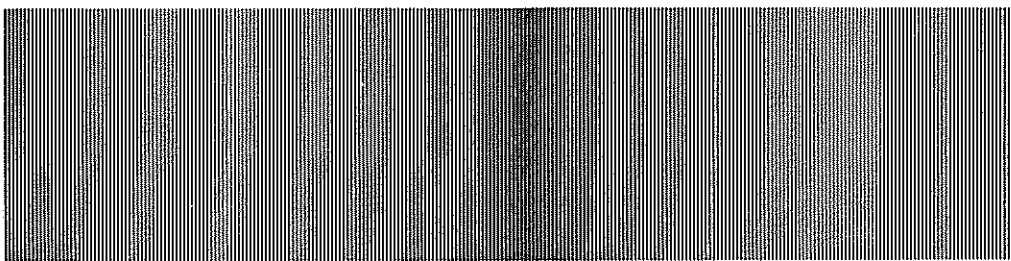


MICRO WAVE NEWS



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A Report on Non-Ionizing Radiation

May/June 1990

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EPA Staff Classifies ELF EMFs "Probable Human Carcinogens" Decision Overruled, May Be Reinstated

Analysts at the U.S. Environmental Protection Agency (EPA) have recommended that extremely low frequency (ELF) electromagnetic fields (EMFs) be classified as "probable human carcinogens." Their recommendation was based on a two-year review of the health effects literature—primarily epidemiological studies.

By designating ELF EMFs as probable human carcinogens,* the EPA staff put them in a general class with PCBs, DDT and formaldehyde (see table, p.9).

The EPA staff also recommended that radiofrequency and microwave (RF/MW) radiation be designated as a "possible" carcinogen—in a class with saccharin.

Dr. William Farland, director of EPA's Office of Health and Environmental Assessment (OHEA), which prepared the report, ordered the ELF recommendation deleted in mid-March because of the absence of both a mechanism of interaction and an observed dose-response relationship. The RF/MW classification was also removed.

The document, *An Evaluation of the Potential Carcinogenicity of Electromagnetic Fields*, will now be issued without risk classifications, although it nonetheless concludes that ELF studies of leukemia, lymphoma and cancer of the nervous system among children and workers "show a consistent pattern of response that suggests, but does not prove, a causal link." (The complete text of the report's Summary and Conclusions appears on pp.11-15.)

(continued on p.9)

EPA's Original Conclusion: 60 Hz EMFs are 'B1' Carcinogens

As late as March 12, 1990, the paragraph below concluded the executive summary of the EPA report. A few days later, it was deleted.

"Concerning exposure to fields associated with 60 Hz electrical power distribution, the conclusion reached in this document is that such exposure is a 'probable' carcinogen risk factor, corresponding to a 'B1' degree of evidence that it is a risk factor. This conclusion is based on 'limited' evidence of carcinogenicity [in] humans which is supported by laboratory research indicating that the carcinogenic response observed in humans has a biological basis, although the precise mechanisms [are] only vaguely understood."

« Power Line Talk »

Woman's Day has encouraged its large readership to write to EPA Administrator William Reilly to reinstate the agency's research effort on EMF hazards. In fact, it went so far as to include a clip-and-mail coupon, addressed to Reilly, in its May 22 article, "Should You Be Worried About Electricity?" By the end of the month, EPA had received over 400 letters—not just coupons. After Dan Rather put the EPA cancer report (see p.1) at the top of the *CBS Evening News* on May 21 and the Associated Press and the *New York Times* followed up with their own stories, EPA's radiation office was deluged with calls—a few hundred a day, according to one senior EPA official. A couple of days later, the head of EPRI went to talk to Reilly about EMFs (see p.10). Even without all the publicity, Reilly had to be personally aware of EMFs. He and his family live in Old Town Alexandria, VA, two blocks from neighbors who are pressuring Virginia Power to reduce ambient magnetic fields from distribution lines—a controversy featured on ABC's *Nightline* (see *MWN*, J/F90 and M/A90). It's possible that even President Bush has now heard about EMFs: one of his sons and his family also live in Old Town.

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The Department of Energy (DOE) will transfer its long-term epidemiological research on ionizing radiation to the Department of Health and Human Services—following the recommendations of an independent advisory panel. The Secretarial Panel for the Evaluation of Epidemiologic Research Activities (SPEERA) was set up by DOE Secretary James Watkins in June 1989 to suggest ways of improving the credibility of the DOE's epidemiology program. In a March report, the panel called for the move in order to "restore public trust" and "assure independence of investigators." It noted that, "Because the department's role is to promote energy production, there is an inherent potential conflict between immediate production goals and health and safety goals." Indeed, some critics have long maintained that health-related studies do not belong in the DOE's domain. "It is...intolerable that the fox could have the exclusive right [or even the primary responsibility] for reporting on morbidity and mortality in the chicken coop," charged Dr. Jack Geiger of Physicians for Social Responsibility in the March 23 issue of *Science*. Among SPEERA's other recommendations are that health and safety work be consolidated within a newly-established DOE office of occupational health and that a policy of greater openness be instituted. The panel called for an additional \$15 million in funding and for the DOE to address "many questions about non-nuclear energy-related risks" (see *MWN*, J/F90). A SPEERA spokeswoman told us that EMFs are on the panel's list. Copies of the SPEERA report are available from: DOE, Public Inquiries Branch, PA-5, Washington, DC 20585, (202) 586-5575.

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After six months, the school board and some parents want to discontinue the yearlong magnetic field measurement program at Florida's Sandpiper Shores Elementary School—albeit for different reasons. Following a court order, teachers at the Boca Raton school have been sporting EMDEX meters since November to monitor exposures from high-voltage lines near the school (see *MWN*, N/D89). "We really feel that the program should be terminated," Abbey Hairston, counsel for the Palm Beach County School Board, told us, citing the consistently low readings—averaging under 2 mG—since the program began. "It's costing us a great deal of money," she said. For their part, three parents, who last year sued to close down the school (see *MWN*, J/A89), want the court to suspend the program until the "kinks" are worked out. In April, their lawyer, Larry Marraffino, took their concerns to the court. Marraffino suspects that Florida Power & Light is "redirecting power," which would explain why the "readings have been very low at Sandpiper, lower than those taken two years ago." After all, he explained, since that time, the demand for electricity in the area has increased. Marraffino told us that the parents are willing to compromise: "We would be happy to have the board let concerned parents send their children to the next nearest school"—where there are no nearby power lines.

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Dr. Granger Morgan of Carnegie Mellon University is taking heat from all sides over his critical review of Paul Brodeur's book, *Currents of Death*, which appeared in the April 1990 issue of *Scientific American*. On one side, Drs. Eleanor Adair and Robert Adair, in their own stinging critique, accuse Morgan of repeating some of the same scientific errors as Brodeur. In an as-yet-unpublished letter to *Scientific American*, the Adairs—mimicking Morgan's attack on Brodeur—charge that, "Morgan himself 'oversimplifies and misrep-

Paul Brodeur To Revisit EMF Issue in "The New Yorker"

Paul Brodeur will publish an update to his "Annals of Radiation" in the July 9 issue of *The New Yorker* magazine—on newsstands July 2. In this fourth feature-length installment on the hazards of EMFs, Brodeur will report on clusters of cancer, birth defects and other ailments among people living close to high-current power lines and electrical substations.

Brodeur published a three-part series on the health risks associated with power lines, radar and video display terminals (VDTs) in June 1989 (see *MWN*, M/J89). Last November, an expanded version of the *New Yorker* articles appeared in book form as *Currents of Death*.

resents...the scientific...evidence.' His description is as faulty as Brodeur's, and for the same reasons. And...his misrepresentations are even more harmful to society." The Adairs claim that many "senior scientists" believe that EMF effects are "not credible and that such effects verge on the impossible" and that the "electrophobia fed by Brodeur and Morgan has no better logical foundation than ESP or astrology." Adding to the fire, on June 5, New York City's *Village Voice* columnist James Ledbetter accuses both Morgan and *Scientific American* of omitting one key fact from the review: Morgan, who pats EPRI on the head for doing a "remarkably good job" in supporting unbiased high-quality EMF research, received a \$300,000 contract from EPRI in 1988.

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BC Hydro would do it again. Vice President Chris Boatman told Canadian television that, if the utility had a second chance, it would still offer to buy the homes of people living along its high-voltage power line on Vancouver Island (see *MWN*, M/J89 and J/A89)—in spite of the British Columbia Utilities Commission's opinion that BC Hydro had acted "imprudently." Over at Ontario Hydro, Paul Newall told the CBC that he thought BC Hydro had overreacted. Newall said that it is "not an action that Ontario Hydro would contemplate at this point in time." The exchange was featured on the April 16 segment of the CBC's *The Journal*. By the end of May, BC Hydro had purchased 55 properties and planned to buy three more (see *MWN*, S/O89 and N/D89), according to BC Hydro's Peter McMullan. Supporting Boatman's position, McMullan told us, "We made the right decision at the right time."

