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LETTERS

Toward a Broader Forum

I thank Elton Kaufmann for his interest in the Forum programs. In his letter (January 1989), Kaufmann encouraged Forum officers to broaden the content of the newsletter and of Forum symposia. I believe we are all consciously working in that direction. Over the past few years, perhaps 60% of our programs have dealt with arms control issues, but we have done better lately: Of the eight Forum-sponsored invited-paper sessions held at APS meetings in 1988, four dealt with education, energy and the environment and the fifth — on the safety of U.S. nuclear production reactors — was only peripherally concerned with nuclear defense. Over the past four years, one of the two Forum awards given annually honored work *not* related to nuclear defense. The newsletter has attempted to attract articles on a variety of subjects, and its editor has authored a number of editorials designed to elicit interest in some of these other issues. True, the past two study groups — on civil defense and land-based missiles — have dealt with nuclear defense, but a third study group is actively assessing the current US energy picture. The short course last April was on nuclear arms control issues but its predecessor concerned energy conservation and renewables.

In all these activities we are, however, strongly dependent on the willing participation of our members. We need high-quality contributions to the newsletter on such topics as carbon dioxide, waste disposal, science education. We need imaginative suggestions for invited paper sessions and volunteers to organize them. We need dedicated workers for our study groups. Let us hear from you.

The Forum is ready to entertain suggestions for a new study and I for one invite proposals on a topic that does *not* deal with nuclear defense. In fact I will make this letter serve as a call for proposals of study group topics. If you wish to make such a proposal, write down your thoughts on why the topic is an appropriate one for the Forum at this time and include a detailed outline, and mail it to me.

Barbara G. Levi
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Light Bulbs Have Global Reach

Replacing an incandescent light bulb with a compact fluorescent bulb seems like a simple act, but the consequences go far beyond saving a few dollars on your energy bill. That compact fluorescent light bulb is a powerful weapon in the battle to protect the global environment. A single 18-watt compact fluorescent bulb produces the same light as a 75-watt incandescent bulb and lasts about 13 times as long.

Over its lifetime, the new light bulb will slow global warming and reduce acid rain by avoiding emissions from a typical US coal plant of one ton of carbon dioxide and about 20 pounds of sulfur dioxide. Or, if it instead saves nuclear electricity, it will avoid the production of half a curie of strontium-90 and cesium-137 (two high-level waste components) and about 25 milligrams of plutonium -- about equivalent in explosive power to 850 pounds of TNT, or in radiotoxicity, if uniformly distributed into lungs, to about 2000 cancer-causing doses. The same fluorescent bulb will also save the cost of buying and installing a dozen ordinary bulbs (about \$20); the cost of generating 570 kW-h of electricity (about \$20+ worth of fuel); and, during its lifetime, approximately \$200-300 worth of generating capacity.

Not bad for a light bulb, costing about \$15-18, that you can install yourself.

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Rocky Mountain Institute Newsletter
1739 Snowmass Creek Road
Old Snowmass, CO 81654-9199

A New International Journal

I write to draw your attention to a new international journal, *Science and Global Security*, that will publishing scientific analyses relating to arms control and global environmental policy options. The journal will be published in both English and Russian starting this summer.

Harold Feiveson is the editor and Roald Sagdeev of the Soviet Space Research Institute and I co-chair the editorial board. Other US members of the editorial board are: Herbert Abrams, M.D., Stanford; John Holdren, Berkeley; Tom Johnson, West Point; Frank Long, Irvine; Milo Nordyke, Lawrence Livermore; Ted Postal, Stanford; and George Rathjens, MIT. Other Soviet members are Vitali Goldanskii, Institute of Chemical Physics; Sergei Kapitza,

Vavilov Institute of Physics; Andrei Kokoshin, Institute for the Study of the US and Canada; Stan Rodionov, Space Research Institute; and Evgenii Velikhov, Kurchatov Institute of Nuclear Energy.

The first issues of the journal are expected to include articles on:

- verification of the dismantlement of nuclear warheads,
- feasibility and verifiability of a ban on nuclear reactors in earth orbit,
- verification of limits on nuclear SLCMs,
- techniques for detecting nuclear warheads,
- scientific results of the NRDC-Soviet Academy in-country seismic-monitoring project
- accuracy of the CORRTX method for estimating the yields of underground nuclear explosions, and
- the possibility of imposing performance limitations on some BMD-relevant technologies.

If you are potentially interested in submitting an article to the journal, write to Harold Feiveson at the Center for Energy and Environmental Studies, Princeton University, Princeton, NJ 08544, or call him at 609-452-4676.

For a complimentary first issue and subscription information, write Gordon and Breach Science Publishers, Marketing Department, P.O. Box 786 Cooper Station, New York, NY 10276.

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Environmental Topics in Physics Courses

An editorial (October 1988) inquired as to whether any physicists had been teaching topics such as the greenhouse effect in their physics courses. I have been doing so in many of my courses, particularly introductory calculus and non-calculus courses, since 1970. See my article, "Environmental topics for introductory physics courses" in the April 1974 issues of *The Physics Teacher*.

Incidentally, the possible climatic role of carbon dioxide was pointed out by physicist John Tyndall in his Bakerian Lecture "On the absorption and radiation of heat by gases and vapours," published in the 1961 *Philosophical Magazine*, when he wrote "It is exceedingly probable that the absorption of the solar rays by the atmosphere...is mainly due to the watery vapor in the air. Every variation of this constituent must produce a change of climate. Similar remarks would apply to the carbonic acid diffused through the air." In an 1896 *Philosophical Magazine* article "On the influence of carbonic acid in the air upon the temperature of the ground," chemist Svante Arrhenius estimated that a doubling of atmospheric CO₂ would increase the surface temperature by 5 to 6 Celsius degrees, with different warmings at different latitudes.

Verily, there is nothing new under the sun!

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ARTICLES

Symposium: The University of California, The National Weapons Laboratories, and Arms Control

With this issue, *Physics and Society* begins a policy of publishing sets of papers based on recent Forum-organized invited sessions at meetings of the American Physical Society. The five papers printed below are based on a session held on the evening of 16 January 1989 at the San Francisco APS/AAPT/AAAS meeting. The session was organized and presided over by Paul Craig, Professor, Department of Applied Science, University of California, Davis, CA. The papers presented here differ somewhat from the program for the session. One listed speaker, John Nuckolls, Director of the Lawrence Livermore National Laboratory, was unable to attend the session. Thus, at the last minute, University of California Vice-President William Frazer, who happened to be in attendance, graciously agreed to extemporaneously present some University and lab views. Also, another of the session participants wasn't able to submit a paper for publication. The five papers printed here include three (Fulco, Blum, Seaborg) based directly on the session in San Francisco, plus two others that I solicited from the University of California (Kane) and Lawrence Livermore National Laboratory (Brown) in order to reflect the range of views expressed at the session.

Editor

Faculty Concerns

Jose' Fulco

There have been many occasions when the University of California faculty have shown strong concerns about the relationship between UC and the weapons laboratories. These concerns have been based mostly on the question "should the university manage the laboratories or not?" About a year before the university regents decided to continue their managerial role over the weapons laboratories, a group of 48 physics faculty of the eight general

campuses wrote a letter to President Gardner requesting several actions by which the university would reaffirm its direct managerial role. At the same time, a large number of faculty members from other disciplines also expressed similar concerns. All these actions prompted the UC Academic Council to appoint a special committee

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to study the relation between the university and the Department of Energy laboratories. This committee should produce a final report by 1990. Therefore, a second question has been added to the faculty concerns: Given that UC is managing the weapons laboratories, what should be the meaning of this management? Should the university exercise fully the five basic managerial functions: planning, organization, direction, supervision, and control, or should it limit itself to only some of them?

Events of the past two years, for example the director's position on stockpile reliability, lobbying of Congress on nuclear testing, the Woodruff-Batzel-Teller controversy, the 1987 Scientific and Academic Advisory Committee (SAAC) report and the following inaction by SAAC and the administration, and environmental problems at Livermore, have prompted widespread critical faculty reactions, reflected in independent articles and commentaries in the national press. These reactions have recently moved the state legislature to pass a bill advising the university to introduce certain changes directed at strengthening its management of the labs. I believe that these events clearly indicate that the present relationship between UC and the weapons laboratories fails in the five managerial functions and therefore cannot be accepted as a direct management relationship.

Therefore, we are back to 1978 when the Gerberding report, which was considered to reflect the views of the faculty, stated: "We also unanimously and strongly recommend significant changes. The majority of our committee endorses continuation *only* if these changes are made."

These changes are embodied in what I consider to be the most important statement of the Gerberding report: "It should continually survey all aspects of the laboratories' programs and policies so as to discharge the university's obligations to itself and to the public by ensuring that the laboratories' participation in the formulation and conduct of their programs be of the highest quality and the greatest objectivity, and that the laboratories not be isolated from the larger world of thought and action." And, further on: "During its deliberations, our committee found the accumulated total of these aspects" (technical and scientific competence, relative proportion of basic and applied research, freedom of expression, secrecy, scrutiny and control of programs, sense of accountability and awareness of the consequences of weapons research) "increasingly important, and now believes that it is by influencing the whole that the university can make its management of the laboratories morally and intellectually responsible."

The above statements define the basis for UC to justify its managerial role as a public service function, a function which is to provide the equivalent to the principle of civilian control of the military with respect to the weapons laboratories. Forty-five years of history tells us how important the weapons laboratories are in defining public nuclear weapons policy and how influential laboratory scientists have become. But laboratory scientists and their administrations are driven by several forces: (a) Their mission, which is to provide technically superior weapons and systems for national security. (b) Their interpretation of what is the best policy in the use of new weapons. (c) Their scientific interest, which moves them in the direction of more interesting and sophisticated systems. (d) The survival of their laboratories, which lead them to fight for continuation and amplification of their original mission.

All of these forces must be controlled, nurtured, and restrained at the appropriate time and in the appropriate circumstances. A society of laboratory scientists without external interactions readily becomes a closed society shrouded in secrecy in which there is a narrowly defined norm to which the members of the society must adapt, or else they must leave. This closed society is a cohesive

force which could shape policies even while representing a small part of the overall society in which it is imbedded. To prevent the weapons laboratories becoming a closed society the university must provide the interactions and the balances, must nurture a diversification of opinions and behavior, must destroy the norms and create the ability to see other choices and to embrace them.

The Gerberding report expresses this in a most concise manner: "We do think it possible — for the university indirectly to affect national policy regarding both nuclear weapons and energy by influencing the character to the laboratories, more fully exercising the managerial functions which are open to it, encouraging openness and facilitating collaboration between the university campuses and the laboratories. Influence of this kind could be important because it would be exerted in areas in which laboratory personnel have a share of the policy making."

Therefore, to justify its management of the weapons laboratories as a public service function, the university must be prepared to indirectly influence national policy and to fully bear the responsibilities for its actions.

Unfortunately this is not the administration's interpretation of it. For the UC Administration, the management of the weapons laboratories implies the appointment of the laboratory directors, some measure of control on the quality of scientific and technical work at the laboratories, and little else.

