FUSION

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December 1982

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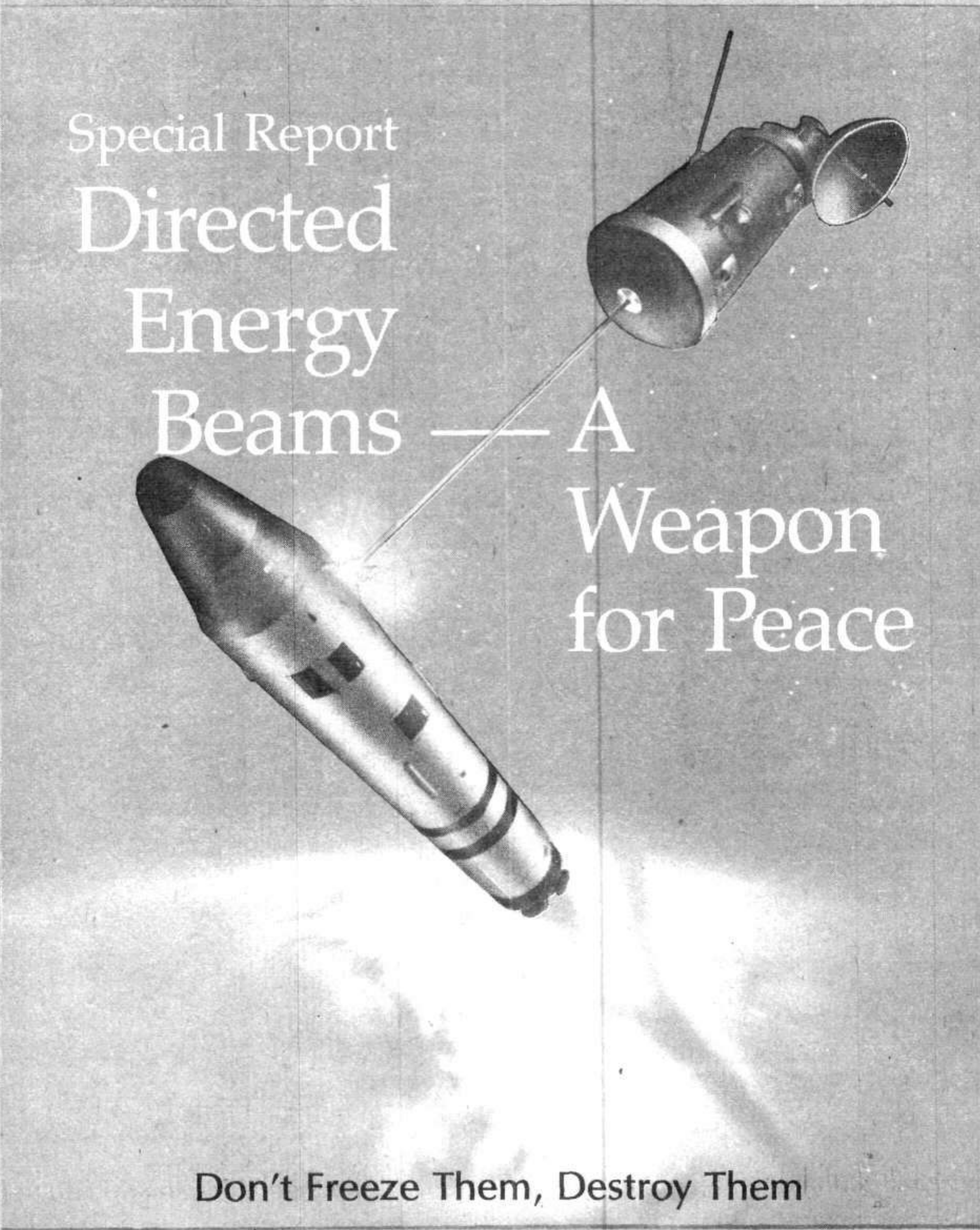
Krafft Ehricke on 'Why Man Must Colonize Space'



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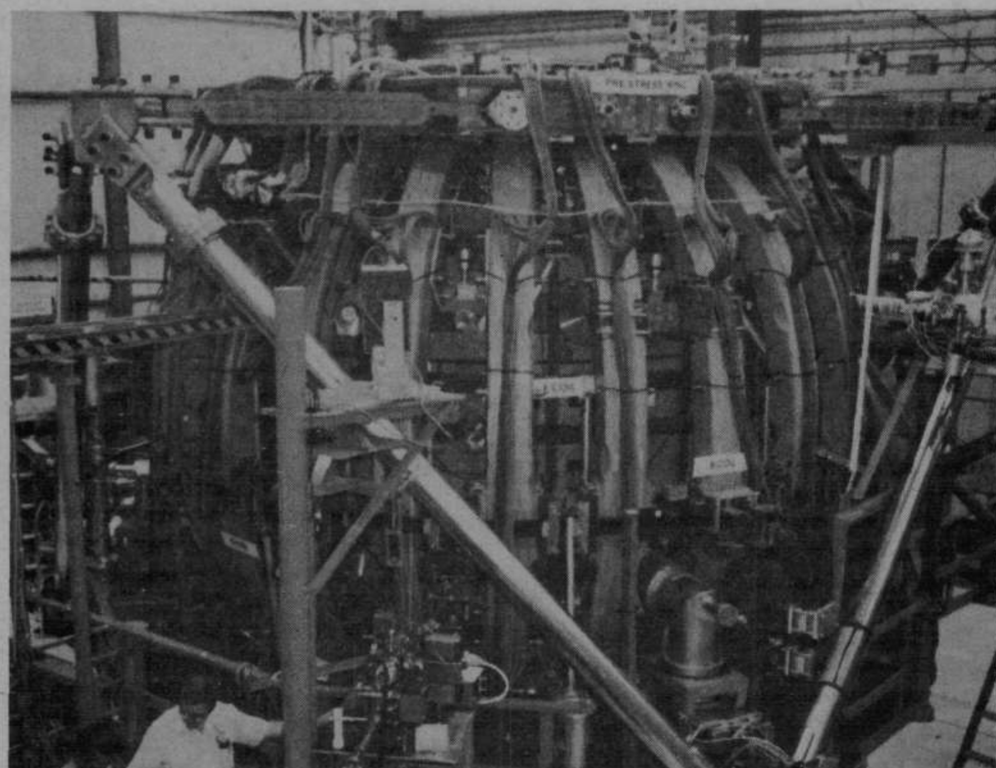

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The views of the FEF are stated in the editorials. Opinions expressed in articles are not necessarily those of the FEF directors or advisory board.

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Note to Libraries and Subscribers

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Subscribers who purchased a 10-issue subscription will receive all 10 issues. The FEF expects to publish ten issues of FUSION in 1983, but only four issues in 1982. Highlights of the six remaining 1982 issues—January through August—will be included in future issues.

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Directed Energy Beams—A Weapon for Peace

For 25 years the specter of nuclear holocaust has terrorized America and the rest of the world. The adoption of a beam weapon development program in itself will not ensure an end to the danger of thermonuclear war. But the fact that both the United States and the Soviet Union were pursuing the development of this inherently defensive weapon system would immediately change the strategic military situation, setting up a new, more rational basis on which the two superpowers can hold arms negotiations. Most important, the development of this frontier area of science—directed energy beams—forces the issue of the primacy of scientific and economic development in creating peace and prosperity.

This is a point the Soviet Union understands. At a time when the United States is in the midst of a political battle over whether to go with a beam weapon development program or continue the MAD (Mutually Assured Destruction) military policies established by Robert McNamara's postindustrial faction, the Soviets have proudly publicized their ongoing project at the ZIL auto factory to develop beam technologies for commercial applications. For the past five years, the scientist who directs the Soviet fusion program, E. P. Velikhov, has supervised a team of scientists in building laser, electron beam, and plasma devices for commercial applications at the Likhachov Auto Factory in Moscow, one of the giants of Soviet industry. In a recent article in the Soviet magazine EKO, Velikhov described how the plant engineers foresaw ways that lasers could help solve certain welding problems. Within two years of collaboration between the plant engineers and the fusion scientists, a laser device was in operation in a new automation system.

"Time doesn't wait," said Velikhov. "When you are dealing with a totally new technology, it is vital to proceed as quickly as possible from the idea to its implementation. . . . We will be able to attract other organizations to this technological orientation and to demonstrate a concrete approach to the introduction of completely new technology in industry. . . ."

Such advances in productivity, enhancing the domestic economy, are also the key to industrializing the underdeveloped sector. As Dr. Edward Teller put it in an Oct. 26 press conference on beam technologies:

> By cooperation with those who are willing fully to cooperate, we can improve the very horrible way of life in the Third World. We can by using technology create a situation where the reasons for war will diminish and keep diminishing. If our allies and we cooperate both in making a stronger defense and bringing about the origin of real peace, the pursuit of the common aims of mankind . . . then in the end . . . even in that part of the world that in its history has never experienced anything like freedom, even there, I think a change of thinking may occur.

It is precisely this aspect of a beam weapon development program that upsets the enemies of progress: Real peace requires development, and development is the antithesis of the postindustrial society. Thus, as quoted in this issue's review of Lord Solly Zuckerman's book promoting the nuclear freeze, the neo-Malthusians like Zuckerman attack scientists and technicians as the chief enemy of their plans to return to a preindustrial society. Hypocritically, these postindustrial advocates are leading the so-called peace movement, promoting a "nuclear freeze." Over the past few weeks, we have made considerable headway in exposing the freeze movement as a hoax that actually intends to freeze technology, especially nuclear-technology, and carry out conventional wars to reduce world population.

Recently, Fusion Energy Foundation board member Lyndon H. LaRouche, who heads up a political action group called the National Democratic Policy Committee, proposed that progrowth forces end the freeze farce and establish a "real peace movement" based on the policy measures outlined by him and by Edward Teller. Specifically, LaRouche proposed as the rallying point for a new peace movement: agreement between the United States and the Soviet Union to independently develop space-based beam weapons, a framework of accords for jointly colonizing the Moon (and later Mars) over the next 20 to 50 years, and a program for industrializing the Third World, based on what Teller called "the common aims of mankind."

A Fight We Can Win

At this point, we have the edge. The propaganda machine of the opposition is not yet geared up to counteract the motion around the beam weapon question created by us, by Dr. Edward Teller, and by the political organization of Democratic Party leader Lyndon H. LaRouche. A leading anti-beam-weapon spokesman at MIT, in fact, complained bitterly recently to a reporter "unless there is a countervailing movement, the American people can be won over to Teller's perspective to develop beam technologies."

This issue of *Fusion* is designed to give our readership

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Viewpoint

The Civilian Space Program: A Time to Set New Goals

by Rep. Ronnie G. Flippo

Some claim that the world is a different place in 1982 than it was in 1958, when Congress passed the enabling legislation of the U.S. space program, the National Aeronautics and Space Act of 1958. However, I doubt that our nation has ever been more troubled or perplexed by the enemy threat than with the launch of Sputnik. Yet, at that time our nation's leaders had the wisdom and foresight to entrust the development of our own space capabilities in a civilian space agency.

The basic tenets of this policy are that:

- "Activities in space should be devoted to peaceful purposes for the benefit of all mankind."
- "The general welfare and security of the United States require that *adequate provision* be made for aeronautical and space activities."
- "Such activities shall be the responsibility of, and shall be directed by a civilian agency exercising control over aeronautical and space activities sponsored by the United States, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States shall be the responsibility of and shall be directed by, the Department of Defense."

The national objectives set forth in the Space Act include: the expansion of human knowledge; the improvement of space vehicles; the development and operation of vehicles to carry instruments as well as living organisms; the establishment of long-range studies on the utilization of space activities for peaceful and scientific purposes; the preservation of the United States as a leader in space science and technology; information exchange with the Defense Department; international cooperation; and interagency cooperation to avoid duplication.

Policy Issues

This provides us with an excellent policy framework with which to work, although there are still important policy issues that need resolution. These policy issues mostly involve levels of funding, bureaucratic turf fights, the role of the federal government vis-à-vis the private sector, and establishment of long-range goals.

Policy, more than technology, has created the separation of civilian and military space programs. Almost any space capability or technology—whether it be weather satellites, remote sensing satellites, communication satellites, expendable launch vehicles, the Space Shuttle, or a future space station—can be exploited for either civilian or national security purposes. But the space environment is not unique in this respect; the same can be said for technologies that are earthbound.

I wholeheartedly and unequivocally support continuation of a separate, open civil space program. This is not to say that I am opposed to cooperative programs nor, where appropriate, the sharing of technology. But if we were to militarize the space program, gone would be the open, peaceful, excitement-oriented civilian space program that has been so important both for national pride and as a foreign policy tool. International cooperation would be inhibited. The open space program facilitates private sector exploitation of technology and therefore makes a more positive contribution to our nation's economy, and only through a strong economy can we afford a strong defense.

Another policy question is: Are we making "adequate provision" to "preserve the United States as a leader in space science and technology," as the 1958 legislation instructs us.

I remain deeply concerned about the need for revitalization of the space program to ensure our technological leadership and our potential for providing mature, well-understood definition of future systems.

Specifically, I am talking about the scope and depth of our preparations for those future actions and concepts which NASA, the DOD, and perhaps our European allies will have to develop to meet major space needs over the next 10 to 15 years. At present, this scope and depth are missing. I am concerned that protracted failure to support an adequate space program could place this nation in a situation where technology would not be ready for us to respond to new needs with deliberation, efficiency, and effectiveness.

Unless we are willing to live with this position of impotence, the only other choice would then have to be to launch a high-priority "crash" program at some future time, with its attendant disadvantages of cost, risk, social disruption, and so forth.

New Needs

What are some of these emerging needs? First, there is the continuing need to ensure U.S. preeminence in space for reasons of national morale, political prestige, advancement of U.S. science and technology, and educational motivation and stimulation. The development of new space systems goals and advanced programs beyond the basic Space Shuttle is a necessary consequence of this need for continued vitality in space, particularly in the light of—to all appearances—a healthy and dynamic Soviet space station program.

Second, studies have indicated that users of space transportation will need—in the early 1980s—more on-orbit time and more on-board power

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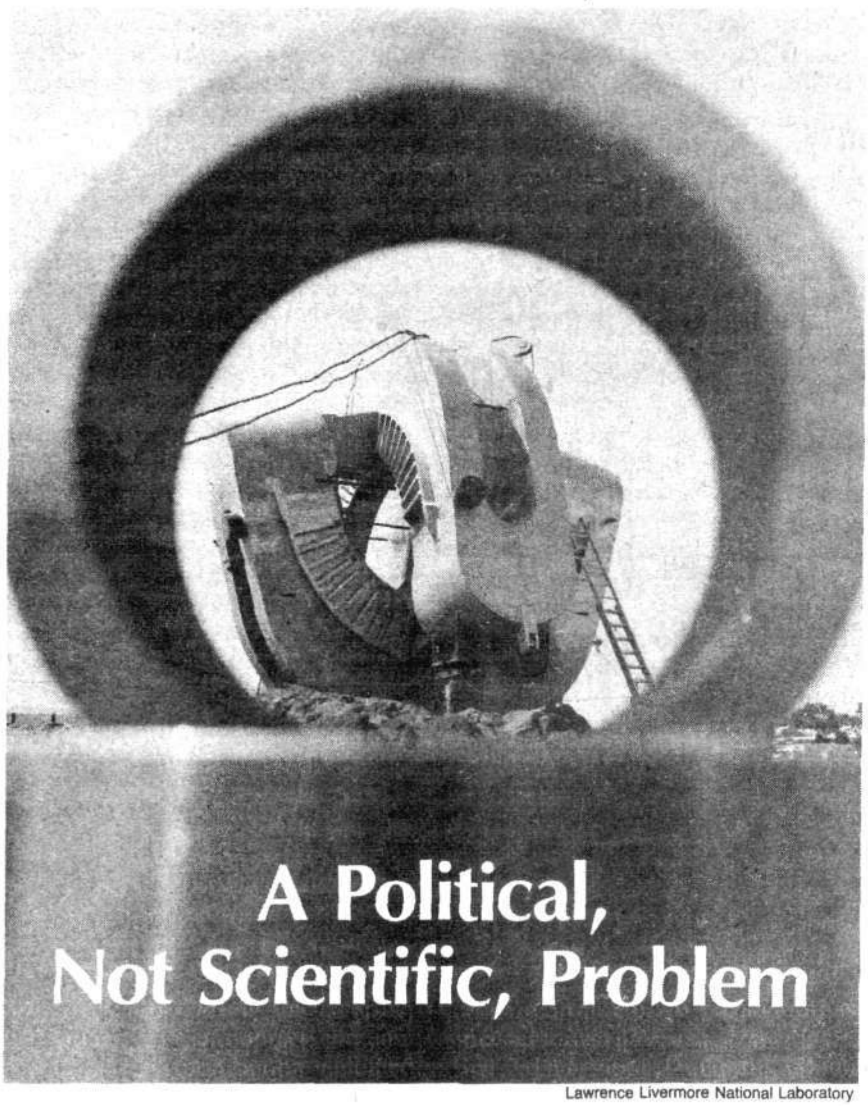
The Commercialization Of Fusion Power:



A Political, Not Scientific, Problem

Lawrence Livermore National Laboratory

The world's largest superconducting magnet, now operating in the Tandem Mirror Fusion Test Reactor.

