LUNCHEON PRESENTATION:

ELECTROMAGNETIC FIELDS: Think Benefits, Not Hazards

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It's a pleasure to be here. One thing that wasn't mentioned in my introduction (Editors note: Introduction and copies of the handouts can be found at end of the presentation.) is that the reason I am here, I guess, is that I was interviewed by Gina Kolata of the *New York Times* Science staff. She published an interview with me on January 16 of this year in the "Science Times" section of the newspaper. I have found out since then that such publicity opens many doors, and I am delighted that it helped to open this door. I'm delighted to be here to communicate with you today.

The handouts give you a brief outline of what I want to say. And I have included one representative set of my data that I will try to speak from to let you know a little bit about the research I am conducting at Brooks Air Force Base.

The thesis I wish to put forward today is that when you think about radio frequency and microwave energy, you should think benefits, not hazards. In the beginning people were thinking benefits. D'Arsonval and Tesla, working more than 100 years ago, were trying to design systems that might be useful in the clinic to cure various kinds of diseases. Shortly after that, at the beginning of the 1900s, came the invention of diathermy, and diathermy, at low frequency and even at 2450 MHz, is still in use today. The patients who came to the clinic, I'm told, would come several times a week, be irradiated for 30-45 minutes at a time, for weeks, and weeks, and weeks on end. These treatments provided deep heating to their tissues where they suffered neuromuscular diseases and the patients were greatly benefited by these treatments.

Of course, many of you know about the invention of radar during World War II and there are lots of anecdotes that you may know better than I. These concern standing in front of radar dishes to get warm or to blow up eggs in the radar beam. Men also stood in front of the beam before taking shore leave, which really didn't work as it was supposed to have done. Shortly after the war came the application of microwave energy to the cooking of food, and it was only just a few years after that that the "hazards" began to erupt. A gentleman named Paul Brodeur, of whom you may have heard, was a reporter for the *New Yorker* magazine. He published a series of articles and then decided to put them into a book that he called *The Zapping of America*, about microwaves, the great hazards and the cover-up by the 'military-industrial coalition. The book started an attitude that we now call electrophobia. But in rebuttal to Paul Brodeur's book, a very dear friend of mine, Professor Robert Vivian Pound of the Harvard University Physics

department wrote a short article in *Science* magazine in 1980. This little article talked about the use of radiant energy for providing comfort heating of people in enclosed spaces. And what he proposed was simply that we consider the possibility of conserving energy by using microwaves for heating. He felt 10 gigahertz, (three-centimeter waves) would be appropriate to provide a little extra heating in indoor environments that could then be held at much cooler temperatures using conventional energy sources than would normally be the case. At the time, the ANSI C9S standard was 10 MW/CM^2 at this frequency. And he calculated that if you lowered the indoor environmental temperature to 52 degrees Fahrenheit, and if you had 10 MW/CM^2 irradiating people in the room, they would feel thermally comfortable.

There are lots of advantages to this system—you could have it applied room-by-room, instant on/instant off as you go in and out of a given room. The power would be regulated for the number of people in the room. Saving energy was a big thing back then and saving energy today is also getting very big. And I am terribly hopeful that the Pound proposal can be revived and that we can really consider providing some of the thermal energy that we need to be comfortable, particularly in the Northern hemisphere, through the use of microwave radiation.

My friend Charles Buffler, who passed away only a couple of months ago, had a little sheep farm in New Hampshire, and he built a small microwave incubator for use in rescuing newborn lambs that had been dropped in the fields and were severely hypothermic. I told him, "Charles, you really ought to patent this thing, because they could really use it in New Zealand and Australia." Unfortunately, Charles wasn't able to do that, but it's another beneficial application of which we can make use down the road.

In the meantime, however, electrophobia has proliferated, and you know as much as I do about it. The second book Brodeur wrote was called *Currents of Death*, and this was about the powerline problem and potential for childhood leukemia produced by powerline emissions. I wrote a paper, sponsored by the IEEE Committee on Man and Radiation--I called it "Currents of Death Rectified"--and I told the truth, whereas Brodeur had not done so. He has written another book, but he has finally retired on the profits of his publications and lectures. His campaign has been taken up by Louis Slesin, who is the editor of a yellow journal—it's printed on yellow paper—called *Microwave News*. This journal comes out bimonthly, and Slesin has picked up on all these terrible "hazards" to humankind, starting with radar, microwave ovens, police radar, the 50-60 Hertz powerline emissions. He is now working hard to convince us of the hazards of cell phones and the emissions from cellular base stations. Don't believe a word of it; there are no hard data to substantiate *any* kind of deleterious effects to human beings from any of these systems. (Applause.) And that's the truth.

