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LETTERS

Randi's Lecture and Forum Awards

I enjoyed reading both the Szilard award and Forum award lectures (October 1989), especially the lecture by James Randi. This lecture ought to be more widely disseminated to the public, and especially to physics teachers, perhaps by publication in *The Physics Teacher*.

I would like to suggest that in the future the Forum present its awards and schedule its major lectures at the Joint APS/AAPT meeting, which attracts a rather general audience of physicists plus many physics teachers, rather than at the March or April meetings, which emphasize a few specialized areas of physics. After all, promotion of public understanding of physics is one of our main goals. Right?

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Response:

It's a good idea, but APS's January general meeting, usually held jointly with AAPS, is soon to be abolished. A new rumor is that AAPT will join APS in April, which is very good, and that they will keep a small January meeting and their usual summer meeting. The APS hopes to broaden the April "Washington" meeting.

David Hafemeister
Representative to the APS Council from the Forum

The Meaning of Quantum Theory, Cont.

Thanks for running my letter (October 1989).

When relativity was new, many physicists who had little background in philosophy wrote carelessly about how relativity theory introduced fresh insights in metaphysical questions — how it supported determinism, abandoned the correspondence theory of truth, led to all sorts of relativisms, etc., but it soon turned out that relativity raised no fresh metaphysical problems. The same thing is happening all over again with QM, perhaps starting with the claim (Eddington, Compton, etc.) that QM supports free will. My own view, which I am prepared to defend, is that the nature of science and metaphysics (as Carnap said, there is no bridge between these two continents) is such that science cannot solve *any* metaphysical problem, let alone raise new ones.

When I say that QM has not raised a single fresh metaphysical problem, we must have a common understanding of two key words: "fresh" and "metaphysical."

By fresh I mean new. By metaphysics I mean problems that by definition are beyond the reach of empirical physics. This is how the word is used by all modern philosophers of science: Russell, Carnap, Popper, Reichenbach, Hempel, to mention a few. In Carnap's often-used phrase, metaphysics has no "cognitive content."

"Philosophy of Science" is a different matter altogether. Carnap rejected all metaphysics as meaningless, but he wrote a book (on which I collaborated) called *Introduction to the Philosophy of Science*. Now obviously relativity and QM have made significant contributions to the philosophy of science. As I stressed in my *Relativity Explosion*, it was relativity theory that made clear that determining the structure of spacetime was an *empirical* question (in contrast to Kant's views). And QM did indeed make clear that physical laws can rest on a basic indeterminacy.

None of this raises a fresh metaphysical problem. For example, the question of whether the future is completely determined by the present, or whether elements of pure chance underlie "being" is one of the oldest questions in philosophy. It was constantly debated by the ancients and the medievals. The Greek atomists injected randomness into the basic structure of the universe by introducing a random "swerving" of particles on a level too small to be seen. Lucretius has a beautiful metaphor on this. He speaks of a flock of sheep moving about at random on a hill. But to a distant viewer, they appear as a white spot that is motionless. Jumping to recent times, Charles Peirce, America's greatest philosopher, firmly believed (before QM) that pure chance was an element in the evolution of the cosmos. He called his view "tychism." It had a major influence on William James. Note also that this old metaphysical question is far from settled today. Many QM experts, Bohm for example, believe (with Einstein) that QM is incomplete and that when a deeper level is discovered, determinism will be restored. And if one accepts (I don't) the many-worlds interpretation of QM, strict determinism *is* restored. Thus, the indeterminism of QM is certainly not a "fresh metaphysical question."

Consider another ancient metaphysical debate. Did the universe have an infinite past, or was it created by a transcendent deity, or did it pop into existence, all by itself, from nothing? Again, this was endlessly debated by the ancients and medievals. QM has shed *no* light on this question. There is speculation that the universe started with a random quantum fluctuation in the false vacuum, but this vacuum has nothing to do with metaphysical "nothing." The fluctuation presupposes quantum fields and laws, and laws of probability. So the question is simply pushed down to a deeper level, but the problem of why there is something rather than nothing is as opaque as ever.

Finally, take the question of whether the tree exists when no one observes it. QM has indeed introduced a tinge of solipsism into the measurement problem, which is far from completely understood, but it certainly hasn't introduced a "fresh metaphysical question." One of Wigner's famous essays, in which he wonders about the persistence of a tree when no one sees it, never mentions Bishop Berkeley!

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Response:

OK, I can agree that quantum mechanics raises no metaphysical problems that have not been raised at some point in the history of human thought. But most of us tend to frame the question in the more limited context of the history of scientific thought (i.e. not Bishop Berkeley) since Copernicus (i.e. not Lucretius, either). Relative to post-Copernican scientific thought, quantum mechanics does indeed raise fresh questions about determinism versus free will, the existence of a purely objective reality, and other matters. Quantum mechanics, or any other scientific theory, should not be expected to answer such metaphysical ("beyond physics") questions, but it does throw them into a fresh perspective, and I think this fresh perspective is important.

Art Hobson

ARTICLES

Tagging Technologies and Reduction of Conventional Forces in Europe

Ruth H. Howes

Introduction

As the United States and the Soviet Union rapidly approach an agreement to limit the non-nuclear forces deployed in Europe, the arms control community is concerned about verification of likely treaty provisions. If the proposed treaty is based on President Bush's arms control initiative announced earlier this summer, it will include ceilings on numbers of tanks, armored troop carriers, artillery pieces, land-based combat aircraft and helicopters based between the Atlantic and the Urals as well as on numbers of troops in the region. Thus verification of the treaty will require each side to monitor on the order of 100,000 individual weapons. Unlike existing strategic weapons systems, conventional forces are deployed and maintained at a large number of bases spread widely over the continent of Europe.

A favorite technique for monitoring on such a massive scale would be to tag each individual weapon in such a way that it could be uniquely identified and could not be upgraded or switched (1). After establishing a baseline inventory of all equipment and the associated tags, inspectors could verify that treaty provisions were being observed by on-site inspection of samples of the weapons limited by the treaty. Samples would be selected by the inspecting side and compared with an inventory prepared by the side being inspected to ensure the accuracy of the inventory. If the treaty required destruction of weapons, the tag of each weapon could be checked and removed from the inventory as that weapon was destroyed.

Details of the inspection procedures including numbers of inspections, types of equipment used by the inspectors and conditions of access to the weapons being monitored will depend on the technology used to tag weapons in the field. If a treaty limiting conventional weapons in Europe follows the precedent set by the INF Treaty, these details will be included as part of the text of the treaty. Therefore research on tagging technologies will be an essential preliminary to conclusion of an agreement limiting conventional forces in Europe.