The ninth International Conference on Plasma Physics, convened by the International Atomic Energy Agency in Baltimore Sept. 1-8, brought together nearly 1,000 of the world's leading plasma physicists and fusion laboratory experimenters. Their reports on the previous two years' research demonstrated that the international fusion effort has continued to make significant progress—even in areas thought to be at an impasse—and that the main barriers to near-term commercialization are political and economic.

Among the advances reported were a dramatic increase in beta, the ratio of plasma to magnetic field pressures, achieved at General Atomic's Doublet III tokamak in San Diego; a factor-of-three further improvement in confinement time, another major fusion parameter, demonstrated by the TMX Upgrade at Lawrence Livermore National Laboratory; and successful operation of the world's largest and most powerful superconducting magnet in the TMFTR, also at Lawrence Livermore. (See interview below.)

A delegation from the Fusion Energy Foundation released the September *Fusion*, a special issue describing how commercial fusion energy could be achieved five years sooner, in the mid-1990s, by exploiting the promise of polarized fusion fuel, one of the most discussed, and least reported on, ideas in the fusion community in 1982.

The FEF also sponsored a public seminar announcing its campaign to "break the story" among the general public—as it did with the now-famous 1978 Princeton Large Torus breakthrough in achieving record plasma temperatures.

The polarized fuel development could "give us a second chance" to move aggressively toward the engineering development of fusion, which is now jeopardized in the United States by budget cuts, *Fusion* editor-in-chief Steven Bardwell told the seminar.

The problems facing the U.S. fusion program were taken up in a speech by Edwin Kintner, who resigned his post as director of the Department of Energy's Office of Fusion Energy in early 1982 over Office of Management and Budget interference. Kintner told the FEF seminar that the scientific feasibility of fusion is not in doubt, but that the program has reached the point where it is necessary to accelerate the engineering side to match the physics. The mandates of the Magnetic Fusion Energy Engineering Act of 1980 are being sacrificed to budgetary considerations, Kintner said.

Budget Shortsightedness

This same shortsightedness has, to date, affected the testing of theoretical predictions about polarized fuel.

In early 1982, researchers at Princeton and Brookhaven laboratories had predicted that deuterium-tritium and other fusion fuels could be magnetically polarized and would stay polarized even in the enormous heat of a fusion reaction. This would enhance the reaction rate by a factor of about 1.5 and produce engineerng advantages in controlling and directing the reaction and designing the reactor.

It took a letter frm Dr. Hans Bethe of Cornell University to presidential science adviser George Keyworth, however, to produce the first discussion of a testing program for the new breakthrough. And Keyworth's reply to Bethe in August indicated that Princeton would have to test the fuel within its current, already constrained, budget.

Keyworth made it clear at the meeting of the Department of Energy's Magnetic Fusion Advisory Committee that preceded the IAEA meeting that his postponement of fusion to 2050 has nothing to do with sientific feasibility. Instead, it is rooted in an acceptance of the collapse in worldwide energy consumption caused by the economic depression. The science adviser told the MFAC meeting, the world "does not need a new energy source by the end of this century."

—Lydia Schulman

An Interview with Stephen O. Dean

Fusion Ready for Engineering Stage

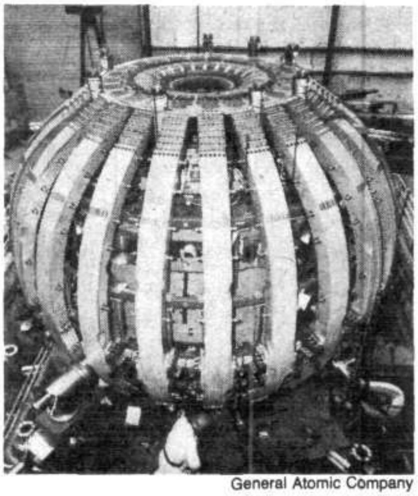
Dr. Stephen O. Dean, president of Fusion Power Associates of Gaithersburg, Maryland, was in government service with the Atomic Energy Commission, the Energy Research and Development Agency, and the Department of Energy for 17 years. Until early 1979, he held the post of director of Confinement Systems Division of the Office of Fusion Energy in the U.S. Department of Energy. Dean was interviewed by Fusion *editor-in-chief Steven Bardwell in September.*

* * *

Question: What were the most important new results in tokamak physics reported on at the International Atomic Energy Agency's ninth conference on plasma physics and nuclear fusion in Baltimore in early September?

This meeting was particularly interesting in that advances were reported on problems which the tokamak was perceived to have by some people, on issues associated with whether tokamaks would make attractive commercial reactors: specifically, the problems of raising the power density in these machines and, second, finding a means of running them in a continuous [rather than pulsed] mode.

I think the most important and impressive results were the ones reported by General Atomic. They reported 4.6 percent beta, which is about twice the previous record of about 2.5 percent. [Beta is the ratio of plasma pressure to the strength of the magnetic pressure containing the plasma—the critical determinant of commercial power density in a fusion reactor.]



General Atomic Company

General Atomic's Doublet III tokamak surpassed expectations in achieving record power densities in 1982.

I think the importance of their result was not just that it was a higher number but that the earlier experiments seemed to be showing some kind of saturation or beta limit. General Atomic went well beyond the values at which the other experiments were saturating with modest amounts of input power. They still have a couple of megawatts reserved there so they may go up even further, and they have now reached values which are about what's needed to build the fusion engineering device. This is still somewhat short, in my opinion, of what will be used in a commercial reactor, but within a factor of 2 of what I think would make a very nice, reasonable, compact and high-powered type of tokamak, the conventional type.

Question: Are these values in the ballpark of what was predicted for noncircular cross-section machines like the D-shaped Doublet III at General Atomic?

Nobody really knew what kind of beta values would be reached in these various machines. The power that's available for these machines is sufficient in the long run to run the machines up into the 10 to 15 percent range. We don't have full power on any of the machines yet, so we haven't really gotten to those values. I think the results are consistent with the original expectation for this amount of power input, but are beyond what most people thought was going to happen in view of the saturation factor that was being observed elsewhere.

I feel that for those reasons the General Atomic results bode well for continued progress toward a higher power density plasma. There was also evidence that the noncircularity of the plasma was in fact contributing to enhanced plasma conditions and hence confinement, and I think there again it was the first time we have seen definite results that show the advantages of noncircularity.

In addition, on the question of continuous operation, results from MIT, where they showed lower hybrid coupling of radio frequency waves into the plasma at higher density, indicate that perhaps we can drive the currents in tokamaks by noninductive means so that we could imagine perhaps eventually a steady-state tokamak or one which doesn't require pulsed transformers. This has important engineering implications.

Question: At this meeting I noticed there were a number of results relating to the question of lower hybrid heating, ion cyclotron resonance heating, and other radio frequency heating. Can you give any idea of the relative significance of these?

I think what these results show is that only in the past couple of years have we started to seriously investigate putting large amounts of radio frequency power in a variety of frequencies into plasmas. We've almost always simply used neutral beams for heating. Now, all over the world, we're starting to see the effect of putting large amounts of radio frequency power at various frequencies into the plasma. I think without exception we are finding better conditions as we do this. I don't know what frequency we'll eventually choose in a reactor, but I think the significance is that we may have a variety of possibilities. If it doesn't work well at one frequency, we'll be able to use a different frequency. We'll be able to tailor the plasma to behave in a variety of ways by appropriate combinations of frequencies into the plasma.

Question: There are two results of other magnetic confinement machines which generated considerable interest at the IAEA meeting. One is the progress of the mirror machine, and the other is the dramatic change in the assessment of the significance of reverse field pinches.

The mirror experiments presented a nice step forward in demonstrating that in the larger tandem mirror we are able to enhance confinement time by something like a factor of 3 beyond that in the smaller tandem mirror, which of course was itself a factor of a couple above what had been achieved in simple mirrors. So, the mirror program, as we make the machines bigger and change their design, is showing the ability to enhance the confinement and reduce the endlosses.

We don't yet have a full demonstration of thermal barriers, and this

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An Interview with V.N. Tsytovich

Toward Understanding Nonlinear Plasmas

Fusion editor-in-chief Dr. Steven Bardwell interviewed V.N. Tsytovich, the leading exponent of the Soviet school of statistical methods in plasma physics, at the Second International Conference on Plasma Theory, held in Goteborg, Sweden, in June.

In the past 20 years, Tsytovich's work on plasma theory at the Lebedev Institute has explicated what are today recognized as the "building blocks" of any theory of energy-dense plasmas: resonant wave-particle interactions in which energy can be efficiently exchanged between high-energy particles and waves in a plasma; the nonlinear stages of a wave-wave interaction, called the modulational instability; and the dynamics of a new, self-generated particle-like concentration of energy called Langmuir solitons.

Tsytovich is highly regarded in the West as one of the most subtle theoreticians active in plasma physics. His recent work on a theory of strong turbulence in plasmas using techniques from classical and quantum field theories has attracted widespread interest.

* * *

Question: There has been remarkable progress in experimental plasma physics in the past five years, both in space research and in fusion. What would you identify as the corresponding theoretical advances during this period?

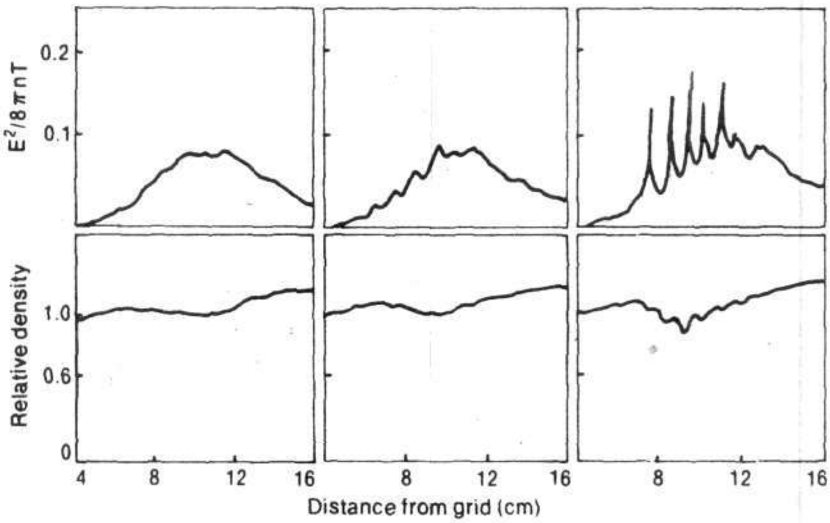
One of the most important discoveries was of resonant wave-particle interactions. This discovery was made in 1961 in a paper by Drummond and Pines and by Sagdeev in a paper published in *Nuclear Fusion*. This resonant wave-particle interaction [the efficient exchange of energy between electrostatic or electromagnetic waves and particles when the velocities of the two coincide] has a very important role in all the physics of plasmas: the interactions of particles with plasmas, beam plasma interaction, laser plasma interaction, and others. It plays a role in the magnetosphere where wave-particle interaction is very important, in the Sun, in the interstellar media, in cosmic ray particle interaction exciting Alfven waves, and so on. It is one of the most interesting branches of physics.

The next point is, I think, the theoretical investigation of modulational instability [a nonlinear electrostatic field interaction in which self-concentration of electric field energy dominates all other phenomena]. We are approaching an understanding of what a strongly nonlinear state of a plasma is. In the strongly nonlinear state it seems as if the plasma has new animals in it, like solitons, or cavitons, or other things that are interacting.

One can say that it is another phase state of a plasma. It is not a mixing of waves traveling in different directions, but it is like a state in which we have these animals very well defined, in space, in time, in very well-defined density depletions, wave traps, and so on. Laser plasma interaction and beam plasma interaction show this; indeed, you can excite those solitons and cavitons very easily. The main interest is, of course, when you apply a very big power to the system; then the plasma gives you this kind of animal and this kind of structure.

The next point is the development of strong turbulence in a plasma. Of course, this is very complicated, but research is now going on to study what happens in this case. The statistical approach was developed in my country by my students and me and also by French scientists.

The most interesting approaches developing use the diagram technique usually used in statistical theory of many-body problems and in elementary particle physics. These modern concepts of theoretical physics and the renormalization processes are important in constructing the strong turbulence. Until now, a strong turbulence in plasmas had been understood



NONLINEAR PLASMA BEHAVIOR

A now classic experiment by A. Wong and B. Quon in 1974 illustrates the nonlinear character of electron beam-plasma interactions. When the University of California experimenters directed a high intensity beam of electrons into an unmagnetized plasma, the energy did not decay into random disordered plasma motion (heat), but created highly ordered, localized structures—particlelike concentrations of energy called solitons. The top row of graphs shows energy as a function of physical position (energy density is given by $E^2/8\pi$, where E is the electric field strength). Notice how the energy concentrates itself into five spikes (the final frame). The solitons in the energy-density ratio correspond closely to density depressions in the background ion plasma (bottom row).

only poorly, but this study of plasma turbulence is a very high point in plasma physics.

The fourth thing is that we should expect new things coming out of the border [areas] between different branches of scientific research. In the border between plasma physics and elementary particle physics, for example, applying quantum electrodynamics to plasma physics, you can even find new interactions between waves and particles which are similar to the Lamb shift in atoms [a small shift in the lines of the hydrogen spectrum, which was the first empirical evidence concerning quantum electrodynamics] and which can cause radiative corrections to quasilinear equations.

I believe that these interactions can create very hot particles by the resonant heating of plasmas. This is important for the CTR [controlled thermonuclear reaction] problem. These fast particle tails created in the domain of relativistic energies are very likely cosmic rays, because it is from this type of interaction that you receive exactly the cosmic ray spectrum and the abundance of heavy elements, in accordance with observation. So this kind of interaction, the radiative corrections to quasilinear interactions, seems to be important, but it is a development on the border of the two sciences, between quantum electrodynamics/elementary particle physics and plasma physics. I think that in the future all the "hot points" will be on the border between these two sciences.

Question: In each of the problems you mentioned—the modulational instability, strong turbulence, and quantum electrodynamics—a solution which is approached nonperturbatively (that is, with a method of analysis using global techniques rather than a microscopic adding-up of interactions) is plagued by essential singularities. And, an attempt to sum up the perturbation series results in a noncoverging series, infinity. In fact, the physics and mathematics of all three problems are very similar. Do you think this problem is insurmountable, or can it be solved?

I think the problem is the following: The infinities found in the usual approaches are removed by the so-called renormalization [which in plasma physics is called] resonance broadening. This resonance broadening completely removes the resonance irregularities. There is no problem about that. But, still, there is a new kind of irregularity, like the soliton collapse problem. This irregularity can, I think, also be removed by proper considerations, but until now there has been no real experimental foundation for the idea that the collapse can proceed to the size of Debye lengths [the characteristic distance of effective interaction between particles in a plasma]. It could proceed to several times the Debye length, but the problem is to prove that indeed the collapse exists. There are many other processes going on simultaneously with collapse.

Rudakov [Soviet fusion scientist L.I. Rudakov] and I explained all this several years ago in a review paper in *Physics Reports.* There are sound waves that can be emitted during the collapse and there are other different processes going on, so it is still uncertain and needs much research to determine how the singularities will be saturated [the "smoothing out" of a singularity resulting from second-order nonlinear interactions that remove the mathematical infinity by generating a new physical interaction].

Question: There are many physicists who have said that plasma physics is merely an application of Newton's and Maxwell's equations, that plasma physics is only a branch of applied physics. Do you agree?

I cannot agree with that because plasma physics is so broad that we cannot understand such simple interactions as collective interactions. These turn out to be so complicated that we must understand them first before we can go on to more fundamental things. Even plasma physics methods are used for elementary particle physics to some extent—for the study of asymptotic freedom of particles, for example. So I think that the understanding of plasma physics can help us much more in understanding fundamental research.

Question: The relation between plasma theory and its practical application is always in the minds of policymakers.

