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California Cancer Cluster: Is RF Radiation Involved?

An abnormally high rate of childhood cancer has been documented in the small agricultural town of McFarland, in Kern County, southern California, but despite years of intense study, health officials have been unable to identify the cause of the cluster. Investigators have focused almost exclusively on chemical pollutants without success. Nor can they explain why McFarland is different from the dozens of similar farming towns spread throughout the San Joaquin valley.

A number of experts – as well as some McFarland residents – believe that a high-power Voice of America (VOA) shortwave transmitter in nearby Delano may play a role in the etiology of the cluster. The Delano VOA station, which is approximately four miles from McFarland, has transmitters with nearly two million watts in total output sending radio programs to Asia and to Latin America.

Three 250 kW transmitters broadcast southeast to Central and South America at 9 and 11 MHz for approximately four hours each day, according to Lynn Smith, the Delano station manager. McFarland is southeast of the VOA transmitter site – the Latin American signals are beamed over the town. (There are also four other 250 kW transmitters, as well as one 100 kW and two 50 kW transmitters.)

Radiation Is as Likely as Chemicals

In a report on the cluster released on January 28, the California Department of Health Services states that it could not "establish a causal link between any specific factor and development of the cancers." The state discounts the possible impact of radiofrequency (RF) radiation. "We don't think that the evidence that we looked at points at all in the direction of non-ionizing radiation as a problem," Dr. Raymond Neutra, the head of the state health department's Epidemiological Studies and Surveillance Section (ESSS) told *Microwave News*.

Others are not so sure. In a telephone interview, Dr. Ross Adey said that, "RF radiation is a significant factor that has not been taken seriously." Adey, the associate chief of staff for R&D at the VA Medical Center in Loma Linda, CA, has been following the McFarland investigation with keen interest for a number of years. "It is possible that the VOA radiation could have an effect on the people living in McFarland," he said. According to his very rough calculations, the ambient levels of RF radiation are in the microwatt per square centimeter ($\mu\text{W}/\text{cm}^2$) range in the town, and he points out that, "There are no animal or human studies related to prolonged intermittent exposures at these levels."

An electrical engineer at Ranger Communications, an electromagnetic

(continued on p.14)

Should Non-Ionizing Radiation Risk Research Be Halted?

Arguing that microwave (MW) radiation is "one of the most thoroughly studied of all potential environmental hazards" and that "fundamental questions are still being raised about the very existence of hazards associated with low levels of exposure," Drs. Kenneth Foster and William Pickard argue that it is perhaps time to make "the conscious decision to leave some questions unanswered."

Foster, of the University of Pennsylvania in Philadelphia, and Pickard, of Washington University in St. Louis, MO, make their case in a commentary, "Microwaves: The Risks of Risk Research," published in the December 10, 1987 issue of *Nature*. The two professors, both engineers, cite three examples of bioeffects which were reported to occur at levels allowed under the 1982 American National Standards Institute (ANSI) standard: microwave auditory, heart rate and blood brain barrier (BBB) effects. In each case, they conclude that there is no low-level hazard.

Dr. Ross Adey, Veterans Administration: Had it not been published in *Nature*, F&P's paper would be better ignored. This and the previous paper in *Scientific American* breach the two essential tenets on which the scientific method has grown to credibility: The investigators shall be thoroughly informed on the state of knowledge in the field and shall present it competently and fairly; and a paper submitted for publication shall be competently peer-reviewed. *Scientific American* and *Nature* are read and accepted as authoritative by a vast worldwide audience of leaders in all fields of science. It is our individual and collective obligation to cleanse the taint of F&P's willful misrepresentation from the scientific literature no matter what it entails.

Dr. Robert Becker, Becker Biomagnetics: F&P have chosen to view the whole question of MW-induced health hazards based on only three effects. Since they find a lack of unanimity on the existence of these effects, they conclude that further risk analysis is unwarranted. They have ignored the literature on other effects of much greater significance as well as that ample body of literature indicating actual risks present in the human population. This paper has no relationship to risk analysis and F&P display a narrowness of vision common to mechanistic engineers: "If there is no demonstrable mechanism of action, there can be no risk." The question they address is too important to be left to such an incomplete and unscientific review, particularly one that reaches such an unwarranted and dangerous conclusion.

Dr. Martin Blank, Columbia University: Everyone has priorities in research but it is inappropriate for a scientist to call for "halting" research.

Foster and Pickard (F&P) say that there are many other effects – "perhaps hundreds," including many associated with 50/60 Hz power line electric and magnetic fields – that remain to be studied. They sum up: "Granted, society must search for hazards of its technologies. But how to cope with the scientific noise that these studies produce? Such searches for hazards can go on too long, and guidelines for ending them must be established."

This commentary has provoked a great deal of controversy within the bioelectromagnetics community. (Foster prompted a similar dispute after he and Dr. Bill Guy published "The Microwave Problem" in the September 1986 *Scientific American* – see *MWN*, November/December 1986 and July/August 1987.) *Microwave News* polled the community for views on the commentary. Some declined the invitation; others were willing to be quoted.

Dr. David Carpenter, New York Department of Health: What they are reacting to is the poor quality of some of the research that gets done. I agree with this. We should improve our standards. We need better quality controls in what gets funded and published. But I would take issue with cutting off research. It is always a mistake to shut off a whole field of research.

Dr. Stephen Cleary, Virginia Commonwealth University: I am surprised that it was published in a scientific journal since it appears to be completely counter to what I understand to be the principles of objective inquiry. In opposition to the views of the authors, I for one have not spent my career searching for "hazards." Considering the present level of support for this type of research, who needs guidelines to end it? If they were needed, who would write them? Considering the apparent difficulty encountered in writing safety standards, I do not anticipate guidelines to end research in my lifetime.

Dr. P. Czerski, Food and Drug Administration: I think this commentary confuses science and research directed to gain fundamental knowledge about EMF interactions and living systems and short-term applied research which arises out of political pressure. In a nutshell, the scientific and societal issues are confused in this article....They are entitled to their point of view, however historical experience (e.g., Michurin and Lysenko) shows that developing guidelines for halting socially undesirable research is a risky enterprise. Societal issues are best solved by democratic means and open discussion.

Dr. Christopher Davis, University of Maryland: F&P have been very subjectively selective about the three phenomena

they chose. The auditory effect is irrelevant to risks due to low-level MWs. The heart rate is not a mainstream experiment in bioeffects research and the BBB, while getting a lot of people excited, has not been confirmed. There are well-documented effects, especially in terms of genetic effects and calcium ion efflux.

Dr. Richard Frankel, MIT: I don't know why they left out the really interesting verifiable effect on calcium efflux, which is leading down a real scientific path.

Dr. Reba Goodman, Columbia University: Given the magnitude of the problems raised by low-level MW radiation and the potential environmental and health hazards, F&P's propositions are extremely unscientific and anti-intellectual. They suggest a moratorium because there are inconsistent findings and occasional modified conclusions. This is common to all research. Oddly enough, *Nature* has consistently failed to publish significant articles dealing with this branch of science. Instead, it has chosen to devote some of its valuable space to F&P's thesis.

Dr. Don Justesen, Veterans Administration: F&P purport to identify a scientific need to shut down unnecessary "risk" research. I'm disappointed in their commentary for several reasons. One, the tacit assumption that investigations in these areas were wholly motivated by hygienic concerns is invalid. Most scientists are driven primarily by curiosity – by a desire to establish and understand functional relations. Second, F&P's history is flawed; in my opinion, they sometimes don't "tell it like it is" – or was. And finally, F&P are guilty of finding fault without offering solutions.

Dr. Samuel Koslov, Johns Hopkins University Applied Physics Laboratory: I get the impression that the authors have not bothered to follow the field for at least five years. The defense of the 1982 ANSI standard seems rather futile in that the NCRP, Canada, Sweden and many local standards have deviated from it, often with recognition of flaws in physical reasoning. The most remarkable aspect of the article is that the advocacy position seems to be to define guidelines to end the search for hazards despite unexplained observations. This is a new line of thinking in science for me.

Dr. Jocelyne Leal, Centro 'Ramon y Cajal' (Spain): This subject of research is not very different from any other subject. In neurophysiology, for example, you can find thousands of results that could not be confirmed, others contradictory and still others due to artifacts. Such outcomes are intrinsic to any experimental research. We are working in a young science, frequently stumbling! But can we afford to deny its importance? From the moment that there is a suggestion that EMFs can affect living organisms, it must be investigated. This is the main responsibility of the scientific community and developed societies.

Dr. Granger Morgan, Carnegie-Mellon University: As you know from my *Science* editorial (232, p.917, May 23, 1986), I think starting and stopping rules for federally-funded risk-motivated applied research are important. I wish that F&P had drawn a sharper distinction between such programs and basic science, where the considerations are very different. In the case of risk-motivated applied research on 60 Hz, we have some good examples of such rules not operating well enough. Work on animal perception studies went on longer than needed and work on animal cancer promotion has been too slow in starting.

Dr. John Osepchuk, Raytheon Research Division: An excellent article. It points to a real problem in the field. I am sure the authors are not calling for a cessation of research except that which leads to fruitless research or to ephemeral results. Instead, I am sure they support research that leads to a permanent and reliable data base.

