done in a concentrated form for the alternatives.

Samuel Koslov, an aide to Marcy, has made a rough estimate that the development of an alternative, light weight compact reactor could cost from $6 billion to $7 billion. Other scientists have estimated it could take as long as 10 years. ($6 billion to $7 billion is the amount of increase in the Navy procurement budget—most of which is shipbuilding—which the Department of Defense has officially attributed to inflation.)

A senior naval expert alleges that in the mid-1960's Rickover should have instigated long-range research into light weight reactors which could be paying off today in the form of some definite answers as to whether to employ them. "Hopefully, our new models will employ 20 years of technology and will be more advanced. . . . No technology will help submarines more than improving their power plants. . . . But because of this technical censorship, today we have nothing. We're just pouring money down the drain to get marginal improvements in the PWR's."

At present, two issues remain unresolved. One is whether the technical evidence warrants the Navy or ERDA undertaking a long-term basic research effort devoted to all facets of light weight nuclear propulsion technology—including the reactors. Whether such a program is timely is by no means clear, and the fragmentation and secretive political environment in which such studies have been conducted has done little to elucidate the question. The answer also cannot be resolved without open discussion between Rickover's experts in this area and knowledgeable, but independent, outsiders.

### Weinberg, Ray Back Research

*Science* solicited the opinions of two prominent scientist administrators in the nuclear field, Alvin Weinberg, the long-term former director of Oak Ridge, and Dixy Lee Ray, former chairman of the AEC, on this question. Both replied unequivocally that they thought such a program should be going on. Weinberg said:

> The matter of ship propulsion is so important a matter that it is imprudent to view the matter with technical blinders. There should be an effort that is sufficiently serious to really determine what the situation is regarding alternate systems in addition to pressurized water reactors. On various occasions, I have urged that alternatives be looked at.

Ray said:

> I do believe the Navy should be looking at alternate reactor propulsion systems. I believe the technology is available for alternate nuclear propellants. The Navy must look at this if it is doing its job and making preparations and planning for the future.

The second unresolved issue is whether, if such a program were undertaken, it would be under the direction of Rickover. Marcy told *Science* that if ONR received "brilliant and imaginative" proposals for light weight nuclear propulsion systems, it would probably send them to Rickover's office for consultation. In fact, he added, if they warranted funding, perhaps Rickover's office, rather than ONR, should sponsor the research. The opposing school of thought is that this course would too much resemble turning the fox loose on the chickens, or, more precisely, turning the chickens into the foxes' den. "There can be no serious work on alternative reactor systems until after Admiral Rickover is gone," one scientist gloomily predicted.

Both unresolved issues may come under active study this summer, when the National Academy of Sciences' Naval Studies Board, a group of non-Navy scientists and engineers, takes a sweeping look at missing links in Navy research. And the Naval Research Advisory Committee, which advises ONR on research problems and in the past avoided tangles with Admiral Rickover, is reported to be actively interested in studying the issue.—DEBORAH SHAPLEY

# Project Seafarer: Critics Attack National Academy's Review Group

The Navy's controversial Sanguine/Seafarer communications system has encountered rough seas in recent weeks. It has received a rousing vote of "don't put it here" from residents of the Upper Peninsula of Michigan, the site most favored by the Navy after two other sites were abandoned because of citizen opposition. Part of its budget has been targeted for slashing by two congressional committees. And a National Academy of Sciences committee that is examining possible biological and ecological effects of the system has been hit with charges that it is "rigged" and "biased," an allegation which distinguished members of the committee indignantly deny, while retorting that their critics are themselves biased. Whatever the merits of the flaps at the Academy, some participants believe it has revealed serious flaws in the procedures by which the Academy seeks to ensure that its committees are balanced or objective in outlook.

The communications system at issue has been under development by the Navy for some 17 years at a total cost so far of about $100 million. Its chief goal is to provide assurance that, in the event of a nuclear war, orders to retaliate would get though to the submarines that carry nuclear-tipped missiles. The communications systems now in use require submarines to place an antenna at or near the surface of the water, thus rendering them potentially vulnerable to enemy detection. But the proposed new system would use ELF (extremely low frequency) radio transmissions that can penetrate hundreds of feet below the surface and, according to the Navy, are virtually impossible to disrupt by man-made jamming or natural interference.