I'd like to talk about a little hard scientific data. Many of you knew the pioneers, some of them are still around, Herman Schwan is one of my mentors and idols. There was also Jim Hardy, who worked with Schwan at the University of Pennsylvania, and who convinced me to get into the

microwave business. And Sol Michaelson, who carried the brunt of all the attacks that were the result of some of Brodeur's books. We have established a Michaelson Research Conference in his honor that meets in August every year at delightful places such as Glacier National Park, Colorado Springs, and other comparable places. If any of you are interested in joining the group, please contact me. We talk hard science, we give people an opportunity to discuss their results openly, we don't have time limits on presentations, and we have a good time in the bargain. Another pioneer was Russell Carpenter, whose son Russ has recently contacted me. The United States Air Force is going to publish a book of reprints of Russell Carpenter's work on microwave cataracts for distribution at the Michaelson Conference this year. Many of you may know John Osepchuk, now retired, but still very active in the IEEE Standard Setting Committee. He is the chairman of IEEE SCC28. I'll take over for him when he steps down late this summer. But I remember when the Bioelectromagnetics Society had a meeting in Boston, John Osepchuk invited many of his special friends out to his house in Concord for supper and a pleasant evening. And when we got there, who should we find but Bill Brown, who had set up his satellite energy system in the backyard at John's house. He demonstrated first how you get up in front of one board, (which was the source, of course), and then you start moving backwards toward the rectenna. He gave a demonstration, and I put my hand up and I said, "Bill, I want to do it, too." And I did. So, from my point of view, that was one of my first microwave exposures. It was a pleasant experience and very benign.

In 1977, when I was working in the Pierce Laboratory at Yale University, I was working with a large colony of squirrel monkeys, studying how they regulate their body temperature. I applied to the Air Force for some funding to use microwaves as an alternate source of heat for the monkeys. I was extremely successful with this work, and graduated to a larger primate, human beings, in 1994. I figured I'd done enough work with monkeys; people now accuse me of conducting monkey experiments on people. And indeed that's sort of what I'm doing because I worked out a specific protocol with the monkeys that seemed to work and I've transferred this to the studies I'm currently conducting. We started out at Yale studying 450 MHz, which was the resonant frequency for squirrel monkeys, but it turned out to be an appropriate frequency for partial-body exposure of humans. And after finishing that study, I started working at 2450 MHz. These were sources I had in place, and the Air Force said to me, "Come on, bring these down to Brooks Air Force Base, we'll give you a job, and you can also make use of some of the other equipment that we have here." So, I have now completed studies at 450 MHz continuous-wave exposure and 2450 MHz, both continuous-wave and pulsed fields. I did another experiment in which we added 15-minute bouts of exercise with a little pedaling exercise machine built out of all plastic. Our subjects on demand had to pedal this device at a rate that would raise their resting metabolic heat production by a factor of two. In resting subjects exposed to microwave energy you never see any change in metabolism; indeed, some subjects even go to sleep. When we made them exercise, we found some interesting things. Exercise would prime their sweat glands and then when the RF was turned on, they would sweat much more than they would normally have done if