The often repeated statement that the main UC management role is to assure the easy expression of dissenting views and the maintenance of some measure of academic freedom compatible with the mission of the labs, while true in principle, does not seem to produce the desired results. We know of only a handful of strong dissenters out of over two thousand technical and scientific personnel. The Woodruff-Batzel-Teller controversy was made public not by the labs or UC but by an outside organization and certainly neither Director Batzel's reaction nor the university's inaction were supportive of freedom of dissent. Finally, I have always been surprised by the lack of public criticism of SDI from laboratories scientists while a large majority of the scientific community interested in national security issues have been so strongly opposed to every aspect of it.

Let me use the rest of my time to talk about the future. I believe that notwithstanding the changes made since the Zinner report (1972), the management style of the university has not changed much. In 1978, the Gerberding report stated: "Besides the significant task of selecting each of the directors and the somewhat less significant fact that university personnel policies apply to laboratory personnel, the university's involvement in the life of the laboratories is barely discernible."

We have two years before a new evaluation of the relationship between the university and the laboratories in preparation for another five year renewal of the contract. I believe that these two years are crucial for the future of the relationship. If at the end of this period, the basic premises of the Gerberding report are not satisfied then the university should not continue its management of the laboratories.

Let me list, then, a minimal set of changes that I believe many UC faculty members consider to be indispensable:

1. Replace the Regents oversight committee for the weapons laboratories with a board of directors composed of regents, university faculty, laboratory scientists, and recognized national security experts from outside the university. This board of directors should provide the structure necessary for the university to exercise fully the basic management functions and to provide the direction, emphasis, trends, and adequacy of the total program. In particular, it must create, maintain, and nurture the conditions for a stronger relationship between the UC faculty and the scientific and technical

personnel of the laboratories.

This proposal has been explicitly made by the Gerberding report: "Our committee recommends the appointment of a board of overseers" that should review all aspects of laboratory programs, insure that the programs are subjected to and based on critical analysis of their impact, participate in the contract negotiations between UC and DOE, encourage a two way flow of inquiry, and foster additional contact between the laboratories and the campuses.

It is interesting to note that this recommendation of the Gerberding report was fought immediately by the Department of Energy. Assistant Secretary for Defense Programs Dwane C. Sewell (a former laboratory employee) states in a letter: "The changing atmosphere at UC has raised the question whether the requirements of two very large and dissimilar endeavors as the nuclear weapons labs and the university can continue to be met as their respective missions require under the administrative arrangement which has worked so well in the past. The question has been also raised by some concerned people in Washington." The message was very clear: Serious attempts to alter a managerial relationship existing at present, i.e. increasing the oversight activities of the university, will result in the termination of the contract by DOE. Apparently, the university decided not to implement the Gerberding proposal. Therefore the new contract is "nearly silent" about the university's oversight role.

2. Choose directors of the laboratories from among the faculty of UC. A similar procedure is followed by AT&T Bell Laboratories in its management of Sandia.

3. Create an independent center or institute for the study of national security and strategic issues, possibly under the Institute on Global Conflict and Cooperation. This center will be dedicated to the study of policies which are or may be influenced by work at the laboratories. It will involve UC faculty, laboratory personnel, and visiting scientists, and could be patterned after the NSF Institute for Theoretical Physics at UC at Santa Barbara. The Center for National Security Studies at Los Alamos may act as a satellite for work involving classified material but it should be integrated into the main UC center. Salary support for extended work periods should be provided from the UC management fee. The laboratories must encourage staff participation in this project, which will require mutual education of all participants. Those UC faculty concerned with the university management role and the future stability of the nuclear world should welcome the creation of a suitable format for their participation in the study of these problems.

It is interesting to notice that the agenda for the Regents meeting of 19 September 1985 contains the following item for action: "Clearly, there are opportunities for further expansion of collabora-

tive education and research. The university administration intends to explore with DOE the initiation of a major program of enhanced laboratory-campus collaboration. Second, the university administration intends to press for a deeper and more broadly-based study of the issues and factors related to arms control, disarmament, and peace in order to bring together persons in the laboratories, on the campuses, and elsewhere who, through collaborative efforts in teaching and research, have a real contribution to make in this area of universal concern".

An important mission of this institute will be to create a new group of independent national security experts, a group being rapidly depleted by the retirement of the original Manhattan Project workers. Since then, essentially only the weapons laboratories have been preparing nuclear weapons national security experts, and these experts have been covering positions in the executive and legislative branches of government, in many think tanks, and in independent institutions. Even the UC liaison officer, Jim Kane, is a former laboratory employee. The past and present chairmen of SAAC, Raines and York, have worked in the labs.

We believe that this is a responsibility that the University of California must carry on to fully satisfy its obligations as a public servant.

4. Each laboratory should create some kind of organization somewhat equivalent to the Academic Senate divisions on each campus. These organizations will have responsibilities for the general control of scientific program quality, for proposing independent scientific initiatives, and for the maintenance of academic freedom of laboratory employees. It is interesting to note that the President of the Society of Professional Scientists and Engineers (not an exclusive bargaining representative) mentioned, in his presentation to the Academic Senate committee on the university's relation with the DOE laboratories, that they would like a formal review mechanism for resolving technical disputes, perhaps including peer review, and more oversight of the fraction of the Livermore budget devoted to basic and long-term applied research.

I believe there is a large measure of untapped intellectual power and expertise in the UC faculty and in the weapons laboratories to generate many new ideas for improving the relationship between the University of California and the laboratories. This power must be tapped. I have personally favored a strong relationship between the University of California and the weapons laboratories. I still think that the university's management of Livermore and Los Alamos could be for the benefit of mankind. However, if the failures of these last two years continue, I believe that a large fraction of the faculty will request that the implicit recommendation of the Gerberding report, i.e. to terminate the relationship, be implemented.

Public Perspectives

Deborah Blum

I have been asked to talk about the public's point of view concerning the University of California and the two nuclear weapons laboratories, Livermore and Los Alamos. Of course, my perspective is that of a journalist, which some would argue is not exactly that of an untainted member of the public. I don't know why. So, what I hope to do is discuss briefly what the journalist's viewpoint is, and then apply it to a specific case study concerning the university and the laboratories.

I'll admit that newspapers aren't always easy to live with. We hold people and institutions to very high standards — decency,

honesty, integrity. Some say we hold others to a higher standard than we do ourselves, which may sometimes be true. A favorite way of putting it in our business is that we are here to "afflict the comfortable and comfort the afflicted." Certainly, we feel a certain responsibility to the public to assure that a public trust is literally that, a trust.

Given that, I'd like to talk about one specific case at Lawrence

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Livermore National Laboratory, involving the university, a weapons scientist named Roy Woodruff, and the famed designer of the hydrogen bomb, Dr. Edward Teller. This is the story of the x-ray laser, one of the key "Star Wars" weapons in the program's early days, and I'm going to try to briefly summarize its high points.

In 1983, Roy Woodruff was an associate director of the lab, in charge of nuclear weapons research. The x-ray laser fell under his jurisdiction because its design called for a bomb-pumped laser, the source of its power being a nuclear explosion. And what's important to this story is that in 1983, as today, there is no working x-ray laser. In fact, there is nothing beyond several quasi-successful tests conducted at the Nevada Test Site.

But late that year, someone leaked Woodruff a copy of a letter that Teller had written to George Keyworth, the White House science advisor, assuring him that the laser was in "engineering phase." He protested it to Teller and to the laboratory director Roger Batzel and was blocked from writing any corrections, according to a complaint he filed with the university. Woodruff thought he'd won a concession to preview any other letters. But a year later, he was leaked two more letters from Teller to Paul Nitze, a chief arms control negotiator, and Robert McFarlane, then the head of the National Security Council. These were even more exuberant. In fact, the one to Nitze suggested that a single laser "the size of an executive desk" could take out an entire Soviet missile field. Woodruff once again asked for Batzel's approval to send letters of correction and, according to lab documents, he was once again turned down.

Thoroughly upset, Woodruff began monitoring the lab's classified briefing records. During 1985, he found that Teller's close colleague, Lowell Wood, had been briefing top officials from the Strategic Defense Initiative Organization about the x-ray laser. My favorite briefing title was "Columns of Fire in the Valley of the Giant Mushrooms." This was, lab scientists said, an unsuccessful attempt to persuade Pentagon officials to ignite the atmosphere with an x-ray laser detonation. Finally, in October 1985, Woodruff resigned his position as administrator of nuclear weapons research and transferred into a research post. He cited his concerns over misrepresentation of weapons programs as a primary reason for resigning.

And we probably would never have heard this story, except that Woodruff began to feel harassed by lab management and took his complaints to the university. Many of the people he sought to meet with there refused to even see him. He met with senior vice president William Fraser, before the 1980 Reykajik summit on arms control, and warned him that the White House was receiving biased informa-

tion on SDI. The summit collapsed over the question of SDI. Fraser acknowledged that he did nothing to help relay Woodruff's view to Washington. Woodruff did eventually regain a position of authority, under the guidance of UC president David Gardner. But Gardner refused to ever meet with him. And the university flatly rejected all his requests to investigate whether the laboratory was honestly representing the "Star Wars" program to White House officials, or his concerns that the "exaggerations" could influence arms control negotiations. Until this day, the University of California, the lab's manager, has conducted no formal investigation of these very troubling issues.

I'd like to quote US Congressman George Brown's reaction to all of this. Brown said, in part, "Why didn't the University of California, which directs the lab and is responsible for the technical quality of its work, exercise more responsible oversight of this situation? Why have the university liaison to Livermore, the senior vice president for academic affairs, and the president of the university, failed to meet with Mr. Woodruff to discuss the evidence he collected, documenting the misrepresentations, despite repeated requests for meetings by Mr. Woodruff? Why has the UC Scientific and Academic Advisory Committee, which reviewed issues pertaining to the university and the nuclear weapons labs under university management, ignored the controversy surrounding the x-ray laser? The regents of the university too were familiar with Dr. Teller's and Dr. Wood's abuse of their positions at the lab, and yet they failed to act."

At the *Sacramento Bee*, we asked many of the same questions. And I'd like to give you a journalist's perspective here on the response. Dr. Gardner, Dr. Teller, Dr. Wood, and Dr. Batzel all refused to talk with me. You know that you've got trouble when people won't even come to the telephone. Dr. Frazer did grant me a brief telephone interview. But he insisted that the university had made no mistakes in its handling of the situation. As a reporter, you know that you've got trouble when people insist that no mistakes were made. Everyone made mistakes. In fact, later when I pushed one of the university's public relations officers on that point, he said the university's only mistake was allowing a public relations fiasco to develop. So, I'd like to tell you my bias here. Livermore makes nuclear weapons, a technology that affects many lives. The management of such a laboratory needs to be scrupulous. It needs to be in the public trust. And from the evidence at my disposal, it would appear to me that this is not a case of upholding the public trust.

Improving the Role of the Laboratories in Contributing to Arms Control

Glenn T. Seaborg

Previous speakers, especially Jose' Fulco, have made a number of useful suggestions for improving the role of the national laboratories in contributing to arms control. Let me begin with a short statement. I have been involved in this issue from all sides.