Prenatal Electric Blanket Use Linked to Childhood Cancer

Children whose mothers used electric blankets during pregnancy had higher risks of brain tumors and leukemia, according to Dr. David Savitz and colleagues at the University of North Carolina, Chapel Hill. This is the first study to link electromagnetic fields (EMFs) from electric blankets to the development of cancer.

In a paper published in the May 1990 issue of the *American Journal of Epidemiology* (131, pp.763-773), Savitz and coworkers Drs. Esther John and Robert Kleckner report that the incidence of brain tumors among the offspring increased by two-and-a-half times—a statistically significant finding. There was a 70% increase in leukemia and a 30% increase for all cancers.

These electric blanket results "are another reason to take the [EMF] issue more seriously," Savitz told *Microwave News* in a telephone interview. Overall, he said, "It's part of the same constellation of evidence pointing in the same direction."

Responding to critics who have argued that some as-yet-undetermined factor was responsible for the increases in childhood cancer observed in past epidemiological studies on power line EMFs, Savitz said that these new results involved "a different exposure with different confounders, so you can't invoke the factor 'X' as has been done with wire codes. The potential source of biases would be different." (For more on this debate, see *MWN*, N/D88 and J/F89.)

The team did not observe any increase in childhood cancer due to prenatal exposures from water beds or from bedside electric clocks.

For those women who used electric blankets during the first trimester of pregnancy, there was a statistically significant 400% increase in brain tumors among their children. But Savitz cautioned that these findings were based on only a small number of cases.

Postnatal electric blanket use by children was also linked

to a 50% increased risk of cancer. Here again, the number of cases was small. For acute lymphocytic leukemia, the increase was 90%—a "larger but imprecise association." Neither association was statistically significant.

The team concluded that, "It is noteworthy that the strongest evidence for positive associations was found for electric blankets, given the evidence that these devices are probably the home appliance with the greatest potential for producing elevated time-integrated exposures....electric blankets are associated with levels up to ten times background."

The new case-control study of the parents of 252 children with cancer was based on data collected in the New York Power Lines Project study of childhood cancer and power line EMFs (see *MWN*, N/D86 and J/A87).

Electric Blankets and Testicular Cancer

Electric blanket EMF exposure "contributes little, if at all," to higher risks of testicular cancer among adult white men, according to a paper appearing in the same issue of the *American Journal of Epidemiology* (pp.759-762).

A team of researchers led by Dr. Rene Verreault of the Fred Hutchinson Cancer Research Center in Seattle, WA, found a 40% increased risk of nonseminoma germ cell tumors—the finding was not statistically significant. They did not observe increases in seminoma. They did note that the risk of nonseminoma tumors increased somewhat with increasing duration of electric blanket use.

The team concluded that "chance remains a plausible explanation for the observation."

Call for Prospective Studies

In an editorial accompanying the Savitz and Verreault papers (pp.774-775), Dr. Richard Monson called for prospective epidemiological studies of EMFs that measure "current and future exposures in a precise and unbiased manner" and

"biologic outcome with precision, without error, and in a timely manner."

"I think there are enough scientific questions to warrant studies that collect data prospectively rather than retrospectively," Monson, of Harvard University's School of Public Health in Boston, MA, told *Microwave News*.

With respect to exposures from video display terminals (VDTs), Monson pointed out that, "Such studies are needed to assess the possible adverse effects of work with [VDTs] and pregnancy. It may seem unrealistic to attempt to assess prospectively the association between [VDT] use and specific birth defects, but is there any alternative?" He added that, "Prospective cohort studies that assess the association between occupational exposures to electromagnetic radiation and cancer may require thousands of study participants and decades of follow-up, but is there any alternative? Prospective cohort studies that assess prenatal and childhood exposure to electromagnetic radiation in relation to childhood cancer may indeed be unrealistic. The need in this context is to develop unbiased methods to assess past exposure."

Low Magnetic Field Electric Blankets Hit the U.S. Market

By the end of the year, at least two major U.S. electric blanket manufacturers will introduce low electromagnetic field (EMF) electric blankets.

Casco-Belton Corp. in Grover, NC, which markets its pro-

ducts under the brand name "Soft Heat," claims that its new wiring design reduces exposures from electric blankets to less than 1 mG. Northern Electric Co. in Chicago, IL, reports that the EMF exposures from its low field blankets and mattress pads—sold under the Sunbeam and Slumber Rest brand names—are reduced by 95%.

Citing the Food and Drug Administration's statement last year that there is no evidence that electric blankets are unsafe (see *MWN*, M/A89), Northern Electric President Ray Mehra said that, "The consensus in the scientific community is that there is no scientifically documented illness that is caused by the electric and/or magnetic fields." But he added that his company decided to "respond to what we anticipate may be a growing demand for low EMF appliances."

David Brantley, product manager at Casco-Belton, said that, "We were prompted by the fact that eventually this issue would become important."

Fears of liability rather than consumer pressures may have been responsible for the marketing move, according to one company spokesman. Indeed, Fieldcrest Cannon, the third major U.S. manufacturer, referred all EMF calls to its attorney, who refused to comment on the company's proposed low field bed products.

Brantley said that Casco-Belton's low field blanket will sell for approximately \$18.00; the standard model retails for about \$16.00. Brantley added that the company anticipates phasing out the standard version over the next 12-18 months. Northern Electric's low field blankets will cost 10% more than their standard models.

More on Sleeping with EMFs

- A prospective epidemiological study of fetal growth retardation and EMFs—from electrically heated beds, among other sources—is now under way at the Yale University School of Medicine in New Haven, CT (see *MWN*, J/A88). The \$1.9 million study, which also covers miscarriages, includes direct measurements of EMF levels in the participants' homes. Yale's Dr. Michael Bracken, the principal investigator, told *Microwave News* that he expects results in 1993. The sponsors are the Electric Power Research Institute and the National Institutes of Health.

- Drs. Keith Florig and James Hoburg survey electric blanket magnetic fields in a paper appearing in the April 1990 *Health Physics* (58, pp.493-502). Florig was, and Hoburg is, at Carnegie Mellon University in Pittsburgh, PA. Using computer models, they estimated that average exposures over the whole body range from 1.5 to 3.3 μ T (15 to 33 mG), with a typical value of 2.2 μ T (22 mG). In particular, they report that whole-body exposures for children are "significantly greater than those for adults." They point out that all U.S. blanket manufacturers recommend that children not use electric blankets, but they note that this warning is often ignored.

- Australians who use electric blankets may be exposed to significantly lower levels of ELF magnetic fields than electric blanket users in the U.S., according to Dr. Vincent Delpizzo of the Australian Radiation Laboratory in Victoria. He notes that Australians use electric *under*blankets, which operate at 240 V, between

the mattress and the bottom sheet. These blankets expose users to average fields of approximately 2 mG, 1.5 mG or 0.5 mG (high, medium and low settings, respectively). U.S. electric blankets, which operate at 120 V and are designed to be used above the top sheet, expose users to average levels of about 5.6 mG. With regard to water beds, Delpizzo notes that they generate higher field levels, 4-5 mG, but only a small proportion of his study group reported using them. See *Radiation Protection in Australia*, 7, pp.67-69, 1989.

- The Electromagnetic Energy Policy Alliance (EPPA) has issued a fact sheet, "Automatic Electric Blankets—Comfort and Value Through Electromagnetic Energy." The four-page pamphlet points out that typical electric blanket magnetic fields are 3-50 mG, considerably below the IRPA ELF guideline of 1,000 mG, and that "the overall body exposure is similar to that generally prevailing throughout the home." It concludes: "...EPPA sees no reason to advise consumers to lose the well-established and valuable benefits which electric blankets provide."

- Some conflicting views on electric blankets were quoted in the *Boston Globe* (December 18, 1989): Dr. Robert Adair, a physicist at Yale University, stated that, "If you followed equal prudence about everything one did in life you'd stay in bed forever, or you'd starve to death because you could eat nothing." Dr. David Carpenter of the New York Department of Health said that he "absolutely" would not buy an electric blanket or let his child use one.

Congressional Moves for More EMF Research

Two new proposals introduced in Congress would provide funds for research on electromagnetic field (EMF) health effects at the Department of Energy (DOE) and the Environmental Protection Agency (EPA).

On May 10, Congressman Frank Pallone (D-NJ) introduced the "Electric and Magnetic Field Research and Public Information Dissemination Act of 1990," H.R.4801. Its key provisions are:

- The DOE would receive \$34 million over five years for EMF research. The amount would increase each year, peaking at \$10 million in fiscal year (FY) 1995.
- At least \$1 million of the new funds would be spent each year on an EMF information center for public education.
- The DOE would investigate alternative electricity distribution systems designed to reduce EMF exposures.
- An advisory committee—made up of representatives of federal and state governments, utilities, public interest groups and academia—would review studies and recommend research priorities. The committee would issue an annual report.
- The DOE would consult with EPA and the National Institute of Environmental Health Sciences (NIEHS) in developing and implementing the EMF program.

Pallone also plans to introduce a separate bill in June that would establish exposure limits along transmission line right-of-ways (see *MWN*, M/A90).

