

THE ELECTRIC WILDERNESS

Andrew Marino and Joel Ray

With a Preface by Robert Becker



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To Linda and Marilyn

PREFACE

The development of electromagnetic energy for power and communications is widely regarded as a boon to mankind and even as the manifestation of civilization at its finest. * Although one cannot dispute that mankind's mastery of this silent force is most responsible for our present global technology, disquieting questions have arisen over its present safety and the wisdom of continued unlimited expansion in its use. The electromagnetic force is, like the nuclear force, one of the four basic physical forces of the universe. While the ego of some men exults in mastering giant forces, have we once again acted like children playing with fire? Thus far we have been able to keep the nuclear genie for the most part in the bottle, but the electromagnetic genie is out of the bottle and all around us. There is no place left on earth that is free of manmade, abnormal electromagnetic radiation. Have we already done perhaps irretrievable harm to the biota, or is there time to step back, look at what we have done, and plan for a safe, logical, and environmentally sound use of this silent force?

When I set in motion the affair described in this book with my letter to Joseph Swidler, then head of the New York Public Service Commission, I naively believed that the questions I raised over the possible hazards of powerline radiation would be settled by the logical, dispassionate methods of science. As *The Electric Wilderness* shows, that was most certainly not the case. Our arguments, based on what we considered clear scientific data, were met with a ferocious onslaught not only against our data but our reputations and even our livelihoods. Legal, political, and bureaucratic maneuvering extended from the local level to the highest levels of the Federal government. Why? Was it simply that we were calling into question a favorite technological application and with it the egos of the engineers, or that our actions might diminish the profits of the industries concerned?

In my opinion we faced a concerted and coordinated effort to suppress the truth, which emanated from the military establishment and was simply aided and abetted by the greed of the utilities and the tarnished testimony of scientists for hire. Today the military is planning and constructing the largest expansion of electromagnetic emitting facilities in history, with the aim of fighting and winning the next World War. In the process the very population, culture, and civilization they are sworn to protect may be placed at risk. Although someone has apparently weighed the relative risks and decided that this was the path to follow, the decision has been made not only without input from the citizens, but with every effort to conceal the risk from them. It seems the same mind-set that led to disaster in Vietnam is still operating that in order to save the village from Communism, we have to destroy it only now the villagers are not our enemies but our own citizens.

*Review by Samuel C Florman of *Networks of Power* by Thomas P. Hughes (Johns Hopkins, 1984), in *The Sciences*, New York Academy of Sciences, 1984.

The decisive information that would help citizens contest this expansion will not be available: as this is being written, the decision has been made to terminate all Federal funding for electromagnetic hazards research. Thus those of us still committed to this fight are effectively deprived of the conclusive proof of hazard which has just begun to emerge. If a serious hazard does exist, no one is to know about it. least of all the citizens of the village. If opposition to a facility develops, no matter how small or obscure, the full weight and power of the establishment will be brought to bear to insure that it is constructed, and that all questions of health hazards are submerged in a sea of doubletalk and outright deception.

The citizens of this country are poorly served by the present system. They lack funds, battalions of lawyers, paid scientific experts, and organization. Their one source of power, concerted action at the ballot box, is continuously subverted by misinformation and distortion. Meanwhile the issue is obfuscated. the public is convinced that no hazard exists, and the scientists who insist on open and public debate are unmercifully attacked.

This book is important not only in the issue it raises of the probable hazard of electromagnetic technology, but in the hazards it reveals that are the result of *raising the issue*. It spotlights the present defects in our political system that leave the citizen defenseless against the powerful manipulations of the government. The truly important questions of our time are those relating to technology and its uses and abuses in relation to human beings. The public has a right to the relevant scientific information. and cannot be denied the right to have a voice in decisions that affect their health, safety. and quality of life. However. though scientists can provide the information, any scheme that calls for experts to make the decisions of relative risk tends to have little value. The only valid and ethical risk analysis must be made by those who are at risk. That requires that citizens have access to the truth. *The Electric Wilderness* is the truth.

Robert O. Becker. M.D.

Loville, N.Y., 1985

AUTHOR S NOTE

The collaboration with Andy Marino which led to this book began, for me, well before we actually met reading his remarkable testimony in the New York hearing, then later watching twelve friends get arrested for resisting the State's right of eminent domain at the Barse's farm in Fort Covington, N.Y. By instinct and profession I was deeply impatient at the violations of language and common sense with which the more rapacious technologies (modern prisons, nuclear plants, atomic weapons) were defended. But what seems today a foregone conclusion regarding my involvement as a writer in the powerline issue was certified only when, in March 1977, I saw Andy in action on the witness stand. Here, I recognized, was a man who not only understood the real issue, but had the scientific wherewithal and especially the will to make that understanding stick. It was, and is, a rare combination of qualities.

It took a while after we decided to write the book to realize that the story had to be told in the first person. Although we planned and wrote *it* together, the experience it described was Andy's: the form of the book had to reflect that.

My understanding of science and policy issues and of the human issues behind them has been greatly broadened by work on this book. I hope the reader, too, will learn something of value from this experience as our society tries to come to grips with the destructive effects of its expertise.

Joel Ray

Ithaca, N.Y.

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DEFINITION

NIEMR (*nee mer*). *n.* acronym for nonionizing electromagnetic radiation: a form of electrical energy: emitted by transmission lines, radio and TV towers. microwave ovens, radar, electric blankets. CB radios, etc. *Synonyms:* microwaves, electromagnetic waves, electric waves, electric signals, electric rays, electric fields, magnetic fields, electromagnetic fields.

Note: Although there are many variations in types of NIEMRs (in frequency, strength, waveform, etc.), the generic term is used in this book. For further clarification, the reader is encouraged to consult the sources listed in the Selected Reading List beginning on p. 111.

PART I

CHAPTER 1

The Meeting

When my boss, Dr. Robert Becker, returned to the lab from the Washington meeting, a new and troubling concern was taking shape in his mind.

