Question 3

Why are research efforts and regulatory efforts out of sync? (That is, the ORP is developing Federal Guidelines while the ORD will spend over a third of their FY 80 funds in understanding the mechanisms of interaction.)

We do not believe that the research efforts in ORD and the regulatory efforts in ORP are out of step. These two programs are closely allied. In part this is because many of the ORD and ORP personnel are scientific colleagues of long standing pre-dating the formation of EPA in 1970 and partly because of the introduction of the Research Committee approach to this area through which ORP exercises an active role in the research program direction.

ORP feels that the present initiation for the development of guidance is appropriate for the following reasons:

(a) there is no present environmental guidance.

(b) the exposure levels recommended in the voluntary occupational guidance assume source control and a population of healthy adults neither of which are appropriate assumptions for the general public.

(c) levels of environmental exposure to small groups of people have been identified that are within approximately two orders of magnitude of the present voluntary occupational limits.

(d) there is a need to provide guidance for future source installation.

ORD is directing approximately 10% of the program's FY 79 funds and only approximately 15% of our FY 80 funds for research on the mechanisms of interaction of non-ionizing radiation. However, we believe that these levels of effort are justified for the following reasons:

(1) There is only one established mechanism which can explain most of the effects of non-ionizing radiation and that mechanism is gross heating resulting from exposures to high levels of NIR.

(2) There is an increasing number of research reports which describe biological effects at exposure levels that are not commensurate with the induction of gross heating. One may cite a large number of Soviet and East European reports as examples. These results suggest that non-ionizing radiation may cause biological effects without producing significant increases in temperature in sensitive tissue. The possibility of such interactions is being pursued by U.S. researchers.

(3) Knowledge of mechanisms of interaction would be an extremely valuable predictive tool in the development of generally applicable environmental guidelines. One may note that the lack of progress in the successful treatment of cancer is directly related to a lack of knowledge of the basic understanding of the mechanism of carcinogenesis. However, we need not have defined all the potential interaction mechanisms before an environmental standard can be set. Again we could use the analogy of cancer, where there are still uncertainties in the causative interactions with ionizing radiation but an environmental exposure standard is still justified.

Question 4

4a. Will any ongoing research projects of ORD help ORP develop Federal guidelines this year? 4b. What will be the ORD input to these guidelines? 4c. When do you think ORD will be able to make a substantive input to the ORP guidelines?

4a. ORP plans to prepare an Initial Draft of the Proposed Rulemaking by April 1980 and a Final Draft by March 1981.

Prior to April 1980 ORD expects to have completed studies of:

(a) the relative effectiveness of pulsed versus continuous wave 425 MHz radiation on the immune system of mice. This will contribute to the resolution of the question whether pulsed sources should be included in a general standard or addressed separately.

(b) the interspecies, dose-response comparison of the teratologic effects of 2450 MHz. This will provide information on the shape of the dose-response curve in the range 1-30 mW/cm^2 and some rough indications of risk estimates for birth defects.

(c) an interdisciplinary assessment of the biological effects of long term, continuous, 20 hour/day exposure. This will provide us with our first data on the health implications of continuous exposure to RF.

Prior to March 1981, ORD anticipates completion of:

(a) a critical assessment of the more recent East European NIR health effects literature. The last comprehensive treastise was essentially completed in 1972.

(b) an epidemiologic study of the correlation between RF emission density and cancer incidence in a metropolitan area. This will provide an indication whether current urban, ambient RF densities appear to correlate with cancer incidence.

(c) an epidemiologic study of the effects of exposure to radar during World War II. This will provide delayed indications of whether prolonged, high-level exposure to pulse microwave radiation correlates with life-span shortening or mortality from a particular cause.

(d) a study of the effects of pre- and postnatal exposure to microwaves on the mortality of infant monkeys. This provides a statistically valid investigation of previous suggestive results.

(e) a study of the results of ambient temperature/humidity and NIR exposure levels on the behavior of monkeys. This is a corollary to the previously conducted rodent studies.

(f) studies of the thermoregulatory responses of the rodents and monkey to chronic, low-level exposure to NIR. These will examine the physiological significance of the potential "hot spot" developments in critical tissues.

(Question 4 continued)

4b. As stated previously, ORD's role in the rule-making has yet to be completely defined by ORP. However, we know that ORD will be requested to provide the health effects background documents for this guidance. ORD will also be represented on the Agency's Rule-making Work Group.

We believe that we have already made a substantive contribution to ORP's data base which will serve in the development of guidance. These contributions include experimental bio-effects research at environmentally significant frequencies. Extended exposure studies have provided research results which call into question the adequacy of the 10 mW/cm^2 guideline as a departure point for the development of general population exposure guidelines.

4c. We believe that we are presently contributing in a number of ways including the area of health effects of RF on human populations.

We expect to contribute even more effectively in the future because of the introduction of the ORD Research Committee approach to the NIR program area. This approach is designed to improve the responsiveness of ORD research to Program Office needs through joint planning of the research program. Interaction with ORP in this context is already well underway and has been factored into our FY 80 program.

Question 5

5a. What projects are coordinated with other Agencies? 5b. What is the longest running project to date? 5c. Are any projects jointly funded? 5d. Will EPA support any very long term (5, 10, maybe 15 years) low-level studies?

5a. Both ORD and ORP have representatives on the Interagency Regulatory Liaison Group (IRLG) Radiofrequency and Microwave Committee which has one of its stated objectives as follows: "Identify common research needs and coordinate a biological and physical research project." Through this committee's comprehensive research plan for the regulatory agencies, all of EPA's research tasks for FY 80 will be coordinated with the two other member agencies on the Committee, the Food and Drug Administration (FDA/BRH) and the Occupational Safety and Health Administration (OSHA). The National Institute for Occupational Safety and Health, due to its supportive role to OSHA, and the Federal Communication Commission also participate on the Committee.

In addition, since 1975, the ORD program on the biological effects of microwave radiation has been actively involved in the US/USSR Cooperative Agreement in Environmental Health, Study of the Biological Effects of Physical Factors in the Environment. The 1977-78 work plan which emphasized behavior included two EPA projects on the neurobehavioral effects of microwave radiation. In the 1979-80 work plan, which was agreed upon in June 1979, the ORD program is responsible for 4 of the 9 projects under Topic 3.1: Study of the Biological Effects of Non-ionizing Microwave Radiation. These tasks involve intramural studies on teratology, immunology and behavior and the extramural study of infant mortality in monkeys exposed to microwaves. The National Institute of Environmental Health Sciences (NIEHS/HEW) is the coordinating agency for the US/USSR Cooperative Program on Physical Factors in the Environment. Other participating agencies are EPA, VA and FDA (BRH).

The manager of the ORD bio-effects program in non-ionizing radiation, Dr. Daniel F. Cahill, is also the manager of the microwave health and ecology program for the Department of Energy's Satellite Power System (SPS). The expertise in EPA's microwave bio-effects program has been used as a key element in the development and implementation of a research plan to study the impact of the SPS microwave radiation on the environment.

5b. The longest running projects to date are the Neurobehavioral tasks which are a part of the US/USSR Cooperative Program. These studies became a part of that coordinated project in 1977 and are included in the 1979-80 agreement.

5c. Joint projects have resulted from our involvement in the SPS project with DOE. A second 2450 MHz microwave exposure system is presently being installed in our laboratory through an interagency agreement with the DOE.

5d. EPA would be willing to support very long term (5-15 years) low level studies when a climate of stable funding and long-term support for microwave research programs develops.

Question 6

6a. Where does the expertise for Epidemiology reside in EPA? 6b. How is this expertise being utilized in non-ionizing radiation research?

6a. EPA's epidemiology expertise resides in the ORD Health Effects Research Laboratories in Research Triangle Park, North Carolina and Cincinnati, Ohio. Approximately 33% of the total is at Research Triangle Park and is available for support of NIR research.

6b. Epidemiologists have been and continue to participate in the technical review of grant applications and serve as project officers on extramural research.

Dr. CAHILL. That concludes my statement.

Dr. GAGE. This concludes our oral testimony at this time, Mr. Chairman, and we stand ready to answer any questions.

Mr. AMBRO. Thank you, Dr. Gage.

Mr. Walker?

Mr. WALKER. Dr. Cahill, you mentioned that research needs have been known since 1971.

Dr. CAHILL. Yes.

Mr. WALKER. Mr. Swicord, who appeared before you, said there was another 10 years of work that still needs to be done in this area.

Is this a serious health and safety concern for the American public that we are now going to have to wait that long for the results of research identified as needed in 1971?

Dr. CAHILL. No, sir, I do not believe the present ambient levels of radiofrequencies have any potential public health impact at this time.

Mr. WALKER. What about the kind of things I mentioned earlier, that you have a number of consumer products coming into the marketplace—in your opinion do they pose the kind of hazard that research should be moving toward?

Dr. CAHILL. Those would be specific sources and they come pretty much under the realm of another agency, the FDA, but I would think given their past performance in the terms of the microwave oven standard, as soon as they know there might be a hazard in the consumer product realm they would be actively investigating standards.

Mr. WALKER. What about people exposed to high levels of radiation in the workplace? Is that a concern of yours?

Dr. CAHILL. I would have to give my personal opinion. That is a problem that is germane to NIOSH, but there is a potential problem in the workplace. That is my understanding and my opinion. My knowledge is incomplete, to be sure, but there may well be.

Mr. WALKER. You know, just from the perspective of sitting here, we identify a problem and really, it is 18 years later before we are in a position to do something about the problem. You have a couple of generations of politicians that come and go in that kind of timeframe, and at some point, the political process is not going to permit that to happen. You will get regulation by default if research in some way does not speak to this kind of emerging problem.

I think here you have almost a classic example. You can identify the problem and really, what we are saying is that 18 years later we can do something about the problem we have identified today. That becomes a very serious question in the governmental policy realm.

Thank you, Mr. Chairman.

Mr. AMBRO. Thank you, Mr. Walker.

Dr. Gage and Dr. Cahill, you are members of the IRLG. Whose position is it in your written statement where you say, "The proliferation of literature reviews has little impact on current research efforts except that the area could use more researchers and fewer reviewers"?

Now, I agree with that.

Mr. Swicord's statement says, "The committee concluded that the most efficient and economical way to achieve this objective was to ask the National Academy of Sciences to undertake an objective, comprehensive, critical appraisal of the world literature on the biological effects of radiofrequency waves."

Is there any contradiction to that?

Dr. CAHILL. Yes; there certainly would appear to be.

Mr. AMBRO. How do you resolve that contradiction?

Dr. CAHILL. Initially the National Academy literature survey was to be an uncritical review of the literature, which I felt would be of marginal technical value but which would have some usefulness as an appendix to an EPA guideline for nonionizing radiation.

Mr. AMBRO. What impact do you have on that IRLG committee, when the committee concluded that the most efficient and economical way is to ask the NAS to do a review of all the literature?

Dr. CAHILL. The IRLG committee rewrote the original NAS scope of work to provide for a critical review of the literature, which is needed, and for which we voted.

Mr. AMBRO. I want you to know that we are not looking for contradictions except to make the point that even though many agencies, including EPA, sit on that committee, and as you put it, sit there and talk to one another, there seems to be intramural headknocking but nothing really happens. There is a review or study and then a committee, and an interagency group or liaison group, or another committee, and another agency, and 14 different regulatory arms and all kinds of other things. But when you look at it from this vantage point, there has to be something pulling it together even though everyone agrees that everyone else does the necessary coordinating, there does not seem to be much coordination.

Perhaps we do need an NAS study, I do not know, but let me ask you about EPA itself. Is there a clear mandate for EPA to act in this area? Do you have a regualtory mandate? Now, I know your shop is the Office of Research and Development, but can you address this?

Dr. GAGE. We have asked Mr. Galpin from our Office of Radiation Programs to come along with us because we figured this would be one of the subjects in quesiton. I would like him to describe the state of our mandate, such as it is.

Mr. GALPIN. If you are referring to a mandate in terms of a congressional statement that the EPA shall set some type of stand-

ard for microwave or radiofrequency no, we do not have such a clear cut mandate.

We are proceeding under the auspices of the Federal Guidance Authority which was given to EPA as part of the Reorganization Plan Three and used to reside with the Federal Radiation Council before it was terminated. It would be under this authority that we would move forward, and have already issued a notification of intent to move forward in setting Federal guidance to other Federal agencies that would direct them as to the levels of control that their operations would have to obtain.

Mr. AMBRO. Well, how do you proceed in ORD to conduct research and development in this area without a specific goal of the regulatory arm of the EPA? I presume you look into the health effects because someone mentioned it, but it is so varied and complex and you have limited amount of funding and personnel for this kind of research.

What is it exactly that you look into?

What do you do?

Why do you do it?

How do you do it?

When do you do it?

Dr. GAGE. Let me just say it was in this area of nonionizing radiation that we recognized that we needed very close communication between our Office of Radiation Programs and an appropriate component of the Office of Research and Development.

We recognize EPA's role in the regulation of nonionizing radiation sources would probably be fairly constrained or at least fairly well limited, given the type of responsibilities that we had transferred to us.

Mr. AMBRO. Constrained and limited to what?

Who makes that determination, and why?

Dr. GAGE. In this particular area, I think it is probably fair to say that we pretty much had to test the waters and to see.

Mr. AMBRO. I tried to give money for ground water research and you did not seem to want it. Maybe you should use an expression other than "to test the waters." [Laughter.]

Dr. GAGE. Very frankly, the early radiation protection guidance documents that were issued by the Agency were quite strongly resisted by a number of groups. Later, however, the documents were quite widely accepted. We are proceeding along similar lines in the area of nonionizing radiation by attempting, first to provide guidance for other Federal agencies and second, to provide guidance for the general public.

Mr. GALPIN. I should mention that the guidance for which we have issued a notification of intent is restricted to that area of radiofrequency exposure of the general public in the general environment. It is not related to consumer devices in terms of the interaction between the individual consumer and the device, nor is it relative to the workplace. The guidance we have put ourselves on record as moving forward on is for the general public, in the general environment.

Mr. AMBRO. Why?

What do you do with it?

Mr. GALPIN. We would anticipate in terms of control mechanisms, this would provide a basis for both the Department of Commerce and the FCC to utilize in both siting of sources and allocating power to sources.

You know, we are 2 years away from having the guide, so to give the details of how it will be carried out would be difficult. This is the kind of thing we anticipate developing down the road.

Mr. AMBRO. Well, it seems to me that what you are doing, is whatever you want to do. Suppose I said to you that Congress would now legislate a standard and if, indeed, we got to that point and did legislate a standard, the reason that would be significant, aside from compressing the time span for regulators to act, is because then you, the researchers and regulators, would say that that standard, the 10 mW/cm^2 one we have been talking about, is terrible for that, but it is all right for this, and it may be OK for that, and I could run down the line.

What would be your reaction; you especially, Mr. Galpin, to the Congress legislating a standard?

Mr. GALPIN. I think it would be difficult for the Congress to do.

Mr. AMBRO. You mean politically?

Mr. GALPIN. No. I just think in order to put together the background to do that. I think also that it would be inappropriate. I think it would be better if you wanted that standard to be set for the various areas, that you mandate that they be done within some period of time if that was the desire of the Congress.

Mr. AMBRO. So, if we say that it would be inappropriate for the Congress to legislate a standard, even to get things moving and to do what industry wants us to do, whether we get them off the hook or not, then we might move in the direction of providing a reservoir of funding and a clear mandate to a centralized agency to perform all of the research and development, assigning missions to other agencies that can do it, and then having feedback from the regulatory arms in terms of their needs.

What do you think of legislation that would do that sort of thing?

Mr. CAHILL. I personally do not think that would be an appropriate thing to do. If you really want to get at a coordinated Federal program, in my opinion, what you need is obviously what I suggested.

Mr. AMBRO. I think yours is the best suggestion so far.

Dr. CAHILL. I think it would be helpful if you got the line managers of all the involved agencies together.

Mr. AMBRO. Who?

Dr. CAHILL. Me.

Mr. AMBRO. Who would get the line managers together?

Dr. CAHILL. Let us have NTIA provide a home and some small staff support to the Interagency Coordinated Program for the Health Effects, and have as the main driver, the group that is responsible for making this Federal program work, this Coordinating Council made up of the line managers from each of the agencies.

Now, this is a small area and it has been a drawback in some respects in getting the research done, but it is an advantage in that we know all one another. I believe we can all work together to deal

with the common problems we have and each agency would still have its own mission and its own needs and research agency—specific research would have to be done by its own forces. The Coordinating Council could assign research on common problems to the various agencies.

Mr. AMBRO. Did this thought just come to you?

Dr. CAHILL. No; I wrote it in my testimony a couple of days ago.

Mr. AMBRO. I am not being facetious. When did you decide to focus on this and develop this kind of approach? How far back? Just recently?

Dr. CAHILL. Yes, fairly recently.

Mr. AMBRO. I am glad you said that because I was going to say that sounds like a reasonable approach.

Why has it not been done?

Dr. CAHILL. There is another feature I would like to throw in. Again, there are two features to make the thing work; one, the line managers working together and in your introductory remarks, Mr. Ambro, you said one of the problems in this area has been the lack of environmental health dollars to go around.

What we might do is provide this Coordination Council which is going to address the common needs of all the agencies with a discretionary fund and this fund, I think, could legitimately be provided on a no-strings basis by industry.

There are precedents. The chemical industry and the drug industry are responsible for demonstrating the safety of their products and they have to invest a lot of money in the health effects of their products.

It seems to me the electronics industry has gotten off scot-free. We are now at the point where we have a legitimate question—do we or do we not have a problem in the general environment and I think that they ought to make a contribution.

Mr. AMBRO. Well, tell me again about the discretionary fund. What would you do specifically?

Dr. CAHILL. Well, sir, there are common needs that transcend any agency's mission—common research needs and ordinarily with the level of funding that each one of the agencies has had recently, you have your own problems just addressing your agency's needs, so in order to come up with the funds for addressing common problems, I would look for another source outside of the Federal Government.

Mr. AMBRO. Discretionary funds, no strings attached?

Dr. CAHILL. Yes.

Mr. AMBRO. Made available by Congress?

Dr. CAHILL. No. To be made available by the electronics industry. Why not?

Mr. AMBRO. Dr. Gage?

Dr. GAGE. You should also address the allied thing we talked about a number of times; even with additional dollars we might not be able to make a great deal of progress in this; that the real shortage is really in the area of trained scientists with the interdisciplinary background.

Dr. CAHILL. I agree with that.

Mr. AMBRO. I wish Dr. Justesen were here this afternoon.

Dr. JUSTESEN. I am.

Mr. AMBRO. Oh, there you are.

Would you mind giving me once more the fast lecture on the interdisciplinary scientist for the benefit of all. We shall turn this again into audience participation.

Dr. JUSTESEN. I am not sure of the question you are asking, sir.

Mr. AMBRO. Well, we keep talking about developing interdisciplinary scientists in order to do this kind of work.

What is your attitude about this?

Dr. JUSTESEN. Two years ago, Dr. Guy and I wrote an editorial on what we called the most dangerous game. Our specific reference was to radiobiological research as it relates to RF radiations, but the thesis that interdisciplinary research is the scientific equivalent of the claymore mine holds true in general.

There are several factors that make the interdisciplinary game a dangerous one. I shall enumerate.

One. The explosion of knowledge during the 20th century has made the scientific man for all seasons as extinct as the dodo. It is virtually impossible to master the subject matter of one discipline or even a specialty within a discipline. How then to learn the Maxwellian physics of wave propagation? the engineering intricacies of field measurement, of dosimetry, and of design and operation of complex electronic systems? the complexities of any one of a dozen biological and behavioral specialities? and the logic and mathematics required to design and evaluate experiments? The answer is, One can't master them all. There are a few bona fide generalists such as Ross Adey at the Loma Linda VA Medical Center, and George Sacher at the Argonne National Laboratories—both of whom, it is fortunate, are members of ERMAC—but most of us have followed the lead of the late Prof. Curtis C. Johnson in establishing—or in trying to establish—an investigative team composed of several experts.

Two. The team approach to research works—witness the flow of innovative publications on RF radiations from the Universities of Washington and Utah and from the private multidisciplinary groups such as that at Battelle's Pacific Northwest laboratories. But the team approach means more professional personnel per project at a much higher relative cost.

Three. Similarly, the requirements for special facilities are greater. In addition to the expensive accoutrements of the modern biological laboratory, the specialized equipment needed for field measurements, for dosimetry, and for exposure and environmental control systems impose even greater cost.

I have already mentioned how the odds of securing grant support are diminished as one goes from monolithic to multidisciplinary endeavor. It is not difficult to see why a study panel or council that considers a modest monolithic proposal at $35,000 per annum and a commensurately modest interdisciplinary proposal at $100,000 per annum will opt for three of the former and none of the latter.

Speaking from personal experience—I receive my primary research funding from the Veterans' Administration, which conducts a mini-NIH system of study panels and councils and operates with a total research budget that has been limited to the point of absurdity—I can readily understand the reluctance of scientists

outside the field to recommend support of one program that would preempt funding of three other programs.

The proper solution to the dilemma, one that doesn't sell well in the era of symbolic gesture and proposition 13, is a large increase overall in funding of health-related research. The more local problem of RF-related grant research can only be resolved by special interdisciplinary study panels that are matched to the needed work and tied to a line item in the Federal budget.

In conclusion, Mr. Chairman, may I say that I am not by nature embued with an apocalyptic vision, but the apparent retreat of the American public from a willingness to support science and technology—much of which is the scientists' fault: We have not articulated their worth and importance—augurs poorly for the ability of our Nation to meet the challenges of our time. We are courting a decline undreamed of by Edward Gibbons. Rome fell for want of moral strength; we may fall by failing to see that our greatest strength—creative scientific and technological endeavor—is suffering continuous erosion.

Mr. AMBRO. Well, I must tell you, whether it is a seminar mode or not, I appreciate the answer. It is too bad those who testify late in the day cannot hear the previous testimony, because I really do not want to get back into this whole business of where we find the scientists and how we find them in order to carry out the kind of work that must be done.

Dr. Cahill, I think your approach is reasonable, but it is just good enough not to be workable and never to happen around here. It seems to me so simple and so easy. You and others have had an input, have been part of a variety of groups working on these problems and yet, your approach has never been suggested before. Maybe that is one of the few benefits that comes out of a congressional hearing.

We, of course, for our part, have to develop reports that respond to legislative efforts on the part of other Members of Congress who are interested in getting things moving and it is going to be kind of a shell game to see how we can get out of this intellectual, scientific semantic thing and do something about what I perceive as becoming a most serious problem.

In any event, we have Ruth Clusen who has been waiting patiently to testify sitting behind you. I will leave the hearing record open for questions to round out the record and ask you, too, if you have any concluding comments to make.

Dr. GAGE. I would just have one idea I would like to append to Dr. Cahill's description of the workings of a possible Coordinating Council and that would be to harken back to your statement of your model.

I think a very important component of the model you talked about was clarifying the responsibilities given to the several agencies involved, and then assigning parts of the research activities on the basis of those assignments.

I do think honestly there have been many gray areas in the responsibilities of the various agencies at this time. I feel that ours is less than firm. I think that we will, in fact, as we put forth guidance, be attacked as going beyond our scope. We are going to take some steps in the Congress and in the administration to

clarify some of these things over the next months and the next few years, and then face up to all these aspects.

Mr. AMBRO. Well, I would just say in response to that and in conclusion, it is too vacillating to say the next few months and the next few years as there is a great time gap there. The problem is attracting the ever-increasing attention of the media, whether it is time or U.S. News & World Report. The fact of the matter is that more and more people are becoming interested in this, and fearful of the impacts of this, and politicians respond to those kinds of attitudes. We are trying to respond in a responsible way, but if we cannot get more than just promises, and vague promises at that, of action somewhere between 4 and 10 years, as Mr. Walker correctly pointed out, you are going to wind up with the Congress doing something probably less than prudent. I therefore urge you and the entire IRLG group to think about that and come up with something more substantial than what we have had thus far.

I thank you for appearing.

Now, we will hear from Mrs. Ruth Clusen, Assistant Secretary for Environment, Department of Energy.

STATEMENT OF MRS. RUTH CLUSEN, ASSISTANT SECRETARY FOR ENVIRONMENT, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. WILLIAM W. BURR, JR., DIRECTOR, OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH, DEPARTMENT OF ENERGY; AND DR. NATHANIEL BARR, OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH, DEPARTMENT OF ENERGY

Mrs. CLUSEN. Mr. Chairman, and members of the subcommittee, I am pleased to be here today to testify on nonionizing radiation and our research efforts in this field.

I have, of course, appeared before your subcommittee on the subject of low-level ionizing radiation, and I should like at the outset of this hearing to emphasize that ionizing and nonionizing radiations represent two distinctly different kinds of environmental agents. The difference is in the energy content of the radiation; the energy content of nonionizing radiation is insufficient to displace electrons and cause ionization of cell components.

Man-made energy systems contribute a variety of nonionizing radiations to naturally occurring levels. I will discuss the contributions from energy systems; how we see these changing in the future; what we are doing and planning to do with respect to evaluating potential environmental impacts; and finally, I will describe how we are coordinating our activities with other agencies. I will, as you requested, focus on the potential health effects of the electromagnetic radiations produced by electrical transmission lines and microwaves.

Microwaves, according to the current reference design, will be used to transit energy from satellite power systems—SPS—to Earth.

Most contributions by energy systems to environmental levels of nonionizing radiation are small compared to either natural levels or to the contributions made by other sectors.

Currently, the principal contributions of energy systems come from electromagnetic fields associated with transmission of high-voltage alternating electrical current in above ground lines. These

electromagnetic fields are in all probability the principal source of exposure of both humans and ecosystems to nonionizing radiation in the ultra-low frequency range of the electromagnetic spectrum.

These low-intensity fields are ubiquitous, and I doubt that there is anyone in this room who has not been exposed to them or is not exposed to them daily. We have no evidence of adverse health and environmental impacts being produced by these fields.

On the other hand, it is not possible to state that no effects are produced. For this reason and because both the amount and voltage of such transmissions are projected to increase in the future, we are looking more carefully at the question of possible effects of these fields on the structure and function of living things.

Transmission line structures and associated rights-of-way can themselves result in esthetic impacts or land-use conflicts. Other environmental effects may result from the flow of electric current in conductors energized at high voltage. In the vicinity of a transmission line there exists both a vertical electrostatic field of high intensity which is a function of the line voltage and a weak horizontal magnetic field caused by current flow in the line. Because either or both fields can induce electrical fields and currents in body tissues, concern has arisen regarding possible adverse biological effects. High-intensity electrostatic fields can also cause annoying electric shocks under conditions that may exist within or near the right-of-way.

In addition, particularly during periods of wet weather, transmission line conductors may go into corona discharge, and thereby produce an audible noise, or interfere with radio and television reception and the operation of other electronic devices.

Since the preponderance of operating transmission lines in this country are of the 60-hertz alternating current or a-c type, the principal environmental concerns are those that are related to a-c transmission.

As line voltages have increased in recent years, concern has increased about the possibility that high-intensity 60-hertz electric fields may induce adverse health or biological effects. This issue has been raised in courts of law and in public service commission hearings when opposition to the construction of transmission lines has developed. These discussions, as well as reviews in the scientific literature, make it clear that existing knowledge is not adequate to permit reasonable estimates of health risks to be made. Clearly, there exists an urgent need for research that will provide the necessary data base.

In 1975, the Energy Research and Development Administration—ERDA—one of the Department's predecessor agencies, initiated a program of research to assess the environmental acceptability of high-voltage overhead transmission lines. The major component of this program consists of a closely coordinated effort, jointly sponsored by the Division of Electric Energy Systems, Assistant Secretary for Energy Technology, and EV's Health Effects Research Division, to identify and quantify health effects of relevant electric fields. This type of coordinated effort has proved essential because of the need for the continuous interaction of engineering and technology specialists with biologist at the research, planning, and management levels.

As in all such studies, health effects of electric fields are investigated under carefully defined experimental conditions in order to minimize the likelihood of artifacts arising from poorly controlled variables such as electric shock, noise, vibrations, or temperature. This effort is designed to develop reliable predictive models.

EV's Environmental Control Technology Division also sponsors several studies to assess controls needed because of health and safety concerns. In addition, the Bonneville Power Administration is conducting studies of ecological impacts of transmission lines. DOE's total electric-field effects program currently consists of some 24 projects funded at a level of approximately $4.8 million.

Mr. Chairman, the Department of Energy's study of electric-field effects consists of eight different program elements, and I should like briefly to review the status of each of these.

ELECTRIC-FIELD MEASUREMENTS

Electric-field measurements are made in the laboratory and at both test facilities and operating lines. Included in this work is an important study of electric-field instrumentation and calibration that is conducted by the National Bureau of Standards, or NBS. Measurements at test facilities and operating lines provide data essential for hazards assessment. Electric field and other measurements are currently being made at two high-voltage d-c test lines, a 1,200 kilovolt a-c test line, and at 3,000 selected locations along 500 kilovolt lines in the TVA system. Electric-field measurements are also of critical importance in biological research where exposures must be accurately known. Specialists on the NBS staff oversee all such measurements in our biological research program.

STUDIES OF BIOLOGICAL EFFECTS IN MAMMALS

In 1976, a study was initiated by a multidisciplinary research team at the Pacific North Laboratories (PNL) in Washington State to obtain quantitative data on biological effects of 60-hertz electric fields on rats and mice.

In this study, a broad range of possible biological responses has been screened. Although the study has not yet been completed, some significant observations have been made. Exposure of rats and mice to 60-hertz electric fields at a field intensity of 100 kilovolts/meter for up to 120 days was found to produce no statistically significant, reproducible effects on a number of measures of metabolic status and growth, bone growth and structure, reproduction, hemotology and serum chemistry, endocrinology, cardiovascular function, or organ and tissue morphology.

Exposure of rats in utero—100 kilovolts/meter—induced a transient effect, at 14 days of age, on motile behavior and development of the righting reflex. Results of both behavioral and neurophysiologic studies suggest that exposure to 60-hertz electric fields—50 to 100 kilovolts/meter—may increase nervous system excitability. In mice exposed to field strengths of 100 kilovolts/meter for 30 days, a possible effect on cell-mediated immunity has been detected and is being further evaluated.

For purposes of interpretation, the PNL investigators have estimated that a 100-kilovolt/meter exposure to rats is equivalent to a

human exposure of 7 to 25 kilovolts/meter. In comparison, field strengths in the range of 4 to 12 kilovolts/meter are typical for the maximum levels measured near the ground under 345 to 765 kilovolt lines.

A companion study in miniature swine is also in progress at PNL under sponsorship of the Electric Power Research Institute. Six additional mammalian studies, conducted at other laboratories, are focused on specific and sensitive response parameters including neural, behavioral, neuroendocrine, and cardiac responses as well as effects on the regulation of metabolic and functional activity by daily biological rhythms. Mice, rats, cats, monkeys, and baboons are used in these studies, which should provide a good index of animal sensitivity and responsiveness to strong 60 hertz electric fields. These are new studies, and only preliminary results have been obtained to date.