On another front, Congressman George Brown (D-CA) is sponsoring an amendment to EPA's annual authorization bill

EPRI Sponsors \$1.6 Million Mouse-Lymphoma Study

The Electric Power Research Institute (EPRI) has awarded Dr. Takashi Makinodan of the University of California, Los Angeles (UCLA), \$1.6 million for a five-year study of lymphoma in mice chronically exposed to ELF magnetic fields. A pilot study is already under way.

The objective of the study is to determine whether magnetic fields are carcinogens, cocarcinogens or cancer promoters, Makinodan told *Microwave News*. Makinodan is a professor of medicine at UCLA and a codirector of geriatric research at the Los Angeles VA Medical Center. Ionizing radiation will be used as the initiator. The mice will be exposed to magnetic fields of less than 1 mG, 100 mG or 10 G, either alone or with low or high doses of gamma rays.

Similar efforts to develop an animal model of EMF carcinogenesis are under way in Sweden and in Canada (see *MWN*, M/J87 and J/A89).

DOE and EPRI EMF Reviews

The annual review of research on the bioeffects of ELF electromagnetic fields (EMFs) sponsored by the Department of Energy (DOE) will be held November 4-8 in Denver, CO. The Electric Power Research Institute (EPRI) will hold its annual utility seminar October 16-19 in Austin, TX.

For the first time in many years, EPRI will not be a sponsor of the DOE meeting (see *MWN*, N/D89). The American Public Power Association and the Edison Electric Institute will continue their support, however.

As in the past, the DOE meeting is open to the public and there is no registration fee. For more information, contact: W/L Associates, 120 W. Church St., Frederick, MD 21701, (301) 663-1915.

This year's EPRI seminar is titled "New EMF Epidemiologic Results & Their Implications." Registration fees range from \$150.00 for EPRI members, government officials and university researchers to \$1,000.00 for others. For more information, contact: Robert Banks Associates, Attn: EPRI Utility Seminar, PO Box 14574, Minneapolis, MN 55414, (612) 623-4646.

that would allocate \$5 million for EMF research—\$1 million in FY91 and \$2 million in FY92 and in FY93. Like the Pallone bill, the measure would require EPA to educate the public on EMF issues and work with the DOE and the NIEHS.

The amendment has been approved by the Committee on Science, Space and Technology and must now pass the full House. It must also win approval in the Senate.

Three States Plan Magnetic Field Mitigation Studies

Plans are under way in three states to study ways of reducing electromagnetic fields (EMFs) from high-voltage power lines.

In Washington state, the Department of Health (DOH) is leading a task force charged with investigating EMF mitigation techniques and their feasibility. The task force was mandated by a state law, enacted in March, which appropriated \$40,000 for the two-year project; an earlier version of the bill called for a \$100,000 budget.

The DOH has been designated by a second law (also passed in March) as the "state radiation control agency," responsible for collecting and disseminating information on non-ionizing radiation, particularly EMFs.

In Florida, the Environmental Regulatory Commission has appointed an independent EMF Task Force to lead a two-year, \$1 million survey of magnetic field mitigation methods and costs. The seven-member task force, which began meet-

ing in January, has not yet decided how to spend the money, Jack Buford, the task force chairman, told *Microwave News*.

In April, Ken Klein, formerly of the Department of Energy and now a consultant, was hired as the project manager. Among the members of the task force is Sharon Rausch, one of three Boca Raton, FL, parents who filed suit to close a school near high-voltage power lines (see p.2). The project, which is being funded by the Florida Electric Power Coordinating Group, is an outgrowth of the state's magnetic field rules proceedings last year (see *MWN*, M/A89).

In New York, the Empire State Electric Energy Research Corporation (ESEERCO), a consortium of NY utilities, is soliciting proposals for methods of reducing power line magnetic fields. The successful bidder will characterize significant sources of EMFs and estimate the economic, environmental and social impacts of potential mitigation approaches.

In April 1988, the state Public Service Commission (PSC), following the recommendations of a staff task force, ordered NY utilities to survey power line magnetic fields and investigate ways of minimizing exposures (see *MWN*, M/A88 and M/J88). Utility representatives presented the survey results at a July 26, 1989 technical conference in Albany, NY (see *MWN*, M/A89 and J/A89). In April 1990, the PSC proposed an interim magnetic field standard of 200 mG for new high-voltage line right-of-ways (see *MWN*, M/A90).

The Electric Power Research Institute reported in 1988 that magnetic fields can be reduced by as much as 50% by changing the phasing of the lines (see *MWN*, J/F89).

Two New Low-Cost Meters

Two new inexpensive ELF magnetic field meters are now available. These complement the growing number of gaussmeters and dosimeters that have come on the market in the last two years. (For a complete list, see *MWN*, J/F90.)

Karl Riley of Magnetic Sciences International has developed MAG CHECK, a sensor which, he says, is similar to Electric Field Measurements' Model 116, designed by Dr. Don Deno. The unit, which costs \$42.00, plugs into any digital multimeter with a 200 mV AC scale. Riley also offers a combined sensor-multimeter, the MSI-20, for \$119.00. Both respond to magnetic fields from 0.1 mG to 200+ G in the 40-400 Hz frequency band. For more information, contact: Magnetic Sciences International, 2425 B Channing Way, Suite 489, Berkeley, CA 94704. Riley can be reached at RFD Box 312, Vineyard Haven, MA 02568, (508) 693-3188.

Widerange Instruments is marketing the MAGAL-ERT model 660. The meter, which costs \$84.50, is a small hand-held unit that gives readings from 0.1 to 100 mG. For more information, contact: George Work, Widerange Instruments, 110 Shelter Lagoon, Santa Cruz, CA 95060, (408) 423-1983.

HIGHLIGHTS

U.S. Army Performance on EMP Safety Faulted

An investigation by *Potomac News* into the U.S. Army's record on electromagnetic pulse (EMP) safety has uncovered a long history of ignoring federal environmental regulations and harassing those who pressed for compliance at the Army's Woodbridge Research Facility (WRF) in Virginia.

In a five-part series published in the April 9-13, 1990 *Potomac News*, a Prince William, VA, county newspaper, Gary Craig and Kevin Carmody describe how two Army environmental officials—Dr. Conner Gibson and John Ganz—were allegedly marked as whistle-blowers by the military, thus effectively destroying their careers.

From 1971 to 1988, the Army operated EMP simulators at the WRF, including the Army EMP Simulator Operations (AESOP) and the Repetitive EMP Simulator (REP). During this time, the Army planned to build a more powerful pulser—the Vertical EMP Simulator II (VEMPS II)—similar to the U.S. Navy's EMPRESS II (see box on p.7).

In documents obtained by *Potomac News* and made avail-

able to *Microwave News*, Craig and Carmody show how the Army neglected the EMP threat to health and safety and resisted reform:

- Three years after the Navy began work on an environmental impact statement (EIS) for EMPRESS II, the Army sought to avoid preparing a similar analysis for its proposed VEMPS II, because the pulser's operation would be "environmentally insignificant," according to a February 13, 1987 Army memo. This opinion came one month before the Washington, DC-based Foundation on Economic Trends (FET) sued the Department of Defense (DOD) to require environmental assessments for its EMP simulators (see *MWN*, M/A87). As part of a May 1988 agreement to settle the suit, the DOD shut down many of its EMP simulators—including those at Woodbridge (see *MWN*, M/J88).
- The belief that operating the WRF EMP simulators at full power caused no significant environmental impact was "consistent with 'gut' feelings," according to a June 1988 Army memo, which conceded that very little information was available. The Army expressed concern that operating at reduced

power "implies past operations [were] 'dangerous/reckless'." The Army also noted that the question of interference with "fly-by-wire" systems aboard aircraft was unresolved.

- The Army "continually stonewalled the issue of safety in fly-by-wire aircraft operations" (e.g., the Airbus 310 and the Boeing 757 and 767), John Ganz wrote in an April 14, 1989 letter to Senator Carl Levin (D-MI). Ganz claimed that the DOD blocked an FET subpoena because his testimony would be "most damaging" to the Army's case. Ganz said that he and Gibson, his supervisor, were branded as whistle-blowers and were held responsible for the closing down of the EMP programs. A federal investigation into these allegations is under way.

- Following the March 1989 airing of a CBS-TV *60 Minutes* segment on an EMP health effects lawsuit (see *MWN*, J/A88 and N/D88), Ganz lost his supervisory position. When he complained to the Army Inspector General, he was cross-examined about his loyalty to his country and given a polygraph test—which he passed. Gibson was dismissed by the Army in May 1989 and died of a heart attack shortly thereafter.

- Even while the EMP shutdown was in force, the Army sought to run a "free field" EMP test using a suitcase pulser at Fort Belvoir, VA. The proposed test was criticized by an attorney in the Army's Office of the Judge Advocate General in a November 3, 1988 memo: "On a statutory and regulatory basis, it is clear that free field EMP simulation requires an environmental assessment at a minimum. EMP testing is extremely controversial and reliable scientific data has yet to be established."