The system originally proposed by the Navy—known as Project Sanguine—was to be mammoth in scale. Some 6000 miles of antenna cable were to be buried in northern Wisconsin in a grid-like pattern covering some 22,500 square miles (41 percent of the state). The area was chosen largely because the underlying rock—the Laurentian shield—does not conduct electricity easily, a circumstance which enhances the efficiency of the antennas. Transmitters were also to be buried, thus making the system relatively impervious to enemy attack.

But political opposition drove the project from Wisconsin, and also from a fallback site in Texas. There were fears the system would attract an enemy strike against the area that accepted it or that it would drive down property values. There were assertions that it really was not vital, or even desirable, for military purposes. And there were worries that it would be harmful to the environment, as well as to animals and people who would be exposed to electromagnetic radiation.

As the outcries against Sanguine mounted, the scale of the proposed system shrank and it lost some of its planned capabilities. Project Seafarer took the place of Sanguine. The Seafarer system now under consideration would encompass only 3000 to 4000 square miles. Its antenna cables, buried 3 to 6 feet below the surface, would be fed by transmitters (far fewer than in the Sanguine system) that would be housed on the surface, where they could not survive an enemy attack. Nevertheless, the Navy contends there are many war scenarios in which the Seafarer capability would be important.

Three sites are currently under consideration for Seafarer—the Upper Peninsula of Michigan, which has the same underlying rock formation as the originally preferred Wisconsin site; an Air Force base and atomic test site in Nevada; and an Army base in New Mexico. The Navy prefers the Michigan site because it would cost about $300 million less to build the system there and because the underlying geology in Michigan would enhance transmission speed and area coverage. But referenda held in the affected areas during the recent Michigan primary elections produced overwhelming votes against Seafarer. The referenda were advisory and are not binding on anyone, but Michigan political leaders have been positioning themselves for a possible graceful decline of the Navy's advances. The Navy has pledged that it will not try to build in Michigan if the governor objects.

Future prospects for placing the system anywhere may depend in large part on the findings of a National Academy of Sciences committee that is reviewing the existing information on biological and ecological effects of electromagnetic radiation at Seafarer frequencies. The committee was set up at the request of the Navy because of continuing controversy over whether radiation from Seafarer might harm animals, plants, humans, or other organisms. There have even been charges (stoutly denied by the Navy) that data indicating a possible hazard have been suppressed or minimized. Thus the Academy analysis is considered an important outside evaluation of the evidence. But even before it has started to compose its initial, preliminary report (due out in August), the committee has found itself engulfed in the controversy it is supposed to allay.

The attack on the Academy has come from separate groups of researchers at the Veterans Administration Hospital in Syracuse, New York, and at Michigan Technological University, located in Houghton, near the heart of Seafarer country on the Upper Peninsula. The complaint by both groups is the same—that the Academy has loaded its committee with scientists who are almost certain to endorse the Navy's view that Seafarer is not harmful, while excluding scientists apt to take the opposite view. However, the charge is called "ridiculous" by committee chairman J. Woodland Hastings, who is head of biology at Harvard. He contends that the 16-member group includes a reasonable balance of viewpoints and expertise.*

The chief basis for the charge that the committee is loaded is that three of its members—Sol M. Michaelson and Morton W. Miller, of the department of radiation biology and biophysics at the University of Rochester, and Herman P. Schwan, of the department of engineering at the University of Pennsylvania—have already written research reports or given testimony indicating that they do not believe ELF fields similar to those under discussion would be hazardous.

