

# MICRO WAVE NEWS

Vol.V No.4

A Monthly Report on Non-Ionizing Radiation

May 1985

## INSIDE...

### HIGHLIGHTS pp.2-8

**Communications Radiation:  
A Focus of Concern**

**ELF and Leukemia: Two New Studies  
and an Evaluation**

**FM EMI to Aircraft**

**WHO-IRPA Criteria Document on  
Magnetic Fields**

**AIBS ELF Report**

### EXCERPTS pp.6-8

**AIBS Report on ELF Radiation**

### FROM THE FIELD p.11

**A Report from Dr. Hans-Arne Hansson's  
Laboratory at the University of Goteborg:  
Research on the Bioeffects of Radar  
Radiation**

### UPDATES pp.8-9

**Virginia Power Line Report** □ **EMI from  
HVDC Converter Stations** □ **New Air Force  
RF/MW Safety Standard** □ **Washington  
Notes** □ **Zurich EMC Proceedings**  
□ **EMC-EMI Review from NBS** □ **ELF and  
OTH-B in U.K.** □ **BRAGS Transactions** □  
**and more...**

### Conferences p.5

### Classifieds p.12

*Microwave News* invites contributions to *From the Field*, our occasional column featuring news and opinions from the non-ionizing radiation community. Letters from readers are also welcome.

## FAA Radar Technician Claims Microwaves Caused Brain Tumor

A former radar technician has filed a \$1.5 million claim against the Federal Aviation Administration (FAA), alleging that he developed a brain tumor following prolonged exposure to microwave radiation. Two other technicians, based at the same FAA installation in Albuquerque, NM, have also developed tumors, as well as endocrine problems.

Andrew Loesch, 54, maintained TACAN equipment for 16 years at various FAA sites in Oklahoma, Texas, Alaska and, for the last seven years, New Mexico. In 1981, after years of assorted health problems, Loesch was diagnosed as having a brain tumor, which doctors have been unable to control with surgery, radiation treatments and chemotherapy.

In an administrative claim filed with the FAA on April 4, Loesch asserts that "the long-term exposure of microwave radiation resulting from his employment with the FAA caused this brain tumor."

In a telephone interview, Loesch's attorney, Michael Allison of De-Layo and Olson in Albuquerque, said that a lawsuit is being planned against the manufacturers of the radiation-emitting equipment.

### Coworkers Have Similar Ailments

Two of Loesch's coworkers, Eugene Shrouf and Ervin Kreischer, have similar medical complaints.

Shrouf, 63, had a benign brain tumor (pituitary adenoma) removed in 1983. He now suffers from hypothyroidism, low testosterone and adrenal damage. In a telephone interview, Shrouf said that his adrenal cortex is badly impaired, forcing him to take medication daily. He worked with TACAN and VOR equipment for 14 years.

Kreischer, 65, had a malignant prostate tumor removed by radical surgery in 1978. Two years later, a second tumor was found, which was successfully treated with radiation therapy. Also in 1980, Kreischer suf-

*(continued on p.10)*

## Swedish Studies Show Changes in Brain Chemistry of Radar Workers

Electromagnetic fields can induce biochemical changes in the brains of radar workers, according to reports from Dr. Hans-Arne Hansson's laboratory at the University of Goteborg in Sweden. Using newly devised analytical techniques, Hansson has shown that radar technicians develop abnormal protein patterns in their cerebrospinal fluids (CSF). Rabbits exposed to pulsed microwaves show similar signs of nervous system damage.

Hansson studied male radar workers, exposed to 1-10 GHz radiation, and found that they suffered an increased frequency of "frontal lobe neuropsychiatric symptoms" and retinal changes. An analysis of their CSF revealed the presence of an "abnormal protein band" — one which they report has not been found in patients with other neurological disorders.

*(continued on p.11)*

## Communications Radiation: A Focus of Concern

Interest is growing in the health effects of radiofrequency and microwave (RF/MW) radiation from communications facilities. Detailed below are several recent developments.

### Vernon, NJ

The long-simmering dispute in Vernon, NJ, is coming to a boil as a consensus is emerging that a health problem exists in the community. Sources indicate that there is a large excess of children with Down's Syndrome in Vernon. Residents contend that the cluster of adverse pregnancy outcomes is related to radiation from three satellite communications stations and scores of point-to-point relay towers; state and corporate officials flatly dismiss this allegation.

Last summer the New Jersey Department of Health released a study discounting citizen claims that there was an abnormal rate of birth defects among babies born in Vernon (see *MWN*, September 1984). Dissatisfied with the study, Citizens Against the Tower (CAT), a local group which is fighting any expansion of communications systems in the area, began its own research. They turned up three times the number of Down's Syndrome cases identified by the state health department, mostly among women under 30 years of age.

CAT took its case to the state's Department of the Public Advocate, which acts as an ombudsman for citizen complaints. Researchers there ran an independent investigation that confirmed CAT's list of Down's cases, and also verified another CAT claim that there were three cases of mole pregnancies (ova which develop abnormally) in the Vernon area.

In a series of interviews, informed sources said that there were at least seven cases of Down's Syndrome among 1,653 pregnancies that reached at least 20 weeks gestation in Vernon between 1975 and 1981. (CAT's count stands at nine.) According to last year's state report, only two cases were expected on the basis of a statistical analysis.

In April, the public advocate's office asked the Department of Health to scrap its study and start a new one to include both reproductive histories and the incidence of cancer in Vernon as well as their possible correlation with non-ionizing radiation. Margaret Conomos of the health department acknowledged that she had the new data and told *Microwave News* that a new analysis is underway. She said that it is still "premature" to undertake the full-scale study requested by the public advocate.

Even if there is a large excess of birth problems in Vernon, most experts believe that the radiation levels from the communications sources are far too low to cause any health effects. According to radiation surveys by Hamilton Communications Consultants of Orange, NJ, the maximum power density near an RCA earth station is 5 uW/cm<sup>2</sup> and just a fraction of a microwatt near an American Satellite Company's (ASC) installation. The surveys were commissioned by the companies. (Western Union also has a sat-

com station in Vernon.)

Similarly, Paul Giardina, chief of the radiation branch in the Environmental Protection Agency's (EPA) regional office in New York City, has told the New Jersey Department of Health that calculations indicate that the RF/MW levels in the community are so low as to be almost immeasurable.

Nevertheless, after checking and eliminating all other environmental factors, CAT's Elise Kreindler maintains that RF/MW radiation could well be responsible for the community's ills. She argues that the cases of Down's are clustered on the ridges in Vernon — in direct line with the satcom antennas. In addition, she contends that most of the Down's children were conceived during a period of bad weather. "In times of rain and fog, the satellite stations turn up their power," Kreindler told *Microwave News*, and "it's likely that the radiation levels were higher than generally believed."

ASC is seeking to expand its facilities in Vernon and is directly affected by the Vernon controversy. Midway through an April 13 zoning board meeting, ASC unexpectedly withdrew its request for a permanent variance and is now only asking for temporary permission to operate a new 7-meter antenna. Another board meeting is scheduled for May 11.

