Electromagnetic Fields and Your Health

Are the electromagnetic fields generated by power lines, TVs, ham radio gear and hundreds of other devices bathing us in damaging radiation? The jury is still out, but you can take steps to protect yourself from danger—real and potential.

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Photos by the author

There is a growing public debate about the safety of electric power lines and the electrical equipment that we use every day in our homes and workplaces. Not long ago, a lawsuit was filed alleging that a Florida woman's brain cancer was caused by electromagnetic radiation from a hand-held cellular telephone. Although the filing of a lawsuit proves nothing (thousands are filed every week, and this one was promptly dismissed by a court), the lawsuit made national headlines for weeks and caused cellular telephone industry stock prices to decline on Wall Street.

The news media regularly cover many facets of the controversy over the possible health effects of electromagnetic fields (EMFs). In addition to stories about lawsuits, there have been numerous media accounts of medical research concerning EMFs—some of them confusing and seemingly contradictory. And there have been news stories about activist groups fighting the construction of new power lines or cellular telephone towers in their neighborhoods.

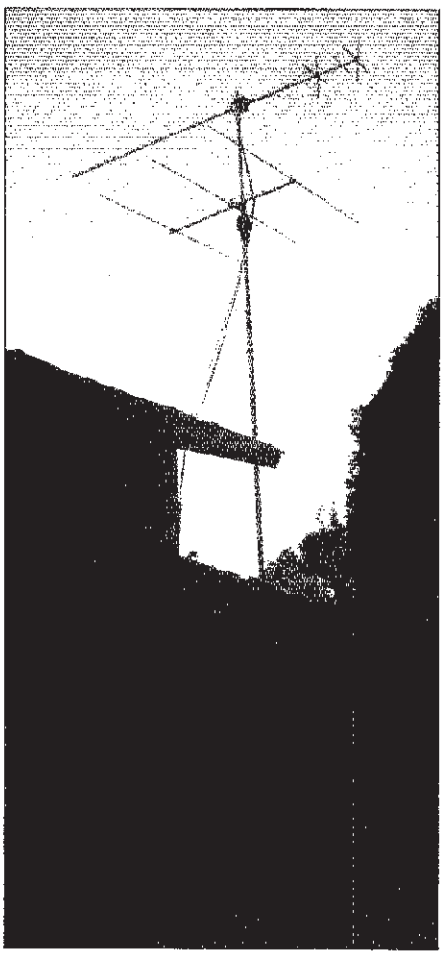
This intense publicity has alarmed many people, prompting them to worry about the safety of their homes, neighborhoods, schools and workplaces. There is a growing concern that the electromagnetic fields produced by power lines and everyday household appliances may be hazardous. As the tension mounts, more and more hams are faced with this difficult question: *Is your Amateur Radio station hazardous to our health?*

Fortunately, enough research has now been done that we know most Amateur Radio activities are quite safe. In fact, scientists from the Federal Communications Commission and the Environmental Protection Agency conducted a field survey of EMFs at typical Amateur Radio stations in 1990. They concluded that most amateur operations do not produce EMFs strong enough to pose any health hazard. And for many years, the American Radio Relay League's Board of Directors has also been monitoring the ongoing research about EMFs and health through a board-appointed Committee on the Biological Effects of RF Energy. There is extensive coverage of the issue of EMFs and health in both *The ARRL Handbook* and *The ARRL Antenna Book*—with recommendations for safe Amateur Radio operating practices.

Amateur Radio is a hobby that can be pursued safely, provided everyone observes a few simple precautions. This article was written to summarize what we know about EMFs and health, and to suggest safe operating practices.

Scientific Background

When scientists talk about electromagnetic fields, they're talking about several very different forms of energy. *Low frequency* or "power line frequency" fields are produced by electric power lines and appliances, typically operating at a frequency of 60 Hz. Much research is now under way concerning the health effects of 60-Hz



This 3-element 6-meter beam is only a few feet above N6NB's second-story hamshack. When the antenna is pointed toward the operating position, fields in excess of ANSI standards were measured in the shack on a laboratory-grade hazard monitor. The transmitter power output was set to 900 watts.

fields—the kind of EMFs found in virtually every home and workplace. Additional research is being done to investigate the possible health effects of *radio frequency* (RF) energy, which is much higher in frequency than the electric energy in power lines. RF energy is produced by radio and television transmitters, radar installations, cellular and cordless telephones, microwave ovens and even remote controls for garage door openers.