I was already working in nuclear research when the German scientists Otto Hahn and Fritz Strassmann discovered the nuclear fission reaction before World War II. Like Leo Szilard, Albert Einstein, J. Robert Oppenheimer, Ernest O. Lawrence, Arthur H. Compton, and many other scientists I was convinced that Hitler's scientists were capable of beating us to the production of the atomic bomb. At the wartime Metallurgical Laboratory of the University

of Chicago, I was responsible for the development of the chemical processes for the separation of plutonium from uranium and fission products to be used after its manufacture in the chain-reacting piles at Hanford, Washington. I was in a position to observe firsthand how Oppenheimer, a University of California professor, played a key role in the creation of the Los Alamos Laboratory to ensure that the Nazis would not beat us to the atomic bomb. I was also on hand when Lawrence, another UC professor, played a key role in 1952 in the creation of the Livermore Laboratory in response to the spectacular increase in the Soviet Union's capability in the nuclear

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weapons field. At the startup of the Livermore Laboratory and during the ensuing years, a number of my students have held key positions in the Chemistry Division and included among these is Roger Batzel, the recent longtime director of the Livermore Laboratory.

I was a signer of the Franck Report in June 1945 that requested our government to use our next available atomic bomb in a demonstration of its horrible potential rather than on a Japanese city. I served as Chairman of the US Atomic Energy Commission from 1961 to 1971 and, in this position, was a prime mover of the Limited Test Ban Treaty of 1963 and the Nonproliferation Treaty of 1968. I have been a supporter of the subsequent arms limitations treaties and am today a strong advocate of a Comprehensive Test Ban Treaty (CTBT).

Thus, I have viewed the dilemma of nuclear weapons that faces us today from many perspectives. The public should know by now that we scientists do not lack the political passions that infect the rest of society. A consequence is that scientists of opposite political convictions may be tempted to take the same body of data and interpret and present it in ways that lead the public toward opposite conclusions. I tried to bear all this in mind when I assumed my duties as the first scientist chairman of the Atomic Energy Commission. My own predilections were strongly on the side of arms control in general and a test ban in particular. I felt that the future of mankind required such steps to arrest the arms race, yet I was not inclined to put down those in the AEC community who held opposite views, usually because of strong feelings about the requirements of national safety. They had many good points to make. There seemed little doubt that there were elements of risk in seeking a test ban agreement with the Soviet Union. The question that weighed heavily, however, was whether the risks of not reaching an agreement might not be greater, for such reasons as President Kennedy set forth.

The opposing views of the Kennedy Administration leadership and much of the AEC community continued to wage war in my head and conscience for the entire period of the test ban negotiations under Kennedy, more than two and a half years. I tried to play the honest broker between them, calling to the attention of each what seemed to be valid points raised by the other. Overall, my hope is that I struck approximately the right balance in attempting to nudge the government apparatus toward policies and practices that favored a test ban, while still according with the technical and national security realities. I have a great sense of satisfaction that we succeeded in obtaining a Limited Test Ban Treaty in 1963, but I also count it as one of the greatest disappointments in my life that we failed in our attempts, at that time, to obtain a CTBT. It is my belief that the United States and the world would be immensely better off today had we succeeded in this broader endeavor. In retrospect I feel that I was wrong in siding with those who demanded a large number of onsite inspections in order to ensure compliance with a CTBT, the main issue that prevented its successful negotiation.

I must confess that during the years of the Johnson Administration, in my official position, I felt obligated on occasion to point out the technical end for certain types of atomic bomb tests. This was especially true when it was national policy to develop major new weapons that could not be developed without testing. It was a clear instance of the old Washington adage "Where you stand is where you sit." However, I did not always allow the conditions of my employment to prevail over my personal convictions. When the debate on whether to deploy the Safeguard ABM system was raging during the Nixon Administration, for example, word reached me repeatedly that the President wanted me to make speeches in favor of deployment. This was not a part of my official duties and I was unwilling to do it, an attitude that did not add to my standing within

the Nixon Administration.

There were scientists within our national weapons laboratories that opposed the Limited Test Ban Treaty and the Nonproliferation Treaty and there were such scientists that supported these steps towards arms limitations. The national laboratories furnished experts to advise our arms limitations negotiators on the intricacies of the nuclear weapons process. I cannot say that in those days there was great support for arms limitations in the national laboratories, although there was more such support in the Los Alamos Laboratory than the Livermore Laboratory.

The situation is better today. The Los Alamos National Laboratory created the Center for National Security Studies in May 1986 with a charter to promote and conduct research and analysis in arms control, national defense, low intensity conflict and terrorism, energy security, and technological competitiveness. This Center has sponsored a number of relevant and interesting conferences, the writing of a number of books, and is presently in the process of producing, jointly with the UCLA Center for International and Strategic Affairs, a one-hour documentary film on the long term future of nuclear weapons (for which I was interviewed for a segment last Monday morning).

At the end of 1988, the Lawrence Livermore National Laboratory was establishing the Center for Technical Studies of Security, Energy, and Arms Control, with an anticipated budget of about \$1.3 million per year.

In July 1989 the University of California will sponsor an international conference on technology-based confidence-building measures to be organized jointly by the Los Alamos National Laboratory, the Lawrence Livermore National Laboratory, the UC Institute on Global Conflict and Cooperation (at San Diego), and several campuses of the UC system. This conference will explore areas of existing and potential cooperation between the United States and the Soviet Union.

These represent moves in the right direction, but there is much more to be done. There has been the perception by UC faculty throughout the statewide system, and I believe with some justification, that scientists from the national laboratories have gone beyond the bounds of propriety in lobbying in Washington against various arms control measures. A number of faculty committees have investigated this situation and written reports that have not led to any substantial results until recently. On 14 March 1986 Professors Jose' Fulco and Walter Kohn of the Department of Physics of UC at Santa Barbara wrote a landmark letter to UC President David P. Gardner, signed by 48 physics faculty of all the general campuses of the university. This letter suggested that questionable arguments were being used by scientists at the Livermore and Los Alamos laboratories to combat the widespread attempts to move toward a verifiable CTBT. They asked that the University propose the following steps to the directors of the laboratories: (1) develop a scientifically sound design and testing program which will point towards the timely end of nuclear weapons testing, (2) develop a firm time-frame for the completion of Item 1 after which nuclear weapons testing will no longer be necessary, and (3) in the interim, reduce nuclear weapons tests to only those necessary for implementation of Item 1. Also in March 1986, approximately 200 nearly identical letters were sent from faculty at the Berkeley campus which called upon President Gardner to determine: (1) whether designs of weapons now in the stockpile are such as to require continued nuclear testing to ensure their reliability, (2) whether the weapons design strategies of the UC labs have been consistent with the US foreign policy objective of achieving a comprehensive test ban, and (3) the extent to which the labs can be said to be actively promoting new nuclear weapons projects that will require nuclear tests, with special attention to the

recent history of the nuclear bomb pumped x-ray laser project.

These letters were referred to the University of California Scientific and Academic Advisory Committee (SAAC), a standing committee appointed by the UC president to advise the regents and himself on matters concerning UC's operation of Los Alamos and Livermore. In a report issued in July 1987 entitled "Nuclear weapons tests—the role of the University of California Department of Energy laboratories," there was a response to the concerns of UC faculty which, in the views of Professors Fulco and Kohn and others, was generally unresponsive and unsatisfactory. They wrote a response, dated 3 September 1987, which indicated that they disagreed with most of the substance of the SAAC report, saying that, in their opinion, this report demonstrates the ineffectiveness of the University's oversight of the weapons laboratories. There were other communications, that I will not attempt to summarize here, from the Academic Senate expressing dissatisfaction along the same lines.

On November 18th of last year, UC President Gardner announced during a Board of Regents meeting at UC Irvine that steps were being taken to strengthen the University's management of the Livermore and Los Alamos National Laboratories. He announced the intended appointment of three liaison officers who will closely monitor a wide range of matters that are of mutual concern to UC, the laboratories, and the DOE. These matters include programmatic review, funding trends, personnel policies and procedures, labor relations, financial management, security, construction, environmental health and safety, human reliability and drug testing, collaborative research among the laboratories and UC campuses, and technology transfer. It is not clear whether this strengthening of the University's management will improve the role of the national laboratories in contributing to arms control. I hope so.

I believe strongly that the litmus test of whether one is truly dedicated to achieving meaningful arms control is the effective and conscientious pursuit of a CTBT. We must stop the qualitative improvement of nuclear weapons. Even now, significant new weapons are being developed or considered that could make the current "balance of terror" much more unstable. Examples are third generation warheads with specialized effects such as enhanced radiation or electromagnetic pulse to kill electronics, the nuclear pumped x-ray laser intended for the Strategic Defense Initiative, and penetrating warheads to destroy command and control bunkers. A CTB would forestall all these dangerously destabilizing developments because the new weapons could not be brought into being without extensive warhead testing. A CTB would also strengthen the nonproliferation regime.

A virtue of a CTB is that it can be achieved, or approached, by a

variety of means. A full-fledged treaty seems foreclosed for the next few years by the incoming administration's attitude, but consideration has been given to proceeding toward a CTB either by declining annual test quotas or by phased reductions in the permitted yield of underground tests. A problem with this approach is that the process could be reversed or terminated and that it would take too long. Many third generation weapons could be developed while tests were still permitted.

An intriguing alternative, recently the subject of U.N. General Assembly resolutions, is to use the amendment procedure in the Limited Test Ban Treaty so as to add underground tests to that treaty's prohibitions and, in effect, transform it to a CTB.

My suggestion for improving the role of the national laboratories in contributing to arms control would be to enlist their wholehearted support in a program of preparing for proceeding toward a CTB. I know that the weapons laboratories claim that they are moving in this direction, but I believe much more could be done. The leadership could wholeheartedly announce their intention to proceed in this direction. I know, of course, that there are members of the weapons laboratories who are vocal in their support of a CTB and for this we should be grateful. The unclassified information that they make available is valuable to those of us on the outside in refuting the specious arguments against a CTB. Incidentally, I think that it is only under a laboratory management like the University of California that these scientists would be allowed to speak out. I believe that military or industrial oversight of the weapons laboratories would not allow such frank discussion.

This is not to say that I don't understand the reluctance of the leadership of the weapons laboratories to move in this direction. As I have indicated earlier, I also on occasion advocated continued weapons testing during the time that I was in a position of responsibility to assure an adequate nuclear weapons capability. However, the international situation has changed dramatically since the 1950's and the 1960's and even the 1970's. The thinking of those times is now outmoded. We are living in a time of glasnost and perestroika and a time of realization that our national security now depends more on spending money for education and nonmilitary basic and applied research and high technology industrial improvements rather than on armaments. We need to increase the scientific literacy of our general population; to educate our work force in the intricacies of a highly competitive technological society, and to ensure the supply of our scientific, engineering, and other intellectual resources upon which our economy has come to depend. We are in danger of becoming a really second-class power unless we readjust our priorities with less emphasis on armaments.

The Importance of the UC/Weapons Labs Relationship to National Security and Arms Control*

Paul S. Brown

From time to time, there has been criticism of UC's management of the DOE national weapon labs at Livermore and Los Alamos. Some charge that UC has failed to provide adequate oversight and others question whether it is even appropriate for a university to be involved with weapons. In this paper, I present my personal views on the subject. I argue that the nation benefits from UC's managing the weapons labs and providing an environment conducive to thought and actions that are independent of bureaucratic pressures.