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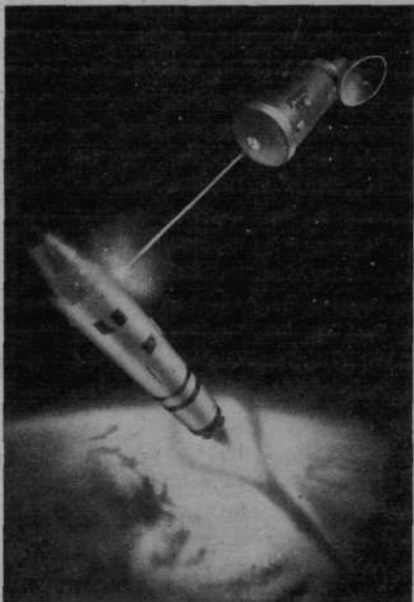
Painting by Christopher Sloan

Beam Weapons Vs. The Nuclear Freeze:

Carlos de Hoyos/NSIPS

Implications for U.S. Strategic Policy

The issue of directed energy beam weapons emerged in 1982 as the focus of a far-reaching debate over U.S. military strategic and economic policy. The Fusion Energy Foundation, fusion scientist Edward Teller, and others have argued that the United States must launch an in-depth program to develop beam weapons not only because these weapons would provide, for the first time in 30 years, a real defense against the horrors of nuclear war, but also because of the spill-over effects on the civilian economy of a crash program to develop this frontier military technology.

Specifically, the *nonclassified* development of the full array of beam technologies—laser, particle beam, microwave, and plasma beam systems—would hasten the development of fusion energy, advanced materials and mining processes, and a host of "plasma age" technologies that, in fostering international development, would eliminate the main cause of war.

On the other side of the debate, the leaders of the nuclear freeze movement have been equally forthright about the economic and strategic policies that motivate their arms control proposals: They oppose peaceful nuclear energy and other advanced technology; they support "postindustrial" solutions for the Third World like population reduction; and they favor a build up of *conventional* weapons.

In a November interview, Col. Jonathan Alford, director of the London-based International Institute of Strategic Studies (a key control center of the U.S. freeze), lambasted the beam weapons proposal as another example of Americans' unfounded "technological optimism." "I think Americans are always searching for technical solutions to problems to save them from uncomfortable decisions, like keeping up conventional forces," he told the *Executive Intelligence Review*.

> *"A successful nuclear freeze will involve a conventional buildup. . . . Disarmament is not our goal."*
>
> Freeze leader Arthur Westing, Fate of the Earth Conference, New York, October 1982

Disarming the Freeze

During a two-week tour of California this fall, *Fusion* editor-in-chief Steven Bardwell disarmed the anti-technology, antinuclear leaders of the freeze, including Rand Corporation counterinsurgency expert-turned-peacenik Daniel Ellsberg and CalTech president Dr. Marvin Goldberger. He went on to address groups in Texas, Florida, and Pennsylvania, and New Mexico and to debate freeze spokesman George Rathjens of MIT.

Bardwell elicited shocked realization from his student audiences that Vietnam War architect Robert McNamara, who helped to launch the freeze movement with his spring 1982 *Foreign Affairs* article on "no first use" of nuclear weapons, is running this peace movement as a cover for new conventional wars in the Third World.

Because he is not bound by government classification restrictions, Bardwell has been able to speak freely about the beam weapons alternative—how the technologies work and how an Apollo-style development program could catalyze economic recovery. (His special report, "Beam Weapons: The Science to Prevent Nuclear War," is available from the FEF for $250.)

The growing interest in the FEF's beam weapons proposal was reflected in the standing-room-only turnout at a Nov. 18 Capitol Hill briefing given by Bardwell and FEF executive director Paul Gallagher. This, the second such briefing on beam weapons in several months, sponsored by Arizona Representative John Rhodes, was attended by a remarkable cross section of individuals from congressional offices, various branches of government, foreign embassies, and the press. Many of the congressional representatives indicated that they had come because their constituencies wanted them there. Five of the offices took copies of the FEF's draft legislation for a beam weapons program (The Directed Energy Beam Ballistic Missile Defense Research, Development, and Demonstration Act of 1983, which appears below).

Plasma Age Science

The FEF campaign for the development of beam technologies actually goes back to the foundation's inception—in the form of its recognition of the importance of investigating the nonlinear, self-organizing features of plasmas for realizing fusion and extending man's mastery of the physical universe. This special report includes a chronology of FEF initiatives and articles in this campaign, compiled by fusion technology editor Charles B. Stevens.

It also features an article by Stevens and Bardwell on the X-ray laser, considered by many the most attractive of the beam weapons, and excerpts from Edward Teller's speech to the National Press Club on Oct. 26, shortly after a conferring with President Reagan, which marked Teller's emergence as a spokesman for "defensive nuclear weapons" and "cooperation [that attacks] the roots of conflict."

—Lydia Schulman

Chronology of the FEF's Fight for Energy Beam Weapons Development

Jan. 1976. "The Concept of the Transfinite" (Campaigner Publications), by FEF research director Uwe Parpart, points to the work on self-organizing plasma structures by Soviet scientists V. N. Tsytovich, V. E. Zakharov, and L. I. Rudakov, and in particular to Rudakov's work on electron beam pellet fusion, as being the type of advanced Riemannian physics research that will revolutionize all forms of technology.

May 1976. FEF Newsletter, vol. 1, no. 5, publishes translation of a March 10 *Pravda* article with the first report on Rudakov's experimental success in achieving electron beam pellet fusion.

June 1976. FEF Newsletter, vol. 1, no. 6, carries excerpts from Tsytovich's paper "New Physical Concepts in Plasma Physics." Dr. Steven Bardwell, current editor-in-chief of *Fusion,* analyzes this advanced Soviet theoretical work and demonstrates that it can provide the basis for obtaining "directed energy" from thermonuclear plasmas.

Sept. 1976. Bardwell elaborates how self-organized plasma structures behave, in *FEF Newsletter,* vol. 2, no. 2.

Oct. 15, 1976. Parpart, in a *New Solidarity* newspaper article, gives details of the Rudakov electron beam pellet fusion breakthrough. He describes how Rudakov transformed the energy of the electron beam into soft X-rays via a plasma and then used these soft X-rays to compress and heat fusion fuel. Parpart indicates that besides representing a major breakthrough for fusion energy research itself, the Rudakov experiments could lead to major new developments in strategic weapons and war-fighting.

March 1977. FEF Newsletter, vol. 2, no. 3, details how the U.S. Energy Research and Development Administration attempted to suppress the scientific results that Rudakov presented in public lectures during his 1976 visit to the United States.

May 1977. In a report titled *Sputnik of the Seventies—The Science Behind the Soviets' Beam Weapon* (Campaigner Publications), FEF board member Lyndon H. LaRouche, Jr., Bardwell, and *Fusion* writer Charles B.

Key to developing beam weapon technologies and fusion energy: Riemannian physics.

Stevens report on both how Henry Kissinger and Robert McNamara have wrecked U.S. military capabilities and how the Soviet Union is harnessing breakthroughs in fusion and plasma physics to develop directed energy weapons capable of destroying nuclear-tipped missiles.

Dec. 1977. Fusion gives further details on the Rudakov case and reports on Dr. Sylvester Kalaski's work on inducing fusion with ordinary chemical explosives in Poland.

Aug. 1978. FEF breaks the blackout on the Princeton Large Torus breakthrough in achieving 70,000,000°K temperatures with stability. *Fusion* carries an article comparing the U.S. and Soviet laser fusion programs, which is picked up and reprinted in the Soviet press.

March 1979. Fusion reveals the direct connection between inertial confinement fusion, the hydrogen bomb, and Bernhard Riemann's 1859 paper "On the Propagation of Plane Air Waves of Finite Amplitude." Stevens reports how Great Britain helped sabotage the U.S. program in fast liner fusion, which is closely related to directed energy plasma dynamics, to prevent collaboration between U.S. and Soviet scientists.

Nov. 1979. Dr. Friedwardt Winterberg's "Some Reminiscences about the Origins of Inertial Confinement" appears in *Fusion*. This article by a leading inertial fusion pioneer further demonstrates the connection between Riemannian science and the H-bomb.

Sept. 1980. Fusion reports on Winterberg's concept of the compression of blackbody radiation for generating an intense burst of soft X-rays, which can then compress fusion fuel to achieve inertial fusion. Within a year the U.S. government will reveal that such "radiation"-driven pellet targets are the basis of its classified hohlraum-type inertial confinement fusion targets.

Oct. 1980. Winterberg's further elaboration of his hohlraum-type targets appears in *Fusion*. Magnetically confined thermonuclear plasmas can be utilized to generate X-rays, which are then used to compress a high-gain fusion fuel target.

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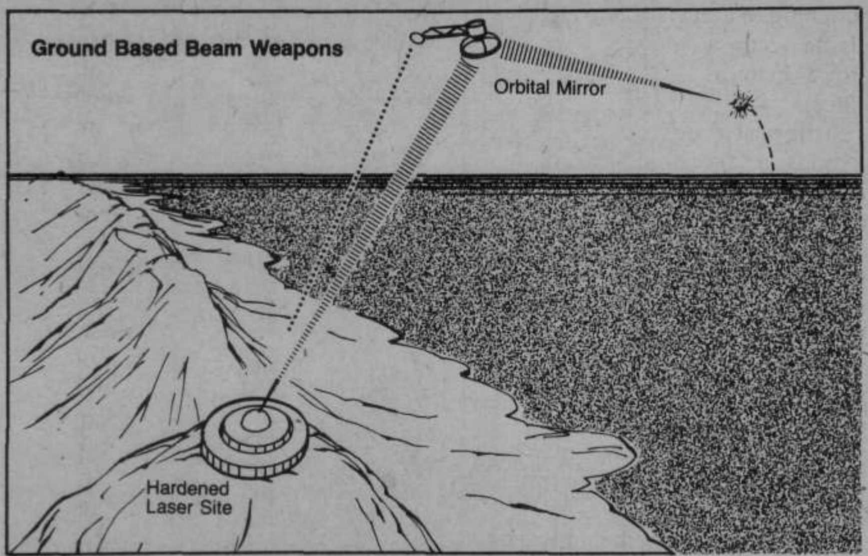


Within five years, the United States could develop a first-generation beam weapon of the sort shown here. This design shows a ground-based laser beam weapon system built on a 12,000 foot mountaintop, which uses a relay mirror in orbit around the earth to provide aiming and tracking. Using an intense beam of light, the ground-based laser generates a pulse of energy sufficient to destroy missiles as they are launched or as they reenter the atmosphere toward their target. The beam generation is accomplished totally on the earth, removing any problems of weight, remote maintenance, or launch capability associated with space-based weapons. By situating the weapon above the bulk of the atmosphere, almost perfect transmission of the laser light can be achieved with long-wavelength chemical lasers.

Draft Legislation for U.S. Beam Weapon Development Program

The Fusion Energy Foundation has drafted this legislation for circulation among congressmen and senators and their constituencies, with the aim of getting such a bill introduced in early 1983.

* * *

The Directed Energy Beam Ballistic Missile Defense Research, Development, and Demonstration Act of 1983

A bill to provide for an accelerated program of research, development, and demonstration of directed energy beam weapons to protect the United States from thermonuclear attack within a decade, to be carried out by the Department of Defense.

Section 1. Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that this act may be cited as the "Directed Energy Beam Ballistic Missile Defense Research, Development, and Demonstration Act of 1983."

Section 2. (a) The Congress hereby finds that:

(1) the world's military balance has been determined for the past 25 years by the existence of an offensive weapon of mass destruction, the nuclear-armed intercontinental ballistic missile, for which there is no defense;

(2) the world's population has been held hostage for 30 years in a purposeful policy of assured vulnerability, in the name of deterrence of the use of these weapons;

(3) the United States has had no protection from the holocaust that would result from the explosion of even a single hydrogen weapon on any city;

(4) there has been no recourse in this period should even an accidental

launching of a nuclear-armed ballistic missile occur, an event that could destroy as many as 15 cities in the United States;

(5) the past three years have brought a series of technological successes whose cumulative import is that it is now possible to begin constructing a means of destroying a limited number of nuclear-armed ballistic missiles in mid-flight, after launch, but before their warheads have been released;

(6) these technological advances using directed energy beam weapons are inherently defensive capabilities and will form the basis of the national security of the United States in the next decades;

(7) directed energy beam weapons refer to the use of laser, particle, and other forms of coherent high-energy sources to disarm offensive nuclear weapons systems;

(8) expert opinion indicates that the technologies exist to begin construction of such directed energy beam weapons that, in the next five years, would be capable of destroying any missiles launched accidentally by any nation and that these technologies could be perfected in the next decade to provide a large margin of protection in the event of a large-scale or total nuclear attack;

(9) according to published reports by the Defense Department and the U.S. General Accounting Office, the Soviet Union is currently spending at least three times as much money as the United States in the development of defensive beam-weapons systems, and the program in the United States has been only a research effort and not a development effort; the consequences of this imbalance thus threaten U.S. national security;

(10) the technology of beam weapons has been provided largely by similar research on nuclear fusion;

(11) these same directed energy beam weapon technologies, when applied in the civilian sector, would accelerate the development of thermonuclear fusion power, which is an unlimited source of energy, as well as a full array of plasma technologies and civilian space applications;

(12) the stimulation of all nuclear and related energy technologies from the directed energy beam research would be the basis of a renewed "Atoms for Peace" program for nuclear exports, and would ensure international economic development, which would decrease the possibility of war; and

(13) the programs established by this act will require the expenditure of approximately $10 billion during the next 10 years.

Section 2. (b) It is therefore declared to be the policy of the United States and the purpose of this act to establish an aggressive research, development, and demonstration program involving directed energy beam weapons systems. Further, it is declared to be the policy of the United States and the purpose of this act that the objectives of this program are:

(1) to proceed immediately with the work necessary to deploy a high-energy laser system within the next five years that could provide a defensive capability against a small number of nuclear-armed intercontinental ballistic missiles;

(2) to accelerate research and development of short-wavelength laser and particle-beam programs, with the goal of determining the optimum research and development path for succeeding generations of beam weapons designed to provide complete protection of the United States against nuclear war, and of putting this system in place within a decade;

(3) to take appropriate measures, modeled on the National Defense Education Act as originally adopted, to ensure the provision of adequate scientific and engineering manpower for the development of these weapons systems and the civilian energy and space technologies that will emerge from applications of this research and development;

(4) to take the necessary steps to ensure the fullest participation of the private sector, colleges, and universities; other government agencies; and allied nations in the directed energy beams weapon development program, recognizing that defensive technologies do not pose a threat to the national security of the United States and that these technologies will not be classified, except as they overlap offensive weapons technologies; and

(5) to consider these technologies, therefore, unclassified until reviewed by a panel including the Department of Defense, the Department of Energy, and the National Aeronautics and Space Administration, which, at its discretion, may restrict access.

Section 3. The Secretary of the Department of Defense is directed:

(1) to conduct a review jointly with the Department of Energy and National Aeronautics and Space Administration of the directed energy beam weapons program and provide, within one year, a program for the most rapid development of this technology, based on the readiness of the technology, rather than budgetary considerations;

(2) to conduct an in-depth review of military strategy to replace the doctrine of Mutually Assured Destruction (MAD) and all aspects of "deterrence" doctrine;

(3) to provide the Department of State with the necessary information and guidance to design a renewed "Atoms for Peace" program based on the export of advanced fission and fusion technologies for peaceful uses;

(4) to provide the Arms Control and Disarmament Agency with the necessary information and guidance to prepare a new proposal to the government of the Soviet Union for negotiation of a mutual agreement for the development of defensive weapons by both nations that would ensure that no third power would ever use the weapon of nuclear blackmail;

(5) to work with the Department of Energy and the National Aeronautics and Space Administration to ensure the transfer of technology in all applicable areas to the civilian sector; and

(6) to work with the Department of Energy to ensure optimal progress in inertial and magnetic nuclear fusion programs.

Section 4. There is hereby authorized to be appropriated to the Secretary, for the fiscal year ending September 30, 1984, $300 million inclusive of any funds otherwise authorized to the Secretary for the purpose of research, development, and demonstration of directed energy beam weapons for ballistic missile defense, and for each succeeding fiscal year such sums as may hereafter be provided in annual authorization acts.

Teller Tells the Press: 'Science Can End the Age of Thermonuclear Terror'

Edward Teller, a member of the President's Science Council, speaking out on defensive nuclear weapons.