- The Army's claims to have complied with federal environmental rules were "a total vulgar fabrication," as well as "pathetic" and "totally indefensible," according to Gibson. Commenting on an Army public relations response to a May 10, 1988 *Washington Post* article on the FET's EMP lawsuit (see *MWN*, M/J88), Gibson said that, contrary to the Army's assertions, there were reports dating back to 1973 showing "serious documented concerns" with respect to the Army's compliance with environmental laws. In January 1989, the Army announced that it would prepare an EIS on EMP before resuming testing at Woodbridge. But six months later, the Army decided that it would no longer operate the simulators at Woodbridge and released an environmental assessment which did not address EMP (see *MWN*, J/F89 and J/A89).

- EMP testing at Woodbridge prompted community opposition—the WRF is located near residential neighborhoods and schools. In an August 1, 1989 letter to the Army, County Executive Robert Noe Jr. wrote that, "Prince William County officials have serious concerns over the human health and environmental impacts of the [EMP] testing that was conducted by the Army" and that the "Army has a responsibility to participate on a long-term basis in the evaluation of any human health impacts that may become evident in the future...." Craig reports that the Army is considering doing an epidemiological study of the WRF workers and that the Virginia Council on the Environment has suggested a similar study of Woodbridge residents.

In a response appearing in the May 11, 1990 *Potomac News*, an Army spokeswoman said that, "There were so many errors in fact in the articles that to attempt to correct them would result in another series of articles...."

A copy of the five-part series is available for \$5.00 from: Barry Loftus, *Potomac News*, 14010 Smoketown Rd., Woodbridge, VA 22192, (703) 670-8151.

Navy Issues Draft EIS for EMPRESS II in Gulf of Mexico

The U.S. Navy has issued another draft environmental impact statement (DEIS) for its Electromagnetic Pulse Radiation Environment Simulator for Ships (EMPRESS II)—this one for operation in the Gulf of Mexico.

The Navy has evaluated four sites for EMPRESS II in this DEIS, each more than 25 miles offshore. The EMP simulator will be used in the gulf for approximately 60 days a year during the months of November through April (see *MWN*, J/A89). For the other six months, EMPRESS II is used in the Atlantic Ocean off the coast of North Carolina (see *MWN*, J/A88).

The Navy foresees electromagnetic interference to electronics as the only serious impact. To protect marine and aircraft electronics, the Navy will set up an air and surface exclusion zone with a height of 6,000 feet and a two-mile radius. With respect to human health, the Navy "will ensure that personnel aboard the ships under test will receive EMP intensities of no more than 50 kV/m."

This is the fourth EIS or DEIS the Navy has issued for EMPRESS II (see *MWN*, N/84, J/F87 and M/J88).

Three public hearings on the DEIS were held in Alabama and Mississippi during the first week of May. For more information, contact: Lt. James Rose, Naval Sea Systems Command (PMS-423), Washington, DC 20362, (202) 746-1386.

USAF Seeks NAS-NRC Study on VLF Bioeffects from GWEN

The U.S. Air Force (USAF) has asked the National Research Council (NRC), an arm of the National Academy of Sciences, to review the potential health effects of very low frequency (VLF) radiation from the USAF's Ground Wave Emergency Network (GWEN). The move came in response to concerns expressed by Congressmen Lewis Payne (D-VA) and Les Aspin (D-WI).

The USAF's proposal is still "under review," Dr. Ray Cooper of the NRC's Board on Radiation Effects Research

HIGHLIGHTS

told *Microwave News*. The final decision will be made by the Executive Committee of the NRC when it meets on June 13. If accepted, Cooper said that the report would take at least a year to complete.

The USAF's formal request came in a March 6 letter from Lt. Col. Stephen Martin, GWEN's program manager at the Electronic Systems Division at Hanscom Air Force Base, MA. Martin asked the NRC to answer a series of questions on GWEN radiation health risks, especially cancer.

In a telephone interview, Cooper cautioned that, "Some of the questions that the USAF wants answered may not be answerable with the present scientific data."

The GWEN communications system is designed to withstand the electromagnetic pulse (EMP) from a nuclear attack. When completed, it will consist of 96 relay towers across the continental U.S. operating at 150-175 kHz. The peak broadcast power for each GWEN tower is from 2-3 kW; it typically transmits six seconds per hour.

Payne's request for a review followed growing community opposition to plans to build a GWEN tower in his district. According to the *Washington Post* (December 27, 1989), a well-attended town meeting in Lovingsston, VA, heard Dr. Stephen Cleary of the Medical College of Virginia in Richmond say that "there is enough information available in the literature [on health effects] to concern people."

For his part, Aspin, the chairman of the House Armed Services Committee, cited the need to update the USAF's final environmental impact statement on GWEN, issued in late 1987 (see *MWN*, N/D87).

Aside from concern over its potential health effects, there is also mounting opposition to GWEN from those who question its cost and utility at a time of reduced risk of nuclear at-

tack. On February 27, Congressman Ron Machtley (R-RI) introduced H.R.4118, which would cut off funding for GWEN. Machtley's bill has gained the support of 13 cosponsors. Senator Claiborne Pell (D-RI) has introduced an identical bill, S.2257, in the Senate.

Nancy Foster, the director of the Amherst, MA-based GWEN Project, which opposes the program, told *Microwave News* that given the "dramatic changes in the world, GWEN should be a prime candidate for any list of Department of Defense budget cuts."

In an effort to defuse concerns about radiation, the USAF set a VLF radiation exposure standard of 50 V/m for publicly accessible areas around GWEN sites (see *MWN*, J/F86). The USAF's standard for its own personnel is 614 V/m.

Vote on Revision of 1982 ANSI RF/MW Safety Standard

Voting is in progress on the final draft of the proposed revision of the American National Standards Institute (ANSI) 1982 safety standard for human exposures to radiofrequency and microwave (RF/MW) radiation. Results of the subcommittee ballot are expected to be announced at a June 9 meeting in San Antonio, TX.

If approved, the proposed standard—designated ANSI C95.1-1990—will go before the IEEE's Committee SCC28 on Non-Ionizing Radiation Hazards for a vote.

In the previous vote, 50 subcommittee members approved the draft, 16 rejected it and 5 abstained. Most of those from federal health agencies voted against the draft. (For more on the proposed revision, see *MWN*, M/A89 and S/O89.)

Przemyslaw A. Czerski (1928-1990)

Dr. Przemyslaw Czerski died of cancer on Sunday, April 15, 1990 in Silver Spring, MD.

Born in Poland, Czerski earned his PhD and MD degrees at the Warsaw Medical Academy. In 1958 he joined the Military Institute of Aviation Medicine. Fifteen years later he became the chairman of the Department of Genetics at the National Research Institute of Mother and Child in Warsaw. In 1981, Czerski came to the United States to work at the Food and Drug Administration's (FDA) Center for Devices and Radiological Health in Rockville, MD.

Czerski's early research was on the hematologic and genetic effects of microwave radiation. He played an important role in setting up one of the first major symposia on microwave bioeffects in Warsaw in 1973. Together with Dr. Stanislaw Baranski, he wrote *Biological Effects of Microwaves* in 1976. At the FDA, he continued his research on the genetic effects of non-ionizing electromagnetic ra-

diation (NIER) at both high and low frequencies. Czerski authored more than 150 publications.

Czerski is perhaps best known for his contributions to the international research community. He encouraged the World Health Organization to initiate NIER programs, first in Copenhagen, then in Geneva. These, in turn, led to the formation in 1977 of the International Non-Ionizing Radiation Committee (INIRC) within the International Radiation Protection Association (IRPA). Czerski was a founding member of INIRC and remained active on the committee until his death. In 1989, the FDA awarded him a commendation for his work.

Czerski is survived by his wife, Ewa, and their two daughters. Dr. Ewa Czerska continues to work at the FDA on NIER biological effects.

Over the years, Czerski made many contributions to *Microwave News*. We will miss him.

The decision on whether to apply EPA's risk assessment guidelines—originally developed for chemical carcinogens—to EMFs will now be made by two independent scientific review groups this summer.

Whatever the outcome, the EMF issue has gone from relative obscurity to national prominence. The question of how to deal with EMFs is now being debated at the highest levels of the Bush Administration and in the halls of Congress.

Regulatory strategies have not yet been formulated, but there is virtually unanimous agreement that a major federal research effort is needed to resolve the uncertainties associated with EMF health risks. It appears almost certain that EPA will resurrect its EMF research effort, which was shut down in 1986 (see *MWN*, S/O85).

A Meeting at the White House

In early 1990, after the OHEA staff made its recommendations and as its report neared completion, briefings were held for senior members of the EPA staff, including Deputy Administrator Henry Habicht II.

On March 6, a group of EPA officials briefed the White House Office of Policy Development. Among those attending the meeting were: Teresa Gorman, associate director of policy development for environment, energy and natural resources; Dr. James Wyngaarden, associate director for life sciences at the White House Office of Science and Technology Policy (OSTP); Richard Guimond, director of EPA's Office of Radiation Programs (ORP); and OHEA's Farland. Also present were representatives of EPA Administrator William Reilly, the Department of Energy (DOE), the Centers for Disease Control (CDC) and the National Cancer Institute (NCI).