the exercise had not occurred. We also very recently did an extension of our 2450-MHz continuous-wave experiment to two higher-power densities than we had used before. The original experiment included a sham exposure, 27 and 35 MW/CM^2 peak power density measured in the center of the subject's back. After five and a half months, I managed to convince the institutional review board in charge of human research that I should be allowed to use a couple of higher power densities, 50 and 70 MW/CM^2. The 70 watts per centimeter squared level is twice the IEEE standard for partial-body exposure of human beings at this frequency. I have the data for these higher power densities on my poster; I'm sorry I won't be able to talk about the poster to you individually. But let me just tell you what we do in these experiments. They are all conducted inside anechoic chambers. The experiment I am currently engaged in is conducted at 100 MHz, the FM frequency, which is a resonant frequency for seated adult humans. So we are heating the whole body though and through, unlike the surface heating at the higher frequencies. But the protocol is always the same: 30 minutes of equilibration one of three environments, cool, neutral, or warm; then a 45-minute exposure to the radio frequency field; and finally a 10-minute cool down before the subject is taken out of the experiment. We are measuring deep-body temperature in the esophagus, at the level of the heart. The subject swallows a little tube, inserted through his nose, and we insert a temperature probe to the tip of the tube, which is located next to the heart. This is the gold standard of deep-body temperature measurement. We measure six or seven skin temperatures, all of these with equipment that has no metallic components whatever. We measure sweating from the subject's chest and back with plastic capsules that pull in air of known-relative humidity, add a little more moisture as it passes over the skin, and then we assess the change in relative humidity downstream. We measure blood flow at four sites on the skin with laser-Doppler flow meter probes. These probes count blood cells going through capillaries and the rate at which they are traveling and we, therefore, get measurements of changes in skin-blood flow. The subject wears a mask so that we can capture the expired air and pull it outside for analysis of oxygen consumption, CO^2 production, and calculate the metabolic heat production of the subject. The figure provided to you has all of these variables plotted as a function of time. This figure shows group data from seven subjects, conducted at an ambient temperature of 28 degrees, which is a neutral environment for a subject in a bathing suit. The upper left panel shows esophageal temperature, which is the black tracing, and an assortment of skin temperatures that are all identified. The lower left panel shows sweating from the back and chest. The upper right shows metabolic heat production--no change whatsoever. And the lower right panel shows skin-blood flow at four sites on the body that are also identified. This experiment was conducted at the power density of 70 MW/CM^2, and is the one that is twice the IEEE/ANSI standard at this frequency for partial body exposures. Notice that there is also no change in the esophageal temperature. We never see a change in esophageal temperature, except in a couple of instances when we are testing native Texans who run esophageal temperatures close to 36 degrees, not the normal 37, and they don't sweat. Their deep body temperature is below the threshold for sweating, and even in the 100-MHz field we don't see these people sweating. In any case, the group data show no change in deep-body temperature, very strong

changes in the skin temperatures measured on the back, which is facing the antenna, and modest increases in the other skin temperatures. But notice that these are tempered over time because when sweating begins these temperatures level off and even fall because of the evaporative cooling of the sweat on the skin. Skin-blood flow will also increase wherever you are measuring it on the body. My poster summarizes all of the data that we have collected at 2450 MHz continuous-wave exposure and shows that across the power densities explored there is no change in metabolism, no change in esophageal temperature, and changes in skin temperature that are related to location of the measurement and also of the environment in which the subject is sitting. The most dramatic change is of the sweating response, which is maximal in the warm environment, a little less in the intermediate environment, and we have no threshold for sweat production in the cool environment even at 70 MW/CM^2.

Well, I can take questions on this later if there is time. But let me move on to possible benefits of this energy. I sat in the morning sessions today, and I listened to you talking, once again, about solar power satellites. My comment to you is "Go for it!" And go for it as fast as you can. If anybody gives you a hard time about "Oh, it's going to hurt people if they get into the beam," or harm birds or other organisms, rely on the data. The data that we have on human beings and nonhuman primates is solid and we can bring it to bear for you.

I hope that the Pound proposal will be implemented soon. I tried to influence a Danish house-building company many years ago to implement the Pound proposal. They were building a house at Brookhaven National Laboratory, and I said, "Why don't you put some RF in one of the rooms there." They looked into it, I sent them a lot of literature, and then all of a sudden electrophobia hit Denmark and they wrote to me and said, "Sorry, this won't fly. People are too afraid of this energy."

There is a colleague of mine, Richard Olsen, who has designed RF coils for reheating or rewarming individuals who have become severely hypothermic. These operate at low frequency, 27 MHz or below. He's also using them for localized heart therapy in the clinic. I have a device for my knees that he built for me because I have severely arthritic knees. I put this little knee brace on and turn on the RF for 15 minutes and, oh, the deep heating makes it feel wonderful. He has designed mittens and booties for Navy Seals to wear under water to keep their hands and feet warm, so that their work won't be impeded. Many other applications for these kinds of coils can be imagined.