### Past Public Statements

Michaelson and Schwan participated in a 1974 Academy study which concluded, with respect to ELF radiation, that "neither animal experimentation nor clinical studies have to date provided clear evidence of a harmful effect of human exposure to stationary or low-frequency electric fields." And all three have submitted expert testimony on behalf of utilities to the New York State Public Service Commission arguing that the fields produced by a proposed high voltage transmission line would not be harmful or unsafe to health or the general environment. The transmission lines would have a frequency and magnetic field comparable to that of Seafarer and an electric field some 10 million times stronger. In the opinion of two scientists who have been testifying on the other side of that New York case—namely, Andrew A. Marino and Robert O. Becker, of the Veterans Administration Hospital in Syracuse, New York—"it is inconceivable that the three named individuals will find that the Sanguine/Seafarer system is an environmental hazard, regardless of the evidence adduced." A group at Michigan Tech headed by Eunice Carlson, associate professor of microbiology, agrees and has urged the Academy to drop from the committee "all members who have gone on public record as believing that ELF radiation is not harmful."

However, the Academy, and the individuals involved, reject the notion that they have prejudged the issue. Miller told *Science* he considers the allegations of Marino and Becker, which were communicated to the Academy in a memorandum, to be "slanderous to my integrity . . . a personal attack which I really resent." He said the Seafarer system, in which electricity flows through the ground, is "entirely different" from transmission lines hung high above ground, just as the hazards posed by a radio become different when it is moved from its usual resting place and submerged in the bathtub beside you. Similarly, Schwan said he has not formed an opinion as to whether the Seafarer system might damage organisms underground, though he acknowledged that the evidence he has seen so far indicates there would be no harm above ground. After the criticisms were voiced, Schwan offered to resign from the committee but the other members urged him to stay on because they wanted his expertise.

Academy officials and committee members also contend that, no matter what the predisposition of the three criticized individuals may be, the committee as a whole is well balanced. No one likes to brand any committee member as having a bias on the issue, but various participants noted that W. Ross Adey, of the University of California at Los Angeles, has for many years butted heads with Schwan in arguments over the effects caused by ELF fields, and that two other committee members—Donald W. Novotny and William G. Reeder—served on a Sanguine evaluation committee appointed by the governor of Wisconsin which issued reports critical of much of the biological work conducted by or for the Navy.

The Academy offered Marino and Becker an opportunity to testify at an open hearing before the committee in March, but they declined largely because, according to Marino, they didn't want to appear as "supplicants" before a "rigged jury" that included their three opponents in the New York case. It had to be on an equal footing or not at all. At the request of the critics, chairman Hastings did explore the possibility of adding Marino or Becker to the committee, but he dropped the effort after the two sent their critical memo to the Academy.

* Other members of the Committee on Biosphere Effects of Extremely Low Frequency Radiation include W. Ross Adey, University of California at Los Angeles; John B. Calhoun, National Institute of Mental Health; Vincent G. Dethier, University of Massachusetts; Thomas S. Ely, Eastman Kodak Co.; Wilford R. Gardner, University of Wisconsin; Leon Gordis, Johns Hopkins University; Sol M. Michaelson, University of Rochester; Morton W. Miller, University of Rochester; Donald W. Novotny, University of Wisconsin; William G. Reeder, University of Wisconsin; William J. Schull, University of Texas at Houston; Herman P. Schwan, University of Pennsylvania; Harold B. Tukey, Cornell University; George M. Wilkening, Bell Laboratories at Murray Hill, New Jersey; and Tai Tsun Wu, Harvard University. The staff officer at the Academy is Samuel Abramson.

"That letter disqualified them," he said. "If we'd tried to appoint them we'd have had resignations from half the committee."

The episode has led some participants to question the adequacy of the Academy's procedures for uncovering bias among prospective committee members. The list of names from which the committee was chosen was generated primarily by the Academy staff with help from relevant consultants, and Hastings added some names of his own. Then Hastings, after analyzing a list of the fields of expertise needed and the potential candidates from those fields, indicated whom he wanted as committee members. Hastings told *Science*, "I personally wasn't sensitive to any stands taken by these people."

Hastings' recommendations then had to gain the approval of other key figures in the Academy. But it was only *after* the committee members were appointed that they were asked to fill out bias statements indicating, among other things, any views they might have expressed publicly on the issues to be considered by the committee. By that time, it would have been embarrassing to ask anyone to withdraw, though Academy officials say they have done so on occasion in the past.