On April 16, the Federal Communications Commission (FCC) denied a request by CAT to force ASC to prepare an environmental impact statement (EIS) for its proposed expansion. In its decision, the FCC stated that the radiation emissions were far too low to force FCC action: "Given the fact that the worst case values of radiation in areas of public access are less than 1/800th of the permissible ANSI limit at the fence line, and less than 1/70,000th of the permissible limit at the public road bordering ASC's property, we find CAT's unsupported allegation unpersuasive."

### Cougar Mountain, WA

As in Vernon, residents of Cougar Mountain, WA (20 miles east of Seattle), are trying to block the expansion of new communications sources. Members of the Cougar Mountain Residents Association (CMRA), many of whom have property next to an antenna farm, are concerned about the potential long-term health effects of RF/MW radiation, and are fighting a proposed addition of a five megawatt UHF-TV station by KONG TV, Inc. The antenna farm already has ten FM stations as well as land-mobile base stations and point-to-point relays.

Dr. David Reynolds, a retired professor of electrical engineering at the University of Washington in Seattle, measured RF/MW levels as high as 822 uW/cm<sup>2</sup> inside a residence near the antenna farm in June 1984. That reading, taken in the family bedroom, was near a metal lamp; in other parts of the house, levels ranged between 146 and 450 uW/cm<sup>2</sup>. A reading of 2,263 uW/cm<sup>2</sup> was taken at the base of one of the FM towers, inside the antenna farm's fence.

Armed with these results, CMRA is trying to convince the local authorities to force anyone seeking to site a new antenna on Cougar Mountain to draft an EIS.

A number of applications for new broadcast sources are pending as local officials wrestle with the radiation problem. Initial decisions by the county to require EIS's have been reversed, and a hearing examiner recently gave KONG TV a permit to build its new 300-foot tower. CMRA is now seeking relief in court: on April 29, CMRA asked the King County Superior Court to reverse the decision.

### FCC-EPA Agreement

Controversies between broadcasters and local residents such as those in Cougar Mountain and Honolulu, HI, (see *MWN*, January/February 1985) have prompted the EPA and the FCC to work together more closely.

In the last month, senior FCC and EPA staffers have approved an inter-agency agreement, which formalizes their cooperative arrangement. Under the agreement, the EPA and the FCC will conduct measurement surveys at specific sites and the EPA will help "develop FCC expertise in prediction methodology and measurement procedures."

This agreement, which took effect on April 1, will last for six months and is likely to be renewed.

The first site visit under the new agreement will be to Cougar Mountain. EPA's Richard Tell and FCC's Dr. Robert Cleveland are planning to take measurements there in May.

### Hot Spots List

The *Washington Post* created quite a stir when it published a list of 231 sites in U.S. cities where FM stations cause RF/MW radiation levels to exceed the American National Standards Institute's (ANSI) guidelines in publicly accessible areas (see *MWN*, January/February 1985). Though based on 1980 data compiled by the EPA, some of the information was confirmed by a recent EPA questionnaire.

Staffers at the EPA and the FCC fumed on seeing the list in the April 17 *Post's* "Health" section. The release hurt the move for inter-agency cooperation as FCC staffers blamed the EPA for promoting the RF/MW safety debate from local siting issues into national news, according to agency officials who asked to remain anonymous.

An EPA press officer said that he had been flooded with calls from all over the country. And EPA's Office of Radiation Programs tried to seal itself off from the controversy by limiting public statements.

### NAB Meeting & Petition

At the time the hot spot list hit the newsstands, nearly everyone with a direct interest in the matter was attending the annual meeting of the National Association of Broadcasters (NAB) in Las Vegas, NV.

On April 16, at a session on non-ionizing radiation, Edward Minkel, managing director of the FCC, told an audience of nearly 100 that the FCC is taking the RF/MW radi-

ation issue "very seriously." He concluded, "I feel confident that the broadcast industry will continue to be very responsive in this area and will take action to prevent any possible negative impact on the public's health."

According to a report in the April 22 *Broadcasting*, EPA's Tell told the NAB that the average cost of reducing radiation exposure at each of the 231 sites where the ANSI limits are exceeded will be upwards of \$3,000 a year for each of the next six years.

On April 19, the NAB asked the FCC to reconsider parts of its decision to require new or modified facilities to prepare EIS's if their radiation levels will exceed the ANSI limits (see *MWN*, April 1985). A similar petition was also filed with the FCC by the TV Broadcasters All Industry Committee, a New York City-based broadcasting group.

Among the points raised by the NAB are that the "Technical Bulletin" planned by the FCC should be circulated for public comment while still in draft form, that the effective date of the rules be delayed from October 1, 1985 to June 1, 1986 or 90 days after the release of the final technical bulletin and that the commission should reconsider its decision not to preempt state and local RF/MW standards.

### Resources

Of related interest are two recent papers:

• M.L. Daley, et al., "Community Fear of Non-Ionizing Radiation: A Field Investigation," *IEEE Transactions on Biomedical Engineering*, 32, 246, March 1985. A team from the Pacific Northwest reports on a field study in the Portland, OR, area where four children in the same class developed cancer. The odds against this cluster were 66,000 to one and, in the absence of any known cause, some citizens blamed a relatively new microwave communications system (operating at 12.43 GHz). Measurements were made and values were found to be "several orders of magnitude below any safety standard in the world." The team advises: "In our experience, theoretical calculations of existing environmental levels of radiation are not accepted by the general public. Community concerns are best alleviated by empirically documenting the levels of radiation within the area of concern."

• S. Tofani, et al., "Analysis of Environmental Pollution by Radiofrequency Radiation from Teleradiocommunication Devices," *Health Physics*, 48, 475, April 1985. Researchers from the National Health Service in Ivrea, Italy, have devised a program for use on a personal computer that can forecast field levels produced by communication repeaters. A copy of the program is included in the paper.

*MICROWAVE NEWS* is published monthly, except in January and July • ISSN 0275-6595 • PO Box 1799, Grand Central Station • New York, NY 10163 • (212) 725-5252 • Editor: Louis Slesin, Ph.D., Associate Editors: Mark Pinsky, Ron Dionne • Subscription: \$200 per year (\$235 overseas) • Copyright © 1985 by Louis Slesin • Reproduction in any form is forbidden without written permission.

## **ELF and Leukemia: Two New Studies and an Evaluation**

Two letters published in the April 6 *Lancet* detail further findings on the possible link between working in electrical occupations and developing leukemia.

### **Milham: Radio Operators**

Dr. Samuel Milham, who first identified a link between occupational exposure to electric and magnetic fields and leukemia (see *MWN*, July/August 1982), has now uncovered "further support for the hypothesis that electromagnetic fields are carcinogenic."

Milham found a higher-than-expected incidence of myeloid leukemia after analyzing (using proportionate mortality ratios) the death certificates of 1,691 members of the American Radio Relay League (ARRL) from California and Washington state who died between 1971 and 1983. He did not see a parallel increase for other types of leukemia.

