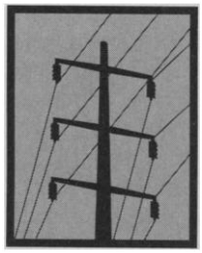
Flying Blind: The Making of EMF Policy

Electromagnetic fields may be dangerous—or they may not. How should policy be formulated in this state of confusion?



Last in series

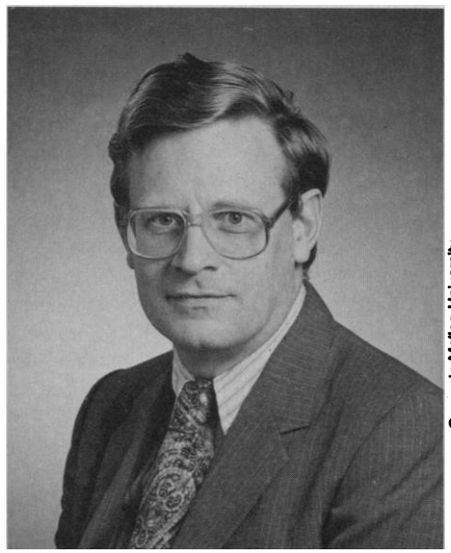
WHEN THE BOEING Company agreed in August to pay $500,000 to ex-employee Robert Strom, who claimed that on-the-job exposure to electromagnetic radiation had given him cancer, it dramatized how high the stakes have become in the controversy surrounding electromagnetic fields (EMFs). Strom, who for 3 years had tested how MX missiles withstood electromagnetic pulses, later developed leukemia and blamed the company, citing scientific evidence that EMF exposure may be linked to different types of cancer. Although Strom had lost an earlier case for worker's compensation, Boeing decided to settle this one out of court, and observers say the decision could open the door to a rash of personal injury cases where cancer victims try to pin the blame on EMF exposure.

But whether Strom *vs.* Boeing is the beginning of a trend or just a one-time accommodation, one thing is clear: EMFs pose a dilemma. On the one hand, there is no solid proof that EMFs are dangerous. Several epidemiological studies have found links between EMF exposure and certain types of cancer, especially leukemias, lymphomas, and brain cancers, but the data are inconclusive (*Science*, 7 September, p. 1096). And lab experiments have shown that low-frequency EMFs like those produced by power lines and electrical appliances can have biological effects, but there is no direct evidence that these effects lead to cancer or other health problems (*Science*, 21 September, p. 1378).

On the other hand, there is an increasing consensus that EMFs may pose some type of health hazard for humans, and many scientists believe this possibility cannot be ignored. "The researchers I speak to put the chances at between 10% and 60% that EMFs will turn out to have some health effects," says Granger Morgan, head of the Department of Engineering and Public Policy at Carnegie Mellon University in Pittsburgh. And, as Strom's case suggests, EMFs have already proven to be threatening to one kind of health: the financial health of corporations. The number of personal injury cases involving EMFs is small but growing, says Thomas Watson, a Washington, D.C., attorney who represents utilities and appliance manufacturers on EMF-related matters. There have also been dozens of attempts by citizens' groups and local governments to block construction of transmission lines and electric substations. "The increasing legal and regulatory proceedings," Morgan says, "indicate that there is a growing social cost of doing nothing."

The EMF quandary is typical of the problems that face policy-makers any time they tackle an issue that depends on scientific information, but on which the scientific data are far from conclusive. Morgan, who has done an extensive study of policy-making in such data-poor settings, says it is possible to formulate a reasonable course of action for the next few years until more is known about EMFs, and he identifies three issues that need to be addressed: regulation of EMF exposure without complete knowledge of the fields' biological effects, funding of further research, and preparation for the possibility that there is a real problem.

Each of these issues offers its own challenges. Regulation is potentially the most contentious issue since it could be quite expensive to industry, but so far there are few limits on EMF levels. The federal government has no guidelines on EMF exposure, although Representative Frank Pallone (D–NJ) has said he plans to introduce legislation to set national exposure standards. Seven states limit the maximum electric field near high-voltage transmission lines, and two of those also have limits on the magnetic fields, but those limits are mostly efforts to make sure that new lines generate no higher fields than existing ones. And no states currently limit the fields from distribution lines, which carry electricity to individual buildings.



Carnegie Mellon University

Prudent avoider. *Granger Morgan advises doing the easy things to lessen EMF exposure.*

Even if EMFs should prove dangerous, there is a major stumbling block to deciding what to regulate: "We don't know exactly what the concept of dose should be," says Thomas Tenforde at Battelle Pacific Northwest Laboratory in Richland, Washington. Laboratory studies have shown that the biological effects of EMFs can vary in unusual ways as the intensity of the field changes—sometimes a field of one intensity will have an effect, while intensities either higher or lower have none. This makes setting an EMF intensity standard problematic, to say the least. "The guidelines we use for chemical carcinogens are [probably] not appropriate for this agent," says Robert McGaughy, who is overseeing a report on EMFs and cancer for the Environmental Protection Agency.