Dr. Richard Phillips, Environmental Protection Agency: It is a biased article. It is a disservice to the other people in the field and to F&P. I don't understand why they wrote it.

Dr. Asher Sheppard, Veterans Administration: F&P attack some straw men in setting up MW effects on hearing, heart rate and BBB as potential hazards. They then tell us these effects can be "explained" as artifacts or denigrated as the expression of contentiousness by a few. Of course, they fail to mention evidence concerning cancer, genetic effects or the altered permeability of eye tissues; nor do they credit the wealth of good research which has come out of inquiry into high- and low-level effects....I am dismayed that the readers of *Nature*, who do not know the limited scope which F&P bring to their pronouncements, will not realize their views are merely provocations from a know-nothing fringe. In a word, it's a "smear."

Dr. Maria Stuchly, Health and Welfare Canada: I have not read anything new there. They carry their assessment too far. I do not share their opinion overall.

Dr. Mays Swicord, Food and Drug Administration: As the authors suggest, the literature contains thousands of reports of RF bioeffect studies of varying quality and results. One can of course prove any point by selectively drawing from such a data base. To do so is either scientifically naive or dishonest.

Dr. Tom Tenforde, Lawrence Berkeley Laboratory: I find it discouraging that two talented scientists such as F&P should take such a dim view of research on the biological effects of microwave radiation. Their point that much confusion has been generated by research that was incomplete or poorly conducted is undoubtedly correct. However, the fact there are unresolved issues in this field argues for more research, not less!

IRPA Relaxes RF/MW Standard

The International Radiation Protection Association's International Non-Ionizing Radiation Committee (IRPA/INIRC) has relaxed some provisions of its 1984 "interim" radiofrequency and microwave (RF/MW) radiation exposure guidelines, especially with respect to low frequency exposures and peak pulsed fields.

Occupational limits are now 614 V/m and 1.6/f A/m for 100 kHz-1 MHz electric and magnetic fields, respectively, and 614/f V/m and 1.6/f A/m for 1-10 MHz (where f= frequency in MHz). There is a provision that if there are risks of RF burns, they can be eliminated "in most situations" by reducing the electric field to 194 V/m for 100 kHz-1 MHz and to $194/f^{1/2}$ V/m for 1-10 MHz.

In the 1984 standard, the two sets of limits were reversed: occupational limits for 100 kHz-1 MHz were 194 V/m and 0.51 A/m for electric and magnetic fields, respectively, and $194/f^{1/2}$ V/m and $0.51/f^{1/2}$ A/m for 1-10 MHz, with the advisory that the limits could be exceeded up to 615 V/m or 1.6 A/m, "provided workers take the necessary precautions to prevent potentially severe RF burns."

Dr. P. Czerski, of the Food and Drug Administration's Center for Devices and Radiological Health and a member of the IRPA/INIRC, told *Microwave News* that by directly addressing the low frequency risks, the limits could be loosened at low frequencies. He explained that the standard is now "more precise." He added that, "It is a loosening predicated on the additional criteria of exposure."

For the general population, the 1984 and 1988 guidelines are identical except for the magnetic field limit between 100 kHz and 1 MHz, which has now been loosened from 0.23 A/m to $0.23/f^{1/2}$ A/m.

The other major change is that the suggested peak pulsed field should not be greater than 1,000 times the six-minute average power density. The 1984 interim limits suggested that the pulsed field should not be more than 100 times greater. Czerski argued that the reduction was needed because the 1984 limit was "too strict, with no good rationale."

In a statement accompanying the new guidelines, the IRPA/INIRC notes that its guidelines are still based on a 0.4 W/Kg whole-body average specific absorption rate (WBA-SAR) because: "A close scrutiny of the available data revealed no need to revise the previously adopted basic WBA-SAR."

The guidelines specify that excessive heating of wrists and ankles can be avoided by limiting body-to-ground currents to 200 mA. The IRPA/INIRC advises that, "In general, RF burns will not occur from currents on point contact of 50 mA or less." The committee notes that a simple ammeter is "sufficient" to verify the maximum current flow.

The IRPA/INIRC considered the potential risks of cancer and congenital abnormalities and concludes that, "Available data are inconclusive and cannot be used for establishing exposure limits."

"Guidelines on Limits of Exposure to Radiofrequency

Electromagnetic Fields in the Frequency Range from 100 kHz to 300 GHz" appears in the January 1988 issue of *Health Physics*. The 1984 guidelines appeared in the journal's April 1984 issue (see *MWN*, March 1984). Members of the IRPA/INIRC are: H.P. Jammet, chairman, France; J. Bernhardt, Federal Republic of Germany; B.F.M. Bosnjakovic, The Netherlands; P. Czerski, U.S.A.; M. Grandolfo, Italy; D. Harder, Federal Republic of Germany; B. Knave, Sweden; J. Marshall, Great Britain; M.H. Repacholi, Australia; D.H. Sliney, U.S.A.; J.A.J. Stolwijk, U.S.A.; A.S. Duchêne, scientific secretary, France.

Radar Radiation Exposure & Unexplained Memory Loss

A pilot who was overexposed to microwave radiation experienced neurological problems long after other overt symptoms disappeared. In a letter to the *Journal of the American Medical Association* (January 15), Drs. Mauricio Castillo and Robert Quencer describe the case of an F-16 pilot who was accidentally exposed to radar radiation.

The 42-year-old civil air patrol pilot felt a moderate heat sensation after standing in front of an F-16's functioning radar system for five minutes last summer. The next morning he noticed a tender lump in his lower neck, which continued to grow and cause discomfort. Over the following month, the lump persisted and the pilot experienced a loss of short-term memory and extreme sleepiness. A doctor found a second small lump at the base of his tongue and diagnosed his condition as being caused by a thermal insult.

The patient's symptoms, which also included the inflammation of his pharynx and vocal chords, disappeared with time – except his memory loss which persisted. A magnetic resonance scan of his brain was normal, however.

This was a "disruptive event" for the patient, Dr. Castillo told *Microwave News*. "He would go shopping and would not know how to get home. He had to carry a card with his wife's telephone number to find out how to get back." But Dr. Castillo added that the patient's memory was improving when he last spoke to him in October.

Dr. Castillo, a radiologist, and Dr. Quencer, who is the head of the Magnetic Resonance Imaging Center, are both at the University of Miami School of Medicine's Jackson Memorial Hospital in Florida. (See also the special report on radiation accidents on pp.10-11.)

LLNL Guidelines for Exposures to Static Magnetic Fields

The Lawrence Livermore National Laboratory (LLNL) has adopted guidelines for exposures to static magnetic fields. The peak allowable exposure limit is 2T, and areas where

fields exceed 50 mT are limited to authorized personnel only.

Writing in the December 1987 issue of the *American Industrial Hygiene Association Journal*, LLNL's Gordon Miller reports that the time-weighted average (TWA) for the trunk is 60 mT. He explains that this guideline is based on limiting the magnetohydrodynamic (MHD) voltage to 1 mV, a level tolerated by primates without evidence of ill effects. It is a "conservative criterion," according to Miller, since it is also based on the assumption that an obese person engaged in sustained moderately heavy work and exposed to 60 mT will experience a voltage rise of 1 mV. The 2T limit is based on the patient-exposure recommendation of Dr. Tom Budinger of the Lawrence Berkeley Laboratory.

Miller cites a warning level of 1 mT for people with pacemakers or prosthetic implants. He explains the rationale thus: "1) Warning at the 0.5 mT level would have meant blocking off a major road on site; 2) no artificial pacemaker has been identified that has a reed switch that functions below 1.4 mT; and 3) the quality assurance testing of reed switches is exceptionally stringent."

Miller cautions that these static field guidelines "cannot be used as standards." He explains that, "The exposure criteria will need to be revised when the results of further research are available." He advocates continued research because of the likelihood that the introduction of superconductors will result in an increase in the number of people exposed.

Miller also reviews time-varying magnetic fields and concludes:

It is also reasonable to suggest that setting guidelines for time-varying magnetic (and electric) fields would be imprudent until the results of animal exposure studies verify or disprove the hypothesis that time-varying fields are mutagenic, carcinogenic, or teratogenic, and the mechanisms by which such fields do harm have been demonstrated beyond reasonable doubt.

CISPR, ISM & Barriers to Trade

The International Special Committee on Radio Interference (CISPR) has called for "urgent action" to review its radiation emission limits for industrial, scientific and medical (ISM) equipment.

In its latest publication (CISPR 23), the committee notes that, "It is evident that equipment which is incapable of being made to meet CISPR limits is being used in practically every country in the world," but also that, "the number of interference complaints which are traceable to ISM equipment is very low compared with that from other sources." In other words, the current standards are not being met, but it does not seem to make a difference in terms of observable electromagnetic interference (EMI).

CISPR calls the present situation "unsatisfactory" and worries that its limits are overly strict and are being used as technical barriers to trade on an ad hoc basis.

Liliane Volcy of the Federal Communications Commission (FCC), who has been monitoring CISPR ISM develop-

ments, told *Microwave News* that past attempts to revise the CISPR ISM limits have failed and that the prospects for the future also look dim. The U.S. has voted against the revisions because they are too vague and because the specifications can be misrepresented and may lead to potential abuse in their application. Volcy explained that, "It is a myth that the U.S. standards are weaker than those of CISPR. They are specified differently and cannot be readily compared."

