect from exposure to the combination of 60 Hz magnetic fields and a reduced geostatic field suggests that geomagnetic fields may interfere with inhibitory behaviors. They would be displayed in situations that required dependence upon subjective estimates of timing and the suppression of impulsive responses.

Our studies have not shown any structural neuropathology in either developing or adult animals. We do not feel that there is a significant risk of structural change at the field intensities normally produced on the ground by power lines.

Accepting that biological effects result from field exposure we are faced with deciding whether these effects might lead to adverse health effects. For most of the findings it must be emphasized that the changes are relatively small. However, some changes, such as the depression of hydroxyindole acetic acid levels in the cerebral spinal fluid seen by Wolpaw and Seegal, are extremely long-lasting. The alterations in circadian rhythms are interesting in that such alterations can be associated with alterations in mood and behavior of subtle types. It is possible that these changes could underlie some of the rather "non-specific" changes which have been reported in the occupational literature on electrical switchyard workers. Certainly, circadian rhythms might be much more suitable parameters to monitor in occupational studies than the more vague subjective responses. A more dramatic effect of fields was the demonstration of a persistent deficit in the response rates of adult rats that had been exposed before and just after birth.

In our studies, no neurobiological effects were seen at field intensities lower than those encountered within the existing right-of-ways of 345 or 765 kV lines. Even those effects encountered were of reasonably small amplitude and could not be said with confidence to indicate health hazards. Our studies are limited in that many of them did not explore weaker magnetic fields or obtain adequate data to determine dose-response characteristics.

C. Cancer

Previous epidemiologic studies on adult and childhood cancer have been questioned because of serious methodological shortcomings. The results of the Savitz study on childhood cancer change the situation considerably because it was designed to minimize flaws in previous studies, and because [the study] was conducted under the supervision of a panel of independent scientists. Even though the Savitz study also has certain limitations, it indicates an excess risk for childhood cancer, in particular leukemias, associated with high current wiring configuration near the homes. Although this study basically confirms the results of the previous studies, the causal relationship is still no more than a hypothesis. However, the basis for this hypothesis is now stronger. The reasons why this is still only a hypothesis are (1) we still only have one well designed study, (2) there are unresolved questions in the Savitz study and (3) there is no basic mechanism known to explain a causal relationship. If future research confirms a causal association between 60 Hz magnetic fields and childhood cancer, public health considerations would have to be developed from (1) baseline risk of childhood cancer, (2) risk increase due to field exposure and (3) distribution of exposure in the population.

On his own initiative, one of the Project investigators undertook studies of the effects of field exposure on the growth of cultured cells in soft agar as measured by the number of clones (colonies) formed. Normal cultured cells do not grow in soft agar unless they are "transformed," and field exposure did not produce transformation. However, the two cancer cell lines tested, which have the inherent ability to grow in soft agar, were reported by the investigator to form more clones after exposure.

Because of the possibility that these results were artifactual, that is, were related not to field exposure but to the inherent variability of the cloning assay, clonogenicity of these same cancer cell lines was examined in a second laboratory. Dr. Hamburger, who participated in the replication study, was the originator of the cloning assay for evaluation of chemotherapeutic agents. In their final report Drs. Hamburger and Cohen report no consistent effects related to field exposure. In the replication study several significant findings are reported but these findings are not reproducibly observed and do not always occur in the same direction, that is in some experiments there are more clones in the control, in other experiments the converse is true.

We conclude that further replications of the influence of fields on the ability of cancer cells to form clones in soft agar are not warranted because: (1) electric and magnetic fields have not been observed to induce transformation in normal cells, (2) exposure of two cancer cell lines in two different laboratories does not provide convincing evidence of an effect of biological significance and (3) extrapolations from the behavior of cancer cells in soft agar to intact organisms cannot be made. Extrapolation of possible field effects on cancer should be done with more relevant assays.

Previous studies were not strongly suggestive of either genetic mutations or chromosomal damage caused by electric or magnetic field exposure. Several independent investigations within the New York State Power Line Projects also failed to find evidence of genetic or chromosomal damage. In light of the epidemiology results future studies on chromosomes should focus on mechanisms of leukemiagenesis, for example oncogenes and promotion. There is currently no convincing evidence for field effects on fertility or growth. Further animal studies would not seem warranted for these variables. Our studies on fetal development have shown no gross morphologic changes. However, the Salzinger results showed persistent changes in

performance of rats that had been exposed *in utero* and immediately after birth. These results may reflect subtle but important alterations of nervous system development that are not reflected in gross morphology.