It was December 1973. Three months before, at a conference in New York City, Becker had been approached by U.S. Navy Commander Paul Tyler with a request to serve on a panel of experts to evaluate some experiments the Navy had funded. It all had to do with an antenna system the Navy was planning to build in northern Wisconsin, a bizarre project involving grids of buried wires that would extend over thousands of square miles of land there. The Navy had been studying ways of communicating with submerged submarines for years: the project, called Sanguine, was believed to be the answer. (It was to be later renamed SEAFARER, and still later ELF, an acronym for Extremely Low Frequency.) But because of the large size of the antenna system, and fears that the NIEMR it would emit might have environmental and health impacts, Congress had ordered the Navy to undertake a series of studies to see whether there would be any problems. All the studies involved exposing living systems to Sanguine-type NIEMR. The program, Tyler had told Becker, was now at its midpoint: initial studies had been completed, and what the Navy needed was expert opinion on the meaning of the results.

Tyler must have realized that of all the scientists attending the conference sponsored by the New York Academy of Sciences Becker was among the best qualified to answer the Navy's questions. And that was in fact true. For fifteen years Becker had been conducting research into the relation between electrical and magnetic forces, and living things, and the three-day Academy conference, entitled Electrically Mediated Growth Mechanisms in Living Systems, was in large measure a result of his work. It was the first time that American scientists had been gathered under such prestigious auspices to explore the subject of bioelectricity: the tributes to Becker were frequent. After he had delivered the keynote paper of the second day, one scientist had acknowledged that we have learned so much from you over the years, in fact, almost everything that we know about this field: another had called Becker's paper one of the most significant in the history of human biology.

Becker's 1973 paper had been the grand summation of his work up to that time. His interest was in growth and regeneration, and in 1958 he had set out to determine how these key biological phenomena occurred. In a way, his interest was an embodiment of the question that had puzzled scientists from the beginning: What is the difference between living and dead?

It had not taken Becker very long to uncover some important clues. Though he had no lab at the time he was Chief of Orthopedic Surgery and mainly concerned with clinical matters U.S. Veterans Administration (VA) hospitals had been gearing up their research programs in response to the Soviet launch of Sputnik in 1957, and he had asked for some funds from the VA Board for a small experiment. He had been reading Luigi Galvani, the 18th century Italian anatomist, and had noted that in an anonymously published experiment Galvani had observed that injury was accompanied by an electrical current. Becker had also read Albert Szent-Gyorgyi's 1941 lecture in which the Nobel prizewinner had hypothesized that the cell might have electrical properties crucial to certain biological functions. Then, after reading a startling Russian paper that reported the regeneration of tomato plants by electricity, Becker requested \$1000 from the VA Board to do an experiment with electricity and animals.

Soon things began to move fast. In the early 1960s Becker obtained the first evidence for his hypothesis that healing and growth were controlled by tiny self-generated electrical signals which mobilized and directed cellular activity. By 1964, around the time I went to work for him, he had postulated the existence of a previously undescribed electrical communications system within living things. These were revolutionary ideas in biology, and they generated a lot of controversy.

Becker's main interest in these ideas was medical. He reasoned that if one could find out how the body heals itself, one should be able to gain control over that process and reproduce it in cases where healing broke down for some reason. But in addition to the medical implications, there were other questions as well, questions that had to do with the origins of life and with the relationship between living things and the natural electromagnetic environment.

If there were these weak neural currents inside living things, did they provide a way for animals and humans to interact with the changing magnetic field of the earth? Becker's research was many-sided. In 1963 he found that the number of admissions to psychiatric hospitals seemed to vary according to changes in the earth's magnetic field. And in 1967 he reported that weak magnetic fields applied to the heads of humans altered their reaction time.

Shortly after that, Becker did a very interesting experiment in which he applied currents to frog blood cells in glass chambers and found that they reverted to a more primitive cell type. Then he was able to regenerate partially the foreleg of a rat with electrical current. Regeneration was a power that amphibians possessed salamanders could grow back whole limbs but not mammals. It was one of the most controversial experiments Becker ever did: there are still scientists today who do not believe it.

By 1973 he had begun to use tiny electrical currents applied through implanted electrodes to cure human bones that would not heal normally. Thus it was just at the time of the New York Academy conference that the

therapeutic implications of Becker's work were beginning to take shape. His research at that point was on bone, but perhaps the techniques of electrotherapy might be eventually applied to soft tissue as well, such as heart muscle. The horizon, in 1973, seemed unlimited.

However, Becker worried that things might get out of hand. Electrotherapy had been used in the nineteenth century, but because of the fraudulent practices of certain charlatans, among other things, belief in the therapy had been undermined. It would be terrible if history were to repeat itself. Physicians might use electrotherapy irresponsibly, before it was fully understood, and people might get hurt. Becker reasoned that if electricity could cause benign growth, it might also cause malignant growth. Several times at the New York conference, Becker warned the other scientists that caution was the watchword. A few bad mistakes with patients and electrotherapy might once again be discredited. He had not spent fifteen years of difficult and often heavily criticized research to see it all go down the drain because some doctor, overanxious for money or fame, induced cancer in a patient he was trying to heal. (For a full account of Becker's research see his recent book, co-authored with Gary Selden, *The Body Electric: Electromagnetism and the Foundation of Life*, William Morrow, 1985.)

*

Because of the worry about the inadvertent side effects of electrotherapy, and because of some experiments I had just finished that showed adverse effects in mice and rats from exposure to certain kinds of NIEMR Becker was supersensitive to the potential implications of the Navy antenna. When he returned to the lab that Monday in December he told me what the Navy studies had found.

There had been seven scientists on the panel. After describing the Sanguine antenna, Tyler told them that the Navy needed to know where to go from there with further studies. He spent most of the first morning reading the results of the more than thirty studies: nearly two-thirds of them had found Biological effects from exposure to the NIEMR, in a variety of species including slime mold, rats, birds, and human beings. Becker had felt he would probably be in the minority on this panel, because in 1973 very few thought that energy of such low frequency and strength could cause biological effects. But what happened surprised him. Before long it became clear that *all* the panel members were thinking the antenna was a potential hazard to human health.