In the face of such uncertainty, governments have a number of options, Morgan says. The most common approach so far has been the similarity-based approach, which simply means: "Don't do anything to make the situation worse than it is." New York, for example, is preparing to adopt codes that will limit magnetic fields from new transmission lines to 200 milligauss on the edge of the right-of-way, a limit that was determined by measuring the magnetic fields near existing transmission lines.

Some observers argue, however, that such standards are meaningless and could damage industry. "You're trying to pick a number because someone says to pick a number, but there's no real basis for it," says Bill Feero, president of the consulting firm Electric Research and Management in Pittsburgh. The danger here, he says, is that once the precedent exists for setting limits, agencies or legislatures may well set limits that are quite expensive to meet without any payback in terms of a healthier environment.

Morgan suggests it should be possible to avoid such problems by using "prudent avoidance"—doing the relatively easy things to sidestep a risk. "In our private lives," he says, "we make these judgments all the time." As an example, he tells how he rearranged the furniture in his son's bedroom so that the bed was no longer adjacent to the point where the electric power cable came

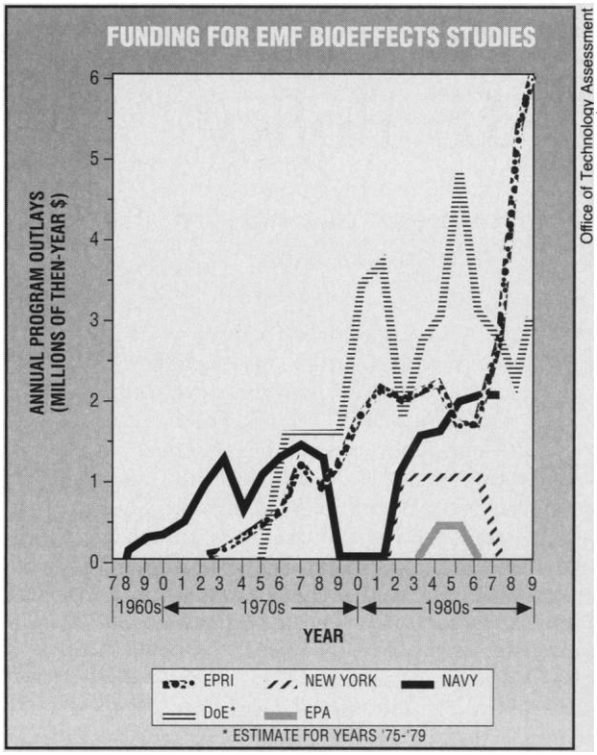
into the house. "I would not spend large amounts of money to redesign my house," Morgan says, "but if it's something simple, why not?"

Indeed, the idea of prudent avoidance has already been used in at least one regulatory case, says attorney Watson. Last year, the Public Service Company of Colorado applied for an upgrade of an existing transmission line. During the hearings, Watson says, "we showed why the utility's work in designing and routing was consistent with prudent avoidance." The upgrade was approved.

It won't be easy to legislate prudent avoidance, Morgan says, since the U.S. legal system tends to classify things as either safe or hazardous. "I can envision the tort system shoving you into a position where you have to spend unlimited money to avoid the fields." Nonetheless, Morgan thinks laws and regulations could be written in such a way to keep the money and effort spent on limiting EMF exposure to a reasonable level. "You could probably justify spending up to a few thousand dollars per person-exposure avoided," he says, based on how much is spent to avoid other hazards and on the current evidence concerning EMFs.

The long-term solution, however, is obviously to understand the biological effects of EMFs well enough to know whether a problem exists, how bad it is, and what to do to avoid it, and this means more research. But research takes money, and there's the rub. Over the past decade, federal and private funding of EMF research has been spread so thin that there has rarely been enough even for replications of positive experiments. "Everybody's working on a different project," says biologist Reba Goodman at Columbia University, who studies how magnetic fields affect RNA transcription. "It's crazy. It's the money."

And that seems unlikely to change any time soon, given the federal budget constraints that Congress is wrestling with. New Jersey's Pallone introduced a bill this summer that called for a 5-year, $34-million research program, but it didn't make it out of committee. And George Brown (D–CA) offered an amendment to an Environmental Protection Agency authorization bill to give the agency $5 million for EMF research from 1991 to 1993, but it, too, went nowhere. That leaves the Department of Energy as the main federal sponsor of EMF research, with $3 million in 1990 and a still-to-be-determined amount for 1991. It could be anywhere between $1.7 million and $4 million, says Imre Gyuk, DOE's program manager for EMF research.



