FUSION

SCIENCE • TECHNOLOGY • ECONOMICS • POLITICS

July-August 1984

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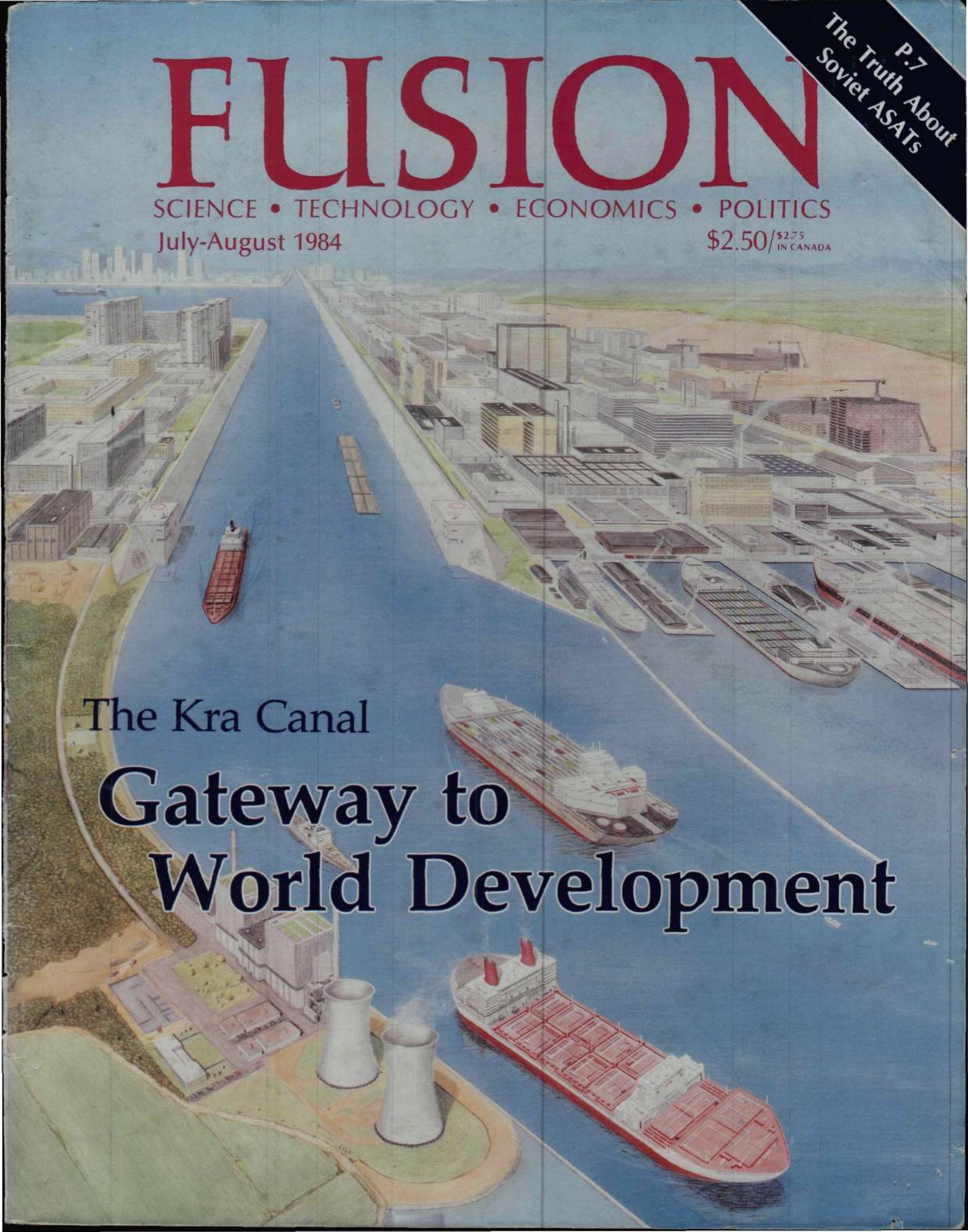
P.7 The Truth About Soviet ASATs



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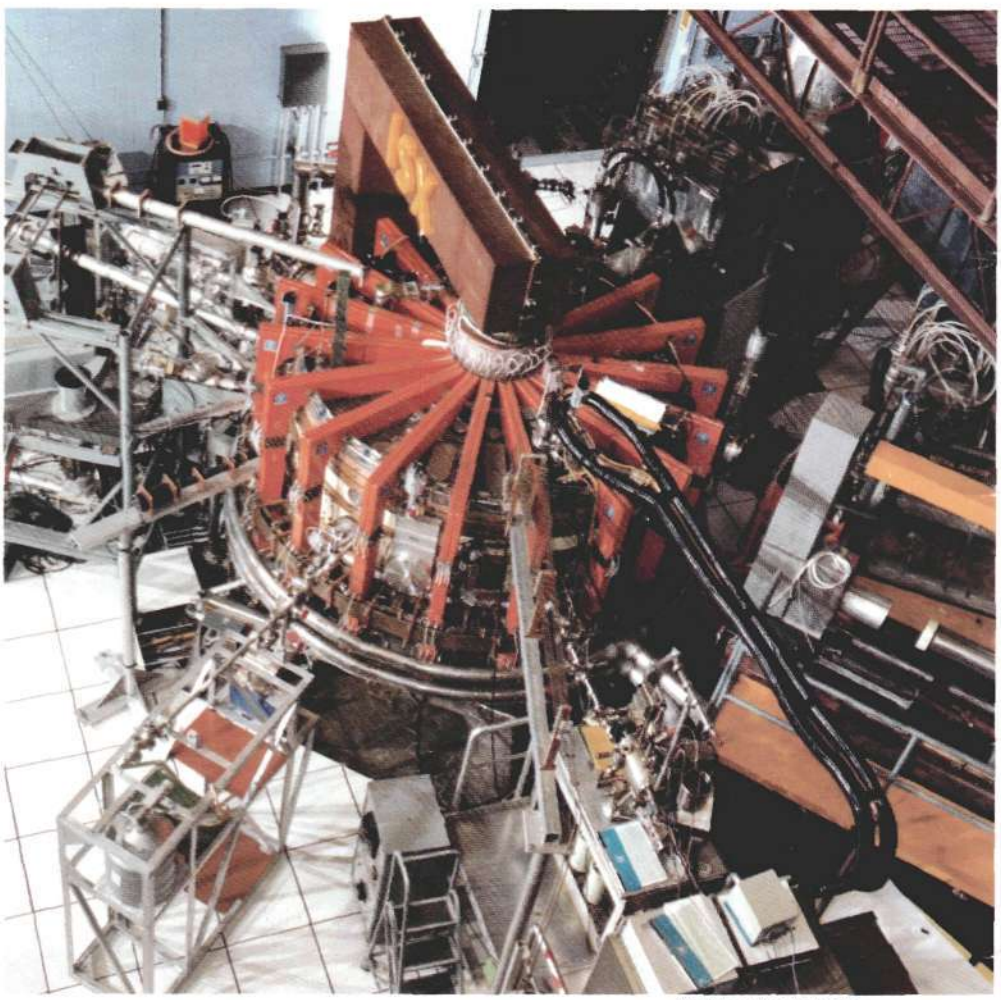