Another important new study at the Illinois Institute of Technology Research Institute is laying the groundwork for future research on biological effects of physical fields associated with high voltage d-c transmission lines. An animal exposure facility is being designed and a systematic plan for biological research will be developed.

STUDIES OF BIOLOGICAL EFFECTS IN OTHER SPECIES

Included in this program element are studies conducted at the Pacific Northwest Laboratories to investigate possible genetic effects of d-c and 60-hertz a-c electric fields in bacterial systems, *Drosophila*—the fruit fly—mammalian cells exposed in culture, and mammalian cells exposed in the animal body.

In work with bacterial cells and fruit flies, specific mutations can be detected and scored using standard methods. With mammalian cells, chromosome aberrations, sister chromatid exchange, and unscheduled DNA synthesis are measured as indices of genetic damage. Limited data on two bacterial systems and fruit flies have been collected, while work with mammalian cells is just getting underway.

MECHANISTIC STUDIES

A basic understanding of how electric fields interact with or couple to living tissue is essential to the development of a coherent theory concerning electric field bioeffects. Research designed to yield conceptual insights is badly needed.

A study recently completed at the University of Rochester has demonstrated that the rate of growth of plant root tips in liquid medium is reduced by exposure to strong 60 hertz electric fields applied through the medium. This response proved to be dose dependent and appears to occur under conditions where the induced electric potential on cell outer membranes is similar in magnitude to the normal or resting cell membrane potential. This observation suggests that the cell membrane may constitute a sensitive site of field coupling. The generality of this phenomenon is to be explored in studies with a species of slime mold, cultured mammalian cells, and cultured chick embryo bone tissue.

Other research exploring the possibility of field coupling at the cell membrane level is in progress at the Jerry L. Pettis Memorial Veterans Hospital at Loma Linda, Calif. Included in this research are studies of the molecular biology of cell membrane surfaces as well as effects of extremely low frequency—ELF—electric fields on membrane transport processes in brain tissue, brain cells, and other types of mammalian cells.

DOSIMETRY

To extrapolate or relate animal data to human exposure situations, it is necessary to equate animal exposures with equivalent human exposures. This requires the use of so-called scaling factors that correct for differences in body size and conformation. Because little work has been done in this area, only approximate values can be assigned to scaling factors at the present time. Work on scaling factors is now in progress at two laborators—Pacific Northwest Laboratories in Washington State and Southwest Research Institute in San Antonio, Tex.—where several methods of measuring or estimating induced fields and currents in animal and human tissues under known exposure conditions are being evaluated.

ANNOYANCE STUDIES

At the National Bureau of Standards, psychoacoustic responses of human subjects to audible noise associated with corona discharge have been under investigation for 3 years. Although this noise is usually of relatively low intensity, it has been found to be somewhat more annoying to humans than a number of other common environmental noises.

ECOLOGICAL STUDIES

The Bonneville Power Administration—BPA—is conducting several observational studies along existing a-c and d-c transmission lines to evaluate possible effects of transmission line rights-of-way on terrestrial and avian species.

In one study, data are being collected on natural vegetation, crops, wildlife, cattle, and honeybees in the vicinty of a 1,200 kilovolt prototype a-c line near Lyons, Oreg. In other work, the nesting of large birds—ravens and raptors—on transmission line structures is under study and effects of BPA transmission lines on bird flight behavior, including collision mortality, is being evaluated.

ENVIRONMENTAL CONTROL TECHNOLOGY

Various advanced control measures—such as wider rights-of-way, greater minimum clearance, and improved shielding—may be needed to minimize adverse impacts. To determine the need and to assess the adequacy of proposed measures, EV's Environmental Control Technology Division undertakes various assessment projects. Recently, a compilation of environmental regulations on a State-by-State basis was completed, and I shall submit a copy of the report with my written testimony.

[The following report was submitted and is included as appendix 6:]

Review of State/Federal Environmental Regulations Pertaining to the Electrical Effects of Overhead Transmission Lines: 1978, HCP/EV-1802, January 1979, prepared for U.S. Department of Energy, Assistant Secretary for Environment, Division of Environmental Control Technology, by Dr. K. R. Shah, P.E., Shah & Associates Inc., Gaithersburg, Md.

Mrs. CLUSEN. An assessment has also been performed on the testimony taken in the recently completed hearings of the New York State Public Service Commission on the licensing of a 765 kilovolt transmission line. The purpose of this assessment was to determine possible needs for additional control measures. A final report is expected to be available in about 2 months, and we will then submit a copy to the subcommittee.

STUDIES OF MAGNETIC FIELDS

No research on bioeffects of 60 Hertz magnetic fields is in progress at the present time, although we are currently evaluating a proposal to conduct behavioral and electrophysiological studies with pigeons, rats, and humans to define sensitivity to sub-ELF—0–30 hertz—magnetic fields and to identify the receptor substrate responsible for observed sensitivities.

However, six projects that relate to health and biological effects of strong static or pulsed magnetic fields are currently being supported by EV's Office of Health and Environmental Research. Although these projects relate primarily to magnetic fusion energy systems and magnetohydrodynamic systems, they are nonetheless important to transmission line research in a generic sense.

One of the projects involves research at the Brookhaven National Laboratory on possible magnetic field induced genetic effects in two genetically well characterized test systems, fruit fly and *tradescantia,* a flowering plant. No statistically significant evidence of induced mutations has been observed to date in either system.

At both the Lawrence Berkeley Laboratory—LBL—in California and the Pacific Northwest Laboratories—PNL—multifaceted studies of diverse biological responses to magnetic fields of different types are being studied in a set of test systems ranging in complexity from macromolecules to animal populations. Physiological studies at LBL have revealed that the electrocardiogram pattern, particularly the amplitude of the T-wave, is altered in both rats and dogs exposed to strong magnetic fields. This response appears to be a reversible threshold phenomenon. At PNL, exposure of mice in utero to strong magnetic fields was found not to produce fetal abnormalities but possibly to affect weights of certain organs in females. No evidence or positive responses has been observed in a study of dominant lethal mutations in mice exposed to strong magnetic fields.

Possible effects of magnetic fields on the fertility of salmon eggs and the clumping of mammalian cells in culture are being further evaluated at PNL. Another interesting observation by PNL scientists is the fact that molecules of agarose, a high molecular weight linear polysaccharide, become alined in aqueous gels when exposed to magnetic fields.

Other ongoing projects include an epidemiologic study of health indices among a group of scientists and technicians occupationally exposed to magnetic fields and two instrument studies—at LBL and PNL—that have made considerable progress toward development of an integrating personnel dosimeter for use in quantifying magnetic field exposures.

COORDINATION WITH OTHER AGENCIES

Success in the management of this program requires close coordination with other Federal agencies having interests in bioeffects of electromagnetic fields.

In this regard, the Interagency Advisory Committee on Electric Field Effects from High Voltage Lines, which was formed by ERDA in 1976 and chaired since then by Mr. Robert Flugum of DOE's Division of Electric Energy Systems, has played a critically important role.

The membership of the committee includes representatives from more than a dozen Federal agencies, including the National Telecommunication and Information Administration—NTIA—of the Department of Commerce. The committee meets quarterly to review all ongoing federally sponsored and other research of interest and to exchange other pertinant information.

The eleventh meeting of the committee will be held next month. NTIA continues to play a leading role in interagency coordination through its Electromagnetic Radiation Management Advisory Council and its Side-Effects Working Group. In addition, by directing the Interagency Task Force on Biological Effects of Nonionizing Electromagnetic Radiation, NTIA is currently involved in a special and important coordinating activity.

I should also like to emphasize that through workshops and symposia that they are sponsoring, the DOE laboratories are contributing very substantially toward effective interagency coordination.

STATELLITE POWER SYSTEM

As you know, Mr. Chairman, in conjunction with the National Aeronautics and Space Administration, DOE is conducting a concept development and evaluation program that will provide for the Congress and the President by June 1980 an assessment of the technical, economic, social, and environmental feasibility of a satellite power system—SPS.

The program is conducted by the Satellite Power System Project Office in the Department's Office of Energy Research. EV is responsible for managing the environmental assessment portion of this program, and I have detailed, full time, Dr. Nat Barr, one of my best scientists, to work on this program. A large part of the environmental assessment is directed at identifying, defining, and assessing the potential health and ecological impacts of microwave generated by the SPS.

Experimental work conducted under this program includes determination of the effects of microwave exposures on transient animal species that might be exposed at high power densities on the rectenna site.

We are preparing to initiate an experimental program amounting to approximately $1 million a year in fiscal 1979 and fiscal year 1980 to determine biological effects of chronic exposure to continuous wave microwaves at the frequency—2.45 gigaHertz—to be used in SPS. These studies will all be conducted with continuous wave 2.45 GHZ radiation at power densities in the range of 10 mW/cm^2 and less. They will include investigations of teratogenic effects, hematological changes, and immune system responses. This portion of the program is supervised for us by EPA.

We are also initiating studies to develop experimental approaches to reducing current uncertainty regarding potential long-term effects for chronic exposures to low power density microwaves. These studies are coordinated with other Federal programs in this area through the Department of Commerce's Electromagnetic Radiation Advisory Council—ERMAC. I will provide a description of these projects in the format requested by the subcommittee within a few weeks?

An early product of this activity was a compilation of existing scientific literature on the health and environmental effects of microwaves. This compilation, undertaken by a team led by scientists at Pacific Northwest Laboratories, confirmed that the existing data base on microwave effects was generally inadequate for assessing the potential human health and environmental consequences of microwave exposures.

Several subsequent compilations and analyses by other agencies have concluded that two areas which are of particular importance to assessing the potential impacts of the operation of the current SPS reference design are the paucity of information on health effects produced by chronic low-level exposures and information on effects in ecosystems and their components. We are recommending that these deficiencies be assigned high priority in the plan now being developed by the task force led by the National Telecommunication and Information Administration.

In addition to potential health and ecosystems impacts of microwaves we are sponsoring assessments and experimental studies of the potential impacts of the SPS microwave power transmission systems on the operation of electromagnetic devices. A portion of the program is devoted to examining how the interaction of the SPS microwave beams with the ionosphere might affect telecommunications systems and climate.

In fiscal year 1979 and fiscal year 1980, DOE will be expending approximately $1.5 million a year for studies in these areas in addition to the $1 million a year on health and ecosystems studies I mentioned previously.

As I stated earlier, in both the planning and conduct of our microwave program we have coordinated our activities with other Federal agencies through ERMAC.

I might say, Mr. Chairman, that over the years ERMAC has provided a very effective means for coordinating the many and varied Federal efforts in this field. Our association with EPA is especially close in that, as I mentioned previously, an EPA group at Research Triangle Park, N.C., is managing our assessment and planning activities and most of our R. & D. activities in the health and ecosystems area. We have developed arrangements with the

National Academy of Sciences to review our microwave activities as they relate to the environmental feasibility of SPS.

Finally, I would like to mention that my staff has worked and continues to work with the National Telecommunications and Information Administration in an effort to prepare and identify R. & D. needed to meet the broad spectrum of agency requirements in this area.

Mr. Chairman, this concludes my prepared statement. I shall be happy to answer any questions you may have.

Mr. AMBRO. Thank you, Mrs. Clusen.

You said that you would supply us with a complete study and without objection, that will be included in the record.[1] That study you said was a compilation of environmental regulations on a State-by-State basis. You also stated on page 3, I think, that ERDA initiated in 1975 a program of research to assess the environmental acceptability of high voltage overhead transmission lines.

Where is the resulting data today?

What happened to that initiative?

Dr. BURR. I think I can address that. It is true that we initiated research to answer the question of the environmental acceptability of the transmission lines and this consists of the components of research that Mrs. Clusen outlined on the effects of the electric fields.

As she stated in her testimony, we have some 24 projects now in this area addressing various elements of that research. We are currently spending $4.8 million in the agency as a whole.

There are lots of problems. For example, you need better capability of measuring the fields; you need better test systems. Some of the facilities that had to be set up were fairly extensive but I think the work is progressing rather well.

Mr. AMBRO. All right, we look forward to seeing a report on the results of the program of research to assess the environmental acceptability of high-voltage overhead transmission lines.

[This report will be furnished to the subcommittee when it becomes available.]

Mr. AMBRO. Dr. Burr, we are 4 years down the line and we have nothing with respect to that initiative in 1975 by ERDA. Your testimony runs through a myriad of studies that have now been initiated. That is good to know. The question is why are you doing all these studies? Who told you to do them?

Do you get together with your colleagues and say that we ought to do these kinds of studies, and if you do, do you put a time constraint or a target date on the completion of the study, or is it just some kind of initiative that is good to have and whenever the scientists can be found to do them, you do them?

Mrs. CLUSEN. Let me say first of all that I believe we in the Office of Environment at DOE are doing these studies because we would need to do them to get some answers in order to carry out our responsibility with regard to the need to know the issues at the time the Department considers recommendations on new high-powered transmission lines. In our case much of this feeds into environmental impact statements, whether there is a significant or nonsignificant effect.

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[1] See appendix 6.

Dr. BURR. I would like to respond also. I agree that our research is responsive to the techology and the time requirements of the technology, in part, dictate the time lines we must meet. We try to give the technology answers that mesh with their needs. In this area, there is a great deal of public concern over whether biological effects occur or not and, of course, it behooves us to try to get the answers.

I think the question of how fast we move is, in part, dictated to us in most areas by the need of the technology.

Mr. AMBRO. Well, for example, have you licensed transmission lines thus far?

Dr. BURR. No, DOE does not license.

Mr. AMBRO. But certain studies should be completed in advance of licensing; yet the licensing proceeds and still this welter of studies continues.

I say this as someone who was in a supervisory position or mayor for four terms. I think it was an open secret that if we wanted to bury something, we studied it. You know, we have so many studies going on in so many directions. Is someone in the Office of the Assistant Secretary for Environment in DOE looking at these things in terms of what to do and in terms of—what do you call them—time lines?

Dr. BURR. In other words, if there is a particular time limit and if we can deliver our environmental information at that time we will. But you must understand that we are working with biological systems. If you are looking at possible late effects of exposure of an animal, then the time required for an experiment is governed by the lifetime of that species.

All of the research we have is directed at answering specific questions and the research is very carefully selected to meet current needs.

Mr. AMBRO. Well, I do understand that you are dealing with a certain lifespan when you are dealing with laboratory animals, but if you sat there and listened to your testimony as I did, and if you heard of the many numbers of studies that you have in progress without any resolution, except for one that you have completed and included in the record, the question would be as it was with me: Where are the results of all these studies, and are they geared to the technology you are dealing with? The technology is there. We want to know about the possible adverse health effects of using the technology.

Do you have an inhouse whip? You know what I am getting at, Mrs. Clusen.

Mrs. CLUSEN. Yes, someone who drives them to a determined end.

Mr. AMBRO. You cannot drive a scientist. I understand that.

Mrs. CLUSEN. I try.

Mr. AMBRO. You need to know why they are doing research, when they are doing it, and how they are doing it. You have all these things in progress; you have the technology there; you have an emerging awareness on the part of the public and you have the Congress screaming at you.

Mrs. CLUSEN. I quite often ask myself and the staff, Mr. Ambro. I have often been told I would not ask the question if I were a scientist so I know what you are saying.

Mr. AMBRO. Is it possible that because there are so few scientists in these rather exotic fields and because they are so hard to get as we have heard witness after witness tell us, that these scientists kind of intimidate the managers and administrators? They could easily say, if you do not like it, I can go somewhere else. I think that is a conclusion that obviously comes to mind.

Just what are you going to do with this guy who is a nuclear chemist or some kind of specialized engineer? Where are you going to get another one if he says I do not want to do it today and proceeds not to do it. It must be a treacherous job dealing with people like that.

Mrs. CLUSEN. Of course, our research is done in the national laboratories or the Research Triangle in North Carolina and thus, we do not have to deal with hiring and recruiting and firing of exotic types of scientists for the most part.

Dr. Burr might want to respond as to whether there is a shortage of particular types. I would say that in each of the studies I detailed, they are designed to serve different ends, as I understand it, and a wide variety of projects. Some of them will help give some of the answers on the SPS.

Although we do not have final answers, I have been a party to a good many NEPA determinations in the past year with regard to transmission lines. We have put in the environmental impact statement, in conjunction with the technology people, what we know at this time and what the indications are, so it is a continuing process.

Dr. BURR. I would like to comment a little more on that. I agree that this is an area that requires interdisciplinary approaches, and we in DOE are fortunate that we have laboratories that really have a broad interdisciplinary base for us to draw from. In this particular area the data base we started with was very small. There was not a lot of knowledge about this subject.

Second, it has been necessary, even in these laboratories, to develop the expertise over time as we put these studies into place so it is partially limited by the availability of researchers in this field.

I do not think we have had any trouble in encouraging a laboratory or an individual investigator to accept funds for research. We are more limited in being able to find the work that we feel will really give us the answer.

Mr. AMBRO. Well, even though there are contradictory views on whether or not we need another review of the literature in this area, is there someone that you look to for expertise in the international literature or national literature, to see if your studies are duplicative?

Mrs. CLUSEN. Part of the coordinating mechanism is supposed to prevent duplication. That is the purpose for which it exists. In our view, as far as the kind of studies we are doing, it seems to be serving that purpose.

As to any individual sources we look to for expertise we, of course, always look to the National Academy of Sciences for peer review of what we are doing whenever we need to.

Dr. BURR. I do not know that I really need to enlarge on that. I think the coordinating mechanism from the standpoint of DOE's requirements is meeting the need quite well.

Mr. AMBRO. Well, I really do not have the capability to ask you about the benefits of, let us say, studies of the biological effects on species such as the fruit fly. Let me conclude by asking you about this whole business of setting a standard which then can be attacked or used as a base or takeoff point for other studies. What do you think of that thought?

Mrs. CLUSEN. Well, personally of course, I could see some value to meeting the public sense of urgency and concern about this matter, but everything we know from our scientific examinations at this point, points to the fact that we are not at all sure there is enough data on which to base a rational standard. Fortunately, this is the case in which the Department of Energy does not have to be a part of the regulatory concept.

Mr. AMBRO. But you do get involved in the licensing or the granting of construction permits.

Mrs. CLUSEN. We can report simply what we are finding. Neither the technology people nor my office, in the course of the permitting system, deal with anything that comes close to standards.

Mr. AMBRO. That may be, but as I have said, these studies, one of which we talked about, should be available for the licensing of transmission lines. Now, the licensing or not licensing, or the modification of the technology, are based on the research that goes on at a number of laboratories. The focal point of determinations will be based on the kinds of studies that you are doing, and with respect to that, it pertains to licensing. Now, while you technically might not be part of a regulatory function, is this not on target with respect to the research that you do and provide to those who do the licensing in DOE?

Mrs. CLUSEN. Yes. I would point out, however, that one of the problems, it seems to me, in setting standards is that in the whole field of nonionizing radiation there are so many different societal needs and uses and we are concerned with such a very small part of it that is difficult for us to make any judgment on what kind of standards should be set.

Up to this point we have, I believe, been satisfied to state what the health effects seem to be as we know them at this time without making any evaluative judgments because our base and experience is so limited. We are simply not experts in this field.

Dr. BURR. The studies were initiated primarily because of the need to understand the environmental acceptability of this mode of energy transmission.

Hopefully, the research that we do will also be useful to those who have to address the question of standards, but that is not the primary objective.

Mr. AMBRO. This has been a long day. I think we have all been saved by the bells.

I would like to thank you for testifying and also your colleagues, Mrs. Clusen, and in concluding, I would ask you if you will comply

with our request to answer any written questions to round out our record.

Mrs. CLUSEN. We will be glad to.

Mr. AMBRO. I would also like to thank all of those who attended this hearing and did not get to comment on what we have developed here. I do not know where it will lead at the moment. As I said at another point, it depends on how many Members of Congress respond to this issue. I would hope that hasty political judgments are not made or made in the absence of prudent deliberations on the part of the staff and committee that are intimately involved in these kinds of questions. But that remains to be seen.

To all of you who were kind enough to come today in response to our invitation, I would like to warmly thank you.

Now, having said all of that we stand adjourned, subject to the call of the Chair.

[Whereupon, at 4:25 p.m., the Subcommittee on Natural Resources and Environment adjourned, subject to the call of the Chair.]

APPENDIX 1

Summary of Federal Research on the Health Effects of Nonionizing Radiation and the Factors Relating to its Control

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SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION: Environmental Protection Agency, Office of Research and Development, Health Effects Research Laboratory, Research Triangle Park, North Carolina

TITLE: Health Effects of Nonionizing Radiation

CONTACT: Dr. Daniel F. Cahill, Director
Experimental Biology Division (MD-71)
Health Effects Research Laboratory
Research Triangle Park, NC 27711
FTS 629-2771

GENERAL PROGRAM OBJECTIVES: In general terms, the objective of the ORD program is to expand the health effects data base. To accomplish this mission, the program will continue to emphasize multidisciplinary animal experimentation in which a significant effort is devoted to long-term, low-level exposure studies. However, in the next few years emphases will include the (1) identification of additional human populations suitable for epidemiological and clinical studies; (2) studies of the dose-effect relationship of reported bioeffects; (3) development of systems to conduct continuous exposure experiments including lifespan and causes of death studies; (4) provide information on the interactions of RF energy with basic biological systems; (5) expansion of the multidisciplinary team to include an emphasis on thermal physiology and additional expertise in dosimetry; and (6) development of a program which includes a stable budget for supporting extramural research.

Research Category	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry	$295K	---	$360K	$285K
Mechanisms of Interaction	120K	100K	250K	135K
Long-term, Low-level Exposure Studies on Animals	100K	330K	260K	170K
Human Studies	---	50K	---	100K
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents	40K	---	40K	---
Biological Effects Studies	475K	95K	550K	180K
Beneficial Applications	---	---	---	---

Sub-Total	$1025K	$575K	$1460K	$870K
Other (Management, animal care, quality assurance, statustics, ADP and pathology support)	330K	---	650K	---
Grand Total	$1930K		$2930K	

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Microwave Dosimetry

B. Specific Objectives: To determine the amount of absorbed energy and its distribution in animals exposed to nonionizing radiation.

C. Milestones/Estimated Completion Date: Continuing.

D. Research Category: Instrumentation and Dosimetry

E. Test Parameters (if applicable)

1. Frequency: 100, 425, 970, 2450, and 9000 MHz

2. Test Species: Mice, rats, hamsters

3. Exposure Duration: See comments

4. Radiation Dose: See comments

5. Other: See comments

F. Funding

1. In-House: $80,000

2. Extramural

3. Prime Contractor

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: This project provides dosimetric data for the immunological, teratological, behavioral, and multidisciplinary long-term, low-level studies. Selection criteria: programmatic priority.

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Pre- and Postnatal Exposure of Squirrel Monkeys to Nonionizing Radiation

B. Specific Objectives: Study of infant mortality and cause of death.

C. Milestones/Estimated Completion Date: 12/80

D. Research Category: Long-term, Low-level Exposure; Important Biological Effects Studies

E. Test Parameters (if applicable)

1. Frequency: 2450 MHz

2. Test Species: Squirrel monkey

3. Exposure Duration: In-utero through 9 months postnatal

4. Radiation Dose: 10 mW/cm^2

5. Other

F. Funding

1. In-House

2. Extramural: $250,000

3. Prime Contractor: Stanford Research Institute

G. Coordination

1. Other Federal Agencies: Department of Energy

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: Contract let 1/79.
Selection criteria: programmatic priority.

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Interspecies Comparison of Teratological Effects of Nonionizing Radiation

B. Specific Objectives: To determine the dose response relationship for the induction of birth defects in exposed animals.

C. Milestones/Estimated Completion Date: 9/80

D. Research Category: Biological Effects Study

E. Test Parameters (if applicable)

1. Frequency: 2450 MHz

2. Test Species: Rat, mouse, Syrian hamster

3. Exposure Duration: 100 minutes/day

4. Radiation Dose: 0-30 mW/cm^2

5. Other: Animals are exposed in utero from the time of organogenesis until term.

F. Funding

1. In-House: $54,000

2. Extramural

3. Prime Contractor

G. Coordination

1. Other Federal Agencies: Department of Energy

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: Selection criteria: programmatic priority.

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Design, Construction, Calibration, Operation, and Maintenance of Nonionizing Radiation Exposure Facilities

B. Specific Objectives: Provide electrical and mechanical engineering support to health effects research program.

C. Milestones/Estimated Completion Date: Continuing

D. Research Category: Instrumentation and Dosimetry

E. Test Parameters (if applicable)

1. Frequency: 100, 425, 950, 1000, 2450, and 9000 MHz
2. Test Species
3. Exposure Duration
4. Radiation Dose
5. Other

F. Funding

1. In-House: $100,000
2. Extramural
3. Prime Contractor

G. Coordination

1. Other Federal Agencies
2. State or Local Agencies
3. Universities
4. Trade Associations
5. Other

H. Comments: Selection criteria: programmatic priority

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Neoplasia Distributions and Radioemission Density in the Portland Metropolitan Area

B. Specific Objectives: Examine whether a correlation exists between ambient RF density and incidence of specific types of cancer.

C. Milestones/Estimated Completion Date: 7/80 completion.

D. Research Category: Human Studies

E. Test Parameters (if applicable)

1. Frequency: Mixed broadcast frequencies

2. Test Species: Human

3. Exposure Duration: Continuous

4. Radiation Dose: 0.05 mW/cm^2

5. Other

F. Funding

1. In-House

2. Extramural: $40,000 (FY 78)

3. Prime Contractor: University of Oregon Health Sciences Center

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: Selection criteria: programmatic priority

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Mechanisms of Interaction of AM Frequencies

B. Specific Objectives: To study the effect of amplitude modulation frequencies and power density relationship on calcium efflux from brain tissue.

C. Milestones/Estimated Completion Date: Continuing

D. Research Category: Basic Mechanisms, Important Biological Effects Studies

E. Test Parameters (if applicable)

1. Frequency: 147 MHz, amplitude modulated at 0-30 Hz.

2. Test Species: Brain tissue in vitro

3. Exposure Duration: 20 minutes

4. Radiation Dose: 0-1 mW/cm^2

5. Other

F. Funding

1. In-House: $48,000

2. Extramural

3. Prime Contractor

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: This research has led to the replication and extension of other American experiments which show an effect of amplitude modulated nonionizing radiation on calcium efflux from brain tissue. Selection criteria: programmatic priority.

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Relative Effectiveness of Pulsed Versus CW Nonionizing Radiation on Immune Defense System

B. Specific Objectives: Determine whether the same average energy delivered continuously or in pulses effects lymphocytes.

C. Milestones/Estimated Completion Date: June 1980 completion

D. Research Category: Biological Effects

E. Test Parameters (if applicable)

1. Frequency: 425 MHz

2. Test Species: Rats, mice

3. Exposure Duration: 1 hours/day; 30 days

4. Radiation Dose: 1-20 mW/cm^2

5. Other

F. Funding

1. In-House: $40,000

2. Extramural

3. Prime Contractor

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: Selection criteria: programmatic priority

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Interaction of NIR With Membranes, Biopolymers, and Brain Tissue.

B. Specific Objectives: Using fluorometric and spectrophotometric methods attempt to determine how NIR interacts with biological systems.

C. Milestones/Estimated Completion Date: Continuing

D. Research Category: Mechanisms of Interaction

E. Test Parameters (if applicable)

1. Frequency: 590, 1000, 2450 MHz

2. Test Species: In vitro samples; rats.

3. Exposure Duration: 20 minutes

4. Radiation Dose: 0.1-25 W/kg; 0.01-60 mW/cm^2

5. Other

F. Funding

1. In-House: $60,000

2. Extramural: $100,000

3. Prime Contractor: Duke University

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments: Contract let 6/79. This research is designed to investigate possible mechanisms of interaction with biological membranes and with energy metabolism in brain cells. Selection criteria: programmatic priority.

II. Summary Statement Covering Small or Miscellaneous Projects.

Additional projects involve the effects of nonionizing radiation on other aspects of immunology, animal behavior, neuropathology, biochemistry and physiology.

III. New Initiatives for FY80

- Epidemiological study of delayed effects, e.g. life-span shortening and causes of death in radar workers.
- Long-term, low-level multidisciplinary studies of animals exposed to 915 MHz in circularly-polarized waveguides, 20 hours/day.
- Initiate program on the effects of microwaves on thermal physiology, including model studies of thermoregulatory systems.
- Investigation of the effect of low-level NIR exposures on the immune system (Poland).
- Critical review of Eastern European NIR health effects research.
- Design a NIR exposure system suitable for lifetime studies in rodents.
- Improvements in the capability for measuring pulsed NIR fields in the environment.
- Refine models of population exposure to NIR.
- Provide NIR field measuring equipment to EPA's regional offices.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL

NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH
5600 FISHERS LANE
ROCKVILLE, MARYLAND 20852

JUL 27 1979

8/1

The Honorable Jerome A. Ambro
U.S. House of Representatives
Washington, D.C.

Dear Mr. Ambro:

The National Institute for Occupational Safety and Health (NIOSH), a component of the Center for Disease Control, was established by the Occupational Safety and Health Act of 1970. Under that act, NIOSH is responsible for conducting research, developing recommended occupational safety and health standards, providing technical assistance to employees and employers, and conducting training and education programs. NIOSH has similar responsibilities to protect the health of miners under the Mine Safety and Health Act of 1977. Under these laws NIOSH has conducted limited research into the health hazards of occupational exposure to ionizing and non-ionizing radiation. We do not have authority for the public health aspects of radiation emissions from electronic products or where other Federal or State agencies exercise authority for health and safety under the Atomic Energy Act. A large part of the NIOSH radiation effort in the past has been in the non-ionizing area and has included programs on visible, infrared, ultraviolet, laser, radiofrequency/microwave radiation, and ultrasonic energy.

Ultraviolet Radiation (UV)
NIOSH transmitted a criteria document on UV to the Department of Labor in 1972. In addition to a recommended occupational exposure standard, the document addressed environmental data, bio-effects, quantitative measurements, and protection and control measures.

Infrared Radiation (IR)
The near-IR portion of the spectrum has been implicated in the development of cataracts and threshold levels have been studied as a function of wavelength. NIOSH reports have been prepared on animal studies which assess eye damage resulting from exposure to near-IR radiation.

Lasers
In 1976, NIOSH published a compendium that categorized lasers into five hazard classes. The report, compiled with the assistance of the U.S. Army Environmental Hygiene Agency, contains technical data on 2,500 laser devices manufactured after 1963.

Visible Radiation

NIOSH sponsored a symposium on the health and safety implications of reduced illumination levels in the workplace in Cincinnati, Ohio, July 11 and 12, 1979. Based on the information presented at the symposium, NIOSH concluded that the only effect on health from reduced illumination levels in the workplace would be an increased occurrence of eyestrain and that there was not evidence for any long-term permanent ocular damage.