Low-frequency and RF energy are forms of *nonionizing radiation*: The frequency is too low to produce enough photon energy to ionize atoms. In contrast, *ionizing radiation*—which is *not* produced by power lines or radio transmitters—can cause severe and well-documented health hazards. Nuclear weapons produce enormous amounts of ionizing radiation, while small, carefully controlled doses of ionizing radiation are used in medical X-ray equipment, for example.

The present controversy concerns nonionizing radiation, including power line frequency and RF energy. Much is now known about the biological effects of this kind of energy, but there is much more that we do not yet know. Before World War II, scientists knew that nonionizing radiation could produce thermal (heating) effects. At sufficiently high power levels, EMFs can cause body heating, which may result in health hazards such as blindness or sterility. Most ordinary household appliances and transmitted radio signals produce EMFs far weaker than those required to produce thermal effects. On the other hand, microwave ovens *do* generate EMFs strong enough to produce thermal effects: That's precisely why they can heat and cook food. The trick is to keep the EMFs safely inside the oven—away from people. For obvious reasons, microwave ovens must meet strict safety standards.

In recent years, a new element in the debate over EMFs and health has been the finding that even at *athermal levels*—energy levels too low to cause body heating—electromagnetic energy appears to have various effects on the human body. The first scientists whose work in this area gained widespread media publicity were *epidemiologists*—medical researchers who look at the health patterns of large groups of people, using statistical methods.

Over the last two decades, a number of epidemiological studies have found that electrical workers have higher-than-normal death rates from certain cancers, including leukemia, lymphatic cancer and brain cancer. Other epidemiological studies have shown that children living near some types of power lines have higher-than-normal rates of leukemia. Still other studies have concluded that persons exposed to certain chemical agents such as solder fumes in addition to high EMFs have up to 10 times the normal rate of certain cancers.

All of these studies involved groups of people who were not ordinarily exposed to EMFs strong enough to cause body heating. Thus, their health patterns suggested that low-level EMFs may pose health hazards.

There have been other epidemiological studies, however, that did not confirm some of these findings. And still other researchers have concluded that environmental factors such as the alignment of the Earth's natural magnetic field may interact with man-made EMFs to alter these health effects. (The Earth's magnetic field is stronger than many man-made fields, but it is a *static, direct-current field*. Most man-made EMFs are *alternating-current fields* operating at a variety of frequencies and power levels.)

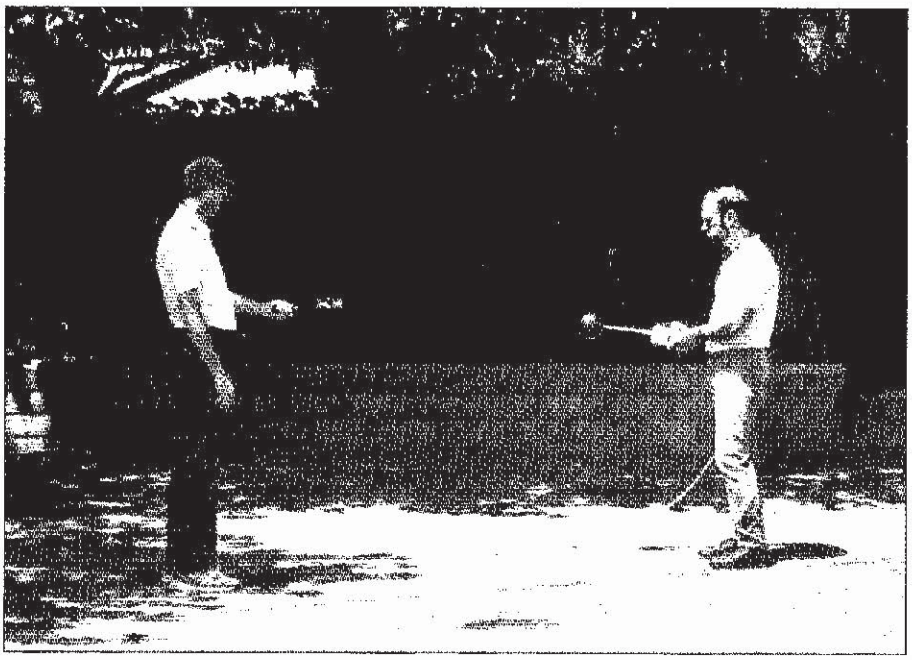
There are other dimensions to this problem, too. Some of the research that failed to confirm a correlation between EMF exposure and health was funded by industry groups that have a financial stake in the outcome of the research. Critics have challenged the credibility of some of the research for that reason. Moreover, epidemiological research only reveals health patterns; it does not prove what caused those health patterns. If electrical workers have an abnormally high rate of certain cancers, that may result from their occupation—or it could result from something else. In short, the work of epidemiologists shows *correlations* without proving *causation*. That raises troubling questions without providing definitive answers.