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FUSION

SCIENCE • TECHNOLOGY • ECONOMICS • POLITICS

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Features

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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

We apologize for irregularity in our printing schedule, but we assure readers that the only pronuclear science magazine in the country intends to continue publishing! Because of financial difficulties, the FEF published only 4 issues of FUSION in 1983. The FEF will now regularly publish 6 issues a year, but only 4 issues in 1984, beginning with Vol. 6, No. 1, May-June 1984.

Subscribers who purchased a 10-issue subscription and those who purchased a 6-issue subscription will receive the number of issues they paid for.

Contributions to the FEF are welcome (and tax deductible).

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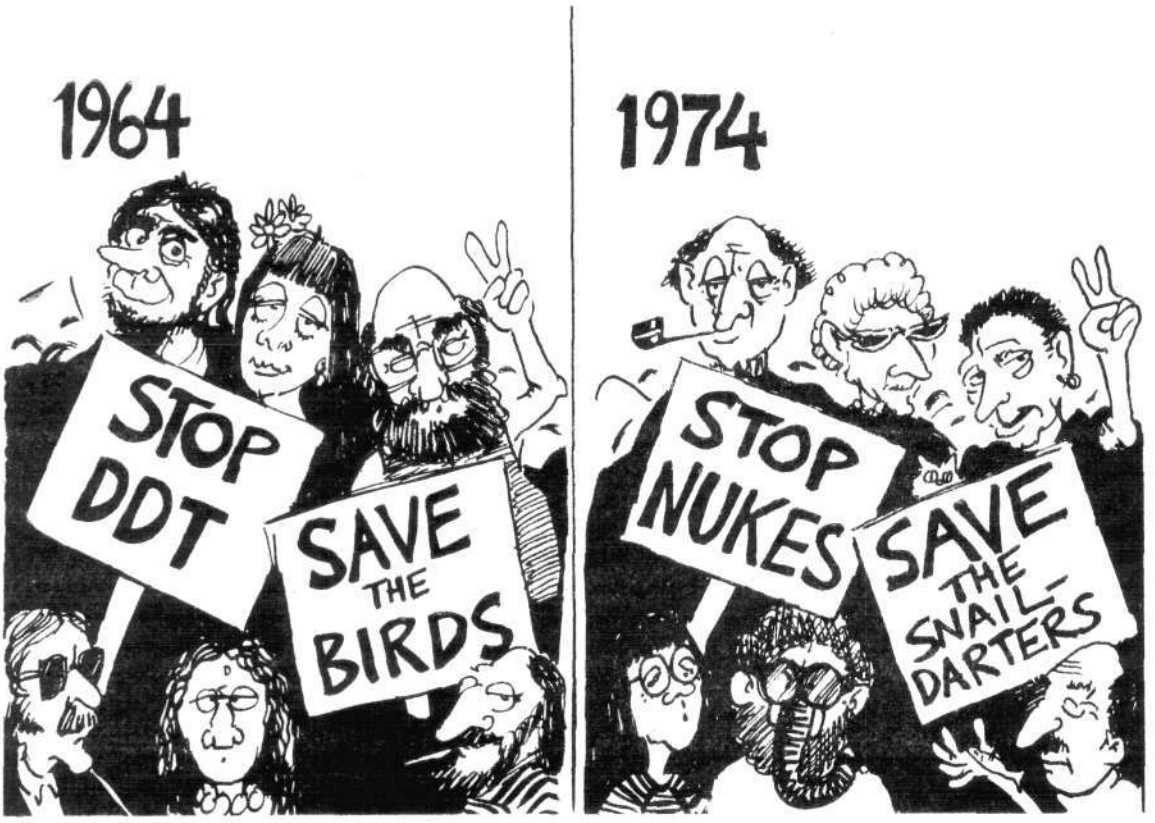
On the cover: Christopher Sloan's illustration of the Kra Canal, depicting the the canal entrance at the port of Songkhla. A nuclear power plant is in the left foreground, the port is at right, and the industrial zone is in the background. Cover design is by Virginia Baier.