RECOMMENDATIONS

Research sponsored by this project and related research have demonstrated [a] variety of effects of electrical and magnetic fields. These findings do not readily translate into concrete regulatory recommendations on width of right-of-ways, line heights, or location of lines near homes. They do, however, lead us to the recommendations which follow:

1. There should be a major research effort on means of power delivery and use that would reduce magnetic field exposures.
2. Further study should be made of the interactive effects of the earth's geomagnetic field and 60 Hz fields.
3. The determination of the existence of thresholds for biologic effects of magnetic flux densities should be pursued.
4. The experiments on field effects on learning ability should be replicated.
5. The possible association between cancer (especially leukemias) and magnetic fields must be further investigated. Several avenues of study should be pursued.

a. There should be further epidemiologic study of residential exposure, conducted at more than one site with careful measurement of exposure.
b. Attempts should be made to correlate cytogenetic and diagnostic subgroups of cancers with exposures.
c. Further investigation of occupational exposure and cancer incidence should be conducted with improved documentation of actual exposures.
d. Animal models should be developed and laboratory investigations designed to explore possible mechanisms of field-induced carcinogenesis. If an effect is documented, then the dose-response relationship should be investigated.

6. Further research on the biologic effects of electromagnetic fields is very important. It should be administered by an agency, preferably federal, which is credible by virtue of being clearly independent of partisan influence.

Conference Calendar

New Listings

November 5-7, 1987: **4th Annual Meeting of the American Society of Clinical Hyperthermic Oncology (ASCHO)**, Houston, TX. Contact: Dr. Pierre Greeff, Associate Director, The Stehlin Foundation for Cancer Research, ASCHO, 1315 Calhoun St., Suite 1818, Houston, TX 77002, (713) 659-1336.

November 10-12, 1987: **2nd Annual Society of Broadcast Engineers (SBE) National Convention**, A.J. Cervantes Convention Center, St. Louis, MO. Contact: SBE, PO Box 16861, St. Louis, MO 63105.

January 5-8, 1988: **National Radio Science Meeting**, University of Colorado, Boulder, CO. Contact: Prof. S.W. Maley, Dept. of Electrical Engineering, University of Colorado, Boulder, CO 80309.

January 27-31, 1988: **International Symposium on Work in a Hot Environment and Heat-Related Disorders**, Khartoum, Sudan. Contact: Dr. Moneim Attia, Chief, Occupational Physiologist, Ministry of Health, PO Box 303, Khartoum, Sudan.

April 18-21, 1988: **1988 International Symposium on Radio Propagation (ISRP '88)**, Beijing, China. Contact: Prof. Sha Zong (Z. Sha), China Research Institute of Radiowave Propagation, PO Box 138/88, Xinxiang, Henan, People's Republic of China.

April 19-21, 1988: **International Conference on Lightning and Static Electricity**, Oklahoma City, OK. Contact: Michael Glynn, FAA Technical Support Center, ACT-430, Atlantic City Airport, NJ 08405, (609) 484-4138.

Upcoming Meetings

August 31-September 2: **22nd Annual Microwave Power Symposium: A Macro View of Microwaves and RF Heating**, Hyatt Regency Hotel, Cincinnati, OH. Contact: International Microwave Power Institute (IMPI), 13542 Union Village Circle, Clifton, VA 22024, (703) 830-5588.

September 1-5: **9th International Symposium on Bioelectrochemistry and Bioenergetics**, Szeged, Hungary. This meeting is a Satellite Meeting of the **9th International Union of Pure and Applied Biophysics**, Jerusalem, Israel, August 23-29. Contact: Dr. Lajos Keszthelyi, Institute of Biophysics, Biological Research Center, Hungarian Academy of Sciences, PO Box 521, H-6701, Szeged, Hungary.

September 7-10: **17th European Microwave Conference**, Ergife Palace Hotel, Rome, Italy. Contact: Microwave Exhibitions & Publishers, Ltd., 90 Calverley Rd., Tunbridge Wells, Kent TN1 2UN, U.K.

September 10-11: **International Conference and Workshop on Electromagnetic Interference and Compatibility**, Hotel Taj Residency, Bangalore, India. Contact: Prof. G.R. Nagabhushana, Dept. of High Voltage Engineering, Indian Institute of Science, Bangalore 560 012, India, (812) 364411, ext. 376.