Optical Radiation

NIOSH has also evaluated optical radiation hazards in the ultraviolet, visible, and infrared spectrum. We have examined hazards in the most common welding processes under a variety of conditions and performed surveys to measure the radiation emissions from the cathode ray tube of video display terminals.

NIOSH has developed a calibration and testing facility to assist in evaluating optical radiation hazards. This facility contains several standard sources and detectors for the calibration of laboratory and field instruments.

Radiofrequency (RF) and Microwave Radiation

Workers are potentially exposed to RF and microwave radiation from a large number of sources and devices, including radio and radar transmitters, industrial drying, heat sealing and curing equipment, and certain medical research devices. Consequently, NIOSH is developing a criteria document for occupational exposure to radiofrequency (RF) and microwave radiation. NIOSH has prepared an extensive bibliography on the bio-effects of RF and microwave radiation.

There are several problem areas in the radiofrequency radiation band (specifically 10-300 MHz). One is that employers and employees often are unaware that they are using RF radiation in their facilities. This may be because industrial uses of RF generators have not been widely publicized and little information is available on their uses. For these and other reasons, estimates of workers exposed to RF and microwave radiation vary from as few as 50,000 to as many as 21 million. There is also little information available on the biological effects at the radio frequencies used in industry.

In our field studies 75 percent of the workers using RF sealing and heating equipment were found to be exposed to RF radiation levels higher than the present occupational exposure guideline. A majority of these workers were women, of child bearing age. Because recent literature indicates that exposure of pregnant animals to RF radiation may harm the fetus, we are conducting animal studies designed to determine threshold levels for reproductive effects from RF exposure.

Page 3 - The Honorable Jerome A. Ambro

I have enclosed a summary of our current program in non-ionizing radiation, using the format you suggested. Please let us know if we can supply you with additional information.

Sincerely yours,

Anthony Robbins

Anthony Robbins, M.D.
Director

Enclosures

FORMAT FOR SUMMARY OF NI(SEARCH PROGRAM

AGENCY/DIVISION: CDC/NIOSH

TITLE (of research program): Assessment of Worker Hazards from Radiofrequency Microwave Radiation and Development of Recommended Standard for Occupational Exposure

CONTACT (name of responsible individual, title, address, phone): Dr. Anthony Robbins, Director, NIOSH
5600 Fishers Lane, Rockville, MD 20857
(301) 443-1530

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years):
To conduct research on the bioeffects of RF/microwave radiation that will assist in the development of a recommended standard for occupational exposure and other efforts to reduce worker exposure.

	FY 1979		FY 1980	
Research Category (defined by OSTP ad hoc Working Group)*	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry		$ 91,000	$ 73,800	$100,000
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
1. Epidemiologic and Industrial Hygiene Studies	$109,000		$112,000	
2. Criteria Documents and Current Intelligence Bulletins	8my	$325,000	0.5my	
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$123,700		$167,000	
Beneficial Applications				
TOTAL	$232,700	$416,000	$352,800	$100,000
	+ 8my		+0.5my	

*A technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978

Summary of NIOSH Research Projects

I.

A. Title: RF/Microwave Teratogenic Effects Study

B. Specific Objectives: (1) establish a dose-response relationship between acute RF radiation exposure and teratogenic effects produced in rats and (2) investigate the effects of protracted RF exposure time at or near the teratogenic threshold in rats.

C. Milestones/Estimated Completion Date: objective (1) is scheduled for completion in December 1979, and objective (2) is scheduled for completion in February 1980.

D. Research Category: Genetic/Hereditary/Developmental (Teratology) and Instrumentation and Dosimetry Development

E. Test Parameters

1. Frequency: 27.12 MHz(CW)
2. Test Species: Sprague-Dawley rat
3. Exposure Duration: approximately 30 to 90 minutes (single exposure)
4. Radiation Dose: approximately 55 A/m and 12.5 mW/g
5. Other: temperature controlled @ 24±0.3°C and humidity controlled @ 50±5% by environmental chamber

F. Funding

1. In-house: $123,700
2. Extramural: 91,000
3. Primate Contractor: NBS, Boulder, Colorado

G. Coordination

1. Other Federal Agencies: OSHA, BRH, EPA, and all other agencies on BENER, ERMAC, OSTP Working Group, and Dr. Howard Clark's Task Force
2. State or Local Agencies: Contact with many of the more industrialized states and numerous local agencies
3. Universities: primarily the University of Washington, University of Utah, University of Alabama, University of Cincinnati, Harvard, Stanford, Columbia, Minnesota, Michigan, Wayne State, North Carolina, Tennessee, University of California at Davis, UCLA Medical Center, University of Connecticut, Unversity of Virginia, Tulane, Vanderbilt and others
4. Trade Associations: Binders Industries Association, United Nations Employee Council, International Newpaper Guild, Society of Plastics
5. Other: International Brotherhood of Electrical Workers, United Rubber Workers, and United Auto Workers

H. Comments: The initial results of the teratology study were presented at the Bioelectromagnetic Symposium in Seattle, Washington on June 22, 1979. A paper will be submitted to Teratology for publication.

II. Summary statement covering small or miscellaneous projects: The NBS is developing a system to more accurately determine the absorbed power (mW/g) noninvasively for any specimen placed in the NIOSH RF exposure system. The system is scheduled for delivery by September 1979. These accurate absorbed power determinations will be useful in extrapolating animal data to humans. NIOSH has also made numerous field measurements of workers exposed to RF/microwave energy. These data are being used to simulate industrial exposure conditions more accurately in the laboratory.

III. New initiatives for FY 1980: A project is being submitted to develop exposure controls for RF industrial heating, curing, and melting devices. It is possible to reduce occupational RF exposure levels to a large extent through exposure controls. Initial information indicates that installation of the exposure controls would cause little or no interference with the industrial processes. A project is also being submitted for RF/microwave exposure surveys requested by private individuals, trade associations, labor unions, universities, Federal, state, and local agencies.

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Criteria Document on RF/Microwave Radiation

B. Specific Objectives: Development and Transmittal of criteria for an occupational exposure standard for RF and microwave radiation.

C. Milestones/Estimated Completion Date: September, 1979

D. Research Category: Human Occupational Exposure Recommendations

E. Test Parameters

1. Frequency: 300 KHz - 300 GHz
2. Test species: n/a
3. Exposure duration: n/a
4. Radiation dose: n/a
5. Other: n/a

F. Funding

1. In-House: 8 man/years
2. Extramural: $325,000
3. Prime Contractor: Equitable Environmental Health, Inc.

G. Coordination

1. Other Federal Agencies
2. State or Local Agencies
3. Universities
4. Trade Associations
5. Other: organized labor, professional societies, environmental groups, and health and safety experts in some foreign countries

H. Comments

II. Summary statement covering small or miscellaneous projects

III. New initiatives for FY 1980: There will be a continuing effort to update and make any necessary changes in the criteria document.

Page 4 - Summary of NIOSH Research Projects

I. MAJOR ONGOING PROJECTS, BY 1979

A. Title: Mortality, Reproductive, and Industrial Hygiene Study of Workers Exposed to MW/RF Energy

B. Specific Objectives: Retrospective epidemiology mortality study of students in the Navy electronics apprenticeship training programs and workers in plants using RF heat sealers, dryers, bakers, and gluers.

C. Milestones/Estimated Completion Date: September, 1981

D. Research Category: Human Occupational Exposure Recommendations

E. Test Parameters

1. Frequency: n/a
2. Test species: n/a
3. Exposure duration: n/a
4. Radiation dose: n/a
5. Other: n/a

F. Funding

1. In-house: $109,000
2. Extramural: n/a
3. Prime Contractor: n/a

G. Coordination

1. Other Federal Agencies: Social Security Administration, Department of Defense, FAA, OSHA field offices.
2. State or Local Agencies
3. Universities
4. Trade Associations: Various trade associations and unions as part of the tripartite review process.
5. Other

H. Comments

II. Summary statement covering small or miscellaneous projects: n/a

III. New initiatives for FY 1980: None

Department of Energy
Washington, D.C. 20585

AUG 20 1979

8-21

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Committee on Science and
Technology
U. S. House of Representatives
Washington, D. C. 20515

Dear Mr. Ambro:

Enclosed is a detailed description of our major research efforts in the field of non-ionizing radiation. This is the follow-up information from the July 12 hearing when I appeared before your Subcommittee on this subject. If I can be of further assistance, please let me know.

Sincerely,

Hal Hollister

for Ruth C. Clusen
Assistant Secretary for Environment

Enclosure

TABLE 1 - HIGH-VOLTAGE TRANSMISSION-LINE FIELDS

U.S. DEPARTMENT OF ENERGY

Division of Electric Energy Systems, Office of Energy Technology
Health Effects Research Division, Office of Environment
Environmental Control Technology Division, Office of Environment
Bonneville Power Administration, Office of Resource Applications

TITLE

"Evaluation of Environmental Impacts and Control-Technology Needs Associated with the Operation of A-C (60-Hertz) and D-C (0-Hertz) Electric Transmission Lines"

CONTACTS

Robert W. Flugum
Chief, Power Delivery Branch
Division of Electric Energy Systems
U.S. Department of Energy
Washington, D. C. 20585
Tel. (202)376-4594

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Research Division
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Office of Environment
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Washington, D. C. 20545
Tel. (301)353-3681

Douglas W. Boehm
Environmental Engineer
Environmental Control Technology Division
Office of Environmental Compliance and Overview
U.S. Department of Energy
Washington, D. C. 20545
Tel. (301)353-5511

Vern L. Chartier
Chief, High Voltage Phenomena Engineering
Bonneville Power Administration
Branch of Laboratories
P. O. Box 491
Vancouver, Washington 98660
Tel. (206)696-0351 (ext. 288)

GENERAL PROGRAM OBJECTIVES

- By direct measurement, obtain a detailed quantitative description of electric fields, magnetic fields, and related physical phenomena that are associated with operating high-voltage a-c and d-c transmission lines.

TABLE - continued

- Develop improved knowledge regarding electric-field and magnetic-field dosimetry.
- Based on the acquisition of additional quantitative data from controlled biological studies, substantially enhance capabilities for predicting health effects of electric fields, magnetic fields, and related physical phenomena that are associated with operating a-c and d-c transmission lines.
- Develop theoretical insights into mechanisms by which electric and magnetic fields interact with biological systems.
- Estimate health risks associated with the high-voltage overhead transmission of electric energy.
- Obtain additional information on ecological effects of operating a-c and d-c transmission lines.
- Further assess needs and availability of environmental control technologies.

Research Category	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry*	304	411	401	400
Mechanisms of Interaction	310	94	323	125
Long-term, Low-Level Exposure Studies on Animals	0	0	0	0
Human Studies	125	200	138	200
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields with Other Agents	0	0	0	0
Biological Effects Studies	2500	1791	2329	745
Beneficial Applications	0	0	0	0
Totals	3239	2496	3191	1470

*Includes measurements of field characteristics of operating high-voltage transmission lines

U.S. DEPARTMENT OF ENERGY

TABLE 2 - HIGH-VOLTAGE TRANSMISSION-LINE FIELDS

I. MAJOR ONGOING PROJECTS, FY 1979 (Representative Studies with Funding Exceeding $100,000)

PROJECT 1 - Division of Electric Energy Systems and Health Effects Research Division (joint sponsorship)

A. Title

"Preliminary Study of the Behavioral and Biological Effects of High-Intensity 60-Hz Electric Fields"

B. Specific Objectives

Develop the facilities, instrumentation, methodologies, and staff expertise required to study effects of 60-Hertz electric fields as high as 60 kilovolts per meter on behavioral and selected biological responses in the African savanna baboon

- Design, construct, and test animal exposure facility
- Develop requisite instrumentation for electric field characterization
- Develop methodologies and protocols for behavioral and biological studies
- Develop dosimetric model relating baboon and human exposures

C. Milestones/Estimated Completion Date

- Complete feasibility study by July-August 1979
- Begin construction of exposure facility for the major study by August-September 1979
- Begin major study in FY 1980
- Complete major study in FY 1982

D. Research Category

Biological effects studies

E. Test Parameters

1. Frequency

60-Hertz

2. Test species

Baboon

3. Exposure duration

21 days

4. Radiation dose (electric field intensity in air)

0-60 kilovolts per meter

F. Funding

Extramural - $1,527,000 (FY 1979); research contract with the Southwest Research Institute, San Antonio, Texas

G. Coordination

1. Other federal agencies

- Via Interagency Advisory Committee on Electric Field Effects from High Voltage Lines
- Via Electromagnetic Radiation Management Advisory Council (ERMAC) and IRAC Side Effects Working Group of the National Telecommunications and Information Administration

2. Scientific community

- Contract reviews
- Presentations at national scientific meetings
- Publication of data in the open scientific literature

H. Comments

Because of the close phylogenetic relationship of subhuman primates to man, this study is of special importance from the point of view of interrelating animal and human responses to external electrostatic fields.

PROJECT 2 - Division of Electric Energy Systems

A. Title

"Biological Effects of High Strength Electric Fields on Small Laboratory Animals"

B. Specific Objectives

- Perform controlled laboratory studies with rats and mice to screen for evidence of response using a variety of biological tests and criteria over a range of electric-field strengths encompassing those that exist at operating and planned transmission lines
- For identified effects, obtain quantitative dose-response data
- Develop dosimetric models that quantitatively relate rodent exposures to human exposures

C. Milestones/Estimated Completion Date

- Major screening tests at high field intensities (25-100 kilovolts per meter) and durations of exposures up to 120 days are nearing completion
- Additional tests involving longer exposures and possibly additional field intensities are under consideration
- Detailed studies of several apparent positive effects are being planned and initiated
- Study will continue at least through FY 1982

D. Research Category

Biological effects studies

E. Test Parameters

1. Frequency

60-Hertz

2. Test species

Rats and mice

3. Exposure duration

Variable, depending on observation being made; longest exposures have been 120 days; includes exposures during development in utero

4. Radiation dose (electric field intensity in air)

0-100 kilovolts per meter

F. Funding

In-house - $608,000 (FY 1979); research contract with the Battelle Pacific Northwest Laboratories

G. Coordination

Same as for Project 1

H. Comments

This study has yielded very extensive quantitative data on many biological response parameters. Although the preponderance of data have been negative (i.e., showing no apparent effects), preliminary evidence has been obtained suggesting that high-intensity electrostatic fields may affect one aspect of the immune response, increase the excitability of nerve tissue, and produce minor effects on development in utero.

PROJECT 3 - Division of Electric Energy Systems

A. Title

"Biomedical Effects Associated with Energy Transmission Systems"

B. Specific Objectives

- Develop facility for exposing small laboratory animals to extremely-low frequency electrostatic fields under conditions that permit various functional activities (behavioral activity, metabolism, and thermoregulation) to be monitored continuously and quantitatively
- Study effects of electric fields on circadian regulation of physiological and behavioral patterns in small mammals
- Determine effects of electric fields on daily activity cycles and thermoregulation

C. Milestones/Estimated Completion Date

- Exposure facility completed in June 1979
- Collection of preliminary data initiated in June 1979
- Study expected to continue at least through FY 1982

D. Research Category

Biological effects studies

E. Test Parameters

1. Frequency

60-Hertz at present; variable frequency capacility (10-240 Hertz) will be developed and utilized later

2. Test species

Rats and mice

3. Exposure duration

Variable (minutes to several hours), it is planned to do extensive work using intermittent (on-off) exposures timed to coincide or conflict with intrinsic body rhythms

4. Radiation dose (electric field intensity in air)

With present fixed-frequency (60-Hertz) system, range is 0-100 kilovolts per meter; it is expected that the variable-frequency system to be developed will have a range of 0-10 kilovolts per meter.

F. Funding

In-house - $358,000 (FY 1979); research contract with the Argonne National Laboratory

G. Coordination

Same as Project 1

PROJECT 4 - Division of Electric Energy Systems

A. Title

"Electric Field Instrumentation and Calibration"

B. Specific Objectives

- Evaluate devices and methods in current use for measuring electric and magnetic fields associated with high-voltage a-c and d-c transmission lines
- Assess methods being used for calibrating such devices
- Develop and document a standard procedure for performing calibrations
- Establish a calibration facility

C. Milestones/Estimated Completion Date

- Consultation with DOE/EES- and DOE/OHER-supported research contractors has been conducted on a continuous basis as requested by DOE program managers
- Consultations expected to continue at least through FY 1982
- Calibration facility is being developed

D. Research Category

Instrumentation and Dosimetry

E. Test Parameters

Not applicable

F. Funding

Extramural - $150,000 (FY 1979); research contract with the National Bureau of Standards

G. Coordination

Same as for Project 1

H. Comments

The NBS contract provides a key source of quality control for the instrumentation and measurement aspects of the bioeffects research effort

PROJECT 5 - Bonneville Power Administration

A. Title

"1200 kV Prototype Line Electrical Studies"

B. Specific Objectives

- Measure electrostatic fields, magnetic fields, and associated phenomena at the Lyons, Oregon, 1200-kilovolt a-c test facility under varied operating conditions
- Determine effects of variables such as line voltage, line elevation, location relative to the line, and weather conditions on the parameters measured

C. Milestones/Estimated Completion Date

- Measurements were started as soon as line was first energized in December 1976
- Data acquisition is expected to continue at least through FY 1982
- Quarterly progress reports and periodic major technical reports are incoroporated into project schedule
- Final report will be issued on completion of project

D. Research Category

Instrumentation and dosimetry

E. Test Parameters

1. Frequency

60-Hertz

2. Others

Line voltage (varied to determine effect)

Line elevation (varied to determine effect)

Distance from line (varied to determine effect)

Weather (variable)

F. Funding

In-house (BPA staff) - $110,000 (FY 1979)

G. Coordination

1. Other federal agencies

- Via the Interagency Advisory Committee on Electric Field Effects from High Voltage Lines
- Via the IRAC Side Effects Working Group of the National Telecommunications and Information Administration
- Via the Interagency Research Coordinating Committee consisting of representatives from the Bonneville Power Administration, Tennessee Valley Authority, Bureau of Reclamation, and Army Corps of Engineers

2. Scientific community

- Presentations at national scientific meetings
- Publication of data in open scientific literature

H. Comments

This study is providing valuable quantitative data on potential human exposures

PROJECT 6 - Bonneville Power Administration

A. Title

"1200 kV Prototype Line Biological Studies"

B. Specific Objectives

- Observe and describe possible effects of the physical fields associated with the Lyons, Oregon, prototype facility on natural vegetation, crops, wildlife, cattle, and honey bees in the vicinity of the line
- Evaluate effects of line voltage, line elevation, and location with respect to the line on the biological parameters studied

C. Milestones/Estimated Completion Date

- Data collection was initiated in the spring of 1976 (i.e., before the line was energized in December 1976)
- Data acquisition is expected to continue at least through FY 1981
- Quarterly progress reports and periodic major technical reports are incorporated into project schedule
- Final report will be issued on completion of project

D. Research Category

Biological effects studies

E. Test Parameters

1. Frequency

60-Hertz

2. Test species

Crops, cattle, trees, small feral animals, and honey bees

3. Exposure duration

Crops - during growing season (3-4 months per year)

Cattle - during grazing season (approximately 10 weeks per year)

Trees - year round (continuous)

Small animals - year round (mainly along edge of right-of-way)

Bees - about 6 months per year

4. Radiation dose (electric field intensity in air)

Crops - approximately 12 kilovolts per meter

Cattle - intensity varies from 0-12 kilovolts per meter depending on location while grazing

Trees - intensity ranges from 0 to 35-40 kilovolts per meter depending on location

Small animals - 0 to about 6 kilovolts per meter depending on location

Bees - 12 kilovolts per meter (observations at 8 kilovolts per meter have been completed)

F. Funding

In-house - $175,000 (FY 1979); research contract with Battelle-Pacific Northwest Laboratories

G. Coordination

Same as for Project 5

H. Comments

Together with another ongoing study and work already completed, this project is serving to define impacts of high-voltage transmission-line fields on natural biota, ecosystems, and species of agricultural importance.

PROJECT 7 - Health Effects Research Division

A. Title

"Bioeffects of Magnetic Fields"

B. Specific Objectives

- Identify, characterize, and quantify biomagnetic effects in experimental systems with special emphasis on the study of physiological responses in small animals and the acquisition of quantitative dose-response data
- Develop insights into mechanisms underlying biomagnetic effects

C. Milestones/Estimated Completion Date

- Major laboratory facility for biomagnetic effects research was completed in FY 1978
- A variety of screening tests with diverse experimental systems exposed to d-c (steady) magnetic fields ranging up to 21.5 kilogauss in intensity are currently in progress
- Detailed study of magnetic-field effects on electrocardiogram measurements was initiated in FY 1979; other effects, as they are identified, will be similarly investigated
- Project is expected to continue at least through FY 1982

D. Research Category

Biological effects studies

E. Test Parameters

1. Frequency

0-Hertz (steady, nonpulsed fields; pulsed fields to be studied in the future)

2. Test species

Mice, rats, rabbits, dogs, turtles, frogs, plants (barley and corn), beetles, and viruses

3. Exposure duration

Variable--includes acute exposures (minutes to hours in duration) and chronic exposures (up to 2 weeks in duration)

4. Radiation dose (magnetic field strength)

0-21.5 kilogauss (21,500 gauss or 2.15 tesla)

F. Funding

In-house - $325,000 (FY 1979); research contract with the Lawrence Berkeley Laboratory

G. Coordination

Same as for Project 1

H. Comments

This is one of two major projects concerned with the identification, characterization, and explanation of effects of magnetic fields in mammalian organisms and other biological systems. The purpose of these studies is to develop a capability, based on reliable quantitative data, for estimating magnetic-field bioeffects from information on exposure parameters. These studies relate principally to other technology areas but are providing information of generic importance to the study of high-voltage transmission-line bioeffects

PROJECT 8 - Health Effects Research Division

A. Title

"Biomagnetic Effects"

B. Specific Objectives

This project is designed to examine a number of biological systems for their response to magnetic fields and to investigate mechanisms of those responses. Systems and responses under study are as follows:

- Mice and fish ova (teratologic, developmental, and mutagenic effects)
- Cell cultures, Drosophila (small fly), and bacterial test systems (mutagenesis, mammalian cell transformation, and carcinogenic potential)
- Mammalian neuron/synapse preparations (neurophysiologic effects)
- Synthetic and biological membranes (effects on membrane kinetics; elucidation of mechanisms of action)

C. Milestones/Estimated Completion Date

- Facilities for biomagnetic-effects research were completed in FY 1978
- In FY 1979, completed preliminary studies of effects of strong d-c magnetic fields (10,000 gauss) on biological development (mouse and trout embryo), mammalian cell morphology and growth, and dominant lethal mutations (mouse)
- These and other studies are continuing in an effort to identify biomagnetic effects; as effects are identified, detailed follow-up studies will be initiated
- Project expected to continue at least through FY 1982

D. Research Category

Biological effects studies

E. Test Parameters

1. Frequency

0-Hertz (steady and pulsed fields; uniform and gradient fields)

2. Test species

Mice, fish, insect (Drosophila), bacteria, and mammalian test systems (cells and nerve preparation)

3. Exposure duration

Variable, depending on response being studied; duration ranges from hours to over 20 days

4. Radiation dose (magnetic field intensity)

0-10,000 kilogauss

F. Funding

In-house - $280,000 (FY 1979); research contract with Battelle Pacific Northwest Laboratories

G. Coordination

Same as for Project 1

H. Comments

Same as for Project 7

II. Statement Summarizing Remaining Projects

The Department of Energy is currently supporting a multidisciplinary program of research to (a) identify, characterize, and quantify health and environmental effects that may be induced by the physical fields associated with high-voltage overhead transmission lines of both the a-c and d-c types, (b) quantitatively define the kinds of exposure situations that humans and other organisms may be reasonably expected to encounter as a result of the transmission of electricity in overhead lines. The goal of the program is to develop capabilities for predicting health and environmental impacts and for assessing needs for control technologies. Comprising the projects not individually summarized are a number of activities designed to advance knowledge in several areas. For example, several studies are providing additional information on animal responses as well as the characteristics of high-voltage transmission line fields (d-c as well as a-c). In addition, studies of cultured cells and tissues are beginning to yield insights into mechanisms underlying biological responses to electric and magnetic fields. Also worthy of note is a retrospective epidemiologic study of occupational exposures to magnetic fields and two projects concerned with the development of magnetic-field dosimeters for occupational use.

III. New Initiatives in FY 1980

It is increasingly apparent that additional research is required in the area of instrumentation and dosimetry as well as mechanisms of field interaction with biological systems. In addition, research is needed on the bioeffects of weak 60-Hertz magnetic fields, an area that has received little attention to date. The study of additional response parameters in subhuman primates is also desirable in order to improve the extrapolation of animal data to man. New initiatives in FY 1980 will require additional funds and/or reprogramming of ongoing research.

Satellite Power System

U. S. Department of Energy
Satellite Power Systems Office
Office of Energy Research

TITLE

Biological and Ecological Effects of Microwave Exposures Produced by Satellite Power System

CONTACTS

Program Contact: N. F. Barr
Satellite Power System Project Office
Office of Energy Research
U. S. Department of Energy
Washington, D. C. 20545
(202) 376-9365

Technical Contact: Dr. Dan Cahill
EPA/ Research Triangle Park
8-629-2771

GENERAL PROGRAM OBJECTIVES

Obtain increased information on the response of biological systems (non-transient species) on which to base regulations regarding permissible population exposures to microwaves. Obtain information on the behavior of transient species exposed to the microwave power beam of the Satellite Power System (SPS). These objectives will be achieved in approximately three years.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-Level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/Other Agents				
Biological Effects Studies		950,000		1,050,000
Beneficial Applications				
TOTAL		950,000		1,050,000

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

I. MAJOR ONGOING PROJECTS FY 1979 (Representative Studies with Funding Exceeding $100,000)

A. Title

Biological Effects of 2.45 GH_3 CW Microwaves

B. Specific Objectives

To validate and extend observations of biological effects under conditions applicable to Satellite Power System Operation.

C. Milestones/Estimated Completion Date

Preliminary report March 1980, Completion October 1981

D. Research Category (OSTP Working Group Categories)

Biological Effects Studies

E. Test Parameters

1. Frequency

2.45 GH_3

2. Test Species

Rodents

3. Exposure Duration

For periods ranging from 1-10 hours

4. Radiation Dose

Exposures to power densities in range 10-100 MW/CW^2

F. Funding

Extramural - Approximately $800,000

G. Coordination

1. Other Federal Agencies

EPA

II. MAJOR ONGOING PROJECTS, FY 1979 (Indicate selection criterion: five or ten largest, greater than $100K, highest priority, etc.)

A. Title

Effects of Microwaves on the European Honey Bee

B. Specific Objectives

Determine effects of 2.45 GH_3 CW microwave radiation at power densities of 10 MW/CW^2 on behavior of European Honey Bee.

C. Milestones/Estimated Completion Date

D. Research Category (OSTP Working Group Categories)

Biological Effects Studies

E. Test Parameters

1. Frequency

2.45 GH_3

2. Test Species

European Honey Bee

3. Exposure Duration

For periods ranging from 1-10 hours

4. Radiation Dose

Exposure to power densities in range 10-100 MW/CW^2

F. Funding

Extramural - Approximately $100,000/yr.

G. Coordination

1. Other Federal Agencies

EPA

III. MAJOR ONGOING PROJECTS, FY 1979 (Indicate selection criterion: five or ten largest, greater than $100K, highest priority, etc.)

A. Title

Effects of Microwaves on Birds

B. Specific Objectives

Determine effects of exposure to Satellite Power System Microwave Beam on Birds

C. Milestones/Estimated Completion Date

Preliminary Report March 1980, Final Report October 1981

D. Research Category (OSTP Working Group Categories)

Biological Effects Studies

E. Test Parameters

1. Frequency

2.45 GH_3

2. Test Species

Birds

3. Exposure Duration

For periods ranging from 1-10 hours

4. Radiation Dose

Exposure to power densities of approximately $10MW/CW^2$

F. Funding

Extramural - $1,000,000

G. Coordination

1. Other Federal Agencies

EPA

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION
ROCKVILLE, MARYLAND 20857

JUL 11 1979

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Committee on Science and Technology
House of Representatives
Washington, D. C. 20515

Dear Mr. Ambro:

Thank you for your letter of June 19, 1978 to Commissioner Kennedy requesting that Dr. Mays Swicord of our Bureau of Radiological Health appear before your Subcommittee to testify on the efforts of the IRLG to coordinate the Federal research program on the health effects of nonionizing radiation.

Dr. Swicord, who is Chairman of the IRLG Committee on Radiofrequency and Microwaves, will be happy to testify on this subject at the scheduled time.

As requested in your letter, you will find enclosed a summary of the radiofrequency/microwave research program being carried on by the Food and Drug Administration (FDA), organized according to the seven research categories of the Office of Science and Technology Policy. The FDA RF/microwave research program summary includes an additional category, product emission studies, because of the importance of this research to FDA regulatory programs.

The individual project summary reports for FY 79 show expenditures in dollars along with actual working level person-years. The figures do not include management or overhead expenses; neither do they include personnel costs (salaries). The overall cover summary sheet summarizes the individual projects and includes personnel and related costs.

Sincerely yours,

Robert C. Wetherell Jr.

Robert C. Wetherell, Jr.
Associate Commissioner
for Legislative Affairs

Enclosures

FORMAT FOR SUMMAR. . RESEARCH PROGRAM

AGENCY/BUREAU: Bureau of Radiological Health

TITLE: Radiofrequency and Microwave Research

CONTACT: Director, Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20857

GENERAL PROGRAM OBJECTIVES: To develop sufficient biological, physical, and engineering information to effectively control radiofrequency and microwave emissions from electronic products in order to protect further the public health. This data base should be extended in the next few years to give positive guidance.

($000)

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry	351.6	75	369.2	75
Mechanisms of Interaction	72.2	136	75.8	136
Long-term, Low-level Exposure Studies on Animals	29.9		31.4	
Human Studies	46.8		49.1	
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents	24.9		26.1	
Biological Effects Studies	259.6	200	272.6	200
Beneficial Applications	12.5		13.1	
Product Emission Studies	259.7		272.7	
TOTAL	1057.2	411	1110.0	411

Policy by an ad hoc Working Group
May 15, 1978

* A Technical Review of the Biological Effects of Non-Ionizing Radiation -- A Report Prepared for the Office of Science and Technology

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Theoretical and Phantom Model Dosimetry

B. Specific Objectives

1. To determine whole/partial body energy absorption of animal specimens and phantom human bodies.

2. Perform theoretical dosimetry on complex biological bodies under plane-wave and near field conditions.

C. Milestones/Estimated Completion Date:

1. Measurement of internal electric field in rabbits and rats exposed to microwave sources in biological experiments, 1980.