Strategic Defense Initiative on the

If the Democratic Party machine around Charles Manatt and Averell Harriman along with the so-called conservatives around the Heritage Foundation and Lt. General Danny Graham have their way, we will be left with the choice of submitting to Soviet nuclear blackmail or fighting a war we cannot win.

On the one side, the Graham crowd in High Frontier is trying to turn the President's beam weapon defense program into a Rube Goldberg makeshift, putting into orbit shrapnel-filled spacecraft that are both ineffective and indefensible. On the other side, various liberal congressmen have submitted legislation to Congress attacking the U.S. beam defense system—legislation that has the stamp of approval from the Soviet Embassy in Washington, D.C. (as the Special Report documents, p. 9). As a result, the Strategic Defense Initiative could have as much as $400 million cut from its funding.

The White House request of $1.78 billion for the Strategic Defense Initiative was already a compromise, a reelection-year concession to the Danny Graham lobby and the Soviet agents of influence in Congress and the Senate. This is about one-tenth the amount needed for the crash effort that we have proposed to develop a layered beam defense system.

At stake here is nothing less than the fate of the Western Alliance, and with it civilization as we know it. There is no longer any doubt that the strategic advantage now lies in development of defensive rather than offensive weapons; defensive beam weapons are here to stay. That the Soviets have a crash program to develop beam weapons is well documented, going back to the 1960s. The question is: How far advanced are they? Are we about to have another Sputnik surprise this year or next?

Under the prodding of Senators Pressler and Tsongas,

Line

key liberal spokesmen in the drive to sabotage this country's beam weapon effort, the Congressional Office of Technology Assessment has issued a dishonest, but much publicized report attempting to refute the work of beam defense authorities such as Maxwell Hunter of Lockheed, Dr. Edward Teller, Lyndon LaRouche, and the FEF. Authored by Ashton B. Carter of the Massachusetts Institute of Technology, the report parallels the arguments of leading Soviet scientist E.P. Velikhov against the feasibility of a beam weapon defense. Yet, to give the appearance of objectivity, Carter is forced to admit that it would take only 160 orbiting chemical lasers to provide worldwide defense against ballistic missile attack. He also admits that the X-ray laser need not be based in space but could be popped up from submarines and could accelerate quickly enough to destroy the current Soviet arsenal.

Carter's principal argument against the X-ray laser's effectiveness is that the Soviets could rebuild their entire missile force so that the boost phase of a missile would be complete before the missile leaves the atmosphere—but this rebuilding would take 20 years. Thus Soviet missiles will remain vulnerable to U.S. X-ray laser defense for quite a while, giving us time to come up with new defenses.

Who Is the Soviet Lobby?

One of the most startling aspects of the fight for beam defense is to see how successful the Soviets have been in influencing both ends of the U.S. political spectrum to promote Soviet policy. The crowd around Richard Garwin and Kosta Tsipis, for example, openly travels on the left (so openly, in fact, that former Washington governor Dixy Lee Ray called Garwin a "traitor" at an international meeting on beam defense a year ago). Their line of attack against beam weapons, however, dovetails with that of the so-called right-wing crowd around General Graham. The Graham group claims to support the development of ABM systems and the concept of mutually assured survival. Yet, by opposing the development of directed energy beam weapons—beam defense based on new physical principles—at this time they are working to undermine the only effective system for a layered beam defense.

The line of the so-called right wing is that laser and associated defensive weapons are diverting funds from less sophisticated kill systems—and besides, they say, beam weapons may not work. Of course, Graham et al. fail to admit that their program is a guaranteed 50 percent failure, according to SDI manager Lt. General Abrahamson, even though it involves a proven technology.

Now a nasty coalition of these traitors has been formed: the National Campaign to Save the ABM treaty. In addition to former President Jimmy Carter and dean of the Democratic Party Averell Harriman, its leading spokesmen include former military advisor Richard Garwin, former national security advisor McGeorge Bundy, former secretary of state Cyrus Vance, and General Maxwell Taylor. These are the same men who 20 years ago were known as the "butchers of Vietnam." They created that bloody war as a no-win situation whose only purpose was to target as large a population as possible for destruction. By this "body count" policy these butchers meant to leave a whole generation of American youth with the knowledge that they had been betrayed, to create a climate of cynicism and despair in the West—the counterculture.

If these opponents of President Reagan's Strategic Defense Initiative win, we may well be catapulted into the war they claim to want to avoid by the very weakness that their policies guarantee.

The *London Times* reported June 13 that 86 percent of the U.S. population support the beam defense program, and 73 percent support it without regard to cost. We and those of you who have organized with us can take justifiable credit for this, but now is not the time for a pat on the back. This crowd of traitors must be prevented from destroying civilization. We may not have too much time left.

News Briefs

The FEF's Beam Defense *book, published in Tokyo by Jiji Press.*

Stuart K. Lewis

Abrahamson: SDI is aimed at 95 or 99 percent effectiveness.

JAPANESE TRANSLATION OF FEF BEAM BOOK SPARKS DEBATE

Beam Defense: An Alternative to Nuclear Destruction was published in Japanese by Jiji Press in early June. FEF research director Uwe Parpart Henke was in Japan to announce the release of the FEF book and to hold seminars with the country's top political, military, and industrial leaders on the technical feasibility and strategic necessity of beam weapon systems. Sixty-five parliamentarians from the Liberal Democratic Party heard Henke give a report on beam weapons at the party's headquarters June 5. The next day, Henke addressed 200 leaders of Japan's major industrial firms at a seminar sponsored by the Keidanren industrial association.

The Jiji Press edition is bound with a red sash that calls for making beam weapons and the doctrine of Mutually Assured Survival the basis for reviving talks between the United States and the Soviet Union.