In a telephone interview from his office at the Department of Social and Health Services in Olympia, WA, Milham said that the observed association with one specific cell type led him to believe that electromagnetic fields are having some kind of effect. "The excess number of myeloid leukemias is much more significant than if I had seen a general excess of leukemia," he explained.

Milham is now testing his hypothesis that there is a relationship between exposure to low frequency radiation and the development of cancer, using a data base on amateur radio licensees compiled by the Federal Communications Commission. Those results should be completed by the end of the summer, he said.

### **Electrical Workers in New Zealand**

Researchers in New Zealand have confirmed previous reports of an increased risk of leukemia among male electrical workers (see *MWN*, March, June and December 1983 and October 1984).

N.E. Pearce and coworkers at the National Health Statistics Centre in Wellington found an unexpectedly high rate of leukemia among electronic equipment assemblers and radio and television repairmen. The total number of cases (546) was too small for a study of specific cell types. Of the 18 cases in electrical occupations, only four were acute myeloid leukemia — fewer than expected.

The New Zealand team suggests that radiation may not have been responsible for the excess number of cancer cases because the two groups of workers were also exposed to metal and chemical fumes.

### **EPRI Evaluation of Wertheimer Study**

The Electric Power Research Institute (EPRI) has released evaluations of the 1979 paper by Dr. Nancy Wertheimer and Ed Leeper that first linked exposure to extremely low frequency magnetic fields with childhood cancer and the follow-up paper by Dr. John Fulton and

coworkers that did not support that finding.

*An Evaluation of Published Studies Analyzing the Association of Carcinogenesis with Exposure to Magnetic Fields* by H.D. Roth of H. Daniel Roth Associates is highly critical of Wertheimer and Leeper's methodology. Among the key problems spelled out in the report are the inadequate validation of their assumptions and methodology regarding exposure to ELF magnetic fields and the use of inappropriate statistical methods for data analysis. Roth found some of the same problems in the Fulton study.

In a telephone interview, Roth refused to answer questions about his study, saying only that "the report speaks for itself."

The EPRI report is the second analysis of the Wertheimer-Leeper study. The first, by Dr. Annemarie Crocetti, was commissioned by the New York State Power Line Project (see *MWN*, June 1983).

A copy of the EPRI report, No. EA-3904 (March 1985), is available for \$10.00 from Research Reports Center, PO Box 50490, Palo Alto, CA 94303, (415) 965-4081.

## **FCC Seeks To Limit FM EMI to Aircraft Equipment**

The Federal Communications Commission (FCC) has proposed new rules to enhance the compatibility of FM radio broadcasts with very high frequency (VHF) aircraft navigation and communication systems. The rules would only apply to new FM stations; existing stations would be exempt unless they alter their facilities in ways that could increase the likelihood of electromagnetic interference (EMI). A spokesman for the Federal Aviation Administration (FAA) said he was disappointed with the FCC proposal.

The FCC states that the rules are needed because the potential for interference is increasing. Although there have been no accidents attributed to EMI, there have been cases of radio noise in the cockpit radio speaker.

The FCC does not believe that broadcast radiation from AM radio and television stations is a source of EMI and has exempted them from the proposal. According to Kathryn Hosford of the FCC's Mass Media Bureau's Engineering Policy Branch, only general aviation, not commercial aircraft, are at risk from FM EMI.

Gerald Markey, acting manager of the FAA's Spectrum Engineering Division, challenged both of these propositions. In a telephone interview with *Microwave News*, he said that, while AM radio is probably not a problem, TV may cause EMI. Markey also argued that all aircraft, including commercial airliners, are at risk from FM interference. "I have the data to prove it," he said.

The FCC places much of the responsibility for the problem on aircraft equipment: "The major cause of the incompatibility between the radio services is the inability of aviation receivers to reject the strong broadcast signal." Hosford said that this is a receiver problem and that "improvements in the avionics would eliminate EMI."

Here again, Markey disagrees. He explained that it is

hard for an aircraft receiver to read a 10 watt signal from an ILS localizer when there is a 100 kW FM station broadcasting in the area. "They were just not built for that," he said.

"There must be a reasonable solution to the overall problem," he added. "We are trying to cooperate, but many of the safety margins have been given to the broadcasters." The FAA has no plans to issue its own rules, Markey said, but the agency will file comments on the FCC's proposals.

According to Hosford, the net effect of the proposal is that FM stations would not be able to locate inside instrument landing system (ILS) or VHF omni-range (VOR) service areas. On "average," she said, stations would have to be more than 29 miles from the end of an airport runway.

The FM broadcast band at 88-108 MHz is adjacent to the aviation VHF band at 108-137 MHz — ILS localizers and VORs operate at 108-112 MHz and 108-118 MHz, respectively. Aircraft communications use the whole 108-137 MHz band.

At press time, the FCC proposal had not yet been printed in the *Federal Register*. Comments are due by October 11 and reply comments by December 11, 1985. For more information, contact Hosford at (202) 632-5414.

## WHO-IRPA Criteria Document on Magnetic Fields

The World Health Organization (WHO) and the International Radiation Protection Association (IRPA) have started work on a new criteria document on "Static and Time-Varying Magnetic Fields."

According to Dr. Przemyslaw Czerski of the Food and Drug Administration, a draft of the document should be ready for review following a working group meeting in May. The current schedule calls for the criteria document to be released in 1987.

In addition to Czerski, the members of the working group include Professor J. Bernhardt, Dr. B. Bosnjakovic, Dr. Michael Repacholi and David Sliney; Dr. V. Ya Akimenko of the Kiev Scientific Institute of General and Communal Hygiene in the U.S.S.R. and Dr. Tom Tenforde of the Lawrence Berkeley Lab in California will consult with the working group as "invited experts."

Immediately before the WHO-IRPA working group meeting, Bernhardt is hosting a *Symposium on the Status of Research on the Biological Effects of Static and Extremely Low Frequency (ELF) Magnetic Fields* at the Federal Health Office's Institute for Radiation Hygiene in Neuherberg, Germany, on May 13-15.

The symposium, which is by invitation only, will bring together some 40 researchers from around the world for discussions of the applications of magnetic fields, bioeffects research, biophysical mechanisms, exposed populations, epidemiological studies and unresolved questions.

Also, before the symposium, beginning on May 6, IRPA's International Non-Ionizing Radiation Committee (INIRC) will meet in Nueherberg to plan its work for the coming year. On the agenda are: electric field exposure guidelines, with special emphasis on power line frequencies, safety aspects of nuclear magnetic resonance (NMR) imaging and the WHO-IRPA magnetic fields document.

At the end of 1984, WHO and IRPA released *Environmental Health Criteria 35: Extremely Low Frequency (ELF) Fields* (see *MWN*, December 1984).

## CONFERENCES

May 26-31: **30th Annual Meeting of the Health Physics Society**, Palmer House, Chicago, IL. Contact: HFS, 1340 Old Chain Bridge Rd., Suite 300, McLean, VA 22101, (703) 790-1745.