September 17-19: **3rd Annual Clinical Hyperthermia Symposium and Workshop**, St. Louis, MO. Contact: Dr. Bahman Emami, Radiation Oncology Center, Mallinckrodt Institute of Radiology, 4939 Audubon, Suite 5500, St. Louis, MO 63110, (314) 362-8500.

September 28-30: **AC/DC Transmission Interactions and Comparisons Symposium**, Boston, MA. Contact: CIGRE, 112 Boulevard Haussmann, 75008 Paris, France, (1) 45-22-65-12.

September 29-October 1: **9th Annual Electrical Overstress/Electrostatic Discharge Symposium**, The Peabody, Orlando, FL. Contact: Michael Martin, 3M/Static Control Systems, 2111 W. Braker Lane, Bldg.501, PO Box 2963, Austin, TX 78769, (512) 834-3117.

October 11-14: **7th Annual Meeting of the Bioelectrical Repair and Growth Society (BRAGS)**, Holiday Inn Downtown, Toronto, Canada. Contact: BRAGS, PO Box 64, Dresher, PA 19025, (215) 659-5180.

October 14-16: **9th International Colloquium on the Prevention of Occupational Risks due to Electricity**, Hotel Melia Castilla, Madrid, Spain. Contact: Berufsgenossenschaft der Feinmechanik und Elektrotechnik, Gustav-Heinemann-Ufer 130, D-5000 Koln 51, F.R.G., (221) 37781.

October 19-21: **International Radar Conference**, London, U.K. Contact: Conference Services, IEE, Savoy Pl., London WC2R 0BL, U.K., (1) 240-1871, ext. 222.

November 2-5: **DOE/EPRI Review of Research on Biological Effects of 50/60 Hz Electric and Magnetic Fields, Air Ions and Ion Currents**, Hyatt Regency Hotel, Kansas City, MO. Contact: W/L Associates, Suite #4, 120 West Church St., Frederick, MD 21701, (301) 663-1915.

NEW BOOKS

Invited Reviews

Jonathan Black, **Electrical Stimulation: Its Role in Growth, Repair, and Remodeling of the Musculoskeletal System,** New York, NY: Praeger, 1987, 225 pp., $45.00.

There is considerable research activity underway which explores the use of electrical stimulation for a variety of clinical conditions related to repair and growth. Jonathan Black has written a useful and readable book on the subject of electrically stimulated repair, growth, and remodeling of the musculoskeletal system.

He provides an elementary summary of the physics of electric and magnetic phenomena. The presentation is "fiercely" tutorial, seemingly dedicated to the idea that "anyone can learn this stuff." Biologists and others outside the physical sciences should have no difficulty doing just that.

The main focus of Chapter 4 is on electrical phenomena in bone, but other tissues are discussed. Black concludes that the current consensus for strain-related potentials in bone is that streaming potentials are most important in the living animal, with piezoelectric effects playing only a small role, if any.

In Chapter 5, Black discusses the three main approaches to electrical stimulation, which he terms faradic (DC current), capacitive, and inductive. The internal fields and currents characteristically induced by the three approaches are compared. He concludes that the basic mechanism for the effect of stimulation is still unknown and that "...the commonality between the 'electrical' effects produced by these three modalities remains a question of the future."

Chapter 6, entitled "Cell, tissue, and organ culture," reviews the results of experiments on various types of cell cultures. Many useful insights into problems of experimental design are given in the process, and techniques for avoiding artifacts are discussed. One conclusion is that strong evidence for specificity of signal is still lacking. All three stimulation modes have demonstrated some effects in *in vitro* studies, but "...the overall implications of such experiments are unclear."

Chapter 7 reviews the experimental animal studies that have been reported in the literature. Among the soft tissue repair models that have been used with electrical stimulation are cartilage, tendons and ligaments, nerves and surface wounds. Fracture healing, osteoporosis, and graft incorporation are covered in the section on hard tissues. Black concludes that electrical stimulation has elicited a wide variety of mostly nonspecific responses. Modest improvement seems to be possible for some soft tissue injuries. In hard tissues, fracture healing can be accelerated, but the results are less clear for osteoporosis.