The UC administration says it performs a public service in

managing the labs. It strives to provide an environment that encourages technical excellence and freedom from political pressures and fosters an atmosphere where debate is possible and intellectual reasoning is dominant. In a different atmosphere, there would be less independent-minded research that could lead to cruder, more dangerous weapons or to the pursuit of poorly conceived concepts. The following examples illustrate how the

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existing environment has worked to the benefit of national security and arms control.

Examples of independent thought and action

In 1982, President Reagan set up a commission led by Professor Charles M. Townes, a Nobel Prize winner in physics from UC Berkeley, to evaluate basing options for the MX missile. The commission sought input from a variety of sources, including weapon systems analysts from Lawrence Livermore National Laboratory (LLNL). LLNL had been studying various basing options for MX and had concluded that all suggested basing schemes were flawed. The fact that such criticisms came from LLNL was ironic, because LLNL also had the task of developing the warhead for MX. While the right hand was developing the weapon, the left hand was showing what was wrong with the system.

Dr. Townes wrote University President David Saxon and said, about Livermore's input: "It was clear that most of the industrial organizations were quite cautious about giving information or making conclusions which would be contrary to Pentagon policy. I was personally impressed that the many persons who helped us from Livermore seemed completely objective in examining the technical facts, in investigating what needed to be looked into, in looking for weaknesses as well as strengths in current proposals, and in being willing to state plainly, though diplomatically, where they did not agree. In most cases, I found individuals from academia also objective, though generally by no means so deeply knowledgeable. I make the above point because I think, contrary to some opinions, Laboratory personnel are often important in giving helpful perspective and ameliorating US nuclear policy, and that this is partly because they are protected by the management structure from obvious pressures to which commercial companies or governmental laboratories are subjected."

The ICBM basing debate goes on. The Winter 1988 issue of *International Security* has an article (1) on MX rail basing by John Harvey, a LLNL physicist, and Barry Fridling, recently an arms control research intern at LLNL. The article addresses the technical problems of rail basing and discusses a fundamental problem with the concept in that its survivability depends on strategic warning. While the article ran counter to Administration policy, it did so with technical objectivity.

Another example where Lab personnel have come to scientific conclusions independent of external policy considerations had to do with Soviet compliance with the Threshold Test Ban Treaty (TTBT). The TTBT is monitored by teleseismic means. There are large uncertainties in seismic monitoring of nuclear test yields, and the Reagan Administration has claimed the Soviets are in likely violation of the treaty. Yet, studies by LLNL verification experts have concluded that the Soviets have been observing a yield limit consistent with TTBT compliance, although a few tests might have exceeded the limit. We have stated our results publicly, have reported them in Congressional testimony by the LLNL director (2) and by other scientific staff members (3), and have impacted the US policy debate. After Roy Woodruff, then head of the nuclear weapon design program, expressed his views on the TTBT in a Washington Post interview, he was awakened at 05:30, California time, by a phone call from the Secretary of Energy asking how he dared oppose Administration policy. Roy reminded the Secretary that he worked for UC and not the Administration, and that he had every right to speak his mind on the issues. Roy reports the Secretary apologized.

LLNL scientists have analyzed the system requirements for deployments of SDI. These analyses have often provided a less

optimistic basis for projecting what might be accomplished by potential SDI deployments than has been projected by other system analysts or by ardent proponents of SDI. A good example is the study of early deployments using space-based rockets. LLNL analyses have shown that while such early deployments may provide an effective defense against the current Soviet missile threat, ten times as many rockets would be required to defend against a modernized Soviet force. LLNL analyses also show that the Soviets could implement cost-effective countermeasures to the proposed early deployments over the same time frame as those deployments. In April 1987, George Miller, the head of the LLNL weapons program, reported on these analyses in Congressional testimony (4).

Regarding the feasibility of SDI, there is a wide spectrum of views at LLNL. The national consensus seems to be there should be a viable research program. However, achieving extremely effective defenses has been described by one of my colleagues as something to be viewed with "healthy skepticism". With few exceptions, LLNL staff members to whom I speak, including the senior program managers, believe that research should be done within the limits of the ABM Treaty. Nearly all the individuals I know are very supportive of the Treaty, and its traditional interpretation. All these views have been held in the face of unquestioning support for SDI by the Administration in Washington. The above examples typify the technical objectivity that exists among weapon lab scientists. This objectivity has often run counter to bureaucratic pressures. For the most part, we have tried to do what is technically correct, rather than what is politically expedient.

Room for dissenting views

Technical objectivity requires that there be room for dissenting views. Some scientists at the labs question that enough technical objectivity exists. For example, there are physicists at LLNL who are openly critical of how the labs do their business. They believe the labs have been overly aggressive in pushing technical programs at the expense of objectivity. Specifically, they criticize the approach to designing weapons. Among other things, they state that the stockpile weapons we have designed should have been more conservatively designed with a CTB in mind and that the labs have used their influence to fight a CTB, intentionally developing weapons that need further nuclear testing for reliability. We hear allegations that the labs do this just to stay in business, have placed obstacles in the way of a CTB and other arms control efforts, and are only interested in developing exotic new weapons.

In response to claims made by some UC professors about the labs and nuclear testing, the UC Scientific and Academic Advisory Committee (SAAC) reviewed the testing practices of the labs. The SAAC report (5) was quite supportive of the labs' design practices and efforts to design robust weapons. SAAC commented that "the labs have been acting under a plan that emphasizes the necessity to be prepared for a CTB." Regarding the claim that weapons were deliberately designed to require continued nuclear reliability testing, SAAC concluded, "... this is not true." The professors have criticized SAAC for failing to deal with certain issues, e.g. whether further testing is needed. It is important to note that SAAC did their review under a specific mandate to determine whether the labs are doing their job properly. SAAC concluded the labs have been acting properly. Other issues were outside the mandate of their review.

In 1987, the LLNL director was asked by six Congressmen to make Ray Kidder, a LLNL physicist and internal critic, available to do a study (6) on stockpile reliability, and the director agreed. Kidder was provided with the time and information he needed for his study. A corresponding study (7), with different conclusions, was

done by the LLNL weapons program. I believe this was the first time that an internal critic has been asked to do such a study, and the fact it happened illustrates the latitude that exists at the labs for freedom of expression of alternate points of view. It is unlikely a similar review by an internal critic would occur elsewhere in the US defense community.

While the dissenting scientists have exerted a lot of leverage on the debate, I disagree with what they have been saying. I believe the fact that they are free to express their ideas, and to criticize, is a healthy situation made possible by the UC management.

The Influence of the weapons laboratories

There has been criticism that the labs exercise undue influence in pushing their programs. In point of fact, the labs have been chartered by Congress, specifically each year in the Defense Authorization Act, to "explore and provide new technologies necessary to maintain US nuclear deterrent forces..." and to conduct "... research on the feasibility of innovative applications of nuclear technology that may eventually be important." An extremely important part of this task is to communicate to the government what can be achieved, and this process is what many refer to as "influence."

I once heard a statement on the question of lab influence that I felt put the issue into perspective. The statement was made by Bryan Hehir, a Catholic Priest who was a key architect of the American Bishops' Pastoral Letter on War and Peace (8). In February 1985, Father Hehir was an invited speaker at a colloquium sponsored by the Bishop of the Oakland Diocese. The colloquium was the second in a series of such events (seven to date) that are being held to conduct a dialog on ethics and nuclear weapons issues. The participants came primarily from LLNL, UC, and the San Francisco bay area religious community.

Father Hehir replied to a question about the labs' role in pushing technology and their impact on policy: "It seems to me the weapons laboratories are going to do what they are designed to do. They're going to be totally involved in this process. They're going to put forward a whole series of propositions. They're going to try to push forward the frontiers of scientific research and they're almost inevitably going to push for technological transition. I'm not against people doing what they are designed to do. What I'm in favor of is political figures doing what they're designed to do. Which is to say, they ought to listen intently to what scientists and technological institutions propose and then they ought to decide on other grounds than the purely scientific or technological grounds what ought to be done. So, in my sense, I'm sure the weapon laboratories do drive the dynamics but I'm not positive I am arguing that they ought not to do it. I'm arguing that other people ought to do other things..."

The labs support arms control in many ways (9)

At LLNL, we have dedicated, growing programs to develop methods of treaty verification (10) and study nuclear proliferation. We have people on temporary assignment to Washington agencies, e.g. DOE, DOD, ACDA, and State Department. Lab personnel have participated in arms control negotiations in Geneva, e.g. the Conference on Disarmament, NPT, SALT II, CTBT, TTBT, PNET, START, INF, the SCC, and the current Nuclear Testing Talks. We are constantly responding to requests for information from Washington and often perform detailed studies in response. Just as frequently, we initiate studies which we deem important to current arms control issues. Recent efforts include a joint study with the Stanford Arms Control Center on the verification of SLCMs (11) and several studies of the impact of a START agreement on

force structures and strategic stability (12, 13). We have also analyzed the stability of transition to a defense-dominated deterrence (14) and the benefits of ASAT arms control (15).

There are criticisms that the labs block arms control measures. The facts contradict these claims, as born out by the examples given above. I sense a strong advocacy for arms control by lab personnel, including the senior weapons program management. Still the perception that the labs get in the way of arms control exists. This is doubtless due to the strong opposition, on technical grounds, by the labs to a CTB over the years. We are constantly called on by DOE and other branches of the government to state our technical views on the impact of test bans. Often, when we respond, we read in the news that we have been lobbying. When the policy-makers want advice on diplomatic matters, they ask the State Department. When they want advice on military matters, they ask the Joint Chiefs of Staff. When they want advice on the technical aspects of nuclear weapons, they ask us. A recent GAO investigation (16) of alleged illegal lobbying activities by weapons lab personnel vindicated the roles we played in supporting DOE in Congressional briefings, and recognized "the importance of the national laboratories in providing technical information and analyses to both DOE and the Congress." The GAO report said that balance was needed in providing such a service and specifically criticized certain use by DOE of lab personnel in management roles.

Improvements are possible

There have been news stories about disputes between Roy Woodruff and Laboratory management concerning overly optimistic assessments made by Edward Teller and Lowell Wood to high-level policy-makers. Roy resigned his position three years ago because of that dispute. A key issue then was who had the right to speak for the Lab's program—a program Roy was in charge of. Roy wanted to write letters to the same policy-makers to present his and the program's views about the technical possibilities, and he was told by his management they preferred he not write those letters, and instead should brief the policy-makers in person. Roy disagreed with this management decision and resigned.

Roy set his principles high. In so doing, he put his extremely promising career in jeopardy. What we are dealing with here is more than a question as to who was right or wrong about the technical assessments. There have always been disagreements among scientists in the past and there always will be in the future. What concerned Roy was how the assessments got carried forward and influenced the policy debate. I believe he was right to be concerned.

I believe the UC Administration should have investigated the reasons for Roy's resignation at the time it happened rather than having had to face the situation several years later. On the other hand, the fact of UC management made it possible to bring this situation out into the open in the first place and to foster subsequent discussions on the issues. The situation may have remained hidden from view had it occurred elsewhere in the defense community.

Clearly, we can do better, and the recent initiatives by UC to provide increased oversight are a step in the right direction. Another step that should be taken is to provide for more internal peer review of technological ideas that could have implications for national policy. While scientists would still be free to speak out on their ideas, policy-makers could look to the internal peer review process for guidance.