LEADING SOVIET SCIENTIST SAYS U.S. BEAM DEFENSE IS IMPOSSIBLE

E.P. Velikhov, vice president of the Soviet Academy of Sciences, used the pages of the *Washington Post* June 24 to summarize his activities in the United States against the beam defense program: "A group of Soviet scientists with which I am associated, the Union of Concerned Scientists of the United States, and the Congressional Office of Technology Assessment were among those studying the issue, and all of them came to the same conclusion: The Star Wars project is a dream that cannot come true. We all had opportunity to discuss our findings at a recent meeting held outside Washington, where we discovered that our scientific conclusions were practically identical."

In contrast to Velikhov's assessment, the U.S. Congress June 12 received a 3-hour classified briefing on the status of Soviet crash programs for the development of both antisatellite weapons and strategic antimissile defenses, as well as on the degree of advancement of the U.S. Strategic Defense Initiative program.

ABRAHAMSON SAYS SDI SYSTEM AIMS AT EFFECTIVENESS OF 95 OR 99%

Lt. Gen. James Abrahamson, manager of the Strategic Defense Initiative at the Pentagon, said that the projects the SDI is working on are aimed at 95 or 99 percent effectiveness against nuclear missiles, not the 50 percent effectiveness of the "High Frontier" proposal of General Danny Graham. Speaking at a meeting of the American Institute of Aeronautics and Astronautics in New York June 19, Abrahamson outlined a defensive system that has a certainty of "70 percent in the boost phase, 70 percent in the post-boost bus phase," with the remaining missiles destroyed by midcourse and point defense.

The June test of the Homing Overlay Experiment (HOE), Abrahamson said, demonstrated "that some of this technology is here today and could be deployed under the ABM treaty." He described the work being done on ground-based lasers, the demonstration of segemented laser mirrors, and the particle beam program at Los Alamos National Laboratory. Arms control hasn't worked in many areas," Abrahamson said, and when we sign a treaty, "the piece of paper only means something in this country."

ADMINISTRATION TAKES A PROGROWTH STANCE ON POPULATION

The White House has reversed the Carter administration policy on population control with a progrowth policy statement to be presented at the United Nations world population conference in Mexico City in August, laying out the advantages and necessity of population growth. The draft statement notes: "Among the less developed nations . . . population increase was . . . directly related to the humanitarian efforts of the United States and other Western countries. A tremendous expansion of health services saved millions of lives every year. Emergency relief helped millions to survive flood, famine, and drought. The sharing of technology, the teaching of agriculture and engineering, the spread of Western ideals and the treatment of women and children, all helped to drastically reduce the mortality rates. . . .

"The second factor that turned the population boom into a crisis," the statement says, "was confined to the Western world. It was the outbreak of anti-intellectualism, which attacked science, technology, and the very concept of material progress. . . .

"In responding to certain members of Congress concerning the previous admininstration's *Global 2000* report," the statement continues, this administration in 1981 repudiated its call for more governmental supervision and control. . . . This administration places a priority upon technological advance and economic expansion, which hold out the hope of prosperity and stability in a rapidly changing world."

SPACE SCIENTIST KRAFFT A. EHRICKE RECEIVES GODDARD AWARD

At its annual meeting in Washington, D.C., May 3, the American Institute of Aeronautics and Astronautics conferred the prestigious Goddard Astronautics Award on Krafft A. Ehricke for his "more than 40 years of practical and visionary contributions to astronautics." Ehricke has been a pioneer in rocket propulsion, including work on the V-2 rocket, the Atlas missile, and the liquid hydrogen Centaur. In accepting the award for her father, who was ill, Krista Ehricke Deer said that her father's work proves that "there are no limits to growth." If my father's engineering designs were implemented, she said, "there would be increased agriculture, increased industry, increased natural resources and quality of life, and increased human creativity. If his ideas were turned into hardware, the world would be a better place."

Ehricke's Centaur was the first liquid hydrogen rocket, a precursor of the Saturn V rockets that launched the Apollo missions to the Moon. Today it is being modified for use with the Space Shuttle to launch deep-space planetary missions and future manned space missions. Ehricke, president of the Space Global Company, has published more than 10 books and 50 papers and articles, and in 1982 he completed a 10-year study on the industrial development and settlement of the Moon, which he describes as "man's extraterrestrial imperative." He is a member of the editorial advisory board of *Fusion*.

Stuart K. Lewis

Ehricke: "More than 40 years of practical and visionary contributions to astronautics."

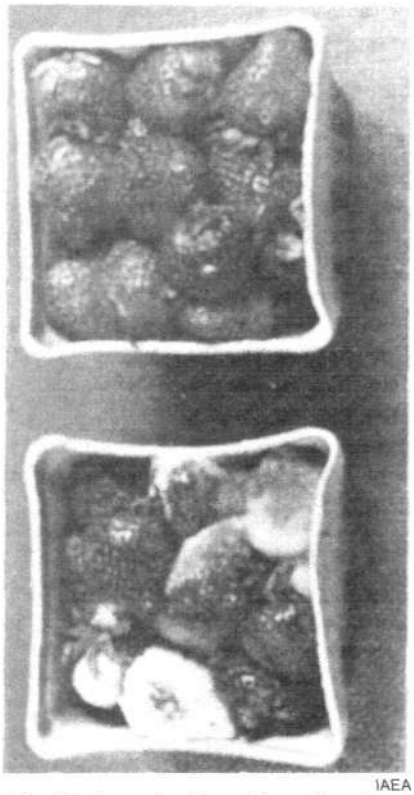
FUTURISTS LAUNCH DRIVE FOR WAR, TERRORISM, LIMITS TO GROWTH

"We'll have to have a real fright, perhaps even a short atomic war, before we have a central world government." This was the advice presented to the World Futures Society conference in Washington, D.C., June 12 by J. F. Leddy, chairman of the Amsterdam-based World Association of World Federalists. Asked to expound on this, Leddy declared: "We have had no real movement toward world federalism, so we need a real fright, maybe a near-miss in nuclear war caused by some kind of accident, or perhaps we have to have Colonel Muammar Qaddafi of Libya getting loose with nuclear terrorism. Maybe we'll need some terrorist to hold New York City ransom. With that kind of scenario, we might find ourselves stumbling into a short atomic war. It will take something like these elements to get people in a state willing to give the United Nations world-federalist powers."