Volcy said that there have been cases of CISPR standards being used to prevent the export of U.S. equipment— notably, medical and welding equipment. When asked if the U.S. has retaliated to control imports, she said that this has not happened, though "the growing protection mood in the U.S. might force some type of retaliation."

Copies of *Determination of Limits for Industrial, Scientific and Medical Equipment* (CISPR 23) are available for \$36.00 each (prepaid), including postage and handling, from: American National Standards Institute, International Sales Department, 1430 Broadway, New York, NY 10018, (212) 642-4900.

CONFERENCES

New Listings

March 8-9: **First International Conference on Formulating Food for the Microwave Oven**, Drake Hotel, Chicago, IL. Contact: The Packing Group Inc., PO Box 345, Milltown, NJ 08850, (201) 636-0885.

June 20-22: **18th Power Modulator Symposium**, Hyatt Hotel, Hilton Head Island, SC. Contact: Leslie Gallo, Palisades Institute for Research, 2011 Crystal Dr., Suite 307, Arlington, VA 22202, (703) 769-5580.

August 8-12: **Non-Ionizing Radiations: Biophysical and Biological Basis, Applications and Hazards in Medicine and Industry**, MIT, Cambridge, MA. Contact: Director of Summer Sessions, Room E19-356, MIT, Cambridge, MA 02139.

August 10-12: **Symposium on Antenna Technology and Applied Electromagnetics**, University of Manitoba, Winnipeg, Canada. Contact: Professor L. Shafai, Dept. of Electrical Engineering, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, Canada, (204) 474-9615.

August 20-26: **7th Annual Scientific Meeting and Exhibition of the Society of Magnetic Resonance in Medicine (SMRM)**, San Francisco Hilton & Towers, San Francisco, CA. Contact: SMRM, 15 Shattuck Sq., Suite 204, Berkeley, CA 94704, (415) 841-1899.

September 27-29: **10th Annual Electrical Overstress/Electrostatic Discharge Symposium**, Marriott Hotel, Anaheim, CA. Contact: Michael Martin, 3M/Static Control Systems Division, 2111 W. Braker Lane, Bldg. 501, PO Box 2963, Austin, TX 78769, (512) 834-3117.

March 7-9, 1989: **8th International Symposium and Technical Exhibition on Electromagnetic Compatibility**, Zurich, Switzerland. Contact: Dr. T. Dvorak, ETH-Zentrum-IKT, CH-8092 Zurich, Switzerland, (1) 256-2790.

May 9-12, 1989: **Dresden Symposium on Electrostimulation**, Dresden, G.D.R. Contact: Dr. K.-J. Schulze, Medical Academy "Carl Gustav Carus," Dept. of Orthopedics, Fetscherstrasse 74, Dresden, 8019 G.D.R.

(The entire 1988 conference calendar appeared in our last issue.)

Brain Tumor Victim Sues HL&P

A Texas family whose land had been condemned for a power line right-of-way (ROW) by Houston Lighting & Power (HL&P) has sued the utility, alleging that the electromagnetic fields (EMFs) from the line caused one of them to develop a brain tumor.

HL&P bought an easement of more than half an acre from Beverly Scott Rainwater for \$11,000 in 1980; there are three buildings on the remainder of the lot. Rainwater works in a house within 20 feet of the 345 kV power line. Her brother, Michael Scott, and his wife, Vicki, live in a house which is approximately 150 feet from the line. Their mother lives further away on the lot. HL&P energized the power line in 1983. In 1987, Michael Scott, then 26, developed an astrocytic brain tumor.

The 345 kV line first became the center of controversy when the Klein Independent School District sued HL&P for placing it across school property without proper permission. In 1985 a jury awarded the school district \$25 million in punitive damages (see *MWN*, November/December 1985). Late last year, an appeals court reversed the award but affirmed the potential health issue – by that time, HL&P had moved the line at a cost of \$8.6 million (see *MWN*, November/December 1987). The decision is being appealed.

In two suits filed on December 14, John McDowell, the attorney representing the family, charged that HL&P should have warned his clients about EMF health risks and also should have moved the line to reduce the family's exposure to EMFs, as it had done in the case of the Klein school. McDowell alleged that HL&P was negligent in its failure to warn the family, which was "inexcusable and reprehensible conduct." In addition, he argued that HL&P committed fraud by not disclosing – in the course of the original real estate transaction – the health risks.

In a telephone interview with *Microwave News*, McDowell said that documents released in the Klein case revealed that HL&P started collecting material on the health effects of power line EMFs in 1975, but had not made this information

public. "Under Texas law," he said, "if you find out about a health risk, you have a duty to warn people about it."

In papers filed with the court on January 11, HL&P denied the allegations.

McDowell said that he does not expect the case to go to trial for at least 12 to 18 months.

EPRI Developments

Dr. Richard Balzhiser has been appointed the new president and chief executive officer of the Electric Power Research Institute (EPRI). Balzhiser has been with EPRI since 1973, most recently as executive vice president. Previously, he was the chairman of the department of chemical engineering at the University of Michigan in Ann Arbor.

Risk Analysis & Measurements

EPRI's electric and magnetic fields (EMFs) group is in the process of reviewing proposals for two new projects on risk analysis and on measurements:

- *Risk Management Frameworks*: The winning bidder on project No.RP2560-1 will assess the potential value of formal risk management methods in addressing EMF concerns and, where appropriate, will develop such frameworks. Proposals were due on December 4.

- *Measurement Project for Utilities*: The contractor for project No.RP2966-1 will organize and run workshops to train utility staffers in the collection and interpretation of EMF measurement data collected with the recently-developed EMDEX system. Proposals were due on December 15.

Revised Edition of the "Red Book"

EPRI has issued a revised version of the second edition of its *Transmission Line Reference Book: 345 kV and Above* (EL-2500), commonly known as the "red book." The 625-page volume features 13 chapters, written by a variety of experts and covering all aspects of high voltage power lines, including EMF effects, corona loss and radio and audio noise. The EMF effects chapter was written by Dr. Don Deno and L.E. Zaffanella, both of General Electric Co. A copy of the red book is available for \$110.00 (\$220.00 outside the U.S.) from: Research Reports Center, PO Box 50490, Palo Alto, CA 94303, (415) 965-4081.

Congressional Hearings Video

EPRI has prepared a 52-minute videotape of excerpts from the three-and-a-half-hour congressional subcommittee on water and power resources hearings held on October 6 (see *MWN*, September/October and November/December 1987). The tape is available in VHS, Beta and 3/4-inch formats for \$50.00; order code: EA87-15. Contact: Susan Rapone, EPRI, PO Box 10412, Palo Alto, CA 94303.

BBC To Cover Power Lines

The British Broadcasting Company (BBC) is in the process of taping an hour-long documentary on the health effects of power line electromagnetic fields.

The documentary will be aired on the BBC's *Panorama* program – roughly the equivalent of the U.S.'s *MacNeill/Lehrer Report*. Tom Mangold, the show's correspondent, told *Microwave News* that the program will be broadcast on March 21. Paul Gibbs is the producer. It is not yet clear whether the documentary will be shown on American television.

Workplace ELF Exposures

A group led by Dr. Joseph Bowman of the University of Southern California (USC) School of Medicine in Los Angeles will soon publish measurement data indicating that "electrical workers" are exposed to extremely low frequency (ELF) magnetic fields that are "significantly above the levels encountered in residences and most offices."

In a paper which will appear in the May 1988 issue of *Applied Industrial Hygiene*, Bowman and coworkers conclude that these elevated workplace exposures lend support to the hypotheses generated by occupational leukemia studies. Many of these studies have found that electrical workers are at a greater risk of developing cancer (see, for example, *MWN*, March/April and May/June 1986). Very little information on the actual exposures of electrical workers has been available, however.

Among those exposed to the highest magnetic fields were: electricians working with industrial power supplies; underground and overhead power line workers; welders; and trans-

mission station and distribution substation operators. The exposures varied considerably – some were above 100 mG, though most were between 10 and 50 mG. In comparison, residential exposures were normally below 1 mG.

The USC team found that elevated magnetic field exposures are not limited to the "electrical worker" job categories, but can also occur near such devices as battery-driven forklifts.

The difference between electric field exposures in workplaces and in residences tended to be lower than in magnetic fields due to the effective shielding provided by metallic electrical equipment.

In an interview with *Microwave News*, Bowman cautioned that his exposure estimates are preliminary and should be considered in the context of a "pilot" study. Bowman was recently awarded a contract by the Electric Power Research Institute (EPRI) to carry out more detailed occupational measurements – that study is just getting started (see *MWN*, July/August 1987).

Wertheimer and Leeper on Epi Study Pitfalls

Reprinted below is a memorandum from Dr. Nancy Wertheimer and Ed Leeper on "Possible Pitfalls in Interpretation of ELF Research." The memo is dated November 4, 1987.