Responding to the questions raised by epidemiologists, a number of medical researchers have launched laboratory based studies of the effects of EMFs on living tissue. There has been an explosion of knowledge about molecular biology and the related field of genetics in recent years, and one of the focal points of this research has been the role of electromagnetic signals at the molecular level. Among other things, there have been studies suggesting that certain types of electromagnetic fields may alter the body's genetic makeup, causing chromosome damage.

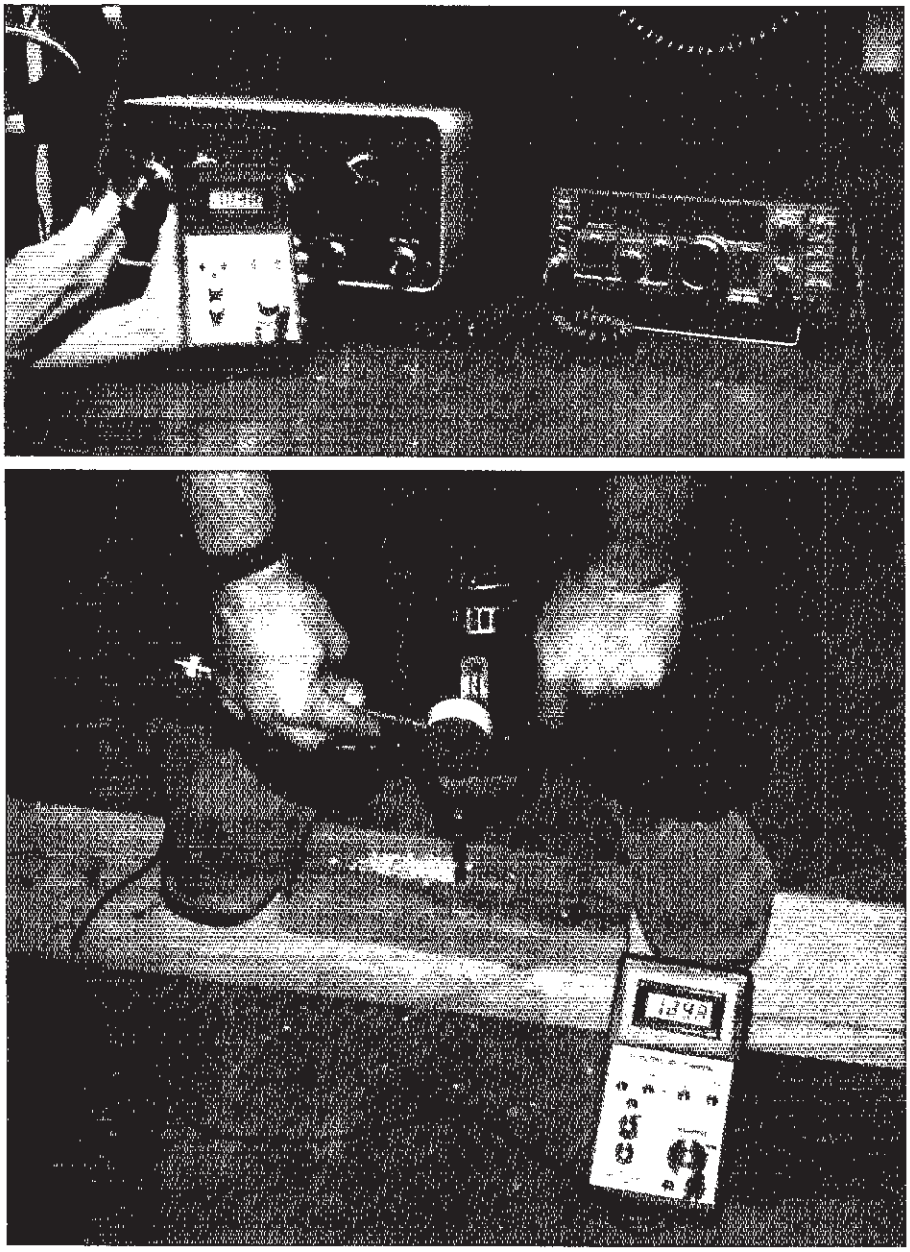
It is also known now that some EMFs may disrupt the flow of vital chemical and electrical signals between cells in the human body. EMFs appear to alter the passage of chemical and electrical signals through the cell membrane (the thin layer of material that covers each cell). This has caused some scientists to conclude that EMFs may sometimes affect the work of the body's immune system in fighting cancer.