2. Develop computer programs for calculation of internal dose in complex geometry exposed to plane-wave, Dec. 1979.

3. Model near-field coupling, 1980.

D. Research Category

#1 Instrumentation and dosimetry

E. Test Parameters

1. Frequency: 915 MHz, 2450 MHz, and others appropriate

F. Funding

1. In-House: 2 man years, 80k

2. Extramural

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79

A. Title: Measurement of Dielectric Properties of Materials and Development of Simulated Materials.

B. Specific Objectives:

1. Development of system for accurate routine measurement of the complex permittivity of materials of biological or dosimetric interest.

2. Development of Semi-automated Network Analyzer System

3. Develop phantoms simulate a fat/bone layer for use in determining dosimetric and leakage data on RF diathermy machines.

4. Develop phantoms which simulate a fat/bone layer for use in determining compliance with proposed microwave diathermy standard.

C. Milestones/Estimated Completion Date: Scheduled completion 1-20-80 for microwave diathermy, Summer 1980 for r.f. diathermy methods development FY 80.

D. Research Category

#1 Instrumentation and Dosimetry

E. Test Parameters

1. Frequency: 27 MHz, 1-12 GHz

F. Funding

1. In-House: .6 man years, $12k

2. Extramural: 40k

3. Prime Contractor: Emerson & Cumings, Inc.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Miniature E Field Probe Development

B. Specific Objectives: To develop broadband, sensitive probes for implantation in living biological specimens, and for mapping of near fields in the close proximity of radiating sources, such as, RF sealers, shortwave diathermy, etc.

C. Milestones/Estimated Completion Date:

1. Obtain miniature 3D implantable probes (3 mm diameter tip)from contractor and evaluate in simulated biological specimens (11/80)

2. Obtain electro-optic modulator antenna devices from Naval Research Laboratories and evaluate in near fields (7/80)

3. Obtain subminiature single axis implantable probe (1 mm tip) from Univ. of Va. and evaluate in simulated biological speciments (12/80)

D. Research Category (OSTP Working Group Categories):
#1 Instrumentation and Dosimetry, IRLG-

E. Test Parameters

1. Frequency - 10 MHz to 3 GHz

2. Test Species - models and living specimens of rabbits, cats, rats.

3. Radiation Dose - measure 0.1 to 10 W/kg.

F. Funding

1. In-House: 0.5 man-year FY 79

2. Extramural: $35k FY 79

3. Prime Contractors: Narda Microwave Corp. and Naval Research Laboratory.

G. Coordination

1. Other Federal Agencies: Naval Research Laboratory, Environmental Protection Agency, USAF School of Aerospace Medicine.

2. Universities: University of Virginia

Miniature E Field Probe Development

H. Comments: The project represents the state of the art in internal dosimetry via E field probes and has supplied several federal and university researchers with prototypes to perform dosimetry in conjunction with ongoing bioeffects research programs.

II. Summary statement covering small or miscellaneous projects:

A fiber optically-linked telemetry system which was previously developed for BRH probes by a private contractor is being upgraded for use with more advanced, smaller probes, where automated, higher performance is required in the telemetry system.

III. New initiatives for FY 80

Continuation of ongoing work to improve the size reduction, performance-optimization efforts of this project.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79: Microwave Oven Standard Enforcement

A. Title: Microwave Oven Performance Standard Enforcement

B. Specific Objectives: To provide analysis and evaluation of radiation leakage survey instruments.
To provide FDA and other Federal agencies, local and state health departments and the U.S. Navy with the precise calibration of microwave oven survey instruments.

C. Milestones/Estimated Completion Date:

1. Evaluated (including extensive lab testing) three new microwave survey instruments, final report to be published by end of FY 79.

2. Calibrated over 350 oven survey instruments for FDA, Navy, NASA, OSHA and many state and local government agencies.

D. Research Category (OSTP Working Group Categories):

#1 Instrumentation and Dosimetry

E. Test Parameters:

1. Frequency: 915 MHz; 2450 MHz

F. Funding:

1. In-House: $37.5k, 2.8 man years

G. Coordination:

1. Other Federal Agencies: Interagency agreement with the U.S. Navy for calibration of oven survey instruments.

2. State or Local Agencies: Coordination with state and local health agencies.

H. Comments:

This project is vital for the public welfare. The technical competence of FDA in the microwave oven field must be maintained to ensure and reduce unnecessary exposure to microwave oven radiation leakage

Microwave Oven Performance Standard Enforcement

II. Summary statement covering small or miscellaneous projects:

An analysis of the leakage from ovens closer then 5 cm from the oven.

Perform theoretical and experimental dosimetry to assess absorbed dose from a typical leaking microwave oven.

III. New initiatives for FY 80:

Implement international calibration intercomparison with Japanese National Standards laboratory.

Evaluate automated oven scanner systems.

Evaluate new and existing oven survey instrumentation.

Continue ongoing support for the enforcement of the microwave oven performance standard.

Analyze leakage fields in close proximity of microwave ovens, scanning at 5 cm and other distances from the oven surface.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Interaction DNA Double Helix with E.M. Fields

B. Specific Objectives:

1. To calculate the interaction of DNA double helices with an electromagnetic field in order to predict microwave absorption. Methods will be explored to determine the mechanism by which microwave action on vibrational modes can effect biological processes.

C. Milestones/Estimated Completion Date: August 31, 1981

D. Research Category

#2 Mechanisms of Interaction

E. Test Parameters: Theoretical

F. Funding

1. Extramural 34,371

2. Grantee: E. E. Ptolofsky
Purdue Research Foundation

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Nonlinear Interactions of Electromagnetic Waves and Biological Membranes

B. Specific Objective:

1. To examine the nonlinear interaction of electromagnetic waves with biological membranes and to look at the effect of electromagnetic fields on the alignment of long chain molecules in the presence of cells.

C. Milestones/Estimated Completion Date: August 31, 1981

D. Research Category:

#2 Mechanisms of Interaction

E. Test Parameters: Theoretical

F. Funding:

1. Extramural - 86,813

2. Grantee: F.S. Batnes
University of Colorado

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79

A. Title: Physical Interaction Studies

B. Specific Objectives:

1. To determine if previously reported (Russian) frequency-dependent introduction of colicin synthesis or lambda phage expression in E. coli under the influence of millimeter-wave irradiation can be confirmed.

2. To develop an optical heterodyne technique for the measurement of microwave absorption in solutions of biological interest.

3. To investigate Brilluoin scattering as a technique for the measurement of microwave absorption in solutions of biological interest.

C. Milestones/Estimated Completion Date: 1982

D. Research Category:

#2 - Mechanisms of Interaction

E. Test Parameters

1. Frequency: 8-12 GHz, 45-46 GHz (E. coli)

2. Test species: E. coli BR-475

3. Exposure duration: For E. coli experiment, typically 90 minutes.

4. Radiation dose: For E. coli experiment, 0.1 - 10.0 mW/cm^2

F. Funding

1. In-House: 1.8 man years, $5k

2. Extramural: $15k (IAG with Navy)

3. Prime Contractor: University of Maryland

G. Coordination

1. Other Federal Agencies: US Navy (Navy is providing partial funding)

3. Universities: University of Maryland, Brooklyn Polytechnic Institute

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Effects of Long Term Low-Level Exposure on Behavior

B. Specific Objectives:

1. To determine the effects of prolonged exposure on conditioned and unconditioned behaviors.

C. Milestones/Estimated Completion Date: 1983

D. Research Category (3)

E. Test Parameters:

1. Frequency: 2450 MHz

2. Test species: Mice

3. Exposure duration: 30 hours

4. Radiation dose: 10 mW/cm^2

5. Other: Subjects were off-spring of exposed females.

F. Funding

1. In-House: $5000 + 0.7 PY

G. Coordination:

1. Other Federal Agencies: NIEHS

III. New Initiatives for FY 1980

Four month exposure of exposed adults; Portion of project included in research plan for the US-USSR collaboration in environmental factors.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Comparative Histopathology of Cataracts

B. Specific Objectives:

1. To compare the histopathology of human and animal cataracts of difficult etiologies

C. Milestones/Estimated Completion Date: 1984

D. Research Category (4)

E. Test Parameters:

1. Frequency: Various

2. Test species: human, rabbit

3. Exposure duration: various

4. Radiation dose: various

F. Funding

1. In-House: $2000 +.5 PY

G. Coordination

1. Other Federal Agencies: U.S. Navy

3. Universities: various

5. Other: Hospitals, clinics

II. Summary statement covering small or miscellaneous projects:

Collaborative study, with USPHS hospital in San Francisco, CA, of 72 radar maintenance technicians on EC-121 radar picket planes, to determine extent of opacities, has data in review.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Behavioral Synergisms between Microwave Radiation and Psychoactive Drugs

B. Specific Objectives:

1. To determine interaction of rf radiation and commonly prescribed drugs.

C. Milestones/Estimated Completion Date: 1983

D. Research Category (5)

E. Test Parameters:

1. Frequency: 2450 MHz

2. Test species: Mice

3. Exposure duration: approximately 8 hrs/day, 1-2 day/wk during gestation

4. Radiation dose: 10 mW/cm^2

F. Funding

1. In-House: $5,000 + 0.5 PY

G. Coordination:

3. Universities: George Washington University

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Biopsychological Studies of Microwave Irradiation

B. Specific Objective

1. To study during exposures to microwave energy at 915 and 2450 MHz the sensory-threshold response of several mammals. Following exposures at selected durations and power densities of irradiation and as fetuses, infants, or adults, additional animals would be examined as adults (a) for learning ability and (b) for visually and acoustically evoked electrocortical responses.

C. Milestones/Estimated Completion Date: August 31, 1980

D. Research Category:

#6 Biological Effects Studies

E. Test Parameters:

1. Frequency 915 MHz, 2450 MHz

2. Test species: Mice, guinea pigs

3. Radiation Dose: Various Dose and Exposure Duration

F. Funding:

1. Extramural - 87,321

2. Grantee: D. R. Justeson
University of Kansas AND
Veterans Administration Hospital, Kansas City

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Electromagnetic Radiation and Biological Systems

B. Specific Objective:

1. To study interactions between weak ultra high frequency electromagnetic fields and the central nervous system. Neurochemical studies of calcium ion binding and amino acid and other putative neurotransmitters as well as behavioral performance studies.

C. Milestones/Estimated Completion Date: February 28, 1981

D. Research Category:

#6 Biological Effects Studies.

E. Test Parameters

1. Frequency: 450 MHz (modulated)

2. Test species: chicks, cats

3. Radiation Dose: Less than 10 MW/cm^2

F. Funding:

1. Extramural - 112,098

2. Grantee: Ross Adey
Jerry L. Pettis Memorial VA Hospital
Loma Linda, CA.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Embryonic Development During Microwave Exposure

B. Specific Objectives:

1. To establish dose-response relationships between exposure and injury to the mammalian embryo

C. Milestones/Estimated Completion Date: 1984

D. Research Category: (6)

E. Test Parameters:

1. Frequency: .915, 2.45 GHz

2. Test species: mouse

3. Exposure duration: 5 min to 4 hr/day during gestation

4. Radiation dose: 10-200 mW/cm^2

F. Funding

1. In-House: $7000 + 2.3 PY

G. Coordination

1. Other Federal Agencies: EPA

3. Universities: Howard University

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79

A. Title: Chromosomal Responses in Microwave-Exposed Cells in Culture

B. Specific Objectives:

To determine sub-lethal responses of microwave exposed cells.

C. Milestones/Estimated Completion Date: 1984

D. Research Category (OSTP Working Group Categories): 6

E. Test Parameters

1. Frequency: 2.45, 10 GHz
2. Test species: Tissue culture cells
3. Exposure duration: In the range, 5 min to 6 months
4. Radiation dose: 5 - 20 mW/cm^2

F. Funding: In-house - $5,000 + 1.3 Person years

G. Coordination: George Washington University, Howard University

II. Summary statement covering small or miscellaneous projects:

Cell growth under conditions of continuous microwave heating to optimum growth temperature.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79

A. Title: Cataract Induction by Repetitive Microwave Exposure

B. Specific Objectives:

To determine whether repetitive exposures to microwave radiation can induce cataracts.

C. Milestones/Estimated Completion Date: 1984

D. Research Category (OSTP Working Group Categories): 6

E. Test Parameters:

1. Frequency: .915, 2.45 GHz

2. Test species: Rabbit, mouse

3. Exposure duration: Repetitive over course of 6 - 18 weeks

4. Radiation dose: 5 mW/cm^2 to 180 mW/cm^2

5. Other: Exposure included far and near field exposures

F. Funding: In-house - $6,000 + 1 Person year

G. Coordination:

1. Other Federal Agencies: U.S. Navy

2. State or Local Agencies:

3. Universities: Tufts

II. Summary statement covering small or miscellaneous projects:

Testicular examination performed on selected exposed mice. Mouse strain genetically pre-determined to form cataracts, and is undergoing inbreeding to improve stability of the cataractious response.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: Acute Microwave Cataractogenesis

B. Specific Objectives:

1. To determine relationship between microwave exposure and cataract formation at various frequencies, and to examine the role of ascorbic acid in the cataractogenesis process

C. Milestones/Estimated Completion Date: 1983

D. Research Category (6)

E. Test Parameters:

1. Frequency: .915, 2.45, 2.9, 10, 14 GHz

2. Test species: rabbits, guinea pigs

3. Exposure duration: < 120 minutes

4. Radiation "dose": Threshold of incident power density for cataract formation

F. Funding

1. In-House: $15,000 + 1.4 PY

G. Coordination

1. Other Federal Agencies: U.S. Navy

3. Universities: Tufts, Brooklyn Polytechnic Institute

H. Comments: Includes pulsed vs. cw, exposure conditions for cataractogenesis

II. Summary statement covering small or miscellaneous projects:

Damage to central nervous system, including paralysis, observed in exposed guinea pigs. Studies of effects of Vitamin C deficiency in guinea pigs.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79:

A. Title: Microwave Cancer Therapy Device Research

B. Specific Objectives: Testing of the safety and thermal effectiveness of microwave cancer therapy devices. Concurrently, BRH staff members are continuing their consulting activities with the clinical cancer therapy community, such as the NIH Radiation Therapy Oncology Group (RTOG), to optimize treatment procedures.

C. Milestones/Estimated Completion Date:

The survey of new hyperthermia system and instrument manufacturers is continuing. Recently developed non-perturbing prototype internal temperature probes are being evaluated for thermal dosimetry application in hyperthermia treatments (to be completed by late Summer 1979).

E. Test Parameters

1. Frequency: 2450 MHz and 915 MHz.

F. Funding:

1. In-House: 0.3 man year

G. Coordination: This program is being coordinated with the Radiation Therapy Oncology Group, supported by NIH/NCI.

II. N/A

III. New initiatives for FY 80: To continue lab evaluations of microwave hyperthermia systems, and to monitor clinical procedures in this area.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 79

A. Title: Microwave Diathermy Performance Standard Development

B. Specific Objectives: Microwave diathermy involves the medical use of concentrated radiation applied to local sites on the body to promote healing of injured muscles, tendons, etc. BRH is developing methods for the determination of heating effectiveness in simulated tissue models (phantoms)& is developing radiation leakage reduction techniques.

C. Milestones/Estimated Completion Date:

1. Develop dosimetric techniques using diathermy equipment, phantoms, and a computerized thermal imaging camera to picture energy deposition in models, of different anatomical sites. (Sept 1979)

2. To develop radiation leakage mapping techniques and reduced leakage equipment prototypes. Jan. 1980.

D. Research Category: Product emission investigation and analysis

E. Test Parameters

1. Frequency: 915 and 2450 MHz

2. Test Species: models of humans (phantoms)

F. Funding

1. In-House:1.7 man year & 23k

2. Extramural:

3. Prime Contractor:

G. Coordination

An FDA regulatory program

H. Comments

Significant Progress made under this program has demonstrated the clinical feasibility of reducing radiation leakage while providing effective heating of the intended tissues.

Microwave Diathermy Performance Standard Development

II. N/A

III. FY 80 Initiatives

Continuation of the refinement of leakage measurement and phantom dosimetry projects.

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects FY 79

A. Title: RF Sealer Risk Assessment

B. Specific Objectives: To ascertain the levels of exposure to operational personnel due to emissions from RF heating and sealing machines. To determine the need for regulation of these products and the amount of involvement FDA should have in light of cross-jurisdictional concerns with other government agencies. Assess the alternative control measures for hazardous radiation from RF Sealers.

C. Milestones/Estimated Completion Date:

1. Through user plant visits, determine the following: magnitude and polarization of the high electric and magnetic fields; duty cycles; exposure field spatial distribution, and the frequency amplitude spectrum.

Results presented to Bureau wide seminar in March 1979.

2. Dosimetric analysis report based on measurements to be issued by end of FY 79.

3. Electric and magnetic field laboratory measurement instrumentation evaluation for the following: calibration; linearity; directivity and polarization; modulation sensitivity and field impedance independence. First draft of report May 1979.

D. Research Category (OSTP)

Product emission investigation and analysis

E. Test Parameters

1. Frequency: (10-40 MHz)

3. Exposure Duration: up to a total of 1 hour over an 8 hour period. (5 seconds "on" per 40 second product cycle)

4. Radiation Dose: During "on" period operator exposure exceeding 1,000 V/m and 9 A/m. Magnetic field exceeds ANSI time averaged standard by a factor of 20.0. Estimated SAR ≈ 5 to 25 W/kg

F. Funding

1. In-House: $28,000 and 1.8 man-year

RF Sealer Risk Assessment

G. Coordination

1. Other Federal Agencies: FDA/BRH is participating in the Interagency Regulatory Liaison Group (IRLG) working program established between OSHA, EPA, CPSC, FCC and NIOSH.

2. State and local agencies Informed through publications and in individual responses to requests for information;and,when available, measurement instrumentation has been supplied.

4. Trade Associations: Working relationships have been established with the major manufacturer of RF sealers;and,a visit to make measurements and evaluate shielding techniques has been scheduled for August 1979. A listing of Unions, manufacturers, and users is being compiled in anticipation of inviting these and other interested persons to a public meeting to discuss possible solutions.

II. Summary statement covering small or miscellaneous projects:

Although rf plastic sealers are the principal concern, wood gluers, metal induction furnaces and related products are also investigated as time permits.

III. New initiatives for FY 1980:

a. Development of RF radiation survey techniques for rf sealers, and to come up with as simple, inexpensive, and useful an instrument package and procedure as possible. The techniques would be intended for use both by inspectors, and by sealer manufacturers and users.

b. Continue contacts with RF sealer manufacturers and users: to document the exact types of equipment already in use and now being manufactured; to document existing provisions made to shield against emission of unwanted RF radiation; and to document the difficulties encountered in applying and maintaining various types of protective shielding.

451-454

SUMMARY OF RESEARCH PROGRAM
Bureau of Radiological Health

I. Major Ongoing Projects, FY 1979

A. Title: RF/Microwave Product Evaluation

B. Specific Objectives: To measure the RF radiation emitted from citizen band (27 MHz) radio and to determine the radiation safety/public health impact of commercially available RF/microwave products.

C. Milestones/Estimated Completion Date:

1. Publish a comprehensive report detailing the measurement techniques and radiation levels at distances of 5, 12, and 60 cm along the vertical height of the most popular types of CB antennas, including hand-held units./Report available in March 1979.

2. Evaluation of the use of commercial RF/microwave radio transceivers and development of possible laboratory measurement investigation./Sept. 1979.

3. Develop computer program listing of all RF microwave products contains radiation safety information and numbers in use, levels, manufacturers, etc./continuing.

D. Research Category (OSTP Working Group Categories):

Product emission investigation and analysis

E. Test Parameters (for the product tested--CB radio)

1. Frequency: (27.12 MHz) at 4 watts into the antenna

3. Exposure duration: Variable--determined by transmit time

4. Radiation Dose: Measured level for CB radio was greater than 200 V/m and 0.5 A/m at 12 cm distant for some of the antennas. Approximately 40 V/m was measured at 60 cm (2 feet from most antennas).

5. Other: CB transmissions are usually short, therefore, the transmit levels in 4 would average out to lower exposure over longer times.

F. Funding

1. In-House: $12,000 and 1.7 man-year

2. Extramural: None

3. Prime Contractor: None

RF/Microwave Product Evaluation

G. Coordination

1. Other Federal Agencies: FCC and EPA contact established and continuing. Final report on CB sent to each

2. State and Local Agencies: Through BRH mailing list CB report sent to several.

3. Universities: Through BRH mailing list, CB report sent to several.

4. Trade Associations: Through BRH mailing list, CB report sent to several.

5. Other: 29 individual requests to the author were filled to date.

II. Summary statement covering small or miscellaneous projects:

Under this task, technical material is also reviewed and professional contacts maintained on various RF/microwave products. This is done to update scientific judgements to answer questions concerning emerging products which emit electromagnetic radiation. These radiations can cause concern by directly exposing the public or by adversely affecting critical devices, such as pacemakers, and other medical devices which supplement or diagnose life function. Some specific radiation sources are: police radar; microwave burgular alarm systems; microwave anti-shop-lifting systems; library book protection systems; microwave door openers; short-wave diathermy devices and anti-pest control devices.

III. New initiatives for FY 1980: To provide a technically-sound base from which to select the most significant electromagnetic radiating products for extensive laboratory investigation and field survey so that the limited resources available are economically utilized. The computer program listing, developed in FY 79, will be utilized to enter in data on population exposure, levels measured or expected, manufactures etc. as time permits. To investigate shortwave diathermy radiation safety (leakage) and heating effectiveness in human tissue models (phantoms).

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234
OFFICE OF THE DIRECTOR

JUL 19 1979

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

We have received your letter of June 26, 1979, in which you requested information about our research programs in the area of non-ionizing radiation. I am enclosing summary statements, using your suggested format, for two programs of the National Bureau of Standards.

The first program develops standards, measurement techniques, and instrumentation to characterize electromagnetic interference and radiation that could potentially cause failure or impairment to the functioning of electronic control systems or cause harm to human beings. The frequency range (0.5 MHz to 30 GHz) of the radiation covered by this task includes most of the communication bands such as those of AM, FM, TV, CB and radar; industrial, scientific, and medical applications; and home appliances such as microwave ovens.

The second program develops measurement standards and techniques to assure the reliability and accuracy of measurements of the electric fields, ion currents and ion density under and around high voltage electric transmission lines. This work is sponsored by the Department of Energy as part of a program to assess the environmental effects of electric fields. The outcome of this larger DOE effort is of high economic importance because it will play a role in determination of whether overhead electrical transmission technology can be expanded to meet the Nation's energy needs.

If we can provide any further information in this regard, please contact me or our Congressional Affairs Officer, Esther Cassidy, on 921-2441.

Sincerely,

E. Ambler

Ernest Ambler
Director

Enclosures

SUMMARY OF RESEARCH PROGRAM

National Bureau of Standards/Center for Electronics and Electrical Engineering

Electromagnetic Interference/Radiation Hazards Metrology

CONTACT: C.K.S. Miller, Acting Chief, Electromagnetic Fields Division
National Bureau of Standards
Boulder, Colorado 303-499-1000 (ext. 4343)

GENERAL PROGRAM OBJECTIVES: To develop standards, measurement techniques, and instrumentation to characterize electromagnetic interference and radiation that could potentially cause failure or impairment to the functioning of electronic control systems or cause harm to human beings.

Research Category (defined by OSTP ad hoc Working Group*)	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry	1580	--	2080	--
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies				
Beneficial Applications				
TOTAL				

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

I. MAJOR ONGOING PROJECTS, FY 1979

The NBS Electromagnetic Interference/Radiation Hazards Metrology task is described below. This effort is supported by both NBS and other agency funds.

A. Title: Electromagnetic Interference (EMI)/Radiation Hazards Metrology

B. Specific Objectives

To develop selected measurement techniques and standards in the frequency range of 0.5 MHz to 30 GHz and the power density range of 10^{-10} W/cm^2 to 1 W/cm^2 needed to characterize electromagnetic interference and radiation that could potentially cause failure or impairment to the functioning of electronic control systems or cause harm to human beings. The radiation occurring between 0.5 MHz and 30 GHz includes most of the communication bands such as those of AM, FM, TV, CB and radar; industrial, scientific and medical applications; and home appliances such as microwave ovens. Over the next five years various EMI monitoring probes will be developed for commercial production. These probes will be used to determine the average power of continuous wave radiation by measuring the electric or magnetic field strength of far-field radiation and the characteristic field strength of near-field radiation. A measurement assurance program for these average power monitoring probes will be conducted. In addition, transverse electromagnetic (TEM) cell test methods will be disseminated to the industry and government that allow the measurement of radiation emissions from or the EMI susceptibility of equipment or appliances.

C. Milestones/Estimated Completion Date

	SELECTED MILESTONES	COMPLETION DATE (FY)
1.	Complete documentation of probe for measuring average electric far-fields up to 1 GHz.	79
2.	Complete automated controller and field portable test measurement set for the U.S. Army Ordnance Electromagnetic Hazard Warning System covering the frequency range 10 kHz to 18 GHz.	79
3.	Complete the evaluation of theoretical models for predicting penetration of electromagnetic fields in buildings.	80
4.	Complete the development of specifications and of test methods for ascertaining the safe operation of automobile air brake restraint systems from electromagnetic radiation.	80
5.	Complete development of automated measurement instrumentation from 300 MHz-18 GHz for free space calibration of probes and antennas in the anechoic test chamber.	81

6. Complete evaluation and documentation of both procedures and measurement systems to establish standard electromagnetic fields covering the frequency range 1 MHz to 18 GHz. 82

7. Based on the documented radiated field measurement instrumentation, methods and standards; initiate a measurement assurance program for radiated field measurements. 83

8. Complete development of automated measurement instrumentation to 30 GHz for free space calibration of probes and antennas in the anachoic test chamber. 83

9. Demonstrate feasibility of a design for a near-field probe that will measure electric field, magnetic field, and power density for the frequency range from 100 MHz to 3 GHz. 84

D. Research Category: Instrumentation and Dosimetry

E. Test Parameters: (not applicable)

F. Funding

1. In-house Support: $830K

Other Agency Support:
a. Transverse Electromagnetic Mode Cell Studies/Army/$50K
b. Affects of EMI on Air Bag Safety Systems/DoT/$225K
c. High Dynamic Range Antennas/Army/$64K
d. Research for RF Sensors/Air Force/$45K
e. Electric Field Probes (Army, Dept. of State/$14.5K each)
f. Specifications for Ordnance Probes/Army/$504K (4-yr. effort)
g. Broadband Power Standards/Air Force/$65K
h. EMI Measurements/Geological Survey/$56K
i. TEM Cell Construction/Bell Labs./$104K

2. Extramural (none)

G. Coordination

1. Other Federal Agencies

In addition to those agencies for which work is currently being undertaken, contact is maintained with EPA, OSHA, NIOSH, BRH, FAA, DOE, FCC, and NTIA BENER (Biological Effects of Non-Ionizing Electromagnetic Radiation) Task Force.

2. State and Local Agencies

Contact with State needs is maintained through the Conference of Radiation Control Program Directors. In addition, specific consultation has been provided to the States of California, New Jersey, and Oregon.

3. **Universities**

The University of Colorado provides some theoretical assistance under contract.

4. Trade Associations

Contact is maintained with Society of Automotive Engineers (SAE), Motor Vehicle Manufacturers Association (MVMA), Aerospace Industries Association (AIA), and Scientific Apparatus Makers Association (SAMA).

II. SUMMARY STATEMENT COVERING SMALL OR MISCELLANEOUS PROJECTS

(none)

III. NEW INITIATIVE FOR FY 1980

Currently a new initiative on Electromagnetic Interference Measurement has been approved for FY 1980 at the $500K level (House mark-up). This initiative would develop measurement techniques and instrumentation to probe the electromagnetic environment to assess potential deleterious effects on electronic systems and to measure susceptibility and emission characteristics of electronic devices, components, and systems; and develop a satisfactory technical language for the description of electromagnetic phenomena.

SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION National Bureau of Standards, Center for Electronics & Electrical Engineering, Electrosystems Division

TITLE (of research program) Standards for Electric Field and Related Measurements in the Vicinity of High Voltage Transmission Lines

CONTACT (name of responsible individual, title, address, phone) Dr. F. Ralph Kotter
NBS, B344-Metrology (Phone: 301/921-3121)

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years) To develop measurement methods, and physical and performance standards to verify and insure the accuracy and reliability of measurements of electric field, magnetic field, ion current and ion density in the vicinity of high voltage transmission lines. Specific objectives are to develop and build a calibration facility for ac (primarily 60 Hz) electric field meters; to develop the technical base for a consensus standard for ac field measurements (both electric and magnetic) in the vicinity of actual high voltage installations -- lines and other equipment; to repeat the same for dc fields; in addition, to develop measurement/calibration capability for ion current and ion density in the vicinit of high voltage dc lines; to provide consultative service to the Department of Energy, the sponsor (continued below)

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry Mechanisms of Interaction Long-term, Low-level Exposure Studies on Animals Human Studies Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents	$ 150 k		$ 150 k	
Biological Effects Studies				
Beneficial Applications				
TOTAL	$ 150 k		$ 150 k	

of the project, on matters relating to electric/magnetic field measurements in conjunction with DoE's larger program on environmental impact of high voltage transmission lines.

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

SUMMARY OF RESEARCH PROGRAM (continued)

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Standards for Electric Field and Related Measurements in the Vicinity of High Voltage Transmission Lines

B. Specific Objectives: To verify and insure the accuracy and reliability of measurements of electric field, magnetic field, ion current and ion density in the vicinity of high voltage transmission lines. Specific objectives are to develop and build a calibration facility for ac (primarily 60 Hz) electric field meters; to develop the technical base for a consensus standard for ac field measurements (both electric and magnetic) in the vicinity of actual high voltage installations -- lines and other equipment; to repeat the same for dc fields; in addition, to develop measurement/calibration capability for ion current and ion density in the vicinity of high voltage dc lines; to provide consultative service to the Department of Energy, the sponsor of the project, on matters relating to electric/magnetic field measurements in conjunction with DoE's larger program on environmental impact of high voltage transmission lines.

C. Milestones/Estimated Completion Date

1. Calibration facility for ac electric field meters -- December 1977 (completed).
2. Technical base for performance standard on ac field measurements -- March 1978 (completed).
3. Facility to produce known dc electric field in the presence of space charge (ions) for calibration of dc field meters -- December 1979.
4. Controlled source of ions for calibration of ion current and ion density measuring instruments -- September 1980.
5. Technical base for a performance standard on dc electric field, ion density and ion current measurements -- September 1981.

D. Research Category: Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields with Other Agents, and Instrumentation and Dosimetry.

E. Test Parameters

1. Frequency: 60 Hz and dc
2.,3.,4.: N/A
5. Electric field strength: 100 V/m - 200 kV/m
   Ion currents: up to 2 $\mu A/m^2$

F. Funding

1. Practically all work done in-house with DoE funding as follows: $150 thousand in FY 1979, $150 thousand in FY 1980

G. Coordination

1. This project is a part of a larger effort by DoE to determine if there are adverse environmental effects due to electromagnetic fields emanating from extra and ultra high voltage transmission lines. We are in very close contact with DoE, its contractors, and with related work sponsored by the Electric Power Research Institute. The consensus standards are developed and disseminated through our participation in the committees of the Institute of Electrical and Electronics Engineers.