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The University's Management of the Weapons Labs

James S. Kane

The University of California manages the two National Laboratories at Los Alamos, New Mexico and Livermore, California through separate contracts with the United States Department of Energy. Although both laboratories conduct a wide spectrum of applied and basic research, their chief mission is the design and test of nuclear weapons. What follows is a brief summary of the history and rationale of the university's involvement.

The university has managed Los Alamos since that laboratory was founded in 1943, and Livermore since that site was established as a branch of the Lawrence Berkeley Laboratory in 1952. The management contracts have been extended at five-year intervals since inception. The two laboratories comprise a huge technical enterprise, with a total annual budget of approximately \$2 billion and employment of over 16,000. Of the annual allowance paid by the Department of Energy for management, approximately \$7 million is received by the university, whose annual budget, including the laboratories, is over \$6 billion.

It might seem strange that a world-renowned university would be involved in an activity that is abhorrent to some of its faculty and students, and indeed to some of the citizens who support it. The issues surrounding the appropriateness of the relationship have been debated extensively at each contract renewal. The Regents of the university hold open hearings prior to their decision, with thorough airing of the various views.

Although the level of intensity of this debate has waxed and waned

over the years, the content has changed little. The participants generally group into three categories: those who believe that the University's association with weapons of mass destruction is immoral and therefore unacceptable; those who realize the need for nuclear weapons as part of the nation's defense, but who believe that the University's involvement detracts from its principal functions; and those who believe that the relationship is appropriate. The latter view has prevailed.

A majority of the Regents have accepted this heavy and often irksome responsibility as a public service. Their reasoning is pragmatic; nuclear weapons are a fact of life, and nuclear deterrence will almost certainly be a key component of national defense for the foreseeable future. The need for nuclear weapons expertise will thus persist. The Regents believe that the responsibility for overseeing this controversial but essential activity is best discharged by a university. The chief reason for this belief is that a university can foster a mode of operation that is different from that of any other institution. The university insists on scientific and technical excellence as the *sine qua non* of its stewardship. It brings as much openness and free discussion to laboratory issues as is possible, given the often classified nature of the work. Further, the university is in no way beholden to the

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federal authorities, and can act as an essential buffer between the independent views that emerge from the technical work, and the political forces that inevitably are brought to bear.

In sum, the university tries to operate the laboratories in accord with the traditions of academia, always recognizing that the nature

of the work and the way in which it is done make this an unattainable goal. Nevertheless, the character of the laboratories has been and continues to be strongly influenced by the university's presence. The service performed by the university is indeed of great value to the nation's citizens.

REVIEWS

The Future of Land-Based Strategic Missiles, Edited by Barbara G. Levi, Mark Sakitt, and Art Hobson

To be published, probably in April 1989, by the American Institute of Physics, New York, approximately 290 pages.

Despite well over a decade of debate, the United States still cannot decide what it wants to do about ICBMs. Fifty MX missiles have found at least temporary homes in old Minuteman silos, while developments on other options proceed at various paces. It is time for a decision. Indeed, the Bush administration and the US Congress are taking this issue up again this spring, and it is possible that important and maybe even final decisions will be made soon.

This book, the result of a Forum-sponsored study, is a contribution to the debate. It is intended to shed light, not heat, so it does not advocate any particular position. It discusses and evaluates the most-mentioned options such as rail-based MX and mobile Midgetman, along with some less-discussed possibilities such as doing nothing, evolving toward a bomber/submarine strategic diad, and basing a few hundred missiles deceptively in a much larger number of silos.

As a related contribution to the debate, the Forum is sponsoring an invited session on ICBM modernization issues at the Baltimore APS meeting. The scheduled speakers are: Les Aspin, Chair of the House Armed Services Committee, Colonel Victor Bras of the US Air Force Office of ICBM Modernization, James Woolsey, an important long-time participant in this issue, and Barbara G. Levi, who will present the conclusions of the present book.

The ten authors of this study wanted to present a more coherent report than is sometimes achieved in collections of individually authored papers. Thus Part I briefly lists the "findings" on which all participants agree. Parts II and III put land-based missiles into their historic and strategic context. Part III defines the viewpoint for evaluation of *all* the options evaluated here: First one must determine the intended *purpose* of our nuclear forces, a question that itself is still widely debated. Then one must examine *which properties* of a missile system enable it to best fulfill the intended purpose. All options should then be evaluated in this light.

Part IV evaluates each option with respect to survivability, stability, lethality, command and control, verifiability, and cost, and as a function of the future strategic arsenals under four possible arms control scenarios: no constraints, SALT II constraints, START-type limits, and "finite deterrence" (deep reductions to 2000 strategic warheads). These are consensus evaluations, representing the views of the entire study group.

Part V, occupying two-thirds of the book, consists of twelve detailed research papers by individual study group members. The

papers analyze many aspects of the options evaluated in Part IV, along with certain overarching considerations such as stability, verification, and command and control. All papers were reviewed by the entire group, but none claims to represent any viewpoint other than that of its author(s).

The book is the responsibility of the study group alone: Neither the Forum nor the American Physical Society reviewed the final product.

The study group hopes that the book will be out in time for APS members to inspect it at the Baltimore meeting, 1-4 May. Look for it along with the displayed books. Here is the table of contents:

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About the study group	
Acronyms and glossary	
Part I.	Study findings, <i>The study group</i>
Part II.	Historical introduction, <i>Paul Craig</i>
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Part V.	Research articles
Ch 1.	Stability of nuclear forces, <i>Barbara G. Levi and David Hafemeister</i>
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Ch 12.	Exploratory concepts for land-based missiles, <i>David Hafemeister</i>

Toward a Comprehensive Test Ban, by Steve Fetter

Ballinger Publishers, Cambridge, MA, 1988, 224 pages, \$29.95.

If I was asked to recommend one book to the the Bush Administration as it drafts national security directives on nuclear testing, I would immediately suggest *Toward a Comprehensive Test Ban*. This well-written book combines Livermore experience with Harvard penmanship. Fetter represents the best of the next, young generation of physicist-analysts of national security issues. The new administration will have a variety of decisions to make such as: Is the Threshold Test Ban Treaty (TTBT) and its protocol ready for submission to the Senate for ratification? Will CORRTX be required on all shots over about 75 kilotons, or will CORRTX be necessary on only a few shots? Will there be more joint verification experiments? After a TTBT, will the administration negotiate seriously on a comprehensive test ban (CTB), or its softer cousin the low-yield TTBT with a quota of one or two tests per year up to a limit of about 10 kilotons?

Nuclear test ban treaties involve many complicated technical and political issues: past history, modernization, verification, stockpile reliability and confidence, safety and security, strategy, the development of third generation nuclear weapons, nuclear proliferation, and policy decisions on nuclear testing. Fetter covers these issues with depth and clarity, but also within the relative brevity of 200 pages, making it accessible to busy policy makers. Because the verification issue has been discussed widely, most recently by the Office of Technology Assessment, I will not discuss that issue, but rather in this limited space emphasize Fetter's handling of stockpile reliability and the associated policy decisions.

Stockpile reliability is the main sticking point for a future CTB. The policy makers and the Pentagon want to have weapons that *work reliably and that appear to be reliable to the Soviets* in order to maintain deterrence. Fetter quickly points out the difference between reliability and confidence: reliability measurements come from nuclear testing, while confidence is the political judgment that one assigns to the results of nuclear testing and other, non-explosive tests. Very high levels of reliability can only be proven by many, many tests. For example, if 10 tests were successfully carried out, there would still be a thirty percent chance that the weapon would be less than 90% reliable, and a 10% chance that it would be less than 80% reliable. Since missile reliability is generally assumed to be 75-90%, there is no need to prove that warheads are much more reliable than this range. In fact, the proof is not there since the proof of 90% reliability would take a tremendous amount of testing. Fetter states that, "In recent years only 8% of all tests were done for stockpile purposes, and few of these were of old weapons. Even if two old warheads were tested each year, this would allow only one stockpile confidence test every 15 years for each weapon type, since there are 25 to 35 types of nuclear weapons in the stockpile at a given time. Furthermore, a single successful stockpile confidence test gives little information about the reliability of the weapon; even a weapon 50% reliable would give a successful test half of the time. The normal stockpile surveillance program which consists of the careful disassembly, inspection, and testing of components from many weapons is far more effective than nuclear testing for detecting deterioration." As it turns out, testing has only been used 8 times out of 300 tests to evaluate defects in stockpiled weapons. There are many methods that can be used to assess reliability.

Statements of *past examples of unreliability* have been used to show the need for testing. For example, Resengren has discussed the 14 (of 41) types of nuclear warheads that have developed stockpile

confidence problems since 1958. One can easily misstate these statistics by ignoring the details of the specific situations. The problems can be grouped into 6 categories: tritium decay, one-point safety, corrosion of fissile material, deterioration of high explosive, low-temperature performance, and other problems. Fetter states that, "These reliability problems resulted either from design errors that were not revealed by the normal testing program during the development phase of a weapon, or from the unexpected aging and deterioration of weapon components after deployment." Now that these failure modes are understood, one would expect designers to not skimp on tritium, to use proper epoxy resins for bonding, and so forth. These kinds of errors are usually found early in the deployment of a system. Fetter states that, "In the past 25 years, all design flaws were discovered within 2 years of first production. By relying only on warheads that have been tested, produced, and deployed for a few years, it appears that problems due to design errors can be substantially avoided." Many of these past problems developed at the time of the 1958-61 moratorium, when new nuclear technologies for high yield-to-weight thermonuclear warheads had just been invented. It is encouraging to hear that the military characteristics for warheads have been expanded since 1982 to include "maximizing warhead lifetime, the ability to replicate the warhead at a future date, and the ability to incorporate the warhead into other delivery systems."

The reliability issue, however one chooses to quantify it, has been unnecessarily exacerbated by the US requiring new warhead designs for new systems, rather than designing some of the new missile systems around present designs. Because the warhead cost is only 10-15% of the missile system costs, the US has used many more warhead types than the Soviets, who tend to use more standardized warhead designs. Now that the US arsenal appears to be essentially modernized with the ALCM, Trident II, MX and Midgetman warheads, there is less incentive to develop many new types of warheads, particularly if a START Treaty is going to become reality. The lowering of the TTBT threshold below 150 kilotons would prevent the development of the third generation weapons, the enhanced electromagnetic pulse bomb, the earth-penetrating warhead, and the nuclear-pumped x-ray laser. If one chooses not to develop these speculative weapons, then a more complete ban mainly affects the issues of reliability and of additional modernization beyond MX and Trident II. Interestingly enough, one of the main arguments for SDI is the creation of uncertainty in the confidence that the Soviets could have in their first strike attack. A CTB would create the same deterrence, but by increasing the uncertainty in Soviet confidence in their weapons, rather than by building SDI weapons.

The policy decisions finally come down to a CTB versus an approximately 10 kiloton low-yield TTBT. The CTB is favored because it really does stop development or modernization of new weapons at its source, it strengthens the nuclear Nonproliferation Treaty, and because it sends good political signals regarding detente and regarding reduced reliance on nuclear war fighting. On the other hand, the low-yield TTBT is easier to verify, maintains the testing team, and maintains confidence in the boosted primaries of the weapons. The phased-in approach of the low-yield TTBT first is the most pragmatic, realistic first step for the cautious US to take, but the Soviets are certainly willing (or so they say) to go the full step with the CTB.