Considerable attention is devoted to the clinical definition of "nonunions." As Black points out in Chapter 8, this is not simply a semantic problem, but can have an effect on the outcome of clinical trials. Even given these difficulties, however, it still seems that the three major types of stimulation are about equally effective in healing nonunions. The success rate is apparently between two-thirds and four-fifths. Black points out that various patient factors can reduce the chances of success and suggests that failure to control for or to exclude cases where stimulation is not appropriate could account for some of the variability of results. He concludes that support for clinical applications other than nonunions is still lacking.

The book is an excellent overview of the field and has the necessary background material – a useful glossary of electrical terms and an extensive bibliography of over 400 references – for readers from different scientific disciplines. It has a balanced presentation of the diversity of points of view in the field, and seems successful in distinguishing the results that are reasonably well established from those that are still tentative or speculative.

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Edwin L. Carstensen, **Biological Effects of Transmission Line Fields,** New York, NY: Elsevier, 1987, 397 pp., $58.50.

There is more involved in doing interdisciplinary work than merely learning some facts about the other area. Schoolboys can recite all sorts of things without understanding the underlying theme. This, regrettably, is what I felt while reading Dr. Carstensen's book. It is a collection of facts, some appropriate, some inappropriate – some never mentioned – very often with the wrong ones emphasized.

One must sympathize with the author's plight, since the issues are extraordinarily complex and in transition. Nonetheless, a basic lack of understanding of how science is conducted shines through these pages. The two disciplines that are involved here are not, as the title suggests, engineering and biology, but rather engineering and science. The difficulty in what Dr. Carstensen has attempted is that whereas engineering tends to serve society, science functions in spite of society. Engineering is excellent in applying what is already known to problem solving. In sharp contrast, the business of science deals with that which is *not* already known. Nowhere is this distinction more clearly drawn than in the continuing tension between the "thermal" and "non-thermal" bioelectromagnetic camps. Because the engineering community has a firm grasp of what joule heating is about it has consistently attempted to explain more biological facts than it should using this parameter; when scientists have reported effects at intensities lower than can be explained thermally, these reports have either been discounted as somehow wrong or they have simply been ignored. And so it is in this book, where the reader senses that the author enjoys strong prejudices against those findings that do not conform to conventional engineering wisdom.

Much of the most critically important research efforts – work by the Parkside group, by Reba Goodman, by Bawin and Adey, by Blackman – is summarily dismissed in tables bearing the presumptuous legends "negated" or "unconfirmed." On top of these arbitrary consignments to the dustbin of science, the author steers away from scientific discussion, failing to come to grips with his subject matter in an analytic way, except insofar as it involves parameters with which he is comfortable—pulse shape, frequency, field strength, current. Nowhere, for example, is it mentioned that Goodman has established, using a number of independent assays, that ELF fields cause significant changes

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in mRNA, and that this may be of no little consequence in oncogenesis, or that the experiments by Greenebaum, Goodman and Marron spanned more than 15 years, or that three separate groups – Bawin et al., Blackman et al. and Dutta et al. – have independently reported calcium-efflux effects. Dr. Carstensen deals with this last area in a particularly troubling manner. He implies that all the calcium efflux work is flawed, emphasizing that in some cases the effect is enhanced by fields and in others it is reduced. Because the author decides, *a priori*, that experiments such as these should go only in one direction, he is oblivious to the alternate, more objective conclusion that these experiments are really confirmations of the first, because in all three cases *changes* in efflux were observed following exposures to certain frequencies.

At least one of his comments is flat-out wrong. The report by Takahashi et al. is not "essentially negative," as he writes, but the direct opposite: they measured a consistent, significant variation in ELF-related DNA synthesis. Perhaps what the author means is that he can't understand why such effects diminish at higher fields. Indeed, the concept of an amplitude window creates great difficulties for Dr. Carstensen throughout the book. For example, there is an interesting passage on p.158: after remarking on a "few unconfirmed claims" that ELF magnetic fields at 0.1 to 0.2 μT may increase the "rate of cancer" while much greater fields do not, he writes that "failure of biological effects to be dependent on the magnitude of exposure is one of the traits which characterize 'pathological' science." This is not the first time that this pejorative expression has been used to characterize observations that do not fit neatly into a third-year engineering text. Everyone's interests would be better served if authors were more circumspect in dealing with work they consider outlandish. After all, there are many ways to do bad science. It is difficult to decide which is worse—those who cut corners in their haste to claim new effects or those whose science is suspect because of their servile attitudes towards benefactors in industry or the military.