Dr. Edward Teller, a nuclear physicist who played a leading role in the Manhattan Project and then went on to participate in the U.S. development of the hydrogen bomb, addressed the National Press Club in Washington, D.C., Oct. 26 on his proposals for ending the threat of nuclear war: the development of defensive nuclear weapons and international cooperation to industrialize the Third World. Teller, 74, is a member of President Reagan's Science Council, a senior research fellow at the Hoover Institution, a consultant to the Lawrence Livermore Laboratory, and professor emeritus at the University of California. A full transcript of his speech and extensive selections from the question period follow.

* * *

One of the obvious things is, a point that absolutely all of us, those present and those absent, every American, I believe, shares, is our determination not to have another war, another big war like the First and the Second World War, or worse. There is no difference of opinion on that point. There is a difference of opinion what is the best way to avoid another war.

Our policies for years have been on the wrong track.

For a quarter of a century we have conceived of our situation as a balance of terror, and the dreadful point is, that the terror is obvious; the balance is not. President Reagan had the honesty and the great courage to state that the Soviets are ahead of us in important military respects, including nuclear weapons. This is obviously not a popular statement. It is obviously not a self-serving statement. And it is obviously a statement about a situation that the American people need to know. But no one except he in high office had the courage to make that statement.

I have talked to many audiences, including students, and I found in general that about 10 percent are for the freeze, about 10 percent are against the freeze, and 80 percent are scared. They have every reason to be. This policy has been introduced by a peculiar man who for seven years was our Secretary of Defense: Robert Strange McNamara. The Mutually Assured Destruction, or MAD policy, is something that I don't see how anybody can like. That people should look for an alternative I fully understand.

But the alternative, the oversimplified proposal of the freeze movement, which has been labeled as simple as a can-opener, will not help us by opening this can of worms. We need, and we can have a much better solution.

No, it is in the nature of development of weaponry that if anything new comes up, and certainly atomic weapons is something very new, the first application as a rule is destructive. And, the defensive uses need very much more sophistication. We have arrived at the point where the ingenuity of several of my young colleagues has produced, to say it very cautiously, proposals for defensive weapons. I, as befits a person advanced in his 70s, was incredulous, but also obviously and greatly interested.

I want to be very clear about this point. I am not talking about one proposal. I am not talking about one magic solution. I am talking about a whole trend. Furthermore, we have good evidence that the Soviets are familiar with the ideas on which we are working.

There remains nothing more for me to do but to tell you what these new ideas are. For that is both difficult and also impossible. It is difficult because of all matter known to man, the one with the greatest inertia is the human brain. To accept, absorb, evaluate a new idea is immensely difficult even in your field. And if it is not in your own field, it becomes almost impossible. And many scientists, many excellent scientists, who looked briefly and in some places with some prejudice, at these new ideas, have rejected them—as I did, when I looked at them the first time. But the more I looked, the more convinced I became. That is why it is difficult. It is impossible, because these ideas—not the details, but the very ideas—are classified. We call it not only secrecy, but "security." It isn't, because the Soviet leaders know; the American people have a need to know. But they are not told.

At the very beginning of the Cold War, the greatest physicist of all, Niels Bohr, said, "In the Cold War it would be reasonable to expect that each side will use the weapons that it can use best. And the appropriate weapon for a dictatorship is secrecy. But the appropriate weapon for a democracy is the weapon of openness."

And "openness" is a weapon. It could bring us and our allies more closely together. It could produce a situation where money counts, but where ideas and their thorough execution, which does not cost very much money—that counts incomparably more. In such a situation, the free democracies, working together, could be irresistible.

From sad experience, I know, and I believe many of you recognize, that the Soviet leaders have an ambition to rule the world as did Hitler. But, there is an enormous difference between the men of the Kremlin and the Nazis. Hitler was an adventurer. The rulers in

Moscow are not. When they are faced with an uncertain situation, they will not embark on adventure.

If "freeze" prevails, the consequences are predictable. People talk about bilateral "freeze." How will you check on fabrication, and what's more important, on research, in a vast country, in the Soviet Union? Will you send over 100,000 Americans who can go everywhere, find out anything? Will that be permitted? If that were truly permitted, I believe it would be the end of the police state in the Soviet Union, and for that, I would give anything. But instead, you know what the situation is. That is how bilateral freeze would be.

I also believe that to try to pursue a freeze, without understanding the situation, without evaluating the alternatives of developing defensive weapons which would act on both sides for stability and peace—we cannot evaluate this without at least discussing the ideas I refer to.

One example: We have a great amount of valuable, relevant material about Soviet civil defenses. A trickle has been published. Why not all? The Soviets know it, they know what civil defense measures they have taken. They know how we know it. They know we get it from refugees. Why not make a beginning with a law which forbids the classification of anything pertaining to civil defense? What should be kept secret in a difficult time and what should not, cannot be judged in a few words and in an oversimplified manner. But that the American people should not know what the Soviet leaders know, and what they need to judge, decisions in some other simple cases, these can be decided.

Ladies and gentlemen, I lived through two world wars. In the first, I was a child, but I knew what was happening. Fifteen million people were killed in the country of my birth, and it was torn apart. I remember the days before the Second World War when the small Chamberlain, not the one who is more than 7 feet tall, went to Munich with his umbrella, and brought home "peace in our time." That peace lasted for one year. And was followed by the killing of more than 15 million people, and the murder of most of my close friends in Hungary, and many of my close relatives. I use the word murder deliberately. This could have been avoided, except for the well-intentioned folly of Chamberlain. This well-intentioned folly may be now repeated by the advocates of the freeze movement.

We must find an alternative, and we must not be led by the simple slogans which are apt to increase the danger of war.

Ladies and gentlemen, this is why I am against the freeze movement, and why I conceive of this issue as probably the most important in this year. Thank you very much.

Questions by the Press

Question: How sure are you the Soviet leaders already know our secrets. How do you know that?

That is a secret! But part of my knowledge comes from little things like published Soviet literature. I don't know how to draw the line between the obvious, what one can obviously talk about, and the subjects which have been classified secretly, because it has even occurred that the obvious has been classified as secret.

We can by using technology create a situation where the reasons for war will diminish and keep diminishing.

Question: How did the Soviets learn what the American people cannot learn?

They are not stupid!

Question: In the 1960s you spoke against the limited test ban treaty on the grounds that a new absolutely clean weapon would soon be developed that would eliminate the hazards of radiation in atmospheric testing. That never happened. Why should we believe you this time that we have defensive weapons to ensure stability and peace?

The questioner is slightly misinformed. I have never claimed that absolutely clean weapons will be developed. I only claimed that weapons can be developed which are clean enough so that their testing will not cause a contamination of the atmosphere which is even approaching anywhere near what we get from natural sources in any case. And this has happened. We know how to make such clean explosives. And I think their testing in the atmosphere should not have been ruled out. One of the consequences of that limited test ban which drove testing under ground, is this: Before the test ban the debris of Soviet tests went into the atmosphere. We could collect it and learn something about what the Soviets are doing. Today we cannot do so. We have no idea what the Soviets actually are doing with their tests, but they have an excellent idea what we are doing, because as Niels Bohr has said, a democracy is just not good at keeping secrets. And if we really would try to keep these secrets, not only imposing it on the people who are reliable but trying to impose it on people like, oh I don't know, like somebody who will sell it to the *New York Times*—I forget his name—that kind of secrecy does not work. And as far as whether you should believe it, the example quoted I don't think proves the question at issue, and may in turn quote a really great man who said once about himself: "I was not always wrong." That was Winston Churchill.

Question: What kind of defensive weapons are feasible and could provide for stability, as you mentioned? ABM? Space weapons?

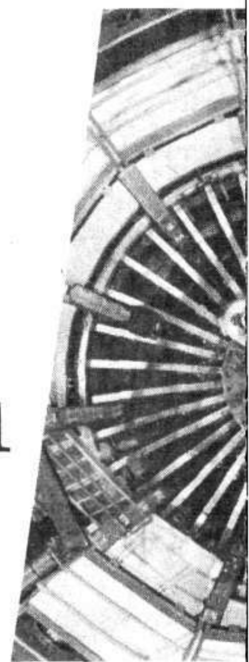
I told you that the kinds that we are working on are classified. If I would now begin to give you a list of all the kinds that won't work, somebody could accuse me of having broken the law. I am not going to break the law. Because without law, we could not live in a decent cooperative society. But in this country, though not in the Soviet Union, you can criticize a wrong law, and if the law is, you can change it. And I don't see any group that could better look into the question how openness can be stimulated than the press.

Question: Do you believe there will be war between the Soviet Union and the United States by 1990?

If the freeze people prevail, and if we don't submit to Soviet dictates, then

Continued on page 27

The natural successor to first-generation chemical laser beam weapons is a space-based X-ray laser antiballistic missile defense system, which the United States could perfect in 12 to 15 years. This new energy-dense X-ray laser technology would be both cost-effective and battle-effective.



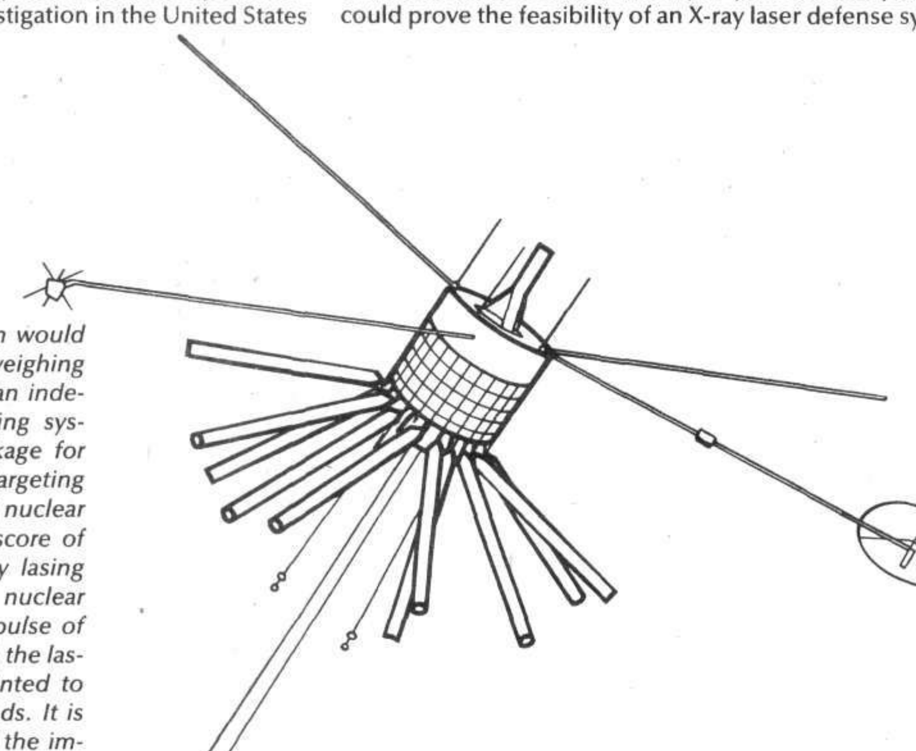
The X-ray Laser: A Second-Generation Beam Weapon

by Charles B. Stevens and Steven Bardwell

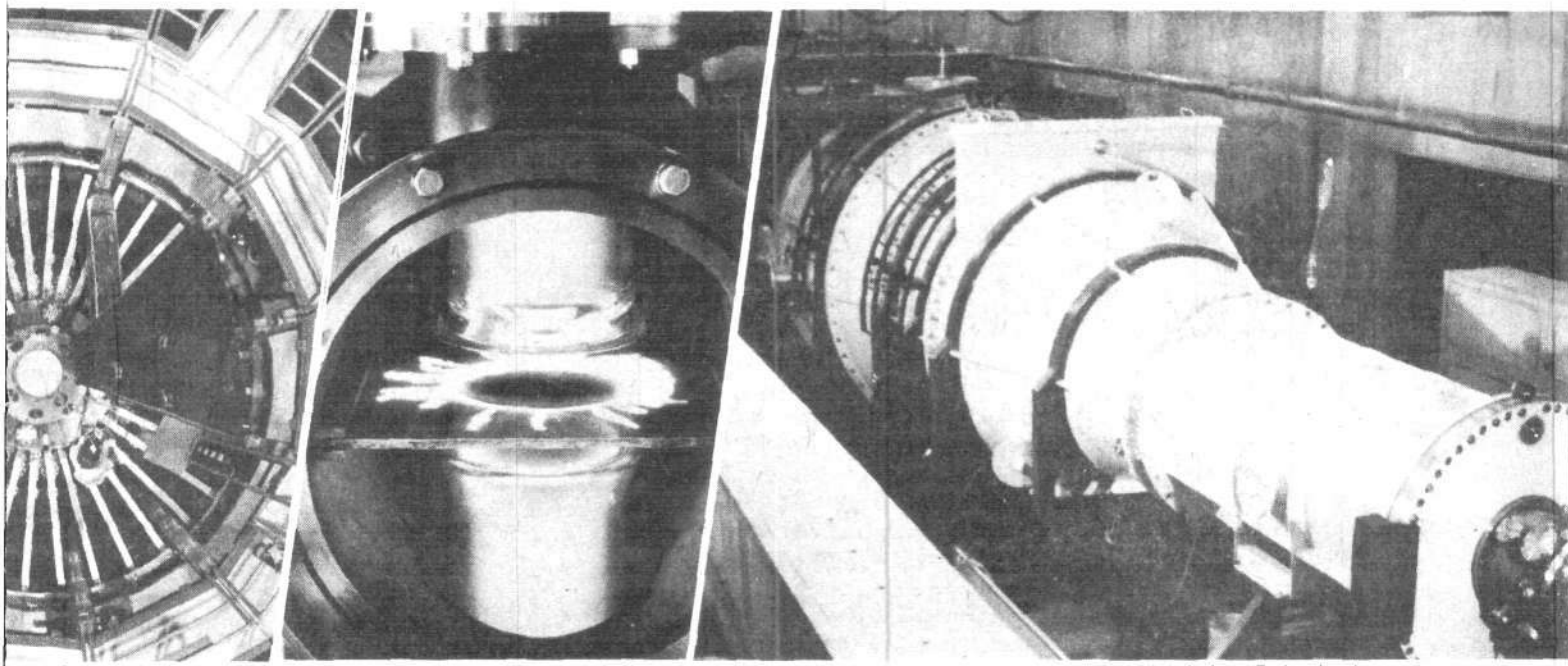
Recent, still-classified experiments at U.S. weapons laboratories have convinced many scientists that a new laser technology—the so-called X-ray laser—could be perfected within the next five years for use as a second-generation defense system against ballistic missiles.

The X-ray laser is complementary to the optical frequency (chemical) lasers and particle-beam weapon technologies currently under investigation in the United States and Soviet Union for ballistic-missile defense; its specific advantages include extreme flexibility in technological development, a very high power-to-weight ratio, relatively low cost, and a high rate of repeatability.

These scientists have privately called for an accelerated research program in X-ray laser defense systems, at an estimated cost of $100 million per year. Such a program could prove the feasibility of an X-ray laser defense system



An orbiting X-ray laser system would consist of a small satellite weighing less than 100 kg, containing an independent targeting and tracking system, a communications package for linkup to more sophisticated targeting and tracking satellites, a small nuclear explosive, and more than a score of thin, 1- to 2-meter-long X-ray lasing rods. The detonation of the nuclear device generates an intense pulse of X-rays that ablatively implodes the lasing rods. These rods are pointed to intercept missiles and warheads. It is the shock wave generated by the implosion process that causes the inner portions of the metal rods to undergo X-ray lasing.



Sandia National Laboratories U.S. Air Force Institute for Laser Engineering, Japan

The development of beam technologies for weapons will also advance the civilian fusion effort. Left to right: the PBFA-1, a particle beam accelerator used for beam production and focusing experiments in the fusion research program at Sandia National Laboratories; an electron discharge laser, one of the most attractive types for space-based beam weapons systems, at Kirtland Air Force Base; and the Reiden IV, Japan's large carbon dioxide laser.

in two to three years, and lead to a deployable ballistic-missile defense satellite using X-ray lasers within five to eight years.

The need for such a defensive weapon system is urgent. For the past three decades the world has increasingly faced the prospect that an all-out nuclear war would incinerate most of its major metropolitan areas within a few hours. And it has been argued in great detail that no foolproof, efficient means of defense of large cities against nuclear-tipped ballistic missiles can be perfected. In every case the antiballistic missile system (ABM) under consideration was incapable of meeting two conditions: resiliency in the face of offensive countermeasures, and unit cost-effectiveness. For each of these systems, unit improvements in the ballistic missile offense were much cheaper than unit improvements in the ABM defense. In other words, in order to realize an effective ABM, the cost of achieving an assured missile kill must be only a small fraction of the cost of the missile system, and the defensive ABM system must be capable of improvement at a rate and cost far less than that of the offensive.