Requirements for Tagging Technologies

Satisfactory tags will have to be very difficult to counterfeit. They must be resistant to removal from the original equipment on which they have been placed and reveal any attempt to move them or tamper with them. On-site inspectors must be able to read the tags quickly and simply in the field and compare them with a baseline inventory. The tags must not provide any signal that could be used for intelligence information or targeting.

Since thousands of tags will have to be provided, they must be inexpensive and easy to install. Ideally they could be installed in the field by troops manning the equipment and the installation checked by samples collected by on-site inspectors. Installers would have relatively little training or manual dexterity, and tags would have to be designed to withstand rough handling and sloppy installation procedures. Because so many items must be tagged, the tags will have to be durable for at least a decade if the problem of placing tags and updating records is not to be insurmountable.

Although the political climate of Europe is hospitable to arms control efforts, the physical climate is less well-disposed toward many types of tags. Equipment will expand and contract under temperature changes in both summer and winter climates from the Mediterranean to the Baltic. Tanks and other treaty limited weapons routinely move through dust, mud, snow, ice and even corrosive salt water. Soldiers in the field are not noted for gentle handling of their equipment, and tanks and personnel carriers do not provide a boulevard ride. Thus any workable tag design will have to be extremely rugged.

Proposed tags divide themselves into two broad groups, attached tags and intrinsic tags.

Attached Tags

Attached tags are manufactured elsewhere and mounted on weapons being monitored. The most sophisticated tagging technology is the electronic identification device (EID) which is an electronic chip mounted on the weapon system. In one version, it is operated by a dual key system with each side holding one electronic key. During an inspection, both sides would agree to activate the tags on a sample of equipment and the tags could be interrogated by electronic equipment mounted on a truck in the field, in a helicopter above the deployment area or on a satellite. It seems unlikely that either side would agree to electronic tags that could be monitored by satellites since these tags might conceivably provide targeting data or enough information on deployments to be militarily useful.

In order to make EIDs tamper-proof, they would need to be equipped with a position-sensing feature or encased in a fibre-optic net. Each side would need to provide a considerable quantity of extra tags so that the other side could inspect a sizable sample before installing the tags on equipment in the field to be sure that the tags did not contain identification signatures which could be used to target the weapon in the event of war.

The major problem with EIDs is to make them rugged enough to survive in field conditions for times on the order of ten years. Not only

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must the electronic components be reliable and durable in extremes of temperature and humidity, but the mounting for the tag must be firm enough so that the tag will not detach itself from the weapon. The need to ensure that the EID mounting is sensitive to any attempt to remove or tamper with the tag may well mean that installation will require relatively skilled technicians provided by the inspecting country. Initial costs of EIDs are likely to be higher than those for other types of tags although reading them during an inspection will be simpler since it can be done with equipment mounted on a vehicle or aircraft.

In the simplest of the attached tag technologies, a transparent glue mixed with mica flakes is spread over an identification number painted on the weapon being monitored. The pattern of mica flakes in the paint is recorded by photographing the tag under lights mounted at several reproducible angles. For inspection, the photographs can be compared with a new set of photographs taken in the field (2). Unless the photographic procedure can be automated, it seems likely that initial photographs of the tags will have to be collected by trained inspectors rather than by field troops. Control of the lighting in the photographs may require that equipment be moved inside during inspection. In addition, the painted surface will probably need an outer coat to protect it from abrasion during maneuvers by the weapon. Although the actual glitter paint tags will be considerably cheaper than EIDs, they will require trained teams for their installation and will be more difficult to inspect than EIDs.

Intrinsic Tags

Intrinsic tags use a unique feature of the surface of a weapon as an identifiable tag. Because they require nothing more than the identification of the surface to be used as a tag, they are easier to install than attached tags. Although they may need to be protected from abrasion by paint or a metal plate, they will not protrude above the surface of the weapon and will therefore be less susceptible to accidental destruction in the field than attached tags. In most schemes for intrinsic tagging, the surface to be used as a tag will be marked and the weapon numbered near the surface tag by stamping or attaching a number and perhaps a barcode onto the metal.

Because the tagging procedure will not involve installation of a complex tamper proof system, it seems possible that intrinsic tags could be installed by the troops in the field who normally maintain the weapon. Each side would thus tag its own systems during the baseline inspection period. Inspectors from the other side could then spot-check equipment to ascertain that the baseline inventory was correct and that the tagging procedures had been correctly conducted. If the tens of thousands of weapons limited by a treaty can be tagged in this way, there will be substantial financial savings. Clearly this procedure will require a means for the tagging team to record unique data on the tag which can then be filed for comparison by either side during on-site inspections.

An initial argument against simple intrinsic tagging is that machined surfaces might be counterfeited using casting techniques, thereby permitting one side to deploy more weapons than are allowed by the treaty. Certainly a skilled counterfeit of a machined surface or a weld can fool a visual inspection. On the other hand, it should be feasible to design a portable scanning electron microscope (SEM) to examine surface tags at sufficiently high resolution to detect a counterfeit. Like the photographs necessary to identify glitter paint tags, a SEM would require skilled personnel for its operation so that initial installation and cataloging of tags would be expensive.

It is possible to monitor intrinsic surface tags using plastic castings of the surface that can be prepared by personnel with a minimum of training. The casts can then be shipped back to the laboratory for storage and analysis with a SEM. During the baseline inventory, all tags would have several casts prepared during initial tagging by the troops actually doing the tagging. These replicas could be stored by each side or in a central cataloging center. To verify the baseline inventory, an inspecting team would reexamine a sample of the tags in place on the weapons and prepare casts of them. The casts made by the inspecting team would then be shipped back to the central laboratory for comparison with the baseline cast for the weapon with the same number and/or barcode using a SEM. In subsequent on-site inspections and during destruction of equipment, similar casts could be prepared, compared with the baseline casts and left on file for future reference.

Using this technology, tags could be installed by troops in the field. Inspecting equipment would consist only of the relatively simple kits needed to prepare the casts. Complex and sensitive systems like the SEM could be kept in laboratories where they would be easier to calibrate and maintain. Finally this sort of intrinsic tagging would not require that data storage capacity be brought to the field. Since identification of a single surface tag might easily involve 10^6-10^8 pieces of information, tags to be compared during a single inspection would involve data storage on the order of 10^{12}-10^{14} bytes. The information could be handled in analog form in the field and digital comparison could be done with advanced computer systems in the lab.

Conclusion

The variety of proposed tagging technologies and the research efforts on them in the national labs and the universities are encouraging signs that a treaty limiting nuclear weapons in Europe will be backed by a workable verification scheme. Development of tagging technologies has reached a stage when the research community must ask the larger scientific, military and political communities to examine proposed tagging schemes for fatal flaws. By "red teaming" tagging technologies, arms control verification can avoid over-reliance on sophisticated technologies which are expensive and do not work well in the field, as well as spotting bugs in simpler, cheaper tagging scenarios. The time for public debate on tagging technologies is now!