June 3-7: **1985 IEEE MTT-S International Microwave Symposium**, Cervantes Convention Center, St. Louis, MO. Contact: John Bogdanor, McDonnell Aircraft, Bldg. 66, Box 516, St. Louis, MO 63166, (314) 232-3936.

June 6-7: **Automatic RF Techniques Group**, St. Louis, MO. Contact: Robert Nelson, Div. 724, NBS, 325 Broadway, Boulder, CO 80303, (303) 497-5736. Held in conjunction with IEEE MTT-S Symposium.

June 10-13: **10th International Aerospace and Ground Conference on Lightning and Static Electricity**, Paris, France. Contact: Lawrence Walko, USAF, AFWAL/FIESL, Wright Patterson AFB, Dayton, OH 45433 in US; or Dr. Joseph Taillet, ONERA, BP 72, 92320 Chatillon, France.

June 11-13: **6th Annual Meeting of the Canadian Radiation Protection Association**, St. John, New Brunswick, Canada. Contact: John Paciga, New Brunswick Electric Power Commission, PO Box 10, Lepreau, New Brunswick, Canada E0G 2H0, (506) 659-2102, ext. 324.

June 16-20: **7th Annual Meeting of the Bioelectromagnetics Society**, Hilton Hotel, San Francisco, CA. Contact: BEMS, 1 Bank St., Suite 307, Gaithersburg, MD 20878, (301) 948-5530.

June 17-21: **1985 North American Radio Science Meeting and Inter-**

**national IEEE/AP-S Symposium**, University of British Columbia, Vancouver, BC, Canada. Contact: Mr. K. Charbonneau, Conference Services, National Research Council, Ottawa, Ontario K1A 0R6, Canada, (613) 993-9009.

June 24-29: **8th International Symposium on Bioelectrochemistry and Bioenergetics**, Bologna, Italy. Contact: C. Bonfiglioli, Institute of Botany, Via Imerio 42, 40126 Bologna, Italy, (051) 234376.

July 10-13: **International Symposium on the Hazards of Light: Myths and Realities**, Manchester, UK. Contact: Dr. R.P.F. Gregory, Dept. of Biochemistry, The Medical School, University of Manchester M13 9PT, UK.

July 14-19: **1985 Summer Meeting of the IEEE Power Engineering Society**, Vancouver, BC, Canada. Contact: PES Special Activities, IEEE, 345 East 47th St., New York, NY 10017, (212) 705-7895.

July 22-24: **22nd Annual Conference on Nuclear and Space Radiation Effects**, followed by July 25-26: **1985 Hardened Electronics and Radiation Technology (HEART) Conference**, Monterey, CA. Contact: K.F. Galloway, Div. 726, NBS, Gaithersburg, MD 20899, (301) 921-3541.

July 22-25: **1985 International Symposium on Microwave Technology in Industrial Development—Brazil**, Campinas, Brazil. Contact: Attilio Jose Giarola, SBMO Symposium Committee, UNICAMP-CCPG (Reitoria), CP 1170, 13100 Campinas, SP, Brazil.

## AIBS Report on ELF Radiation

In its report released in March, the American Institute of Biological Sciences' (AIBS) Committee on the *Biological and Human Health Effects of Extremely Low Frequency (ELF) Electromagnetic Fields* unanimously agreed that:

- ELF electric and magnetic fields can, at least in some frequency and intensity combinations and under certain circumstances, cause a variety of effects at any of several levels of biological organization of plants and animals or in vitro preparations.
- Additional research on coupling of living systems to ELF electric and magnetic fields, on mechanisms of interactions, and on responses of biological material to such fields will be necessary to gain a more nearly complete understanding of the biological significance, if any, of interactions of these fields with living systems.

With respect to the Navy's ELF communications system, the AIBS panel unanimously concluded that:

- It is unlikely that exposure of living systems to ELF electric and magnetic fields in the range of those associated with the Navy's ELF Communications System can lead to

adverse public health effects or to adverse effects on plants and animals.

- Because of certain ambiguities in the scientific literature, the Navy should continue to monitor the literature and respond appropriately to any significant new information.

According to Captain Ronald Koontz, program manager of the Navy's ELF Communications System, the Navy will decide on whether to prepare a supplemental environmental impact statement on the ELF system on the basis of the comments it receives on the AIBS report (see *MWN*, March, July/August and September 1984).

The Navy has requested comments on the report by July 1. Copies are available from the National Technical Information Service (NTIS), Springfield, VA 22161, (703) 487-4650. NTIS Order No. ADA152731. (Note: some people are having problems obtaining the report from NTIS. Koontz told *Microwave News* that he has remedied the situation and that he welcomes all comments, even those that do not meet the July 1 deadline.)

Excerpts from the summary and conclusions of the 289-page AIBS report are reprinted below.

### Excerpts of AIBS ELF Report

**"Coupling of Living Organisms to ELF Electric and Magnetic Fields"** by William T. Kaune, Battelle Northwest (Chapter 2).

Unfortunately, the ability to estimate internal electric fields resulting from the exposure to external electric and magnetic fields is still rather limited. Exposure to external fields in the air has received the most attention, and a considerable number of techniques and data are available for homogeneous models. However, virtually nothing quantitative is known about the effects on induced-current distributions of the nonhomogeneous electrical structures of living organisms. For example, it might be predicted that induced current would concentrate in the cardiovascular system because blood is a considerably better conductor at ELF frequencies than most other tissues. However, for this to happen, current would have to pass through the walls of the blood vessels and, as far as is known, no data are available on the electrical properties of these tissues. It can reasonably be expected that knowledge of ELF electric and magnetic field dosimetry will be greatly expanded in the next few years.

**"Possible Biophysical Mechanisms of Electromagnetic Interactions with Biological Systems"** by Mays L. Swicord, Food and Drug Administration (Chapter 3).

...Unfortunately, no proposed theories to date clearly explain how electric or magnetic fields can cause the experimentally observed effects in biological systems....

The concept of cyclotron resonance proved to be useful for Liboff in predicting ELF experimental results... Additionally, one can now conceive of how the system may be overdriven creating a power window. Too large a field could disturb the resonant condition for order....

The concept of externally imposed order (the external fields encouraging the system to order randomly distributed energy) may have application to interactions with large molecular structures, such as membranes, or macromolecules, such as DNA.

This concept is not too far removed from Frohlich's suggestions concerning Bose-Einstein condensation....

The theoretical prediction of field interactions with the DNA molecule by Van Zandt, Kohli and Prohofsky (1982) is perhaps the only theoretical model that has been confirmed by experimental measurements. The experimental work was performed at frequencies above 400 MHz, and thus, its applicability to ELF effects is in question. A resonant length at ELF frequencies would be comparable to the entire length of the DNA molecule in a chromosome, which would be on the order of 1 cm. Conceptually, it is possible to excite such a molecule, but it seems rather speculative....