The five-day World Futures Conference included presentations from such antiscience figures as Dr. Alexander King, cofounder and president of the Club of Rome, and Gary Imhoff, executive director of the Washington-based group called Carrying Capacity. "Limiting population is not enough," said Imhoff. "Population contraction is required for a decent world. Birth reduction is an imperative."

LOUSEWORT LAURELS TO U.S. AMBASSADOR TO INDIA

This issue's Lousewort Laurel's award goes to Harry Barnes, U.S. ambassador to India, for his encouragement of a project sponsored by the Sulabh Institute of Applied Research to generate electricity from biogas produced by human excreta. In a country that has just announced plans to build four large nuplexes to provide large-scale electric power (see *Fusion* May-June 1984, p. 9), such enthusiasm by the American ambassador is misplaced. The Sulabh project is not only inefficient and smelly, but costly. To pay for 3 km of street lights, the project had to double the charge on its 46-seat public latrine.



IAEA

After 15 days of refrigeration, the strawberries treated with gamma irradiation (top) are as good as new.

NEW FDA REGULATIONS COULD OPEN UP COMMERCIALIZATION OF FOOD IRRADIATION

Pending changes in the U.S. Food and Drug Administration regulations will open up the commercialization of food irradiation in the United States—after 40 years of rigorous testing for safety and wholesomeness have proved the technology to be safe and beneficial. The long-awaited changes will permit 100 kilorads of irradiation to process food. This low dose level is sufficient to kill any kind of insect in any physiological stage. A primary use will be disinfesting citrus and tropical fruits and disinfesting grain in storage. In addition, potatoes, onions, and garlic can be irradiated to inhibit sprouting (6 to 15 kilorads), strawberries and blueberries can be treated to inhibit mold and prolong shelf life, other fruits such as bananas could have their ripening process delayed (25 to 35 kilorads). Congress killed the emerging technology in 1958 when it classified food irradiation as a "food additive," requiring extensive testing product by product to get clearance from the FDA. The proposed 100 kilorad limit is too low to enable the United States to derive the full benefits from the technology. The internationally accepted standard is 1,000 kilorads, ten times the limit the FDA is now considering.

LIVERMORE'S NOVA LASER TEST FIRES 8 OF 10 BEAMS

Fusion scientists at the Lawrence Livermore National Laboratory successfully test fired 8 of the 10 beams of the $176 million Nova laser facility in early July, delivering a total light pulse of 57 trillion watts in a billionth of a second. Wehn Nova becomes fully operational at the end of 1984, it will succeed the Japanese Gekko XII laser at Osaka University as the world's most powerful laser.

Nova is designed to demonstrate breakeven, generating far more fusion energy than the laser energy required to compress the fuel pellet. Livermore scientists plan to test polarized fusion fuel with Nova, and they are now carrying out a brute-force program to develop techniques for polarizing fuel in the tiny spherical fuel pellets. Lining up the atomic spins—polarization—of fusion fuel can greatly improve the efficiency of inertial confinement fusion and thereby reduce even further the production costs of fusion energy. Nova will carry out laser fusion experiments at three different wavelengths: infrared (1.05 micrometers), visible green (0.53 micrometers), and ultraviolet (0.35 micrometers). The shorter wavelength ultraviolet is expected to achieve the most efficient implosions and soft X-ray generation.

Although laser fusion is the primary objective of Nova, the very first Nova experiments will be directed toward demonstrating a laboratory scale X-ray laser. Incoherent X-rays generated by the Nova laser light, when it is directed onto metal foils, will provide the appropriate pump energy. The pump soft X-rays excite coherent X-ray pulses from a gas flowing between the pump metal foils. Plans are also in the works, once the laboratory X-ray laser is demonstrated, to use it for making three-dimensional, subatomic-scale pictures of living cells and other materials. These laser-generated pictures are called holograms, and because X-rays have such short wavelengths and therefore such fine resolution, these holograms are called microholograms.

Christine Moon, 1910-1984: A courageous fighter for life.

MRS. CHRISTINE MOON DIES IN CHICAGO, MAY 16

The Fusion Energy Foundation was saddened to learn of the death May 16 of Christine Moon, wife of Dr. Robert Moon, professor emeritus at Chicago University. Mrs. Moon, an accomplished poet and artist, is survived by her husband, four children, and twelve grandchildren. Dr. Moon, a nuclear physicist and veteran of the Manhattan Project, is a founding member of the Fusion Energy Foundation and a member of *Fusion*'s scientific advisory board.

Afflicted with Parkinson's disease since 1959, Mrs. Moon until her very last days participated fully in activities to further science and culture and to uplift the spirit and material well-being of mankind. She, along with her husband, traveled to Rome to be a founding member of the Club of Life in October 1982, and she accompanied Dr. Moon to FEF seminars and conferences. "We are honored to have had the company of such a courageous fighter for life," said *Fusion* managing editor Marjorie Mazel Hecht.