Acknowledgements

The author wishes to thank Dr. Alex Devolpi of Argonne National Laboratory for helpful discussions of this paper including several unpublished communications.

References

1. A good overview of verification of a CFE Treaty is found in Russell Maxfield and Arend J. Meerborg, "Two Ways to Verify a CFE Accord," *Arms Control Today* 19, 18-21 (August 1989).

2. Glitter paint tags are described in Christopher Joyce, "The Telltale Tags That Help to Trust and Verify...Or Not," *New Scientist*, 48 (July 29, 1989).

Symposium: Plasma Physics, Public Policy, and the Future of Fusion

The following four papers form another of our sets of papers based on invited sessions at APS meetings. This set is based on a session held on 13 November 1989 at the annual meeting of the division of plasma physics in Anaheim, California. A manuscript was not available for the fifth paper in the session, by Mark Crawford of *Science Magazine*. The session was chaired by Stephen O. Dean, President of Fusion Power Associates.
Editor

Introduction

Stephen O. Dean

A fusion power plant can be operational early in the next century. However, a firm national commitment is necessary to accomplish that goal.

Extraordinary progress in fusion has been made during the past twenty years. The plasma conditions (temperature, density, confinement) necessary for the substantial release of fusion energy have been systematically approached (Figure 1). That progress was achieved in facilities committed in the 1970s. During the 1980s, the fusion budget has declined to about one-half of its 1980 level. No major new facility has been constructed since the TFTR in 1976. It is time to commit to a policy that will lead to practical fusion power.

The goal of the fusion program should be to demonstrate early in the 21st century that fusion is a safe, reliable, environmentally-attractive and economically-competitive energy source. Strong national management will be required to accomplish this goal.

The strategy that should be followed to achieve this goal has four essential elements:

• continue to improve the science and technology basis for practical fusion applications;
• construct a U.S. magnetic fusion burning plasma experiment;
• participate in the design, construction and operation of an international fusion engineering test reactor; and
• construct a U.S. fusion power demonstration facility that produces net electrical power and provides the basis for commercial power plants.

The proposed strategy is shown in Figure 2.

The budgets required depend on the schedule desired. If the U.S. magnetic fusion budget does not increase beyond its current level of$300-350 million, then the schedules would surely slip. The amount of annual funding required for technology development depends critically on the planned schedules for the test facilities and the fusion power demonstration facility.

The author is President of Fusion Power Associates, Professional Drive, Suite 248, Gaithersburg, Maryland 20879. He presented this statement to a subcommittee of the U.S. House Committee on Science, Space and Technology, on 4 October 1989.

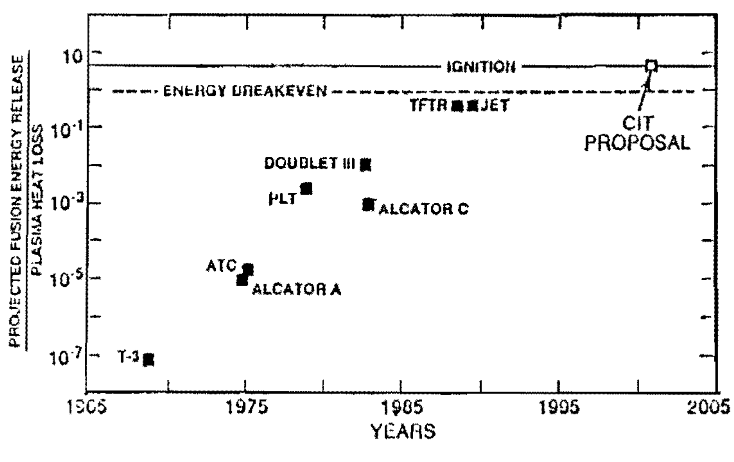

Figure 1. Progress in Achieving the Condition Required for Fusion Power.

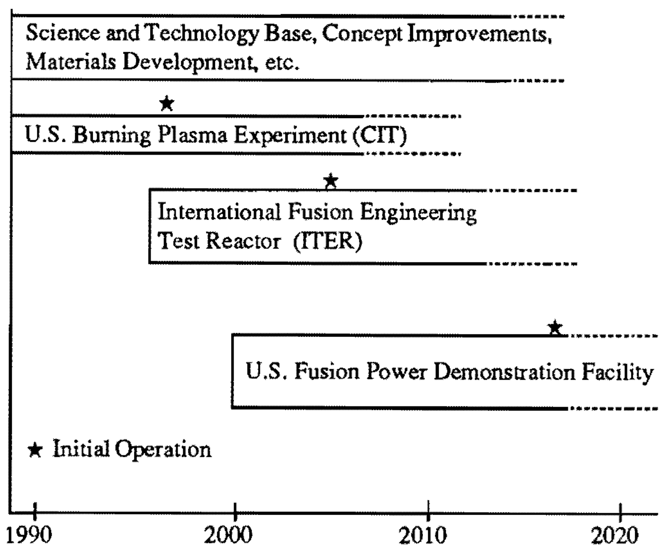

Figure 2. Schematic of U.S. Fusion Energy Strategy

The Impact of Environmental Issues on Public Support for Fusion Research

Jan Beyea

Support for fusion power research is very weak in the environmental community. Before I offend fusion supporters though, let me say that I do support fusion research, although not necessarily at the level of 350 million dollars per year, at which the program is now funded. As a physicist, I think the possibility of reaching ignition is terribly exciting intellectually. But as an environmental professional, I have to question a funding level that is ten times higher than federal research expenditures on photovoltaics and four times higher than federal expenditures on all solar power (see USDOE Budget Highlights, Fiscal Year 1990, Office of the Controller, Washington D.C., 1989). Concerns about the size of the fusion budget seem to be rather common with others too.

There are two indications of a narrowing support base:

(1) Fusion power is supposed to have environmental benefits. Yet, the recommendations of the environmental community to President Bush when he took office was to zero the fusion budget. True, none of the larger environmental groups paid much attention to this part of "Project Blueprint," prepared for the incoming president, and the process wasn't very open (I heard about this recommendation too late to influence it). Nevertheless, this action is an indication that the environmental community sees better places to put federal dollars and has, as I shall discuss below, real questions about the current fusion power proposals.

(2) For the last few months, as part of a National Academy panel that is reviewing the federal energy R&D program, I have had the opportunity to meet with dozens of engineers and scientists working in the energy field outside of fusion. When the subject of fusion comes up, there is often laughter. It may be possible to convince Congressional staff that investments in fusion make a lot of sense, but if the fusion community can't convince professionals outside the field, it won't be long before these negative views spread to Congress.