Microwave incubation is another potential benefit. It would be great if we could build microwave incubators for premature infants. The convective incubators we have now dry out the skin, the infrared incubators burn the babies sometimes; microwave frequencies can be tailored to the size of the child and anybody else who is in or near the field will be unaffected. We concentrate the energy in the babies, and I would sure like to see that. I did a seven-year study under NIH funding in which we looked into this possibility for infant rats. I don't like to do rat

studies, but we did because they were convenient. And we had infant rats irradiated from birth until weaning for eight hours a day, and we let them grow up, mate, and produce offspring. We could find nothing wrong with the irradiated rats or their progeny.

Microwave hyperthermia as an adjunct for cancer treatment has been ongoing for some time. It's not perfected yet, but it should be pursued diligently. It's wonderful and has great promise.

And I wish I had a microwave sauna in my house in which I could go in and sit for a while. I used to do this anyway in the lab; I used to disable the interlocks on the chamber doors and go in and sit in the RF field for 15 or 20 minutes. It helps the arthritis tremendously.

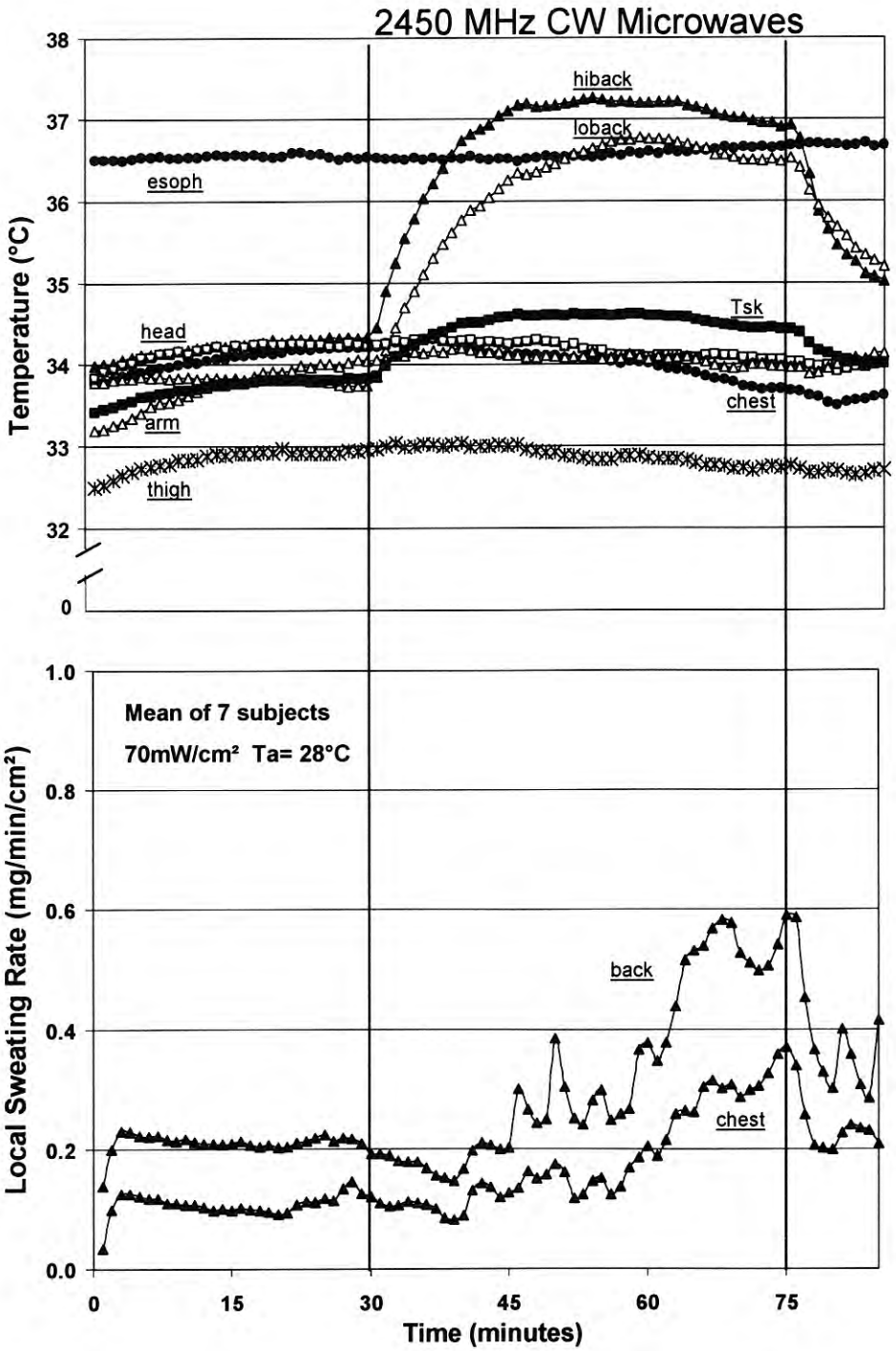
So, my view is that radio frequency and microwave radiation is the wave of the future. The military is using it in spades. They are developing many kinds of weapons systems, radars, and other devices. The Air Force alone has more than 8,000 different types of RF emitters in the field already. There is nothing that can compare to it to do certain kinds of jobs that need doing. Communications and television, I mean it's exploding. So, you folks are on the right track. And my view is, we ain't seen nothin' yet, as far as our use of microwaves is concerned. But we have a challenge, and the challenge is still electrophobia. It's still out there. The Louis Slesins are still telling people how insidious this energy is. My response is we must educate the people, and this project that's going on at Thomas Jefferson High School was so exciting to me that I was almost in tears. They're finally doing something, getting students interested and knowledgeable about this kind of science. More power to you, and if there's anything I can do to help, please let me know. But if we could get kids at first grade or kindergarten, you know, we could give them very, very elementary lectures on what this energy is and how it interacts with them. We could go to PTA meetings, to get the parents interested. We can lobby our representatives and senators in congress. We can talk to science reporters, who don't know as much science as they think they do, most of them, and we can educate them so that they write more nearly the truth in the articles they publish in the paper. My advice to you is to lean on the hard data. If you want to know where it is, let me know and I'll tell you. Lean on the standards. The new IEEE standard is going to be higher than the current one, and it's largely because of the data I have collected, I'm happy to say. The dosimetry these days is getting much, much better, and far more refined. The modeling in which we will incorporate human physiology into the dosimetric models is just over the horizon.