On the second day, the panel began to draw up a lengthy list of recommendations. It was clear there had to be further study, especially on humans. Becker interpreted some of the results as due to a lowering of the body's normal resistance, a kind of NIEMR-induced stress, similar to what had happened to the mice and rats in our own study.

In the middle of the deliberations someone pointed out that the Sanguine NIEMR was similar in nature to that produced by high-voltage powerlines, and that in the largest lines, those of 765 000 volts, the strength of the NIEMR might be as much as a *million times stronger*. That realization, said Becker, had really thrown the group into a quandary. They had been asked

there to review studies on the antenna. What could they do about power-lines, which might represent an even greater potential hazard involving many more people? The discussion became heated, but eventually the scientists agreed they had to recommend some action by the government. Their concluding recommendation was that the Navy should inform a special committee advisory to the President that many Americans might be at risk from powerline NIEMR.

But Becker's concern didn't end there. For when he returned home that weekend he read in the newspaper that the Power Authority of the State of New York (PASNY a kind of state TVA) planned to build a 765 000-volt line from the Canadian border to Utica, and that the route would take it not far from where some of his friends lived. He had noticed all the powerlines and radio and TV and microwave towers on his way to the airport. he said all emitting forms of NIEMR but he remembered telling the panel that there were no really big powerlines in New York. The newspaper notice drove home the point, once and for all that people *were* at risk.

I didn't pay as much heed to these ramifications as to the fact that the Navy studies seemed to confirm what we were finding: I guess my main reaction at the time was elation. Here we were doing experiments with very little money, and the Navy was coming up with similar results, after the expenditure of millions of dollars. I'm sure that aspect of it pleased Becker too, and he was no doubt thinking that we might get some funding from the Navy. Money was always a problem in the VA lab.

Anyway. I settled down to design another series of experiments, and the NIEMR hazard disappeared from my mind, until six months later.

CHAPTER 2

Simpson Arrives

The new experiments we decided to do were in connection not with power-lines but with Becker's bone-healing work. There were a couple of reasons for them. Because the beneficial effects of the electricity on Becker's patients might conceivably be due not to the NIEMR itself but, say, to the metal in the electrodes, we had to test this Possibility by using NIEMR without wires in experiments on animals. Instead of implanting electrodes we would expose animals to NIEMR that involved no contact whatsoever with tissue. The other reason was that it might be possible to develop a therapy that did not use electrodes, a noninvasive therapy. Before Becker could try it with humans, we had to check it out on animals.

So I designed an experiment that would expose rats to NIEMR for thirty days. We would compare these animals with control rats that lived in exactly the same circumstances without exposure, and see what the differences were. It was a low-budget experiment, and I built the apparatus in my basement at home, using leftover scrap wood and metal shelving. Paneling, and trim from when I had remodeled my living room. Esthetically the result wasn't particularly appealing, but functionally it was perfect. It fit smoothly with the regular procedures for animal care at our facility, and I used it in experiments with over 500 animals for more than thirty months and had no significant problems. When the time came to build the power supply to provide the NIEMR, cost was again the overriding consideration, so I used the cheapest source of power available electricity from the wall outlet, with suitable provisions to protect against the danger of shock.

Soon after the study began, I saw changes in the exposed rats that were not occurring in the controls. The exposed animals seemed to gain less weight and drink less water, and they had altered levels of blood proteins and enzymes. Since the results were clearly adverse, they tended to foreclose the use of certain kinds of NIEMR in our clinical work, and that was pretty much what I saw as their value.

But when Becker looked, he saw something more. He saw powerlines. The NIEMR I was using was, after all, from electricity derived from a wall outlet, and that was at a frequency of 60 Hertz (cycles per second) the frequency of the entire electrical distribution system in North America. Becker asked me what the results meant with regard to 765 OGO-volt lines. I said I hadn't the foggiest idea. Did I know what the strength was in relation to that of such lines? I did not: I guessed one would have to be very close to the wires maybe within a foot or two to experience the same strength I had used in the study, but I really didn't know for sure. Well, said Becker, find out. And as he left he said. Do the experiment again.

I repeated the experiment twice: the results were the same.

Then, in July, Becker told me he had just had a call from a lawyer with the New York Public Service Commission (PSC), who wanted to come and see him about a powerline hearing. That's when I learned that, immediately after he had returned from Washington and the Navy meeting, Becker had written a letter to several state regulatory agencies, to tell them that the powerline planned by PASNY might be a health hazard. He alerted them to the Navy studies and urged them to explore the issue before they allowed the line to be built. I asked whether he'd had any response, and he said an engineer from Niagara-Mohawk (NiMo), the local utility, had called and said rather rudely that he thought Becker was raising a bogus issue. The agencies had not responded until now. It seemed that *another* 765 000-volt line was being planned for the Rochester area, by NiMo and Rochester Gas and Electric (RG&E), and that the NIEMR issue had been raised in that hearing by a citizens group.

Becker asked me if I would sit in on the meeting with the lawyer, whose name was Bob Simpson.

As I say, powerlines were the furthest thing from my mind. And in a way it's odd that I didn't feel more strongly about the connections Becker was making, because when it came to other forms of pollution I had strong feelings. In fact, three years earlier, partly as a result of a public hearing on a quarry operation that was screwing up my neighborhood, I had decided to go to law school so I could learn how to argue environmental cases. But it was the well-known kinds of pollution I was thinking of then: air and water pollution, food additives, pesticides, and so on. I loved my research work with Becker, but I also had ambitions about going into court some day and arguing the case that would establish the constitutional right to a clean environment. Also, I was married, and beginning a family, and I was concerned about what kind of world my kids were going to have to deal with. When Simpson called to see Becker, I had been out of law school for a month, and I was wondering how I could begin using my legal training but not in relation to power-lines.