In defense of this book, it certainly is easier to be critical in hindsight. It is unfortunate that it was assembled during the very time that a number of new developments were becoming more distinct, especially the Savitz study, but also some of the newer models that appear promising in terms of interaction mechanisms. One hopes that as the scientific community continues to cement the experimental and theoretical evidence for low-level bioelectromagnetic effects, the engineering community will correspondingly mute its overreaction.

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Sisir K. Dutta and Richard M. Millis, editors, **Biological Effects of Electropollution: Brain Tumors and Experimental Models,** Philadelphia, PA: Information Ventures, Inc., 1986, 245 pp., $45.00.

This book is a collection of 18 papers presented at a symposium at Howard University in September 1985, with the addition of "An Overview of the Electropollution Literature" consisting of more than 150 abstracts dealing with 13 different aspects of the problem culled from the BENER Digest.

As the subtitle suggests, there is a moderate emphasis placed upon brain tumors (and nerve cells) and model systems with which to attack the problem. However, the content of the individual papers presents a little of something for everyone. The first paper, by Elder, is a brief but excellent summary of the issues related to promulgation of exposure standards for RF. Gandhi's paper discusses such proposed standards from the point of view of his own research on induction of RF currents. Brain tumors are discussed by Lin and by Spitz and Johnson, all three of whom present the same data as in their journal publications. The paper by Blackman is particularly interesting and possibly of considerable importance. He presents data indicating that the intensity and direction of the local geomagnetic field interact with the intensity and frequency of the experimental field (either direct ELF or ELF-modulated RF) in a fashion consistent with a magnetic resonance phenomenon. This observation may lead to a useful concept of mechanism of action — something that has been lacking so far. Other papers deal with microwave effects upon behavior, calcium flux across cell membranes, neurotransmitters and proposed model systems for experimentation. Gordon presents a reasoned approach to the problems of relating animal experimentation to humans and Parshad reports a new observation that pulsed microwaves at low SARs kill neuroblastoma cells in culture.

The section of abstracts from the literature represents a fair cross section of the available data; however, in several of the sections it seems that more significant citations could have been used. For the experienced worker in the field the book does not represent anything particularly new and it is not complete enough to constitute a good survey. It is, however, a very useful introduction to this controversial field for the scientist who is interested but not yet knowledgeable. It should be in all engineering libraries and would make a useful addition to medical school libraries as well.

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Charles Polk and Elliot Postow, **CRC Handbook of Biological Effects of Electromagnetic Fields,** Boca Raton, FL: CRC Press, Inc., 1986, 503 pp., $165.00.

The appearance of this handbook signals a significant new step in the maturation of bioelectromagnetics, a discipline which covers an exceptionally broad range of topics. When considering a handbook, one looks for authority, accuracy, completeness and conciseness, while hoping that the treatment of developing areas won't too soon be out of date. Although I have some grave regrets, the book is a success.

Many of the 11 chapters are authoritative, including several that are the most elegant treatments I know. C. Polk's introduction to the physical principles which underlie electromagnetic interactions with biological systems gets the book off smartly. K. Foster and H. Schwan follow with a highly readable article on dielectric theory and dielectric measurements of biological materials. High marks also go to M. Stuchly and S. Stuchly for a review of theory, technique and apparatus in radio-frequency dosimetry, and to R. Frankel for a comprehensive overview of biological magnetism from its historical roots to the recent work on the wondrous perfect little magnets synthesized within some cells.

Thermoregulation (E. Adair) and the techniques of RF tis-

sue dosimetry (J. Lin) are also treated with distinction. Chapters like these serve well the purpose of a handbook: to provide an intuitive understanding of essential relationships, a few fundamental equations, and those essential derived results we want to have at hand.

Most of the reviews of biological studies do less well, in some places failing to present a cohesive portrait of the research, in others being dated, and in still others omitting important information. Faced with a vast number of topics and reports, various styles emerge, ranging from "encyclopedic" to "tabular with comments." On the plus side, the final chapter on "Modulated Fields and 'Window' Effects," by E. Postow and M. Swicord makes an insistent effort to illuminate fundamental mechanisms, and provides the greater measure of the scientific "jousting" to be found in the entire book. In contrast, M. Miller's out-of-date review of ELF bioeffects mostly honors worn shibboleths. And nowhere in the book is it emphasized that membrane events are the central feature of a host of biological and biochemical responses to low-level electromagnetic fields.