So, my message is, I stand ready to help you. I have put a couple of brochures over here. My Air Force Research Laboratory colleagues, in San Antonio, said, "Take some of our brochures, because if you have people in this group who are interested in testing out systems, wanting to know interactions of the energy from certain systems in animals or humans, talk to us. Talk to us if you have questions on dosimetry. We can arrange contracts and we can do the work. We are the number one center in the world for doing this. We have more different emitters, more frequencies, better-trained personnel, we've got a wonderful installation down here, and we are at

your service." I also put out some brochures about the new International Committee on Electromagnetic Safety (ICES), which is the new name of the IEEE Standards Coordinating Committee 28. ICES is working on standards for the full range from zero hertz to 300 gigahertz and we'll have two new standards out within the next couple of years. So, let me know if you think I can help you. It has been a pleasure to talk to you.

Dr. Eleanor Adair is a senior scientist for electromagnetic radiation effects, of the U.S. Air Force Research Laboratory at Brooks Air Force Base, Texas. Dr. Adair received her Ph.D. in Experimental Psychology with a minor in Optical Physics from the University of Wisconsin. She joined the research faculty of Yale University, and since 1968 she has concentrated on quantifying the mechanisms that underlie the regulation of body temperature, in both humans and non-human primates, exposed to a wide variety of thermal stimuli. In 1975, she began to examine the consequences of exposure to low intensity microwave fields on physiological and behavioral thermoregulatory responses of squirrel monkeys. Her other research involves the predictive modeling of human thermoregulatory responses during exposure to radio frequency fields and, currently, the measurement of thermoregulatory responses in human volunteers.