Limited sources. *U.S. funding for EMF research has been mostly through the Electric Power Research Institute and DOE.*

Some scientists say that the source of the funds for EMF research is just as important as the amount: "Who controls the funds? That's the only question as I see it," says Allan Frey, an independent consultant and long-time researcher into the biological effects of electromagnetic radiation. To date, most of the funding for EMF research has come from agencies that have a real or perceived tie to the electric power industry.

The Electric Power Research Institute (EPRI), a private organization funded by utility companies, has consistently been the major funding source for EMF experiments; this year it will spend $6 million on the research. In the federal government, most of the low-frequency EMF work has been paid for by DOE, which many scientists perceive as having a pro-energy bias. "Each [of the major funding agencies] has very decided views," Frey says. "Scientists are concerned about losing funding if they upset their sponsors. It's a real fear."

For their part, the funding agencies deny they put any pressure on researchers. "We all want to know the truth," says Leeka Kheifets, an EPRI program manager in charge of epidemiological studies. And some scientists agree. "We've been totally left alone to do this study," says Michael Bracken, a Yale epidemiologist overseeing an EPRI-funded project on the effects of electric blankets on pregnant women. "The people we deal with [at EPRI] are scientists just like we are." If it were any other way, Bracken says, he would quit.

But other researchers say they can't be oblivious to the source of their money. "These are expensive experiments and we can't afford to lose the funding," says one scientist who has been in the field for several years. That researcher adds that while the funding concerns do not affect how the research is conducted, they do make a difference, for instance, in how the results are reported to the media. "I don't want to come across as some nut who scares the whole population," the researcher says.

As a result, some researchers are calling for other federal agencies to play a role in funding EMF research. One candidate is the Environmental Protection Agency, which had a small low-frequency EMF program in the mid-1980s until budget cuts killed it. The agency is interested in getting back into the field, says the EPA's McGaughy. But that agency too is subject to political influences that may play a role in determining its posture toward EMFs. The report on EMFs now under revision at EPA provides a case in point.

In a preliminary draft of the report, the authors had concluded that electromagnetic fields were a "probable human carcinogen," a classification that would have made them subject to a variety of regulations. But "probable" was weakened to "possible" by higher-ups in the EPA, and several media reports suggested White House pressure was behind the switch. The White House did see the preliminary draft, McGaughy acknowledges, but he says the decision to make the change "came from our own in-house discussions."

Conversely, observers familiar with the workings of EPA suggest that politics may have had a role in the original "probable carcinogen" classification. "In the last 1½ to 2 years, [some people at the EPA] have decided that EMFs are a way to get their budget jacked up," says one university scientist close to the field. An official in another government agency analyzes the report this way: "The original bias was, 'Go find the dirt—there is a causal connection [between EMFs and cancer].' Then a bias was put on top of that saying, 'It's not all that serious.' "

Perhaps the best candidate for new EMF funding, many researchers say, would be one with no previous connection with EMFs and with a solid track record in funding basic biological research. These criteria seem to point naturally to the National Institute of Environmental Health Sciences,

one of the National Institutes of Health. In the past, NIH has had a reputation among researchers as not being very receptive to proposals to study EMFs, but that seems to be changing. "We do have an interest [in funding EMF work]," says Anne Sassaman, director of extramural research and training at NIEHS, which is located at Research Triangle Park, North Carolina. Two weeks ago, Sassaman met with representatives from several other funding agencies, including the EPA and the National Institute of Neurological Disorders and Stroke, as a "first step" toward funding EMF research, including a possible "targeted program."

Whoever funds the basic biological research, there is one other funding issue that must be considered. "If EMFs do pose a risk, the persuasive evidence could emerge rather quickly—within 5 to 8 years," Morgan says. "There will then be fairly rapid pressure to start doing things to avoid EMF exposure." So if we are to avoid "lots of dumb, cost-ineffective measures" 5 years from now, research on lessening EMF exposure needs to start immediately.

Some simple steps have already been worked out. Last year, IBM announced it had found a way to reduce electromagnetic radiation from its video display terminals. Northern Electric, manufacturer of Sunbeam electric blankets, now makes a blanket with greatly reduced field strengths. And most utility companies are arranging the wires in their high-voltage transmission lines to reduce the magnetic fields, Feero says. However, EMFs from local distribution systems, which have been implicated in some epidemiological studies as being linked with childhood leukemia, will be much harder to reduce, says Frank Young at EPRI. One major problem is that the grounding of home electrical systems to water pipes or the earth creates a return circuit independent of the utility wires, and the current through this grounding system creates EMFs in a complicated fashion.