Viewpoint

The Truth About The Soviet ASAT Program

by James E. Oberg

James E. Oberg is a professional space engineer in Houston, working on the Space Shuttle project. Generally considered one of the West's leading experts on the Soviet space program, he has published 200 articles on space topics (including feature articles on space militarization in the April issues of Science Digest *and* Omni*) and six books (including the widely respected* Red Star in Orbit*).*

Fusion *asked Oberg to comment on recent anti-ASAT legislation introduced into Congress that claims that the Soviets have only a "primitive" ASAT and that their ASATs are launched on "unique" rockets that could be detected upon launch.*

* * *

One aspect of the disarmament debate has been heating up lately, because of a combination of recent weapons tests, diplomatic efforts, and White House reports. It deals with the issue of antisatellite weapons, ASATs.

On Jan. 21, 1984, the U.S. Air Force tested its air-launched ASAT missiles, without the actual warhead. The Soviets have had an operational ASAT satellite for years, but last August—in what turned out to be his last public appearance ever—Soviet Premier Andropov declared a "unilateral moratorium" and urged visiting American senators to block the American weapon.

Then, in early April, the Reagan administration released a special report on the prospects for a negotiated U.S.-Soviet ban on such weapons. The report was required by Congress. In it, Reagan's experts concluded that the prospects for substantive negotiations and a verifiable treaty were next to zero.

This conclusion did not sit well with many vocal opponents of the Air Force's air-launched ASAT missile. Congressmen, lobbyists, commentators, and academics have been strenuously promoting the idea of a "freeze" on further space weapons tests. The White House report published April 2 is in direct opposition to such advocacies.

While the debate rages, confusion over the facts of the issue has reached near-cosmic proportions. The technology itself can be obscure, and Soviet statements have been notable for their lack of candor.

Many of the proponents of an equivalent American "freeze" on ASAT testing, as a prelude to negotiations to ban such weapons entirely, have been victims of gross misperceptions and errors of fact. Before a serious public debate can develop to affect administration policy, it must be founded on reality, and it must abandon a number of fallacies.

Fallacy #1: The Soviet ASAT is "primitive, cumbersome, inept," or any number of pejorative terms.

This is false. Claims that the Soviet system works only half the time are based on juggled statistics that combine flight results from tests of the operational radar-guided system with tests of a newer infrared guidance system. The newer system has not performed well, but the operational system has scored successfully in six out of the last seven shots, over the past decade. Since U.S. satellites, potential targets for the Soviet ASAT, do not carry countermeasures to the old system, the new Soviet ASAT is still unnecessary for ensuring a very high "kill probability" for any single shot.

Fallacy #2: The Soviet system, which uses a 150-foot booster rocket, is easily observed by American spy satellites and any negotiated ban could be easily verified.

This is false. The Soviet ASAT uses a booster called the SL-11 (or the "F"-class, based on the SS-9 ICBM), which is also used by a number of other military space programs. In 1982-1983 there were 20 launchings of this booster (including several *after* Andropov's self-proclaimed moratorium), but only one carried an ASAT. So the presence of such a booster on a launch pad (there are several pads in Central Asia and also north of Moscow) is not an indication of violation of a hypothetical ASAT ban. The Soviet orbital weapon is launched under an aerodynamic protective shroud indistinguishable from that used by the other programs, so the ASAT warhead would have to be spotted out in the open, during transport. It is even shorter than the American ASAT missile, and is consequently far more difficult to spot.

Fallacy #3: The U.S. system is "far more sophisticated" and thus offers a provocation to the Soviets to build a matching system.

This is false. While the guidance of the U.S. ASAT missile is indeed more precise than that of the Soviet ASAT satellite (since it uses direct impact rather than a blunderbuss shrapnel charge as kill mechanism), the weapons can be fairly compared only in terms of actual capability. In this regard, there is little difference in altitude range, reaction time, reload capability, or detectability. The major difference is that the Soviet system is operational now (and has been for a decade), while the U.S. system will not be operational until 1987-88 at the earliest.

Fallacy #4: The Soviets have promised to stop testing their own ASAT satellite, and to dismantle their system as part of a negotiated disarmament.

This is false. What Andropov really promised last August was that "the Soviet Union would never be the first to put any kind of antisatellite weapons into space." This solemn vow was sadly invalidated by the Soviet's preexisting history of exactly such acts: putting antisatellite weapons into space. Soviet officials have steadfastly denied they have such a weapon, and consequently they are supposed to have nothing that needs to be dismantled.

Strictly speaking, the Air Force test last January did not violate the moratorium since no warhead was installed

(only the ASAT rocket booster was launched, an operation the Soviets themselves have carried out as well, several times since Andropov's pledge). The Soviets have *never* explicitly stated that they possess any space weapon of any kind, and they have *never* promised to dismantle "their antisatellite weapon," under any circumstances.

Fallacy #5: If the Soviets were to dismantle their antisatellite "killer satellite," space would once again be demilitarized.

This is false. The Soviets also possess an antisatellite capability based on their antimissile system around Moscow, and short of dismantling that whole system (an extremely unlikely prospect) would be able to retain that capability even under the most stringent treaty verification efforts.

Fallacy #6: The development of the American system will "force" the Russians to "match" it.

This is false. The Soviet system already possesses all essential capabilities that the American system is supposed to have several years from now.

Fallacy #7: The air-launched nature of the American ASAT missile makes it extremely destabilizing since it is much more flexible than the Soviet ASAT missile.