Two concepts — electrochemical processes and solitons — definitely have applicability for ELF effects, but are too general at this point and have no experimental confirming evidence....

At most, the mechanisms suggest that field interactions resulting in a biological response are physically conceivable.... The connection between mechanisms and observed biological effects has not been made. Thus, no useful predictive theory currently exists in the assessment of hazards of electric or magnetic fields.

**"Biological Effects of ELF Magnetic Fields"** by T.S. Tenforde, University of California, Berkeley (Chapter 4).

Although a wide variety of biological effects resulting from exposure to ELF magnetic fields have been reported in studies on cellular, tissue and animal systems, the only phenomenon consistently replicated is the induction of magnetophosphenes. The minimum field intensity required to induce magnetophosphenes using a sinusoidal time-varying field is 10 mT, and this level is significantly greater than the ELF magnetic field intensities to which humans are routinely exposed....

A large number of investigations have been carried out during the past two decades to assess the biological effects of ELF magnetic fields... These studies have led to both positive and negative findings of ELF magnetic field effects, and there is little consist-

ency among reports from different laboratories. An example of the difficulty in interpreting these studies is provided by the many reports on animal behavior in ELF magnetic fields. A majority of the investigations carried out with low field intensities have indicated the occurrence of behavioral alterations, whereas nearly all of the studies conducted with higher field intensities have provided no evidence for field-associated effects on animal behavior....

In the context of analyzing the potential biological effects of the extremely low intensity magnetic fields produced by the ELF Communications System, two general conclusions can be made....

- Although numerous behavioral, physiological and biochemical effects of ELF magnetic fields have been reported on the basis of laboratory studies, very few of these experiments were carried out using low field intensities comparable to those associated with the ELF Communications System. The reports which indicate that measurable perturbations of biological processes occur as a consequence of exposure to extremely low intensity fields must currently be viewed with caution until the results have been established by independent replication in other laboratories.

- Recent epidemiological studies suggest that a correlation may exist between cancer incidence and exposure to the power frequency magnetic fields present in residential and industrial environments....The methodological and dosimetric deficiencies of the published epidemiological studies are numerous, and the available evidence that a correlation exists between cancer incidence and ELF magnetic field exposure cannot be regarded as conclusive. A critical need exists for carefully designed epidemiological and laboratory studies to clarify this issue.

**"Cellular Studies of Effects of ELF Electric and Magnetic Fields"** by Asher R. Sheppard, VA Medical Center and Loma Linda University (Chapter 5).

The following conclusions can be drawn from *in vitro* studies of cellular systems:

- A review of the experimental data shows that electric and magnetic fields of various strengths, frequencies, and waveforms can alter biochemical and physiological functions in cellular systems. It is difficult to be precise in the extrapolation from *in vitro* exposure conditions to *in vivo*. However, it is clear that in many cases the *in vitro* exposure conditions could not occur for any environmental exposure, and in other cases the tissue-level field strengths are at the level of some exceptional environmental exposures that could not be achieved by the ELF Communications System. Generally, the system's electric and magnetic fields are so weak that very few studies examined fields at that level.

- The quality of the research conducted with ELF fields varies considerably. A few findings have been replicated or studied intensively enough to be accepted as without obvious artifact or experimental error. Much of the research is at a preliminary level and requires further intensive study before results can be accepted without serious question.

- With the exception of studies on magnetophosphenes and bone growth, the functional or biochemical changes seen *in vitro* have not been closely linked to *in vivo* conditions, nor has the expression of the laboratory observations in a whole organism been established.

- At the very low field strengths typical of the ELF Communications System antenna environment, only the calcium efflux studies appear to involve similar strength electric fields. Only the studies of slime mold mitotic cycle, fibroblast growth, and chick embryogenesis involve magnetic fields like those of the system,

and these occur only close to the antenna wire.

- None of the *in vitro* studies or other studies of cellular systems indicates that significant functional changes might occur in organisms subjected to the electric and magnetic fields in air near the ELF Communications System's antenna.

- On the basis of an analysis of the literature on biological effects of ELF electric and magnetic fields on cellular systems, and despite the considerable uncertainties on issues of biological interests and importance, there is essentially no probability of deleterious biological effects on organisms exposed to the ELF Communications System's fields in air.

**"Interaction of ELF Electric and Magnetic Fields with Neural and Neuroendocrine Systems"** by Larry E. Anderson, Battelle Northwest (Chapter 6).

Numerous studies have been initiated to determine to what extent an electrical environment containing electric or magnetic fields of 1 to 300 Hz poses a health hazard to living organisms (particularly to humans). The biological effects reported in many of the experiments have not yet confirmed any pathological effects, even after prolonged exposures to high strength (100 kV/m) fields or high intensity magnetic (10 mT) fields. Areas in which effects have been demonstrated appear to be primarily associated with the nervous system, including altered neuronal excitability, altered circadian levels of pineal hormones and indications of transient arousal responses. In addition, in several instances where unconfirmed or controversial data exist, observed effects may or may not be real (e.g., changes in serum catecholamines or corticosteroids, morphology of brain tissue, and changes in electroencephalographic wave forms). It is not yet known whether these and other putative effects are due to a direct interaction of the electric field with tissue or to an indirect interaction, e.g., a physiological response due to detection or sensory stimulation by the field....

Results to date have demonstrated various neurological effects in specific species exposed in the laboratory to a wide range of field strengths. The extrapolation of specific effects that occurred under controlled laboratory conditions to a general assessment of the health risk for a human population exposed to electric or magnetic fields is very tenuous....

...Experimental results to date show no clear implications of health risks to humans exposed to a range of from 1 to 300 Hz electric fields. The amount of data on comparable magnetic fields is still too minimal to make such an assessment.

**"Hematologic and Immunologic Effects of Extremely Low Frequency Electromagnetic Fields"** by Ralph J. Smialowicz, U.S. Environmental Protection Agency (Chapter 7).

Many of the studies reviewed here are flawed because of poor experimental design and statistical analysis of the data. In those studies that appear to be well designed and adequately analyzed, no clear, consistently reproducible and physiologically significant effects of ELF fields on the hematologic or immunologic systems or on their cellular elements have been demonstrated. The reported alterations caused by ELF fields have, for the most part, been found to be transient and mild in nature. The fact that no consistent effects have been observed even when similar exposure conditions and experimental parameters have been used indicates that low level ELF field induced effects are very subtle and consequently may be of little or no physiological significance as regards the hematopoietic and immunologic systems.

**"Reproductive and Developmental Effects in Mammalian and Avian Species from Exposure to ELF Fields"** by Neil

## EXCERPTS

**Chernoff, U.S. Environmental Protection Agency (Chapter 8).** Given the criteria for adequate evaluation, it is impossible to draw any definitive conclusions concerning the effects of ELF fields on reproduction or development in either avian or mammalian studies. Although a number of studies have reported possible agent-related findings, few of these studies have dealt with dose-response phenomena, and none have been clearly replicated by different research groups....