Simpson arrived on 15 July 1974, in the morning. He was younger than I, and had been out of law school only a few years. His only job had been on the PSC staff. He told us a little about the public hearing in Rochester. The experts testifying for the power companies had said there would be no hazard from the NIEMR, but the citizens group had refused to accept their assurances and had found evidence enough so that the issue ought to be seriously addressed. Simpson showed us the testimony of the main company expert. I thought it was not only inaccurate but downright ignorant. For example, the expert had said that cows under a 765 000-volt line were contented because he had seen their tails wagging.

Simpson asked, was there really a potential health risk? No question about it, said Becker. He detailed for Simpson the adverse effects that the Sanguine program had turned up, and said that the powerline NIEMR would be far stronger. He also told him about the experiments I was doing on the rats, and that they had been twice repeated with the same results.

Becker is a proud, direct man who likes to be recognized for what he knows and what he can do. As with the request from Paul Tyler to come to Washington, it was flattering to be asked by a government representative to

help him do his job especially when his job was to help protect the public interest. Sensing this trait, Simpson asked Becker whether he would be willing to testify about the possible health risk in the hearing. Becker was a teacher the best I had ever encountered and this was the role in which he felt most comfortable: it was that side of him to which Simpson was appealing.

Becker wanted to know the details. Simpson answered in a way that understated the work that would be involved, and I could see that Becker was rising toward a decision to testify. Though the citizens group had uncovered some preliminary information, they scarcely had the expertise to testify as Becker could, and I think Becker understood that. Simpson said Becker's testimony would consist of a written report to be transmitted to the power companies, and later perhaps a day of cross-examination in Albany by the power company lawyers. After that, PSC would decide whether the 765 000-volt line could be built, and if so, how it would have to be regulated.

Simpson seemed wary of me. He hadn't known that I would be sitting in on the meeting, and when he found out that I had just finished law school, he seemed surprised: he was probably juxtaposing biophysicist and lawyer and wondering exactly what I was and where I fit in here. His invitation to testify was extended only to Becker.

But Becker suggested that both of us should testify. After all, I had actually done the rat studies, and I had in-depth training in the mathematics and physics of electricity (which is why he had hired me in the first place). Also he may have been thinking that my legal knowledge would be helpful, though I doubt that was foremost in his mind. (He had arranged things so that I could go to law school, but he really had little use for lawyers)

The legal aspect of the hearing certainly interested me. In fact as I listened to Simpson and considered the power company testimony that had already been given in the case, I had an insight into the way the legal system worked that shook me a bit because it seemed so obvious and yet I hadn't really considered it. It had to do with evidence. The point was that judges made their decisions on the basis of evidence presented to them. If some piece of information was in evidence it could be used in deciding, but if it wasn't in evidence it couldn't. Now the scientific merit of the companies' testimony was abysmal. But the judge didn't know that, and the citizens group had no real scientific expertise and neither did Simpson. The net result would be the elevation of ignorance and grossly self-serving statements to the level of fact, so as to support an inevitable decision that the line would be safe. What I realized that day as I listened to Simpson was, simply, that if you control the evidence, you control the outcome.

I wondered what it would be like working with Simpson. He troubled me a little. First, he as much as admitted that he'd been assigned to the case because he was the low man on the PSC totem pole. His real interest was utility rate regulation. I couldn't imagine *anything* more dull or boring than that, and it didn't make me especially confident in him. How could he be expected to handle a case involving arcane scientific concepts?

The other question was why he was asking Becker to testify. The Sanguine committee report had been classified For Official Use Only, so Becker didn't feel he could properly use it in a hearing. Why not ask Tyler to testify, or at least the investigators who had done the actual experiments? As I saw it, all

we could present were articles in the scientific literature if there were any and our own experiments, which were preliminary. That didn't stack up well against all the expensive Navy work. I asked Simpson about it. He said bluntly that he had asked as many people as he could identify, and they had all refused: he didn't really know why.

In the end, Becker established that we would both testify. Simpson said we would be paid for our time, but Becker instinctively realized that would be a bad idea, because it would restrict our independence. He told Simpson no, we would do it for free. That turned out to be a very wise decision.

The only perk Becker requested was that on the day we were to be cross-examined the hearing should be held in Syracuse. He had patients to consider. Simpson said he saw no difficulty in arranging it. And that was that.

*

During the next few months Becker and I worked on our reports for Simpson to send the power companies. I found eight studies published in the open scientific literature that described biological effects in animals or humans from exposure to NIEMR similar to that of a powerline. I described these studies, and also my own rat experiments, and with the help of a former classmate who had become a physics professor. I calculated the strength of the NIEMR from the proposed line at various measured distances from the wires. As I had expected, it became progressively weaker with increasing distance from the line. What I didn't expect was the great distance to which perceptible radiation would extend several thousand feet. This calculation also allowed me to relate my rat study to the powerline. I found that the strength I had used there was comparable to the strength at chest height directly underneath the wires.

Becker's testimony began with a brief recounting of his research over the past fifteen years, to show the firm scientific foundation on which his opinions rested. His medical conclusions were that the existing data showed NIEMR to be a biological stressor, and that as a physician he would have to assume the effects would be harmful.

It would be unethical, Becker wrote, to expose people to levels of NIEMR greater than ambient levels without their permission. Such exposure would be tantamount to human experimentation without informed consent. Before he, as a doctor, could expose human beings to such fields, he had to comply with every provision of the Human Experimentation Regulations, which included obtaining their informed consent and telling them that they could terminate their participation at any time. It seemed to Becker absurd that power companies could expose people without their consent, in the pursuit of profit.

We finished the reports in October and Simpson mailed them to the power companies. It was the first time ever in the U.S. that scientists moreover, scientists with all the right degrees, experience, and requisite professional affiliations had presented hard evidence in an official forum that a health risk could result from exposure to powerlines.

The reaction of the power companies to our testimony was immediate and telling. They requested that the Rochester hearing be suspended so they could produce new witnesses. And soon after, things began to develop in such a way that we knew we had opened a real can of worms.