David Hafemeister
Physics Department
California Polytechnic State University
San Luis Obispo, CA 93407

NEWS

Forum Election Results

Our new vice-chair is Tom Moss. Our new members of the Forum Executive Committee are Sam Baldwin, Rustum Roy, and Valerie Thomas. Richard Scribner, our present vice-chair, automatically becomes our new chair. Our two most recent chairs, Barbara Levi (present chair) and Dietrich Schroeer (past chair) are automatically members of the Executive Committee.

Forum Officers for 1989-90

Chair: Richard Scribner
Vice-chair: Tom Moss
Secretary-Treasurer: Henry H. Barschall
Representative to the APS Council from the Forum: David Hafemeister
Representatives to the Forum from the APS Council: Stephen Brush, Richard Freeman
Past Chairs: Barbara Levi, Dietrich Schroeer
Executive Committee: Sam Baldwin, Elmer W. Colglazier, Glenys Farrar, Rustum Roy, Valerie Thomas
Newsletter Editor: Art Hobson

Minutes of the January 1989 Meeting of the Forum Executive Committee

A special meeting of the Executive Committee of the Forum on Physics and Society was held 15 January 1989 in the Westin St. Francis Hotel, San Francisco, CA. Members in attendance were Barbara Levi, Richard Scribner, Heinz Barschall, William Colglazier, Dietrich Schroeer, Tony Nero, Tony Fainberg, Paul Craig, Steven Brush and David Hafemeister. Art Hobson and Gerald Epstein were present as observers. Bill Havens and Harry Lustig each sat in on part of the meeting. Levi called the meeting to order at 15:00

Burton Award. The first item of business was a report on the Burton Award Committee by its chair, Heinz Barschall. The APS formed this committee to consider the criteria for an award to honor physicist Joe Burton, who was an active member of the Forum. A benefactor of the APS, Mrs. Apker, had pledged half the funds to support an annual award of \$2000 provided the APS can raise the matching funds. Those funds were not yet in hand so the APS Council had not taken any action on the subject of the Burton Award at its January meeting.

The Burton Award Committee had originally proposed that the efforts for which the award might be given would include "social equity" (meaning equality of opportunity for women and minorities), public understanding of the interface of physics and society, international cooperation among scientists and physics education. These are all topics in which Joe Burton made considerable contributions during his lifetime. However, some controversy developed over the priority implied by the order in which these topics might be listed.

The Burton Award raises several issues relating to the current Forum Award because the two overlap strongly. At the same time,

the APS is considered new rules regarding awards that might prevent the Forum from using its dues money, as it has in the past, to give an award stipend of \$ 250. The Forum Endowment Fund has only about \$1000 at present. The new rules might possibly prevent the Forum even from paying travel expenses for the award recipient to receive his prize. These new rules, if approved by Council, would be phased in over three years. The Forum was being encouraged to forgo the Forum Award to prevent overlap with the Burton Award, if it becomes a reality. Havens stated that the number of awards was doubling every seven years, and that APS is anxious to restrain this growth. An alternative proposed by Barschall is to turn the Forum Award into a Forum Lectureship, for which the Forum would be allowed to pay travel.

After Barschall's presentation, considerable discussion ensued. The proposal to phase out the Forum Award raised two issues. One concerned the exact wording of the eligibility criteria for the Burton Award. Executive Committee members present tended to feel that no one of the possible contributions mentioned in the eligibility statement should carry more weight than another. There was some concern that the Award might be given disproportionately for efforts in social equity, if that item were mentioned first. The other issue concerned with Forum representation on the Awards Committee. Although the APS President technically appoints the members of the Awards Selection Committees for all APS awards and prizes, in practice, he or she has largely followed the slate proposed by the Forum for the Forum and Szilard Awards. With the Burton Award, the Forum would not necessarily have such control over the composition of the selection committee.

Schroeer made the following motion: "The Forum endorses the establishment of the Burton Award, and will hold the Forum Award in abeyance for three years after the establishment of the Burton Award, after which we will reconsider the status of the Forum Award. Given that the Forum's interests are diverse, we encourage the Burton Award Committee not to emphasize any single area as its primary criterion for choosing the Burton Awardee. We encourage the president of the APS to place at least one past or present officer of the Forum on the Burton Award Selection Committee. It is expected that the Burton Awardee would be asked to give a talk at a Forum session."

Fainberg seconded the motion. Discussion ensued over how much representation the Forum might desire on the selection committee. Fainberg moved that the motion be amended to add: "and one current member of the Forum Executive Committee" after "...at least one past or present officer of the Forum" and before "on the Burton Selection Committee." Hafemeister seconded the motion. The amendment to the motion passed 9 to 1. The motion as amended passed 10 to 0.

There remained some concern about the future of the Szilard Award, if APS institutes is proposed rules changes. Hafemeister and Scribner volunteered to solicit donations for a \$30,000 endowment for this award. It was suggested that they try to contact friends of Szilard's (Hafemeister had already written to his nephew). Hafemeister and Scribner also planned to talk with such organizations as the MacArthur Foundation and the Natural Resources Defense Council.

ByLaws Changes. The next item of business concerned proposed changes to the By Laws. The Committee on Governance of the APS will not have finished its current work for 18 months, so the Forum should not wait for its report before undertaking revisions. Levi presented the Executive Committee with By Laws Changes dealing

with three basic corrections: 1. To put the Vice Chair in charge of Forum programs at APS meetings. 2. To provide for the Executive Committee to appoint an editor of the newsletter rather than have the Vice Chair automatically serve as the editor. Both changes would make the By Laws consistent with current operation. 3. To change the language to a neutral form, that is, to replace "he" throughout by "he/she." The proposed amendments are attached. Fainberg moved that the Executive Committee present the attached ByLaws Changes to the membership for discussion at the annual membership meeting in Baltimore this May. Voting must be by mail. Schroer seconded the motion. The motion was passed unanimously.

Program Committee Report. Scribner gave a brief report on the programs being planned for forthcoming APS meetings. There will be an invited-paper session on verification at the meeting of the Division of Condensed Matter in St. Louis this March. At the spring APS meeting in Baltimore, the Forum will run sessions on sea-launched cruise missiles, the comprehensive test ban treaty and the awards session featuring Tony Nero on risk assessment and James Randi on scientific fraud. Scribner asked for suggestions for one other session. Barschall felt that the sessions were already too heavily weighted towards arms control and that Scribner should try to get a better balance. Fainberg suggested a session on the land-based missile. Scribner was also interested in conducting a workshop on cruise missiles, a possible topic, he felt, for a Forum study. He was asked to write a letter to request money for a one-day workshop.

APS Treasurer's Report. Lustig reported that the Forum has \$22,000 in its account. He felt that the Forum motion concerning the Burton Award was a very positive move. He suggested a possible future Forum session might deal with the topic of physics journals.

Forum Councilor's Report. Hafemeister circulated copies of a report he had presented at the APS Council meeting to stress the many Forum activities. He had been concerned before the meeting that the Council might require APS members to pay an additional \$5 to join the Forum, but no such motion was made. This might possibly change once the Governance Committee makes its final report. Hafemeister reported that the book from the arms race short course would soon be available. Brush mentioned that Brian Schwartz had written a memo to the Divisions, asking them to become involved in the activities of the Education Committee. Levi volunteered to serve as a Forum liason to the Education Committee, as she was a newly appointed member of that body.

Funding for the Energy Study. The Executive Committee approved the expenditure of funds for travel money so that the Energy Study Group could have one final meeting in conjunction with the spring APS meeting.

Call for Nominations. Levi asked officers to forward to her any nominations for persons to serve on APS Committees.

Hafemeister moved the meeting be adjourned. Schroer seconded the motion. The motion passes and the meeting was adjourned at 17:10.

Barbara Levi

Proposed Changes in the Forum's ByLaws

These proposed changes in the ByLaws of the Forum on Physics and Society will be discussed at the Forum's business session, to be held at the Baltimore APS meeting on Tuesday 2 May 1989, at 19:30, just prior to the 20:00 Forum Awards lectures. These changes will be voted on later by mail.

These changes to the current ByLaws are proposed to make the ByLaws consistent with the manner in which the Forum now operates. They do not propose any change in current operations. In the proposed changes below, the existing text is given, with the text affected by proposed changes surrounded by square brackets. This is followed by the text to replace that in square brackets and an explanation of the change.

• Article V, Section 2:

Current Wording: The Chair[man] shall preside at all meetings of the Executive Committee at which [his] attendance is possible. After consultation with the Executive Committee, [he] shall appoint all committees, other than the Executive Committee, necessary to conduct the affairs of the Forum and shall serve as a voting member of any committee, other than the Nominating Committee. The Chair[man] shall prepare a yearly report..

Replacements: "Chairman" beomes "Chair"
"his" becomes "his/her"
"he" becomes "he/she"

Explanation: The changes are made to apply to either sex. Similar changes will be made throughout the By Laws in the words denoted by curly brackets. Other incidences will not be explicitly noted here but the changes will be made throughout the By Laws.

• Article V, Section 3:

Current Wording: The Vice-Chair[man] shall act as Chair[man] when the latter is unable to perform [his] duties. The Vice Chair[man] shall [prepare and distribute the Newsletter].

Replacement: [serve as Chair of the Program Committee. His/her responsibilities shall include the scheduling of contributed papers within the areas of interest of the Forum, as well as arranging sessions of invited papers sponsored by the Forum.]

Explanation: Formerly, the Vice Chair was in charge of the Newsletter and the Secretary/Treasurer was in charge of Programs. Because the Forum appoints an editor of its Newsletter, the job of programs has been shifted to the Vice Chair.

• Article V, Section 4:

Current Wording: The Secretary-Treasurer shall keep the Council and Executive Secretary informed of the current activities and needs of the Forum. {He} shall, throughout the year, if and when necessary, notify the Executive Committee of matters requiring its attention. [He shall notify all members of the Forum of Forum meetings at least sixty days before the date of each meeting. He shall assist the Program Committee in arranging details of each meeting.] {He} shall prepare minutes of each meeting of the Executive Committee and of each Business Session of the Forum, and submit these minutes to each member of the Executive Committee, and to the Executive Secretary within four weeks after each meeting.

Replacement: He/She shall notify all members of the Forum of Forum Business Sessions before each such Session.

Explanation: The modification of the first sentence allows for the announcement of the Forum Business Session in the APS Bulletin and in the Forum Newsletter that preceded the meeting at which the business session is scheduled. These publications do not always come out sixty days before the meeting. The second sentence is deleted because the Forum Vice Chair heads the Program Committee.

- Article IX, Section 1:

Current Wording: The Chairman, with the advice of the Executive Committee, shall appoint members of the Nominating Committee, a Membership and Publicity Committee, [] and a Program Committee.

Addition: [a Fellowship Committee]

Explanation: We now have a Fellowship Committee so the By Laws should provide for this. Note that for some time we have not had a Membership and Publicity Committee, but such a committee will be reinstated next year.