This is false. The American system needs an air-mobile launcher mainly to allow a head-on launch from directly in front of a target satellite, which otherwise could pass hundreds of miles to the east or west of the ASAT base. Worldwide basing has no obvious advantage since any reasonable target's orbit will always eventually carry it within range of the United States several times a day. In contrast, the Soviet system can use fixed launch sites because it has the speed and endurance to wait for the precise moment the launch pad is carried by Earth's rotation into the target satellite's orbital plane, at which point the Soviet "killer-satellite" goes into orbit and spends several hours hunting down its prey. The American system is much more severely limited in lifetime and speed.

Fallacy #8: The U.S. ASAT is dangerous because it can kill a Soviet satellite secretly, leading the Soviets to assume that any satellite failure might be the result of enemy action.

This is false. The Soviets have deployed a chain of infrared satellites which pass over North America, watching for missile launchings. The American ASAT booster rocket is probably big enough to be noticed by these satellites, providing firm confirmation of enemy action.

Fallacy #9: The American ASAT missile is destabilizing because it can attack Soviet communications and missile-warning satellites (while the Soviets do not have a similar capability).

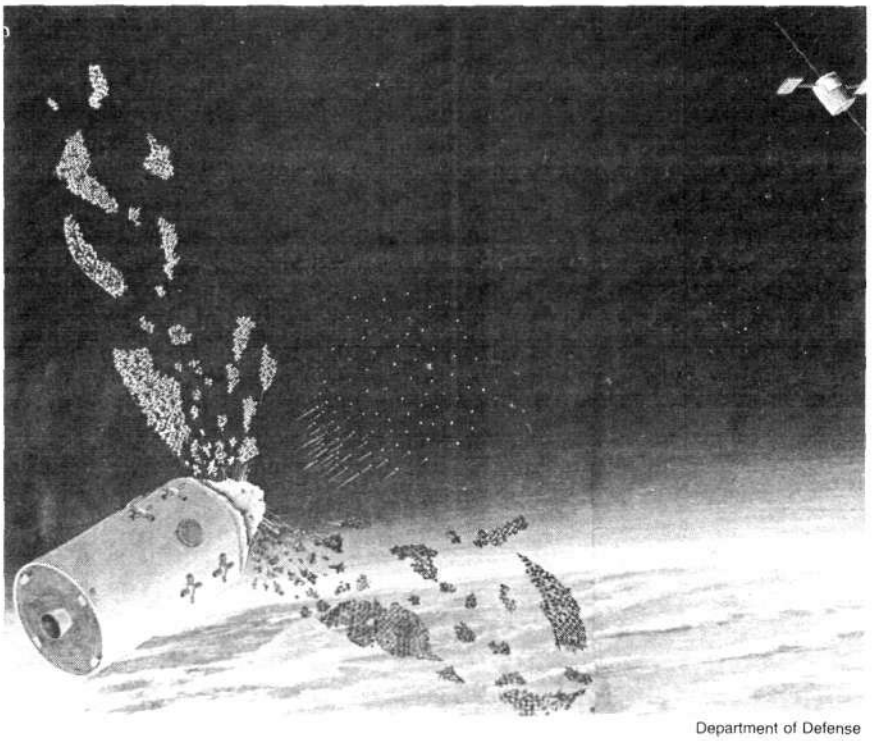
This is false. While these Soviet satellites do dip to within 400 miles of Earth's surface, well within the presumed range of the ASAT missile, they do so over the far southern oceans, off the coast of Antarctica. The current carrier for the ASAT missile, the F-15, would need gross modifications and Rube Goldbergish ad hoc rearrangements to reach these points.

Fallacy #10: There is no military need for the American ASAT missile.

This is false. The Soviets have been diligently developing and deploying nuclear-powered active radar satellites for scanning the oceans for Western naval forces. These systems would, under conventional warfare conditions, be able to pinpoint fleets and to direct long-range strike forces against them. The Soviet intention to develop such a capability was the deciding factor in the U.S. decision to develop a counter to it.

The facts in this case need not depend on "appeals to authority" of blue-ribbon panels of experts. They can be determined by a diligent examination of the public record, including material published by the Library of Congress's Congressional Research Service, the British Interplanetary Society, the Foreign Broadcast Information Service (for firsthand accounts of Soviet statements), the Stockholm International Peace Research Institute (SIPRI), as well as many charts and tables published by the anti-ASAT groups themselves (particularly those released by the Federation of American Scientists).