THE UNDER SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

RESEARCH AND
ENGINEERING

14 JUL 1979

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Chairman Ambro:

This is in response to your letter of 27 June to the Secretary of Defense regarding research into the health effects of non-ionizing radiation.

The Department of Defense program in this area addresses the radio frequency radiation (RFR) portion of the electromagnetic spectrum, i.e., from 0 to 300 GHz. Our program comprises two broad avenues of approach: empirical observation which provides expedient near-term answers to operational questions; and more fundamental long-term scientific approaches to improving our understanding of the phenomena of interaction between RFR and biological systems.

I am enclosing brief program summaries, using the formats you suggest. For the sake of convenience and to indicate program relationships, the summaries are condensed across Services where appropriate. Since the topic of RFR bioeffects is a highly complex one, I have taken the liberty of including also an additional summary statement indicating our aims and concerns, and providing further information on coordination.

From our point of view, the present program is constrained not so much by funding as it is by the relative paucity of scientific and technical manpower in this field of endeavor. I hope the Committee will consider the problem of encouraging budding scientists to take an interest in this complex and important emerging area, which represents unique interactions between the biological and physical sciences.

I am pleased to have had this opportunity to make these remarks available for the record.

Sincerely,

Gerald P. Dinneen

Gerald P. Dinneen
Principal Deputy

Enclosures 3
Research Program Format I
Research Program Format II
Summary Statement

SUMMARY OF RESEARCH PROGRAM

Agency: Department of Defense

Title: Biological Effects of Radio Frequency Radiation

Contact: Col. Phillip E. Winter, MC, USA
Mil. Asst. for Medical and Life Sciences
Office of Under Secretary of Defense
for Research and Engineering
Washington, D.C. 20301
Phone: (202) 697-8535

General Program Objectives:

Develop technological tools (dosimetry and instrumentation) for RFR bioeffects scientific studies.

Develop understanding of basic mechanisms of RFR/biosystems interaction, multiple-emitter effects, and development of beneficial applications of RFR.

Identify and quantitate, by empirical means, bioeffect risk associated with currently deployed or developmental military RFR systems, to provide for human safety standards which minimize risk, and permit optimal system deployment.

Research Category	FY 1979		FY 1980	
	In-House	Extramural	In-house	Extramural
Instrumentation and Dosimetry	775	665	880	1,073
Mechanisms of Interaction	907	791	1,420	1,616
Long-term, Low-level Exposure Studies on Animals	430	546	555	500
Human Studies	---	---	---	---
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/Other Agents	96	9	130	84
Biological Effects Studies	1,162	843	1,456	1,439
Beneficial Applications	20	5	5	90
Total	3,390	2,859	4,446	4,802

Enclosure 1

SUMMARY OF RESEARCH PROGRAM

I. Major Ongoing Projects, FY 1979

Selection is on the basis of topics of major interest to DoD, arranged in rough order of priority.

A. Dosimetry

Objectives

1. Develop new/improved instrumentation for use in characterizing and quantifying human exposures as well as exposures associated with controlled biological studies.

2. Develop new/improved instrumentation for use in measuring internal dose in humans and experimental animals exposed to RF waves or fields.

3. Improve dosimetric data and improve dosimetric models.

4. Determine distribution of RF energy deposited in human phantom models and compare with distribution in animal models exposed under circumstances common to bioeffects research.

Milestones

FY 79 - Refine methods for image processing and improved time delay resolution for non-invasive transmitted microwave signals in development of a 3-dimensional dosimetric image in simulated human tissue and animal organs.

- Complete development of probe for improved measurement of dielectric properties in situ in a canine model.

FY 80 - Develop microwave-phased array antenna for non-invasive high-speed 3-dimensional dosimetric analysis of animal organs and simulated human tissue.

- Complete study of human phantom energy distribution at one frequency.

FY 81 - Develop mathematical techniques for processing data from phased array antenna system to improve spatial resolution of imaging.

- Initiate development of complex human phantom.

- Complete second frequency distribution map in human phantom.

Enclosure 2

- Complete single frequency distribution map in viro in primate.

Research Category: #1 (Instrumentation and Dosimetry)

Test Parameters (Variables?)

1. Frequency: 50 Hz - 13 MHz; 500 KHz - 1300 MHz; 1000 MHz - 18 GHz.

2. Test species:

a. excised animal tissues/cells (canine kidneys, canine fibroblasts, red blood cells)

b. rhesus monkeys

c. phantom (simulated) human tissues

3. Exposure duration: 15 seconds - 4 hours.

4. Radiation dose: $0.5 mW/Cm^2$ - $250 mW/Cm^2$.

Funding ($000)

1. In-house- 775

2. Extramural - 605

3. Prime contractors: American Electric Laboratories, University of Utah.

Coordination

1. Federal Agencies: BRH/FDA, EPA, NTIA, NIEHS.

2. Other: Committee on Man and Radiation (COMAR) International Microwave Power Institute (IMPI), URSI.

Comment

Army, Navy and Air Force participate in this project area. The Air Force Dosimetry Handbook developed by this effort has become a standard reporting reference.

B. Basic Mechanisms

Objectives

1. Measure dielectric relaxation spectra of cell fractions and biopolymers in the range 50 Hz to 18 GHz.

2. Confirm frequency dependent conformational state alterations in biopolymers.

3. Confirm organelle specific toxicity of microwave radiation as a function of frequency.

4. Determine effects of pulsed microwave induced thermoacoustic expansion.

5. Determine effects of RF exposure on structure and function of biological membranes.

6. Evaluate the importance of bound water on low level RF energy absorbtion.

7. Evaluate the cellular genetic implications of the molecular effects of RF energy.

8. Elucidate effects of RF on immune mechanisms.

9. Determine neuromuscular junction effects of microwave energy.

Milestones

FY 79 - Establish increased sensitivity in methods to detect precataract changes in rodent tissue.

- Develop optical system for study of nerve membrane alterations using birefringence end point to compare pulsed versus continuous wave at the same average power.

FY 80 - Study cumulative effect of repeated low average, high peak power on rodent lens.

- Compare continuous versus pulsed made with conventional heat for precataract formation.

- Complete study of pulsed versus continuous wave on red cell membrane.

- Complete studies on neurocardiac effects.

FY 81 - Determine effect of microwaves on active membrane transport.

FY 82 - Determine electrical properties of bound/free water in relation to membrane effects.

Research Category: #2 Mechanisms of Interaction.

Test Parameters

1. Frequencies - 50 Hz - 100 GHz; emphasis on 0.96, 1.2, 1.3, 2.45, 2.8, 6 and 12 GHz.

2. Test species:

   a. squirrel monkey

   b. rat, rat tissue, cells and organelles

   c. turtle cells and organelles

   d. sheep and rabbit red blood cells

3. Exposure duration - varies, 5 second - 4 hours.

4. Dose - 0.1 mW/Cm^2 - 200 mW/Cm^2, 0.01 - 20 W/Kg.

Funding ($000)

1. In-house - 907

2. Extramural - 1130

3. Prime contractors - Wayne State University, Purdue University, University of Utah, Georgia Tech, University of Maryland.

Coordination

1. Federal agencies - BRH. EPA, NTIA, NIEHS, ERMAC.

2. Trade Association - COMAR, URSI, IMPI.

Comment

Army, Navy and Air Force participate in this project area.

C. Chronic Effects of Microwave Exposure

Objectives

1. Assess relative biological consequences of pulsed versus continuous wave radiation.

2. Assess the biological effects of long-term low-level RFR exposure.

3. To provide animal data as the basis for extrapolation to human exposure to operational systems (i.e., PAVE PAWS).

Milestones

FY 79 - Initial contract awarded, waveguide equipment and facility constructed.

- Begin pilot study in rat.

FY 80 - Initiate full-scale study.

FY 81 - Preliminary analysis.

FY 82 - Final report.

Research Category: Long-term, low-level studies on animals.

Test Parameters

1. Frequency

a. peak pulsed power - 2, 2.8, 5.6, 9.6 GHz

b. long-term low level - to be selected for scaling to 450 MHz in man.

2. Test species - rat

3. Exposure duration - varies, up to 18 months.

4. Radiation dose - to be determined.

Funding ($000)

1. In-house - 50

2. Extramural - 546

3. Prime contractors

   a. Cobes Electronics, Inc.

   b. University of Washington

Coordination

1. Federal agencies - DOE, NASA

2. Other - American National Standards Institute

Comment

Peak-pulsed power simulator for this study is a unique device; will be available to support other qualified investigators. This is an Air Force project.

D. Chronic Exposure to Extremely Low Frequency (ELF) Radiation

Objective

Determine the effects of chronic exposure to ELF electric and magnetic fields on young primates. Emphasis is on growth and development.

Milestones

Ongoing - Periodic monitoring of biochemical, physiological health status of test animals.

FY 84 - Completion

Test Parameters

1. Frequency - 72 and 80 Hz

2. Test species - rhesus monkey

3. Exposure duration - 22 hours/day

4. Dose - 20 V/M, 2 gauss

Research Category: Long-term, low-level studies on animals/

Funding ($000)

1. In-house - 380

2. Extramural - none

Coordination

1. Federal agencies - DOE, NTIA, NIEHS

2. State - Michigan Governor's Science Advisory Committee, Wisonsin (several agencies)

3. Other - Battelle Pacific Northwest Labs, Electric Power Research Institute, Argonne National Laboratory

Comment

This is a Navy project.

E. Behavioral Effects of RFR

Objectives

1. Determine whether RFR produces alternatives in behavior and/or performance for wave modulations at or near EEG frequencies.

2. Determine effects of pulsed and CW microwaves as taste aversion, learning and drug modification of behavior in animals.

3. Determine behavioral effects of resonant power absorbtion.

Milestones

FY 80 - Complete taste aversion studies.

FY 81 - Complete learning modification effect studies in primate.

FY 83 - Complete studies of gross combined effects of RFR and drugs known to affect behavior.

Research Category - Biological Effects Studies

Funding ($000)

1. In-house - 528

2. Extramural - 251

3. Prime contractors - University of Texas, Battelle Pacific Northwest Labs

Coordination

1. Federal agencies - BRH, EPA, NTIA, NIEHS, ERMAC

2. Trade Associations - COMAR, URSI

Comment

Army, Navy and Air Force participate in this project area.

F. Central Nervous Systems (CNS) Effects of RFR

Objectives

1. Determine sensitivity of CNS to interaction with RFR.

2. Describe histological, physiological and biochemical effects of RFR on CNS. Emphasis on neuroendocrinology, information transfer and processing, blood flow and bolld-brain barrier transport.

Milestones

FY 79 - Complete description of blood-brain barrier histochemical effects.

FY 80 - Initiate study of spinal nodes, complete gross histopathology survey.

FY 81 - Complete studies of blood flow, blood-brain barrier transport effects.

Research Category: Biological Effects Studies

Test Parameters

1. Frequency - 0.915, 0.918, 1, 1.7, 2.45, 2.8, 6 GHz

2. Test species: rhesus, rabbit, hamster, rat, mouse

3. Exposure duration: varies, maximum 60 minutes, repeated

4. Dose - varies 0.01 - 10 W/Kg

5. Field - incident 1-100 mW/cm^2, pulsed and CW

Funding ($000)

1. In-house - 408

2. Extramural - 242

3. Prime contractors: George Washington University, University of Washington

Coordination

1. Federal agencies - BRH, NTIA, EPA, NIEHS

2. Trade Associations - COMAR, IMPI, URSI

Comments

Army, Navy and Air Force all participate in this program area.

II. Summary of Miscellaneous Programs

- Combined stress response to multifrequency exposure in rats (Army).

- Enzyme inactivations by exposure to high average power microwave irradiation (Army).

- Develop mathematical models to describe frequency dependence and/or "window" effects; attempt to validate mathematical prediction model (Air Force).

- Prepare a quarterly compilation of abstracts in bioelectromagentics (Navy).

- Support workshops and symposia (Navy).

- Empirical study of effects of RFR on the immune system (Navy).

III. New Initiatives in FY 80

- Begin program to develop data base on energy absorbance characteristics of animal tissues exposed to near-millimeter wave irradiation (Army).

- Investigate effect of RFR on ion concentration and fluxes in the brain. Evaluate the effect of ELF modulation and a variety of carrier frequencies (Navy).

- Initiate studies of the effect of RFR on cell cycle mechanisms and conformational changes in biomolecules (Air Force).

SUMMARY STATEMENT

The Department of Defense (DoD) science and technology program to study the biological effects of radio frequency radiation (RFR) is a relatively new program, dating back only to 1968. Before that time there was very little scientific effort anywhere in this technical area. Since then, the program has passed through a phase of initial exploration and is now maturing. As currently structured, the program comprises two broad avenues of approach to the complex issues of RFR bioeffects. The first, empirical observation, uses animal models to provide answers to more immediate questions of possible human/ecological hazard in particular operational circumstances. The second, more fundamental scientific approach, seeks to expand our knowledge and understanding of the characteristics of the interaction of RF radiation and biological systems. The two approaches are complementary. The lack of basic scientific data makes the empirical approach a necessary expedient. Both approaches are predicated on the need to fully understand the risks which may accompany use of radio frequency radiation, the benefits of which are relatively well known so that decisions as to deployment of any military RFR system may be rationally derived. Concerns with possible bioeffects of RFR stem from these considerations:

- Combat Performance. The battlefield environment of the future will be replete with RFR emitters of many kinds, both friendly and enemy. DoD must insure that military performance on the ground, on the sea and in the air is not accidentally or purposefully degraded by the incidental RFR environment.

- Occupational Hazards. The DoD deploys and operates a wide variety of RFR emitters. Each system has its dedicated operator and repair staff--all of whom may be expected from time to time to be exposed to a greater extent than is the general civilian (or military) public. DoD needs to know what risks, if any, are entailed by this occupational exposure, to establish standards which will minimize such risks as can be identified to optimize safety/operational relations. The military profession is inherently risky; but the risk should be minimized wherever and whenever possible.

- Public and Environmental Concerns. Some military RFR systems have the possibility by reason of power and location of impacting on the general public and the surrounding environment. DoD recognizes the responsibility to provide the public with as much information as possible on bioeffects real or potential of such systems, and to provide adequate scientific data to demonstrate lack of effect. The data required are necessary for an informed public to appreciate the risk/benefit ratio of a given defense application, so that standards and judgments about operational deployment and constraints thereon can have a rational rather than emotional basis.

- Beneficial Bioeffects. A very small part of the DoD effort is directed at exploration of the potential beneficial bioeffects of RFR. As knowledge of the fundamental bases of RFR interaction with biosystems increases, it is anticipated that RFR applications such as imaging or pharmacological enhancement may result in significant advances in medical technology.

The art and science of the study of RFR bioeffects is new; it is also complex. The complexity arises from the number of variables which must be considered in any comprehensive research program in the health effects of non-ionizing radiation. The characteristics of the radiation such as frequency, power, modulation, exposure duration and geometry of radiation; and characteristics of the biosystem such as geometry of orientation to the radiation field(s), energy capture characteristics, resulting induced fields, temperature response, organism size, and organs, tissues, cells and molecular species involved; each has profound implications for bioeffects determination. In spite of public demand, simple trial-and-error experiments will not readily yield rapid resolution of the many unknowns.

The DoD research program in the bioeffects of non-ionizing radiation is conducted in a closely coordinated fashion at four Service medical R&D laboratories (Walter Reed Army Institute of Research, USAF School of Aerospace Medicine, Naval Medical Research Institute and Naval Aerospace Medical Research Laboratory) with participation by universities and industry working on contract.

Within DoD, program coordinating occurs at several different levels. At the investigator level, there is frequent informal contact with interchange of data and ideas. There is also cross-utilization of exposure facilities and conduct of joint scientific studies. At the middle science/management level, coordination is effected through the Tri-Service Electromagnetic Radiation Panel (TERP) which comprises senior science managers from each Service medical R&D organization. The TERP meets several times per year. It is currently revising the Tri-Service Plan, and sponsors scientific and technical seminars annually. Finally, OUSDRE reviews the program formally and informally at frequent intervals, most recently annually. The review medium has been the informal Joint Medical Research Conferences, and the formal Topical Review the most recent of which was 6 June 1979.

Outside DoD there are also several levels of coordination. At the investigator level, technical information exchange is facilitated by participation in Union of Radio Science International and by sponsorship by TERP and other DoD agencies of open scientific seminars. All of the DoD bioeffects research program is unclassified. In addition, DoD exposure facilities are made available to, and utilized by, other Federal agencies. Most notably the facility at Walter Reed Army Institute of Research has been used by Navy, Armed Forces Radiobiology Research

Institute, National Institute of Environmental Health Sciences, Bureau of Radiological Hygiene, National Institute of Occupational Safety and Health, as well as the Canadian Defense Ministry. At the Agency level, DoD is represented, and active on the Electromagnetic Radiation Management Advisory Committee, the Side Effects Working Group and the BENER task force.

The DoD reports its program annually to the National Telecommunication and Information Agency (NTIA) and was represented on the Office of Science and Technology Policy (OSTP) ad hoc working group.

Given the complexity of the research area concerned, DoD is satisfied that current coordinating mechanisms are adequate, particularly given the relatively small size of the scientific community involved.

July 13, 1979

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Committee on Science and Technology
U. S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Thank you for your letter of June 26. The enclosed summaries of our nonionizing radiation research programs are in response to your inquiry.

If we can be of any additional assistance or provide further clarification of the material we have supplied do not hestitate to contact me.

Sincerely,

David P. Rall, M.D., Ph.D.
Director

Enclosures

NIH/NIEHS/OPPE:GMKingman:sac:7/13/79
Official File located in NIEHS/NIH

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION National Institute of Environmental Health Sciences/Laboratory of Environmental Biophysics

TITLE (of research program) Effects of Microwaves on Teratology and Development

CONTACT (name of responsible individual, title, address, phone)
Dr. Donald I. McRee, Work Group Leader-Nonionizing Radiation
National Institute of Environmental Health Sciences
P.O. Box 12233, Research Triangle Park, NC 27709, Phone: 919/541-3382, FTS 629-3382

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)
Objectives of this program are to determine the effects of 2.45 GHz microwave radiation on embryonic development and the resulting effects on growth and development, immunological response, biochemistry, behavior and reproductive capability of the mature specimen which were exposed only during development. In the next few years, we want to determine the thresholds for teratogenic effects and at what levels functional changes occur in the mature specimen which were exposed only during development.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$143,000		$190,000	$50,000**
Beneficial Applications				
TOTAL	$143,000		$190,000	$50,000**

** R & D (energy funds)

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION National Institute of Environmental Health Sciences/Laboratory of Environmental Biophysics

TITLE (of research program) Effects of Microwaves on the Nervous System and Behavior

CONTACT (name of responsible individual, title, address, phone)
Dr. Donald I. McRee, Work Group Leader-Nonionizing Radiation
National Institute of Environmental Health Sciences
P.O. Box 12233, Research Triangle Park, NC 27709, Phone: 919/541-3382, FTS 629-3382

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)
The objectives of this program are to study both the acute effects of microwaves on neural preparations in order to determine basic mechanisms of interaction and the long-term, low-level, effects of microwaves on neurochemistry and behavior in animals exposed for at least three months. In the next few years, we want to determine the effects of microwaves on nerve vitality and their influence on ionic balance in neural preparations. We also want to determine the effects of daily exposure for 3 months on blood chemistry and behavior at various frequencies (915 and 2450 MHz) and power densities.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$150,000	$65,000**	$140,000	$100,000***
Beneficial Applications				
TOTAL	$150,000	$65,000	$140,000	$100,000

R & D contracts (40,000 energy money);*R & D contracts (100,000 energy money)

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION National Institute of Environmental Health Sciences/Laboratory of Environmental Biophysics

TITLE (of research program) Study of the Basic Interaction Mechanisms of Microwaves with Biological Systems.

CONTACT (name of responsible individual, title, address, phone)
Dr. Donald I. McRee, Work Group Leader-Nonionizing Radiation
National Institute of Environmental Health Sciences
P.O. Box 12233, Research Triangle Park, NC 27709, Phone: 919/541-3382, FTS 629-3382

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)
The objective of this program is to investigate the mechanisms of interaction of microwave radiation with biological membranes, cell systems, and ionic transport. In the next few years, we want to have a better understanding of the potential for microwaves to interact with biological systems and an explanation for some of the biological effects already reported in the literature.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$40,000		$73,000	
Beneficial Applications				
TOTAL	$40,000		$73,000	

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION National Institute of Environmental Health Sciences/Laboratory of Environmental Biophysics

TITLE (of research program) Effects of Microwaves on Cardiac Function

CONTACT (name of responsible individual, title, address, phone)
Dr. Donald I. McRee, Work Group Leader-Nonionizing Radiation
National Institute of Environmental Health Sciences
P.O. Box 12233, Research Triangle Park, NC 27709, Phone: 919/541-3382, FTS 629-3382

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)
The objective of this program is to study the effects of 2.45 GHz microwaves on the cardiac function in both embryonic hearts and adult animal hearts. The effects of microwaves on hearts subjected to myocardial ischemia will be examined. We want to determine the conditions of microwave exposure which produce changes in heart rate and biochemical and physiological changes in hearts subjected to myocardial ischemia.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$45,000		$45,000	
Beneficial Applications				
TOTAL	$45,000		$45,000	

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

I. MAJOR ONGOING PROJECTS, FY 1979
(Largest 5 of 11 projects, high priority listing in OSTP report)

A. Effects of 2.45 GHz Microwave Radiation on Embryonic Development, Immunological Response, Behavior, and Reproductive Capability

B. The objective of this project is to determine the effects of 2.45 GHz continuous and pulsed microwave radiation on developing mice and quail embryos. Teratogenic effects will be studied in both mice and quail. Effects on growth and development, immunological response, biochemistry, behavior and reproductive capability of adult quail exposed only in ovo will be determined.

C.

Milestones	Estimated Completion Date
Teratogenic evaluation	July 1, 1980
Growth and development	July 1, 1980
Immunological response	September 30, 1980
Behavior	September 30, 1981
Reproductive capability	September 30, 1981

D. Biological Effect Studies

E. Test Parameters

1. Frequency - 2450 MHz
2. Test species - mice and Japanese quail
3. Exposure duration (mice) - 8 hrs/day during 1-6 days of development
   (mice) - 8 hrs/day during 6-15 days of development
   (Japanese quail) - 24 hours/day for first 12 days of development
4. Radiation dose (mice) - 5.3 mW/g, 22.3 mW/g, 31.8 mW/g
   (quail) - 4.1 mW/g

F. In-house

A. Effects of Microwaves on Neural Response

B. Isolated neurons such as the abdominal ganglion of the Aplysia, lobster ganglia, the sciatic nerve of the frog, and the saphenous nerve of cats will be exposed to CW, pulsed and modulated microwave radation in the power density range of 0-100 mW/g. The effects of the radiation on nerve function and the mechanisms of interaction involved in any changes will be investigated.

C.

Milestones	Estimated Completion Date
Nerve vitality studies (CW exposure)	September 30, 1979
Nerve vitality studies (pulsed exposure)	September 30, 1980
Nerve vitality studies (modulated exposure)	September 30, 1981
Ionic transport studies	September 30, 1981

D. Biological Effects Studies

E. Test Parameters

1. Frequency - 2.45 GHz
2. Test species - nerves from Aplysia, lobster, frog and cats
3. Exposure duration - 0.5 hrs to 5 hrs
4. Radiation dose - 0,5,10,20,50 and 100 mW/g

F. In-house

A. Investigation to Determine the Peripheral and Central Receptors Mediating Effects of Microwave Radiation on Brain Activity

B. The objective of this research is to identify the biological structures that transduce microwave radiation into auditory activity and to investigate possible effects of microwave radiation on the metabolic activity of brain structures outside the auditory system.

C.

Milestones	Estimated Completion Date
Response of single fibers in auditory nerve	July 1, 1980
Measure metabolic activity of brain using ^{14}C autoradiography	July 1, 1980

D. Biological Effects Studies

E. Test parameters

1. Frequency - 915 MHz, 2450 MHz (CW and pulsed)
2. Test species - rats and cats
3. Exposure duration - 24 hours
4. Radiation dose - 2.5 mW/cm^2 and 10 mW/cm average incident power
   12.5 W/cm^2 incident peak power

F. R and D contract

G. Research Triangle Institute
Research Triangle Park, North Carolina

A. Effects of Microwave Radiation on the Nervous System

B. The objective of this project is to determine the effects of long-term, low-level, exposure to 918 and 2450 MHz microwave radiation on the central nervous system and behavior by measuring:

1. Biochemistry - Serum content for sodium, calcium, phosphorus, PTH, SH groups and cholinesterase activity of the blood and 17-ketosteriods in urine will be measured.
2. Behavior - Animals will be evaluated for free-operant and free-repertoire behavior. Animals will be observed in the irradiation chambers and their specific orientation to the field, sleep, grooming, sniffing, rearing, drinking, eating, etc., will be recorded.
3. Electroencephalography - EEG recordings will be made on the animals following the four month irradiation period.

In addition to the above endpoints, some behavioral teratology, data will be obtained.

C.

Milestones	Estimated Completion Date
Effects on behavior	October 1, 1978
Effects on biochemistry	September 30, 1979
Effects on EEG	September 30, 1979
Behavioral teratology	September 30, 1979

D. Biological Effects Studies

E. Test parameters

1. Frequency - 918 and 2450 MHz circularly polarized
2. Test species - rat
3. Exposure duration - 7 hrs/day for 3 months
4. Radiation dose - 4.0 mW/g (918 MHz)
   1.25 mW/g (2450 MHz)

F. R and D contract

G. University of Washington
Seattle, Washington

A. Effects of Microwave Radiation on the Nervous System

B. The objective of this project is to determine the effects of long-term, low-level exposure to 915 and 2450 MHz microwave radiation on the central nervous system and behavior by measuring:

1. Biochemistry - Biochemical analysis of the chloinesterase activity of the blood, the SH group in the blood, and ketosteriods in the urine will be made.
2. Behavior - Rodent activity will be measured using a rodent activity wheel. Water and food intake will be measured. Rats will be trained to lever press for food reward on a FR-DRL multiple schedule. Total response and reinforcement for each schedule component will be recorded. Interesponse times on each schedule components will be recorded.
3. EEG - EEG will be recorded biweekly using epidural removable stainless steel electrodes. These recordings will be made while the microwave radiation is turned off.

C.

Milestones	Estimated Completion Date
Effects on behavior	September 30, 1979
Effects on biochemistry	September 30, 1979
Effects on EEG	September 30, 1979

D. Biological Effects Studies

E. Test parameters

1. Frequency - 915 MHz and 2450 MHz plane wave
2. Test species - rat
3. Exposure duration - 7 hrs/day for 3 months
4. Radiation dose - 4.0 mW/g (915 MHz)
   1.25 mW/g (2450 MHz)

F. R and D contract

G. University of Utah
Salt Lake City, Utah

II. The specific absorption rates in biological systems exposed to various microwave frequencies and power densities must be accurately known before meaningful experimental results can be obtained. Although our primary objectives are to determine the biological effects of microwaves, many biological test systems require unique exposure chambers, instrumentation, and exposure techniques in order to achieve accurate dosimetry while being maintained at their most viable conditions. An ongoing project entitled, "Microwave Exposure Systems and Microwave Dosimetry," is specifically concerned with these problems.

Several small projects relating to the effects of microwaves on the heart have been initiated during the past year. The first of these projects is entitled, "Effect of Microwave Radiation on the Heart Rate of Embryonic Quail." The objectives of this project are to determine if microwave radiation interacts with 8 day old embryonic quail hearts by producing a change in heart rate. The second project is entitled, "Effects of 2450 MHz microwave Radiation on Cultured Heart Cells." The objectives of this project are to determine if 2450 MHz microwave interact with biological material at the cellular level. The heart cells will be obtained from developing Japanese quail embryos which will be exposed for the first 8 days of development. Biochemical studies and electron microscopic photography of cardiac tissues will be used to determine if the microwaves have any effect on cardiogenesis. The final project concerned with the effects of microwaves on the heart is entitled, "Influence of 2450 MHz Microwave Radiation on Cats Subjected to Myocardial Ischemia." This project will examine the course of myocardial ischemia while the heart is being exposed to microwaves.

A project to investigate the effect of 2450 MHz microwaves on the secretory response of mast cells is being performed. Exposure of mast cells for 3 hours to 8.5 and 42.5 mW/cm^3 caused no change in the morphological characteristics or cell viability. Irradiated mast cells were stimulated by compound 48/80, a potent, non-cytotoxic histamine releasing agent. The microwave exposure had no effect on the stimulating characteristics of compound 48/80.

III. Two new initiatives will be developed during FY 1980. We will increase our efforts in the area of basic mechanism studies and will support through contracts studies on behavioral teratology and long-term, low-level effects. In the basic mechanisms of interaction studies, we will concentrate on effects of microwaves on membranes and on ionic transport using cell systems and nonmylinated neurons. Spin labelling and electron spin resonance (ESR) will be used as an analytical technique for looking at possible membrane changes as well as radioactively labelled ions whose movements are important in biological functions.

Recent studies have shown that microwave exposure levels as low as 0.5 mW/cm^2 have caused changes in animal behavior when exposed for 7 hrs/day for a three month period. Offspring of dams exposed to low-levels (0.5 mW/cm^2) during development were also found to have behavioral changes when reaching maturity. NIEHS plans to fund through contracts additional studies at a frequency of 2450 MHz and decreasing power densities until a threshold for the changes is determined.

NIEHS

EXTRAMURAL GRANT PROGRAM

SUMMARY FIGURES FOR EXTRAMURAL GRANT PROGRAM

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
		(X 1000)		(X 1000)
Instrumentation and Dosimetry		58		58
Mechanisms of Interaction		0		0
Long-term, Low-level Exposure Studies on Animals		33		33
Human Studies		0		0
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents		95		95
Biological Effects Studies		178		178
Beneficial Applications		0		0
TOTAL		364		364

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

FORMAT FOR SUMMARY OF RESEARCH PROGRAM (Continued)

II. MAJOR ONGOING PROJECTS, FY 1979 (Indicate selection criterion: five or ten largest, greater than $100K, highest priority, etc.)

A. Title MICROWAVE EFFECTS OF EXCITABLE MEMBRANE SYSTEMS

B. Specific Objectives See attached Research Objectives sheet

C. Milestones/Estimated Completion Date Project End Date: 01/31/80

D. Research Category (OSTP Working Group Categories)
BIOLOGICAL EFFECTS STUDIES

E. Test Parameters (if applicable)

1. Frequency

2. Test species

3. Exposure duration

4. Radiation dose

5. Other

F. Funding

1. In-House

2. Extramural FY 79 (DCO): $37,517 FY 80 (DCO): $ -0-

3. Prime Contractor

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments

Summary statement covering small or miscellaneous projects.