Some Academy representatives are suggesting that appointments should be made conditional upon review of the bias statement, but others consider it presumptious to ask scientists to reveal their stockholdings, commercial affiliations, grant support, and other such matters if they are not sure they will actually be appointed. And for every scientist who wants to tighten up the bias procedure, there is another who wants to weaken it. Schwan, for example, considers it "an awful thing" for the Academy to ask what stands he has taken on an issue. "It intimidates my freedom of expression," he said. "Where's the borderline between such things and what happens in Russia?"—PHILIP M. BOFFEY

# Chemical Carcinogens: Industry Adopts Controversial "Quick" Tests

For generations, industry has been introducing new chemicals into the environment in staggering numbers without really knowing whether they might be hazardous. And the public, assuming there was nothing to be done, or not thinking about it, has passively tolerated the situation. But then the environmental movement came along, as did the calculations by epidemiologists that a large proportion of all cancers are environmentally caused. As a result, there has been growing pressure to force industry to evaluate new chemicals before they are released, on the theory that safety should be tested in the laboratory and not in the environment. And there is a good chance that Congress this year will pass the Toxic Substances Control Act that would mandate premarket testing (*Science*, 13 February).

The major impediment to premarket testing has been the lack of a test system that is reliable, fast, and cheap. However, during the past few years some progress has been made in that area, largely because of the leadership of biochemist Bruce Ames of the University of California, Berkeley. Ames developed a simple system for taking a quick look at the mutagenic, and by implication, carcinogenic, properties of chemicals.

No one yet is sure just how reliable a predictor the Ames test—a bacterial system—is, but it is generally thought to be the best available of its type. In view of the probable passage of the Toxic Substances Control Act, the chemical industry has begun, during the past year or so, to use the Ames, and other quick tests, on its own in order to get some idea of the safety of new products. In the process, industry itself may help to answer questions about the value of various types of screening systems by generating sufficient volume of data on which to base scientific judgments.

At present, the only officially recognized way to test a chemical for carcinogenicity is to see whether it causes cancer in laboratory animals, which takes 2 to 3 years and costs about $100,000 per chemical. Citing the time and money involved, industries have been notoriously reluctant to routinely screen new products in animals. On the other hand, they hesitate to invest huge sums of money in the development of new products without knowing whether those products will later be banned as carcinogens. Therefore, industries have seized on a variety of quick and inexpensive tests that, they hope, will tell them whether substances are carcinogens. This has led to a curious situation in which industries are implicitly endorsing the tests at the same time that scientists and legislators deliberate over whether companies should be forced to use them.

The extensive use by industries of these quick tests is hailed by many scientists as a change in the tradition of wanton release of chemicals into the environment even while debate continues on how to evaluate potentially harmful substances in accord with the pending Toxic Substances Control Act. Ames reports that 60 or 70 major companies, including such giants as American Cyanamid, Inc., Merck Sharp & Dohme, and Dupont have asked him to supply them with the strains of salmonella bacteria he uses in his system. Numerous other firms do not test their products themselves but send them to commercial laboratories for testing.

Companies are reluctant to discuss their uses of the quick tests, but Ames relates one story told to him by investigators at American Cyanamid's agricultural division. It seems that American Cyanamid found what looked like a promising new pesticide that turned out to be highly mutagenic when tested in Ames' bacterial strains. Not willing to just drop their new product the investigators of American Cyanamid took a second look and found that this mutagenic effect was due, not to the primary chemical but to an impurity in the pesticide. Now, Ames reports, the company has removed the mutagen from the pesticide and has decided that it is worthwhile to go the full route with the purified product by testing it in animals.

The Ames test is based on the presumption that many cancers are related to mutations or some sort of damage to the DNA of a cell and, therefore, that agents that are mutagenic are likely to be carcinogenic as well. After searching through innumerable bacterial strains, Ames hit upon some mutants of *Salmonella typhimurium* that have lost the ability to make the amino acid histidine. Consequently, in a histidine-free culture medium, these bacteria cannot grow. What Ames has shown is that, when these bacteria are exposed to mutagenic chemicals, they undergo additional muta-