The loss of support can be attributed to the zealous overstatement of claims for fusion. People have heard claims of miracles before, for instance in regard to nuclear power, and have become skeptical.

The problems facing fusion power are twofold. The obvious acknowledged problem is how to dispose of the radioactive material produced by stray neutrons. The unacknowledged problems are more numerous.

The first concerns the production of nuclear weapons. Fusion power plants based on the deuterium-tritium (D-T) cycle will make great breeders of weapons-grade material. Fusion scientists swear they will never do such a thing, but they will be under great pressure to use this neutron-rich process to make weapons. D-T fusion has many of the same proliferation problems that are associated with fission reactors.

Secondly, there will be a temptation to use neutrons from fusion to make fuel for conventional fission reactors. Thus, fusion may not offer an escape from fission after all.

Cost is another problem. Supporters of new technologies have tended to underestimate cost, sometimes by as much as a factor of ten. There is the suspicion floating around that the same may be true for fusion power.

Finally, competition is a problem. Developments in other energy technologies are tending to eclipse fusion.

What developments are taking place in other energy fields that drain support from fusion power? Energy efficiency, most certainly, from superwindows to highly efficient jet engines. Idiot-proof fission reactors are another. Even the moribund nuclear community is generating some excitement (outside of environmental circles, at least) with the possibility of these melt-down-free reactors, which rely on passive safety devices rather than pumps and diesel generators.

In photovoltaics the cost of PVs has dropped so much that even electric utilities are looking on them with favor as peakers for the late 1990s. It doesn't take too many calculations to recognize that peaking units can be turned into baseload suppliers with an economic penalty of about a factor of three (e.g., by generating hydrogen while the sun is shining and burning the hydrogen when it isn't). PVs will soon be able to produce base load power at a rate that is only five times higher than current costs, and the trend line for photovoltaic costs is dropping rapidly. It might take covering a land area the size of the interstate highway system, but the prospects for PVs over the time frame it will take to develop fusion look excellent. Certainly, it is hard to say that the prospects for fusion are any better.

CO_2-free coal has been promised by the coal intellectuals. Meyer Steinberg at Brookhaven has a working model of a plant that strips the hydrogen from coal to be used for energy purposes, leaving the carbon to be sequestered. Although a large energy potential is lost this way, the costs of coal are so cheap that the process may well compete with fusion for a very long time, even should fusion power prove practical.

Fusion power will have serious acceptability problems. Radioactive waste from neutron capture is the more serious one. Because of skepticism generated in the public mind by overstatements made by fission advocates, the public is unlikely to buy the argument that fusion radioactivity is okay. The issue of breeding fissionable plutonium or uranium for nuclear weapons and reactor fuel is also going to raise considerable public concern.

If the fusion community is to survive, it will be necessary to face up to those aspects of fusion that are perceived as problems. Rhetorical response may work in the short run, but improving the fusion program to respond to the concerns will be needed in the long run.

Facing the problems requires cleaning up the arguments and recognizing successes in other fields. The arguments against fusion programs must be heard. Advocates of fusion must talk to their enemies, not just their friends. They must not promise more than they can deliver to head off yearly budget cuts or to get increases. For instance, they must consider what would happen if the Compact Ignition Tokamak doesn't work? Won't that mean the final blow to fusion credibility?

Most importantly, the neutron problem with D-T fuel must be faced.

H.P. Furth in a statement before the Subcommittee on Investigations and Oversight, House Subcommittee on Science, Space and Technology, 3 Oct 1989, said, "The use of D-T fuel serves to increase fusion power production by a factor of about 300 relative to deuterium fuel. Correspondingly, there are significant incremental costs associated with neutron shielding, remote-handling equipment, and tritium-handling systems ...." Given the upswing in environmental concerns, I do not think the D-T cycle will ever be a politically practical energy source.

There do exist fusion cycles in which neutrons are scarce, for example cycles that make use of He^{-3}. Yet those cycles are never shown as part of the official vision of fusion. Clearly, delaying commercial fusion power to a second generation cycle will push back

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the dream further into the future, making it even more difficult to justify funding to the practical-minded. But, without the ability to generate broad public support, the program is not going to survive at a very high level of funding.

Fusion supporters need to emphasize research on alloys with low waste production. A low neutron fusion process coupled with alloys optimized for waste minimization might be politically acceptable. Fusion advocates also need to build proliferation resistance into their conceptual designs.

If I were to make a case for fusion, I would be more modest than fusion advocates. I would want to make sure that support for any program was grounded completely in science. I would justify fusion as an insurance policy, particularly for global warming.

If we have nuclear fission in 2030, then fusion breeders will be politically acceptable. If fission is not acceptable, which is quite likely, fusion has a better chance of being accepted (especially if it gets away from neutron-rich cycles).

To give fusion a chance in the political marketplace I would insist that fusion cycles be designed to be proliferation-resistant and low in production of radioactive waste. And, I would only fund fusion at a fraction of solar energy.

Fusion advocates should support photovoltaic research, but argue for an increase in overall energy spending to allow the fusion program to develop.

This raises the question of how much money should be spent on energy research. Of the $400 billion spent on energy each year, less than 1% is spent on research. Global warming concerns justify an increase in energy research but do not automatically justify raising the support for fusion, given the current imbalance in current funding levels. We need a re-ordering of priorities. It is not credible to consider photovoltaics as less important than fusion.

The fusion community has a choice. It can escalate the rhetoric, gain short-run salvation, and then follow the terminal route of the Clinch River Breeder Reactor program. Or it can tone down promotion and accept a reduced, but sustainable, program.

It is de rigeur nowadays to say something about cold fusion. I have reserved my remarks on the subject for the end.

During 1989, as I followed the flurry of media reports about the possibility of fusion taking place at low temperatures inside a metal matrix, I became most concerned with the possibility that the extreme claims would be true. Imagine a fusion source with no neutrons and negligible expense to produce. The environmental implications would be disastrous. Why? If people can move mountains cheaply, the natural world will be transformed. As the saying goes, "power corrupts and cheap power corrupts absolutely."

The Future of Fusion

Harold K. Forsen

In thinking about what phase of this subject might be most interesting to the audience, it is hard not to focus on just what fusion is, where it fits, what its cost and benefits might be, and most importantly when — not if — it will be available. And yet perhaps the real key question is, in fact, "if".

Fusion has been an active research program in the United States since the early 1950s. It is now thirty-five years later and the question has got to be: why so long? I notice in the sessions today, there are many who are younger than this age. Maybe controlled thermonuclear fusion as an energy producer is not meant to be. Certainly critical elements of this question are rightfully being asked more intensely by the Congress, by the new energy secretary, by some members of the scientific community and the general public.

Why has this potentially unlimited source of energy with relative benign environmental impact taken so long? Why are current experiments so costly, and why has the fusion community spent so much money doing so little?