If the body's cancer-fighting T-cells fail to detect that a particular cell has become cancerous because cell-to-cell communication is disrupted by EMFs, that would increase the risk of a tumor developing. There is also laboratory research indicating that EMFs may inhibit the body's cancer-fighting ability in other ways.

Researchers have found that certain EMFs reduce the activity of messenger enzymes called *protein kinases* and also affect the way cell growth is regulated. There is also evidence, now confirmed through research in several countries, that EMFs



Dr Robert Cleveland (FCC) and Ed Mantiply (EPA) measure RF fields generated by a hidden wire antenna at a condominium complex. When local restrictions force hams to use indoor or hidden antennas, extra safety measures should be taken.



Many home appliances produce strong low-frequency electromagnetic fields. The 60-Hz field generated by this hand drill, for example, is in excess of 1200 milliGauss. In contrast, the 60-Hz field 12 inches in front of the 1-kW Amateur Radio amplifier is about 10 mG. The main sources of 60-Hz fields in ham gear are power transformers and cooling fans.

sometimes work together with cancer-promoting chemicals to increase the risk of cancer beyond that associated with either the chemicals or EMFs alone.

EMFs also appear to change the body's rate of production of certain hormones that have cancer-inhibiting effects, such as melatonin. Some studies have found that persons sleeping under electric blankets have lower-than-normal levels of melatonin production *when the blanket is operating*, but their melatonin production returns to normal when the blanket is switched off. Some scientists think the effect of EMFs on melatonin production may explain many of the apparent health effects of exposure to low-level fields.

As with the epidemiological studies, laboratory research has raised questions and stirred controversy. Some laboratory studies have been difficult to *replicate*: Other researchers have not always observed the same results when they attempted to repeat some experiments. There appear to be other variables that affect the outcome of research on the biological effects of EMFs.

For example, there is evidence that low-level EMFs have significant biological effects only at certain frequencies and intensities—and not at other frequencies or intensities. There is a general rule about toxic and cancer-causing chemicals: If some is bad, more is worse. That rule may not necessarily apply to EMFs, however: Some studies have detected biological effects of low-level EMFs—but *not* when the field is stronger.

There are also studies showing health effects at certain frequencies but not at adjacent frequencies. And there are studies suggesting that a radio signal modulated by certain low frequencies, or a signal that is keyed or pulsed, has more harmful effects than an unmodulated, steady carrier. Scientists call these kinds of phenomena *window effects*, and they greatly complicate any attempt to understand the relationship between EMFs and health.

There is an unfortunate footnote to this research on window effects: Much research seems to indicate that there is a window at 50 or 60 Hz—the exact frequency of the electric energy traveling through millions of miles of in-home wiring in the US and many other countries; EMFs at higher and lower frequencies may not have the same health effects as 60-Hz fields. And yet, the financial and technical obstacles that would stand in the way of changing the frequency of ordinary household ac current—should that prove to be desirable—are staggering.

Safe Operating Practices

After reading this far, if you are uncertain about the possible health effects of EMFs, you're not alone. The scientific community itself does not agree about this issue. In fact, medical doctors, biologists, physicists and other scientific researchers are engaged in an intense, sometimes-emotional debate about the health effects of EMFs. There is a computer bulletin board system for scientists concerned about this issue; messages posted there range from esoteric discussions of these complex issues to personal attacks on some scientists who espouse views not shared by others!

If the experts don't always agree, how can the rest of us know what is safe and what isn't? The American National Standards Institute (ANSI), a private body that sets voluntary standards for industry, has had guidelines for exposure to EMFs for many years. In fact, the ANSI guidelines have been revised downward repeatedly to reduce the recommended safe levels of EMF exposure.

ANSI adopted its latest guidelines in 1992, *but many health scientists have questioned whether even the newest guidelines are adequate to protect public health.* Recently, the Environmental Protection Agency publicly questioned the adequacy of the 1992 ANSI standards in an official statement to the Federal Communications Commission.

Some scientists challenge the newest ANSI standard on several grounds. For one thing, it's primarily intended to prevent exposure to EMFs strong enough to cause thermal effects, not exposure to weaker

EMFs that may cause athermal effects. Nor does the ANSI standard take into account the effects of modulation. And the ANSI standard applies only to RF energy, not to low-frequency EMFs that are so central to public debate these days.

There is no generally accepted standard in America for exposure to the low-frequency fields produced by power lines or home appliances. And in general, there is considerable uncertainty about what level of electromagnetic energy should be considered safe.

Another problem is that RF fields are difficult to measure. The price of a professional quality RF power density meter runs well into four figures, and low-cost meters for home use are often grossly inaccurate. Even the best meters may not be accurate in the *near field*, the area close to an antenna where the potential for hazardous RF energy levels is greatest.