Studies conducted by the Fusion Energy Foundation point toward a two-stage implementation of a beam-weapon ballistic missile defense system:

(1) *The deployment of a high-energy laser system within the next five years.* This system would use a hybrid basing design, having the laser and its power source on the Earth (at an altitude above 10,000 feet) with an array of orbiting mirrors. The laser, since it is ground-based, has no restrictions on size, weight, efficiency, or power supplies, and is used to direct a high-energy pulse to any of the mirrors in its vicinity. The orbiting mirror performs the functions of target acquisition, pointing, tracking, and focusing. Since only a few lasers would be required to service many mirrors, a true area defense capability is possible using this hybrid basing. The primary mission of this first-generation system would be protection against a relatively small number of missiles from an accidental launching by one of the superpowers or the launching of a nuclear weapon by a third power. The catastrophic consequences of either of these possibilities—which are both much more likely in the near-term than an all-out nuclear exchange between the superpowers—would be completely nullified by the existence of even this relatively primitive first-generation system.

(2) *The second- or third-generation beam weapon based on X-ray laser technologies.* Using the same target acquisition, pointing, and tracking techniques employed in the first-generation system, the tremendous cost and weight advantages of the X-ray laser would result in a completely space-based system capable of protecting the United States against the thousands of missiles that would be involved in a worst-case all-out nuclear attack. Such a system could perform this much more difficult mission within 12 to 15 years.

The X-ray Laser: Unique Capabilities

Over the past year Dr. Edward Teller has been quoted by leading defense officials as stating that a new discovery achieved by the Lawrence Livermore National Laboratory "is the most significant development in strategic war-fighting since the H-bomb." According to Teller, the X-ray laser "will tip the battle in favor of the defense for the first time in the history of the nuclear age." Teller has stated publicly that "the United States could have an effective shield against the terrible threat of thermonuclear holocaust within the next several years if we but invest another $100 million a year in an accelerated program for perfecting this defensive system."

In the past few months, as high-level scientists and Washington officials have corroborated, Teller and Dr. Lowell Wood of Livermore have begun an increasingly public campaign for a crash program to perfect a space-based X-ray laser antiballistic missile defense system within the next several years. While constrained by classification regulations from even mentioning the name of the X-ray laser in public, Teller has provided sufficient hints in a number of radio and television appearances over the past months so as to leave no doubt in the minds of experts about his statements on the X-ray laser.

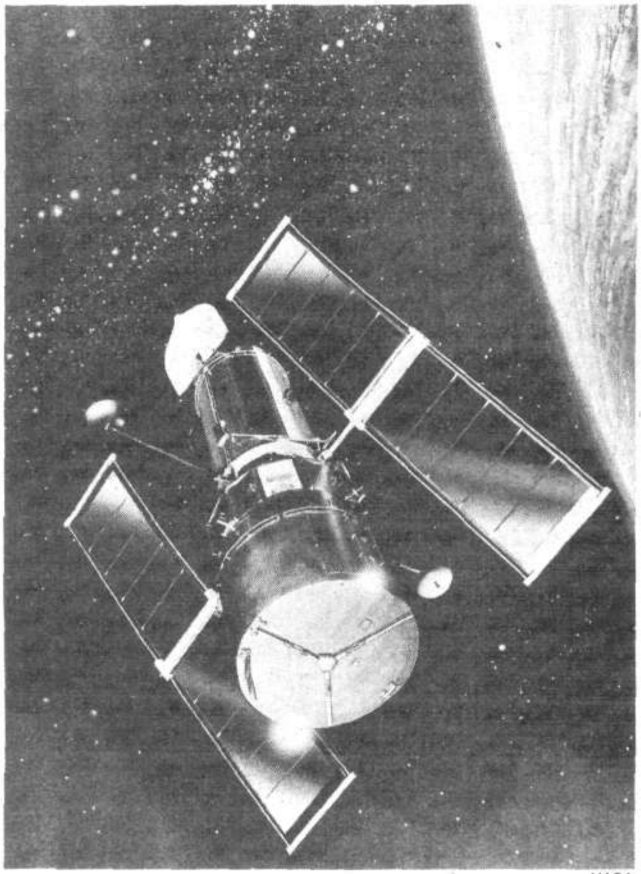
Teller has emphasized that if the government classifications he has vehemently opposed were lifted, he is certain that the American people, presented with the facts about the X-ray laser defense system, would demand that it be built.

The development of a laser operating in the X-ray wavelength has been the subject of much theoretical and experimental research for the past two decades. In fall 1980 we were informed that experiments to demonstrate such a laser were about to begin. In the Feb. 23, 1981 issue of *Aviation Week and Space Technology*, Clarence A. Robinson, Jr. reported that scientists from Lawrence Livermore National Laboratory had successfully conducted such tests at the Nevada underground nuclear test site. Rumors in the scientific community report that the test was much more successful than the researchers involved had anticipated. One such rumor notes that the energy pulse produced by the X-ray laser was much more powerful than expected, with the result that the detector which researchers had hoped to use to measure the energy output from the device was vaporized by the X-ray laser pulse!

The components of the Livermore X-ray laser consist of thin metal rods a few meters in length, in which X-ray lasing action is induced by a burst of X-rays or neutrons generated by a small nuclear-fission explosive. The resulting X-ray laser beam travels in the same direction as that in which the metal rod is pointed. As reported by Robinson, the X-ray wavelength is at .0014 microns. The beam intensity is several hundred trillion watts, with a length of a few billionths of a second. With an energy of about 1 million joules per rod, this is equivalent to 250 grams of TNT in terms of crude energy. The fission explosive itself is quite small, ranging from 100 to 1,000 tons of TNT equivalent. Each fission explosive is capable of simultaneously pumping approximately 50 lasing rods, each capable of independent targeting.

For the purposes of determining the viability of the space-based X-ray laser as an effective shield against missiles, it is important to understand some of its key operating characteristics:

In nuclear explosions most of the energy generated emerges from the nuclear fireball in the form of intense



NASA

The development of NASA's Space Telescope, shown here in an artist's rendering, required advances in pointing and tracking technology that are also needed for beam weapons systems that can identify and aim at targets thousands of kilometers away in space. Under construction by Lockheed, the Space Telescope will be placed in orbit by the Shuttle in 1985.

X-rays. During explosions within the atmosphere, this X-ray burst is quickly absorbed by the molecules within 100 meters of air surrounding the fireball. (It should therefore be noted that the X-ray laser can operate only against targets in space or in the upper portions of the atmosphere above 100,000 feet where the air is very diffuse.)

The X-ray laser, thus, requires no fragile optics—mirrors, lenses, beam polarizers, and so on. Lasing efficiency and beam quality are determined by the composition of the rod, the mixture of radiation from the nuclear charge, and the latter's timing. Theoretical beam divergence can be extremely small, so that the X-ray laser beam can remain concentrated over extremely great distances in space. It is possible in principle for the perfected Livermore X-ray laser to destroy hardened targets as far away as the Moon.

Taken together, the above parameters of improvement mean that the X-ray laser can begin at a very crude level—possessing a kill range of 500 kilometers and effectiveness only against the thin skin of rocket boosters that can be targeted within the first few minutes of the missiles' launching. Then, it can be rapidly improved to the point that a third- or fourth-generation X-ray laser could destroy the most hardened warheads from ranges up to 100,000 kilometers. At the same time the number of assured kills per X-ray laser module could be increased from two or three to hundreds.

The cost per unit missile kill of the X-ray laser ABM in space is the smallest of any proposed beam weapon system. And since any offensive missile or antisatellite rocket interceptor directed against an X-ray laser unit will always cost orders of magnitude more than the X-ray laser unit itself, the strategic defense in nuclear warfighting is at a great advantage if the X-ray laser can be perfected to the point that it is an effective killer of missiles.

Inherent Advantages

The theoretical physical basis for the inherent advantages of the nuclear-explosive-pumped X-ray laser all derive from its great energy densities.

The energy released per atom by ordinary chemical processes is of the order of a few electron volts (one $eV = 1.6 \times 10^{-19}$ joules), while nuclear fission generates over 20 million eV per atom. Therefore, nuclear fission can provide a pulsed energy source millions of times more efficient, pound for pound, than any type of chemical fuel. The specific form of energy released by fission is in itself millions of times more energy-dense than those forms generated by chemical or ordinary electric processes. This qualitative advantage of fission, if its energy output can be directly utilized, translates into a quantitative factor on the order of thousands.

The nuclear-pumped X-ray laser maintains all the energy per weight advantages noted above—by a factor of at least several billion—while simultaneously requiring a minimal unit weight of about 10 to 20 kilograms. This is hundreds of times smaller than any chemical, solar, or nuclear reactor power system.

In terms of deployment, defensibility, replacement rate, and cost, these factors of kills per unit weight deployed and unit scale are crucial for determining the cost and battle-effectiveness of any space-based system. It is a simple fact, even given the success of the Space Shuttle, that a substantial portion of the cost of any space-based system is determined by the weight that must be placed in orbit.

It should be noted that only another space- or ground-based weapon would be capable of effectively fighting the X-ray laser systems. And in the final analysis, because of the same weight and scale factors discussed above, it is likely that only the X-ray laser itself provides an economical and effective counter to the X-ray laser ABM system.

System Constraints

Killing nuclear-tipped missiles requires not only effective weaponry but also the capability to identify the targets, aim at them, and determine whether an effective hit has been achieved.

Today there are a number of early-warning systems for detection of all types of missile launchings. These consist of optical telescopes; ground- and space-based radars—both over the horizon and direct line of sight; infrared detectors that pick up the hot rocket exhausts; laser radar; long-wavelength infrared telescopes, which are far more sensitive to heat than the type of infrared detectors utilized in the first early-warning satellites (these telescopes can pick up small, cold objects over thousands of kilometers in space and the upper atmosphere and even discriminate between heavy warheads and light decoy balloons that have the same external characteristics as the heavy warheads); and finally, various X-ray and gamma-ray detectors currently deployed in satellites to detect nuclear explosions.

Once fired, the X-ray beam travels at the speed of light to the target. During the 10 milliseconds it takes the beam to arrive at the targeted missiles over a range of 500 kilometers, the missile has moved at most a few meters. If the million-joule X-ray beam pulse hits the large booster stages of the missile, it will produce a large shock and destroy the interior of the rocket fuel and engine.

Deployment for the first generation of a space-based X-ray laser ABM system would consist of hundreds of individual X-ray lasing units placed in orbit together with a separate system of targeting and surveillance satellites. The system would be directed toward detection of nuclear-tipped missiles and their destruction in the booster stage of their launching. Each X-ray laser unit would shoot at 10 to 100 individual missiles within the first few minutes after their launching.

The minimum effective kill range for such a system of orbiting X-ray lasers would be about 500 kilometers from the X-ray laser to the targeted missile.

Ten to twenty Shuttle flights could deploy upwards of 500 X-ray laser units into orbit such that at all times all possible launch points on earth are covered with a sufficient number of X-ray lasers to kill thousands of missiles taking off from one specific area.

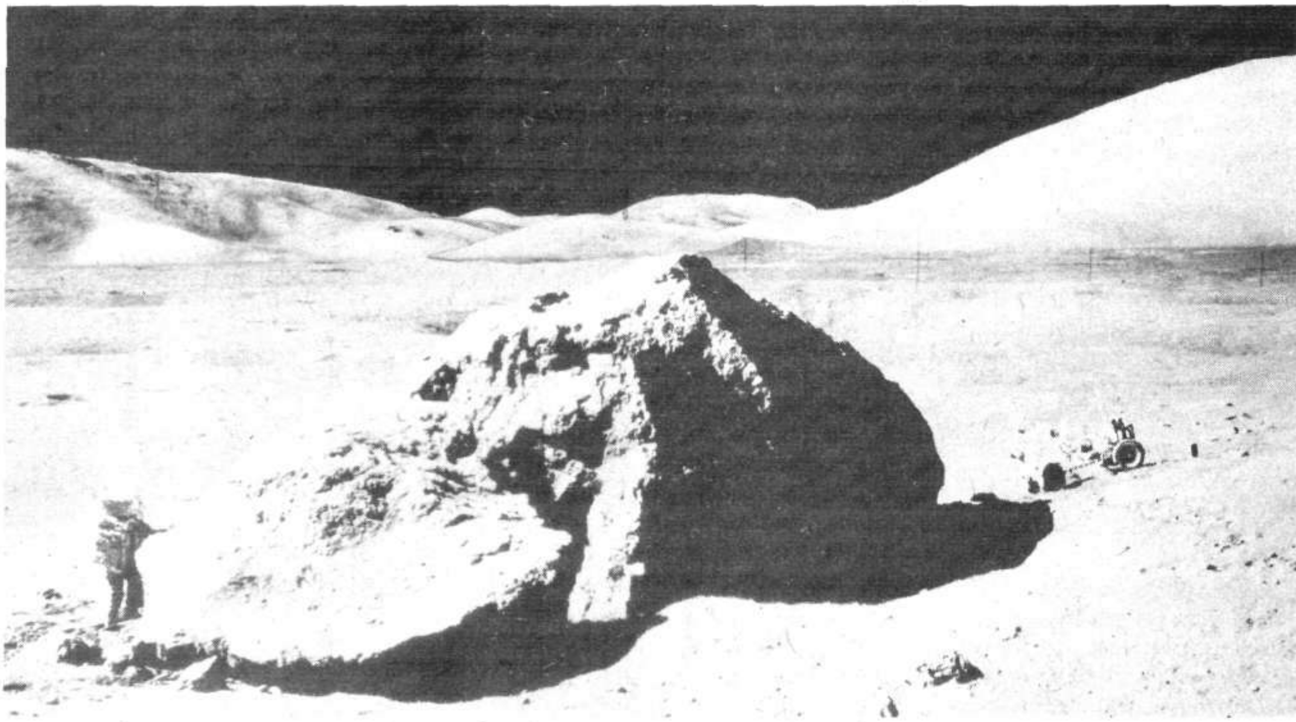
The current status of the X-ray laser, as noted, is that it has been scientifically demonstrated in principle. U.S. experiments with underground nuclear tests are slowly proceeding at a rate of one test shot every three to six months. The current estimate is that 20 to 30 carefully planned test shots will be needed to perfect a workable X-ray laser. The basic philosophy of this current program is that a high probability of success must first be assured before an expensive nuclear underground explosion is carried out. Furthermore, the complex data from these test shots must first be unscrambled and analyzed before another test is carried out. Therefore, this low-risk R&D program will probably arrive at a perfected X-ray laser within the next 5 to 10 years.

In the meantime, information is circulating in intelligence circles that the Soviet Union has mounted a serious X-ray laser development program.

Teller and Wood have insisted that given a high-risk effort, in which tests are carried out in parallel and without more than a 10 percent confidence level for success, a perfected X-ray laser can be realized within several years after 100 or so test shots.

Charles B. Stevens directs fusion energy engineering research for the Fusion Energy Foundation, and plasma physicist Steven Bardwell is the editor-in-chief of Fusion.

The Extraterrestrial Imperative:



Why Mankind Must Colonize Space

by Dr. Krafft A. Ehricke

EDITOR'S NOTE

Krafft Ehricke set out in the late 1950s, spurred on in part by the critics of the then emerging U.S. space program, to develop a thoroughgoing philosophy of space development and growth in general. Out of this effort came a series of papers and articles on the extraterrestrial imperative; a major book on the subject, *The Extraterrestrial Imperative—From Closed to Open World,* awaits publication.

The exploration and colonization of space, Ehricke concluded, is not an "option" or luxury for 20th-century civilization to undertake if it so chooses, but an evolutionary necessity. Space development is absolutely essential to provide the materials, energy, production space, and waste sink for a human population that is continuing to expand in numbers and in mental/technological capabilities.

Ehricke's characteristic approach to problems—to look beyond the immediate task at hand—is reminiscent of the universalist outlook of the great scientists of the past whose works inspired Ehricke as a young man in Germany—da Vinci, Giordano Bruno, Kepler, Leibniz, and others—and also of his more immediate predecessors and teachers in the field of space flight—Konstantin Tsiolkovsky and Hermann Oberth.