The utility industry is already beginning to study how it might solve these problems, however, and that decision—undertaken even before the fields are proven to be a hazard—seems to sum up the entire dilemma over EMFs. This research policy, as obvious as it seems, could end up costing power companies a lot of money, Feero says. "The trouble is, as soon as the industry comes up with a technique to lower exposure by an order of magnitude, somebody will force them to do it, even without the facts [about risks]. Nonetheless, Feero says the cost of not doing it could prove to be a lot greater if EMF's do indeed turn out to be a human carcinogen. "It's a gamble the industry has to take." ■ ROBERT POOL

GE's Cool Diamonds Prompt Warm Words

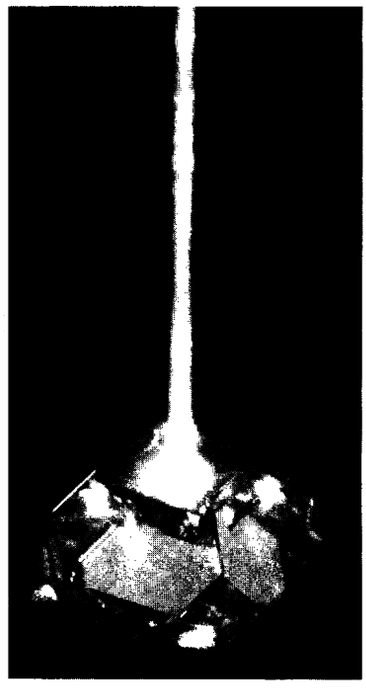
Scientists at Harvard and MIT charge that General Electric has "arrogated to itself" the life's work of a lowly researcher

HOW MUCH CREDIT does a big research company owe an amateur who's been hanging around its labs for years and badgering its staff to test a pet idea, when suddenly his idea may be worth, say, $50 to $100 million a year?

That question is now bedeviling the General Electric Company in a spat between its research lab in Schenectady, New York, and a 43-year-old Harvard phenomenon named Russell Seitz. In his own words, Seitz's profession is "oldest living graduate student." He has no degrees, graduate or undergraduate, but has spent a lot of time in the labs of Harvard and the Massachusetts Institute of Technology (MIT).

It was at Harvard in the early 1970s that Seitz says he first became convinced that isotopically pure diamond made from carbon-12 would be an excellent conductor of heat. Though he published nothing on it in peer-reviewed journals, he talked about the idea to numerous scientists—including GE researchers—and even filed for a related patent in 1975. He says he couldn't get GE to test the idea.

But GE did eventually make an isotopically pure carbon-12 diamond. The company announced the achievement in July this year and reported that the material is the best room-temperature heat conductor ever made—about 850% more efficient than copper and 50% better than natural diamond (*Science*, 6 July, p. 28). The discovery, which GE says it made without any help from Seitz, has been widely hailed as a U.S. success story in a field dominated by Japanese firms. Already, conventional diamond is used to remove heat from certain electronic chips and cutting tools. Potential future applications may be found for laser optics, specialized high-energy circuits, and new uses in higi-stress mechanical edges.



General Electric

Whose baby? *A laser shines on GE's carbon-12 diamond, the world's most efficient heat conductor.*

The spat between Seitz and GE broke into the open on 27 September at an international meeting on synthetic diamond technologies in Washington, D.C. Seitz rose from the audience to ask GE researchers why they have not cited his ideas. Privately, he accuses GE of "ripping off my life's work."

The claim is startling, and so is the list of famous names Seitz collected on a letter of protest he sent to GE's board of directors 2 weeks ago. The signers include physicists Nicolaas Bloembergen and Richard Wilson of Harvard, philosopher W. V. Quine of Harvard, physicist Philip Morrison and computer scientist Marvin Minsky of MIT, and former presidential science adviser George Keyworth II. Says Bloembergen: "Our point is: look—why try to bury this guy, who has really worried about [carbon-12 diamonds] a lot in his lifetime and advocated doing something?" The letter says: "Having virtually arrogated to itself the most important part of Seitz's life's work, GE should equitably compensate him for his long efforts to persuade GE to make this extraordinary material."

GE officials insist they owe Seitz nothing. Walter Robb, senior vice president for corporate research and development, responded sharply to the academic protest in a letter addressed to Keyworth on 19 September. Robb wrote: "Mr. Seitz's assertions that he played a role in GE's isotopically pure diamond inventions are groundless." He dismissed Seitz as "one of many modern-day proponents for this field of research."

Seitz also got a brush-off at last week's conference from William Banholzer, manager of GE's advanced inorganic materials lab and a member