Clearly I have set up more strawmen and questions than there is time for at this forum. However, this is as it should be since the scientific community itself must provide the answers. Indeed, the community appears to be coming together to provide its views.

Let me then spend the rest of my time putting some of these issues into perspective. This admittedly comes from a former fusion researcher who has not been really active in the field for almost twenty years.

The understanding of plasma physics necessary to design a fusion reactor, with the level of confidence needed to justify the cost, is a moving target. The required knowledge is different for each proposed configuration and the physics is sufficiently complicated that we may have to settle for much empirical rather than theoretical understanding. We must put this into perspective as a very large fraction of applied science falls in this category. This does not mean that the scientific community will never get there, but it does suggest that they may never be able to predict the detailed operation of an arbitrary configuration operating over a wide range of parameters.

What does this mean for the government and the public as they attempt to make choices among the energy alternatives? What is the responsibility of the government in particular? This has interested many of us more recently than perhaps in the past.

Within the energy sector the government has, as its main responsibility, the providing of reasonable technical options and the associated data base on which private investment decisions can be made to develop those options. This does not mean that the government must provide all data or all options or even be contributors to all ideas. The private sector then puts itself at risk to develop options in the face of economic, safety and environmental and some technical uncertainty. What the private sector will not tolerate is undue economic uncertainty or political uncertainty.

How then does the government choose its alternatives and options? It sets up panels of experts to provide advice, institutions to review proposals for funding recommendations, and, ultimately other institutions to carry concepts to some state of development. Clearly, there are more ideas and alternatives than there are funds to evaluate or institutions to develop. In my view, there is no mandate that all good ideas deserve federal funding.

What then has happened in fusion? From its start as a possible neutron source for special nuclear materials production to a possible energy source today, the program has gone through considerable trauma. The budget has varied somewhat with the price and security of oil supply until now, when it appears headed for some floor level. Meanwhile, technical progress has been steady and impressive.

Various advisory groups to the Department of Energy have been formed over the years. The Energy Research Advisory Board reports to the secretary on energy issues including fusion. The Magnetic Fusion Advisory Committee reports to the secretary's designee for fusion, the Director of Energy Research, who has further recently

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commissioned a review by a panel of the National Research Council. Congress has received input from the Office of Science and Technology Policy panel on fusion. Each and every one of these panels have given what appears to be sound advice and they all say that the research is excellent, the progress is outstanding, and the next steps should be taken.

What then is the problem and why is the goal of fusion power continually receding? To me there are two reasons. One is that there is no current demand for energy that cannot be met by a number of other alternatives. Fusion does not at this point have a customer or an advocate outside the scientific community. The second is that the federal budget is very tight, and given the cost of new progress in fusion, the fusion budget is fair game for cuts.

During the previous administration, fusion was not considered to be an energy program but a research program. This meant that no flagship projects should be undertaken and that fusion should strive for something called its highest potential. International collaboration then compounded the issues. Design of an international power reactor has proceeded under a four party team made up of the European Community, Japan, the Soviets, and the U.S. We are now told the program is an energy program but funds are *removed* so that it can compete in a race for the next test device with a weapons program concept that has never been part of the government's energy program.

The country needs an energy policy that provides alternatives as insurance against technological, economic or political surprises. The environment and other public policy issues must be considered in this plan along with other issues such as demand growth, plant retirement, licensing, conservation, and natural resource availability.

Fusion must have a place in this plan which means projecting a future cost and schedule. To determine this we must move ahead to understand the remaining scientific, engineering and institutional issues. The fusion community is the only accurate source for this data, and it must get its act together to make it happen. The community today is not speaking with one voice and this is very confusing to those who fund and make other key decisions.

Some Frank Observations

Paul Gilman

Some frank observations of the fusion community and its efforts:

• When fusion advocates promote fusion energy as a clean, limitless, and totally safe energy source, they do a disservice to the program. Congressmen know that issues are not that simple.

• A more balanced view, namely that fusion is a long-term option which should be pursued as part of an overall "bet-hedging" strategy to cover all possible energy options, is a more productive approach. This, coupled with the tremendous potential "pay-off" for fusion, justifies the program. Unfortunately, this very argument guarantees that fusion research must share funds which are spread among many research efforts.

• The present research program at the Department of Energy is called an "energy program." It is not. The community that participates in the program has a predilection toward basic research. The fusion community has also taken advantage of the Reagan Administration's preference for basic research over technology development to stress this element of the program. This predilection and strategy may have helped the program in the short-term, but it is also responsible for the waning interest in maintaining high levels of funding for the program.

Now, how do you turn the trend of decreased funding and interest around?

Congress rarely proposes initiatives. The Executive Branch does. They need to become advocates, and with no consensus within that branch there is little possibility that they can lead.

Congress and the Secretary of Energy both believe a high-level review group should review the program. This group could be the key to setting a new, more stable course for the program. Once this is done, Congress may be able to act more decisively.

The community should also be cautious in how it promotes international cooperation. At times the Congress urges international cooperation when it is not enthusiastic about a project and does not wish to fund it. At other times the international competition for intellectual prestige is a sufficient reason to fund a project. The community must move cautiously here.

The author is Administrative Assistant to Senator Pete Domenici.

FORUM ELECTIONS

It is time for Forum members to elect their officers. This year, elections are being held for vice-chair, two executive committee members, and secretary-treasurer. Ballots will be sent to Forum members by means of a separate mailing. Here, we give biographies and statements by the two candidates for vice-chair, the three candidates for the two executive committee positions, and the candidate for secretary-treasurer. A fourth candidate for the two executive committee positions withdrew at the last minute, leaving no time to find a replacement. On the strong recommendation of the nominating committee and the Forum chair, the Forum's present secretary-treasurer is running unopposed for re-election. The nominating committee members are Sam Baldwin (chair), David Hafemeister, and Anthony Nero.

Rush D. Holt (vice-chair)

Background: Rush D. Holt became Assistant Director of the Princeton Plasma Physics Laboratory in August 1989. Previously he was Chief (Acting), Nuclear and Scientific Division of the Office of Strategic Forces Analysis at the U.S. Department of State. From 1980 through 1987 he was on the physics faculty of Swarthmore College in Pennsylvania, where he taught a full range of physics courses, as well as courses in arms control and science and decision making. He was an American Physical Society Congressional Scientist Fellow in 1982-83, working in the office of Representative Bob Edgar of Pennsylvania. He has been a visiting scientist at the National Center for Atmospheric Research in Boulder, Colorado; a visiting observer at the National Solar Observatory at Kitt Peak, Arizona; and a summer fellow at the Woods Hole Oceanographic Institution. He was an undergraduate physics major at Carleton College in Minnesota and received his PhD from New York University. His primary area of research is solar physics. He serves on the APS Panel on Public Affairs, his term expiring in 1990.