- Article XII, Section 3 (a proposed addition):

Current Wording: None

Addition: The Editor of the Newsletter shall be appointed by majority vote of the Executive Committee for a term of three years. At the end of each three-year term, the Executive Committee shall review the performance of the Editor, and may choose either to terminate or renew the appointment. If a vacancy for editorship develops, the Executive Committee shall appoint a Search Committee and must solicit applicants for the position by announcement in the newsletter at least 12 weeks before any meeting of the Executive Committee at which the Editor is to be selected. The Editor shall attend meetings of the Executive Committee but shall not have a vote.

Explanation: This section is completely new, for there is currently no provision in the ByLaws for the selection or removal of an Editor of the Newsletter. Because the Forum Newsletter is more substantial than that of the Divisions, we require an editor whose tenure is longer than the two years served by a Forum Officer.

APS Council Meeting in San Francisco, Highlights

Physics Planning Committee. The Executive Council has authorized \$50,000 to establish a Physics Planning Committee to develop a unified plan for all the subdivisions of future physics research. The plan would not be a one dimensional list, but rather a multi-dimensional matrix. POPA will publish some graphs on physics funding trends and present plans, showing problems ahead. APS is searching for nominations for the Chair and members to this committee.

Governance. In about 2 years, the APS governance will probably change from the Executive Committee/Council to the Executive Board and Assembly, with each APS member being in a "home division."

APS NEWS. In about a year, a professional newsletter will replace the news part of the Bulletin of the APS, with the funds coming from the more directed, and reduced mailing of BAPS.

Funding of Awards. Soon there will be a motion to require a minimum endowment for the Awards. Thus, the Forum Awards may need funding.

POPA Studies. Several ideas are being discussed, but all on the back burner for now. Send suggestions to DH.

Baltimore/DC Meeting. AAPT was invited in, but they prefer to travel to many cities.

Forum Membership. Now at 4141, up 100 from a year ago.

Over the past four years the Forum has held 35 invited sessions and 4 contributed sessions and 10 short courses at APS meetings, produced a book (*Nuclear Arms Technologies in the 1990s*) based on a short course, finished and published two studies (*Civil Defense*

and *The Future of Land-Based Strategic Missiles*), and begun a third study (on energy).

Dave Hafemeister
Forum representative to the APS Council

Forum Business Session in Baltimore

The Forum's annual business session will be held at the Baltimore APS meeting, on Tuesday 2 May 1989, at 19:30, just prior to the 20:00 Forum Awards lectures announced below. One item of business will be the proposed changes in the Forum's ByLaws (see these proposed changes above). All Forum members are invited to attend.

1989 Szilard and Forum Awards

1989 Leo Szilard Award for physics in the public interest : To Anthony Nero of Lawrence Berkeley Laboratory, "For his outstanding research on a broad spectrum of problems dealing with issues of physics, the environment, and public health, including the identification of radon as a major health hazard, in the study of indoor pollution, and in nuclear proliferation and reactor safety." The American Physical Society's Szilard Award is given annually to an individual or group who has constructively applied physics in the public interest.

1989 Forum Award for promoting public understanding of the relation of physics to society: To James Randi, "For his unique defense of science and the scientific method in many disciplines, including physics, against pseudoscience, frauds, and charlatans. His use of scientific techniques has contributed to refuting suspicious and fraudulent claims of paranormal results. He has contributed significantly to public understanding of important issues where science and society intersect." The American Physical Society's Forum Award is given annually to an individual or group who has promoted the public understanding of the relation of physics to society.

Forum Sessions at the Baltimore Meeting

The spring meeting, being held in Baltimore during 1-4 May this year, is traditionally the big meeting of the year for the Forum. In Baltimore, we will have the Forum Awards and the Awards lectures, several invited paper sessions, a physics-and-society contributed paper session, and our annual business session. We hope that the physics-and-society community will try to attend this meeting this year and every year.

Forum Awards Lectures. Barbara G. Levi, Rutgers University, Forum Chair, presiding. Tuesday 2 May at 20:00. These lectures will be preceded by a business meeting at 19:30 in the same room, all Forum members invited.

- Anthony Nero, Lawrence Berkeley Laboratory, University of California, Berkeley, "From reactors to radon: toward a new environmental consciousness." Introduced by Barbara G. Levi.

- James Randi, "The day the water lost its memory." Introduced by Peter Zimmerman, Carnegie Endowment for International Peace, Washington, DC.

Nuclear Sea-Launched Cruise Missiles: Missions, Verification, and Arms Control. Richard Scribner, School of Foreign Service, Georgetown University, presiding. Probably Monday evening, 1 May.

- Rose E. Gottemoeller, RAND Corporation, "Roles and missions of nuclear SLCMs."
- George N. Lewis, Center for International Security and Arms Control, Stanford University, "Cruise missiles and early warning."
- Valerie M. Thomas, Center for Energy and Environmental Studies, Princeton University, "Verification of limits on nuclear SLCMs."
- Sally K. Ride, Center for International Security and Arms Control, Stanford University, "Arms control options for nuclear SLCMs."

A Comprehensive Test Ban: Interplay of Technology and Policy. Lewis Duncan, Associate Dean for Research, Clemson University, Clemson, SC, presiding. Tuesday 2 May at 14:30.

- Gregory E. van der Vink, Project Director, Seismic Verification of Nuclear Test Ban Treaties, Office of Technology Assessment, US Congress, "Overview of nuclear testing and verification."
- Willard J. Hannon, Program Head, Verification Program, Lawrence Livermore National Laboratory, University of California Livermore, CA, "Thinking about nuclear test ban issues."
- Frederick K. Lamb, Professor of Physics, University of Illinois, Urbana, IL, "CORTEX evaluated."
- Steven Fetter, Assistant Professor, School of Public Affairs, University of Maryland, College Park, MD, "What is testing really for?"

ICBM Force Modernization: Technology and Issues. Probably Wednesday evening, 3 May.

- Les Aspin, Chairman of the House Armed Services Committee, US House of Representatives, "Congress and ICBM force modernization."
- Victor Bras, Col., US Air Force, Office of ICBM Modernization, US Department of Defense.
- Barbara G. Levi, Rutgers University, "Results of the APS/Forum land-based missile study."
- James Woolsey, Shea and Gardner Law Firm, Washington, DC, "Future decisions and ICBM force structure."

Physics and Society Contributed Paper Session. Look in the meeting program for time and place. Try to attend this session, and join in the discussion! This session is an annual event; next year, contribute your own paper. We list here those contributed papers known to us as we go to press. For a complete listing, see the meeting program.

- Richard Scribner, Georgetown University, School of Foreign Service, "Science advice and national security."
- David Hafemeister, Professor of Physics, California Polytechnic State University, San Luis Obispo, CA, "Infrared monitoring of a ban on nuclear power in earth orbit."
- Allen Lindh, US Geological Survey, "Calculations of the risks of catastrophes, including the risk of nuclear war."
- Art Hobson, Professor of Physics, University of Arkansas, Fayetteville, "US land-based missile problems: will superhard silos help?"
- Richard Scribner, "Limiting SLCMs: physics and policy."

Forum Session at the St. Louis Meeting

The St. Louis meeting, held 20-24 March, will have come and gone by the time you receive this newsletter. Next year, we'll try to get this announcement in *before* the meeting. Anyway, one Forum invited session was held at the St. Louis meeting:

Technology for Nuclear Arms Control: Monitoring Compliance with the INF Treaty and Possible Future Agreements.

- Edward Lacey, Director of the On-Site Inspection Office, Department of Defense, "On-site inspection for the INF Treaty."
- Stanley Fraley, Project Director of the Perimeter and Portal Monitoring Project, Sandia National Laboratory, "The physics of perimeter and portal monitoring for arms control."
- Donald Bauder, Project Manager, Tagging for Verification Program, Sandia National Laboratory, "Tagging: 'fingerprints' and electronic labeling for arms control."
- Peter Zimmerman, Carnegie Endowment for International Peace, Washington, D.C., "Multispectral and moderate resolution satellite sensing for verification."

Nuclear Arms Technologies in the 1990s

Nuclear Arms Technologies in the 1990s, edited by Dietrich Schroerer and David Hafemeister, (486 pages, 1988, clothbound, \$61.50 list price/\$49.20 to members) has just been published by the American Institute of Physics as AIP Conference Proceedings Number 178. This book is based on the Forum-sponsored short course on the arms race held at George Washington University in Washington, DC, on April 16-17, 1988, and contains several articles in addition to those based on the talks at the short course. This book was reviewed in *Physics and Society*, January 1989, p. 7-8, where you will also find the entire table of contents.

The Future of Land-Based Strategic Missiles

The American Institute of Physics will soon publish, probably in April 1989, *The Future of Land-Based Strategic Missiles*, edited by Barbara G. Levi, Mark Sakitt, and Art Hobson. This book is the second published Forum-sponsored study, following the first such study *Civil Defense: A Choice of Disasters*, edited by John Dowling and Evans M. Harrell, published by AIP in 1986. A third study, on energy, is currently in the works. *The Future of Land-Based Missiles* is outlined above, in the "Reviews" section of this issue.

Student Pugwash: "New Challenges Posed by Global Interdependencies"

The sixth biennial Student Pugwash International Conference will assemble 90 undergraduate and graduate students from around the world to explore ethical and value questions posed by advancing science and technology. The students will join accomplished men and women from government, business, and academe for an intensive week of discussion focusing on:

- changing definitions of security
- access and equity in health care technology
- the impact of science on the future of medicine

- the computer/human interaction
- energy options and their environmental impacts
- development, technology, and the environment

The conference will be held at the University of Colorado, Boulder, 18-24 June 1989. For more information, contact: Conference Coordinator; Student Pugwash USA; 1638 R Street, NW, Suite #32; Washington DC 20009. Phone 202-328-6555.

Faculty: Please inform students of this opportunity and encourage them to apply.

The New Dialogue with Nature

An interpretative symposium on social and humanistic applications of the new non-linear natural sciences will be held at the University of South Dakota, Vermillion, SC, on 7-8 August 1989. The symposium will be held jointly with a four-day World Archaeological Congress meeting. Topics include nervous systems, chemical oscillations, vehicular traffic, evolution, mathematics of chaos, the growth of cities, business cycles, and population dynamics. For information or registration contact Dr. Leroy Meyer, Department of Philosophy, University of South Dakota, Vermillion, SD 57069-2390 (605-577-5486), or Dr. George P. Scott, Ilya Prigogine Center, University of Texas, Austin, TX 78712 (512-471-7253).

Save the Newsletter!

More precisely, ask your library to save it. We have found that many, perhaps most, libraries routinely toss anything that is labeled "newsletter," as soon as the next issue arrives. "Journals" are kept, and indexed in the card files, but newsletters are seldom even kept. Although many libraries will not want to index *Physics and Society* in their files, because indexing is expensive, it should be possible for them to simply keep the back issues instead of tossing them.

Join the Forum!

Get the Newsletter!

If you are an APS member it is easy, and free to join the Forum and receive our newsletter. Just complete and mail (to the editor) the following form, or mail us a letter containing this information. (Nonmembers: see the masthead, on p.2).

I am an APS member who wishes to join the Forum and receive the newsletter.