III. New initiatives for FY 1980.

SECTION 1

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

RESEARCH OBJECTIVES

LEAVE BLANK

PROJECT NUMBER

1 R01 ES 1938-01

ID ADDRESS OF APPLICANT ORGANIZATION

Medical College of Virginia, Virginia Commonwealth University
12th and Broad Streets, Richmond, Virginia 23298

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE, AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT, BEGINNING WITH PRINCIPAL INVESTIGATOR

Cleary, Stephen F., Associate Professor, Biophysics

TITLE OF PROJECT

MICROWAVE EFFECTS ON EXCITABLE MEMBRANE SYSTEMS

USE THIS SPACE TO ABSTRACT YOUR PROPOSED RESEARCH. OUTLINE OBJECTIVES AND METHODS. UNDERSCORE THE KEY WORDS (NOT TO EXCEED 10) IN YOUR ABSTRACT.

An investigation of the effect of electric fields at microwave frequencies on the induction of action potentials in excitable membrane systems is proposed. The objective of the research is to differentiate between effects due to the impressed microwave electric field as contrasted to other microwave-specific thermal and nonthermal effects. A waveguide irradiation technique will be used to expose the algae chara australis and other excitable cell systems to low intensity microwave radiation in the frequency range of from 2 to 4 GHz in a thermostated irradiation chamber. Initially continuous wave microwaves will be employed, followed by an investigation of pulse modulated fields. The cell systems will be of sufficient size to permit the measurement of action potentials with electrodes exterior to the waveguide, thus minimizing interactions between the microwave field and the detection system. Prior to microwave exposure the mean threshold electric field strength for the induction of the action potential will be determined by the use of a variable amplitude pulsed current stimulator. Thresholds will be redetermined during and after exposure of the cell system to microwave radiation of known field strength. Variations in the excitation threshold will be interpreted in terms of the summation of the field strengths of the impressed stimulus and the microwave field. The independent variables to be investigated will be mocrowave field strength, microwave frequency, pulse duration and amplitude, latency for recovery of pre-exposure threshold and temperature.

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FORMAT FOR SUMMARY OF RESEARCH PROGRAM (Continued)

I. MAJOR ONGOING PROJECTS, FY 1979 (Indicate selection criterion: five or ten largest, greater than $100K, highest priority, etc.)

A. Title VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION

B. Specific Objectives See attached Research Objectives sheet

C. Milestones/Estimated Completion Date Project End Date: 12/31/80

D. Research Category (OSTP Working Group Categories) COMBINATION OF RADIO FREQUENCY RADIATION OR HIGH VOLTAGE TRANSMISSION LINE FIELDS w/ OTHER AGENTS

E. Test Parameters (if applicable)

1. Frequency

2. Test species

3. Exposure duration

4. Radiation dose

5. Other

F. Funding

1. In-House

2. Extramural FY 79 (DCO): $40,880 FY 80 (DCO): $43,340

3. Prime Contractor

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments

Summary statement covering small or miscellaneous projects.

III. New initiatives for FY 1980.

SECTION 1

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

RESEARCH OBJECTIVES

LEAVE BLANK

PROJECT NUMBER

9 R01 ES 1937-04

NAME AND ADDRESS OF APPLICANT ORGANIZATION

University of Texas Health Science Center at Dallas, Southwestern Medical School
5323 Harry Hines Blvd., Dallas, Texas 75235

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE, AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT, BEGINNING WITH PRINCIPAL INVESTIGATOR

Robert M. Lebovitz, PhD, Associate Professor, Physiology Department

TITLE OF PROJECT

VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION

USE THIS SPACE TO ABSTRACT YOUR PROPOSED RESEARCH. OUTLINE OBJECTIVES AND METHODS. UNDERSCORE THE KEY WORD (NOT TO EXCEED 10) IN YOUR ABSTRACT.

The purpose of this research is to document the effects of microwave radiation (MWR) on the nervous system by examing single unit discharge in those sensory systems that are responsive to continuous wave or pulse modulated MWR. Previous work in our laboratory confirmed that single units in the vestibular pathway and single units in the auditory pathway show an acute response to continuous wave and pulsed MWR, respectively. The primary aims of the projects will be to derive a more complete quantitative understanding of these interactions, to investigate the underlying physical mechanisms, and to evaluate the general biological significance of these MWR effects in cats. Similar studies using laboratory primates will then follow. The response of single vestibular units and of single auditory units to appropriate physiological stimuli will be recorded via glass micropipettes located in the eighth nerve and in brain stem vestibular and cochlear nuclei. Thus functionally identified, the subsequent response of the units to MWR (915 and 2450 MHz) applied to the head will be noted. For vestibular units, the emphasis will be on their response to physiological angular accaleration of the head as compared with their response to exposure to near field continuous wave MWR. For auditory units, the emphasis will be on their response to physiologic acoustic stimuli (tone bursts and clicks) as compared with their response to pulse modulated MWR. The capability of pulsed MWR to mask acoustic stimuli will also be examined. Calibration of the MWR dose will be in terms of regional absorbed energy density. Recording sites will be suitably marked and verified by histological examination. We will apply these data to the analysis of the biological hazards to pulsed MWR and of the biomedical utility of this interaction of MWR with the central nervous system.

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FORMAT FOR SUMMARY OF RESEARCH PROGRAM (Continued)

I. MAJOR ONGOING PROJECTS, FY 1979 (Indicate selection criterion: five or ten largest, greater than $100K, highest priority, etc.)

A. Title BIOLOGICAL EFFECTS OF 60 HERTZ ELECTRIC FIELDS

B. Specific Objectives See attached Research Objectives sheet

C. Milestones/Estimated Completion Date Project End Date: 01/31/80

D. Research Category (OSTP Working Group Categories)
LONG-TERM, LOW-LEVEL EXPOSURE STUDIES ON ANIMALS

E. Test Parameters (if applicable)

1. Frequency

2. Test species

3. Exposure duration

4. Radiation dose

5. Other

F. Funding

1. In-House

2. Extramural FY 79 (DCO): $30,563 FY 80 (DCO): $ -0-

3. Prime Contractor

G. Coordination

1. Other Federal Agencies

2. State or Local Agencies

3. Universities

4. Trade Associations

5. Other

H. Comments

Summary statement covering small or miscellaneous projects.

III. New initiatives for FY 1980.

SECTION 1

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

RESEARCH OBJECTIVES

LEAVE BLANK

PROJECT NUMBER
1 R01 ES 1621-01

NF

ID ADDRESS OF APPLICANT ORGANIZATION

Research Foundation of SUNY
P. O. Box 7125, Albany, NY 12224

for and in conjunction with
SUNY Upstate Medical Center
750 East Adams St., Syracuse, NY 13210

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE, AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT, BEGINNING WITH PRINCIPAL INVESTIGATOR

A. A. Marino, PhD, Principal Investigator, Orthopedic Research

TITLE OF PROJECT

BIOLOGICAL EFFECTS OF 60 HERTZ ELECTRIC FIELDS

USE THIS SPACE TO ABSTRACT YOUR PROPOSED RESEARCH. OUTLINE OBJECTIVES AND METHODS. UNDERSCORE THE KEY WORDS (NOT TO EXCEED 10) IN YOUR ABSTRACT.

60 hertz electric fields arising from electric power transmission lines are ubiquitiously present in the environment. The strength of such fields varies directly with the operation voltage of the transmission line and inversely with distance from the line. Biological effects attributable to low frequency electric field exposure have recently been described, notwithstanding earlier work minimizing the biological significance of such fields. Preliminary results obtained in our labroatory show that a 60 hertz electric field of 150 volts/cm is a biological stressor. This is, field exposure alters normal growth in rats and mice and produces changes in the levels of serum hydroxycorticosterone and serum proteins. This project involves the systematic study of these phenomena in greater detail.

Presently, the human health hazard associated with exposure to 60 hertz electric fields is unknown. There have been no systematic studies of such effects and consequently there are no federal or state standards for permissible non-occupationally related exposure. Continuing our initial work, we propose the following experiments to evaluate the biological effects of 60 hertz electric fields at 150 volts/cm:

1. The effect in rats on serum hydroxycorticosterone, triglycerides, total proteins and the effect on growth, tissue structure and food and water consumption.
2. The effect on reproduction in mice.
3. The effect in rabbits of acute and chronic exposure.

The experiments will be repeated as a function of field strength and frequency.

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II. Summary statement covering small or miscellaneous projects.

The balance of the research projects supported by the NIEHS for research on nonionizing radiation effects includes thermal and nonthermal effects of microwaves, interactive carcinogenic effects of ultraviolet radiation with polycyclic aromatic hydrocarbons and other chemical compounds, investigations of the biologic effects of high-intensity electrical fields, and a small activity toward devising new uses for laser technology. Not all of these projects include nonionizing radiation as a major focus of the project objective.

III. New initiatives for FY 1980

The NIEHS Task Force II and subsequent program planning activities recommend additional involvement of NIEHS in nonionizing radiation research, to include studies on microwaves, ultraviolet and infrared radiation, electromagnetic field effects and laser use. The program planning groups have recommended expansion of research at the molecular experimental and epidemiologic levels.

The relatively small grants activity in nonionizing radiation effects reflects to some degree the limited number of research projects being pursued in this area and the lack of a discrete program. New NIEHS program initiatives will identify related research areas and active investigators and will encourage submittal of research applications for funding consideration.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20591

JUL 16 1979

7-19

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

This is in reply to your letter of June 28, in which you asked for information about Federal Aviation Administration research efforts concerning nonionizing radiation. I am pleased to enclose, for your consideration, the information you have requested.

Sincerely,

Clark H. Onstad
Chief Counsel

Enclosures

52-362 O - 80 - 22

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION
Federal Aviation Administration/Civil Aeromedical Institute
TITLE (of research program)
Effects of Microwave Radiation on Prenatal Development
CONTACT (name of responsible individual, title, address, phone)
Mr. Edwin A. Richardson, Agency Industrial Hygienist, AAM-430
Federal Aviation Administration
800 Independence Avenue, SW., Washington, D. C. 20591 (202) 426-3769
GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)

To assess the biologic effects of low levels of microwave radiation and provide estimates of risk of injury as a function of microwave dose. The end result is hoped to be technical expertise which will enable aviation and public officials to meaningfully address possible harmful effects.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$203,400		$113,600	
Beneficial Applications				
TOTAL				

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

SUMMARY OF RESEARCH PROGRAM

I. This is the larger of two major research projects ongoing in the FAA involving Biological Effects of Nonionizing Radiation.

A. The title of this research project is "Effects of Microwave Radiation on Prenatal Development."

B. The specific objectives of the project are to assess the biologic effect of low levels of microwave radiation and provide technical expertise so that possible harmful effects of microwaves on aviation personnel and the public may be more meaningfully addressed by the responsible officials. The principal research objective is to provide estimates of risk of injury as a function of microwave dose.

C. The estimated completion date of this project is 1983.

D. The research category of this project is in that part of OSTP biological research involving effects on fertility and reproduction. It also involves genetic effects.

E. The research parameters will involve investigation of irreversible effects of low levels of microwave radiation of previously studied sensitive biologic systems. Stages to be studied are pro-nuclear zygote, two cell, and 8-day embryo of the mouse. The responses will be teratologic changes, prenatal death, and change in rate of development. The frequency used will be 2.54 GHZ and will involve up to 128 mice. Sixty-four will be exposed to continuous or pulsed circularly polarized microwaves. The other 64 mice will be sham irradiated. Exposure durations will last during critical stages of development of the mouse embryo. The radiation dose will be controlled throughout the test by the scientist in control.

F. All funding for this research is in-house with funds provided by the Office of Aviation Medicine.

G. There is coordination on this project with the National Telecommunications and Information Administration of the Department of Commerce.

H. We hope to expand this project in the future to include (1) A long term study on tumor incidence in mice exposed in utero to microwaves, (2) Dose response relationships of microwaves in combination with other agents, (3) Microwave Effects on DNA repair processes in mouse embryos.

II. The FAA has no other nonionizing research projects other than the two enumerated at this time.

III. The FAA has no new initiatives for FY-80.

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION
Federal Aviation Administration/Civil Aeromedical Institute

TITLE (of research program)
Studies of Microwave Effects on the Central Nervous System

CONTACT (name of responsible individual, title, address, phone)
Mr. Edwin A. Richardson, Agency Industrial Hygienist, AAM-430
Federal Aviation Administration
800 Independence Avenue, SW., Washington, D. C. 20591 (202) 426-3769)

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)

To study possible effects of Nonionizing Electromganetic Radiation (NEMR) on the nervous system and therefore on human performance. Later objectives include direct effects of NEMR on the functional characteristics of single nerve cells, also synergic reaction of NEMR with intoxicants such as ethanol or medications.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals				
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies	$89,100		$97,800	
Beneficial Applications				
TOTAL				

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

SUMMARY OF RESEARCH PROGRAM

I. This is the smaller of two major research projects ongoing in the FAA involving Biological Effects of Nonionizing Radiation.

A. The title of this research project is "Studies of Microwave Effects on the Central Nervous System."

B. The specific objective of the project is to demonstrate the direct effects of defined amounts of Nonionizing Electromagnetic Radiation (NEMR) on the nervous system and therefore on human performance. Such a demonstration is critical to any understanding or prediction of possible harmful neurobehavioral or neuroendocrine effects of NEMR.

C. The total time envisioned for the completion of this project and its attendant microthermal investigations is approximately 5 years.

D. The research category of this project is that part of OSTP biological research involving NERM effects on the mamalian nervous system.

E. The research parameters will involve investigation of the effects of microthermal temperature changes such as 0.5° C on brain cell function. Using pigeons and squirrel monkeys as subjects micropipette electrodes will be inserted into the anterior hypothalmus and posterior brain stem thermosensitive zones and recordings made of changes in single neurone activity elicited by changes in brain temperature induced by heat or microwave radiation. The effects of change in cell function in such critical areas could lead to some of the neoendocrine and stress responses attributed to low level NEMR. This particular study will be conducted using 2.45 GHz pulsed RF with a dose rate of 10 to 100 $\mu W/cm^2$ or more as the suggested microthermal effects are at these incident energy levels. The system equipment to be used makes it possible to calibrate the system so that changes in neurone patterns can be determined and correlated.

F. All funding for this research is in-house with funds provided by the Office of Aviation Medicine.

G. There is coordination on this project with the National Telecommunications and Information Administration of the Department of Commerce.

H. When absorbed dose and response data is available from the above work, we hope to expand this study to include the effects of NEMR on "event-related evoked potentials" in human volunteers.

II. The FAA has no other nonionizing research projects other than the two enumerated at this time.

III. The FAA has no new initiatives for FY-80.

VETERANS ADMINISTRATION
OFFICE OF THE ADMINISTRATOR OF VETERANS AFFAIRS
WASHINGTON, D.C. 20420

SEPTEMBER 10 1979

Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Committee on Science and Technology
House of Representatives
Suite 2321, Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

Enclosed please find the summary descriptions of the research programs of the Veterans Administration on the health effects of exposure to ionizing radiation which you requested in your letter of June 28, 1979.

Please let me know if I may be of further assistance.

Sincerely,

MAX CLELAND
Administrator

Enclosures

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION Veterans Administration

TITLE (of research program) Research and Development

CONTACT (name of responsible individual, title, address, phone) Lawrence B. Hobson, M.D., Ph.D. (15A)
Deputy ACMD for Research and Development
Veterans Administration Central Office
810 Vermont Ave., NW, Washington, DC 20420
(202 389-2616)

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)

See Attached Sheet

Research Category (defined by OSTP ad hoc Working Group)*	FY 1978		*FY 1979	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry	-	-	-	-
Mechanisms of Interaction	-	-	-	-
Long-term, Low-level Exposure Studies on Animals	35,000	400,000	35,000	400,000
Human Studies	29,110	-	7,698	-
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents	-	-	-	-
Biological Effects Studies	331,912	156,299	361,846	143,739
Beneficial Applications	13,562	9,000	15,500	-
TOTAL	409,584	565,299	420,044	543,739

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

*Specific funding levels for FY 1980 are unpredictable because of research funding mechanism.

PRINCIPLES AND OBJECTIVES OF RESEARCH PROGRAM

The primary mission of the Department of Medicine and Surgery of the Veterans Administration - to provide high quality medical care to veteran patients - is served by the research and development program in three ways:

1. The production of new knowledge, techniques, or products leading to improved prevention, diagnosis, treatment, and control of disease, as well as correction or compensation of defects. These research products benefit veteran patients and mankind in general.

2. The attraction and retention of a high quality professional staff that improves the care of the VA's patients.

3. The provision of the stimulating intellectual environment necessary for the educational programs in VA health care facilities as well as serving in support of (1) and (2) above.

These objectives can be achieved only by research and development of high quality. The program, therefore, constantly strives to improve the results achieved.

The results of development and of directly applied research, including clinical studies, can have an immediate effect on patient care. Such applications, however, depend upon research commonly called basic. Scientists performing basic studies also advise and assist other staff members in pursuing their research.

Title: (Part 1) Mechanism and Prevention: Long Wave UV Carcinogenesis and Photoaugmentation.

(Part 2) Lethal Action of UVA on Bacteria, Fungi, and Mycobacteria: Mechanism, Therapeutic and Prophylactic Efficacy.

Specific Objectives: (Part 1) To determine the mechanisms by which long wave length ultraviolet light (UVA) enhances sunburn susceptibility and the detrimental effects of sun on skin.

(Part 2) To determine effectiveness and effects of defined wavelength of UVA radiation on pathogenic skin organisms.

Milestones:
- Identified histological electron microscope changes that result when rays (UVA-UVB) are combined.
- Demonstrated timeframe in which two types of radiation have to be received in order to induce damage.
- Demonstrated that combining UVA and UVB will induce cancer at a faster rate than UVB alone.
- Demonstrated successful treatment with UVA of clinical skin infections that were unresponsive to antibacterial therapy.

Research Categories: Human Studies, Biological Effects Studies, Beneficial Applications

Test Parameters: Single and repeated UVA and visible light exposure at varying dose levels and frequencies.

Funding: VA Merit Review program currently provides $60,236 per annum exclusive of P.I.'s salary. Fiscal Year 1980 level of support will be approximately the same.

Coordination: Emory University School of Medicine, Atlanta, Georgia

Comments: Principal Investigator is Chief, Dermatology Section at the Veterans Administration Medical Center,

Atlanta Georgia. Principal Investigator is also conducting a study sponsored by Environmental Protection Agency and another sponsored by National Cancer Institute (R01-CA 17555). Both are related to non-ionizing radiation.

Title: Potential Biogenic Mechanism(s) and Systemic Prophylaxis for Actinic Skin Cancer

Specific Objectives: To determine the potential involvement of cholesterol alpha oxide in ultraviolet carcinogenesis.

Milestones: The involvement of cholesterol alpha oxide metabolism in the development sequence of UVL carcinogenesis has been demonstrated. This provides a basis for understanding the anti-cancer properties of antioxidants.

Research Category: Biological Effects Studies.

Test Parameters: Varying dose levels, frequency, and duration of ultraviolet light will be used. Hairless mice are the model system for this study.

Funding: VA Merit Review program currently provides $34,211 per annum exclusive of principal investigator's salary. Fiscal Year 1980 level of support will be approximately the same. Extramural funding of $66,000 is being provided by the National Cancer Institute.

Coordination: Baylor College of Medicine, Houston, Texas
National Institutes of Health

Title: Evaluation of Electrical Techniques for Stimulation of Hard Tissue Growth

Specific Objectives: To evaluate the effect of electrical stimulation on bone growth by systematically testing various forms of electrical stimulations.

Milestones: Demonstration that direct currents at physiological levels are capable of stimulating a significant osteogenic response.

Research Category: Biological Effects Studies.

Test Parameters: Techniques in use include 1) low-level direct current (DC), high-level DC, pulsed DC, alternating current (AC) and pulsed magnetic fields (PMF).

Funding: VA Merit Review program currently provides $115,400 per annum exclusive of P.I.'s salary. Fiscal Year 1980 level of support will be approximately the same. Extramural funding of $19,126 is being provided by National Institute of Environmental Health Sciences.

Coordination: SUNY Upstate Medical Center, Syracuse, NY, National Institute of Environmental Health Sciences.

Comments: Principal Investigator is Chief, Orthopedic Section, Veterans Administration Medical Center, Syracuse, NY.

FORMAT FOR SUMMARY OF RESEARCH PROGRAM

AGENCY/DIVISION - Veterans Administration

TITLE (of research program) - Biological Effects of Microwave Radiation

CONTACT (name of responsible individual, title, address, phone) James J. Smith, M.D., Director, Nuclear Medicine Svc.
VA Central Office, Washington, D. C.
Telephone: 389-3195

GENERAL PROGRAM OBJECTIVES (describe where you want to be in the next few years)
Long-term low-level and intermediat-level irradiation of unrestrained, unanesthetized rhesus monkeys' face and eyes should continue for at least 5 additional years to determine long-term effects on the eye, central nervous system, behavior and progeny. It is our plan to continue this ongoing study and to include microwave irradiation of the fetus to determine if mutagenic effects occur.

Research Category (defined by OSTP ad hoc Working Group)*	FY 1979		FY 1980	
	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry				
Mechanisms of Interaction				
Long-term, Low-level Exposure Studies on Animals	37,000		20,000	
Human Studies				
Combination of Radio Frequency Radiation or High Voltage Transmission Line Fields w/ Other Agents				
Biological Effects Studies				
Beneficial Applications	unfunded		unfunded-but research application in progress	
TOTAL				

* A Technical Review of the Biological Effects of Non-Ionizing Radiation. A Report Prepared for the Office of Science and Technology Policy by an ad hoc Working Group, May 15, 1978.

I. MAJOR ONGOING PROJECTS, FY 1979

A. Title: Biological Effects of Microwave Irradiation

B. Specific Objectives: Chronic irradiation of rhesus monkeys' head to determine presence/absence of ocular effects and effects or behavior/performance of instrumental tasks.

C. Milestones/Estimated Completion Date: From the beginning with four operantly responding rhesus monkeys (1973) to the present (1974), with a total of 20 test monkeys; tests of behavior, work output, aversion to microwave irradiation, social behavior, fecundency, fetal abnormalities and cataractogenesis have proven negative. The research and observation should continue to at least 1984 so as to rule out long-term effects.

D. Research Category: Long-term Biological Effects, Ocular and Behavioral.

E. Test Parameters:

1. Frequency: 9.31 GHz, pulsed

2. Test Species: Macaca Mulatta

3. Exposure Duration: 15 to 20 minutes each animal on days scheduled for irradiation (many hours of irradiation have been accumulated since 1975 with equal time for observation during control session).

4. Radiation Dose: 150 to 450 mW/cm2 to the rhesus head and eyes.

5. Other: The rhesus monkeys have bben trained to operate a manipulandum for apple juice while being irradiated/or not (as the experimental protocol dictates). Behavior is assessed during manipulandum operation and social behavior is observed both before and after irradiation. Physical examination of blood elements and blood chemistry are performed twice yearly concurrent with ocular examination. Visual assessment of health status is made on a daily basis as is work performance on the manipulandum.

F. Funding:

1. Veterans Administration

G. Coordination:

3. Universities:

a. University of New Orleans, School of Engineering, New Orleans, Louisiana

b. University of New Orleans, Department of Psychology
New Orleans, Louisiana

c. Tulane University School of Medicine
Department of Ophthalmology, New Orleans, Louisiana

d. Deltal Regional Primate Research Center, Covington, Louisiana

H. Comments: The project has been going smoothly with the cooperation of a large number of people involved from the above institutions.

II. SUMMARY STATEMENT

Within the scope of the large project described above there are miscellaneous projects summarized here: studies of the effect of microwave radiation on (1) peripheral nerves; (2) in conjunction with phenobarbitol anesthesia; (3) as an adversive physical agent compared with infrared radiation; (4) on social hierarchy of groups of rhesus monkeys and; (5) as a possible means for tumor treatment.

III. NEW INITIATIVES FOR FY 1980

Investigators at the New Orleans VA Medical Center and the Tulane University School of Medicine are planning studies of the possible adjunctive effect of microwave radiation, with ionizing radiation and chemotherapy on animal and human tumors. The equipment and expertise of the research program reported herein will play a major role in this planned investigation.

52-362 O - 80 - 23

SUMMARY OF RF RADIATION (MICROWAVE) RESEARCH PROGRAM, KCVAMC

A. Title: Biopsychological studies of microwave radiation

B. Specific Objectives: To determine acute and long-term effects of high intensity irradiations (that parallel those given in clinical diathermy) on behavioral and physiological endpoints of small animals.

C. Milestones: A number of short-term and long-term studies is underway; the limiting factor is longevity. Some longevity studies have been underway for three years and will require two or more years to complete. Other longevity studies under consideration may require 7 to 10 years to complete.

D. Research Categories: Instrumentation and Dosimetry (microwave dosimetry had its birth at KCVAMC in 1967, as did development of the multi-mode cavity for biological experimentation; work on both is active at present); Biological Effects Studies (Behavior, teratology, electrophysiology are primary endpoints); Beneficial Applications (Extensive pilot work has been underway for 18 months on therapy of glioblastoma in murine models).

E. Test Parameters: 918- and 2450-MHz carrier frequencies; mice, rats, guinea pigs, rabbits; 10-min. to 4 days' exposure durations; 500 uW/g to 250 mW/g dose rate; exclusive use of multi-mode ~~xxx~~ cavities.

F. Funding: USPHS grant through FDA will enter seventh year of funding 1 SEPT 79 at at level during FY-80 of $60,000; V A merit-reviewed program currently provides about $46,000 per annum exclusive of P.I.'s salary; FY-80 level of support has not been announced by VACO.

G. Coordination: P.I. is a member of several groups (NAS, Ad Hoc OSTP working group, NCRP Scientific Committee 53, ANSI sub-committee C-95.4, etc.) the provide informal coordination of research activities. P. I. is also Chairman of the IEEE's Committee on Man and Radiation (COMAR), which has a primary function in didactics but also informally serves to coordinate research among federal and non-federal investigators.

H. The P. I. has recently presented testimony before the U. S. House* with respect to research needs in the area of RF radiation. This testimony is in the hands of Dr. James Smith and may be used (or not used) as he sees fit.

Summary Statement: None

New Initiatives for FY 1980: Considerable expansion of radiation facilities will be undertaken at KCVAMC if the P. I.'s merit-reviewed program for the period FY-80 to FY-83 is approved at recommended level.

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* THE PRINCIPAL INVESTIGATOR MADE IT CLEAR, IN HIS PRESENTATION, (SEE ATTACHMENT) THAT HE WAS APPEARING AS CHAIRMAN OF COMAR — COMMITTEE OF MAN AND RADIATION — OF THE INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE) AND NOT AS A REPRESENTATIVE OF THE VA.

RESEARCH PROGRAM IN NONIONIZING ELECTROMAGNETIC RADIATION

Jerry L. Pettis Memorial Veterans Hospital
Loma Linda, CA 92357

Principal Investigator: W. Ross Adey, M.D.
Associate Chief of Staff/Research & Development
(714) 825-7084, ext. 2264
FTS 785-2264

Reporting Date: 7/19/79

PROGRAM SUMMARY

This research group under the direction of Dr. W. R. Adey has been engaged continuously in studies of bioeffects of low-level nonionizing electromagnetic radiation since 1965. The program was located at the UCLA Brain Research Institute from 1965 to 1977, where pioneering observations were made on behavioral, physiological and biochemical effects of both extremely-low-frequency (ELF - 1 to 100 Hz) fields, and of radio (RF) and microwave (MW) fields with ELF amplitude modulation.

Convergent aspects of these observations in brain tissue have established a consensus, now confirmed by other groups, that tissue transductive mechanisms in the sensing of low-level ELF, RF and MW fields involve a hitherto poorly studied class of electrochemical interactions known as cooperative processes. These processes differ from so-called "equilibrium processes" that have been the basis of classic biophysical and biochemical explanations of nervous excitation. Briefly, they depend on resonant interactions of charged atomic particles separated by considerable atomic distances. Since these "non-equilibrium reactions" are set in motion by very weak triggering events, they are clearly important in determining thresholds for tissue sensitivities to environmental EM fields, and thus in the establishment of safety standards for human exposure. They are discussed further below.

It should be emphasized that these cooperative processes in biological systems have only recently become a focus for research in key areas of

molecular biology that include immunology, endocrinology and neurobiology. Their significance in tissue sensitivities to a very broad range of physical and chemical stimuli is now recognized, but they may well have continued to escape detection in the absence of specific searches. They provide mechanisms for enormous amplification of initial weak triggering events, particularly at the surface of cell membranes, perhaps as much as several million times, so that our concepts of minimal effective stimuli for nonionizing electromagnetic fields, particularly in the brain, have been continually revised downward over the past decade.

INVESTIGATIVE TEAM

Major elements in this research program, together with key investigators, have been progressively transferred from the UCLA Brain Research Institute since July 1977. The research team includes:

Dr. Suzanne M. Bawin, neurophysiologist and biophysicist

Dr. Sen Lin-Liu, molecular biologist and physicist

Dr. Richard Lawrence, computer specialist and biomathematician

Dr. Philip M. Sagan, physiological psychologist

Dr. Asher Sheppard, biophysicist and neurophysiologist

Dr. Harold Tinberg, molecular biologist and histologist

GENERAL PROGRAM OBJECTIVES

These involve the study of mechanisms underlying cell and tissue interactions with weak nonionizing EM fields. Special emphasis will be placed on mechanisms of EM field detection at brain cell membrane surfaces by quantum mechanical "amplifying" mechanisms (cooperative processes). Since these cell surface mechanisms are also involved in immunological and hormonal actions, we are also studying cooperative processes in cultured human T-lymphocytes, human red blood cells and in cultured bone cells. The broad

biological significance of cooperative processes makes their elucidation a major frontier in molecular and cellular biology in the next decade.

Extramural funding is currently provided by Department of Energy, FDA Bureau of Radiological Health and Southern California Edison Company:

	FY 79		FY 80	
Research Category	In-house	Extramural	In-house	Extramural
Instrumentation and Dosimetry		$ 30,000		$ 30,000
Mechanisms of Interaction	$ 15,000	225,000	$15,000	225,000
Long-Term, Low-Level Exposure in Animals		40,000		40,000
Biological Effects Studies	15,000	75,000	15,000	75,000
Beneficial Applications	5,000	30,000	5,000	30,000
Total	$35,000	$400,000	$35,000	$400,000

Research Tasks, supporting agency and assigned investigators are shown in Table 1.