Statement: The Forum is the most important group of the American Physical Society — because it is the most needed. The Forum demonstrates continually the real contribution to be made by applying clear, physical thinking to societal problems. Most physicists see the problems and have some ideas for improving matters, but face professional and disciplinary limitations on how physicists should use their skills. By providing an unbiased framework for exchanging ideas and bringing respectability to that exchange, the Forum provides a much needed reminder to us APS members of our obligation to serve society, not only through our regular scientific research, but also through direct confrontation of problems at large.

We don't have to look far for problems suitable for Forum attention. We face problems of environmental degradation, arms out of control, misguided defense claims, weak and poorly rewarded science teaching, restrictions on international scientific communication, public misapprehensions about science, a country that seems blind to its energy problems, policy decisions based on pseudoscientific beliefs, and skewed R&D priorities. We also find outstanding and inspiring examples of scientists working toward solutions of those problems, some of whom have been recognized with Forum and Szilard Awards.

The Forum sessions at APS meetings, "Physics and Society" newsletter, the workshops, the study groups and short courses, and the awards ceremonies have been very good — often excellent. They need continual encouragement, not overhaul. In addition, the Forum may improve its effect, for example, by (1) involving more people throughout the physics community who have some time to give to these efforts without making the leap to full time policy work (at a minimum, we need to find ways to involve the several thousand physicists who are interested enough in Forum activities to have joined but who are not among the "Forum regulars" on studies, workshops, and other undertakings), (2) working more closely with the editors of *Physics Today* and other journals to produce articles and editorials, (3) producing workshops and a handbook to help scientists communicate more effectively with officials who need the results of our work and providing recognition (beyond the existing awards) for the work of scientists on societal problems so that such work may eventually be seen as fully legitimate use of professional time and talent.

Ruth H. Howes (vice-chair)

Background: Professor of Physics and Astronomy and Director of the Center for Global Security Studies at Ball State University. PhD, nuclear physics, Columbia University. Research interests: physics applied to arms control particularly verification; also energy and long-term environmental problems. Guest Researcher with Arms Control Verification Group at Argonne, 1988-present. William C. Foster Fellow in the Verification and Intelligence Bureau of the U.S. Arms Control and Disarmament Agency, 1984-85. Participant in Forum Civil Defense and Land-Based Missile studies and co-chair of the current Energy Study. Member of the APS Education Committee 1986-present.

Statement: The Forum on Physics and Society has traditionally had two primary functions in the APS community: to provide high quality, unbiased technical analysis of problems facing society and to educate the physics community on problems which need input from physicists and what physicists have to say about these problems. Education and analysis have been carried out by the Forum studies, short courses and invited sessions at APS meetings. These activities should continue. In addition, Forum should continue to maintain its tradition of involving physicists from industry and a variety of academic institutions so that it does not risk becoming inbred. *Physics and Society* should continue its growth and the increase in quality of articles which have characterized it during the last several years.

In the next two years, Forum should take a leading role in promoting technical literacy for the general public. The group must take a more active role in designing physics curriculum at the university and high school level to ensure that physicists recognize the interaction of their discipline with society and that non-physicists learn enough physics to become intelligent voters on the many technical issues currently decided by ballot.

To educate the physics community, Forum should prepare a list of potential colloquium speakers for circulation with *Physics and Society* and to department chairs around the country. Invited sessions must be presented at all APS meetings, and the Executive Committee should ensure that the sessions cover a wide range of technical issues including arms control, energy, the environment, the ethics of research, and the relationship of physicists to other communities such as Congress and the press.

Gerald L. Epstein (executive committee)

Background: Jerry Epstein is currently directing the Dual-Use Technologies Project in the Science, Technology, and Public Policy Program at Harvard University's Kennedy School of Government. He came to the Kennedy School from the Congressional Office of Technology Assessment, which he joined in 1983 as a Congressional Fellow. At OTA, he studied a variety of defense technology, arms control, and energy issues, and he directed OTA's 1987 study of fusion energy. He received his PhD in astrophysics from Berkeley. He is participating in the Forum's ongoing energy study.

Statement: In a society where the boundaries between political, social, and technical issues are often fuzzy, organizations such as the Forum are particularly important. I am hopeful that the Forum's traditional tools—*Physics and Society*, Forum-sponsored sessions at APS meetings, and special study groups convened under Forum auspices—will continue to take an active role in improving the level of debate on controversial issues. Just as important—and maybe more so—is the Forum's role in calling attention to issues that are not now as controversial as they should be. A good example is the Forum's current work on energy, a topic that is forgotten but not gone.

Science and technology are important parts of a great many public policy issues, but they rarely dominate. Therefore, the physics community—including the Forum—will have to work with many outside organizations and communities to contribute effectively to current problems. I think it is important that the Forum promote such contacts.

Michael I. Sobel (executive committee)

Background: Professor of Physics, Brooklyn College of City University of NY; member of Doctoral Faculty of CUNY; Research Collaborator, Program on Nuclear Policy Alternatives at Princeton's Center for Energy and Environmental Studies; Board of Directors, Long Island Alliance to Prevent Nuclear War; member FAS, UCS,

UCS Speaker's Bureau. PhD, Harvard. Research: nuclear theory, few-nucleon problems, heavy ion physics. NATO Postdoctoral Fellowship and Senior Fellowship. Visiting positions: Niels Bohr Institute, Weizmann Institute, Hahn-Meitner Institute, others. Author of *Light*, a book for a general audience. Taught courses on energy and on the arms race. Visiting Senior Research Physicist, Princeton, 1988-89. Current interests: reductions in tactical nuclear weapons and verification; depressed missile trajectories; collaborating on a study of finite deterrence.

Statement: Some suggestions: (1) The Forum short courses on the nuclear arms race were extremely valuable to me in learning about this field and preparing to teach. I would encourage the offering of more such courses on a variety of subjects, including local and global environmental problems, medical physics, and other applications of new technologies (space exploration, information processing, superconductivity, imaging). (2) Studies of technical issues with societal implications, like the recent Forum report on land-based missiles, are a valuable contribution to the interaction between physicists and the community. I would propose a parallel program to prepare nontechnical accounts of science-and-society issues for an audience of educated laymen, and perhaps for an audience of students at the high school or lower level. (3) Certain issues, like the energy crisis and the arms race, have become the subjects of courses at many universities, and some good textbooks have become available. But many teachers, I believe, would be pleased to have edited collections of important recent articles on these subjects. I would suggest that the Forum consider sponsoring some such collections.