Many "heresies" of our 1979 paper have now become almost commonplace: There is, today, fairly good acceptance for the importance of magnetic (not just electric) fields (MFs), and for the possibility that physiological effects may occur with milligauss fields; for the role played by ground-return currents in putting MFs out into the environment; for the validity of wiring configurations as an index of MF exposure; and for the relatively modest exposure from most appliance sources (as opposed to the 1979 consensus that the "25 gauss hairdryer" precluded any possibility of an effect from milligauss fields) – and so forth.

We feel our track record has been a decent one. And we hope that, on the strength of it, our further ideas on the subject will be seriously considered. Those ideas include the following:

1. *Little increase in cancer is to be expected among young children exposed prenatally to the most extreme sources of chronic MF exposure.* We have seen this pattern in our own data and in that of Fulton, Myers, Tomenius and Savitz. Moderate exposures before birth were, in each case, associated with increased cancer after birth; but extreme exposures, encountered prenatally, were not. Our hypothesis is that this pattern occurs because MFs can have an

adverse effect on tissue development which, if it is severe and occurs in the first trimester of pregnancy, may often lead to prenatal abortion rather than to postnatal cancer.

2. *Little increase in cancer is to be expected in subjects who once lived at high-exposure homes, but who left those homes more than two or three years prior to cancer diagnosis.* (See Table 7 of our adult cancer paper, and the discussion of "onset age" in our 1979 paper. Note also that the Savitz study deals almost entirely with addresses occupied within three years preceding diagnosis.) And presumably a similar pattern may hold for occupational exposures.

3. *An increase in cancer rate may not be seen at all ages for a given type of cancer.* A discussion of this possibility is presented in some detail in our recently published paper, "Magnetic Fields and Cancer Subtypes" (*Annals of the New York Academy of Sciences*, 502, pp.43-54, 1987).

We have written this memo to urge those involved in epidemiological work on MF effects to try to explore the above ideas in their project planning and in their interpretation of results. Not all the ideas may prove valid, but there is a reasonable amount of evidence for them in existing data. And if they are valid, then not to include them in evaluating studies could lead to false negative conclusions, since each idea delineates an area where increased cancer risk may *not* occur with increased MF exposure, even if the hypothesis that MFs affect cancer proves to be true generally.

Congressional Questions on ELF Research

Following the October 6 hearing on the health effects of the extremely low frequency (ELF) electromagnetic fields (EMFs) associated with power lines, Congressman George Miller (D-CA), the chairman of the House subcommittee on water and power resources, asked the witnesses to follow up their testimony by supplying written answers to a number of detailed questions. Reprinted below are excerpts from some of those questions and answers. The complete exchanges will be published in the official hearing record, which is now at the printer and should be available in a couple of months. (See also MWN, September/October and November/December 1987.)

Dr. Ross Adey, VA Hospital, Loma Linda, CA

Q: When will the NCRP report on ELF to EPA come out?

A: We anticipate completion of the final draft in the spring of 1988. However, in accordance with NCRP procedures, review of this draft by the governing board is likely to take another year before publication.

Q: Please describe how the Department of Health and Human Services (HHS), in particular the NIEHS, has been involved in research on the biological effects of transmission lines. Have you ever tried to get funds from NIEHS or NIH?

A: I am not aware that any agency of HHS has ever been involved in significant support of any studies of possible health effects of power lines, either through support of individual projects or on a programmatic basis.

NIEHS has had a small program of intramural and extramural research, but this has dwindled in the last three years to an insignificant effort. The focus of intramural research at NIEHS was on reproductive abnormalities resulting from microwave exposure of birds' eggs. These studies were terminated two years ago and the laboratory closed. Studies of health effects of non-ionizing electromagnetic radiation (NIR) have held a low priority at NIEHS since their inception about 15 years ago, placing far greater emphasis on toxicology of environmental chemical pollutants. However, *NIEHS management has never considered the potential importance of joint actions of EM fields and chemical pollutants in cancer promotion and other health hazards....*

It has been the NIH custom to refer research proposals on NIR to radiology study sections with memberships composed almost exclusively of ionizing radiation biophysicists and physicians. In consequence, I and others are frequently requested to act as external reviewers on these proposals on an *ad hoc* basis. There is the presumption in this policy that there is no need for a separate study section to represent the constituency of researchers in NIR, or worse, that ionizing radiation scientists are inherently competent to examine these proposals. I submit that this is perilously close to malfeasance in public office. In essence, *we have grown contemptuous and frustrated by NIH policies to the point where it is recognized that no good purpose is served by submitting research proposals to NIH.*

The NCI sent a representative to several scientific meetings and symposia on bioelectromagnetics in 1985 and 1986. Personal discussions with him failed to elicit any indication that he grasped the significance of either the physics or the biology of these presentations. His own area of professional competence is restricted to ionizing radiation. It would not seem realistic to expect that his reports to NCI management would reflect a pervasive awareness of the scope and content of current knowledge.

Dr. Robert Becker, Becker Biomagnetics

Q: To do research adequately, a researcher needs upfront funding to finance research for approximately how many years?

A: The minimum number of years for which funding must be assured is three to four years....If the regulatory agencies or other branches of

the federal government require that the mechanism of action of such fields upon the human be determined before any action is taken, much valuable time, as well as lives, will be lost. Speaking as a physician I believe that such information is not required to deal with this urgent health problem. I therefore recommend that two approaches be taken concurrently. One, that laboratory evidence linking such exposure to cancer and genetic abnormalities be expedited. ...Two, to link such fields with human diseases in the real world, large-scale epidemiological studies need to be performed. It is via this approach that one will be able to determine the actual level of such fields that is productive of harm....I further suggest that such studies be undertaken at the two ends of the electromagnetic spectrum currently in use, that is, at the 60 Hz power frequency and at microwave frequencies.

Q: Do you think that chronic exposure to ELF fields has an effect on progeny and birth weights?

A: I believe that the data obtained in my laboratory and published in 1975-76 indicated that chronic exposure to ELF fields results in decreased birth weight and survivability of progeny....I further believe that the extensive studies done at Battelle and funded by the DOE are supportive of my results....

Sheldon Meyers, EPA

Q: How was the public policy decision to cut out all funding for NIR made at EPA?

A: The purpose of the NIR research program at EPA was to provide scientifically credible data on health effects to support guidance to other federal agencies on matters regarding NIR. The agency's Science Advisory Board reviewed a report on the biological consequences of radiofrequency (RF) radiation completed in 1984, and concluded that the report provided a scientifically defensible basis for developing guidance for RF radiation. The agency then considered expanding its research program on the health effects of ELF radiation. However, when ELF was considered next to other emerging priorities, such as radon, indoor air, stratospheric ozone, and global warming, it was ultimately decided the NIR research program would have to be phased out in order to increase our activities in these other important areas.

Dr. Jerry Phillips, Cancer Therapy & Research Foundation

Q: How would you describe the current state of funding for ELF NIR studies?

A: A number of adjectives come to mind when asked to "describe the current state of funding for ELF NIR studies," including, but not limited to, pathetic, abominable, and disgraceful. Dr. Ross Adey and others, testifying at the October hearing, have already painted a dismal picture in which frustrated scientists must confront a decrease in DOE's ELF budget, near extinction of ONR's budget, and no appropriate programs at either NSF or NIH. It appears that the electric utility industry is now funding more ELF work than any federal agency, a situation which, because of that industry's proprietary interest in such research, should, if nothing else, cause the government to fund well-planned and well-directed ELF research at a level at least comparable to industry's. Furthermore, while the U.S. is generally a leader in world science, one now sees us taking a definite back seat in government commitment and funding to the much smaller country of Sweden in the area of NIR research....I and several of my colleagues have encountered reluctance on the part of those charged with reviewing NIH and NSF grant proposals to recommend funding research in the area of bioelectromagnetics....I would recommend committing to a ten-year ELF research program. Individual researchers applying for ELF program funds should, as is

done commonly now, submit proposals detailing three to five years of scientific study, recognizing that funded projects would be eligible for renewal as is done at the NIH or NSF.

Dr. Richard Phillips, EPA

Q: What would be an appropriate level of funding for the federal government and non-federal organizations to spend during the next five years to adequately research the health effects of non-ionizing radiation?

A: ...It is my opinion that it would require about \$7-8 million a year for five years to adequately research the health effects of ELF radiation.

Q: Earlier this year, I understand you attended the electromagnetics meeting in Portland. How would you assess what was reported at the meeting? Do you think that non-ionizing radiation presents a serious health risk?

A: ...The results have shown the following: 1) There is an association between the incidence of cancer in humans and exposure to 60/50 Hz magnetic fields. 2) A number of mortality studies in the U. S. and in Europe have shown that the incidence of cancer is elevated above the general population level among workers in electrical and electronic occupations. Such workers are likely to encounter exposures to electric and magnetic fields at power frequencies, i.e. 60/50 Hz. 3) Exposure of laboratory animals to 60 Hz electric fields causes a phase delay in the circadian rhythm (daily biological rhythm) and a marked reduction in the normal nighttime increase in the level of melatonin, a hormone produced by the pineal gland located in the brain.... 4) Exposure to ELF radiation during a certain period of the circadian rhythm of laboratory animals reduces the effectiveness of drugs to relieve pain. 5) An increased incidence of fetal malformations has been reported in swine, rats, mice, chickens and humans exposed to ELF radiation. 6) Exposure of human cancer cells in vitro to 60 Hz EMFs increases their rate of growth. 7) Exposure of brain cells in vitro increases the efflux of calcium ions from brain cells at specific frequencies and amplitudes. 8) Exposure of cells in vitro activates protein production by DNA and may alter gene expression. The observed effects are frequency specific. 9) Exposure of cells in vitro activates the production of ornithine decarboxylase, an enzyme that may be important in cancer promotion.