The attempt to treat electromagnetic exposure standards in a few lengthy tables found in an appendix is inadequate and introduces inaccuracies. In recognition of the importance of such public issues, several authors discuss the epidemiologic and experimental evidence for an association of cancer with exposure to electromagnetic fields, but none of the treatments in this fast-moving area is satisfactory or up-to-date.

A glance at the excellent index shows that engineering and biophysical topics are covered with completeness, while the scope of biological topics is more limited. I was also disappointed because there is little sense of excitement or of the flow of developments and scientific ideas in the pioneering work now going on in bioelectromagnetics. Despite its inordinately high price, the handbook should find its way to many desks where it will prove a trusted companion as well as a continuing source of stimulation and provocation.

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Briefly Noted

Theodore Bullock and Walter Heiligenberg, editors, **Electroreception,** New York, NY: Wiley, 1986, 722 pp., $99.95.

In his review (*Nature*, May 7, 1987), Professor James Gould of Princeton University called this collection of papers "a well-organized, systematic explication of what is known about electroreception in fish."

William E. Burrows, **Deep Black: Space Espionage and National Security,** New York, NY: Random House, Inc., 1986, 401 pp., $19.95.

The U.S. will have spent close to $50 billion for "technical intelligence collection" in the 1980s, according to Burrows – almost twice the cost of landing men on the moon. Yet most of the programs which generate communication, photographic or signal data are top secret, or in Washington jargon, "black." Burrows raises the cloak of secrecy and provides a detailed look at the space-based systems that have become an integral part of our defense establishment.

H. Keith Florig, **Population Exposure to Power-Frequency Fields: Concepts, Components and Control,** Ann Arbor, MI: Dissertation Information Service, University Microfilms, Inc., 1986, 265 pp.

For his doctoral thesis at Carnegie-Mellon University, Florig investigated people's exposures to ELF electric fields, primarily power lines and electric blankets, and the shielding from external sources provided by houses. He concludes with a discussion of regulatory strategies in the absence of firm bioeffects data.

Barton C. Hacker, **The Dragon's Tail: Radiation Safety in the Manhattan Project, 1942-1946,** Berkeley, CA: University of California Press, 1987, 258 pp.

Hacker summarizes the work of doctors and scientists dealing with the known and unknown dangers of nuclear energy in the era of the Manhattan Project. Their work in the development of regulations to protect against ionizing radiation is covered in detail.

Bernhard Keiser, **Principles of Electromagnetic Compatibility, 3rd Edition,** Norwood, MA: Artech House, Inc., 1987, 383 pp., $60.00.

Keiser has been teaching a short course on EMC for the practicing engineer at George Washington University for more than ten years. This volume is essentially the course notes, covering all the basics from grounding, bonding and shielding to FCC, VDE, CISPR and military standards.

Richard L. Miller, **Under the Cloud: The Decades of Nuclear Testing,** New York, NY: The Free Press, 1986, 547 pp., $24.95.

Miller has written an extraordinarily detailed history of the U.S. nuclear testing program. He traces the movement of the radioactive clouds that crossed the country between 1951 and 1962, sprinkling fallout on American cities.

Wilbert F. Snyder and Charles L. Bragaw, **Achievement in Radio: Seventy Years of Radio Science, Technology, Standards and Measurement at the National Bureau of Standards,** Washington, DC: US Government Printing Office, 1986, 842 pp., $55.00; Order No.003-003-02762-6.

This large book recounts the history of NBS's accomplishments in radio science from its first measurements in 1911, ten years after Marconi successfully transmitted a message across the Atlantic Ocean, to today's concerns over electromagnetic interference. The authors – each worked for the bureau for more than 40 years – cover a lot of ground, from ELF to millimeter waves. The volume is well illustrated, with copious footnotes and references.