She assumed her current position in October 1996. She has numerous awards and is a Fellow of six scientific societies. She has been the secretary-treasurer of the Bioelectromagnetics Society and chairman of the IEEE Committee on Man and Radiation. She now serves as vice chairman of the IEEE standards coordinating committee 28 and is also a member of the National Council on Radiation Protection and Measurement (NCRP) Committee 89-5. She served as cochairman of the IEEE subcommittee that set the current guidelines for human exposure to radio frequency fields.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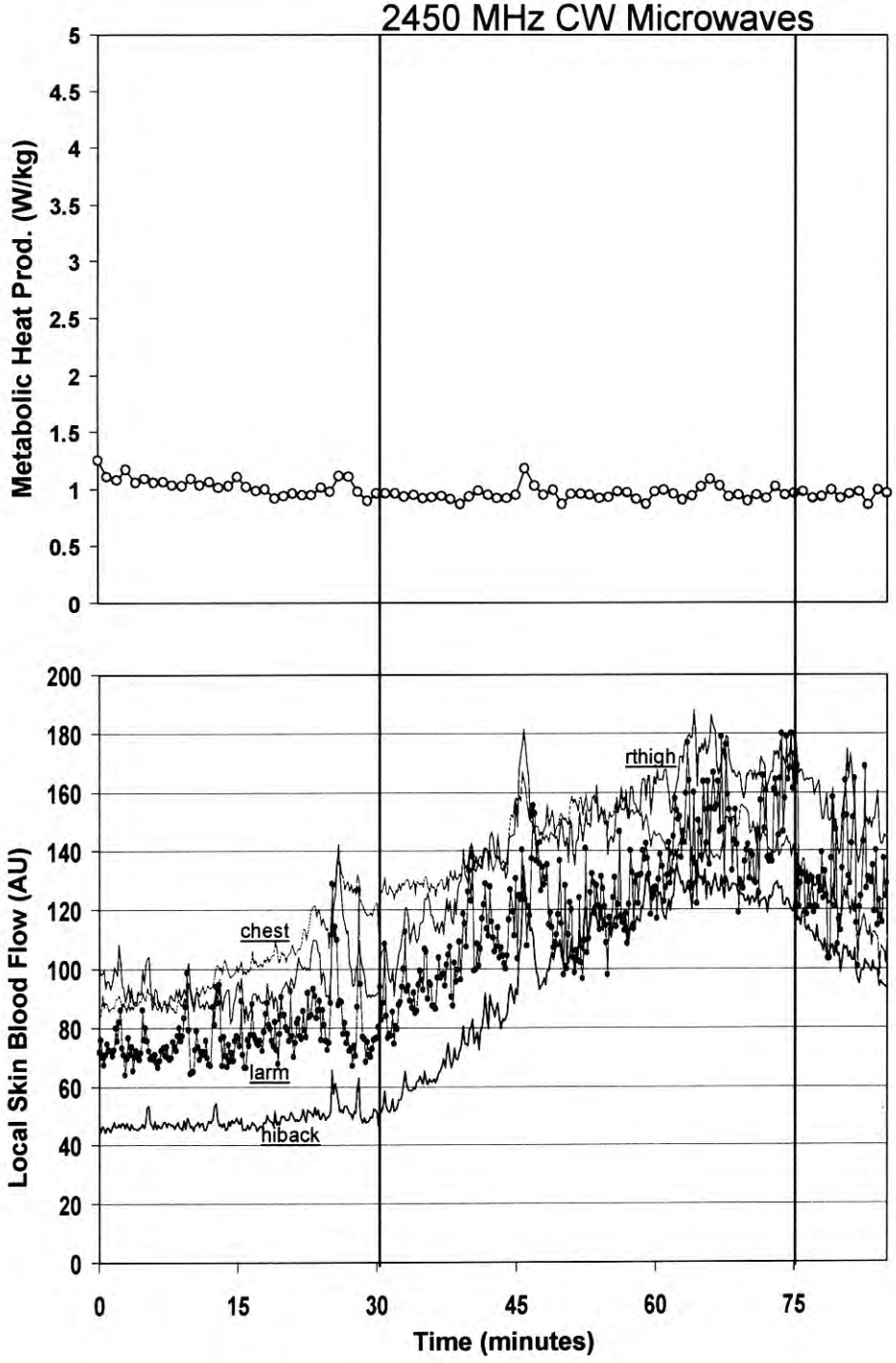
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