...I have to conclude that exposure to ELF radiation can produce adverse biological effects. However, before one can state with any degree of confidence whether or not exposure is harmful to humans, and at what level and with what duration of exposure, we need to verify the effects that have been reported, quantify them in terms of exposure level and duration of exposure, and establish a basis for extrapolation of this data from animal studies and in vitro studies to the situation for humans....

Q: On September 16, 1986, you spoke in Toronto at a utility symposium on the health effects of EMFs. At that time, you said you wouldn't buy a home along a power line right-of-way (ROW). Do you still feel this way?

A: Yes. The reason for my answer at the Toronto meeting was based primarily on economics....If a causal relationship is established between exposure to magnetic fields and cancer, homes adjacent to ROWs of 230 kV or higher high-voltage power lines are very likely to show a marked depreciation in value. Accordingly, I would not buy a home on the edge of a ROW of a high-voltage power line. My answer to this question is still yes, not only for the economic concern I had at the time of the Toronto meeting, but because additional information that has come from more recent research indicates there may truly be a health hazard associated with chronic exposure to ELF radiation.

Robert Rabben, DOE

Q: [In a] memo provided by the Office of Energy Storage and Distribution to the subcommittee, it says, "In DOE's view, investi-

gation of the potential for health hazards due to EMFs is in the public interest. While research has shown that there are probably few direct short-term effects, the possibility of cancer enhancement cannot, at this point, be totally excluded." In view of the above statement, why did DOE expect a decrease in funding for FY 1988?

A: We believe that sufficient funds were requested to continue examining the most important health issues.

Dr. Leonard Sagan, EPRI

Q: What sort of clearance process does a researcher receiving funds from EPRI have to go through before the researcher's results are published? Do EPRI-supported researchers have to agree to restraints on what they find?

A: Results of EPRI-funded work may be published as either EPRI reports or in the open scientific literature. Studies published as EPRI reports are edited by EPRI staff members for both readability as well as for scientific accuracy. There are no restraints on what EPRI-funded researchers may publish in the open literature. Our standard contract does request that a copy of manuscripts be provided us at least one month before submission. Normally the EPRI project manager would [review] a manuscript with the investigator and suggest changes if warranted. They are not mandatory, however.

Q: In 1979, Dr. Nancy Wertheimer found results which some considered startling. Why didn't EPRI agree to fund a repeat of the Wertheimer study to confirm or deny her findings?

A: EPRI was not asked to fund a repeat of the Wertheimer study. We chose not to take an initiative to repeat this work because the New York Power Lines Project undertook a replication, the results of which are now available. EPRI has initiated a study of childhood leukemia and its possible relation to EMFs in another city, Los Angeles. Still another study is now in our planning process.

Dr. David Savitz, University of North Carolina

Q: If there were no limits on funding, what studies would you recommend be supported?

A: The electric utility worker study that we are conducting and a similar study conducted by investigators in Canada and France constitute one important strategy for expanding knowledge of the effects of occupational exposure. More work might be done, but these studies seem sufficient in that realm.

The area which is being developed more slowly and is in great need of government funding is the study of residential EMF exposures and childhood cancers. If funding were available, the next study of this issue should: 1) Cover a geographic area (probably three to five large urban populations) of sufficient size to study newly diagnosed cases of leukemia, brain cancer, and possibly lymphomas, along with controls identified around the time of case diagnosis; 2) Use a coordinated exposure assessment protocol based on wiring and in-home measurements. This is not radically different from our study or the ongoing Los Angeles study, but the study size would be notably advantageous, and by fine-tuning the methods based on past experience, a superior study would result.

It might also be noted that studies of this type are very difficult for independent investigators to develop because of their expense and logistical complexity. I would estimate that this study would cost at least \$2-3 million. The NCI has a tradition of noting suggestive findings and embarking on the most definitive study possible to confirm or refute those suggestions. An excellent example is the national bladder cancer study designed to address concerns with artificial sweeteners. I participated in a multi-center study of invasive cervical cancer with similar goals of addressing suggestive literature with more definitive information. Thus, I would be most supportive of the NCI developing (ideally with the collaboration of outside investigators) such a multi-center study of residential magnetic field exposures from power lines and childhood leukemia, cancer and lymphoma.

SPECIAL REPORT

U.S.A.F. Investigations of Radiation Incidents

At least ten times from June 1984 to June 1986, the U.S. Air Force (USAF) has investigated actual or possible overexposures of personnel to radiofrequency (RF) radiation. According to documents obtained by *Microwave News* under the Freedom of Information Act, officials at the Occupational and Environmental Health Laboratory (OEHL) at Brooks Air Force Base (AFB), TX, have confirmed partial or whole-body exposures above the USAF's permissible exposure limits (PEL) in five of the incidents. The USAF's frequency-dependent PEL is keyed to a specific absorption rate (SAR) of 0.4 W/Kg over a six-minute period.

The following summaries of the ten incidents are based on OEHL's reports. Copies may be obtained from: OEHL, Aerospace Medical Division, Brooks AFB, TX 78235. Refer to the report numbers that appear at the end of the summaries.

- On September 14, 1983, six workers were exposed to 420 MHz fields possibly as strong as 390 mW/cm² at Clear USAF Station, AK, when a technician accidentally switched on a high-power AN/FPS-92 tracking radar while the men were performing maintenance work (see *MWN*, November 1983, January/February and December 1984 and November/December 1985). OEHL conducted an RF radiation hazard survey at Clear on April 28, 1985, at the request of FELEC Services, Inc., the USAF's contractor for the facility. Though the survey report included no data that pertains directly to the accident, it concluded that the AN/FPS-92 radar "cannot be operated when personnel are in the radome," where the men had been working. The OEHL survey measured a maximum field of 3 mW/cm² from the AN/FPS-92 on the rooftop of a building 700 feet from the transmitter. Fields atop the roofs of scanner buildings located in front of AN/FPS-50 Detector Radars ranged from 5 to 30 mW/cm², and the USAF concluded that personnel should be prohibited from entering these areas during radar operation.

(Report No.85-105RN998FRA)

- On June 12, 1984, while installing an antenna on top of a TRC-87B radio van in 90-degree weather, an air national guardsman with the 103rd Tactical Control Squadron in Orange, CT, reported feeling hot. At one point the airman, Donald Wilson, inadvertently bumped against a support at the base of the antenna, which he said "felt like he had touched a hot car seat," and he immediately withdrew his arm. OEHL investigators later estimated that the contact lasted no longer than two seconds. Wilson's supervisor noticed the airman was sweating and told him to come down. The entire incident lasted 10-15 minutes, according to the investigators, who recreated it on February 4, 1985. They could not determine whether the system was transmitting during the incident, but the TRC-87B antenna, which runs at 259.4 MHz, was set to operate at 10 watts. The doctor who examined Wilson immediately after the incident observed a "mild" second-degree burn on part of one arm and first-degree burns on both arms. He "presumed" that the more severe burn resulted from RF exposure, according to the OEHL report. Two days later, Wilson reported nausea, diarrhea and cold, clammy skin after working outdoors. Officials supervising the recreation concluded that the airman "definitely was not overexposed" to RF radiation and that his second-degree burn was sunburn, aggravated by contact with the hot metal antenna support. Wilson may have been exposed to approximately 90 mW-s/cm² at his head, hands and torso and to approxi-

mately 1 mW-s/cm² at his upper arm, where the second-degree burn occurred. The PEL for the system's frequency is 2.59 mW/cm². Wilson's other symptoms were diagnosed as heat exhaustion.

(Report No.85-066RN491CRA)

- On September 1, 1984, two radio technicians for the Air National Guard in Savannah, GA, were attempting to fix a power amplifier problem inside a 775 MHz electrical equipment shelter (equipped with an MRC-113(V)2 open waveguide 283 CCS ANG) when they noticed that a waveguide collar connector and clamps had not been secured in a previous maintenance adjustment. In a test, the workers measured what they thought was a significant level of RF leakage into the shelter. That evening, TSgt. Ian Carson, who had been working near the shelter door, felt tingling in his hands, and as of February 1985, the date of OEHL's report, he continued to suffer intermittently from hand- and finger-joint pain. Investigators who reconstructed the event in December 1984 concluded that the worker was exposed to a maximum of 57 and 90 mW/cm² in his left and right hand-wrist areas, respectively. While finding that Carson had been overexposed – the applicable PEL is 7.75 mW/cm² – the OEHL report offered no clear explanation for his ailment, but concluded that induced current was not the cause. The second worker did not report adverse effects, and the USAF concluded that he had not been overexposed. Although not noted in the text of the report, Carson complained (in an attached statement) of suffering from previously non-existent high blood pressure. The USAF recommended further medical evaluation and suggested that technicians conduct RF radiation surveys of waveguide junctions at the end of all maintenance activities.