CHAPTER 3

Escalation

Becker's 1973 letter to the agencies, which ultimately led to Simpson's visit, had been in response not to the RG&E/NiMo powerline (he hadn't even known about it at the time), but to the one planned by the Power Authority (PASNY). At the time our testimonies were mailed, PASNY's hearing before the PSC was well under way and proceeding smoothly. PASNY was saying that there was no danger from the NIEMR. There were groups in northern New York also opposed to the PASNY line, but they had not been able to convince the PSC hearing officer as the Rochester group had that NIEMR might be a problem. Indeed, PASNY seemed so certain their line would be approved that during the hearing they had begun to negotiate purchases of materials and contracts for the purchase of power from Quebec. Looking at the transcripts from that hearing, I got the feeling that the hearing examiner in charge, a man named Thomas Matias, was simply going through the motions. I assumed that he had read Becker's letter and was simply ignoring it. For a judge, Matias was disturbingly casual. When a farmer voiced fears that birds flying near the line might be electrocuted, Matias replied "Well, then, we won't have to shoot them."

Our testimonies for the RG&E/NiMo hearing wound up changing PASNY's plans as well. As a result things began to get much more complicated for me and Becker.

Once we had raised the NIEMR issue, the bureaucrats in the state agencies realized that it would make no sense for one hearing examiner to conclude that there was a health risk because of our testimony there, and for another to conclude that there was *no* health risk from an identical line because we did not participate in *that* hearing. The feeling began to develop that there had to be some sort of proceeding that would settle the matter once and for all a kind of generic hearing. But whereas RG&E and NiMo were content with a delay that would enable them to prepare a new and better defense, PASNY was not. They were a state authority, for one thing, and for years had been used to getting their way. Moreover, the line from the Quebec border, which would tie into an enormous future supply of electricity from the huge James Bay hydro project, had already been granted certain federal exemptions on the basis of its importance to national security. Also, PASNY's line was planned for operation much sooner than the Rochester line. So PASNY began to apply pressure on PSC for an expedited decision.

Then came word that the agencies were beginning to squabble among themselves about how to deal with the unfamiliar health issue we had raised, Besides PSC and PASNY. the Department of Environmental Conservation (DEC). the Attorney General, and the Department of Agriculture and Markets were jockeying for position: many fundamental questions emerged.

Not only was the issue new, but the type of hearing envisioned was unprecedented as well, Which agency should in fact be responsible for overseeing the state s inquiry into the health and safety of high-voltage powerlines? Which issues should be raised or considered in the hearing~ Other issues had emerged in the Rochester hearing: electrochemical pollution. TV and radio interference, electric shock, effects on cardiac pacemakers, noise. Should all these factors be considered, in addition to the question of human exposure to the NIEMR? What procedures should be established? What was the best way. for instance, of making the other five companies in New York parties to the proceeding so that when and if they proposed to build 765 000-volt lines, the entire hearing wouldn t have to be repeated ?

In the end, a broad agreement was reached. The RG&E/NiMo application would be joined with that of PASNY. and all companies in the state would be given an opportunity voluntarily to participate, which meant that if they did, the results would be binding on them. What the establishment of a new hearing meant for Becker and me was brand new testimony. Because the inquiry had expanded so dramatically, because so much more was riding on what we said, these new documents would have to be even stronger than before. At least, though. we would have a full year to develop them, because PSC decided to adopt a two-step procedure. In Step One, all the physical characteristics of the lines would be established. This part would involve mainly engineering testimony to determine the amount of noise the line would make (especially in foul weather), the amount of ozone it would produce, the type and extent of radio and TV interference, the levels of current induced in large metal objects under the line, and, most important. the strength of the NIEMR at various distances from the wires. This step of the hearing would take about one year. Then Step Two would address the crucial question: what dangers would these physical realities pose for humans ? PSC ruled that no further lay testimony would be admitted, only that of experts. The judges in charge of the new hearing would be Lawrence Gollomp. from the Rochester hearing, and Thomas Matias. Later, Gollomp would be removed and Matias would become the chief judge.

The expanded hearing procedure made no one happy, except of course the citizens who would have to live near the lines. The whole purpose of the Rochester citizens group in pressing the NIEMR issue had been to uncover scientists who could testify for them, and that had been accomplished the day Simpson came to see us. PASNY officials were very upset: with their own hearing close to finished, the new hearing was a big step backward for them. RG&E. one of the power companies most hostile toward state bureaucracy and regulation on general principles, it seemed now found its fate directly tied to that of a state agency. one with resources that dwarfed its own. The power companies that had no plans for 765 000-volt lines saw no reason at

all for a hearing: after all, there were thousands of miles of such lines in operation and no evidence that anyone had ever been hurt by them, DEC wanted to *force* every power company to participate in the hearing, not just invite them in as PSC wanted to do, The Health Department was ambivalent throughout. It felt that our testimony involved public health matters and should be presented under its aegis. However, that would be difficult to arrange in the context of a state licensing procedure that had been established previously by the legislature, and in any case the Health Department admitted that it had no expertise to make judgments on the NIEMR issue. So in the end it acceded to the PSC plan, with the recommendation that Becker and I be sponsored by the PSC staff, That meant the Attorney General could not participate because he had no witnesses,

For Becker and me. the expanded procedure was just plain scary. We had started out to testify in one local hearing, involving one line and two upstate companies. and now our potential adversaries were the entire New York State utility system, including a powerful and virtually unregulated state authority. At one point we learned that even one out-of-state company was going to join in. We had submitted our October 1974 testimony under what looked to be dispassionate conditions, It had seemed reasonable to me that developments outside the orbit of the electric power industry could have gone unnoticed by the industry, and I saw our role as providing information from just such an unanticipated source to those in the industry with the wherewithal to make necessary changes to protect the public. I actually expected to be treated with respect, if not gratitude, for performing this public service.