UPDATES

BIOLOGICAL EFFECTS

EEPA Review... The Electromagnetic Energy Policy Alliance (EEPA), an industry group based in Washington, DC, has released a *Biostatistical Review of Selected Literature on the Biological Effects of Radiofrequency Electromagnetic (RFEM) Energy*, an 89-page critical analysis of 32 published studies. The reviews were written for EEPA by Dr. Murray Selwyn of Statistics Unlimited, Inc. (a consulting firm in Auburndale, MA), Dr. Jennifer Anderson of Boston University and Dr. Constantine Maletskos, a consultant long associated with the NCRP. The 32 papers, which were selected by EEPA, cover a mix of different types of effects at various frequencies from ELF to MWs and come from around the world, including the U.S.S.R., Poland and Spain. According to Selwyn, the "overall statistical quality of [the] papers was low," but he also pointed out that they were "about typical" of papers in other fields. The report concludes that "the set of studies reviewed provides no conclusive evidence of harmful effects, except for laboratory studies where RFEM radiation produced substantial heating." Copies are available for $195.00 each from Richard Ekfelt, EEPA, 1255 23rd St., NW, Washington, DC 20037, (202) 452-1070.

EMP

Protecting Medical Devices... The U.S. Army is continuing research on ways of protecting medical devices against EMP (see *MWN*, January/February 1986). The Army has awarded IRT Corp. of Vienna, VA, $469,000 to develop specifications for hardening medical equipment and methods for verifying its immunity. One specific system which the Army wants to protect from EMP radiation is the MEDEX Military X-Ray system.

Is 50 kV/m the Right Threshold?... The maximum ground-level electric field from a nuclear EMP is 50 kV/m, according to most unclassified sources. Indeed, EMP simulators like EMPRESS II are designed to test electronics up to that threat level. But will this level provide adequate protection from a high-altitude nuclear attack? Maybe not, according to Rudy Garbely of ITT-Cannon. Writing in the May issue of *Defense Electronics*, Garbely warns that, "It has been impossible to verify this number [50 kV/m] with real-world testing." He also points out that, "Anyone touching a path to electrical ground at the moment of the blast could be burned or even electrocuted."

GOVERNMENT

NIEHS Stops In-House Research... The National Institute of Environmental Health Sciences (NIEHS) has closed down its in-house research effort on non-ionizing radiation bioeffects – following the example set by the EPA. Dr. Don McRee, who headed the program and is now a grant reviewer, told *Microwave News* that NIEHS stopped supporting the program "due to its loss of priority" at the agency. NIEHS is still funding extramural research, however; at present, Drs. Ernest Albert, Om Gandhi, Eugene Goodman, Bill Guy and Sol Michaelson have grants.

U.S.-U.S.S.R. Cooperation Continues...NIEHS's McRee is also the coordinator of the U.S.-U.S.S.R. joint project on non-ionizing radiation bioeffects. The project's next meeting, which will include a review of the last two years of research and planning for the next two years, is scheduled for the week of October 18 in Research Triangle Park, NC. Professor Mikhael Shandala of the A.N. Marzeev Institute of General and Communal Hygiene in Kiev will lead the Soviet delegation – three associates from the Kiev institute and Dr. T. Kalada of the Institute of Occupational Safety and Health and Dr. N. Vasilevsky of the Institute of Medicine, both in Leningrad. The October workshop will be open to the public. Those interested in attending should contact McRee at NIEHS, PO Box 12233, Research Triangle Park, NC 27709, (919) 541-1442.

MEASUREMENT

VDT Fields... Due to the increasing concern over adverse effects of VDT fields, the EMC Society of the IEEE has set up a working group (No.1140) to develop a standard for electric and magnetic near-field measurements in the 1 kHz to 1 MHz frequency range. H. Stephen Berger of The Electro-Mechanics Co. in Austin, TX, and Jim Greeson of IBM in Research Triangle Park, NC, are co-chairing the working group, which is planning to have its first meeting on August 25 in Atlanta, GA, during the IEEE EMC Society's annual symposium. For more information, contact Berger at Electro-Mechanics, PO Box 1546, Austin, TX 78758, (512) 835-4684.

MEETINGS

EMP Bioeffects... The Boeing Corp. hosted a two-day meeting, *Joint Government/Industry Conference on Biological Effects of Occupational Exposure to Electromagnetic Pulses (EMP)*, June 17-18 in Seattle, WA. The conference, which was attended primarily by DOD staffers and defense contractors, was organized to see if there were any health problems among those working with EMPs, according to Bill Morgan, the chief of radiation health protection at Boeing. No problems were reported, he said in a telephone interview, and now Boeing is considering relaxing its exposure standard of 50 kV/m

to match the 100 kV/m level adopted by the U.S. Air Force and under consideration by the American Conference of Government Industrial Hygienists (ACGIH). "We're still on the fence," Morgan replied when asked whether Boeing will follow suit. The company has an ongoing epidemiological study of EMP health risks, but the number of workers exposed is too small to get reliable data: "It will take another 330 years to have enough numbers to make the study significant," Morgan said.