COMMENTARY SUBMITTED BY PRINCIPAL INVESTIGATOR ON PROPOSAL FOR "A COMPREHENSIVE FEDERAL RESEARCH PROGRAM ON THE HEALTH EFFECTS OF NONIONIZING RADIATION

It would be a grievous error to presume that the knowledge needed to develop such a program exists within the bureaucratic structure of cognizant Federal agencies in Washington. The nature of the scientific problem demands close and continuing liaison with scientific leaders in the field. These individuals should be at the core of decision making on national research goals. This function has been the raison d'être of the Electromagnetic Radiation Management Advisory Council (ERMAC). Its role in this most important task has been significantly eclipsed with the disbanding of the Office of Telecommunications Policy (OTP) in the Executive Office of the President and the transfer of the ERMAC and related functions to NTIA within the Department of Commerce.

ERMAC has played a vitally important coordinating role over the past decade, catalyzing interagency communication, initiating communication between investigators, and providing a unique forum for scientific evaluation of current national needs and in determination of national scientific (as opposed to bureaucratic) priorities. It has provided a unique documentation on the scope and content of current research programs. Indeed, much of the information currently needed by the House Subcommittee on Natural Resources and Environment is available in the last ERMAC report.

A high priority in any national research program should be the study of mechanisms of tissue interactions with low-level, nonionizing fields. Recent research, including our own pioneering studies, has emphasized that these interactions may be based on long-range, resonant atomic and molecular phenomena. These "cooperative" or "dissipative" processes belong to the class of nonequilibrium interactions, and are distinct from equilibrium reactions which have been thought to characterize physiological systems from the earliest days of biomedical research. In important respects, these processes are as conceptually new in the physical sciences as they are in biology and medicine. They now offer the astrophysicist understandings in cosmology as radically new as are the prospects for their application in the medical realms of immunology, endocrinology and the functioning of the brain. They may also provide important keys to an understanding of mechanisms of cancer and aging.

Because our awareness of these cooperative or dissipative mechanisms is so new, we should move cautiously but incisively in evaluating their biological role. Nonionizing electromagnetic fields will undoubtedly provide a unique tool in this research, for they appear to offer one of the very few avenues to an understanding of the extreme sensitivity of living tissues to certain

very weak electrochemical interactions, processes that have continued to defy solution in terms of classic equilibrium chemistry and physics.

A national research program developed within this framework should go far to obviate grave risks of empiric national or local regulatory intervention in the absence of true knowledge of biophysical mechanisms. Hopefully, it would minimize the risk of equating biomedical hazards with superstitious anecdotes and ritual. The fruits of its research should become the cornerstones of rational legislative and regulatory deliberations.

TABLE 1.

TASK	AGENCY	INVESTIGATORS
1. Tissue dosimetry	BRH	Adey, Sheppard, Bawin, Bassen (BRH)
2. Neurochemistry a. Intact cat - Ca^{++} - amino acids b. In vitro - chick, cat cortex	BRH	Bawin, Adey
3. Theoretical models	BRH	Sheppard, Bawin, Adey
4. Monkey behavior, 450 MHz & 7 Hz - Interresponse times	BRH	Sagan
5. Chickens and ducklings (450 MHz, 16 Hz) - Activity - Interresponse times	BRH	Sagan
6. Chickens and ducklings - Field intensity sensitivity 450 MHz, 16 Hz mod. 0.5-5.0 mW/cm^2	BRH	Sagan
7. Aplysia electrophysiology (single neuron recording) a. Temperature dependence of membrane potentials b. Extracellular DC field sensitivity c. ELF electric fields (1, 10, 16, 30, 60 Hz and DC) with current densities 10^{-7} to 10^{-3} A/cm^2	SCE	Sheppard, French
8. Rat hippocampus electrophysiology (hippocampal slice) a. Effects of ELF, 7, 16 and 60 Hz fields on ionic fluxes b. Effects of 450 MHz, 16 Hz modulated fields on ionic fluxes. (Also 7 Hz modulation.)	SCE	Lin-Liu, Bawin
9. Development of 450 MHz Crawford Cell exposure apparatus	SCE	Sheppard, Adey

TABLE 1.

TASK	AGENCY	INVESTIGATORS
10. Sensory and behavior studies in rats exposed to 60 Hz fields (absolute threshold determinations). Comparison between 16 and 60 Hz.	SCE	Sagan
11. Subjective time estimation in monkeys exposed to 60 Hz 1 kV/m fields and comparison with 7 Hz fields	DOE	Sagan
12. a. Chronic exposure of rats to 60 Hz fields, 1000 V/m with behavioral tasks (Task 1, food reward; Task 2, water reward)	DOE	Sagan
b. Similar experiment with 450 MHz field modulated at 60 Hz		
13. Effects of steady and ELF oscillating magnetic fields on Aplysia nerve cells (intracellular recording)	DOE	Sheppard, French
14. ELF field effects on neuronal behavior in hippocampus (direct tissue stimulation, frequencies 1-60 Hz)	DOE	Bawin, Adey
15. RF field effects on neuronal behavior in hippocampus (modulation frequencies 1-60 Hz)	DOE	Bawin, Lin-Liu
16. a. ELF field effects on bone cell growth (16, 45, 60 and 75 Hz)	DOE	Adey, Luben (Univ. of California, Riverside)
b. RF field effects on bone cell growth (450 MHz field, modulation frequencies 16, 45, 60 and 75 Hz)		
17. a. Ionic fluxes in synaptosome fractions from rat cerebral cortex exposed to ELF fields (1-60 Hz)	DOE	Lin-Liu, Bawin

TABLE 1.

TASK	AGENCY	INVESTIGATORS
b. Similar studies in synaptosomes exposed to RF fields, modulated at 1-60 Hz	DOE	Lin-Liu, Bawin

APPENDIX 2.

Reprinted from the Proceedings of the 1978 Conference on U.S. Technological Policy.

Dr. Don R. Justesen is Director, Neuropsychology and Behavioral Radiology Laboratories, at the U.S. Veterans Administration Medical Center in Kansas City, MO. He led the Conference Workshop on Radiation and serves as Chairman of the IEEE Committee on Man and Radiation.

Workshop on Radiation

Scientific, Technological, and Sociological Implications of Research on Biological Effects of Radio-Frequency Electromagnetic Radiations

Don R. Justesen, Arthur W. Guy, John M. Osepchuk, Carl H. Sutton and Edward L. Hunt

The Committee on Man and Radiation (COMAR) is a singularity among the many technical groups and societies of the IEEE. Each of its 30 working members is scientifically conversant, not only with engineering and physical aspects of non-ionizing, radio-frequency electromagnetic waves (RF radiation) but also with biological and medical aspects as well. This multidisciplinary makeup is reflected by the diversity of specializations of the membership, which includes psychologists, biologists and physicians, in addition to physicists and electrical engineers.

The Committee's primary charge is to educate. By drawing upon a collective knowledge that embraces scientific activity in the government, the university, and the private sector, the members of the Committee serve as educators of a constituency that includes the public as well as the international membership of IEEE. The aim of enlightenment is attempted through release of position papers, through sponsorship of formal and informal meetings, through written contacts by individual members with private citizens and with members of the Congress, through publication of reviews, and through appearances by its members at public, judicial, and legislative hearings.

To educate is to advocate, but COMAR's advocacy is not that of a special interest group. Whatever the benefits and hazards of RF radiation, the IEEE member will suffer no less than the private citizen from harmful encounters with electromagnetic fields. Indeed, the thousands of engineers who labor in close proximity to RF waves have the most to lose from faulty use or from misunderstanding of hazards of this form of energy.

Education of the public might be the most critical link in the multi-national effort to resolve the energy problem by technological advance. In the United States, the fires of inflation are fueled by oil that arrives from foreign soil—by an adverse import-export ratio that cheapens the dollar and spawns a vicious economic cycle in which ever greater dependence on foreign resources increasingly diminishes the nation's economic capacity to deal with

the energy problem. That the U.S. has the technical competency and material resources to resolve the problem is not to be questioned. But whether a sometimes apathetic, sometimes aroused and frightened public will support the necessary technological advances in the current climate of distrust of corporate enterprise and government is conjectural. Almost all sources of energy are being viewed by some segments of the public with apprehension. Nuclear energy is under attack everywhere by environmentalists. Farmers are bull-dozing high-voltage power lines in Minnesota. Citizen's groups are opposing the installation of microwave navigational devices in harbors of New York City, are seeking to abort missile-early-warning systems in California and Massachusetts, and are even attempting to prevent operation of 1-watt microwave telephonic repeaters in New York, New Jersey, and elsewhere.

Whatever the merits of particular cases, one judgment can be made about many of the instances of opposition to devices that make use of RF energy: The driving force does not stem from scientific evidence of peril, but results from a lack of understanding by the public of the nature of RF waves. The antidote is education, but an effective means of providing it has yet to be articulated. Perhaps this meeting of the scientific, technical, and legislative minds can provide a forum for reaching and instructing the public through its elected and appointed officials.

To illustrate and showcase the activities of COMAR, four of its members have been asked to discuss issues that fall within the Committee's sphere of concern. Dr. Arthur W. Guy, a biological engineer on the faculty of Rehabilitative Medicine at the University Hospital in Seattle, will discuss an international program of scientific exchange. Dr. Guy and several American engineers and scientists have been working with professional and scientific counterparts in the Soviet Union on a number of problems involving RF radiation.

Following Dr. Guy, Dr. John Osepchuk, an electrical engineer who is consulting scientist at the Raytheon Company's Research Division in Waltham, MA, will review recent studies of video display terminals that are of more than passing interest, not only to the engineer, but to the student of human behavior.

After Dr. Osepchuk, Dr. Carl Sutton, a neurosurgeon on the faculty of the University of Miami's School of Medicine and a pioneer in experimentation on microwaves as a therapeutic agent in treatment of brain cancer, will review recent advances in clinical applications of RF radiation.

Finally, Mr. Edward Hunt, a civilian scientist at the Walter Reed Army Institute of Research—a physiological psychologist and an expert on ionizing and on RF radiations—will address some general issues about education of the public on biological effects and hazards of low-level RF radiation. Mr. Hunt, who speaks for himself and not for the Department of the Army, was recently commissioned by Sub-Committee C95.4 of the American National Standards Institute (ANSI) to organize and supervise a critical review by a large body of experts of the nearly 5000 reports in the world's literature on biological effects of microwave radiation.

International Program of Scientific Exchange: One of the more vexing problems of interpreting biological effects—and of establishing rational limits—of exposure to microwaves and to other RF radiations arises from the gap between Western and Eastern standards. In the Soviet Union, for example, the limit for continuous occupational exposure is 10 $\mu W/cm^2$, which is a thousandfold more restrictive than the ANSI guide number of 10 mW/cm^2 in the U.S. A major factor in this gap is a difference in philosophy of standards. The Soviet approach is to observe for a threshold of RF radiation below which *no biological effect* occurs and then to incorporate an additional safety factor of one or more orders of magnitude. The approach in the United States has been to observe for a threshold of *damaging* radiation and then to incorporate a safety factor of an order of magnitude. Both approaches have limitations. The American approach encounters a conceptual snag in that no concensual basis has been reached for differentiating benign effects from hazardous effects. The more conservative Soviet approach suffers from a failure to entertain a trade-off between risks and benefits. If the same philosophy were implemented for the automobile and for visible light, our Russian colleagues would be walking around in total darkness.

Quite apart from philosophy of standards, early Soviet reports of biological effects at very low power densities of RF radiation have long been a puzzlement to Western investigators. Subsequent attempts

by American scientists to resolve the riddle of reported low-level effects led to speculation that exposure facilities of Soviet scientists may conspire for multipath radiations, which can complicate measurement of incident fields. Moreover, absence of dosimetric—*absorbed*-energy—measurements has precluded quantitative assessment of reported biological effects.

In an effort to gain a better purchase on East-West differences, a program of scientific exchange was inaugurated several years ago by the National Institute of Environmental Health Sciences under the direct supervision of Dr. Donald McRee. His Soviet counterpart is Dr. M. G. Shandala, a physician who directs the Marzeyev Institute of Communal and General Hygiene in Kiev. Dr. Shandala is an official responsible for establishment of Soviet standards of RF exposure of the general population.

As a result of a dozen exchange visits, half to the U.S. and half to the Soviet Union by engineering and biological scientists of both countries, much has been accomplished in the way of mutual edification. The delegations from the United States have discovered that, while many earlier concerns were justified, there is impressive evidence in the Soviet Union of engineering and scientific competence. Soviet engineers visited by the American delegations have been responsive in acknowledging earlier problems and have worked quickly to design and fabricate instrumentation that reflects marked improvements over earlier devices. The American delegations have learned that Soviet biological studies often possess an important feature lacking in Western studies: *ecological validity*—or what might be called experimental modelling that more nearly resembles the way that RF radiation is encountered by people in the real world. Soviet biologists have conducted many long-term experimental studies; only a handful has been reported by Western investigators. Soviet physicians have conducted numerous epidemiological surveys; few have been attempted in the West. And finally, the long-term Soviet studies, experimental and epidemiological, are closely matched; i.e., animals are exposed in settings that more nearly resemble the actual settings in which workers are exposed to RF fields. The Western scientist can make a good case for the tightly controlled environmental conditions that have characterized his researches, but he is beginning to realize that a pooling of methodologies that incorporates the environmental and dosimetric rigor of the West with the long-term exposures and ecologically valid designs of the East will be necessary if the potential hazards of low-level fields are to receive creditable scientific evaluation. In short, the Soviet scientist has profited from U.S. engineering, and the U.S. scientist, from Soviet methodology.

It is still too early to evaluate collaborative biological studies that are being conducted or are being planned in the USA and USSR, but preliminary results indicate that current U.S. guidelines of exposure in some parts of the RF spectrum are too lax—and Soviet standards, too stringent. Through this program of international cooperation, we may some day arrive at internationally agreed upon standards that will protect the worker and the man and woman on the street without denying them the amenities and necessities of modern RF technology.

Study of Video Display Terminals: While the engineer does not associate the cathode-ray tube (CRT) or other components of the video display terminal (VDT) with conventional sources of microwaves or with other RF radiations, writers for the popular press, both in their written communications and in appearances on radio and TV broadcasts, have claimed that RF radiation at dangerous levels might be emitted by VDTs. Inspired by these claims, two editorial workers for the *New York Times*, who developed cataracts during the course of using VDTs, filed a grievance. During the ensuing hearing, the testimony of several ophthalmological experts and the data of exhaustive engineering test of the *Times'* and many other VDTs were made a part of the record. The hearing revealed that, other than visible light, virtually no measurable radiations, ionizing or non-ionizing, are emitted by these devices. The heated filament of a CRT does generate a small amount of microwave energy, as does any incandescent lamp, and relatively much larger amounts of infrared and visible radiations—which are effectively shielded by the VDT's metal enclosure—but even the unshielded CRT would not as a *black-body* radiator emit as much microwave energy as the human body. Indeed, the VDT receives more microwaves by far from its human operator than he does from the VDT! That the *Times*—and the VDT—was found innocent of

liability is instructive as is the *belief* by the plaintiffs that they were the victims of RF radiation. Similarly instructive are beliefs by many others that RF radiation from VDTs has been the cause of miscarriages, birth defects, and other disorders.

The hearing and its record are of more than passing interest to the behavioral scientist. The VDT has potential to serve as a control, a placebo of sorts, for the imprecations of well-meaning but technically uninformed writers. By cataloging the number of complaints against an innocent electromagnetic device, one might gain insight on the frequency with which other devices—hair dryers, electric blankets, airport radars, etc.—are spuriously charged with guilt.

It would be fallacious, of course, to argue that the cataracts mistakenly ascribed to VDTs are also falsely ascribed to other sources that do emit significant quantities of RF energy. What is of interest is the demonstration that the perceived danger of the VDT lies in *nominal*, not in physical characteristics of the electronic device: Cathode Ray Tube. The argument seems to be, if a source generates rays, it is dangerous.

The behavioral scientist and practitioner are needed to explore an interesting problem. Hour upon hour spent in monitoring a video screen can exact a toll in the way of eye strain and boredom. Add to this the stress that accrues to an individual who reads and believes media accounts of VDT-caused cataracts and birth defects and one has a complex of factors that can easily conspire for human anxiety and misery. As Tom Stewart, a leader of the European effort to evaluate VDTs has noted, there is a need ". . . to realize that something lies behind the [viewer's] eyes." It may now be an academic question, but it is certainly appropriate to inquire, *is not the insult from chronic anxiety that might be induced by false reports possibly more damaging to more people than the physical emissions of RF devices that are increasingly being stigmatized?*

Several months ago, a written inquiry had been received from an individual who wanted to know if the Committee on Man and Radiation had studied or had prepared a position paper on VDTs. The letter was referred to Dr. Justesen for action. Dr. Justesen responded by saying that it might be appropriate to assemble a team of engineers and psychiatrists to examine the VDT problem. I thought Dr. Justesen was joking until the extensive evidence about the radiological benignity of VDTs came into my possession. Now I realize, in line with Tom Stewart's observation, that there is something behind the eyes that indeed lies more in the province of psychiatry than in engineering.

Recent Advances in Clinical Applications of RF Radiation: Advances in biological applications of RF energy are providing a new set of weapons for the physician. Among the recent uses of electromagnetic energy are those for imaging body structures beneath the skin, for rapid thawing of blood or organs that are frozen for preservation, for making palliative lesions in the nervous system, and for the treatment of cancer with hyperthermia.

A group at the Massachusetts Institute of Technology has pioneered the use of microwave radiometry to detect breast cancer. Since rapidly growing tumors beneath the body's surface cause elevated skin temperatures over the lesions, it has been possible to use infrared thermography to detect and locate superficial cancers. The microwave radiometer, which operates at 3.3 GHz, is able to detect more deeply located cancers by measuring differences in the body's own microwave emissions. In an initial series of tests on human patients, the true-positive rate of detection with microwave radiometry or with thermography alone was about 70%, and when the techniques were combined, the true-positive rate of detection rose to 96%, which compares favorably with the most advanced X-ray diagnosis. This completely non-invasive technique is still undergoing clinical evaluation by the original investigators, who are studying other wavelengths to determine optimal microwave frequencies for the greatest diagnostic utility. It is likely that once the methodology for sub-surface cancer detection has been standardized, it will be possible to extend these methods to the diagnosis of other medical problems, such as cerebrovascular and peripheral vascular occlusions, which claim or impair hundreds of thousands of lives every year in the United States.

Another approach to the imaging of internal bodily structures has been developed by a group at the University of Utah. This approach takes advantage of the ability of the body and its internal organs to transmit microwave energy, which has enabled

determination of the water content of the lungs. A transverse cross-sectional image is produced by a computerized tomographic scanner while microwave applicators are in position. So far, the method has only been used on infra-human subjects. When it is ready for application to human patients, it will be possible to determine the amount of water in the lungs, as well as rate of accumulation, so that conditions such as incipient pulmonary edema can be detected in early stages and treated appropriately before clinical emergencies arise.

At the University of Ottawa, microwaves at 10 GHz have been used to image the movement of blood-vessel walls. With this technique, it is possible to differentiate between normal arteries and those that are partially or totally occluded by arteriosclerosis. Work on a similar device is being done at the Walter Reed Army Institute of Research. These techniques may ultimately replace the commonly used invasive technique of arteriography with contrast substances.

In addition to applications for imaging of subsurface structures and organs, microwaves have been used to thaw biological materials that are frozen for preservation prior to their use in patients. It is now possible to thaw frozen blood rapidly and to preserve integrity of the cellular elements by the use of microwave radiation. This technique has been employed by a group at the Georgia Institute of Technology, where microwaves are also used for rapid, uniform thawing of frozen kidneys. After this technique has been perfected on animals, it is likely to be useful for thawing, without cellular damage, all human organs stored in tissue banks. This technology should significantly increase the availability of kidneys and other tissues for transplantation.

Radio-frequency energy has been used since 1965 by a group now at the University of Miami School of Medicine to produce thermal blocks in the lateral spinothalamic tract, which conducts pain impulses from the extremities and trunk. With this technique, a wire electrode is inserted into the tract within the upper cervical spinal cord, and RF current is used to produce a thermal lesion of predictable dimensions, thereby rendering the patient free of intractable pain. Similar blocks induced by RF currents have enabled neurosurgeons to control intractable facial pain and to halt undesirable involuntary movements, such as the hand tremors of Parkinson's disease.

A widely studied application of RF energy at the present time is for production of whole-body hyperthermia or specific heating of tumors in the treatment of cancer. It has been demonstrated repeatedly that such heating can destroy tumor cells selectively, if properly applied. The heating can also increase the antitumor effects of ionizing radiation, such as that from cobalt or X-ray therapy, and of antitumor drugs, which are administered while the tissues are heated.

A group at the Brooklyn Veterans Administration Hospital has employed RF energy, which is passed between electrodes placed on opposite sides of the pelvis, the abdomen, the chest, or the base of the neck, to heat tumors that have spread through these areas. The investigators have based their approach on the concept that blood flow in some tumors is much slower than that in the normal tissues in heated areas. In this way, tumors can be heated selectively to a higher temperature than that of the normal tissues in which they are embedded, since the tumors receive less cooling by circulating blood.

Microwaves appear particularly promising in cancer treatment for providing predictable, reproducible, and easily controllable hyperthermia in circumscribed areas. With microwaves, the location of the tumor beneath the body's surface determines the depth of penetration needed to heat it. Penetration is an inverse function of the frequency of the microwave radiation.

A group of cancer researchers in Australia and one at Indiana University have employed microwaves at 434 MHz in combination with standard radiation therapy. In a number of their cases, the results reported with the combined treatment appear superior to those achieved with standard radiation therapy alone. Unfortunately, measurement of temperature in human tissues while they are being irradiated is difficult, and has not been attempted in most cases. As a result, it is difficult to relate precise temperature levels to clinical results.

At the University of Miami School of Medicine, microwave energy at 2450 MHz has been employed to treat a malignant line of brain tumors that are implanted subcutaneously in mice. Animals in which one flank tumor is heated to 42 °C for two hours exhibit resorption of malignant tissue, while an un-

treated tumor in the contralateral flank continues to grow. Since 1970, the same concept of local tumor hyperthermia has been used to treat malignant brain tumors of human patients. An immersible heat probe was developed that contains a resistive element heated by direct current. Intratumoral probe temperature can be selected and maintained automatically. For example, the probe can be maintained at a temperature of 42 °C for one or more days, during which time antitumor drugs are continuously administered. Then the probe is removed and a craniotomy is performed in order to remove the devitalized tumor tissue. The same objectives have led investigators at the University of Maryland to develop an ultra-thin microwave probe that can be implanted surgically into deeply placed, non-resectable, malignant tumors of the brain.

The most challenging problem in the treatment of malignant tumors is presented by cases in which multiple metastatic lesions originating elsewhere in the body have spread to the brain. Multiple deposits of malignant tumors make it apparent that hyperthermia of the entire brain will be required to heat all of the tumor cells present. It will probably be necessary to employ an array of microwave applicators, rather than a single applicator, in order successfully to heat the brain. Much research on animals in this area remains to be done, including post-irradiation tests of behavioral and neurological competency, to insure that normal tissues of the brain have not been damaged.

Within the next decade, it is likely that heating by RF energy will become one component of a standard regimen that combines X-radiation and chemotherapy with hyperthermia of tumors. Recent important technical advances and the increasing scope of research on biological effects of RF radiation are paving the way to a genuine breakthrough in cancer therapy.

Education of the Public on Effects of Low-level Radiation: Mankind's technological progress has generated numerous products and byproducts that, as revealed in a seemingly unending series of disclosures, result in real and potential hazards to health and life. A partial listing includes automobiles, aerosols, cigarettes, asbestos, insecticides, fertilizers, food additives, plastics, fossil and radioactive fuels, aluminum wiring, stepladders, chemical processing, drugs, and medical devices. With each disclosure—augmented ironically by technological diagnostic advances in the health and environmental sciences—the general public and those who are involved occupationally are made aware of the increasing list of hazards. Sometimes the bad news is disseminated immediately by the mass media through *their* improved technologies. The concern of individuals who are subjected to each hazard, and the actions they take or fail to take to gain protection, depends largely on the amount and quality of their information, their degree of understanding, and their collective judgment of benefits and risks, as expressed through the political process. With the recently developed public awareness and, in some quarters, intense concern with real and potential hazards of RF energy, we who are technically involved and knowledgeable about the development, applications, and consequences of this form of energy have, in turn, become acutely, sometimes painfully aware that the product of our professional involvement has been added to the "disclosure list," and that we have come of age in this aspect of our technologically based society. Whereas a decade ago we were concerned with the curiously large discrepancy between U.S. Guidelines for microwave exposure and the Eastern European permissible exposure standards, the latter of which are based on a mild neuropsychiatric syndrome ("neurasthenia"), we now are faced with a public concern for cancer, cardiovascular disease, stillbirths, birth defects, and blindness, all of which are alleged to result from occupational and general-population exposure to microwaves at very low levels —typically below those associated with Eastern European standards. Also, officials of local jurisdictions under public pressure seem ready to act with little or no qualified information to impose highly restrictive limits of exposure.

What now remains to be seen, and what is essentially the charge to COMAR under its charter as a contributor to public understanding, is whether technically valid information can be imparted to the public and to its representatives that would enable them to arrive at rational decisions and enactments. The IEEE has demonstrated its professional and moral concern for health issues in RF radiation by its co-sponsorship, with the U.S. Navy, of the Radiation Hazards Standards Project of the American

National Standards Institute, which has resulted in a continuing series of reports, the first published in 1966, on the Safety Level of Electromagnetic Radiation With Respect to Personnel. The IEEE served as an early supporter of scientific symposia on biological effects of electromagnetic energy by sponsorship of meetings, through the aegis of the Microwave Theory and Techniques (MIT) Society, that attracted the interest of biologists as well as engineers. And in establishing COMAR in 1972, IEEE demonstrated an early recognition of the need for dissemination and interpretation of technical information to the public. However, the efforts of the past, if simply continued, might not be any more adequate in the present climate of opinion to the nurturing of public understanding than they have been in preparing the public to evaluate the proclaimed "disclosures." The focus of effort needs to be changed and expanded.

Today, there is no lack of dissemination of technical information on research reports of biological effects, and the number and technical quality of these researches are on the rise. There is now an abundance of scientific meetings and workshops, and the technical reviews suitable for the scientific community are plentiful and still increasing. Much of the public concern has resulted from the piecemeal translation of this technical information into lay terms by writers for the mass media who, however well meaning and highly skilled as communicators, are poorly informed about science and engineering. Two factors are lacking that can be redressed. One is competent interpretation of the technical literature for public consumption. The second is the education of the public on the nature of scientific information: How this information is related to standards' setting; how the limits of present knowledge necessitate further research; and how to distinguish between effects that are based on scanty scientific information that cannot be decisively interpreted, and potential effects that are based only on conjecture or imagination that should not be interpreted, however fearful such imagined effects might be. Armed with this type of information, public evaluation of "disclosure" reports is more likely to be rational, unreasoned public decisions less likely, and an understanding of future developments and applications of RF energy more readily established. The means for conveying this type of educational material cannot be set forth in great detail, but some of the needs can be outlined in a series of propositions. The list is not exhaustive, and serves merely to indicate the type of information that needs to be disseminated.

1. *Not all biological effects are hazardous.*

To be hazardous, a biological effect must have certain properties, i.e., those of non-recovery or persistance, the criteria of truly pathological or disruptive conditions.

2. *Knowledge of biological effects is finite.*

At any given time, knowledge of biological effects (including hazards) consists only of those phenomena and mechanisms that have been reliably demonstrated. Only positive experimental findings contribute to this knowledge. Negative experimental findings are non-informative except for the highly particular circumstances in which any one experiment is conducted. It is impossible to conduct an infinite number of experiments, which would be needed to test all possible circumstances; consequently the experimental method cannot verify a *lack* of effect, cannot prove a negative.

3. *Knowledge, to be reliable, must be based on independent confirmation of data, on generality over a range of conditions, and on correlation with other, previously established data.*

Reports of a single experiment, however provocative and important in potential implications or useful for guiding further research, seldom can be considered reliable until additional research has verified and extended the information.

4. *Guidelines for limiting exposures should be based on reliable knowledge of hazardous effects.*

The ANSI guidelines for limiting exposure to RF radiation are based on reliable knowledge of hazardous effects of heating, with an explicit factor of safety included to compensate for uncertainties of measurement and for environmental factors that could compromise the organism's ability to cope with heating. By mandate, the ANSI guidelines are subject to change if new knowledge of hazards is forthcoming, but as the only consensually validated mechanism of insult is hyperthermia, any reduction in exposure limits that might be based on supposition or suspicion of other hazards would carry no guarantee of "safety." No guideline can be a warrant for protection unless it reduces risks associated with a *known* hazard. This principle in no wise mili-

tates against the corollary principle that no agent should be tolerated at a higher level than that which necessitates or justifies its presence. A guide number is not an optimum but a maximum that best serves its intended purpose when the actual level of an agent is manifoldly less.

5. *Lowering of guideline numbers to reduce risks to unknown hazards is counterproductive.*

To lower the limits of RF exposure might impair utilization now and cripple future developments of RF energy ("benefit") without appreciably reducing known risks ("cost"). The benefit-to-cost ratio might be uselessly reduced with an overall loss to society.

6. *Some biological effects of low-level RF radiation have been experimentally verified in laboratory animals and human subjects; some effects are difficult to verify. In both cases, relevance to exposure standards is unknown.*

Some effects have been verified and related to other knowledge, sufficiently to be considered reliable, e.g., the auditory or RF-hearing response to pulsed microwaves, and altered membrane exchange or transport of calcium ions in *in vitro* brain materials in response to low-frequency electric fields and to pulsed microwaves. There is no evidence that these effects are hazardous. Some effects have not been adequately evaluated, verified or related to other knowledge to qualify yet as reliable effects, e.g., apparent changes of blood-brain-barrier permeability, alteration of experimental animals' response to drugs, and activation and altered excitability of the nervous system in experimental animals.

7. *Some potential biological effects of low-level RF radiation have not yet been tested, but are badly in need of evaluation.*

There are as yet no data on the biological response to ultra-long-term continuous exposure to RF radiation; the need for such experiments is critical.

8. *Some potential biological effects are primarily conjectural, are scientifically unfeasible, or are essentially irrelevant.*

It is highly conjectural, for example, to attribute the high relative incidence of cardiovascular diseases in cities of North Karelia (Finland) to exposure in that region to microwaves from remote Russian radar antennae. Not only is this link conjectural, but recent reports relate this condition to dietary and other risk factors that on the basis of extensive scientific and medical knowledge are of much greater relevance. Similarly, the alleged hazards of RF radiation from video-display terminals, when no measurable level of RF radiation exists, is also essentially irrelevant. These hypothesized hazards of microwaves are not only irrelevant, but are needlessly fear-provoking.

In summary, critical content analyses of "disclosure" reports should address these eight propositions, and should involve consultations with experts such as electrical engineers and public health professionals. These analyses would be valuable in helping the citizen to understand and interpret reports of hazards in the popular media. Because thousands of engineers among the IEEE's 190,000 members are qualified to speak to technical problems of RF radiation, there is a rich, largely untapped, geographically dispersed resource from which officials of local communities can obtain guidance and information.