But that's not the way things were working out, In bits and pieces over the next few months, we began to learn that we were to be the objects of a witch-hunt. Rumors began to circulate that the industry was going to get Becker and Marino. and Marino in particular was to be the target. Though our experiments had been jointly planned. I was the one who actually performed them, who searched the literature for other reports of comparable studies which showed effects, and who contacted other investigators working on NIEMR bioeffects. I was the dangerous one.

But it wasn't just the power industry reaction that bothered me. Even within PSC, the agency we were to testify for, the wheeling and dealing caused serious problems, One that outraged me involved Simpson's boss, Arthur Rheingold, who was the PSC Assistant General Counsel. Simpson called me one day, dejection in his voice, to say that Rheingold was going to take over the case. I did not trust Rheingold. I thought he was attracted by the idea of handling two potential superstars, and by the likelihood of taking expense-paid trips around the country to drum up other witnesses: I did not want him representing me in the courtroom. I told Simpson to tell Rheingold that if Simpson didn't stay, he could kiss me goodbye as a witness. Luckily. the threat worked, and Simpson staved.

I was pretty unsure where I stood when I did that, and it was a risk. But something told me I had to stand firm. Now I know it was one of the most important things I ever did. By early 1975 Simpson and I were developing a good rapport, and he kept me abreast of the politics of the hearing. Most of my reservations about him had evaporated, and I thought him honest and

direct, very unlike most of the double-talk artists in the agencies. We were both getting caught up in the morality of what we were doing as well, and reinforced each other about the importance of the case. If Rheingold had taken over the case. I probably would have quit if not immediately, then somewhere along the way. And my instincts about him were perfectly right later he quit PSC to become General Counsel for one of the biggest U.S. power companies.

Another problem, which developed because of the intra-PSC confusion, involved Matias. The power company lawyers were talking to him, trying to arrange the rules in a way that would best favor their position. Specifically they wanted me and Becker to testify first. so they could see what we were going to say before they filed their own testimony. Well, that burned me up. Already in the Rochester hearing there had been concealment and subterfuge by the companies they had ignored Becker's letter, they had refused to release to Simpson certain secret studies done by the industry, and they had kept their own witness in the dark about damaging information so why the hell should they get an advantage now? Such a deal would have relieved them of any burden to discuss evidence for health risks that they knew about: they would only have to react to what we said. Matias let it be known that he thought that was a fine idea. But we objected. strenuously. and eventually Matias changed his mind. Everybody would file testimony simultaneously.

Finally, Matias was badgering me. through Simpson. to renege on our initial request that hearing sessions that involved us should be held in Syracuse. Apparently he didn't want to have to travel away from Albany. The more I looked at Matias. the more petty he seemed. I really began to worry about testifying before him, and having him judge me.

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As the hearing grew more complex, I felt myself being pushed farther and farther from the warm, comfortable, uncontroversial life I had led before Simpson came. I was married to a fine woman and had three young sons. I had a house in the country with a garden and five acres of land. I had a secure job in an exciting lab, and a boss who was going to be famous some day and who treated me with generosity and confidence in my abilities as a scientist. It's true that I was still uncertain about my ultimate place in the scheme of things. about my overriding purpose in life my Jesuit teachers at St. Joseph's had embedded in me a sense of ethical obligation that I still hadn't fully identified or understood but otherwise things were going well. Basically I felt I had control of my life. But now, with the proliferating complexities of the hearing. I wasn't so sure anymore. I wanted to quit ... to get off the spot ... to go back to the way things were. I didn't want people angry at me. especially people who could do me harm. And even though Becker and I had obtained permission from the VA Director to testify, I was scared that the VA officials in Washington might decide that I was too controversial and maybe even fire me. At my lowest points I even worried that the Character Review Committee of the New York Bar would find me too controversial. and hence unfit to be licensed to practice law in New York.

Perhaps I lacked the courage to quit. I don't know. Maybe I was afraid it

would look as if I was being pushed out. and what would everyone think? (By this time the press had begun to interview us.) But I really think it was something deeper that made me stay on. I viewed myself as a logical person, like Mr. Spock. Why should I quit? Nothing has happened, only vague fears and rumors. Besides. I m right. I know I m right. It simply wouldn t be logical to quit. So I couldn t quit and be logical, and I couldn t stay and be content. In the end I stayed and in the process of deciding that I learned quite a bit about myself.

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Early in March 1975 Simpson called to tell us the names of the new experts who had been hired by the companies. One of the names on the list gave me a real start Herman Schwan.

When I had been taking graduate courses in Philadelphia. before I came to Syracuse. I had audited one of Schwan s courses. He was so intimidating in the classroom that students rarely even asked him a question. Later, when I came to Syracuse for my Ph.D., Schwan s papers had often been required reading.

He was one of the most prominent biophysicists in America. Why. I wondered. was he testifying in a state powerline hearing? Surely he knew it would be time-consuming, politically controversial, a general pain in the neck? It seemed incongruous.

There was only one other name on the list that either of us recognized, and was almost equally puzzling. It was a veterinarian named Solomon Michaelson. from the University of Rochester. Several years earlier Becker had hired Michaelson to inspect the VA s animal research facility, and the reason Becker remembered him was that someone high up in the VA had *told* Becker to hire *him*, rather than someone else: it seemed to him that Michaelson had some sort of clout. But Michaelson hadn t impressed Becker as anything more than a competent vet why was *he* testifying in a powerline hearing on human health risks?

CHAPTER 4

The Biophysicist and the Veterinarian

Putting aside the question of whether it was wise, I was in a legal proceeding and I tried to think like a lawyer. The issue was the nature and extent of a health risk associated with exposure to the NIEMR of a powerline. How would the power-company experts testify? I looked for the answer in what they had said and done in the past.