The exposure of mammalian species to magnetic fields indicates a possible increased growth rate (Grissett 1979), but the experimental design does not allow for definitive conclusions on this point. In avian species, studies have indicated that such fields produce adverse effects (Delgado et al. 1982; Ubeda et al. 1983), but the nature of the internal variability and lack of dose-response data in these studies again do not allow for definitive conclusions.

**"Human Studies of Carcinogenic, Reproductive and General Health Effects of ELF Fields" by David A. Savitz, University of Colorado School of Medicine, Denver (Chapter 9).**

The studies of residential exposures, in balance, contain preliminary suggestions of an elevated risk of cancer that have not yet been thoroughly refuted or confirmed. The studies of Wertheimer and Leeper (1979, 1982) and Tomenius, Hellstrom and Enander (1982) are sufficiently credible to raise the interest that has ensued but are inadequate in demonstrating that ELF fields cause cancer in humans. In spite of a lack of support from laboratory studies, the possibility that ELF magnetic fields act as cancer-promoting agents remains a hypothesis worthy of further study....

The studies of cancer among occupationally exposed groups contain more reports of lower quality and even fewer details. The letters to the editor provide suggestions of some modest increase in leukemia occurrence among workers in "electrical occupations," but are inherently weak due to a reliance on broad occupational titles. These studies constitute very limited evidence to address the question of whether ELF fields are related to cancer risk. Until the exposure patterns of appropriate workers are as-

essed in relation to subsequent cancer risk, the presence or absence of an association cannot be resolved with any certainty.

The available literature on human cancer risk related to electric and magnetic field exposures does not support the presence of a causal association. Rather than a literature of methodologically sound but contradictory studies, a more accurate characterization of this literature is a predominance of methodologically flawed and inconclusive positive reports....

The literature on the human health effects of ELF fields does not provide any convincing indication of a threat based on studies of cancer, reproductive outcomes or general health....

...Continued examination of this issue is needed, which should culminate in more credible, conclusive results than have yet been produced.

**"Potential Effects on Natural Biota in Operating an Extremely Low Frequency Communications System" by Robert G. Lindberg, University of California, Los Angeles (Chapter 10).**

- The ecological risk of operating the redesigned USN ELF Communications System is low. The risk is probably less than that projected in the National Academy of Sciences [NAS] 1977 evaluation.

- The complexity of ecological systems makes it impossible to rule out the possibility of some component of the ecosystem responding to electromagnetic fields generated by the ELF Communications System. The prediction of low risk is an assumption that should be verified through ecological research conducted in concert with operation of the ELF Communications System.

- Research published since 1977 does not alter the conclusions drawn by the [NAS] in 1977 nor does it negate their recommendations for additional research on the effects of ELF electromagnetic fields on biological systems.

- Ecological effects, if detected, in the vicinity of the operating ELF systems will be subtle not catastrophic; may require a long time to develop; and are of secondary importance to changes produced by the construction of the Communications System.

## UPDATES

### COMPATIBILITY & INTERFERENCE

**EMI From HVDC Converter Stations...**A new study by the International Engineering Co. of San Francisco, CA, indicates that a scale model approach is "a practical and cost-effective method to study EM effects" from high voltage direct current (HVDC) converter stations. The study, funded by EPRI, found that "valve-hall screening is effective in containing EM waves but that conductors through building walls provide a path for some EM energy to reach the converter station exterior." A copy of the report, *Radio Interference From HVDC Converter Stations* (No. EL-3712), which includes an extensive annotated bibliography, is available for \$26.50 prepaid from Research Reports Center, PO Box 50490, Palo Alto, CA 94303.

### GOVERNMENT

**Washington Notes...**The FDA has reorganized the Center for Devices and Radiological Health's Office of Science and Technology. Sources indicate that the move was de-

signed to put more emphasis on the regulation of medical devices — at least partially at the expense of radiation research....The Frequency Management Advisory Council (FMAC) met in Washington, DC, on April 10. Among the topics covered were spectrum requirements for a U.S. space station, RF/MW radiation bioeffects, high-definition TV and preparations for discussions on the HF broadcasting band at the upcoming World Administrative Radio Conference (WARC). FMAC has nominated new members to enhance the council's expertise in bioeffect issues; they are awaiting official approval. For more information, contact NTIA's Charles Hutchison at (202) 377-0805....The FCC has issued a "Report and Order" on obtaining recognition of and protection against harmful EMI for communication satellites in geostationary orbit in preparation for the next Space WARC meeting in August. The text of the FCC notice appears in the March 21 *Federal Register* (50 FR 11418)....The FDA has reduced some of the paperwork needed to apply for exemptions from requirements



to post radiation safety warnings on microwave ovens. For details, see the April 5 *Federal Register* (50 FR 13565).

#### INTERNATIONAL

**OTH-B and ELF Antenna in the U.K....**The British Ministry of Defence is exploring the possibility of siting an over-the-horizon backscatter (OTH-B) radar in northern Scotland to enhance its air defense systems. The OTH-B, which is based on U.S. technology, is still in the early stages of testing, but government officials hope to announce its development formally by early next year, according to a report by Chris Mullinger in the April 2 *Scotsman*. The defense ministry is also planning an extremely low frequency (ELF) transmitter in Scotland to improve submarine communications. The *New Scientist* magazine reported on March 14 that government officials have refused to comment on a report issued by a University of Sussex researcher that there are 11 potential sites for the 40 km antenna. But the researcher, Malcolm Spaven, working with a local disarmament group, apparently plans to oppose construction of the transmitter because he claims that it is unnecessary. The Ministry of Defence has stated only that it is considering two or three mainland sites.

#### MEASUREMENT

**EMC-EMI Review...**Four members of NBS's Electromagnetic Fields Division in Boulder, CO, have published a major article, "A Review of Electromagnetic Compatibility/Interference Measurement Methodologies," in the March issue of the *Proceedings of the IEEE*. Mark Ma, Motohisa Kanda, Myron Crawford and Ezra Larsen present a summary of radiated emission and susceptibility measurement techniques. In their 25-page review, they weigh the pros and cons of some of the most popular methods: open area sites, TEM cells and reverberating and anechoic chambers.

#### MEETINGS

**Zurich EMC Proceedings...**Attendance at the Zurich EMC symposium in March broke all records, attracting 845 participants and exhibitors, compared to totals of 629 in 1983 and 529 in 1981. The People's Republic of China sent six representatives to Zurich — China's first time at the EMC symposium. Of the 116 papers presented, 34 were from the U.S., less than in 1983. The proceedings of the *6th Symposium and Technical Exhibition on EMC*, a 636-page volume with the texts of the papers, are available for 100 Swiss francs (about \$37.00), includes postage, from Dr. T. Dvorak, EMC Symposium, ETH-Zentrum-IKT, 8092 Zurich, Switzerland, (411) 256-2790.