NAB & RF Compliance... The National Association of Broadcasters (NAB) will feature a seminar on *RF Radiation Regulation Compliance* on September 12 at its *Radio '87* conference in Anaheim, CA. Among the panelists will be Dr. Bob Cleveland of the FCC, John F.X. Browne, who runs his own consulting firm, Dane Ericksen of Hammett & Edison and Ken Keane of Wilner & Scheiner. For more information, contact: NAB, 1771 N St., NW, Washington, DC 20036, (202) 429-5300.

OVENS

Leaks Increase with Age... Old microwave ovens leak more than new ones, according to a radiation survey by Dr. Timothy Miller of the Fermi National Accelerator Laboratory (Fermilab) in Batavia, IL. Measurements of 80 ovens between 1974 and 1985 revealed that the greatest leakage was usually at the top and right edges of the door seal. Only five of 425 readings met or exceeded the FDA's 5 mW/cm² emission standard; all five ovens were built by the same manufacturer. Miller, the group leader for environment and safety at Fermilab, told *Microwave News* that the five ovens were made by Litton; these were older units with an average age of 6.6 years. The mean leakage level was 0.2 ± 3.1 mW/cm². In a paper in the *American Industrial Hygiene Association Journal (48*, pp.77-80, January 1987), Miller noted that this leakage level is "considerably less than [those in previous studies] and may be the result of improved oven design." He concluded that the optimum frequency for surveying oven leaks is once a year. In a telephone interview Miller said that this year's survey showed no leakage above the FDA standard.

POWER LINES

The Regulatory Dilemma... The research group at Carnegie-Mellon University in Pittsburgh, PA, led by Dr. M. Granger Morgan, reviews the problems of trying to regulate risks under uncertainty in an article on "Power-Frequency Fields" appearing in the Summer 1987 *Issues in Science and Technology*, which is published by the National Academy of Sciences.

STANDARDS

Portland Vote Near... After years of debate about an RF/MW exposure standard, the Portland (OR) City Council is set to vote on a proposed ordinance on August 12. The present favored option is a level that is one-fifth of the ANSI standard, or 200 μW/cm² between 30 and 300 MHz. Originally the city's Bureau of Planning had proposed a 100 μW/cm² standard, but there was greater support for the higher limit (see *MWN*, September/October and November/December 1985). An amendment lowering the proposed limit back to the 100 μW/cm² level has been introduced and will also be considered on August 12. At its July 22 meeting, the council adopted a resolution asking for a study of the merits of registering and monitoring sources of RF/MW radiation but, according to Steven Gerber of the city's Bureau of Planning, "the funding for the study is not yet in hand." Gerber added that a "quick and dirty" estimate of the economic impact of various RF/MW standards indicated that a 200 μW/cm² rule would have no impact on Portland broadcasters, but that a level of 125 μW/cm² would probably require the installation of some new antennas and the movement of others. At 100 μW/cm², there would be "definite" effects and at 75 μW/cm², "substantial" changes would be necessary, he said.

Ovens in Belgium... The Belgian government has proposed a microwave oven emission standard that is essentially the same as that set by the American FDA: 1 mW/cm² for new ovens and 5 mW/cm² for those already in use. Comments are due on August 25; the standard is scheduled for adoption on January 25, 1988. A copy of the proposal, which is in French and in Dutch, is available from the National Bureau of Standards' Office of Product Standards Policy, Adm. Bldg. A629, Gaithersburg, MD 20899, (301) 975-4037. Ask for TBT/87.58.

ETC...

Noise on Demand... It's touted as "The Ultimate Device for the Communications Age." It's "Hang-Up Helper," which can imitate the scratchy noise of phone line static: "When hopelessly trapped in an unwanted telephone conversation, simply hold 2-3 sheets of Hang-Up Helper next to the mouthpiece. Crinkle it between your fingers to create the static-like noise and tell the person, 'There's trouble on my line. I'll have to call you back.' Then hang up." Developed by the owners of an advertising agency, Hang-Up Helper has a suggested retail price of $4.95. For your own box of the 3-inch-square foil sheets which "get you off the hook," contact: Hang-Up Helper, PO Box 5474, Austin, TX 78763.

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