Comments: There is a common thread that links all of these discussions. That thread is the restrictive bond of uncertainty. We have too many questions and too few answers. We can say with certainty that many of our Soviet colleagues believe that prolonged exposure to low-level microwave radiation results in a mild, reversible syndrome ("neurasthenia") that resembles chronic depression. We can say with certainty that a small but influential group of Americans believes that the horrors of cancer, heart disease, blindness, and birth defects are the legacy of exposure to the same weak fields. Notwithstanding the American penchant for one-upmanship, we cannot explain the basis for these beliefs on any other grounds than our belief that two factors are operating: 1) What is known scientifically by scientists is not understood by the public; and 2) what is unknown scientifically is feeding both public and scientific controversy.

The scientist, the engineer, the physician, and the legislator must all contribute to the goals of improved understanding. The fount of hard knowledge is the laboratory, but its creative products are conditioned by the ingenuity and material resources of the investigator. There is enough evidence now of low-level biological effects of RF waves that a concerted effort should be made to determine their *modi operandi*, their mechanisms of interaction.

To declare, as most contemporary American researchers do, that effects are not necessarily hazards is a truism that will not quell the fires of controversy. Needed are testable, experimentally falsifiable hypotheses of interaction that can set the stage for consensus. For example, there is virtually no doubt among scientists that the amount of energy being coupled to a non-resonant biological body in an RF field at a power density of 100 $\mu W/cm^2$ is not the stuff of brute force. The cubit of thermalized RF energy added to the energy of resting metabolism in an adult human being at this intensity of radiation is smaller by more than three orders of magnitude. Yet sinusoidally modulated RF waves at 100 $\mu W/cm2$ can produce reliable changes in behavior and in brain chemistry of mammals if sufficiently sensitive assays are used. Since brute force is not a factor, why not an alternate hypothesis that a *receptor* system is being activated by the RF "signal"? Receptors are biologically "tuned" elements that are sensitive to quantities of energy at the photon level (the mammalian retina) and can detect the minuscule perturbations of Brownian movement (the cochlea). Evidence from laboratories in Sweden and England indicates that the retina may indeed be the site of detection of weak magnetic fields. Other evidence from the U.S. indicates that neural tissue *per se* may function as a receptor of weak electromagnetic fields. Given testable hypotheses of field-receptor interactions, the investigator could structure and perform many experiments that in turn could lead to isolation of sensitive substrates and provide a biophysical account of the nature of the interaction.

The assumption of receptor-mediated effects does not preclude hazardous interactions. Conceivably, natural receptors of electrical or magnetic fields may play a role in orientation, navigation, and timing of biological rhythms, as theorized by R. Wever of the Max Planck Institute. And conceivably, artificially generated electromagnetic fields may act as sources of EMI; specifically, as sources of *biological electromagnetic interference* (BEMI). There is no direct evidence of BEMI, but such a concept is testable in the laboratory and exemplifies the sort of falsifiable hypothesis that can serve as a goad to fruitful experimentation.

The production of scientifically satisfying evidence, say, that a given weak-field effect is not a hazardous effect, would not solve the problem of public understanding. Well taken is the observation that new avenues of dissemination of information must be developed. The engineers of IEEE, at the behest of the Institute's General Manager, Richard Emberson, and through the aegis of COMAR, are attempting to consolidate plans to co-sponsor a special symposium in cooperation with prominent medical and scientific societies on biological effects of RF radiation. The intent is to recruit the best scientific, engineering, and medical minds to the task of preparing master lectures that treat extant knowledge in depth and are summarized in lay language by skilled writers. In recognition that science is not a monolith of absolutism and that its conclusions are always open to revision, the planners of the symposium will conduct it on an open basis and encourage formal discussion and criticism of each lecture by one or more experts. This effort would not solve the problem of unanswered scientific questions, but it would mark the beginning of an attempt to bring the science and technology of RF waves in an understandable way into the public's awareness.

The Congress and the Executive Office can do much to heal the breach of knowledge. Well conceived, well coordinated research is much needed—the one issue that finds all parties to the RF controversy in agreement—but the current fragmented efforts are unequal to the task. Long-term studies of effects of continuous exposure to low-level radiations are an imperative, but neither the funding, facilities, or incentives are available to inaugurate such studies.

The problems, if viewed only within the Federal research establishment, are manifold. Extramural programs of grant-supported research are virtually nil, victims of a trend toward contracted research that has resulted from a vicious circle—no study panels exist with the number and diversity of talents to provide expert peer review; in the absence of an expert panel, why submit a grant proposal? The problem is not that there is too much contracted research, or that contracted research is inferior, only that the grant process provides an alternate and productive means of adding to the store of scientific knowledge. In the marketplace of creative science, no better means has been found to capitalize on the open competition of ideas and talent.

Another problem involves the complex algebra

of agency priorities. There is recognition at the national level that RF radiation in the ecosphere is a high-priority issue. But within any given agency, RF radiation is relegated far below other, more pressing local problems that involve the agency's mission. In the Medical Corps of the Army, malaria poses more of an immediate threat than do RF waves. In the hospital system of the Veterans Administration (VA), alcoholism and schizophrenia are problems of greater moment. In the Environmental Protection Agency (EPA), automotive effluvia, toxic agents in sources of culinary water, and thermal pollution by nuclear reactors are more pressing concerns. And so it goes.

A way must be found to add up these low, within-agency priorities to reach the justifiably higher sum that will enable commitment of money, manpower, and time to an adequate, total program of research. Several years ago the suggestion was made to establish a new agency along the lines of the old AEC—the RF Energy Commission?—that would make a program of biological research its highest priority. This suggestion, if implemented, would create more problems than it would solve, if only because it would divorce from each agency its particular concern for RF waves. The EPA's environmental mission differs from the medical mission of the VA, which differs, in turn from the military mission of the Army, and so, too, for each of the Federal agencies, 13 in all, that are sponsoring in-house biological studies. The solution lies elsewhere.

Finally, there are the problems of coordination and oversight, which were intensified by President Carter's abolition of the Office of Telecommunications Policy (OTP) and subsequent relegation of its oversight committee, the Electromagnetic Radiation Management Advisory Council (ERMAC), to the Department of Commerce. Thirteen agencies, each with substandard commitments of time and effort to programs of biological research, are unlikely to be cost- and data-effective unless welded together in an enterprise that is coordinated at the highest level.

What, specifically, can the Congress do? The Committee on Man and Radiation recommends that it prepare legislation leading to:

1. Establishment within NIH or FDA of a study panel composed of scientists, engineers, and physicians of demonstrated competence in the area of biological effects of non-ionzing electromagnetic radiations. A corollary need is allocation of a line-item budget that is adequate to support a program of extramural research, which would be merit reviewed by the study panel, recommended by appropriate council, and funded by NIH or FDA. The National Science Foundation should also be considered as an independent and important source of extramural funding of research.

2. Enactment, after careful study of each agency's needs and means, of a mechanism for providing an intra-agency budget line for biological studies.

3. Re-establishment, at the level of the Executive Office, of a body that has responsible authority to provide scientific and fiscal oversight of Federal programs of research on biological effects of RF waves.

4. Reaffirmation and increased commitment of support for the USA-USSR program of scientific exchange in the area of biological effects of RF radiation. This program holds the greatest promise for near-term resolution of the politico-scientific issues that are feeding the fires of controversy.

The bottom line of these recommendations, if acted upon, is augmented Federal funding by a few millions of dollars annually for research that helps clarify the ifs, whens, and whats of RF hazards. A commitment should also be made to realize the great promise of RF technology in the area of medical applications. The alternative of maintaining the status quo might cost far more, both in tangible outlays for litigation, enforcement, and compliance, and in the intangible but painful toll of public unrest and uncertainty.

APPENDIX 3.

The Committee on Man and Radiation; A Commitment to the Public Interest

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The Committee on Man and Radiation: A Commitment to the Public Interest

Don R. Justesen

Victor Hugo in Les Miserables wrote of "...a devine and terrible radiance that transfigures the wretched." I would be taking excessive literary license were I to claim that Hugo foresaw the successful remission of terminal cancer by application of intense radiowaves, yet his words are prophetic of developments in medicine that will enrich if not radically transform the oncologist's practice. In another sense, the terms "devine" and "terrible" are apropos in that they identify the extremes of professional and public attitude toward microwaves and other radio-frequency (RF) electromagnetic radiations. Few persons will deny the blessings of safer navigation, better communication, and faster transportation that are enabled by radio waves and their associated electronic technologies, although some have voiced the opinion that these gains might have been won at the expense of the public's well being.

There is always a loss or exchange with every technological advance. Sometimes the loss is personal but difficult to gauge, as when privacy and literacy were curtailed by mass production and widespread use, respectively, of the telephone and television. Sometimes the loss is more compelling, as in the realization that X-ray diagnosis compromises the lives of some patients while saving the lives of thousands more. Whatever the loss or gain, it is the net advantage or disadvantage that must be weighed. The potential trade-offs that are incumbent with man-made emitters of electromagnetic energy are therefore legitimately associated with concerns for the safety of those who make and of those who use the products of RF technology. The Committee on Man and Radiation (COMAR) was

born of these concerns.

In 1972, Leo Young and Mark Grove, both electrical engineers and members of the Institute of Electrical and Electronic Engineers (IEEE), observed that no formally constituted body of scientists existed in the United States with a collective expertness in physical, engineering, biological, and medical aspects of non-ionizing electromagnetic radiation. In contrast, there were (and are) many public and private assemblies with a charge to evaluate effects of ionizing radiations. To fill the void, COMAR was established as a voluntary activity of the Technical Activities Board of IEEE, and Mark Grove became its first chairman. From its inception until the present time, COMAR has numbered among its membership both engineers and representatives of the life-science disciplines, including medicine. Representation of public and private, industrial and academic institutions has been the rule as has geographical dispersion of members across the North American continent.

Mark Grove was succeeded as Chairman of COMAR by Allen Ecker in 1974, who in turn was succeeded by me in 1977 when Dr. Ecker left Georgia Technological Institute for a private position. At the present time, COMAR's working membership comprises 30 persons whose names, specialties, and affiliations are given in the Appendix.

The fundamental charge to COMAR's members is to educate. Nominal responsibility is to the international membership of IEEE, which numbers more than 190,000 engineers and applied professionals, tens of thousands of whom work in close proximity to RF waves and are among those most likely to suffer insult from excessive exposure to RF radiations. Mandated responsibility is also to the public, which, in keeping with IEEE's long history of public service and concern, must be safeguarded from ill

effects that might arise from products of the electrical engineering art.

COMAR is not a monolith of opinion. While its members are recruited for their excellence as scientists or practitioners, there is no "party line" to which they subscribe. Indeed, on two occasions within the past year I have been involved as a consultant in legal matters in which one or more members of COMAR have provided testimony for "the other side." I recall one incident in which a member of COMAR, a Fellow of the IEEE, was surprised to learn that he and I, respectively, had been asked to testify by counsel for plaintiffs and counsel for defendants in a pending suit over a radar installation. But his surprise in no wise diminished the candor, commitment, or cooperation that he gave his counsel--or that I gave mine. (As it turned out, we both offered much the same technical advice and, perhaps coincidentally, the suit was dropped before coming to trial).

No, COMAR is not a monolith of opinion, but a forum in which specialists exchange information and views, a sounding board by which the significance of experimental results are evaluated, and a gathering point around which theory and data, cause and effect, and predictability, probability and prevention are debated and deliberated.

The members of COMAR respond to their charge to educate in many ways. I have already mentioned legal consultations. In addition, the members participate in meetings of the Institute and of allied engineering societies; they conduct formal courses; they appear on radio and television; they draft position papers; they write letters, reviews, and editorials; they participate in groups that advise the Congress and the Executive Office; they support and take part in programs of international scientific exchange; and, of course, they participate in activities of many professional and

scientific societies. One example of such participation is the April, 1979 Symposium on Microwaves that was sponsored by the New York Academy of Medicine and gave rise to the special issue of the Bulletin in which this paper appears; of the 15 working scientists who presented papers, nearly half were members of COMAR. Another example is the January, 1980 Annual Meeting of the American Association for the Advancement of Science in San Francisco, which will feature a special symposium on Microwaves in Biology and Medicine. This symposium was initiated by and will feature many members of COMAR.

There are many unanswered--and unanswerable--questions about biological effects of RF radiation; the members of COMAR make no pretense of omniscience and do not hesitate to acknowledge hiatuses in the current base of biomedical data. On the other hand, the members are quick to recognize that absence of knowledge is not an invitation to pessimistic and precipitous judgement; that hard propositions from scientific study, not loose assertions, are the best guide to policy and action; and that prudence, not ill-advised presumption, must guide the continuing evaluation and re-evaluation of potential hazards of RF radiation.

The members of COMAR do take justifiable pride in the collective expertness of their Committee. Consequently, they disdain the unfounded speculations that have been offered as gospel to the public by apocalyptic expositors who lack critical judgment or scientific credentials. The members' reaction to the unreasoning person and the unreasonable proposition is well in accord with Lord Russell's dictum: Let not non-experts disagree when experts are in agreement.

Experts do not always agree, especially when a scientific book has as many unfinished chapters as that which records the influence of RF

radiations on biological systems. Three issues of particular concern to COMAR's members are all focussed on the unresolved question of effects of ultra-long-term exposure of human beings to fields that range upward in intensity from 100 $\mu W/cm^2$. These issues are identified with industrial RF heaters, thousands of which are being operated in the plastics, leather, and lumber industries by women of child-bearing age; with the small civil but relatively larger engineering populations that are exposed to emissions associated with VHF television and FM broadcasts, which are at critical wave lengths with respect to resonant (enhanced) absorption of RF energy by human beings; and with the proposed solar-powered satellite, which would shower the biosphere with microwaves for decades of time. A fourth issue arises from the increasing clinical use of RF diathermy. These deliberate and sometimes life-saving exposures to highly intense radiation are in need of much further evaluation for possible adverse sequelae.

The concern for unresolved issues is being addressed with the disclipine that must characterize a credible scientific body. The most pervasive flaws in the arguments of persons who perceive biological dangers in weak RF fields are those of equating effects of X and gamma radiations with those of RF radiations; of identifying effects of extremely high levels of RF radiation with those at low levels; of confusing hygienically trivial effects with hazardous effects; and of assuming that the <u>absence</u> of data--as opposed to presence of damning data--is implicative of adverse influences. Discipline is founded upon the insistance than positive, reproducible reports must underlie useful and enforceable propositions about the nature and hazards of RF waves.

As the sole private body of experts in the U.S. that is charged to evaluate and educate with respect to biological influences of RF radiation, COMAR has an important obligation to its parent institution that is inseparable from that to the public at large. In this connection, I note that no one has contributed more to mankind's material progress than has the engineer. And no one has more concern than the engineer that the wonderous machines of his making serve well and do not injure the larger community of which he is an indispensible and caring member. If this endorsement appears self congratulatory, I hasten to add that, like many members of COMAR, I am not an engineer. My formal training lay in experimental psychology and technical philosophy; my professional associations are in academic and investigative medicine. These disciplines do not endow one with expertness in engineering, but they do promote the capicity to understand the engineers--and to comprehend their admirable concern for and contributions to human welfare and progress.

The engineer has long enjoyed a vocation of technical excellence that is shaped by a compassionate regard for the general public he has been trained to serve. This inseparable technical and social commitment has been and will be the mainspring of activities and judgments by the Committee on Man and Radiation.

SUMMARY

The origin, scope, and charge of the Committee on Man and Radiation (COMAR) are discussed in relation to its sponsor and its parent society (The Technical Activities Board of the Institute of Electrical and Electronic Engineers), its international membership, and its activities. The purview of COMAR is the radio-frequency (RF) electromagnetic spectrum, which ranges in frequency between D.C. and three terahertz (between 0 and 3×10^{12} Hz) and includes the emissions of power lines, radio, television, radar, and other sources of non-ionizing electromagnetic radiation. The charge to COMAR's members is to analyze scientific data that bear on the biological response to RF fields and to interpret implications of these data for the safety and well being of the Institute's membership and of the general public. The collective expertness required of COMAR's charge is provided by a working membership of 30 engineers, physicists, life scientists, and physicians, all volunteers, who are drawn from private and public, industrial and academic sectors in the United States and Canada. Because of its broad interdisciplinary membership, COMAR is a singularity in the IEEE and, indeed, is the sole body of North American experts on biological effects of RF fields whose advocacy is the public interest.

Appendix

1979 Roster of Working Members

Committee on Man and Radiation
Institute of Electrical and Electronic Engineers

Don R. Justesen, Ph.D., Chairman
Neuropsychologist
U.S. Veterans Administration

Eleanor Adair, Ph.D.
Physiological Psychologist
John B. Pierce Foundation
and Yale University

Peter Barber, Ph.D.
Biological Engineer
University of Utah

Fred L. Cain
Physicist
Georgia Institute of Technology

H. Allen Ecker, Ph.D.
Electrical Engineer
Scientific Atlanta, Inc.

Richard Frankel, Ph.D.
Biophysicist
Massachusetts Institute of Technology

James W. Frazier, Ph.D.
Biophysicist
University of Texas

Carl. L. Frederick, Sr., D.Sc.
Electrical Engineer
Private Practice

Om P. Gandhi, Sc.D.
Biological Engineer
University of Utah

H. Mark Grove
Electrical Engineer
Department of Defense

William B. Grupen, Ph.D.
Materials Scientist
Bell Laboratories

Arthur W. Guy, Ph.D.
Biological Engineer
University of Washington

Louis N. Heynick
Physicist
Stanford Research Institute

Edward L. Hunt
Experimental Psychologist
Walter Reed Army Inst. of Research

William M. Leach, Ph.D.
Radiation Biologist
Food and Drug Administration

Justus F. Lehmann, M.D.
Rehabilitative Specialist
University of Washington

James C. Lin, Ph.D.
Biomedical Engineer
Wayne State University

Daniel McGlynn, Ph. D.
Biophysicist
Rockwell Corporation

[Continued next page]

J.G. Miller, Ph.D.
Physicist
Washington University

John C. Mitchell
Physicist
Air Force School of Medicine

William M. Mumford
Electrical Engineer
Bell Laboratories (Emeritus)

Stuart Nachtwey, Ph.D.
Radiation Biologist
Nat'l Aeronautics and Space Adm.

John M. Osepchuk, Ph.D.
Microwave Engineer
Raytheon Company

Peter Polson, Ph.D.
Biological Engineer
Stanford Research Institute

Elliot Postow, Ph.D.
Biophysicist
Department of the Navy

Fred J. Rosenbaum, Ph.D.
Electrical Engineer
Washington University

Moris L. Shore, Ph.D.
Radiation Biologist
Food and Drug Administration

Maria A. Stuchly, Ph.D.
Electrical Engineer
Health and Welfare Canada

Carl H. Sutton, M.D.
Neurosurgeon
University of Miami

W.A. Geoffrey Voss, Ph.D.
Electrical Engineer
University of Alberta

Max Weiss, Ph.D.
Physicist
Bell Laboratories

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APPENDIX 4.

August 6, 1979

The Honorable Jerome A. Ambro
Chairman, Subcommittee on Natural
Resources and Environment
Science and Technology Committee
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Ambro:

During the July 12, 1979 Oversight Hearing by the Subcommittee on Natural Resources and Environment of the Committee on Science and Technology of the United States House of Representatives, Dr. Don R. Justesen testified about the abundance of misinformation about RF radiation and the harm that this misinformation can cause.

AHAM is in full agreement with Dr. Justesen that such misinformation abounds. In fact even the Boston Globe which he believed was worthy of positive mention, on June 21, 1979 succumbed and headlined an article on "Uranium Tailings, A most severe radiation problem" with the caption "800,000 in Salt Lake City live in 'microwave oven.'"

While AHAM attempts to correct such misinformation when it is brought to our attention, AHAM's record of success is less than adequate.

AHAM would like to recommend that the Subcommittee's report on the oversight hearing urge the Bureau of Radiological Health of the Food and Drug Administration to move more aggressively to counter and correct misinformation about RF radiation particularly as it relates to its use in electronic products. Perhaps an information program designed to educate the public about this most useful form of energy would be helpful.

Sincerely yours,

Robert Holding

Robert L. Holding
Vice President
Federal Relations

RLH:chk

APPENDIX 5.

Food and Beverage Trades Department
AFL-CIO

WILLIAM H. WYNN
President
ROBERT F. HARBRANT
Secretary-Treasurer

July 20, 1979

Honorable Jerome A. Arabro, Chairman
Subcommittee on National Resources & Environment
House Committee on Science & Technology
2319 Rayburn House Office Building
U.S. House of Representatives
Washington, D.C. 20515

Dear Sir:

The Food and Beverage Trades Department, AFL-CIO, is concerned with the potential long-term, chronic health effects of non-ionizing radiation, a topic addressed by your subcommittee in hearings on July 12, 1979. Among our 2.75 million members are employees in the tobacco, bakery and restaurant industries who work with microwave ovens on a daily basis. We are concerned that the health of these workers may suffer as a result of this occupational exposure.

Research findings on the health effects of non-ionizing radiation are sparse but alarming. We believe that there is a pressing need for more research on this subject, including both epidemiological and animal studies. We further think it essential that such research be conducted and coordinated by Federal agencies specifically charged by Congress with the protection of public health. The conflict of interest which can arise when "user agencies" conduct health effects research can and must be avoided.

We encourage your support of high quality, unbiased research on non-ionizing radiation. Prevention of disease can only be achieved by diligently studying and attacking potential health problems; rather than reacting to a dead body count!

Sincerely,

Robert F. Harbrant

Robert F. Harbrant
Secretary Treasurer

[illegible] ENTH STREET, N.W.
W[illegible] ...STON, D.C. 20006
(202) 347-2540

HCP/EV-1802
UC-11, 97a

APPENDIX 6.

Review of State/Federal Environmental Regulations Pertaining to the Electrical Effects of Overhead Transmission Lines: 1978

January 1979

Prepared by
Dr. K. R. Shah, P.E.
Shah & Associates Inc.
Gaithersburg, Maryland

Prepared for
U.S. Department of Energy
Assistant Secretary for Environment
Division of Environmental Control Technology
Under Contract No. EV-78-X-01-1802-0

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EXECUTIVE SUMMARY

Since the introduction of the National Environmental Protection Act (NEPA) of 1969, many federal and state agencies have enacted legislation to minimize the impact on the environment traversed by new transmission lines proposed by the nation's electric utility industry.

Initially, the major thrust of these regulations was in the category of "transmission line aesthetics." Lately however, because the public became more informed and educated on other aspects concerning the safety of overhead lines and with the increase in the number of miles of overhead extra-high voltage (EHV) transmission lines, the emphasis has shifted to the electrical effects of overhead lines designed for operation at 230 kV and above. Electrical effects of overhead transmission lines are corona-generated effects consisting of radio and television interferences, audible noise emission, ozone generation, and ion drift; induced voltage effects on humans, animals, and metallic objects; ground current potential effects; and conductive coupling effects. In recent years, some state agencies have introduced regulations for limiting the electrical effects of the proposed overhead transmission lines. These limitations are imposed through either state enacted legislation or through the certification process.

To develop this report, appropriate agencies of the state and federal government were contacted to obtain existing and proposed

legislation dealing with these electrical effects. This report reviews these regulations through June, 1978. It makes no attempt to review either the design of transmission lines, operation and maintenance practices of any electric utility, or proceedings of all certification applications submitted to the states by the electric utilities. The following conclusions were derived:

a. Only 27 states had enacted legislation enabling the preparation of environmental impact statements for the proposed transmission lines. Two others, New Jersey and Delaware, have to comply only with coastal zone permit regulations. All these states are required to address the impact of the electrical effects of overhead transmission lines on the environment traversed.

b. Concerning interference to communication facilities, 26 states, the Federal Communications Commission (FCC), Rural Electrification Administration (REA), and the Office of Nuclear Reactor Regulation (ONRR), require evaluation of the impact on and implementation of measures to protect the quality of radio and television reception and other communication facilities. However, neither the states nor the responsible federal agencies have developed guidelines or quantitative values for evaluating performance.

c. Concerning public safety and comfort, 28 states, the REA, and the ONRR require evaluation of public safety and comfort and undue hazard to property along the area traversed by the proposed lines during construction, operation, and maintenance. Only Oregon limits the electric field to 9 kV/m ac rms maximum within the right-of-way. No other state or federal agency has established any quantitative value on maximum permissible electric field strength at ground level. However, because most of the states have adopted the National Electrical Safety Code, they will have to design overhead lines so as to limit the current due to electrostatic effects to 5 mA (rms). There are no quantitative limits or nonquantitative requirements from any state concerning magnetic fields generated by overhead lines.

d. Concerning noise pollution, there are 24 states with enabling legislation for noise control. Only 10 states have established noise guidelines. The permissible audible noise emission limits at the property line vary from 40 to 70 db(A). Also, the permissible sound pressure levels at various octave band frequencies vary from state to state.

The EPA, which has the primary responsibility for noise source emission regulations, has identified requisite noise levels to protect public health and

welfare for a large number of situations.

The REA and the ONRR require estimation of audible noise during the operation of transmission lines and a discussion of any corrective measures to minimize the impact of this noise.

e. Concerning air quality, 28 states have enabling legislation for air quality. Twelve states and the EPA have air quality standards dealing with ozone and oxides of nitrogen emissions. The EPA has the following standards:

Ozone:	0.08 ppm (by volume) not to be exceeded more than once a year.
Oxides of nitrogen:	0.05 ppm maximum annual arithmetic mean.

I. INTRODUCTION

Since the introduction of National Environmental Protection Act (NEPA) of 1969, federal and state agencies have enacted legislation to minimize the impact on the environment traversed by proposed transmission lines.

Initially, the major thrust of these regulations was to provide "transmission line aesthetics." However, because, the public became more informed and educated on other aspects concerning the safety of overhead lines and with the increase in number of miles of overhead extra-high voltage (EHV) transmission lines, the emphasis shifted to the electrical effects of overhead lines designed for operations at 230 kV and above. In recent years, some state agencies have introduced legislation and guidelines for limiting the electrical effects of the proposed overhead transmission lines.

The purpose of this report is to review environmental regulations pertaining to the electrical effects of overhead transmission lines. This report discusses environmental regulations of all the states and federal agencies and gives any quantitative values available. It does not attempt to review either the design, operation, and maintenance practices of any electric utility on the proceedings of certi-

fication applications submitted to states by the electric utilities. Instead, it highlights general concerns and trends.

Electrical environmental effects of overhead transmission lines are classified (Ref. 1) as follows:

a. Corona generated effects:
   1. High frequency interference including radio interference (RI) and television interference (TVI)
   2. Audible noise emission
   3. Ozone generation
   4. Ion drift for HVdc lines

b. Induced voltage effects on humans, animals and metallic objects resulting from:
   1. Electrostatic coupling
   2. Electromagnetic coupling

c. Ground-current potential effects

d. Conductive coupling effects

Most of the regulatory agencies have developed impact evaluation guidelines into the following four areas:

a. Interference to Communication Facilities
b. Public Safety and Comfort
c. Noise Pollution
d. Air Quality

Hence, in this report, both radio and television interferences will be discussed in the section entitled: Interference to Communication Facilities; induced voltages, ground current potentials, and conducive coupling effects and corona generated "ion drift" phenomena of HVdc lines will be discussed in the section entitled: Public Safety and Comfort; audible noise emission will be discussed in the section entitled: Noise Pollution; ozone generation will be discussed in the section entitled Air Quality. A brief summary of these electrical effects preceeds each discussion of the regulations.

II. ENVIRONMENTAL REGULATIONS: ANALYSIS AND ASSESSMENT

Electrical utilities have to comply with state regulations for the construction, operation, and maintenance of overhead transmission lines. In some cases, they may also have to comply with federal regulations, since there are times when federal approval is required.

Environmental regulations pertaining to the electrical effects of overhead transmission lines are therefore classified into following categories:

a. State regulations
b. Federal regulations.

A. METHODOLOGY

Appropriate agencies of each of the states and federal government were contacted by telephone to obtain existing and proposed legislation dealing with these electrical effects. Even though the specific names of the agencies contacted varied from state to state, the following is a list of state and federal agencies which supplied official documents on which this report is based:

State Agencies:

1. Public Utility Commission
2. State Environmental Protection Agency
3. Department of Ecology
4. Department of Noise Control
5. Department of Air Quality
6. Department of Health

Federal Agencies:

1. Federal Communication Commission (FCC)
2. Environmental Protection Agency (EPA)
3. Department of Defense (DOD)
4. US Nuclear Regulatory Commission (USNRC)
5. Bonneville Power Administration (BPA)
6. Tennessee Valley Administration (TVA)
7. US Department of Interior-National Park Services
8. Federal Bureau of Land Management (BLM)
9. US Department of Agriculture-Rural Electrification Administration (REA)

B. ASSESSMENT OF REGULATIONS

1. State Regulations

All of the 50 states have some regulations for the safety of the public and property in proximity of the line. As a result, electric utilities design, operate, and maintain the transmission lines to meet safety requirements even though some states do not require preparation of an environmental impact statement for the proposed transmission facility.

Analysis of the state regulations (Ref. 2-86) revealed that 25 states have enacted legislation requiring the preparation of environmental impact statements for proposed overhead transmission lines with respect to electrical effects (Fig 1). Two states, New Mexico and Wyoming, require environmental impact statements, but not specifically for electrical effects. Additionally, two other states, New Jersey and Delaware, have to comply with coastal zone permit regulations. For the remaining states where there are no such requirements, state regulations, however, are such that the state regulatory agencies responsible for granting permission to construct overhead lines do have the final authority in determining the effects of the proposed facility

on the safety, health, and welfare of the public and property.

Table-II shows, voltage levels above which these regulations apply varies from 60 kV for Nevada, to 400 kV for Kentucky. Also, the minimum line length above which these effects will have to be addressed at permissible minimum voltage levels vary from 0 to 10 miles. No definite trend or rationale can be established for these wide variations.

2. Federal Regulations

All federal agencies, by law, are required to issue environmental impact statements for the proposed overhead transmission lines. Table-I summarizes a list of federal agencies responsible for development or implementation of electrical environmental regulations.

III. INTERFERENCE TO COMMUNICATION FACILITIES

A. SUMMARY OF HIGH FREQUENCY INTERFERENCE EFFECTS

Interferences from overhead lines to communication facilities are produced by:

1. 60 Hz steady state voltages from electromagnetic and electrostatic coupling.

2. Harmonic noise voltages induced in telephone and railroad communication circuits due to harmonic currents in ac and dc overhead lines at frequencies varying from 60 Hz to 200 kHz.

3. Corona discharges from conductors, insulators and hardware which to noise currents and voltages at frequencies ranging from 0.1 to 100 MHz.

Communication facilities of general interest in environmental routing of overhead transmission lines are: radio and television transmitters and receivers, telephone lines, railroad communication circuits, microwave transmission facilities, radar sites, and other military installations.