Herman Schwan had come to America from Germany in 1947 under Project Paperclip, a controversial government program to import German scientists immediately following the end of World War II. (See Clarence Lasby's *Project Paperclip: German Scientists and the Cold War*, Atheneum, 1971.) Schwan worked for the U.S. Navy until 1950, when he became a professor at the University of Pennsylvania. He had done some kind of NIEMR research in Germany during the war, but I couldn't determine exactly what. After he came to the USA he began to publish papers which said that the laws of physics, properly interpreted, showed that the only effects of NIEMR on living things would be through heating or shock.

It seemed that Schwan's writing was intimately bound up with the federal government's concern, which surfaced in the 1950s, about military employees who were beginning to report various injuries from working around radar eye injuries, temporary and permanent sterility, internal bleeding, and other problems. In response to these reports, an Air Force surgeon, Colonel George Knauf, was picked to determine how much NIEMR was safe for personnel. Knauf and Schwan began to work together. Although the USA was then a leader in NIEMR-producing technologies, its expertise was in engineering rather than the biological aspects of NIEMR. Of all the biological experts at that time, Schwan was the most important.

Schwan regarded the stories of nonthermal injuries—those which happened to people without any evidence of heat, without their having felt anything—as anecdotal and unreliable. Either these effects were secondary to actual heat, he reasoned, or they didn't exist. Thus, to Schwan, NIEMR was safe if it didn't cause heating. Well, then, what was the maximum level that would not cause thermal effects? Schwan's answer was simple. The body could handle a certain amount of heat, for example by sweating, but if the heat reached the point at which the body's defenses broke down, temperature would rise and injury would result. According to his calculations the safe level would be 10 milliwatts per square centimeter (a measure of power

intensity delivered to an area of surface). No heat under that level and no effects without heat.

Schwan's numerical value apparently provided Knauf with just the handle he needed. The problem became a simple one of validating Schwan's thermal threshold. Even in the 1950s, there were some who felt that Schwan's position of heating-effects-only was not correct, but from the beginning their opposition never amounted to much, and it seemed that Knauf never seriously questioned Schwan's assertion that heating was the only possible effect.

In 1955 the Department of Defense provisionally accepted Schwan's safety level of 10 mW/cm^2 and Knauf got the go-ahead to fund a series of animal experiments to verify Schwan's calculations. The studies were called the Tn-Service Program.

One of the participants in this program was Solomon Michaelson at the University of Rochester. Michaelson had become an expert in the use of the beagle dog as a test animal, and, in a revolting series of experiments, he literally cooked dogs alive with NIEMR at levels of 50 to 100 mW/cm^2 . He measured and recorded such things as the location of burns, the oozing of fluid from the brain and eyes and body temperatures, which reached 106 – 108 F. In each case, Michaelson noted the exact cause of death which resulted when the dogs could no longer handle the heat. Later, in the 1960s, he did similar experiments on dogs with x rays, again at lethal levels.

Michaelson's work for the Tn-Service Program was basically confirmed by other investigators. Gross, acute effects had been observed at NIEMR levels only slightly above Schwan's safety level. From this finding it was concluded, with strange logic, that Schwan's level was safe. There was not one instance of a Tri-Service Program experiment conducted at intensities *below* Schwan's level.

Schwan was subsequently appointed chairman of a committee of the American National Standards Institute (ANSI), whose goal was to set a NIEMR level for industry. It came as no surprise when ANSI also accepted Schwan's position and 10 mW/cm^2 became the safe level for such industries as radar and radio, as well as many that used NIEMR in the workplace to do a variety of jobs sealing packages, treating seeds, operating equipment, providing security, and many other tasks.

Schwan published dozens of papers and gave hundreds of lectures over the next twenty years, all reflecting his view that heating was the only NIEMR effect. His rise was steady in the American scientific establishment, culminating in his election to the National Academy of Engineering.

It was hard to work through this complex history, but it seemed that there was general government and industry agreement that 10 mW/cm^2 was safe—that is, that there were only thermal effects. And it also seemed that the scientific basis for this view rested heavily, maybe even exclusively, on the shoulders of Herman Schwan. Whenever anyone referred to the 10-mW/cm^2 rule, Schwan was usually cited as the authority; and Schwan himself usually cited others only for support, not for authority.

What Schwan actually said in most of his papers was that there were no *known* biological effects of NIEMR below 10 mW/cm^2 . But in fact there

were some such reports, particularly from the Soviet Union, whose existence Schwan never seemed to recognize. What Schwan seemed to convey was that there couldn't be any such effects. Certainly the common opinion was that 10^2 mW/cm^2 was safe. But since almost no work had been done in the USA at or below that level, the only possible scientific basis for Schwan's view must have been a mathematical or theoretical analysis. Indeed, as I found, that was true. Schwan's view was based on calculations involving nonbiological models.

The NIEMR situation, and Schwan's role in it, was also disturbing for me in another way. In Becker's lab I had been doing experiments with bone, tendon, and other tissues, measuring their electrical and magnetic properties. There was very little government or industry interest in this work. I did an experiment, published a paper, and then did another experiment. The NIEMR exposure situation was just the opposite; I found twenty-two federal agencies that had some jurisdiction or interest in NIEMR bioeffects, and the number of companies whose industries that were interested was simply huge. What Schwan said or wrote was very much a matter of interest to them. He was a consultant to this company and had a grant from that agency—everything he did seemed to be related to companies and agencies, and to the military.

Despite his awesome reputation, Schwan did little actual experimental work himself, particularly after 1970. His work was mostly mathematical analysis, and the rehashing of his earlier theoretical calculations. I felt that Schwan's papers were not serious attempts to prove the validity of the 10^2 mW/cm^2 rule, they were rationalizations of it.

All in all, Schwan's track record suggested that in the New York hearing he would do a calculation and conclude from it that the powerline would be safe. But calculations involving living organisms are a lot like statistics with a little creativity one can make them say almost anything. Since Schwan wasn't doing any biological experiments, I wasn't too concerned about the substance of what he would say. Yet I was awfully wary about him personally and his connections he looked like a big fly swatter, and I felt a little like the fly.

What about Michaelson? What was he going to say?