NAME(print) _____

ADDRESS _____

COMMENT

Ethical Values Should Limit Scientific Research

The following article is reprinted from *Science and Religion: Opposing Viewpoints*, Janelle Rohr, editor (Greenhaven Press, St. Paul, MN, 1988), pp. 197-202, where it was excerpted from original publication in *The Double-Edged Helix: Genetic Engineering in the Real World*, by Liebe F. Cavalieri (Convergence Series, Praeger Publishers, New York, 1985). It is reprinted here with permission of Praeger Publishers. Liebe F. Cavalieri is a member of the Sloan-Kettering Institute for Cancer Research and teaches biochemistry at Cornell University Medical College. Readers' comments on this article are welcome.

Editor

Modern scientific research in this country has become increasingly mission-oriented. When the research is economically important, its results are often applied with little loss of time; such was the situation with the transistor, the heart of modern electronics. In that case, and in many others, science acted as an arm of technology. It is foolish for scientists to close their eyes to this reality, when they should be guarding science against abuse and exploitation for commercial purposes that have little to do with either human needs or the acquisition of pure knowledge. In traditional fashion, most scientists have not felt the need to become involved in the applica-

tion of their discoveries; indeed, they have carefully avoided any such intervention, arguing that this is not their domain. This simplistic notion, which came into vogue about 150 years ago, is irrelevant and even dangerous in modern times. In the face of recombinant DNA technology, which will most certainly affect the lives of future humans, this archaic view of the pursuit of knowledge is especially in need of substantial updating, for if the scientific community will not guard the public interest when a powerful but highly esoteric new scientific technique is discovered, who will?

Contrary to prevailing fears, the acceptance of public accountability and responsibility by the scientific community would not preclude the pursuit of knowledge for its own sake. In fact, that pursuit is currently being phased out with no good justification.

Genetic engineering

Recombinant DNA technology has immense societal implications, embodying applications to medicine, agriculture, and industry; its possible influence on ecological systems and future generations of humans is incalculable. It will permit manipulation of the gene pool of the earth, and thus manipulation of the nature of all life. At this time, techniques have already been developed by which genes, which are composed of DNA, can be shuffled about so that DNA from any source—say, animals or viruses or fruit flies—can be inserted into living bacteria. Inside the bacteria these genes can

be made to perform their normal functions, if all goes according to Hoyle, even though they are outside their normal habitat. Recombinant DNA presents scientists with a new and uniquely powerful means for altering living cells according to their design. One Nobel laureate has said: "We can outdo evolution." The biological scientists' responsibility is therefore immense; it is as great, or greater, than that which fell upon physicists a few decades ago. I suspect that many of the implications of this technology has been cast aside by the scientific community because a more enlightened view would require a general examination of societal problems, and the solutions to those problems might place constraints on the scientific enterprise.

Meanwhile, although the public awe of science continues, there is a growing uneasiness about technology. Someday, as the nuclear, ecological, and now genetic hazards and threats grow larger, this unease is likely to erupt with destructive force as a full-scale antiscientific and antiintellectual movement.

Integrating values with science

The social consciousness of most scientists does not extend to their own sphere of activities. This is not a criticism; it is an observation. For example, many molecular biologists take pride in their "liberal" political views: they marched in protest of the Southeast Asia war; they fought against the use of chemical and biological warfare; they decry radioactive contamination by nuclear wastes; they abhor pollution. In brief, their values seem to be related to the bettering of the human condition. Yet in their own realm many of the same scientists fail to take note of the possible ill effects that could follow from their work; they make the implicit, vague assumption that all science is good, as though its beneficent application were foolproof. This leads to the illogical conclusion that any and all goals are equally desirable in the search for knowledge, and this is somehow connected with freedom of inquiry. Scientists are rightly concerned about freedom of inquiry. But when it is discussed, insistence upon the neutrality of science often aborts rational analysis. Some scientists hold up the specters of Galileo or Lysenko at any suggestion of public accountability, although their histories are not relevant to the issues of public and environmental safety raised, for example, by recombinant DNA technology. Scientists still feel comfortable with seventeenth-century arguments concerning knowledge and truth, arguments that take no account of modern technological society and the accelerated impact of science on everyone.

Science and the industrial system

A common feature of technologies is that they respond first to the needs of the industrial structure that spawned them and second, if these do not interfere with the first, to human needs. This is the immutable contradiction of our industrial system; it is a system that, by design, depends on production and growth. The physical realities of finite energy supplies, the limited ability of the environment to absorb pollution, population growth and the finite potential for food production, and ultimately the projected thermal instability of the planet, force the inevitable conclusion that growth must cease within a few decades. By anyone's calculus there can be no setting aside of this dilemma. The choice is clear: let matters proceed in a more or less random fashion to the natural and ominous end point or try to transform the present socio-economic structure based on unrestrained technology, by developing appropriate controls. The practice of science as we know it cannot continue unrestrained, in the present milieu, for its results are bound to be applied by the

industrial establishment in the name of progress. But, as the scientist Bentley Glass asks, "—can we honestly set aside the conclusion that *progress*, in the sense of ever-growing power over the environment, must soon come to an end?"

In attempts to maximize the best and minimize the worst, technocrats place a high degree of confidence in cost-benefit (or risk-benefit) analysis. But such analysis becomes more irrelevant as time goes on; indeed in many areas, such as the alteration of the landscape for industrial reasons, cost-benefit analysis is completely inadequate. Aesthetic, ethical, and moral questions involve value judgments, to which the "hard" numbers required for cost-benefit analysis cannot be assigned. Decisions involving those questions must therefore be political, not technical.

Alternative technology

It is not so much technology, itself, as its present vast scale, that creates the problems. The application of science to the development of intermediate and alternative technologies could be highly beneficial. Such technologies emphasize natural processes, the use of renewable resources, labor-intensive instead of energy-intensive production, and minimal waste...Giant technological approaches are in general renounced. Philosophically, this approach is capable of achieving a state of human fulfillment not possible with a surfeit of material goods. We have already proved that a plethora of hardware, drugs, and consumer goods have not achieved this aim. The convergence of so many technologies has reduced the public to a listless, frustrated mass of humanity without a meaningful function. Another technology will not solve the problem; that will require a monumental and courageous political decision, backed by the determination of all of us.

In the face of such fundamental problems, cries by scientists for freedom of inquiry seem banal, self-serving, and irrelevant. The cries are a result of what Theodore Roszak has called the "single vision" of science—the view that the content of human life can be comprehended only through a scientific understanding of its inner machinery, by a complete dissection and analysis. This reductionist philosophy has created and nurtured the technological state, and it has done so at the expense of the value of wholeness. This is an unfortunate outcome for science, which does not inevitably demand application as technology; nor is science incompatible with other, more human philosophies. It is the emotional and commercial content of science, put there by our culture, that has led directly to the problems. Science practiced in a newly responsible way could play a vital role in extricating society from the impending crisis. But this means that scientists will have to develop a social conscience, convey this to the people, and above all, teach their newly acquired wisdom to the technocrats.

To call for an awakening of scientists, technocrats, and the masses on whom technology is practiced sounds all but hopeless, to be sure. But there is no other way to halt the impending technological disaster. Scientists have had freedom from accountability and responsibility for a very long time. They have the knowledge and the qualifications necessary to recognize the dangers of our present technological course, and they cannot escape from the moral responsibility of acting to change it—even at the sacrifice of cherished prerogatives.

Liebe F. Cavalieri

Editorial: Reflections on the Forum's Missile Study

The Forum's study of US strategic missile vulnerability (see "Reviews" in this issue) will be published soon. Having labored, along with several fellow-physicists, over this study, I would like to offer three personal (i.e. not necessarily those of the study group) observations.

First, the United States has been off-course on land-based missiles for well over a decade primarily because of its focus on the MX missile. This focus stems, in turn, from a desire to present the Soviets with the largest possible offensive threat. The MX, with its ten highly lethal warheads per missile, can be a quick and inexpensive way to threaten a large number of Soviet warheads in their silos. Whether one regards such a "counterforce capability" as wise or foolish, it is clear that our focus on this particular missile has made it difficult for the nation to agree on what to do about the increasing vulnerability of its ICBMs.

The problem is simple: The MX is just too big. It is too big to base invulnerably in a way that is feasible politically and financially, and that makes sense strategically. The most recent solution, rail-garrison basing, is financially and perhaps politically feasible (the trains will be kept mostly on military bases, so the "public interface" problem isn't too difficult), but it requires a three hour warning time and this could be destabilizing. The problem is that the Soviets might decide to attack the trains in their vulnerable garrisons at an early stage of an escalating crisis.

Superhard silos? MX's ten warheads could make it "profitable" for the Soviets to attack such silos with very large very accurate warheads such as the old 20-megaton SS-18 mod 3 delivered with today's SS-18 accuracy.

Land-mobile basing? MX is too heavy.

"Multiple aim point" basing? President Carter tried this one. That's one reason he soon became ex-President. The idea was to house a few hundred MXs deceptively inside a few thousand silos. MX's large size and weight implied that it should be housed in horizontal shelters, and these in turn needed to be spread out over a large expanse of land so the Soviets couldn't destroy two or more shelters with one shot, and this in turn meant that it would need to occupy a significant portion of Utah. The good citizens of Utah demurred.

Perhaps it is time to look seriously at something other than the MX.

Second, there are no solutions without arms control. There appears to be no feasible land-basing scheme that can, *unilaterally*, make US land-based missiles invulnerable. Soviet cooperation, i.e. arms control, is essential. Land-mobile missiles can be invulnerable *if* there are limits on the number of Soviet warheads, limitations on deployment of offshore strategic submarines, and a ban on depressed-trajectory missiles. Superhard silos can be invulnerable *if* there is a ban on terminally-guided maneuvering warheads, and a ban on earth-penetrating warheads. A multiple aim point solution (but with a smaller missile than the MX, placed in vertical silos) could work, *if* there are limits on the number of accurate Soviet warheads. And so forth.

Even in the tough world of nuclear strategy, we cannot go it alone. If we want to retain land-based missiles at all, we must cooperate with the Soviets on the arms control measures needed to keep such missiles invulnerable.

Third, this problem should have been studied much more thoroughly and much earlier. We appear to have opted for the MX, in the mid-1970s, for the same reason that we opted for multiple warheads in the late 1960s, and for increased accuracy throughout the 1970s and 80s: because it was very potent militarily, and because it was technically and financially feasible. Little thought was given to broader US security questions, such as "What Soviet responses might it produce?" or "What will be the arms control implications?" or "How will this affect the overall likelihood of nuclear war?"

We don't really think very hard about what we are doing. For example, the best and broadest study of ICBM basing problems of which I am aware is the 1981 Office of Technology Assessment report *MX Missile Basing*. As its title implies, OTA's assigned task was to "review the various ways in which the new MX ... missile could be based, ..." (I quote from the Foreword). The OTA study was never designed to look beyond the MX, because we had already decided on the MX, irrespective of basing problems. It was a typical case of "here is the answer; now, what was the question?"

We see this kind of thoughtlessness again and again, whether it is nuclear war or nuclear power or ozone or tropical rain forests. If it is doable, and if it brings money or power, we do it. Later, we learn the consequences. If we put, say, five percent of the effort into studying the broader spin-offs of technology that we put into discovery and exploitation, the world would be far healthier.

Maybe we need a five percent "science and society" tax.

Art Hobson