(Report No.85-051RN406BRA)

- On January 23, 1985, Senior Airman Richard Russell, a ground crew member at Bergstrom AFB, TX, was overexposed to RF radiation while inspecting an AN/ALQ-119 electronic counter measures (ECM) pod of an F-4 jet. Russell felt heat intermittently from his knees to his chest during the procedure. After reporting the problem, Russell was examined for possible symptoms of RF overexposure. The AN/ALQ-119 ECM pod is a jamming device used to protect the fighter jet in flight. In the reenactment of the incident – which took place at Eglin AFB, FL, due to concerns for EMI – an investigator also felt the heat sensation. OEHL estimated that the average power density levels ranged from 5.7 mW/cm² at Russell's head to 147.5 mW/cm² at his hands; his chest, groin and knees were also overexposed. The system's operating frequency is classified, but the stated PEL for 1-300 GHz is 10 mW/cm².

(Report No.85-113RN017GRA)

- On February 1, 1985, a Cannon AFB, NM, technician was troubleshooting an APM-358 Microwave Signal Source Test Set Drawer for a possible microwave leak when he felt a warm sensation in his left hand. After the technician shut the system down, a cracked waveguide connector was discovered – but the USAF did not promptly investigate or examine the technician, Airman First Class Mark Innis. Only when a macule (blemish) appeared on Innis's hand five days after the incident did he undergo medical care. The drawer's output signal is between 15.7 and 16.9 GHz at 100-150 milliwatts, mitigated by a 3 dB attenuator. OEHL concluded that, "Innis's sensation of warmth in his hand is consistent with the frequency range to which he could have been exposed." Though OEHL could not recreate the incident because the defective waveguide had been replaced, investigators estimated that the technician's whole-body exposure

was no more than 5.3 mW/cm², compared to a PEL of 10 mW/cm². Officials reported that his heat sensation could be attributed to the exposure but, because no burn occurred within 24 hours of the incident, they concluded, "It is difficult but not totally impossible to link the seemingly coincidental development of a transient macule to the exposure incident." They decided that no medical follow-up exam was necessary because there was no overexposure, and they recommended that personnel adhere to safety guidelines. (Report No.85-079RN028DRA)

• A technician at the McGhee-Tyson Airport in Knoxville, TN, was overexposed to RF radiation while conducting power amplifier performance checks on a 4.4-5 GHz AN/TRC-97A transportable communications system. On four or five nonconsecutive days between March 5 and April 3, 1985, the technician, TSgt. Larry Roberts, conducted three or four 10-15-minute power checks per day. The discovery of a defective waveguide on April 3 prompted an investigation. OEHL found that the 1,000 watt power amplifier source was reflecting as much as 300 watts two feet away, where Roberts was working. In the "worst case" scenario, OEHL calculated that Roberts was exposed to 26 mW/cm² each time he ran a performance check. The PEL at the amplifier frequency is 10 mW/cm². According to the report, RF radiation exposure effects "are not considered to be cumulative," and therefore, each exposure was considered independent. The OEHL's report did not say whether Roberts felt ill at any time, and though he underwent a medical exam, the results of that exam were not included in the report, which was released two months after the OEHL investigation. "Receipt of a completed medical evaluation...has been delayed for a number of unavoidable reasons," the report explained. (Report No.85-104RN332FRA)

• A civilian worker painting part of the containment of a phased array radar at Eglin AFB, FL, reported feeling flushed and dizzy and suffering from headaches and "chest pressure" in June 1985. Mark Stewart had twice previously painted the containment without falling ill. All three work periods were between June 10 and June 21. The AN/FPS-85 Radar operates at 400-500 MHz, but the precise frequency is classified. OEHL investigators found that Stewart was not overexposed; although fields in the areas where Stewart might have been were as high as 12 mW/cm², the OEHL concluded that he came no closer than four feet to an active radar element and thus, most likely, was exposed to fields on the order of 0.5 mW/cm², compared to a PEL of 4-5 mW/cm². The USAF recommended that all areas of array faces "should be considered as potentially hazardous." No medical evaluations beyond the initial examination immediately following the incident were deemed warranted. Investigators noted that fields on the ground in front of the radar "greatly exceeded" the USAF safety standard and specified that these areas, which are fenced off, should be marked with radiation warning signs. (Report No.85-148RA058HRA)

• On September 10, 1985, two airmen at Myrtle Beach AFB, SC, were overexposed to RF radiation while performing a maintenance procedure on a QRC 80-01. The device is a modified AN/ALQ-119 electronic counter measures (ECM) pod, operating in several frequency bands, all greater than 1 GHz. While repairing the device, Airmen First Class Gary Deeds and James Bell were unable to complete a mid-band balance test - they repeated the 5-10-minute procedure four times. After both men felt heat coming from the system, their instructors noticed that the QRC 80-01's dummy load was missing, indicating unintended emissions. According to the report, Deeds was anxious about having been exposed, but felt nervous about the possible repercussions of reporting the incident. He suffered "flu-like" symptoms, such as headaches and general

weakness, but returned to duty after a medical examination. Measurements taken during the OEHL's investigation suggested exposures ranging from less than 0.05 mW/cm² at the airmen's heads and below their waists to 90 mW/cm² at their hands; their abdomens and waists were exposed to 30 and 50 mW/cm², respectively. Deeds was exposed four times during the incident, while Bell was exposed at least once. The PEL above 1 GHz is 10 mW/cm². According to the OEHL report, "The exposure to the hands was the only one to have been at what could be called biologically meaningful levels." The report also cited the conclusion of a medical advisor (not the doctor who examined Deeds): "The only biological response which would be expected is the perception of heat which did take place. I do not consider the 'flu-like' symptoms related to exposure - it is not a known effect." He suggested that stress, rather than RF exposure, caused the symptoms and recommended against medical follow-up. (Report No.85-179RN137KRA)

• Three civilian workers experienced a combination of cramps, headaches, nausea and soreness after doing routine maintenance on the AN/DPS-5 Tethered Aerostat Radar System (TARS) at the Cudjoe Key USAF Station in Florida. TARS is a USAF balloon-borne surveillance radar, which operates at 3.22 GHz with a peak power of 1236 kW. One of the three men worked on TARS on April 1, 1986, and the two others worked on the system two days later. All were employed by RCA, which maintains the radar system. Billy Fortner, the worker who serviced TARS on April 1, suspected RF radiation "spill-over" and later reported cramps and soreness. Paul Williamson and Charles Lafferty, who performed power output adjustments on the radar for about 15 minutes on April 3, later reported headaches, nausea and midsection soreness. All three men were sent to a civilian hospital, which "did not differentiate between nuclear and RF radiation and therefore conducted some unnecessary procedures," according to the OEHL report. OEHL determined that none of the men were exposed to radiation levels above 1 mW/cm², compared to a PEL for occupational exposure of 10 mW/cm², and concluded that there could not have been overexposure because the men did not experience heat sensations or reddening of the skin while working. OEHL also found that Fortner's symptoms were not associated with microwave radiation because they started 20 hours after the incident and that Williamson and Lafferty, who began feeling sick within 15 minutes of the incident, probably suffered heat stress and motion sickness (the TARS radar unit rotated). The USAF recommended against further medical follow-up for the workers, but urged that an RF hazard training program be set up. (Report No.86-044RN0088FRA)

• On June 12, 1986, two men were exposed to 0.1 mW/cm² of 4950 MHz radiation from an AN/MST-TIA (MUTES) scoring radar while painting an air conditioner on the roof of a nearby building at La Junta, CO. Airman First Class Ted Leach, the first man to be exposed, had hung warning signs on two TLQ-11 radars housed in the building where he was painting but did not post a sign on the MUTES. After 45 minutes of painting, Airman First Class Kevin Coleman relieved him. Leach then noticed flashing lights on the MUTES, indicating that it was transmitting. Coleman was exposed for no more than 10 minutes, according to OEHL investigators. In measuring radiation levels on the roof, the investigators found that neither worker was exposed to fields in excess of 0.1 mW/cm², although fields as strong as 10 mW/cm² were measured in accessible areas. The PEL at 4950 MHz is 10 mW/cm². OEHL's report concluded that written safety procedures are sufficient to control roof traffic and to prevent future exposures. The investigators found no medical evidence of overexposure and recommended against medical follow-up. (Report No.86-070RN0063HRA)

UPDATES

BIOLOGICAL EFFECTS

Schwan Lecture...In 1986, Dr. Herman Schwan, professor emeritus at the University of Pennsylvania, delivered the Lauriston S. Taylor Lecture at the annual meeting of the National Council on Radiation Protection and Measurements (NCRP). The NCRP has now published Schwan's talk, *Biological Effects of Non-Ionizing Radiations: Cellular Properties and Interactions* (Lecture No.10), in booklet form. It is available for \$12.00 from: NCRP Publications, 7910 Woodmont Ave., Suite 1016, Bethesda, MD 20814, (301) 657-2652. The lecture will also be published as part of the proceedings of the NCRP's 1986 meeting.