Several sources characterized the meeting as an "information exchange." A staffer in Reilly's office told *Microwave News* that "it's not unusual" for EPA to advise the White House in memos or briefings about a significant issue. Gorman was unavailable for comment.

At a congressional hearing on power line health risks held by Rep. Peter Kostmayer (D-PA) just two days after the White

House meeting, representatives from the DOE and EPA did not reveal that a major policy change was under discussion (see *MWN*, M/A90).

As late as March 12, the EPA evaluation recommended classifying ELF EMFs as "Class B1—probable human carcinogens." Within a week, the designation was deleted.

EMFs Pass the "Duck Test"

EPA insiders told *Microwave News* that the deletion of the B1 designation[†] for ELF EMFs was a compromise between the staff's recommendation and Farland's proposal to classify EMFs as "Class C—possible human carcinogens."

In a telephone interview, Farland explained that he personally deleted the B1 designation because "it was not appropriate at this time to classify EMFs as a carcinogen as we have classified other chemicals."

Farland said that he will ask two committees of experts—an external review panel and EPA's Scientific Advisory Board (SAB)—each to decide how to resolve the issue of risk classification.

Asked whether a chemical agent with the same carcinogenicity data as ELF EMFs would have been classified as B1, Farland replied: "I would still have some concerns classifying it as a probable human carcinogen if I really did not understand how it was working."

"The kind of information we have is enough for me to say that there is something going on and that the epidemiological data should not be dismissed," he said. "On the other hand, there is not enough to cause undue alarm. We need additional research."

Rep. Kostmayer urged EPA not to shy away from a cancer risk designation. In an April 25 letter to Reilly, Kostmayer wrote, "There can be no doubt that power line EMFs have passed the 'duck test': If it acts like a potential carcinogen, it must be addressed as a potential carcinogen." He stressed that, "The technical reasons given by EPA for not formally classifying power line EMFs as a 'potential carcinogen' may have merit, but for the purpose of protecting American citizens the distinction is moot."

Potential Carcinogens: EPA "Weight-of-Evidence" Classification and Hazard Ranking

Class A: Human Carcinogen

Arsenic (H)
Asbestos (H)
Benzene (M)
Diethylstilbestrol (H)
Vinyl chloride (H)

Class B: Probable Human Carcinogen

B1: Limited Epidemiologic Evidence
Acrylonitrile (M)
Cadmium (M)
Creosote (H)
Ethylene oxide (M)
Formaldehyde (M)

B2: Sufficient Animal Evidence
Beryllium (M)
Carbon tetrachloride (M)
DDT (M)
PCBs (M)
Dioxin (H)

Class C: Possible Human Carcinogen

Methyl Chloride (L)
Saccharin (L)
Trichloroethane (L)

Hazard Ranking: (H)=High; (M)=Medium; (L)=Low. Source: Office of Health and Environmental Assessment, EPA, June 1988.

The management of EMF risks will fall on EPA's ORP. Marty Halper, ORP's division director with responsibility for non-ionizing electromagnetic radiation (NIER), told *Microwave News* that EPA would not respond any differently whether the designation were A, B1 or C. Referring to siting battles over new power lines and radars across the U.S., he said, "The public is already extensively regulating EMFs: the net cost to society of EPA regulations may be less than what we are paying now."

Indeed, speaking at a conference in Cleveland, OH, at the end of April, ORP's Dr. Doreen Hill said that EPA is "swamped" with requests for EMF information from the public (see p.2).

"You can no longer say there are no biological effects due to ELF EMFs," Halper said. "But I can't say what the public health implications are. We're not talking about a radon in terms of potency, but we're also not talking about a zero effect."

RF/MW Radiation: A "Possible" Carcinogen

The OHEA report grew out of EPA's plan to issue rules for human exposures to RF/MW radiation (see *MWN*, J/A86). In 1986, EPA decided there was a need for an independent evaluation of the results of the long-term exposure study led by Dr. Bill Guy of the University of Washington, Seattle, which indicated an increase in cancer among rats chronically exposed to non-thermal doses of RF/MW radiation (see *MWN*, J/A84 and Mr85).

In the March 12 version of the OHEA report, the EPA staff recommended that RF/MW radiation be designated as a Class C carcinogen:

For modulated non-thermal RF radiation, the human evidence is inadequate and the animal evidence is 'limited' based on the finding of a field-induced increase in the incidence of carcinomas of all sites in rats in an experiment that produced minimal tissue heating. Therefore, the evidence of carcinogenicity for non-thermal modulated RF radiation dictates a classification as a 'possible,' or Class C, carcinogen. In this case it is not called a carcinogen risk factor since the radiation treatment alone induced the effects without an additional factor in the experiment protocol.

This conclusion was also deleted from the review draft.

In an interview, ORP's Halper said that, "I am not ready to say we don't have concern outside the ELF area. We don't have the data." He emphasized that the document addresses all NIER. "We're being very careful to talk about NIER, not just ELF," he said.

* In 1986, EPA issued guidelines to assist in ranking suspected carcinogens in a consistent manner. There are five categories: "Human Carcinogens" (Group A), "Probable Human Carcinogens" (B), "Possible Human Carcinogens" (C), "Not Classifiable as to Human Carcinogenicity" (D) and "Evidence of Non-Carcinogenicity for Humans" (E).

† Chemicals which have been rated as probable human carcinogens on the basis of animal bioassays are designated as Subgroup B2. When the classification is based on human epidemiological studies—as in the case of ELF EMFs—a B1 designation is used.

EPRI CEO Goes to Washington To Talk EMFs

Dr. Richard Balzhiser, the president and chief executive officer (CEO) of the Electric Power Research Institute (EPRI), was in Washington at the end of May to talk to senior governmental officials about electromagnetic fields (EMFs).

On May 23, Balzhiser met with Dr. James Wyngaarden, associate director for life sciences at the White House Office of Science and Technology Policy (OSTP). Two days later, Balzhiser, accompanied by EPRI Vice President Dr. George Hidy, the director of the institute's environment division, met with EPA Administrator William Reilly and his staff. While in Washington, Balzhiser also spoke to officials at the National Academy of Sciences.

"Balzhiser wants to encourage as many agencies as possible to initiate work on EMFs on their own in order to have a broad scientific research program," EPRI's Barbara Klein told *Microwave News*. "We don't want to be the only players." Klein noted that Balzhiser and Hidy also had other energy-related issues on their agendas.

Dr. Robert McGaughy, project manager for the OHEA report, told *Microwave News* that the document "only addresses cancer and not central nervous system or reproductive effects."

Review Schedule

In an unprecedented move, Farland has decided to release a draft of the document to the public in June, before it is reviewed by EMF experts outside of the agency. "There is enough interest in the document to warrant its early release," he said. As a result, many federal agencies with responsibilities for EMFs will first see the document at the same time as the public.

In late May, EPA sent letters to potential reviewers seeking their participation: McGaughy said that he plans to assemble six to eight experts. This external review panel is scheduled to meet in Research Triangle Park, NC, at the end of June to discuss the draft document.

Following the March 6 White House meeting, the representatives from the DOE, NCI and CDC requested and received copies of the OHEA draft report. Each has already submitted comments to EPA. Informed sources told *Microwave News* that the NCI was critical of the EPA effort. The White House did not submit comments.

Sources said that the DOE distributed dozens of copies of the OHEA review to its staff and to its contractors.

After the external review is completed and the document is revised, it will go to the SAB Radiation Advisory Committee. Originally, EPA planned to make the draft public at that

time.

Whether the external review panel or the SAB will reinstate the B1 classification is not known. But the SAB is already firmly on record as favoring an EPA research program on EMFs.

In a May 4 letter to Administrator Reilly, Drs. Oddvar Nygaard and Raymond Loehr, the chairmen, respectively, of the SAB Radiation Advisory Committee and the SAB Executive Committee, argued that EPA should take an aggressive role in EMF policy. "The [SAB] continues to urge the agency to undertake a leadership role in this complex and important area," they wrote. "There is enough substance to the science in this area to require your attention." In 1988, the SAB wrote to then EPA Administrator Lee Thomas advising that the agency take an active role in NIER bioeffects research (see *MWN*, S/O88).

Specific plans for EMF research remain unclear. Farland

told *Microwave News* that, "At this point there is an initiative in the several-million-dollar range," adding that most of the work would be done outside EPA. But other EPA officials said that no more than \$2 million will be allocated for EMFs and new research may not begin until October 1991—that is, the 1992 fiscal year. They added that there continues to be resistance within EPA to resuming an in-house research effort.

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FROM THE FIELD

Summary and Conclusions of EPA's EMF Cancer Report

Reprinted below are the "Summary and Conclusions" of the Environmental Protection Agency's (EPA) draft report, An Evaluation of the Potential Carcinogenicity of Electromagnetic Fields (EMFs). This summary, dated June 1990, will accompany the draft of the report which will be distributed to the external review panel, assembled by EPA.