Concern has been widely expressed, both in the physics community and in society at large, about the lack of interest in science among young people today. Explanations are many. But my observation is that many thoughtful and bright young people perceive science, and physics especially, as not supportive but primarily destructive of human values. Relative to other scientific organizations, the Forum is probably in the best position to act to reverse that perception, and I would give high priority to Forum efforts in that cause.

Alan Sweedler (executive committee)

Background: Alan Sweedler is a professor of physics, Director of the Center for Energy Studies at San Diego State University and Codirector of the Institute for International Security and Conflict Resolution, San Diego, California and a research associate at the University of California's Institute on Global Conflict and Cooperation. After completing his PhD in 1969 from the University of California, San Diego, he spent two years on the faculty of the University of Chile in Santiago, Chile, sponsored by the Ford Foundation. While at the University of Chile he established the first laboratory specializing in superconductivity and assisted in the development of graduate research in the then newly established Faculty of Sciences.

He returned to the United States in 1972 to take up a position at Brookhaven National Laboratory as a research physicist where he remained until 1977. While at Brookhaven, he worked extensively on neutron-induced disorder in superconducting compounds. In 1978 he joined the faculty at California State University, Fullerton and in 1980 was appointed to the faculty at San Diego State University.

Sweedler founded and directs the University's Center for Energy Studies, a multidisciplinary institute that focuses on energy systems analysis with particular emphasis on energy related issues in Latin America and the southwestern United States. He has served as an energy advisor to UNESCO for energy policy and planning in Brazil, has worked on energy and development issues in Mexico and as a consultant to the California Energy Commission and the San Diego Association of Governments. In addition to his work in the energy field, Sweedler has been active in the area of international security and arms control where he is currently working on conventional arms control in Europe and the interrelation between environmental issues and national and international security. He was recently appointed to serve as the Codirector of the newly established Institute for International Security and Conflict Resolution at San Diego State University.

In 1985, Sweedler was chosen as one of two Congressional Science Fellows of the APS and in 1987 he was awarded a Carnegie Science Fellowship in International Security at Stanford University's Center for International Security and Arms Control.

He was elected to membership in Sigma Xi and Phi Kappa Phi and is a member of the American Physical Society, AAAS, the Arms Control Association and Association of Borderland Scholars.

Statement: Having worked in foreign countries, a national laboratory and academia, I have had an opportunity to directly experience a variety of professional settings. This has enabled me to see how physicists can provide input to decision-making processes which have a direct bearing on public policy in general and science in particular. My own participation in this process, through serving as one of the APS Congressional Science Fellows and involvement in issues relating to energy and development in third world countries and arms control and international security, has convinced me that physicists can make an important contribution to many societal problems where technology is an important component. In addition, I believe that sound scientific and technical education and training for students in developing countries will be a critical factor in providing the human resources needed to develop the economic and political infrastructure of these countries. Here again, physicists can play a very important role; as teachers, researchers and advisors in developing research and training programs.

The Forum provides an opportunity for physicists and other scientists to come together and exchange ideas in an open and stimulating setting. If elected to the committee, I will encourage discussion of the role that science and technology can play in providing assistance to developing nations, particularly in the areas of energy, environment, education and training.

Henry Barschall (secretary-treasurer)

Background: Henry Barschall has a PhD from Princeton and has taught physics at the University of Wisconsin-Madison since 1946. He has spent much time and effort on APS activities, as a member of Forum Executive and Fellowship Committees and of the APS Council, Chairman of the Division of Nuclear Physics, and Editor of Physical Review C (for fifteen years). He represents the APS on the Governing Board of the American Institute of Physics and chairs the AIP Subcommittee on Information Technology. He is a fellow of the AAAS and of the American Academy of Arts and Sciences, and a past chairman of the NAS physics section. He has served a 2-year term as the Forum's Secretary-Treasurer.

Statement: Having recently retired from many of my professional assignments I have time to help the Forum by taking care of the needed paperwork. I have served on enough APS, AIP, and NAS/NRC Committees that I am very familiar with the organizations with which the Secretary-Treasurer has to interact. This experience may benefit the Forum.

REVIEW

Nuclear Fears: A History of Images, by Spencer R. Weart*

Harvard University Press, Cambridge, MA, 1988, 535 pgs, $29.50 (cloth)

Spencer Weart has set himself an ambitious task: the scholarly exploration of our culture's interaction with nuclear science and technology from the turn of the century to the present day. Although primarily historical, this is history with a difference. The author, Director of the Center for History of Physics at the American Institute of Physics, a historian with a PhD. in physics, brings the tools of history, psychology, sociology, and anthropology to bear on the popular, political, and technocratic responses to humankind's exploitation of the atomic nucleus. This is total history, a history of "mentalities" or widely expressed attitudes: *A History of Images*.

In this over-specialized age there are few serious attempts such as this to integrate our fractured knowledge. We need more total histories.

A more accurate title might be *Nuclear Myths* (using "myths" in both its trivial sense as "fairy tale" and its profound sense as "poetic or symbolized truth"), for it recounts not only our fears but also our hopes. Furthermore, it is a history not only of images, of symbols, but also of the "objective reality" of nuclear power and nuclear bombs.

The focus, however, is on the fears and the images. This tone is set in the first of the book's historically ordered five parts, "Years of Fantasy, 1902-1938." In a *tour de force* ranging over the history of alchemy, an incredible variety of science fiction films and plays and novels, the history of radioactivity, and journalistic and public responses to all of this, Weart presents us with the popular symbols and fantasies that have accompanied the nuclear debate and, indeed, the general debate over technology and values. We encounter the image of science as Frankenstein's monster created thoughtlessly and gone out of control; the technologists' dream of gleaming white cities where hunger is unknown and electricity is too cheap to meter; the central scientific myth of transmutation, "the passage through destruction to rebirth." In our technocratic (i.e. pertaining to technology and science and its infrastructure) culture, such images are powerful, universal, and archetypal in the Jungian sense.

In part two, 1939-1952, nuclear fears confront nuclear reality at Hiroshima. Here, imagery yields partly to the "objective" histories of strategic bombing, the Manhattan Project, and post-nuclear national security debates. I found the sexual imagery especially enlightening (pp 147-148): SAC commander Curtis LeMay's description of the nuclear bomb as a "baby—clinging as a fierce child against its mother's belly" and of "electronic snakes packed into every inch of a bomber's body, monstrous treasures throughout the stiff flesh;" the Hiroshima bomb, dubbed "Little Boy," cradled within an airplane named after the pilot's mother; bombs routinely referred to as "eggs" and bombers routinely given female names; bombs cartooned as cigar-shaped masculine creatures; the 1930s and 1940s references to dangerously seductive women as "bombshells." Such images may be rationally contradictory, but they share the psychological power of sex, birth, and death.