Ehricke is perhaps best known in the United States—where he and his wife, Ingeborg, have lived since 1946—as the father of the Centaur, the first liquid hydrogen-oxygen upper stage rocket, whose initial development he directed at the Convair Division of General Dynamics-Astronautics beginning in the late 1950s. For years Ehricke had been urging the U.S. Air Force, especially the Air Research and Development Center, to build an upper stage rocket with highly energetic liquid hydrogen-oxygen propellants, because he recognized its importance for delivering what were then large payloads of up to 1 ton to geosynchronous orbit, the Moon, and planets. (The Air Force was at the time more interested in propellants that could be easily stored and handled.) First used atop the Atlas intercontinental ballistic missile, the Centaur stage has in fact been used on almost every one of NASA's unmanned interplanetary probes, as well as in the Apollo program (Surveyor).

Currently president of the Space Global Company in La Jolla, Calif., Ehricke is doing research and editing his collected works (1939-1980) for publication.

"The most profound meaning space exploration could possess is to have its own evolutionary logic." Above, Apollo astronauts explore a giant lunar boulder.

This article is adapted from a talk Ehricke gave in November 1981 in New York, the last stop on a three-week lecture tour of Europe sponsored by the Fusion Energy Foundation. Ehricke's stay in West Germany coincided with a crescendo of environmentalist demonstrations in that country, and there were attempts by mindless "Greenies" to disrupt several of the forums where he spoke. Ehricke's answer to the Greenies, and to their Club of Rome-spawned limits to growth philosophy, is that the entirety of evolution and human development has been and still is characterized by overcoming creatively what appear to be limits to growth—not by regression and the insipid, anemic cultural pessimism and future fright characteristic of their limited minds.

* * *

IT IS DISCONCERTING to encounter the same shock troop kind of tactics, and the same kind of rallies with lots of emotional heat but little light of knowledge or reason, at the end of my life as I have seen as a young person in Berlin in 1929 to 1932. I sometimes wonder how many wars it takes, and how many deaths, before something is really learned. Of course, each generation has to gain its own experience. But it shows a distinct lack of intelligence to refuse to learn from the experience of the preceding generation.

The youth of West Germany and other nations have unfortunately been greatly misled. It is not necessarily the case that anybody who does not look like he would frighten a Neanderthal man half to death, and who is actually able to write and to read, is not worth listening to, because he must be a hopeless reactionary. However, today if a person even talks about space flight or nuclear energy, then the "ecopaths" and cultural pessimists literally consider this to be an outright provocation that they will do their utmost to prevent.

The sad thing, of course, is that these are people without hope, without goals; that's the important thing to point out. They are the product not of an education in the classics, in the sciences, in technology, but of an education in hopelessness, in frustration. "It's too late," they say. "Maybe our ancestors have accomplished a number of great things, but we have reached the limits to growth; we can only go backwards."

These people are great in attacking; they are great in saying, this technology could be misused, there are too many dangers associated with nuclear power, and so forth. But they have no positive proposals to make. Are we then to suffer indefinitely because relief-giving technology could be misused?

In 1979, of all things in the Year of the Child of the United Nations, there were 12 million children who did not reach their first birthday. That's 50 percent more than all battle deaths in World War I, in four years. And that is an outrage to a species that calls itself civilized.

If you bring such things up with the Greenies, then either you get an insult or they try to wiggle out into generalities or to lure you down another track with a new unfounded claim. Or you may—and I'm not making this up—get a vague proposal such as we ought to go and *talk* to the people in the Third World. Does the mother of a starving child appreciate somebody coming down and talking to her, perhaps having a nice cup of tea?

Stuart Lewis/NSIPS

"Are we to suffer indefinitely because relief-giving technology could be misused?" Krafft Ehricke at the podium, New York, November 1981.

The Setting of Goals

Of course, technology can be misused. But there is a way out, and the way out is education and the setting of goals. We have to give young people goals.

I remember to what extent the course of my life was affected by the fact that I saw the science fiction film *The Lady in the Moon* in 1929, for which Professor Hermann Oberth, the German rocket pioneer, was the scientific adviser. I visited the stage at the film studio near Berlin, where the moonscape had been built up. We didn't know what exactly the lunar surface looked like at that time, but that sandy moonscape was astoundingly real.

The experience electrified me at the time and set powerful goals for me. Since that time, I've been light years out and never found a limit to anything. Then, in 1971, some people discovered "a limit to growth." I've spent my whole life trying to find a limit, and there is no limit to growth. There is, of course, a limit to multiplication. But this distinction is lost on those people who are philosophically, culturally, and in so many other respects relatively poor.

Growth Versus Multiplication

Meadows and Forrester, for example, in their book *The Limits to Growth,* compare the growth of mankind to the mindless and senseless multiplication of lilies in a pond. I never considered mankind a lily in a pond, senseless and mindless. One is already expressing a negative mental attitude by using such an analogy. Experts no longer take this limit to growth nonsense seriously. Even the Club of Rome is trying to back off from it—now that the philosophy has done its damage—in order to sneak into public confidence in some other way. The *Global 2000 Report*, a warmed-over version of the original limits to growth nonsense, contains outright misinformation and, like its infamous predecessor, totally ignores the human capacity for limitless growth.

Growth, in contrast to multiplication, is the increase in knowledge, in wisdom, in the capacity to grow in new ways. And that's what nature shows us in the first place, on a very large scale. The entirety of evolution is growth, not multiplication. Comparative evolutionary analysis shows that when saturation of a given growth potential was reached, multiplication set in. Multiplication eventually interferes with the existing environment—biological or human. To the quantitatively (linear or exponential) rather than qualitively extrapolating mind, the pressure of multiplication appears to be a limit to growth, when in reality, evolutionary pressure is nature's preparation for the next growth thrust.

The distinction between multiplication and growth is crucial and accordingly is a central aspect in my study *The Extraterrestrial Imperative*, written in the 1960s. Long before the Apollo program, when we were working on interplanetary probes in the early 1960s, there was already criticism of the space program. My concern over this mounting criticism and the lack of proper responses to it drove me to continue what I had started in the late 1950s—to develop a philosophy of space and of growth and of technology in general; but particularly space in the sense of asking the question: Is this space exploration really only the result of super technology, a fad of the superpowers, or is there something deeper to it?

Now, the most profound meaning it could possess is to have its own evolutionary logic. If the development of space is consistent with the logic of evolution, then it is certainly a serious natural phenomenon, not a superficial fad. This, incidentally, has nothing to do with the freedom of will of the human being versus the animal. There are laws of evolution, usually derived from laws of physics, laws of chemistry, entropy, and so forth. Vis-à-vis these laws, the human being does not have freedom of *will* but freedom of *decision*. The *consequences* of the decision are inexorably subject to natural laws, and that's where *responsibility* enters into the decision process. The laws of evolution are very definitely the laws of nature and, therefore, affect the human world as well, because, as part of life, we are part of nature.

I went into an extensive analysis—and it was a veritable eye opener—for example, to explore what life forms could have done differently after the primordial organic remains were consumed. These fossils, incidentally, were not of biological but of abiological origin, the carbon-hydrogen combinations formed in the primordial environment by the influence of various energy forms. Life literally faced total disaster, total extinction at that point. What interested me was how this situation had evolved, in what order the various "component" crises converged and compounded into one great crisis—I called it the First Great Crisis—of energy, material resources (at that time limited to "food"), material processing (metabolization technologies), waste disposal (pollution), and environmental limitations—hence the need for environmental expansion in order to achieve a juxtaposition of working and living space. Crises of that type, but of lesser magnitude and consequence, show up repeatedly in evolution and human history; but this was the inexorable coalescence of all five crisis elements in a great crisis, threatening the survival of all. When the first great crisis occurred, life was planetogenic and on a preindustrial evolutionary level; that is to say, it was totally dependent on independently and incidentally formed planetary resources of this little Earth, formed long before life even arose. In that sense, they were fossil resources. Today we are still on the planetogenic evolutionary level, "living" on independently, accidentally formed biofossils but nevertheless limited energy sources coal and oil.

The Extraterrestrial Imperative

It was in the course of the First Great Crisis that the extraterrestrial imperative asserted itself for the first time on this planet; namely, when one particular one-cell organism, the photoautotroph, evolved an enzyme that was capable of utilizing solar energy to produce chemicals that stored energy. The "conventional" autotrophs then were one-celled organisms that were trying to gain energy (food) from whatever suitable chemicals they could find to metabolize (react with catalytically). They were distinct from another category of one-celled organisms of the parasitic kind, called heterotrophs, and in a very loose sense forerunners of today's animals. The heterotrophs lived off the autotrophs and ultimately off each other. So we had in that very primitive proto-biosphere an analogous hierarchy to the one we know in today's biosphere: plant types, plant-eating animal types, meat-eating animal types.

The photoautotrophs were the first organisms to develop an enzyme (a metabolic catalytic "tool") that enabled them to utilize the energy of an extraterrestrial source. They set evolution on the path from planetogenic to astrogenic biological life. It was a stunning technological growth thrust. Through the photoautotrophic process, life began to develop its own means of production, hence, to assume control over its energy supply—its food supply—resolving the first of three of the crisis elements.

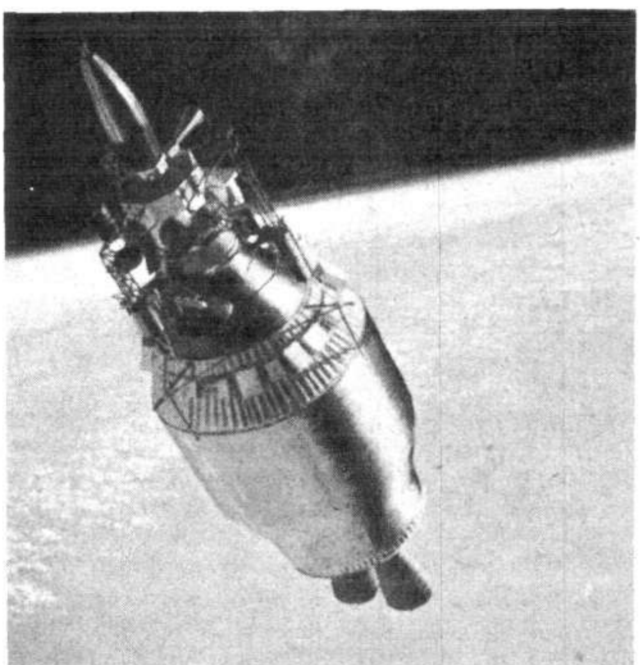
The Industrialization of Life

I analyzed what alternatives life could possibly have had. There were essentially three choices, which I shall summarize later. To make a long story short, there was no positive alternative to advanced technology (metabolism). And what evolved *was* very advanced technology, because the photoautotroph was, of course, the forerunner of today's chlorophyll molecule. If you look at the photosynthetic process in the chlorophyll molecule, it's more complicated than our most complex and intricate chemo-industrial operations.

What happened at that point was no less than the first industrial revolution. It was the industrialization of life: mass production of the basic staples of life—sugar and starches—chemical energy, combined in carbohydrates by means of chemical controls. All controls and processes were still only chemical. Not until the human brain had evolved did life reach the state of being able to handle atoms in a controlled manner. The fusion reactor in the center of our solar system, the Sun, also could only be used as far as its leakage was concerned—namely, the radiation energy that reached Earth.

With this industrialization came two things. First, time was gained, but, as we shall see, only a grace period. Second, more immediately, something terrible happened: As in every industrial process, there was pollution. At that time pollution was the release of the waste product of photosynthesis, namely, free oxygen into the environment. (If there had been Greenies among the autotrophs, they would have demanded the immediate cessation of photosynthesis, something the Greenies today are worshipping!) The untouched "First Earth" was indeed totally polluted with free oxygen. This was terrible, because it destroyed precisely the Earth environment that was able to create life, and changed it over into today's industrialized biosphere.

Let's pause and understand the crucial point of what happened at that stage and how it relates to natural processes at large. First, there was a great crisis. Second, living matter responded negentropically; that is, by advancing technologically to higher levels of energy processing, controls, and more sophisticated, complex ordered organic systems. Therewith, this type of matter continued on a *macroscopic* scale of giant molecules and increasingly large organic structures. Negentropic trends can be traced back to the formation of elements in stars; that is, to the ordering of random motion of subatomic particles into atomic structures of growing complexity. Lighter elements are formed in normal stellar "metabolic" processes, the heavier elements in more violent processes of unstable stars, all the way up to nova explosions in which uranium and thorium formed—long-life "batteries" stored with the energy bursts of stars in their death throes. Biological life, in a sense, extends the negentropic tendency to larger structures. The human life form is able to expand it to other worlds and to increasing cosmic creations. This means many things, but very basically and common to all, it means that life has to interact in an ordinary sense with the wildly disorderly primordial environment; and as life grows, it has to interact with it on a growing scale. Now we can be more specific: When this fundamental process seems to have reached its limits (that is, the existing process no longer suffices), a great crisis occurs.



General Dynamics

An artist's conception of the modified Centaur rocket proposed for the Space Shuttle. The rocket would be carried in the payload bay and be used as an upper stage rocket to launch spacecraft from Earth orbit.

Negentropic Growth

As the First Great Crisis gathered momentum, life had only three choices: It could perish for good. Or it could reduce its one-celled organisms to spore existence—a type of cosmic hibernation in which it would, in the form of bacterial spores and viruses, survive for millions of years a journey through space on the terrestrial "plank," waiting for environmental conditions to improve sometime in the future. In this condition, life would have glimmered on an extremely low, near-extinction level. The third choice, which is the course that life took, was to leap boldly over the existing limits in interacting with primordial resources by means of a growth thrust, utilizing higher technology. In short, the choices were: give up and perish, regress to a minimal state of existence, or advance and grow. Sounds strangely familiar? It is; we are in the gathering Second Great Crisis. We'll come back to that shortly.

Life took control, and the control had to be industrial. Certainly, under the then existing conditions, the destruction of the life-creating environment of the First Earth was unavoidable. But, evolutionarily speaking, the point was no longer to maintain an environment in which life could be created, because life *was* created. (If you want to look at it religiously, that part of Creation had been completed—the rise of life on this planet.) Now the issue for life was *development and growth.* That could no more be done in the environment of the first Earth than the human being can grow to full maturity in the womb of the mother, or humanity in the biospheric womb of one planet. It must get out eventually. There is a growth process that is associated with the separation from the original umbilical. When a confluence of crises occurs—and the challenge to the status quo that called for and led to photosynthesis is a classical example—then the umbilical to the old environment has to be cut. The process of humanization is the process of emancipation from the biospheric original with its law of the jungle.

Now, I said a while back that photosynthesis gained only a grace period for life. There are two basic points here. The first is that although life saved itself through technological growth, its future was far from problem free.

The second point is that, generally, in solving one problem, life creates new problems. Club of Rome and associated confused minds imagine that by rejecting growth, by regressing into a state of cattle-like contentedness, we will eventually arrive at a problem-free world—probably one where people dress in bed sheets, wear flowers in their hair, hop and skip on a green meadow or sit under a tree playing the guitar or "doin' nothing," or some ludicrous notion like that. In fact, because the nature of evolution is negentropic, it thrives on problems. Here I have limited myself to one example, photosynthesis, because we can't go through every phase of the evolutionary sequence, and not all are quite that dramatic; but at every turn this innate negentropic tendency is fundamental.

Conditions for Development

So, following the spread of photosynthesis, two problems remained: pollution and environment. No question, there was pollution. Free oxygen is deadly to a cell that floats in paradisic nakedness, in a reducing, say, a non-oxidizing atmosphere. The cells had no mantle to protect them against this chemically aggressive element. The cells consisted of carbon and hydrogen to which oxygen has a particularly strong affinity. Given the opportunity, it would destroy the cell's somatic and genetic structure. Oxygen is not admitted to the cell nucleus to this day. So, the solution caused a problem that called for further growth. A cell mantle had to be formed—an oxygen-resistant cell mantle, a primordial form of our skin. This solution produced new growth. With the existence of the cell mantle, cells could begin to coagulate under that mantle. Now began another technological advance—the development of multicellular creatures.

The cells could start specializing, and they could form colonies with division of labor among specialized cells, which would take in food, digest, eliminate waste, and so forth. This specialization represented tremendous progress; it was a prerequisite for conquering the waters of Earth everywhere and for eventually getting on land, which in turn accelerated the development of the sensory and nervous systems. The interaction between information input and need for information storage and response to survive, in turn, boosted the evolution of the brain—the animal brain and, ultimately, the human brain.

With the protective cell mantle, multicellular organisms needed—and thanks to cell specialization became capable of developing—a chemosynthetic metabolism more advanced than the earlier fermentation-type had been. This was especially necessary for the parasitic half—the nascent animal life, which lived off the plants.