7.1. Introduction

In this chapter each of the major chapters in the document are summarized; a final section presents a discussion of the relationships among the individual chapters and the overall conclusions.

7.2. Mechanisms of Interaction Between Tissue and EMFs

The basic processes by which energy from EMFs of RF and ELF frequencies is coupled to the body are described in this section. The frequency dependence of the RF power absorbed by an organism is dominated by the body size, so that mice, rats and humans have different RF absorption characteristics. For ELF fields and the lower RF frequencies near the source, the relationship between the electric and magnetic fields is not fixed, as it is for RF fields, and they are evaluated separately in this document. From the point of view of EMFs, the body is composed of a solution of ions; it is an electrical conductor and the penetration of electric fields into the body is very poor at ELF frequencies. Since the body is composed of nonmagnetic materials, an external time-varying magnetic field permeates the body, inducing ionic currents.

The human evidence, as described in the next section, suggests that magnetic fields rather than electric fields are associated with cancer incidence, and mechanisms have been sought to explain how weak currents induced by ELF magnetic fields could interact with cells and body tissue in such a way as to induce a carcinogenic response. Three classes of models for this interaction are reviewed: (1) The surface compartment model deals with the movement of ions towards and away from the inner and outer surfaces of the plasma membrane of the cell, and deals with ion-selective membrane channels, ionic pumps and membrane ion fluxes. The model describes the movement of ions in response to perturbations of electric fields and magnetically induced currents around the cell. (2) The ion cyclotron resonance hypothesis was developed in part to explain the frequency sensitivity of calcium ion efflux studies of brain tissues. If the rela-

tionship among the frequency of time-varying magnetic field, the strength of a parallel static magnetic field and the ionic charge to mass ratio of an ionic species is correct, then the ion will resonate, or synchronously follow circular paths in a plane perpendicular to the field. In one experiment demonstrating this effect, conditions were set up for calcium cyclotron resonance, and the movement of benthic diatoms was measured. The experiment showed that calcium ions entered into the cell under these specific conditions and stimulated the motion of the cells, whereas the cell is normally impermeable to calcium. This type of mechanism could be the basis of an induced selective ion permeability of the plasma membrane and might ultimately be capable of explaining both frequency selectivity of these effects and the sensitivity to small induced currents. (3) Another class of models deals with cooperative motions of an ordered array of lipid bilayer molecules and describes how a weak field affecting the motion of the whole array could be transferred to just one site in the array. These theories have not yet been tested in the context of ELF biological processes. At the present time, these basic models of tissue interaction with EMFs cannot be linked to the biochemical or cellular processes involved in the development of malignant growth.

7.3. Human Evidence

The effects of human exposure to EMFs from several sources have been reported. This document discusses ELF fields separately from higher frequency exposure where possible. Children with residential exposure are more appropriate subjects than adults for evaluating the effects of ELF fields, since children have relatively little exposure to higher frequency fields and occupational chemicals as a consequence of their normal activity patterns. Consequently, studies of childhood cancer associated with residential exposure to 60 Hz power frequency fields are discussed separately from occupational exposure to adults, which involves a mixture of both ELF and RF

fields.

7.3.1. Studies of Children: There have been six case-control studies of cancer in children examining residential exposure from power transmission and distribution systems and two additional studies examining childhood cancer in relationship to fathers' occupations. Five of the six residential exposure studies showed positive associations with ELF field exposure; three were statistically significant and the other two had odds ratios greater than one but not statistically significant. Where different cancer sites were evaluated, leukemia, nervous system cancer and, to a lesser extent, lymphoma were found to be in excess in the five residential studies showing positive associations. (Electric fields are not believed to be a critical factor.) The measure of magnetic field exposure was variable in the six studies. Wire code configurations and proximity to distribution lines were used for five of the six studies, and measurements were taken in two of the six studies. There is a good, but not perfect, correlation between measured magnetic fields and wire code configurations. In two of the studies in which magnetic field measurements were made, cases were observed in those exposed above 2-3 mG (0.2-0.3 μ T) but not in people exposed below that level. Although one study found a significant dose-response relationship with respect to surrogate measures of exposure, reliable dose-response information is not available due to the use of dichotomized exposure categories and due to small numbers of cases within the exposure groupings. Issues pertaining to personal exposure and latency have not been addressed. The two paternal occupational studies found statistically significant associations between neuroblastoma and brain cancer, respectively, in children and their fathers' exposure to EMFs. There was also one report of a cluster of a rare tumor type (endodermal sinus tumors) in adolescent girls exposed to EMFs from power distribution lines....

The consistently repeated pattern of leukemia, nervous system cancer and lymphoma in the childhood studies and the ruling out of several confounding exposure factors in the Savitz et al. (1988) study argue in favor of a causal link between these tumor types in children and exposure to ELF magnetic or electric fields. However, the fact that the odds ratios are small and in many cases not statistically significant indicates that the association may not be strong and therefore argues against a causal relationship.

7.3.2. Studies of Adults

7.3.2.1. Residential Exposure to Power Frequency Fields: In a total of four reports of cancer mortality or incidence in adults residing near electrical power distribution equipment, three were nonpositive and the fourth was clearly positive. In a case-control study of adult leukemia in Los Angeles, there was no association with electric blanket usage in the home. In contrast to childhood cancer, the adult studies were more difficult to interpret because they lacked the statistical power to detect a relative risk of the magnitude typically observed in the childhood studies and because there was little evidence that the cases were exposed to levels of EMFs higher than fields to which the controls were exposed. Therefore, no conclusions can be made about a cancer response and adult exposure to residential fields.

7.3.2.2. Occupational Exposure to ELF and Mixed Frequency Fields: Over 30 reports dealing with cancer incidence or mortality in workers in electrical and electronic occupations have been reviewed. These exposures have involved 50 or 60 Hz power frequency fields as well as mixtures of higher frequency fields which are typically poorly defined. The studies have been carried out in Europe, New Zealand and the United States. Many of them were re-examinations of previous studies or evaluations of vital records, cancer registry or occupational data bases, and thus the populations were not formed to test the specific hypothesis of whether EMF exposure is associated with increased cancer risk. Most of them used death certificates as a source of occupational information; this information furnishes

only a very crude indicator of actual exposure to EMFs. Many of these are proportional mortality studies, which are less informative than studies of cohort and case-control designs because their results are affected by extraneous causes of death.

In these studies three types of cancer predominate: (1) hematopoietic system, especially leukemia and specifically acute myeloid leukemia; (2) nervous system cancer, including brain tumors; and (3) malignant melanoma of the skin. These cancer sites are found consistently across different geographic regions, age groups, industries, occupational classifications and study designs. Given this diversity of studies, in addition to the likelihood that across broad job categories the exposures to various chemicals is not uniform, it is difficult to identify any single agent or group of confounding exposures that could explain the consistent finding of these same cancer sites.

7.3.2.3. RF Exposure: Reports that focused primarily on exposures to RF radiation have shown mixed results, but most of the studies were difficult to interpret. Two early reports concerning microwave [MW] exposure of the U.S. embassy personnel in Moscow and radar exposure of U.S. Navy personnel showed only a slight tendency for increased cancer risk at all sites, and somewhat higher odds ratios for hematopoietic system cancers. A study of personnel in a World War II radar research and development laboratory found no convincing evidence of increased cancer incidence, but errors of exposure misclassification are likely. A series of reports of ham radio operators found a statistically elevated incidence of acute myeloid leukemia and other neoplasms of the lymphoid system, but no clear dose-response trend was seen with longer exposure, where the degree of exposure was inferred by FCC operator license class. One report of military exposure to radar found increasing rates of hematopoietic cancer of specific sites, but a lack of detail limits the ability to interpret the results.

7.3.3. Summary of Human Evidence: The strongest evidence that there is a causal relationship between certain forms of cancer, namely leukemia, cancer of the nervous system and, to a lesser extent, lymphoma, and exposure to magnetic fields comes from the childhood cancer studies. Several studies have consistently found modestly elevated risks (some statistically significant) of these three site-specific cancers in children. In two of the studies in which magnetic field measurements were made, cases were observed in those exposed above 2-3 mG (0.2-0.3 μ T) but not in people exposed below that level. This is supported by the fact that children have relatively few confounding influences that could explain the association. In fact, the few potential confounders and biases that might have had an effect on the results were examined by one of the authors in some detail and found not to be a serious problem. No other agents have been identified to explain this association. However, there are contradictory results within these same studies, and dose-response relationships could not be substantiated. Furthermore, there is little information on personal exposure and length of residency in the EMFs.

Additional, but weaker evidence that there is an elevated risk of leukemia, cancer of the nervous system and perhaps other sites comes from occupational studies of EMF exposure. Although many of these studies have found an excess risk of these forms of cancer with employment in certain jobs that have a high potential for exposure to EMFs, few or no measurements have actually been taken in those occupations. Furthermore, information about occupation has come generally from sources that could be characterized as sketchy. The likelihood that misclassification or information bias is present in these studies is high. However, exposure misclassification, if random, tends to bias relative risks toward the null. Despite these weaknesses, the occupational studies tend to support the results of the

childhood studies, since the excess relative risks occur at the same sites.