In 1953-1963 the horrors continue with the unfolding of the H-bomb story, but now hope appears in the uncertain form of "atoms for peace," i.e. nuclear power.

Concerning the horrors, Weart provides a non-fiction example of a madman who almost destroyed the world (p. 230). According to former Kennedy administration advisor Raymond Gartoff, at the peak of the 1962 Cuban missile crisis an American spy in Moscow sent a false warning that the Soviets were about to launch their weapons. Having learned that he was about to be arrested, the spy "evidently decided to play Samson and bring the temple down with him." In addition to the reference given by Weart, Gartoff recollects this incident in detail in his *Reflections on the Cuban Missile Crisis*, pp. 39-41.

Another insight, more hopeful, is the "tremendous fact" that "it is democratically elected governments, alone of all types of government, that have never in history made war upon one another" (p. 248). Apparently, no one had noticed this. It might be the most important idea in the book.

Concerning atoms for peace, there is implicit in this history an important answer to the question "who killed nuclear power?", and a lesson for all powerful technologies. Shortly after World War II, the Atomic Energy Commission was created to oversee both nuclear power and nuclear weapons. The great hope was organizationally tied to the great fear. Nuclear power, already heir to general nuclear fears and to the Manhattan Project, was saddled with the entire dark apparatus of the national security state: secrecy, propaganda, cover-ups, fear of the enemy, military bureaucracy, military budgets, masculine tough-mindedness, unreasonable faith in technology. The AEC's condescending attitude toward "civilians," the historic mistake made by removing Oppenheimer's security clearance, the dominance of self-righteous ideologues such as AEC Chairman Lewis Strauss, the shoddy public relations and lies associated with early nuclear tests, guaranteed that the public would forever link bombs and reactors and be forever skeptical toward all things nuclear. Regardless of the rational protestations of nuclear power advocates, the public will not accept complex technologies in the face of evidence that the individual people who control that technology are not to be trusted. Not only technologies, but technologists, must prove themselves.

These three parts form the bulk of the book. They are excellent and thought-provoking.

The fourth and final major part (part five is a shorter appendage), focusing on the "reactor wars" of the 1970s and 1980s, is weak. Rather than a history of deep cultural influences, it emphasizes the "objective" debate over politics and technology, a well-worn topic treated mostly in well-worn fashion. Worse, many will read it as a pro-nuclear tract, tending to trivialize anti-nuclear concerns about accidents and waste and proliferation while quoting pro-nuclear arguments as though they represented a scientific consensus. For example, while bashing Barry Commoner, Helen Caldicott, the Sierra Club, and the Union of Concerned Scientists, and granting only a few faintly admiring remarks to the powerful anti-nuclear arguments of Amory Lovins, Weart uncritically recounts the standard industry arguments about the "real reactor risks." These polemics are out of place here, and distract from the many serious lessons that the book does offer. I think that Weart is trying too hard to find some justification for nuclear physics.

The political analysis here misses some important connections. Nuclear power's difficulties may have more to do with economics than with fears and protests, a point of view insufficiently noted here. The cultural and economic significance of the 1979 accident at Three Mile Island, surely a seminal event in the demise of nuclear power, is barely noted (pp. 336-7). The Vietnam War is never mentioned.

While noting nuclear protest's "great silence" in the 1960s, Weart fails to tie this silence to the contemporary immersion of the counterculture in the fires of that war. Nor does he note the effect of the war in building a strong disaffected minority, nor the coincidence of the 1970s anti-nuclear and environmental movements with the recession of that counterculture's interest in Vietman

The emergence and overall significance of the women's movement is likewise overlooked, but the important nuclear power gender gap is noted in three striking paragraphs (p. 367). While twice as many men as women associate nuclear power with progress, twice as many women as men associate it with dangers. This "strong divergence turned up in every poll, in every country, at every time." Although not noted by Weart, a similar gap is recorded in all polls regarding nuclear weapons and more general questions of war and peace, since at least the time of the Vietnam War.

Overall, the book communicates not just a history of nuclear fears, but also a view that those fears are naive and mis-directed. Some of us will disagree. For example, Weart attacks popular imagery for its overconcentration on the nuclear question. But perhaps the nuclear question is simply the most obvious example, and therefore the most plausible target. It is good tactics to concentrate. Amid Bhopal, dying lakes, the greenhouse effect, ozone depletion, smog alerts, genetic manipulation, fetal transplants, and more subtle disasters such as the overspecialization of knowledge and the alienation of our urbanized society from its natural roots, the citizen scarcely knows which way to turn. One cannot attack them all. Perhaps popular distrust of technology must, like knowledge itself, specialize if it is to have impact.

The myth of the technocratic culture as a monster created thoughtlessly and gone out of control is compelling precisely because it has a great deal of validity. Weart recognizes this fact, especially in his treatment of nuclear weapons, but fails to do justice to it.

The book concludes with the author's image of "a society that will merge Arcadia with the White City, a society where the citizen will sing with both poets and engineers." This prospect of the wise use of technology is perhaps the ultimate social goal of the human race. Although I have been somewhat critical in this review, it is because I take the book seriously as a useful contribution toward that goal. It is a good book, one whose strengths far outweigh its weaknesses, for too few of us possess the knowledge, the energy, and most importantly the aware concern, to attempt such a significant and wide-ranging venture. It should be read by students (and not only those enrolled in schools) of the history of technology in general, and of nuclear technology in particular.

Art Hobson

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NEWS

Promote Science and Society Awareness! Inform Others About the Forum

Distribute *Physics and Society* to others, either by loaning or photocopying your copy, or by writing to the editor (address on page 2) and requesting any number of copies, from a few for acquaintances to as many as 100 (if available) for distribution to physics departments or at meetings. If you distribute very many copies it would be helpful to make an announcement, or to enclose in each copy a note, encouraging Forum membership.

Urge others to join the Forum. *Physics and Society* is sent free to all Forum members, and Forum membership is free to APS members. To join the Forum, APS members need only indicate their desire to join on the annual APS membership renewal notice, by listing "Forum" on the front side of the notice as described under "renewal instructions." Alternatively, APS members can join the Forum by filling out the following statement of intent and mailing it either to the editor or directly to the APS:

I am an APS member who wishes to join the Forum:

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NASTS Conference

The National Association for Science, Technology and Society (NASTS) will hold it fifth annual Technological Literacy Conference on 2-4 February 1990 at the Crystal Gateway Marriott, just outside Washinton, D.C. The program will include hands-on workshops, papers, participatory events, exhibits, panels, and tutorials. Sessions will be built around the following 5 STS themes:

- education and information
- technology, industry and work
- environment
- health and bio-medicine
- moral, ethical, philosophical perspectives.

For more information, contact Franz Foltz, Meeting Manager, 117 Willard Building, University Park, PA 16802, (814)865-3045.