**BRAGS Transactions...**Last year's meeting of the Bioelectrical Repair and Growth Society (BRAGS) was in Kyoto, Japan (November 5-8). Those who were unable to go can now get a copy of the *Transactions*, which includes the abstracts of the 54 papers presented and the 28 posters, by sending \$25.00 (including postage) to BRAGS, PO Box 64, Dresher, PA 19025, (215) 659-5180. *Transactions* from past years are still available. 1981: \$10.00; 1982: \$18.50; 1983: \$20.00.

#### POWER LINES

**Virginia Report...**The Virginia legislature has approved a resolution calling on the state to formalize its oversight of the health and safety concerns posed by high voltage transmission lines. *Senate Joint Resolution No. 126* asks the State Corporation Commission (SCC) and the Department of Health to monitor ongoing research and the health department to report its findings to the General Assembly each year. The resolution is just the latest development in an eleven-year debate that began when the Appalachian Power Co. asked the SCC for permission to build a 765 kV powerline from Jackson's Ferry to Axton. Following commission approval in 1978, Citizens for the Preservation of Floyd County (CPFC) appealed the decision, but it was upheld by the state's Supreme Court. State Senator Madison Mayre brought the issue before the legislature in 1984, and a seven-member subcommittee, chaired by Mayre, was set up to see if state power line regulations were needed (see *MWN*, November 1984). The subcommittee's report, *The Health and Safety Effects of High Voltage Transmission Lines*, (Senate Document No. 11) recommends that the SCC hold a hearing on health and safety issues for all proposed 765 kV power lines in the affected localities. (It also includes selected testimony from the subcommittee's hearings.) Meanwhile, the battle against the Appalachian Power Co. line goes on. CPFC's Betty Yapp told *Microwave News* that in mid-April the group petitioned the SCC to reconsider the need for the line. For more information about the joint resolution and the subcommittee report, contact Ms. Terry Mapp Barrett, Division of Legislative Services, 910 Capitol St., PO Box 3-AG, Richmond, VA 23208, (804) 786-3591.

#### STANDARDS

**AF Safety Standard...**Last October 12, without fanfare, the U.S. Air Force adopted new safety standards for exposure to RF/MW radiation. The standard has two parts: (1) the ACGIH standard for occupational exposures; and (2) the ANSI standard for the general population. According to Lt. Col. John Burr of the AF Medical Service Center at Brooks AFB, TX, the somewhat less stringent occupational standard was adopted because access to restricted areas can be limited for certain personnel (such as those under 55 inches in height). The ANSI standard covers the families of servicemen living on Air Force bases, for example. Burr explained that both standards are based on a maximum whole-body specific absorption rate (SAR) of 0.4 W/Kg, but the maximum permissible levels vary for different exposed populations. AFOSH 161-9 replaced the previous 10 mW/cm<sup>2</sup> standard, last revised in 1978. Burr is also the chairman of a Department of Defense (DoD) working group, with representatives from the Air Force, Army and Navy, which is coordinating new standards for all of DoD (see *MWN*, May 1982). He said that the group's work should be completed by the end of the year. A copy of the new Air Force standard is available from Burr at AF Medical Service Center/SGPA, Brooks AFB, TX 78235.

ferred a heart attack that has left him severely incapacitated. Last year, he developed bone cancer and had additional radical surgery.

Kreischer worked on TACAN and VOR equipment at the FAA facility in Albuquerque for 20 years, from 1960 until he retired at the end of 1980. When asked if he thought his ailments were connected to his exposure to microwave radiation, he said that initially he had not thought so, but he is reconsidering in light of recent findings suggesting such a link.

When asked the same question, Shrouf said that "It's more than just a coincidence that between the three of us working at the FAA in Albuquerque, we have many of the same effects that showed up in the University of Washington long-term study."

According to Shrouf, he, Loesch and Kreischer spent the most time working on TACAN, ILS and VOR equipment in the FAA's Albuquerque office.

Loesch's claim follows a series of recent reports indicating possible links between microwave radiation and cancer and endocrine disorders (see *MWN*, July/August 1984 and March 1985), brain tumors (see *MWN*, October 1984) and biochemical changes in the brain (see *MWN*, December 1984 and story on p.1).

The claim was filed with the FAA's Southwest Regional Office in Fort Worth, TX. Ms. Gerry Cook, a FAA public information officer in Fort Worth, said that Loesch's legal papers had been received and were under review. She said that it would be premature to comment further but added that it is likely that the claim would be referred to the FAA's Washington office.

Shrouf and Kreischer said that they are exploring an approach other than legal action in order to win compensation for their injuries. Neither would comment on their plans, however.

TACAN stands for "tactical air navigation;" TACAN equipment operates at 1.025-1.213 GHz. Many TACAN systems also emit some X-ray radiation from the rectifier tubes in the high voltage power supply. VOR is the abbreviation for "very high frequency omni-range."

### **Parallels to Engell Case**

The link between TACAN radiation and cancer first surfaced in the early 1970's when two technicians at the Naval Air Rework Station at Quonset Point, RI, both developed pancreatic cancer and endocrine disorders.

In March 1977, Robert Engell filed a \$4.5 million suit against ITT, Raytheon, General Dynamics, Varian Associates and Rockwell International. All of the defendants settled out of court. The financial details of the agreements were never revealed, though Engell's attorneys told *Microwave News* at the time that Engell was satisfied with the settlement (see *MWN*, January/February 1983).

ITT was the last defendant to settle; the company reached an agreement with Engell's attorneys on December 23, 1982 — just before a jury trial was about to begin in U.S. District Court in Hartford, CT.

Following the disclosure that the technicians — who

worked side by side — both developed pancreatic cancer, the Navy and the National Institute for Occupational Safety and Health (NIOSH) started a study of TACAN radiation and its possible impact on maintenance technicians. Paul Brodeur describes the Navy-NIOSH study, as well as the FAA's participation, in his 1977 book, *The Zapping of America*. **Working Conditions Detailed**

In a telephone interview, Loesch described the working conditions at the FAA in Albuquerque. From 1969 until 1976, his desk was 10-12 feet from an active TACAN klystron tube. He also worked on VOR and instrument landing system (ILS) equipment. "One or more times a month, for a period of about three hours," he said, "I sat directly in the radiation pattern for the purpose of accuracy measurement of the ILS. This was normal procedure and went on for seven years."

Loesch said that he thought that VOR radiation was less serious than that emitted by TACAN.

In his administrative claim, Loesch relates how he brought the issue of excess stray radiation from the TACAN facilities at Dalhart and Amarillo, TX, to the attention of his superiors in March 1962: at that time, he "perceived this stray radiation as a technical problem, but had no idea that it presented a threat to his health," according to Allison, Loesch's attorney.

Less than a week later, T.J. Edwards of the FAA's Fort Worth, TX, office replied by memorandum that the stray radiation described by Loesch might be common at other TACAN facilities. Pending further internal discussions, Edwards asked Loesch to stop working on the radiation problem until he received new instructions.

According to Loesch, no one ever contacted him again about radiation emissions from TACAN during his next 14 years at the FAA.

Kreischer said that he was never informed about possible radiation risks.