The highly efficient form of chemosynthesis was oxygen metabolism. This development was crucially important, because it extended indefinitely the grace period. Photosynthesis needs among other things CO_2—CO_2, water, sunlight, plus a few other chemicals. Of these, CO_2 is relatively a most limited resource in the atmosphere of Earth. There was plenty of water, and there was a practically infinite energy source whose lifetime was a multiple of the evolutionary time constants; that is, the time it takes for a new species to evolve through mutation, a recombination of genes, and natural selection.

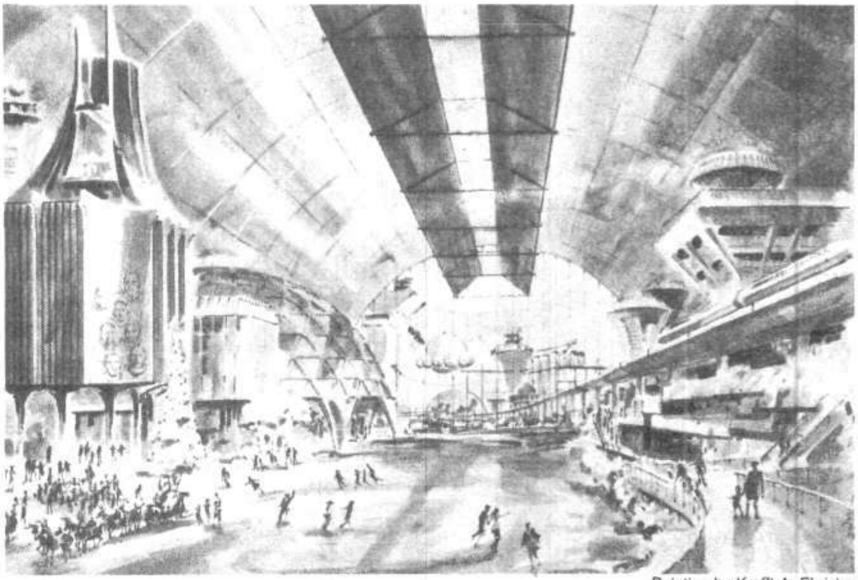
Initially, the evolution of the species took 600 or 700 million years. Later, the evolutionary pace quickened, especially on land. An adequate energy source had to have a lifetime of billions of years to match the evolutionary constants. But what did not match the evolutionary constants, especially the early ones, was the supply of CO_2. And if there would not have been the technology of oxygen metabolism, the CO_2 supply of Earth would have been exhausted before life could even have had a chance to evolve on land. Thereafter, it would have been back to square one. With the recycling of CO_2 through the oxygen metabolism, and with the recycling of other materials in general through the biospheric machinery, photosynthetic technology was no longer bound in an evolutionary-limited grace period. Now it could function as long as solar energy was available and as long as the genetic infrastructure that permits the biosphere to function was not destroyed.

Energy and Materials

Now I come to the last of the five great crisis elements: environment. Every organism, whether it is a single cell or something as complex as we are, performs work. As you are sitting here you are performing work—your heart performs work, your lungs perform work. That is basic physics. Every organism is a work-performing machine, whatever else it may be. It is also basic physics that every work-performing machine has to have a comparatively "infinite" materials environment. In other words—and that was the root of the First Great Crisis and is the root of the second one—living organisms have to have an open world, because in a closed environment they soon must cease to perform work; they must die. Life has to have a source of low-entropy (high capability of performing work) energy and a sink for high entropy (low work-performing, waste) energy; and it has to have a source of materials and a sink for waste.

If life is limited to one planet, as are biotechnology and bioindustry, then, because of the Second Law of Thermodynamics, the entropy law, there must be an infinite energy source—then the Sun, now fusion—and an infinite energy sink—namely, space. As far as materials were concerned, however, biotechnology had to opt for a quasi-infinite source and (waste) sink through recycling.

Biotechnology recycles some 20 elements, and for that it needs the entire planet. We use the entire periodic system of elements, plus some more, and that does not lend itself to biospheric-type recycling on our planet. Furthermore, we do not want to destroy the "Second Earth"—the biospheric Earth, because it is in our interest, and in our capability, to preserve it. That capability hinges



Painting by Krafft A. Ehricke

Christmas in Selenopolis, seat of lunar civilization. Selenopolis is the ultimate state in Ehricke's five-stage program for industrializing the Moon, using its own vast resources and taking advantage of its high vacuum and low gravity. Selenopolis is based on nuclear energy (fission and fusion) and a large population of at least hundreds of thousands, growing to millions in the next century. The modularized bioniches, like the one depicted here, can grow ever farther across the moonscape as the lunar economy can support them, and they will offer different climates and seasonal variation.

on two requirements: The first is the control of energy processing, which can only be done effectively through nuclear technology—that is, fission and fusion. Solar, geothermal, and so forth can play supporting roles, but fundamentally, we have to go to the source of solar energy. Solar processing energy was the big deal some 3 billion years ago; it was a tremendous breakthrough in those days. Today, we can and must reach deeper, directly to fissionable and fusionable nuclear energy. It is important to note that having a clean, abundant energy supply, as through fission, also improves our capacity for recycling waste materials.

Nevertheless, the second requirement stands. That is environmental expansion, not only to get to new materials but, equally important, to acquire new production space to develop new means of processing materials, beyond what is possible on Earth (for example, at zero-gravity), and to develop new, more efficient technologies, not feasible or suitable on Earth (matter-antimatter reactors most likely belong in this category).

The Second Great Crisis

Now we are facing what I call the Second Great Crisis. In this context it is necessary to point out another key characteristic, applying only to a great crisis: the rise of a major new *umbilical* metabolism that, following a gestation period in the old environment (the biosphere, in the human case), emerges to prove or disprove itself as an evolutionary success or dead end. By umbilical metabolism I mean a metabolism capable of interacting energetically and materially with the primordial environment. In the evolution of life on this planet, the most visible and, if you will, revolutionary umbilical metabolisms are photosynthesis, which made life astrogenic, and information metabolism, which gave life a cosmic intelligence component. Information metabolism (in this solar system) is the unique ability to acquire information and data, breaking them down into their basics (abstraction) and recombining them into coherent systems of knowledge, insight, and skills storable in the brain.

In my first volume of *Space Flight*,[1] which I published in 1959, I observed that if life were to continue its drive of ever further expansion—and it had now to overcome the limits of the atmosphere and of the vacuum—it would logically have to evolve an information metabolic brain. This would allow it to use primordial material in an intelligent manner and to move out into space. And this now allows us to establish a "Third Earth," so to speak, a synthesis of biosphere and human sphere, and grow as human beings unfolding into an unforeseeable variety without destroying the Second Earth, because soon we no longer will rely on it exclusively, if we have wisdom and foresight, which is somewhat questionable.

Here again, the womb example has analogical significance, in the sense that the child who was at first parasitical in the body of the mother later on becomes the protector of the mother. So today, when there is a big drought in Africa, we employ helicopters to fly the animals into areas where there is water. Primitive man would have been very happy to have slaughtered as many animals as he could. It wouldn't have occurred to him to do anything else but to utilize that momentary fix those poor animals were in. We have the power to help only because we are emancipated. And we are emancipated, and we have to continue to emancipate ourselves, because we are children of the biosphere; we are not pets of the biosphere.

There is an analogy with a household. In a household there are two powers: the lady of the house and the man. And then there are two other "life forms": the pets and the children. For the pet, the ultimate state is one of maximum adaptation to the existing household/environment—to find an ecological niche, so to speak. The child, on the other hand, never has that kind of niche. It is being prepared to *outgrow* the household and establish its own world. The child is raised for emancipation, the pet for maximum adaptation to existing conditions. So the entire philosophy that we must adapt to the biosphere is fundamentally, evolutionarily, and naturally wrong.

But the important factor here is that whenever a new umbilical metabolism arises in nature, it is in the context of a great crisis and the confluence of crisis elements is particularly pronounced as is the case today also. A new umbilical metabolism can grow only in the womb of the environmental niche that the preceding umbilical metabolism has created. But it can do so only for a limited time. Then it has to emerge in the sense of becoming progressively less parasitic and progressively more in control of itself, of its production, and its resources, independent of Earth's biospheric womb—in short, emancipation from planetogenic to cosmogenic state. There *is* a "ninth month." And if that ninth month is not adhered to, both the embryo and the mother body are destroyed. Today this means that if 4 or 5 or 6 billion people fall back on a life-style of an embryonic mankind, it will destroy mankind by billions, and it will devastate the entire biosphere.

And now the extraterrestrial imperative asserts itself again, this time on a larger basis, because we now are able to enlarge our environment beyond Earth. After it had industrialized through photosynthesis and oxygen metabolism, life enlarged its environment also. It spread through Earth's oceanic cosmos (and the volume of the oceans in relation to plankton compares to that of the solar system, at least to Saturn, in relation to Man); it went onto the land—a world as "alien" to early life as the Moon, Callisto, or Titan are to us; and it went in the air; and there, of course, that biotechnology had to stop. Some 15 million years ago, during the Miocene epoch in the latter part of the Tertiary Period, the limits of anatomic and sensory biotechnology were pretty much reached. The solar energy processed photosynthetically had reached a maximum. Accordingly, the rise of free oxygen content of the atmosphere began to level off. A dynamic equilibrium between biosphere and greater primordial environment had been reached and could readily be maintained. Why wasn't it? Again, because life is negentropic, dynamic, and does not tolerate static, stagnant conditions, however paradisic, because they are death.

Negentropically, any equilibrium is only the start for a new disequilibrium—in distinction from an entropic equilibrium, which is a "dead," static equilibrium. Water reaches the lowest level; rocks roll down mountains where they lie for the next million or billion years in a state of random disorder. We are surrounded by matter that is in a high state of order—the trees, plants, flowers, and animals. These animals, for example, are highly developed, negentropically. Why is an eagle or a falcon more beautiful than was the archaeopteryx, for example, one of those primordial birds? Simply because the eagle and falcon are aerodynamically perfect. Just as the modern jet plane is beautiful compared to those pre-World War I monstrosities. And gazelles, lions, or tigers are in many ways more beautiful than those primitive animals that existed at earlier ages of life. The technology has been constantly perfected.

Of course, within those ecological niches, there are limits reached of maximum adaptation. People who lack the perspective of eons come to the wrong conclusions about our problems today, because they are fooled by the static conditions seemingly implied by local perfection in a maximally developed biosphere into which they were born. They are fooled not to see the irresistible evolutionary pressure. There is a limit to perfection, as there is a limit to multiplication. But there is no limit to growth. Precisely because perfection along a particular line leaves only two options—multiplication or a new beginning and growth on the next level—the inevitable choice is growth, and perfection becomes at the same time end and beginning.

When a new umbilical emerges, it has to form its own environmental niche. In the case of information metabolism, I call it androsphere, a distinct form but also in analogy to the biosphere (with no intent to offend the ladies, because I don't use *andro* to mean male only; I consider androsphere an enlightened humansphere). The biosphere is an "Open World" to plants and animals, the androsphere is an Open World to information metabolic life forms. We can travel into space; we can take with us everything we need including what was created before us—an unbelievably grand heritage. With the development of photosynthesis, life has reached the stage of "have photosynthesis will travel." Wherever we go, we can take photosynthesis, hence its animal complement, with us. We can take them to the Moon. . . .

In the mist of the coming century I see a polyglobal three-dimensional civilization tower. In retrospect its foundations were laid in the twilight of the past millennium by those who understood the magnificent call of the extraterrestrial imperative. This three-dimensional civilization underwrites a magnificent future also for Terrestrians.

But there were those among them who did not have the capacity for understanding that their world could reach to the stars; and so they rooted and burrowed into the ground. Instead of placing themselves in the eon-spanning force field of evolutionary growth potential, they regressed, whining and shouting slogans. Fearful to grow, they atrophied to barren stumps on a clump of earth and became stillbirths of the biosphere. Instead of elevating their planet to the acropolis, the garden of the solar system, they let their vitality decay into grotesque gratitude for being permitted to exist at all. They were incapable of comprehending that having grown from organism to mind, life will, in thrusts of further growth, rise ever higher above its origin. In a miserable world of stagnation, poverty, and backwardness, they may indeed manage to trigger the ultimate catastrophe of releasing nuclear energy in an entropic holocaust.

One can only hope that by then a Selenian humanity will have come into existence through what little farsightedness existed before the Terrestrians dealt their magnificent future the final blow, should they allow themselves to be led into such depths. The new humanity, Homo sapiens extraterrestris, will slip his moorings from the burning docks of Earth and set sail on a new course into the Open World of limitless growth—negentropically and steady as you go!

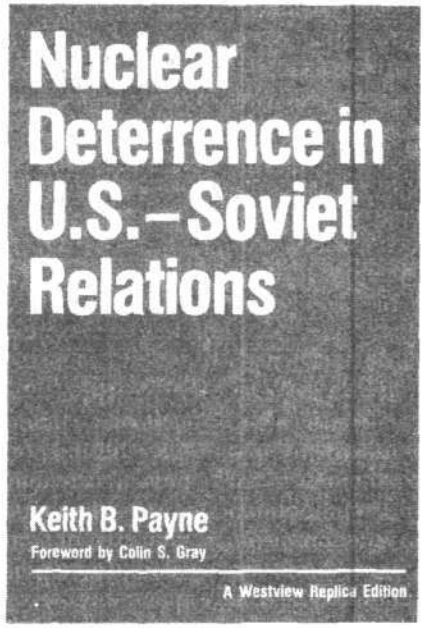
Note

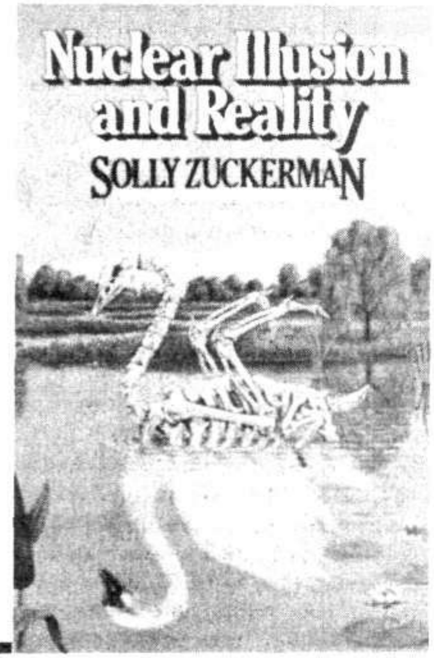
1. Krafft A. Ehricke, *Space Flight*, 3 vols. (New York: D. Van Nostrand, 1959), a history and technical study of space technology and concepts.

The Realities of a Technology Freeze

Nuclear Deterrence in U.S.-Soviet Relations
Keith B. Payne
Boulder, Colo.: Westview Press, 1982.

Nuclear Illusion and Reality
Solly Zuckerman
New York: The Viking Press, 1982





The trend in the process of development and deployment of nuclear weapons derives its momentum not from any formulation of well thought-out operational requirements but from the minds of enthusiastic technicians plying their trade in the military laboratories. . . . At base the momentum of the arms race is undoubtedly fueled by the technicians in government laboratories and in the industries which produce the armaments. . . . In the nuclear world of today military chiefs who by convention are a country's official advisors on national security, as a rule merely serve as channels through which the men in laboratories transmit their views. It is he, the technician, not the commander in the field who starts the process formulating so-called military needs.

There lies the problem. The nuclear world of today has come about because basic scientific enquiries into the nature of matter led to an understanding of atomic structure, and so to the demonstration that the atom could be split with the release of vast amounts of energy. From that moment, technology assumed command. A new future with its anxieties was shaped by technologists, not because they were concerned with any visionary picture of how the world should evolve, but because they were merely doing what they saw to be their job.

Harold Macmillan once observed that politicians have to run hard to catch up with the scientists. But if their goal is peace, then politicians are in the wrong race. The scientists who work in the defence departments of governments or in defence industries are not apostles of peace. . . .

An effort should be made to end all work, vain as it is, to devise ABM defences.

Solly Zuckerman, *Nuclear Illusion and Reality*

In the course of a sometimes amusing, sometimes shocking account of U.S. policymaking since the McNamara era, Keith B. Payne presents an analysis of U.S. and Soviet thermonuclear war-fighting capabilities that should cause sleepless nights for the millions of U.S. citizens who have permitted the likes of Robert Strange McNamara, Henry Kissinger, James Schlesinger, and General Maxwell Taylor to destroy both the nation's defense and its economic and scientific foundation.