Field strengths can be calculated using mathematical formulas, but that, too, fails to take into account the random hot spots that often exist in the near field. Fortunately, the low-frequency fields from power lines and appliances are easier to measure than RF power densities.

If there is no consensus about safe energy levels, and if EMFs are difficult to measure, what can we do to minimize the potential health hazards of EMFs?

Several years ago, Professor M. Granger Morgan of Carnegie Mellon University offered a simple proposal: practice *prudent avoidance*. Dr Morgan said we should avoid unnecessary exposure to EMFs as a common-sense response to potential—but not yet proven—health hazards. He didn't suggest that we all abandon our electric appliances and go off to live in the woods in cabins without electricity, but he did suggest that we minimize exposure to EMFs when it's practical to do so.

He said, in essence, to avoid electromagnetic fields strong enough that they *may have* adverse health effects. The League has adopted Dr Morgan's approach: The RF safety sections of major ARRL publications urge radio amateurs to practice prudent avoidance wherever possible.

Which amateur operating practices are clearly safe, and which ones might be hazardous? Here are some suggestions based on guidelines developed by the League's Bio-Effects Committee:

• Transmitting antennas should be mounted well away from living areas. If medium or high transmitter power (100 W or more) is to be used, antennas should be mounted on a mast or tower at least 35 feet above any populated area if possible. The FCC/EPA study indicated that with an antenna that high, there is little RF energy where people are.

Because feed lines can radiate in some cases, when installing open-wire line (or even coaxial cable if the SWR on the line is high), it's best to route it away from areas where people will be spending a lot of time.

• When using a ground-mounted or mobile antenna, be careful not to transmit when anyone is near the antenna. A good rule of thumb is to avoid transmitting when anyone is within three feet of a car-mounted 2-meter FM whip if you're using a typical 25-W transceiver. With a 100-W amplifier, don't transmit when anyone is within five or six feet of a whip antenna. If you're using a beam antenna and 100 W or more, follow the 35-foot rule: Don't transmit when anyone is within 35 feet of the *front* of the antenna (the direction where the antenna is pointed). It may be safe to transmit when people are a little closer to the antenna if everyone is below it or behind it, not in front of it.

• Exercise particular care when using indoor antennas, including those mounted in attics, because in some situations they can generate substantial RF fields. As much as possible, try to locate indoor antennas as far from people as possible. Use low power (10 W output or less), and keep your transmissions short when someone might be near the antenna.

• Never use a power amplifier that has its metal cover removed. The cover provides shielding, keeping the RF energy inside the unit—not out in the room.

• If you're going to experiment with UHF or microwave equipment, or do moonbounce communications, discuss your installation with experienced operators before getting on the air. UHF and microwave antennas and waveguides—as well as high-gain moonbounce antennas—may produce hazardous levels of RF energy and must be installed carefully so that no person is in the line of fire. Never look into an activated waveguide or stand in front of a high-gain VHF-UHF antenna when the transmitter is on.

• When using a hand-held transceiver, use the lowest power possible and keep the antenna as far from your head as possible. Within the scientific community, there is disagreement about the safety of "handy talkies." Most hand-helds have been exempt from the ANSI standard because their power output is too low to produce significant whole-body heating. However, there is growing evidence that even 1- or 2-watt hand-held radios may produce significant EMFs within the user's head, with possible health effects that are not yet fully understood. (The potential for a health hazard is greatly reduced when a hand-held radio is used in its low-power position, with only a fraction of a watt of output power.)

• Be aware that low-frequency fields exist in your home. If possible, avoid being within 24 inches of any electric motor or power transformer while it is turned on. Hair dryers, ac-operated hand drills and other electric devices that are held close to the body when in use often expose users to stronger EMFs than those produced by Amateur Radio equipment. Nevertheless, it is a good idea to stay about 24 inches away from the fans and power transformers found in high-power amplifiers and 12-V power supplies, for example.

Further Information

The issue of electromagnetic fields and health is as complex as it is controversial. It isn't possible to cover this topic fully in a short article such as this one. A more detailed and technically oriented treatment of the subject appears in the "RF safety" sections of current editions of *The ARRL Handbook* and *The ARRL Antenna Book*. The bibliography there lists some of the major scientific works in this field.

Wayne Overbeck, N6NB, holds PhD and JD degrees and is a Professor of Communications at California State University, Fullerton. He first became interested in this subject because his own operating activities—VHF DXing and contesting with high power portable stations on mountaintops—require special precautions to minimize EMF exposure.

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