Bioeffects Critique...The U.S. Air Force has released a *Critique of the Literature on Bioeffects of Radiofrequency Radiation: A Comprehensive Review Pertinent to Air Force Operations* (USAFSAM-TR-87-3), by Louis Heynick, who recently retired from SRI International. The 691-page review covers non-ionizing radiation effects in the 10 kHz-300 GHz frequency range and was commissioned as a reference source for environmental impact statements on radiation-emitting USAF systems; it features more than 600 references. For more information, contact: James Merritt, USAF School of Aerospace Medicine, Human Systems Division, Brooks AFB, TX 78235, (512) 536-3583.

COMPATIBILITY & INTERFERENCE

ESD Suspected in MX Explosion...Plaintiffs in a lawsuit filed last September, which alleges that the armed forces have not adequately addressed the issues of hazards of electromagnetic radiation to ordnance (HERO), have asked the Pentagon to produce reports on a recent MX missile fire which killed five technicians (see *MWN*, September/October 1987). The explosion occurred while fuel was being loaded into the first stage of an MX missile at a Morton Thiokol plant in Utah on December 29. Although company officials have not specified the cause of the accident, the plaintiffs suspect that electrostatic discharge (ESD) was to blame. The lawsuit, now in pre-trial discovery, also seeks data on more than 50 weapons systems accidents – including six other solid fuel explosions and some of the recent UH-60 Black Hawk Army helicopter crashes (see *MWN*, November/December 1987). In court papers, the plaintiffs – whose number has grown from four to 39 and now includes Physicians for Social Responsibility – allege that there are similarities between the MX accident and a 1985 Pershing II missile explosion in West Germany (see *MWN*, June 1985).

Assorted Notes...In our September/October 1987 issue, we featured a report on the efforts of NBS's François Martzloff to control conducted EMI. For more on this, see Ivars Peterson's article, "In Search of Electrical Surges," in the December 12 *Science News*....The Microwave Filter Co. has issued *The*

Filter Book, which covers the company's products in the 1 MHz to 26 GHz frequency range. Copies are available from: Microwave Filter Co., 6743 Kinne St., East Syracuse, NY 13057, (800) 448-1666, or (315) 437-3953 in NY....Two Texas Instruments Inc. researchers have published "Characterization of Metals as EMC Shields" in the September 1987 *IEEE Transactions on Instrumentation and Measurement*....Comsearch Applied Technology, Inc. of Reston, VA, has won a \$5.6 million contract from the Naval Surface Warfare Center in Dahlgren, VA, for below-deck EMI services....In our last issue, we noted the conflict between British radio astronomers and broadcasters over limited frequency space. Now, according to the December 24/31 *New Scientist*, the potential interference problem appears to have been resolved by reallocating spectrum space given to air traffic controllers; broadcasters can now hope for a fifth television channel by 1991, leaving astronomers free to detect pulsars without EMI.

GOVERNMENT

FCC on FM Boosters...The FCC has proposed adding FM booster stations to its list of facilities that must comply with its RF radiation health regulations. The move was prompted by July 1987 FCC rules that lifted the previous 10-watt limit on output power. Now, FM boosters can be much more powerful – up to 20% of the maximum permissible ERP of the primary station. In 1985, the FCC issued regulations requiring applicants for its licenses to either meet the ANSI RF/MW radiation safety standard or complete an environmental impact statement (see *MWN*, April 1985 and March/April 1987). Comments were due by February 8, with reply comments due by February 23. For more information, contact: Dr. Robert Cleveland at the FCC's Office of Engineering and Technology, (202) 653-8169.

...and on Satcom Stations...On December 30, the FCC issued a public notice (No. DS-703) reminding all applicants for transmitting earth stations that they must "include a statement that the station is in compliance with the environmental radiation health standards" codified in the commission's regulations. Those not in compliance must submit an environmental assessment.

MEASUREMENT

Magnetic Field Meter...Electro-Metrics has introduced a new meter that can measure low-level magnetic fields. The MFM-11 unit has a minimum sensitivity level of 1 nT from 20 Hz to 50 kHz – users can select any one of a large number of frequency bands within this range. In addition, filters are available to screen out power line noise. The unit costs \$6,995 and is designed primarily for TEMPEST and EMC applications. For more information, contact: Paul Sikora, Marketing Manager, Electro-Metrics, 100 Church St., Amsterdam, NY 12010, (518) 843-2600.

MEETINGS

Hanford ELF Symposium...In October 1984, DOE, EPRI and Battelle Pacific Northwest Labs sponsored the 23rd Hanford Life Sciences Symposium on the *Interaction of Biological Systems with Static and ELF Electric and Magnetic Fields* in Richland, WA, home of the Battelle Labs. The proceedings of the meeting are now available. Because of the long delay in publication, many of the papers are no longer current. Nevertheless some of them are still useful and among these are: Dr. Hans-Arne Hannson's (of Sweden) observations of "lamellar bodies" in cerebral tissue of exposed animals. Dr. Gregory Lotz and Jack Saxton's (both of the Naval Aerospace Medical Research Lab in Pensacola, FL) second study of monkeys chronically exposed to ELF fields (see *MWN*, September 1984), designed to simulate the U.S. Navy's submarine communications system, which operates between 72 Hz and 80 Hz. Lotz and Saxton also reviewed the lab's first monkey study – a final report on that experiment was never published. Also of particular interest is Dr. Don Deno's (of GE) discussion of exposures to weak electric and magnetic fields in the home. In all, there are more than 40 papers by researchers from around the world. A copy of the 553-page paperback volume is available for \$25.00 from: Dr. Larry Anderson, Battelle Pacific Northwest Labs, PO Box 999, Richland, WA 99352, (509) 375-2294.

Israeli Meeting Canceled...The *International Symposium on Interaction of Electromagnetic Fields with Biological Systems*, which was scheduled to be held this March in Israel, has been canceled "due to lack of interest" (see *MWN*, November/December 1987).

MILITARY SYSTEMS

Microwave Weapons...If you want to know what a microwave weapon looks like, open the December 7, 1987 issue of *Aviation Week* to page 85 for a picture of the U.S. Air Force's "Gypsy microwave device," which is being used to test the susceptibility of electronics systems. The Gypsy device can produce more than one *gigawatt* of power in short pulses and is tunable over the frequency range 800 MHz to 40 GHz. The Air Force program is based at Kirtland Air Force Base, NM, where a conference on high-power microwave (HPM) technology was held in December 1986 (see *MWN*, January/February 1987)....According to the May 4, 1987 *Aviation Week*, the HPM effort sponsored by the Defense Nuclear Agency (DNA), the U.S. Air Force and the U.S. Navy has a budget of \$15 million in fiscal year (FY) 1988....Some of that money will go to the company that successfully responds to a DNA request for proposals (RFP No.DNA001-88-R-0009, issued on November 25) for 45 months worth of studies on the effects of HPMs on weapons systems, on methods to protect such systems and on the feasibility of propagating HPMs

through the atmosphere. Among the options listed in the RFP are experiments designed to "determine the maximum microwave power density...that can be propagated through the atmosphere before air breakdown occurs" and tests to determine the HPM susceptibility of orbital satellites. The winning contractor will need a top secret security clearance....The Lawrence Livermore National Lab (LLNL) and the Sandia National Lab are also working to assess the vulnerability of electronics to HPMs. There is a short article on the program in the July 1987 issue of *Energy and Technology Review*, published by LLNL....And in its March 1987 issue, the magazine featured a longer item on LLNL's research on HPMs and pulsed power....Dr. James Benford of Physics International in San Leandro, CA, reviews "High Power Microwave Simulator Development" in an article appearing in the December 1987 issue of the *Microwave Journal*....The U.S. Army has its own product – a radiofrequency (RF) weapon. In the August 24, 1987 *Defense News*, John Rosado of the Harry Diamond Labs in Adelphi, MD, is quoted as saying that "the nature of warfare will be completely changed by the use of [RF] weapons." Rosado also noted that RF radiation could be used over a wide battlefield with phased arrays....Some of the DOD's concern over RF and HPM weapons is reflected in a recent glossy pamphlet, *The Soviet Space Challenge* (issued in November 1987), in which the DOD notes that, "The Soviets could test a ground-based [RF] weapon capable of damaging satellites in the 1990s."...Watch for the review of "Tactical Microwave Weapons" by Dr. H. Keith Florig of Carnegie-Mellon University in the March 1988 issue of *IEEE Spectrum*.

OVENS

CU Ratings and Warning...In its January 1988 issue, *Consumer Reports* rates microwave ovens. At the top of the list are units by Litton, GE, Whirlpool and KitchenAid, with prices ranging from \$328 to \$385. As for safety, Consumers Union (CU) found that all the ovens tested were "well within" the FDA's leakage standard and notes that, "A door seal on all recent models minimizes leakage even when slight gaps develop between the door and the oven."...In its February 1988 issue, CU issues a warning concerning what appears to be the use of scare tactics to sell an oven radiation meter. CU cites an ad by American Health Products of Houston, TX, which quotes the bulletin of the "National Microwave Safety Council" as urging that all ovens be immediately checked for leaks and which also quotes *Business Week* as warning that CU found many leaking ovens. The trouble is that the CU quote is 15 years old, and CU could find no trace of the council. And the Houston outfit, which sells its meter for \$29.95 is not listed in the Houston telephone book. The FDA is now trying to track down both the Houston company and the council – so far, without success.