The studies of residential adult exposures to EMFs provide little evidence of a risk of leukemia, mainly due to lack of statistical power and/or probably little exposure to levels of EMFs which have been found to be associated with cancer in children. These studies cannot be interpreted as evidence either for or against a causal association between cancer and EMF exposures. On the other hand, the case-control study of cancer in Colorado residents does support an association of central nervous system cancer and lymphoma if proximity to high-current electrical wiring configurations is assumed to be an adequate surrogate for exposure.

The studies of adults exposed to RF radiation produced mixed results, primarily because of limited sample size, inadequate length of follow-up, imprecise exposure data and lack of information on potential confounders. These problems prevent conclusions to be made about causal relationships with RF exposures. However, the statistically significant excess risks of leukemia in amateur radio operators require further examination.

7.4. Animal Carcinogenicity Evidence

7.4.1. ELF Fields: No lifetime animal carcinogen bioassay studies of ELF fields have been reported in the literature. Two studies currently in progress are designed to observe the induction of a carcinogenic response to chronic magnetic field exposures.

7.4.2. RF Radiation: Two chronic studies in mice have used unmodulated RF radiation at 800 MHz and 2450 MHz, respectively. Two studies in rats have used pulse modulated 2450 MHz of low power density and pulsed RF of all frequencies from 0 to about 20 MHz of high power density, respectively. One mouse study used pulsed RF radiation of 9270 MHz.

7.4.2.1. Unmodulated RF Radiation: For unmodulated RF radiation, one of the mouse studies (Szmigielski et al., 1982) shows that the radiation enhances the growth rate of spontaneous mammary tumors and in a separate experiment enhances the growth rate of skin tumors initiated by a chemical carcinogen, benzo(a)pyrene. In a shorter test (3 months), the same authors showed that the radiation also enhances the growth rate of transplanted lung carcinoma cells, an effect attributed to the lowering of cell-mediated immunity. Unfortunately, histopathology was not reported in the other mouse study (Spalding et al., 1971), so conclusions about carcinogenicity from that study are difficult to make.

The special nature of the response indicates that unmodulated RF radiation might be a promoter or cocarcinogen, since the growth rate of spontaneous breast tumors, BaP-induced skin tumors and transplanted lung sarcoma cells is enhanced by the radiation. There is a remote possibility that body heating could have contributed to this response, since the absorbed RF power is estimated to be at least one-half of the basal metabolic rate of the animals.

7.4.2.2. Modulated RF Radiation: For modulated RF radiation of relatively low power density [i.e., excluding the high power electromagnetic pulse (EMP) experiment of Baum et al. (1976)], the mouse experiment (Prausnitz and Susskind, 1962) showed a reversible pattern of lymphoma and leukemia which, in serial sacrifices, occurred toward the end of the 14-month exposure period but was not present in animals after a 5-month recovery period. However, the short 4.5-minute daily exposure was intense enough to raise the body core temperature by 3°C, raising the possibility that thermal effects were a contributing factor in the response. The rat study (Guy et al., 1985) showed the induction of benign adrenal medulla pheochromocytomas and a statistically significant increase in carcinomas of all organ and tissue sites. There was also a higher incidence of glandular organ carcinomas which was unaccompanied by an increase in the incidence of benign tumors of these sites. Although an increase of

tumors of all types in the aggregate is regarded as only minimal evidence of carcinogenic action by chemical agents, the fact that the RF radiation affects all tissues in the body independently of their individual biochemical characteristics constitutes a reason to consider the aggregate count a relevant finding.

7.5. Supporting Evidence of Carcinogenicity

Section 5.11. presents a summary of the effects of EMFs on a variety of basic biological phenomena relevant in some way to mechanisms of carcinogenesis; that information is not repeated here. ELF fields of relatively high intensity (producing induced body currents on the order of 10 $\mu\text{A}/\text{cm}^2$) have enhanced DNA synthesis, altered the transcription of DNA into mRNA, altered the molecular weight distribution during protein synthesis, delayed the mitotic cell cycle, induced chromosome aberrations, blocked the action of parathyroid hormone at the site of its plasma membrane receptor, induced enzymes normally active during cell proliferation, inhibited differentiation and stimulated the growth of carcinoma cell lines, inhibited the cytotoxicity of T-lymphocytes (which indicates an impairment of the immune system) *in vitro* but not *in vivo*, inhibited the synthesis of melatonin (a hormone that suppresses the growth of several types of tumors), disrupted the morphology of neurons and glial cells in the central nervous system and caused alterations in the binding of calcium to brain tissues. The large variety of exposure conditions and the lack of detail on the geometry of the biological samples in these studies preclude a systematic evaluation of the actual induced currents and field strengths at the tissue and cellular level that are causing these effects. In addition, the lack of reproducible results between laboratories limits the interpretation of much of this literature.

RF fields modulated at the same ELF frequencies that cause some of the effects noted above also result in the same responses, indicating that the ELF component may be responsible for these effects. Unmodulated RF radiation has not caused any of the effects noted above except for chromosome aberrations. None of the EMFs have caused gene mutations, sister chromatid exchanges or DNA damage (as measured by DNA breaks, DNA repair or differential killing of repair defective organisms) in a large number of studies.

Only three ELF effects have been induced at field strengths comparable to the low environmental exposures at which human cancer has putatively been caused: (1) the calcium efflux from brain tissue preparations using 16 Hz crossed electric and magnetic fields; (2) calcium efflux from chick brain tissue after exposure of the developing embryo to electric fields; and (3) the inhibition of melatonin synthesis by the pineal gland when a static magnetic field of approximately the strength of the earth's magnetic field is changed through a small angle of rotation. The results of the first experiment are one of several phenomena that show a complex dependence on frequency, intensity and orientation with respect to the earth's magnetic fields.

In view of these laboratory studies, there is reason to believe that the findings of carcinogenicity in humans are biologically plausible. However, the explanation of which of the biological processes is involved and the way in which these processes causally relate to each other and to the induction of malignant tumors is not understood. Most of the effects have been observed at field strengths that are many times higher than the ambient fields which are the putative cause of the childhood cancers in residential situations; as a consequence, many of the candidate mechanisms may not be really involved in the response to low environmental fields. The same issue of low-dose extrapolation arises in the evaluation of chemical agents.

7.6. Integrated Discussion of Separate Chapters

The occurrence of cancer in humans exposed to low frequency

FROM THE FIELD

EMFs has been observed under several different conditions in different populations. Residential exposure of children, but not adults, has been associated with leukemia, lymphoma and brain cancer, and the same sites occur in multiple studies of children. The fields involved in these associations are magnetic and not electric fields, made up of primarily 60 Hz components but with inevitable high frequency components introduced by electric motors and the switching of currents on and off. In a few studies, these effects have been observed in children exposed to average magnetic fields above 2-3 mG (0.2-0.3 μ T) but have not been seen in children exposed to smaller fields. The types of EMF exposures in the occupational studies are variable according to job category, with some jobs involving pulsed and modulated RF fields as well as 60 Hz power frequency components.

There is some, but not well-established, evidence that higher frequency components have different effects than 60 Hz components. Electrical switchyard workers exposed to spark discharges just before blood samples are taken have chromosome aberrations, whereas similar workers with no such exposure do not. Chromosome aberrations have been induced by unmodulated RF fields as well as by ELF fields. A recent preliminary report of an epidemiologic study of telephone workers shows a different effect (rare breast tumors in males) in people working in the "central office," where switching equipment is typically concentrated, than in cable splicers (leukemia) who presumably are exposed to predominantly 60 Hz power frequencies. Both electric and magnetic fields are more effective in inducing currents in the body if their frequency is higher, so that if induced currents are responsible for these effects, then the higher frequency components are expected to be more effective. If it is true that, as two studies indicate, the fathers' occupations in electrical jobs is a factor in the development of leukemia in their children, then the question is raised whether the effect could be transmitted via heritable genetic damage in sperm. This speculative hypothesis needs to be investigated.

Although there are several candidate EMF-induced biological phenomena...that could explain how a cancer response is caused in the whole organism by these fields, none of these or any combination of them has been verified experimentally, either in laboratory animals or in humans. Without understanding which combination of these is relevant to the carcinogenic process, it is not possible to hypothesize what aspect of EMF exposure is responsible for biological effects: i.e., frequency, average peak field strength, duration, time of day, whole-body average versus local critical site, electric versus magnetic fields, orientation with respect to the earth's static magnetic field. The choice of which aspect of the fields is the most relevant could be based on either knowledge of the correct mechanism of action or on empirical epidemiology correlations, but, given the current lack of information, neither method can serve as a basis for a dose-response analysis.

There are several indications that EMFs might contribute to the induction of cancer via indirect mechanisms, in contrast to a direct mutagenic action of DNA as is the case with nitrosamines, polycyclic aromatic hydrocarbons or other DNA-alkylating agents.

First, EMFs have not caused gene mutations in any of the large number of experiments carried out with both ELF and RF fields.