Payne shows the progress and results of a hypothetical, nuclear first strike against Soviet intercontinental ballistic missile (ICBM) silos. "The initiation of an exchange by the United States," he says, "would simply effect the disarmament of the U.S. ICBM force while leaving 816 Soviet launchers intact with approximately 3,571 warheads." This prospect, Payne documents, is the direct result of the doctrine of deterrence, which he appropriately dubs "assured vulnerability."

The U.S. Minuteman force poses little danger to Soviet ICBMs, he explains, because the throw weight of the Minuteman is too low to deliver warheads large enough to destroy hardened silos. By contrast, the Soviet SS-18, with a throw weight 8 times that of the Minuteman II, can deliver 10 warheads twice as powerful as the 1 warhead deliverable by the U.S. missile. Thus, Payne shows that a likely scenario for a Soviet first strike would leave the United States 107 missiles with 215 warheads, while the Soviets had 1,186 missiles with 4,120 warheads left.

The original argument behind the decision to develop the weak Minuteman force was that it was only necessary to develop ICBMs that could retaliate against Soviet cities and industry and thus deter war by threatening destruction of Soviet society. Deterrence advocates argue that the development of any more powerful or more advanced weapon systems would "destabilize" the balance that deters war. Antiballistic missile (ABM) systems are needed only to defend U.S. ICBMs, they insist.

As Henry Kissinger told a congressional committee in 1979: "Since the middle 1960s, the growth of the Soviet strategic force has been massive. . . . This has happened without the United States attempting to make a significant effort to rectify that state of affairs. One reason was that it was not easy to rectify. But another was the growth of a school of thought to which I myself contributed . . . which considered that strategic stability was a military asset and in which the amazing theory developed, i.e., historically amazing, that vulnerability contributed to peace and invulnerability contributed to the risks of war."

"When the administration with which I was connected sought to implement an antiballistic missile program," Kissinger continued, ". . . it became the subject of the most violent attacks from the theory that it was destabilizing, provocative, and an obstacle to arms control . . . because opponents of BMD [ballistic missile defense] saw in the strategic vulnerability of the United States a positive asset."

On the other hand, Payne documents that the Soviets never adopted deterrence and always emphasized the development of war-winning capabilities. He concludes his book with a call for a U.S. return to "classical strategy," a policy of developing war-fighting capabilities, and he laudably calls for development of space-based laser ABM systems.

Payne's chilling analysis is good—as far as it goes. But he never identifies exactly who the villain here is, and how the United States was convinced to adopt a war-losing strategy. Some readers might conclude that Kissinger and other deterrence advocates are simply incompetents.

Lord Solly Zuckerman's book, *Nuclear Illusion and Reality,* amply documents both why American policy has left the nation's defenses assuredly vulnerable and who did it. Zuckerman speaks not only for the British tradition of H.G. Wells, dedicated to the necessity of controlling science and its advancement, but also for an increasingly influential group of American policy makers who, as Kissinger intimates, have largely shaped Western military strategy in the nuclear age.

As James Schlesinger outlined the ideological premises of this faction 20 years ago, their starting point is an explicitly Malthusian world view:

"We have gone around the world spreading the 'gospel of plenty' raising the level of expectations. . . . In the nature of things, these rising expectations can never be satisfied. . . . Despite the modifications of the original Malthusian dogma over the years, the danger remains that excessive growth of population will wipe out the gains of economic progress. Any economic revolution will shortly be wiped out by a Malthusian counterrevolution and the illusion of growth. It is unwise to overstate the importance of economic growth per se."

Zuckerman and his American counterparts draw that same conclusion concerning the advisability of a MAD (Mutually Assured Destruction) doctrine, the danger of scientific progress, the attractiveness of a nuclear freeze, and the necessity of a conventional military buildup, and they have been joined in this policy by some of the most prestigious of post-World War II policy makers.

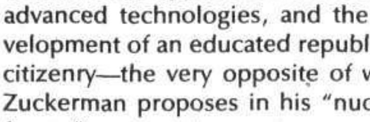
Zuckerman argues for what he calls the "flexibility" of conventional forces, as opposed to nuclear war. What he expresses is the centuries-old distinctly British military doctrine of "set-piece warfare" that has dominated U.S. strategic thinking since the ouster of General Douglas MacArthur as U.S. commander in the Pacific. This British military doctrine holds that the mission of the military is to preserve the assets of the empire, including the prevention of economic development in subject colonial regions. Hence, the emphasis on conventional war-fighting capabilities.

In contrast, Republican military doctrine views the primary role of military forces as nation building. Since George Washington and Alexander Hamilton's inauguration of the critical role of the army engineer in making improvements in the civilian economy, this was the military doctrine of the United States. Admiral Hyman Rickover's naval nuclear reactor program, which also built the U.S. domestic nuclear power industry, was the last great example of the military's role in nation building domestically.

Republican military doctrine also holds that the rest of the world should be aided to become sovereign national republics. When this effort fails and hostilities break out, the military's mission does not end with the mere defeat of the adversary, but extends into the postwar reconstruction to obliterate any traces of oligarchical policy making, as President Lincoln attempted to do in the South and General MacArthur succeeded in doing in Japan. Victory is achieved only once the defeated nation has emerged as a sovereign power based on industrial development. Such a military doctrine demands the application of the most advanced technologies, and the development of an educated republican citizenry—the very opposite of what Zuckerman proposes in his "nuclear freeze" arguments.

Zuckerman, who since World War II has in large part articulated official British science policy, presents readers with every variant of popular gossip that now forms the ideological basis of the nuclear freeze movement. Any American who still believes in the tradition of progress, based on scientific and technological advancement, will find ample documentation here of how the U.S. advocates of deterrence—now, like McNamara, leading the nuclear feeze movement—are firmly rooted in the British Wellsian tradition.

—Robert Gallagher



Editorial

Continued from page 2

of 200,000 progrowth Americans the ammunition they need to win this fight before any "countervailing movement" gets off the ground. Our draft legislation, the resolution on the back cover for beam weapon missile defense development, and the other information in the special report are intended to be circulated and used with elected officials, especially congressmen, and various organizations. It was this kind of organizing and educational activity two years ago by the *Fusion* readership that led to the almost unanimous passage in Congress of the 1980 fusion legislation.

The stakes in this fight are high. Beam weapon technologies, if developed, can end the reign of thermonuclear terror and open up a source of unlimited energy—fusion power—thus giving the world the possibility of a lasting peace. But you—our readers—have to mobilize to support this fight quickly. As Soviet fusion scientist Velikhov put it, "Time doesn't wait."

Fusion Ready

Continued from page 6

is the objective of the mirror program at Lawrence Livermore Laboratory during the next six to eight months. At that point we will be able to make an assessment of what a real tandem mirror reactor will look like. Right now we don't have sufficient fundamental data to verify our assumptions on thermal barriers. But that should all clear up in the next year, and certainly I think we are going in a positive direction. . . .

On the reverse field pinch, we've had the emergence, as a surprise in the last year, of a fairly small experiment doing considerably better than it was designed to do, for reasons which weren't predicted in advance and aren't fully understood but are quite dramatic. One of these is the "dynamo effect," in which the plasma seems able to continue to exist because of its own dynamics in a confined state, independent of what we're doing to it from the outside.

Question: I was impressed by the statements of Dr. Donato Palumbo, the head of the European Community's fusion program, and Dr. Shigeru Mori, the head of the Japanese program, on their continued optimism about commercial fusion development and on the broad-based commitment that they've made to fusion research. They reported on a number of impressive experiments. How do these programs fit together with the prospects for progress in the United States?

I think that it's clear that both the Japanese and the Europeans are now committed to fusion as a development program, as opposed to just a research program. They both have program plans that lead to power reactors; both seem to have a more reliable financial commitment to carrying these programs out than we have in the United States. . . . Palumbo said, for example, that he has a five-year budget and he knows that his available funds will not be less than specified in this budget during that entire five years. . . . This gives him the ability to plan his program with some confidence. Mori stated that in Japan, fusion was elevated a few years ago to what they call a national project, and that means that it's not something that is played around with in the budget every year. It means that the country is committed to funding it at the levels required to carry out the objectives of the project and those objectives are quite ambitious.

I think that both the Europeans and Japan have their programs on a par with, at least, and maybe somewhat more aggressive than what the United States has, even though I think Americans could still argue that we are turning out more interesting results by and large. This is more because we've put more commitment in the past rather than where we stand today. The new European and Japanese machines are comparable to or maybe bigger and better than our TFTR [Tokamak Fusion Test Reactor], and they are clearly organized to go the rest of the way.

However, I don't think that there is any likelihood that Japan and Europe will break into the lead in terms of building a power reactor several years before the United States. I think that they are not quite confident of themselves to run away from us in that regard.

Teller Press Conference

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such a war will become likely. If we behave more reasonably, and the first step should be the rejection of the freeze initiative, then I think under the leadership of the present administration, we still have a very good chance to postpone any confrontation, and to create a situation where more and more postponement is possible—where we can do much more than avoid war.

By cooperation with those who are willing fully to cooperate, we can improve the very horrible way of life in the Third World. We can by using technology create a situation where the reasons for war will diminish and keep diminishing.

If our allies and we cooperate both in making a stronger defense, and bringing about the origin of real peace, the pursuit of the common aims of mankind, at least in the free part of the world, then in the end even in the Soviet Union where tyranny was endemic—and I here include czarist Russia for centuries—even in that part of the world that in its history has never experienced anything like freedom, even there I think a change of thinking may occur. . . .

I am not telling you that if we can avoid war now, and I think we can, then the golden age will be here. We will have many other problems, and perhaps even greater ones. But I want to have for my children and my grandchildren the chance to confront these new problems, to struggle with them, and to do it as individuals.

Question: You oppose the freeze. You opposed SALT II, you opposed the limited test ban treaty. Are there any arms control agreements you favor? What are they?

. . . [T]he real measures which I favor are not treaties which start by the word "don't." I am in favor of treaties which start with the word "do," which encourage cooperation and which attack not the means of warfare, but the roots of conflict.

Viewpoint

Continued from page 3

than the Shuttle can provide. This applies particularly to such areas as space processing, space technology, and life sciences, as well as free-flyer capability.

As a consequence, economies of scale will force a growing number of individual satellite functions to aggregate on common space platforms, with payload size and mass tending to increase during the next two decades. This requires increased emphasis on the construction of large structures in orbit, powered by new orbital power augmentation systems. It also puts a premium on the ability to service these systems adequately in orbit.

I am keenly aware that the capability for continuous manned orbital operations is not yet at hand in this country, and neither are the vehicles and techniques for space construction, operation, and servicing in either low earth or geostationary orbit. This need calls for an extension of the Shuttle capabilities, for the development of permanent manned facilities in orbit, and for manned geosynchronous mission capability.

In the context of the clear needs that are presently foreseen, proper planning for the future will result in a balanced civilian space program that will make major contributions to our economy and national prestige.

This country responded admirably to the Soviet challenge to U.S. technological leadership and has provided a continual source of national pride from the world-recognized events of Apollo landings, the orbiters and landers on Mars and Venus, the spectacular science and imagery of Jupiter and Saturn, and more recently the launch, orbit, and airline-like touchdown of the Shuttle orbiter.

Today, there is a need for guidance—for direction—to set before the nation a vision of where we are going. I hope that with the success of the Space Shuttle the administration and Congress can get down to the business of setting new goals.

A little over one year ago, the Subcommittee on Space Science and Applications released a report on our civilian space policy that concluded that a high-challenge space engineering initiative was both technically feasible and desirable and recommended that the administration commit itself to such a project. The report further stated that a prime candidate would be established of a manned, multipurpose, space operating base in low-earth orbit. The report further recommended that NASA reaffirm the nation's recommitment for continued exploration of our solar system through intensive investigation of other planets.

I sincerely hope that the present administration will embrace these recommendations and will make the national commitment to establish a permanent presence in space while maintaining a balanced space science and applications program.

Ronnie G. Flippo, a Democratic congressman from Florence, Alabama, is chairman of the House Subcommittee on Space Science and Applications.

Nonlinear Plasmas

Continued from page 7

They argue that if we do not understand the science, how can we presume to build a machine that uses this knowledge. What do you see as the relation between plasma theory and fusion development? Do you think the development of fusion must wait on the solution to problems of plasma theory?

I think that fundamental plasma research needs to be developed and performed. This kind of research is being done at the University of California at Los Angeles [on the Microtor and Macrotor experiments] and is also being done in my country.

I don't think that fusion development has to wait, because even using empirical laws you can go further and build an energy source now. You use the empirical laws to build bigger machines.

Any fundamental discovery later will have a fundamental effect on humanity's life. Fundamental theory is more essential, more practical, than any other thing. If we do this, then it will be much easier to understand all the plasma behavior in other cases.

Chronology

Continued from page 10

Nov. 1980. Uwe Parpart lectures on advanced Riemannian physics and the LaRouche-Riemann economic model at Lawrence Livermore National Laboratory.

July 1981. Fusion confirms *Aviation Week* and *Space Technology* reports that Lawrence Livermore scientists have demonstrated the principles of an X-ray laser system, consisting of a small nuclear weapon and a number of metal rods. X-ray output from the nuclear charge is absorbed by the metal rods and converted into a coherent beam of X-rays that traverse the rod lengthwise. Thus each rod could be pointed in a separate direction. One such assembly could theoretically destroy scores of incoming warheads in space.

Aug. 1981. FEF publishes Winterberg's book, *The Physical Principles of Thermonuclear Explosive Devices. Fusion* carries an article by him on nuclear and thermonuclear directed beam weapons, in which he elaborates concepts for nuclear weapon driven X-ray lasers, railguns, particle beams, and directed shock waves.

Sept. 1981. Fusion reports on Los Alamos National Scientific Laboratory studies showing that antiballistic missile defense systems are both technologically and economically feasible.

March 1982. FEF board member Lyndon H. LaRouche, Jr., issues *Only Beam Weapons Could Bring an End to the Kissingerian Age of Mutual Thermonuclear Terror: A Proposed Modern Military Policy of the United States* (National Democratic Policy Committee). A month earlier LaRouche, in a major Washington, D.C. political address, had called for an open race between the Soviet Union and United states to develop beam weapon ABM capabilities to stop ICBM barrages or nuclear threats from any source.

June 1982. Bardwell and FEF executive director Paul Gallagher give a Capitol Hill briefing on beam weapons, at the invitation of Rep. John Rhodes (R-Ariz.). The FEF launches a national campaign to expose the nuclear freeze and promote beam technology development as the alternative.

Resolve to Survive!

We urge readers to organize local elected bodies, state legislators, and civic organizations to adopt the following resolution:

Resolution on Directed Energy Beam Defense Development

WHEREAS, the only possible means for ending the age of thermonuclear terror is the development of the beam weapon technology to destroy nuclear missiles in midflight with more than 99 percent effectiveness, and

WHEREAS, the science and technology for such weapons systems deployment exist as the established or early potential capacity of both superpowers, and

WHEREAS, crash effort to develop beam weapons would incur no net cost to the U.S. economy since the civilian by-products would stimulate a higher technology economic boom, and

WHEREAS, the weakening of the West through the present world depression, combined with regional conventional warfare in the developing sector, makes thermonuclear war an increasing possibility in the immediate years ahead, and

WHEREAS, a commitment to such development mandates the direction of medium- to long-term credit for rapid technological progress of U.S. agriculture and other goods-producing and transportation industry, in an increasingly energy-intensive mode, thereby providing employment for millions of unemployed U.S. workers and providing the basis for world economic recovery,

THEREFORE, BE IT RESOLVED by the ______________________________
(organization or institution)

of the ______________________________
(state of, city of)

that this body, motivated by the best interests of the population for which it is responsible, hereby calls upon the Congress of the United States to:

1. Relaunch the NASA program on an expanded scale, including the Mars landing program, the manned space lab, and an accelerated Space Shuttle program as the necessary elements of the capability to launch a space-based antiballistic missile system;

2. Double the thermonuclear fusion research appropriation, now at under half a billion dollars per year, to ensure the broad-based fusion program necessary to lay the scientific foundation for developing directed particle-beam systems. The goal established in the McCormack bill passed by Congress in 1980 for a fusion engineering reactor by 1990 and a commercial reactor by 2000 must be reached;

3. Immediately accelerate the high-energy laser program, with the goal of achieving a defense capability against a small number of ICBMs within the next five years;

4. Immediately accelerate the short-wavelength laser and particle-beam program, with the goal of determining the optimum research and development path for immediate and succeeding generations of beam weapons designed to provide complete protection against nuclear war by the middle of the next decade;

5. Encourage from the federal level the shifts in the area of educational policy that will be necessary to create a whole generation capable of carrying out the tasks of a fusion-based economy.