Assorted Notes...The sales of microwave ovens continue to shatter all records. The Association of Home Appliance

UPDATES

Manufacturers, based in Chicago, IL, reports that more than a quarter of *all* appliances shipped in 1987 were microwave ovens – the largest annual shipment of any major appliance in history....On a more somber note, three physicians from the University of Iowa in Iowa City describe two cases in which infants suffered burns from microwave ovens. "Microwave Oven Burns to Children: An Unusual Manifestation of Child Abuse" appears in *Pediatrics*, 79, pp.255-260, 1987.

PEOPLE

Sheldon Meyers, director of the EPA's Office of Radiation Programs since August 1984, is leaving his post to become the agency's associate administrator for international activities. **Richard Guimond**, the head of the EPA's radon division, is taking over for Meyers....**Thomas Keller** has been appointed chief scientist at the National Association of Broadcasters (NAB). Keller will work out of the NAB's new Broadcast Technology Center, which seeks to encourage the development of high-definition television. **Michael Rau**, a staff engineer, is taking over many of Keller's former duties. Rau has been named a vice president and the acting head of the NAB's

Science and Technology Department....**Jules Cohen** will receive the NAB's Engineering Achievement Award at this year's convention in Las Vegas on April 9. Cohen is the president of Jules Cohen & Associates, a consulting firm in Washington, DC....**Dr. Forrest Lee Carter** of the Naval Research Lab in Washington, DC, died of cancer on December 20. Among Carter's many interests were the emerging fields of molecular electronics and solitons....The Bioelectromagnetics Society (BEMS) has decided not to present its D'Arsonval Award this year. The prize is given in recognition of outstanding research achievement. (Sources say that the BEMS board was divided between two candidates.)

ETC...

Radio Radio Everywhere... Anne Scully lives in Hull, MA, near WBZ's 50 kW transmitter, and she can pick up the station from her radiator and from her telephone. She told *The New York Times* (January 17) that her neighbors can pick up WBZ from their microwave ovens and their toilets. NPR's *All Things Considered* also aired a light-hearted piece on Mrs. Scully's troubles the same week.

McFarland Cancer Cluster (continued from p.1)

compatibility consulting firm in Los Angeles, told *Micro-wave News* that, although he had not made any measurements in McFarland, he thinks that a "substantial" field would impinge on a town as close to the VOA transmitter as McFarland. The engineer, who has nearly fifty years of experience in electromagnetic field measurements – much of it in southern California, said that he has received numerous inquiries about the possible impact of the VOA radiation on McFarland. "It is far more significant than parts-per-million chemicals," he said. The engineer asked that his name not be used.

Other experts have raised the possibility that some kind of synergy between toxic chemicals and non-ionizing radiation may be at work in McFarland. Laboratory studies indicate that microwaves can enhance the carcinogenicity of benzopyrene and the teratogenicity of cytosine arabinoside (see *MWN*, May 1981 and January/February 1987). Microwaves can also act synergistically with drugs (see *MWN*, February 1981).

Indeed, new experimental evidence points to the efficacy of the combined action of RF radiation and chemicals. Adey explained that, "Work in our laboratory by Dr. William Fletcher has shown that weak modulated RF fields can significantly enhance chemical cancer promoters. Together they disrupt communications between cells through gap junctions. These findings are consistent with modern cancer models, which emphasize that this type of disruption leads to unregulated cell growth."

In addition, some of those interviewed said that the intermittent nature of the VOA broadcasts could pose a greater health risk than constant exposures, because on-and-off stimuli prevent biological systems from adapting.

Since 1975, at least 12 children have developed cancer in McFarland, which has a population of approximately 6,000. Six of the children have died. Eight of the cases were diagnosed in the 1982-1985 time period, which constitutes a much rarer cluster. Two of the cases were identified before 1982 and two after 1985.

Many different types of cancer have been diagnosed among the McFarland children, including leukemia and brain and kidney cancer.

In a telephone interview from McFarland, Connie Rosales, a mother of one of the cancer victims, said that she thinks at least two additional cases should be counted as part of the cluster. In addition, as we go to press in early February, there are news reports of the diagnosis of the 13th childhood cancer case in McFarland – a seven-year-old with a brain tumor.

According to Dr. Matthew Zack of the Chronic Disease Control Division at the Centers for Disease Control in Atlanta, GA, cancer clusters occur "fairly frequently," but eight cases in four years is "exceptional." Zack is a member of the newly-established McFarland Advisory Committee, chaired by Dr. Kenneth Kizer, the head of the California health department.

In addition to the cancer cluster, McFarland had "relatively high rates" of infant deaths in 1982-1983 and of fetal deaths and low birth weights in 1981-1983.

Because of the grouping of cancer cases in 1982-1985, ESSS officials, who wrote the new report, placed particular emphasis on the period from January 1980 to January 1982 as the time when McFarland would most likely have been exposed to a toxic agent. They call this period the "window of vulnerability." McFarland's Rosales said she is skeptical about the window theory. A previous study by the county failed to identify any cause for the cluster based on then existing (1986)

conditions.

In numerous interviews with *Microwave News*, ESSS officials said that they had been advised by the VOA and by the Environmental Protection Agency (EPA) that the non-ionizing radiation levels in McFarland were "well below all existing standards." The ESSS report states that the EPA reviewed the VOA data and concluded that "any adverse health effects" in McFarland citizens were "unlikely to be related to RF radiation." ESSS adds, "We agree with this conclusion."

ESSS staffers are also skeptical about a possible link between VOA radiation and the cluster because they have been unable to document any changes in broadcasting from the Delano station during 1980-1983.

The state report also finds that it was unlikely that water contamination by nitrates and arsenic triggered the cancers. After reviewing existing records of pesticide use, the study found nothing abnormal in the types or amounts of pesticides applied in McFarland. "What we saw were commonly used pesticides in usual amounts," the report concludes. Nevertheless, four pesticides – dimethoate, fenbutatin oxide, dinoseb and dinitrophenol – have been targeted for further study.

The only partially suggestive finding in the state study is that 80 percent of the fathers of the cancer cases, compared to 45 percent of the fathers in a control group, worked in the crop fields in the time interval between three months before pregnancy and the date of diagnosis of the child's cancer. According to the report, "This is of borderline significance." The state plans to study this finding further in the next phase of its investigation.

Only one set of RF measurements has ever been carried out in McFarland. On February 6, 1986, a team of VOA engineers measured a level of $10 \mu\text{W}/\text{cm}^2$ under a local power line and concluded that, "This implies that any health problems encountered in McFarland city were not directly linked to the VOA facility in Delano."

One of the engineers who took the measurements in McFarland and who no longer works at the VOA, told *Microwave News* that all their measurements were keyed to the levels specified in the 1982 American National Standards Institute (ANSI) standard: "We did not expect to find anything and we didn't."

The VOA did begin negotiations with the EPA to measure RF radiation levels at Delano and at other VOA stations. Due to lack of funds, however, no interagency agreement was ever completed and no additional measurements were taken.

Many non-ionizing radiation bioeffects experts agree that more detailed measurements are needed. In a telephone interview, Dr. Sam Milham of the Washington state Department of Social and Health Services said that, "It would be a good idea to do some measurements." Milham recently published a study showing that amateur radio operators have an increased rate of cancer mortality (see *MWN*, November/December 1987).

At the first meeting of the new advisory committee on January 29 in McFarland, a Kern County resident raised the

issue of the need for more non-ionizing radiation measurements. At this time, the state has made no commitment to additional radiation measurements.

Very few studies of low-level exposures have ever been completed. In one landmark study carried out at the University of Washington in Seattle, rats exposed for their lifetime to the equivalent of the levels allowed by the ANSI standard showed a statistically significant increase in cancer (see *MWN*, July/August 1984 and March 1985).

In 1986, a group of Italian researchers showed that rats exposed to RF levels that were 4,000 times below the ANSI guidelines experienced developmental ill effects (see *MWN*, November/December 1986).

Until recently, the proposition that low levels of non-ionizing radiation could be biologically active or play a role in the development of cancer has been dismissed. In the last two years, however, a large body of evidence has accumulated indicating that extremely small (50/60 Hz) power line magnetic fields – as low as 2-3 mG – may promote cancer (see *MWN*, November/December 1987). The California study did investigate the distribution of power lines in McFarland but found no "significant changes" during 1980-1982.

The emerging link between a cancer risk and magnetic field exposures may be important in McFarland. Engineers explain that at shortwave frequencies, the ground-level magnetic field is stronger than the electric field component. Indeed, the VOA's own 1986 field survey at the Delano station shows that the measured magnetic field at 1,535 feet from one of the antennas was often greater than at 935 feet.

Also, last year, a preliminary epidemiological study by the Hawaii Department of Health indicated that people living near broadcast radio and television stations had a statistically significant higher rate of cancer than those whose homes were not near broadcast towers (see *MWN*, May/June 1987). In addition, the Cancer Research Center in Hawaii has identified a leukemia cluster among children living near a U.S. Navy communications complex at Lualualei on the island of Oahu (see *MWN*, May/June 1987).

A retrospective and an ongoing prospective epidemiological study of members of the Polish military exposed to RF and microwave radiation indicate a threefold increased risk of developing cancer; for some types of cancer, the risk is seven times greater than for controls (see *MWN*, March 1985 and January/February 1987).

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