Second, there is no indication from the animal studies that RF fields cause a *de-novo* induction of tumors. On the contrary, the mice experiments by Szmigielski et al. (1982) indicate that unmodulated RF radiation acts as a growth stimulator for preexisting tumors. The same growth-stimulating or promotion characteristics of RF fields could explain the induction of glandular tumors in the Guy et al. (1985) lifetime rat study of modulated RF radiation, since many of the glandular tumors in that study had a naturally high spontaneous

incidence.

A third factor indicating that there may be multiple causes of carcinogenic action is that 120 Hz-modulated 2450 MHz radiation can act as an initiator of phorbol ester-promoted cell transformation in mouse embryo cell cultures.

Finally, there are possible cancer induction mechanisms mediated by the central nervous system causing neuroendocrine influence on cellular proliferation. These mechanisms involve possible extremely sensitive detection of magnetic fields by the retina with resulting neural control of pineal melatonin activity, which in turn modulates estrogen and prolactin levels in the blood supply to the breast, prostate and other hormonally-sensitive tissues. Other speculative chains of events could be fabricated from the existing information in this document, and this one is mentioned here only as an example that there are many possible explanations but no verified ones.

In view of this, it is likely that if EMFs do contribute to the induction of cancer, the causal relationship will probably turn out to be dependent on many chemical factors and physiological conditions that are currently poorly understood.

There are two issues in the hazard evaluation of chemical carcinogens that are analogous to issues for EMFs. It may be helpful to explore whether the assumptions and conventions developed for chemicals are applicable to the EMF problem.

One analogy is that EMFs are mixtures consisting of several frequencies, intensities and combinations of electric and magnetic fields, which (for ELF frequencies) occur in arbitrary proportions. One approach to the assessment of chemical mixtures is to identify hazardous components of the mixture and, assuming additivity of components, consider the risk of the mixture to be proportional to the risk of the hazardous components. If this concept were applied to the EMF problem, then magnetic fields from 60 Hz power usage in the home would be the only "hazardous component" identified, although there is some indication that occupational exposures of adults to mixed fields may cause the same effect. Laboratory studies under relatively controlled conditions of exposure have not been able to test the additivity assumption for EMF components or for chemical components except for a few rare cases, but one feels more comfortable with the latter. With chemical agents, the basic phenomenon is ultimately some chemical reaction, which is expected to have additive properties at low enough concentrations, or at least to be monotonic in the sense that more chemical produces a greater effect. With EMFs, however, the ultimate causative interaction between fields and biological systems is unknown, and there is certainly no additivity with RF and ELF fields, or with ELF electric and ELF magnetic fields. The consequence of not being able to add the risks for different exposures is that the effects for each combination must be investigated and assessed separately.

Another analogy is the similarity between the "biologically effective dose" for chemical agents and the critical electrical measure of tissue "dose" which causes the effect for EMFs. For chemical agents the relationship between "administered dose" and "effective dose" has been studied occasionally, but only rarely. In the absence of this information, the default position for chemical agents has been to assume a linear relationship. Then there are hosts of unresolved questions in determining whether the biological effect is proportional to the "effective dose." These questions arise when, as is usually the case, the mechanism of action is not known. Here again the linearity assumption is made in the absence of knowledge, and the overall default position is that the adverse effect is proportional to the administered dose of the chemical agent. For EMFs, the "tissue doses" could be calculated, typically with great difficulty and uncertainty, but the same type of questions needs to be answered about which of these dose metrics are relevant for EMF exposure. As with

chemical agents, the choice of a candidate mechanism of action dictates which tissue dose metric is appropriate, and there could be several mechanisms for each of the administered agents. For EMFs, the default linearity assumption is not appropriate basically because there are frequency and intensity "windows" of activity for more than one EMF-induced biological effect and such "window" interactions cannot be ruled out as contributory to cancer causation.

In conclusion, the several studies showing leukemia, lymphoma and cancer of the nervous system in children exposed to magnetic fields from residential 60 Hz electrical power distribution systems, supported by similar findings in adults in several occupational studies also involving electrical power frequency exposures, show a consistent pattern of response that suggests, but does not prove, a causal link. Frequency components higher than 60 Hz cannot be ruled out as contributing factors. Evidence from a large number of biological test systems shows that these fields induce biological effects that are consistent with several possible mechanisms of carcinogenesis. However, none of these processes has been experimentally linked to the induction of tumors, either in animals or humans, by EMFs. The particular aspects of exposure to the EMFs that cause these events are not known.

In evaluating the potential for carcinogenicity of chemical

agents, EPA has developed an approach that attempts to integrate all of the available information into a summary classification of the overall weight-of-evidence that the agent is carcinogenic in humans. At this time such a characterization regarding the link between cancer and exposure to EMFs is not appropriate because the basic nature of the interaction between EMFs and biological processes leading to cancer is not understood. For example, a real possibility exists that exposure to higher field strengths is actually less hazardous than exposure to low field strengths. Because of this uncertainty, it is inappropriate to make generalizations about the carcinogenicity of EMFs. As additional studies with more definitive exposure assessment become completed, a better understanding of the nature of the hazard will be gained. With our current understanding we can identify 60 Hz magnetic fields from power lines and perhaps other sources in the home as a possible, but not proven, cause of cancer in people. The absence of key information summarized above makes it difficult to make quantitative estimates of risk. Such quantitative estimates are necessary before judgments about the degree of safety or hazard of a given exposure can be made. This situation indicates the need to continue to evaluate the information from ongoing studies and to further evaluate the mechanisms of carcinogenic action and the characteristics of exposure that lead to these effects.

UPDATES

LITIGATION

FM Radio-Cancer Suit Settled...KYGO, an FM radio station near Denver, CO, has settled a lawsuit alleging radiation-induced cancer for an undisclosed sum. The suit, filed in August 1988 against station owner Jefferson-Pilot Broadcasting, Inc., charged that RF radiation had caused Beryl Main to develop non-Hodgkin's lymphoma and had exposed his wife to an increased risk of cancer (see *MWN*, S/O89). The agreement was reached in late March just as the case was about to go to trial. "I'm not permitted to disclose the terms of the settlement," Bruce DeBoskey, the Mains' attorney, told *Microwave News*. "I am totally unable to describe them." DeBoskey, of Silver & DeBoskey, is based in Denver. A 1986 survey by the EPA identified RF levels as high as 300 $\mu\text{W}/\text{cm}^2$ on the patio/deck of the square dance camp Beryl Main owned and operated with his wife near the KYGO broadcast tower—a hotspot of 10.35 mW/cm^2 was measured at the base of the tower (see *MWN*, M/A87). After the data were released, KYGO lowered its power output from 100 kW to 1 kW and agreed to limit radiation levels on camp property to 10 $\mu\text{W}/\text{cm}^2$ (see *MWN*, M/J87). The station later moved its antenna and transmitter.

OVENS

Salty to the Core...Salty foods cooked in a microwave oven may not heat evenly, two microbiologists at the U.K.'s Leeds University have concluded after doing a simple experiment with mashed potatoes. In a letter to *Nature* (April 5, 1990), Drs. Stephen Dealler and Richard Lacey describe how the

higher the salt (or any other ionic compound) concentration in mashed potatoes, the lower their core temperatures after microwave cooking. They suggest that their finding may explain the recent increases in salmonellosis in the U.K., which is associated with eating incompletely cooked foods. Prepackaged microwave foods—which often have high sodium concentrations—might also be affected, they note. They suggest that the poor penetration of microwaves in saltier foods might be due to "the induction of electrical/ionic flow in the surface of food," and that this would also explain why "commercial food heated in microwaves commonly boils on the surface but is cool on the inside." (For more on incomplete cooking, see *MWN*, Ju81, A82, S/O88 and M/A89.)

PEOPLE

Dr. Carl Durney of the University of Utah, Salt Lake City, has been elected to membership in the National Council on Radiation Protection and Measurements (NCRP)....Dr. Andrew Marino, the editor of the *Journal of Bioelectricity*, has announced that Dr. Ross Adey of the VA Medical Center in Loma Linda, CA, and Dr. Jocelyne Leal of the Ramón y Cajal Hospital in Madrid, Spain, have become assistant editors of the journal. Dr. Jerry Phillips, who recently joined Adey's lab, is stepping down as an assistant editor....Dr. Keith Florig has left Carnegie Mellon University to join the Arms Control and Disarmament Agency in Washington, DC....Dr. Sol Sax, formerly chief physician at Ontario Hydro, is now director of occupational health for Boeing Canada's DeHavilland Division, based in Downsview, Ontario.

CLASSIFIEDS

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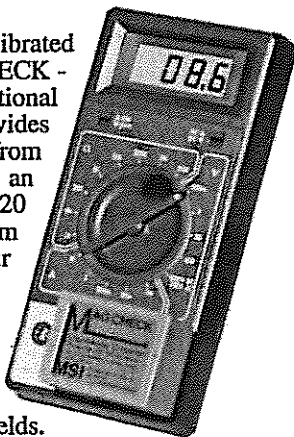
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