After his work for the Tri-Service Program, and beginning sometime around the late 1960s, Michaelson began to advocate strongly the position that, as long as NIEMR levels were below those he used on his dogs, they were completely safe. About 10 mW/cm^2 , he said, was a good figure. Above that the body couldn't handle the heat. Moreover, said Michaelson, the scattered reports by American, German, and Soviet scientists that NIEMR below the thermal threshold could cause effects were all incompetent and should be ignored. Michaelson was especially critical of the Soviet scientists who found effects. He accused them of hiding data, and intimated that they were fabricating results. The Soviets were excessively concerned with safety anyway, he said: if the USA adopted their safety levels which were far more stringent than ours—the harm that would be done to industry and the military would outweigh any proposed public health benefit.

At the same time he began to say such things publicly, Michaelson's career took off like a shot. He was appointed to committees of the National

Academy of Sciences, the World Health Organization, North Atlantic Treaty Organization, President's Office of Telecommunications Policy, Electric Power Research Institute, American National Standards Institute, Veterans Administration, National Institutes of Health, Walter Reed Army Institute of Research, and the Navy. In many instances, Michaelson appeared at hearings in tandem with Schwan. In more than fifty publications, he reiterated his position regarding NIEMR safety levels.

But in a Congressional hearing in 1973, Senator John Tunney of California brought Michaelson's attention to the fact that he had changed his position. Before 1967, Tunney pointed out, Michaelson had said that there were too many unknowns to try to establish a NIEMR safety level, that the 10-mW/cm² standard had to be re-examined, and that Soviet reports showed there *was* a basic nonthermal effect. But testifying now, on behalf of the microwave oven industry, Michaelson was saying that 10 mW/cm² was exceedingly safe, that it was inconceivable that lower levels could be hazardous, that no new data from the literature and no new valid arguments have been presented to change the situation from what it was last year, four years ago, or fifteen years ago.

Have you changed your opinion? asked Tunney. This was Michaelson's answer: he was now affiliated with many organizations and, as a result, I feel more confident now than what I appeared to have been in 1967.

Michaelson had published some surprisingly nasty articles attacking the work of one particular American investigator, an ophthalmologist named Milton Zaret. These articles led me to Zaret, and to some interesting information. Zaret had worked on a research program called Project Pandora. This was a secret Defense Department research program set up in the mid-1960s to study the biological effects of NIEMR, and its apparent aim was to determine whether the Soviets were carrying out offensive warfare against the employees of the U.S. Embassy in Moscow by means of a NIEMR signal beamed into the building. Zaret had already found that nonthermal levels of NIEMR could cause cataracts, when he was asked in 1965 to become a medical investigator for Pandora. In the course of his research he duplicated some Czechoslovak experiments in which NIEMR bioeffects had been found, and performed other studies involving effects on the eyes. He wanted to continue his work, but in 1973 a committee headed by Michaelson told Zaret his work was worthless and recommended that his funding be terminated. After that Michaelson bird-dogged Zaret on the question of NIEMR-induced cataracts. Whenever Zaret reported his results, Michaelson a veterinarian would dispute them. In one instance Michaelson wrote directly to the editor of a journal that had accepted one of Zaret's papers, to try to have it withdrawn from publication. What made the whole story really incredible was that Zaret, at Michaelson's request, had operated on Michaelson's aged mother and had restored her sight, which had been lost because of cataracts in both eyes.

I had never seen anything like Michaelson and what he was doing. He was like a Manchurian Candidate aimed at the opposition to the 10-mW/cm² rule. The thing that cinched it in my mind was his testimony for Rockland Utilities in New Jersey.

Rockland wanted to build a large antenna, and the local landowners were

concerned about its safety. Michaelson testified on behalf of Rockland and said that no one would be exposed to levels above 10 mW/cm^2 , and therefore that the antenna was safe.

With Michaelson on the stand, a lawyer representing the citizens held up a book on NIEMR bioeffects written by Dr. Zinaida Gordon, a Soviet scientist. The book described experiments in which adverse effects had been found at nonthermal levels. What do you make of this, Dr. Michaelson? asked the lawyer. Well, Michaelson said, she's a woman.

When the lawyer recovered enough to ask Michaelson to explain what he meant by that, Michaelson began attacking Dr. Gordon's research as faulty. One of the biggest flaws, he said, was that she had used metal cages for the animals, when she should have used plastic.

Question: What is polystyrene?

Michaelson: That's a plastic.

Question: (quoted from Dr. Gordon's book) . the cages were made of polystyrene.... Now, Doctor, do you still state that this woman used steel cages?

Michaelson: Yes. .

Question: In other words, even though she told everybody she uses polystyrene, she uses metal cages. is that right?

Michaelson: Yes.

Judge: Is it possible that she had the wrong picture in the book?

Michaelson: No

There was no doubt in my mind what Michaelson would say in the hearing: he would attack anyone read Becker and me who reported bioeffects due to NIEMR.

The power companies also had other witnesses who like Michaelson were from the University of Rochester. None seemed to have any relationship to the NIEMR issue, so there was no possible way I could anticipate what they would say. The one exception was a botanist named Morton Miller. Miller was a Sanguine investigator who had studied the effect of Sanguine NIEMR on bean roots. I presumed that he would testify that the powerline NIEMR would not hurt the grass and trees. Since the hearing was about possible health risks to people, I didn't think that was very important, so I never gave Miller much thought.

As a lawyer, I didn't think the power companies had a significant affirmative case. All they could do would be to present calculations, call people names, and perhaps show that the grass and trees would be okay. Now the law says that the power companies have to show that the line will be safe before they get a license that is, they have the burden of proof on the issue. If they can't sustain that burden and I didn't see how they could then they don't get the license. I talked to Simpson about this point from time to time in 1975, and he told me that Matias didn't agree. Matias thought that since Becker and I had raised the issue, the burden of proof was on us. Well, I thought that maybe he was just jerking us around with comments like that because we wouldn't agree to have the hearing in Albany. But it turned out that Matias was more serious than I thought.