Loesch's court papers detail his medical problems over the last 12 years. In July 1974, Loesch had his first episode of complete numbness in his right leg, arm and hand; over the next six months, he had six more attacks of right-side numbness. These episodes continued to occur over the following years.

In early 1976, Loesch retired from the FAA with a medical disability. On April 27, 1981, he suffered a grand mal seizure and his doctors found he had a brain tumor. Later that year, the tumor was removed surgically, and Loesch was given radiation therapy.

In mid-1982, Loesch's episodes of numbness returned with greater severity; his vision and motor skills deteriorated. In 1983-1984, he had a series of acute seizures. In May 1984, a CT scan indicated that the tumor had recurred. Doctors at the Mayo Clinic confirmed this diagnosis and found the tumor to be inoperable.

Loesch has also filed a medical malpractice suit against the doctor who read his brain scan in 1976. The doctor who diagnosed his tumor in 1981 told him that it should have been detected in 1976. ●

Hansson and coworkers have also observed similar CSF changes in rabbits exposed to pulsed microwaves. In a paper presented at a workshop last summer, Hansson reported: "The results of these studies [with rabbits]...suggested that even humans occupationally exposed to microwaves of moderate to high intensity could be at risk of brain damage."

Hansson's paper will be included in *Electromagnetic Waves and Neurobehavioral Function*, to be published by Alan Liss, Inc. of New York City in the early fall. Hansson will present the data on the radar workers and the rabbit experiments at the Bioelectromagnetics Society meeting in San Francisco, CA, June 16-20. ☉

### Report from Hansson's Laboratory

*Reprinted below is a report of a recent visit to Dr. Hans-Arne Hansson's laboratory at the University of Goteborg in Sweden by Dr. Thomas Rozzell of the Office of Naval Research's London branch office.*

Preliminary results from Sweden suggest that high-level microwave exposure may affect certain proteins in the brains of radar maintenance technicians.

I recently visited the University of Goteborg, where I had extensive conversations with Dr. Hans-Arne Hansson of the faculty of medicine. Hansson described in some detail the changes that he and other members of the faculty, in the Department of Neurology, have observed in a number of radar workers and laboratory animals exposed to high-level microwaves. While these results are preliminary now, Hansson and his team have a number of replicates and are in a position to discuss the data. In this article, I will give details of these new findings, but stress again that they are preliminary.

As a physician, Hansson serves the military complex at Goteborg by providing medical care two mornings per week for enlisted persons and officers. Part of the group that he sees comes from the radar school. This is a school that trains radar operators and maintenance personnel. In a visit to the school, I observed the physical layout of the radar equipment, including antennas, generators and operating consoles. I also discussed the current safety regulations with officials at the school.

Within the last two years, Hansson has seen about 11 radar maintenance technicians who were long-time (15 years or more) employees of the school. These men all had symptoms of central nervous system damage. Many were unable to perform the jobs properly and had a number of complaints that led Hansson to send them to the Department of Neurology for a more thorough examination, which included an analysis of the protein patterns in their cerebrospinal fluid (CSF). He decided to do this as a result of some observations that he had made in rabbits whose heads had been exposed to high levels of microwaves.

The analysis of the CSF of the radar workers showed the same changes in the protein patterns as was found repeatedly in the rabbits. In order that the reader might better understand the significance of these findings, I will discuss some details of the procedure.

CSF plays a role in maintaining stability in the central nervous system. It has a characteristic crystalloid and colloid composition. Changes in the composition of the CSF reflect changes in the metabolism of the brain, in the cerebrovascular state and in the CSF hydrodynamics. Proper analysis of CSF can indicate pathologically degenerative brain diseases. The majority of the proteins normally present in CSF are derived from serum, and the

protein content in CSF is about 1/200 of that in serum. This difference is maintained through the relative impermeability of the blood-brain barrier (BBB) to large macromolecules like proteins. Passage through the BBB seems to depend on both filtration and vascular transport.

A technique has been developed at the University of Goteborg to separate CSF proteins. It is essentially an affinity chromatography method that employs isoelectric focusing as an analytical electrophoretic system (Wikkelsö, 1982). In this method, the CSF-specific protein fraction is separated into approximately 30 protein bands by isoelectric focusing. It is possible to accurately identify prealbumin, microglobulin and beta-trace proteins. If there are changes in the proteins — either qualitatively (i.e., there are new ones present or old ones missing) or quantitatively — they are readily seen by this technique. Since CSF has been studied for many years and taking it is relatively routine in a large number of diagnostic procedures in neurology, there is quite a bit known about the "normal" pattern of CSF proteins. The method is used as a complementary diagnostic tool in degenerative central nervous system disease.

When Hansson began studying rabbits, he exposed them for 1 hour at an average power level of 55 mW/cm<sup>2</sup>, using 3.07 GHz microwaves pulsed at 300 Hz (the pulse width was 1.4 us). While the average power was 55 mW/cm<sup>2</sup>, the peak power was approximately 1,000 mW/cm<sup>2</sup>. He reported that the specific absorption rate was measured in the rabbit brain and found to be 20 W/Kg average. Exposures were to the right side of the head while the animal was restrained but not anesthetized. During this time, the brain temperature rose about 1 [degree Celsius].

When the CSFs of these rabbits were analyzed (blindly) by the neurochemist at the Department of Neurology, it was found that there were different patterns of proteins in the exposed animals than in the controls. These are not subtle differences requiring a lot of expertise to observe. They are very dramatic, with very different bands which I could clearly see with my untrained eye. Furthermore, upon microscopic examination of the brain on the exposed side of the head, it could be seen that there are morphological changes in the glial cells. Here again, these are very dramatic and not difficult to see. As evidence of this, Hansson let me look at some slides — and without knowing what I was observing, I could readily see and describe the difference between sets of brain tissue that (I later learned) came from different sides of the head of an exposed animal and tissue that came from the brain of an unexposed animal. Without prompting, I was able to adequately describe the differences. If I could see them, they must be real.

While it is certainly not clear at this time exactly what the changes in the CSF of the radar workers mean, it does point to a possible new effect of high-level microwave exposure. Unlike the situation with the rabbits, there are no brain tissue samples to study in the humans. Recently, the radar school in Goteborg has instituted substantial changes in its maintenance procedures. A number of safety measures and devices are in place that should prevent anyone from being exposed to operating radar at levels above the human exposure standards. These measures include new standards as well as new interlocks that prevent activation of radar units while personnel are working near the antennas.

This is an area that I will watch. Hansson has promised to keep me informed as he accumulates more data. At the moment, there are only about 11 patients in the sample, and he feels he needs at least twice that many before any concrete statement can be made.

Wikkelsö, C., *Cerebrospinal Fluid Proteins in Degenerative Neurological Disorders*, PhD Thesis, Department of Neurology, University of Goteborg, Sweden, 1982.

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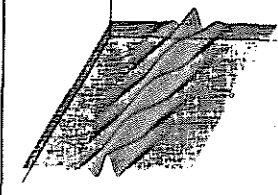
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