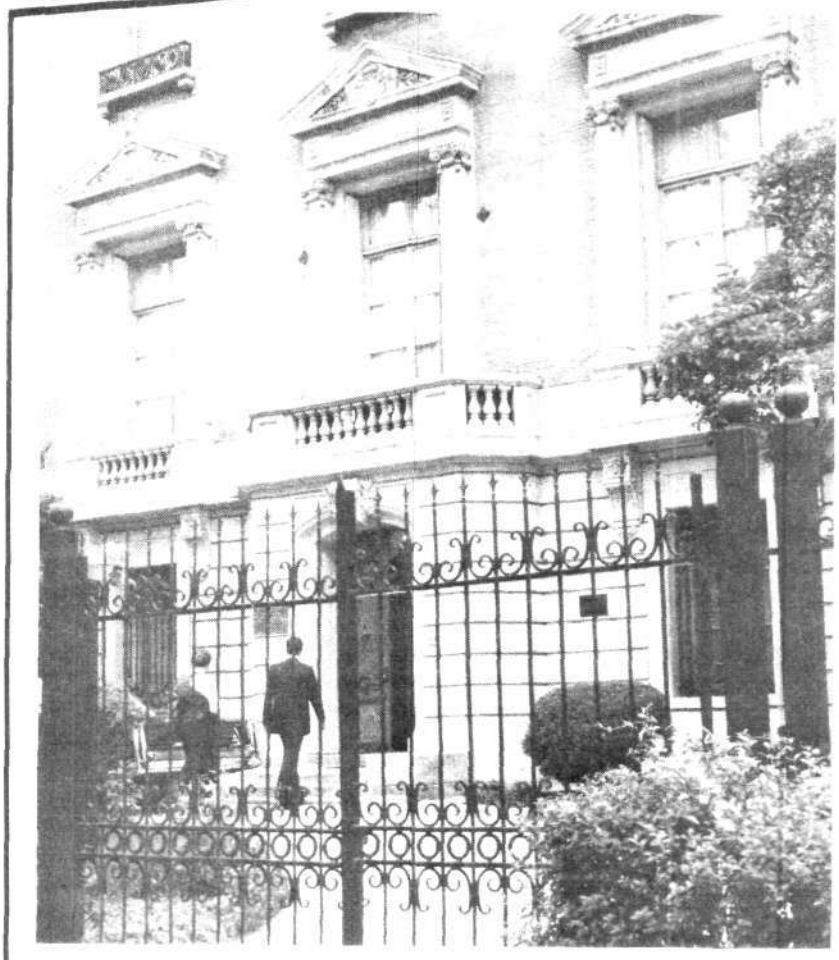
But until those facts enter the policy debate, there is no prospect for any realistic basis for either national policy debate nor international disarmament negotiations. Debaters who ignore the facts sabotage their own professed points of view.



Department of Defense

Artist's conception of a Soviet ASAT designed to destroy space targets with a multipellet blast.

MADE IN MOSCOW?



The Soviet Embassy in Washington, D.C.: export center for a U.S. ban on beam defense.

The Legislation Against U.S. Beam Defense

To the ordinary American, eliminating the threat of nuclear war by developing a beam defense to knock out hostile nuclear missiles in the first few minutes after launch sounds like a good idea. Yet, numerous bills, resolutions, and amendments aimed at crippling the Strategic Defense Initiative, which would develop such a beam weapon defense, have recently been introduced in Congress. Far more amazing than the apparent willingness of Congress to undercut the country's defenses is the fact that much of this legislation originated in the Soviet Embassy in Washington, D.C.

The shocking evidence of this fact comes from Carol Rosin, the founder and president of an obscure Washington thinktank, the Institute for Security and Cooperation in Space (ISCOS).

According to Rosin, ISCOS has been passing anti-beam-weapon and other antidefense legislation drafted by her contacts at the Soviet embassy to Capitol Hill, where it has then been introduced by such liberal Congressmen and Senators as Joe Moakley (D-Mass.), Mel Levine (D-Calif.), Paul Tsongas (D-Mass.), Larry Coughlin (R-Penna.), George Brown (D-Calif.), and Larry Pressler (R-S.D.).

Although Rosin claims that she is interested purely in fostering "better relations" between the United States and the Soviet Union, nothing could be more absurd. The facts are that the Soviets have been working on their own directed-energy antiballistic missile defense (ABM) since the early 1960s, have developed and successfully tested an antisatellite (ASAT) weapon, have outpaced this country in several crucial military areas, and are now working overtime to ensure their strategic advantage by preventing the U.S. from developing comparable technology.

Rosin openly admitted recently that ISCOS's "main goal is to alert people to the dangers of weaponization of space. We are working closely with the Soviets on this." She boasted how she and the Soviets collaborated on House Joint Resolution 120, the anti-space-weapons bill that has 128 cosponsors. Here is how Rosin said it happened:

"[Rep.] Joe Moakley saw me on TV discussing the weaponization of space and called me up. I suggested that he get a resolution introduced in Congress about it. I then called Dan Duedney of Worldwatch, who wrote a draft resolution. I took it to my contacts at the Soviet embassy. They told me to change certain language. . . . For example, I had 'weapons in space' and they changed it to 'space weapons of all kinds.' They thought this was a better negotiating position. The Soviets don't like to compromise. I then got the resolution to Moakley, and he presented it. . . . It calls for immediate bilateral talks with the Soviets for a comprehensive treaty banning any ground-based or space-based weapons."

House Joint Resolution 120's com-

panion piece, Senate Joint Resolution 129, was introduced by Senators Larry Pressler, Paul Tsongas, and Gary Hart.

Target: ASATS

Rosin's group also takes credit for Congressional assault on the U.S. ASAT program. On May 23, the House of Representatives voted 328 to 181 for an amendment to the fiscal year 1985 defense authorization bill that bans further testing of U.S. antisatellite weapons. Sponsored by Rosin collaborators George Brown and Larry Coughlin, the amendment would cripple U.S. ASAT capabilities, which are an essential component of an effective strategic defense system. At this writing, the Senate is about to begin debate on its own anti-ASAT measure, an amendment sponsored by Sen. Charles Percy (R-Ill.).

Rosin boasted in an April 23 press release that ISCOS had worked hand-in-glove with the Soviets to swing Congress behind the ASAT moratorium. ISCOS, the release said, "played a role in setting up the August 1983 meeting between the late Soviet premier [sic] Yuri Andropov and a delegation of six U.S. Senators in Moscow, at which Andropov announced a unilateral ASAT moratorium and proposed a space weapons treaty." The release also stated that ISCOS "had provided delegation members, led by Sen. Claiborne Pell [D-R.I., an ISCOS board member] with briefings on the Soviet space weapons position" and had "worked with delegation members and the Soviet government to produce the Andropov statement."

Carol Rosin: Washington lobbyist for antiscience legislation and Soviet policies.

Privately, Rosin disclosed that she not only had asked one delegation member "if he would suggest an anti-space thing" in his meeting with Andropov, but also "drew up a proposal on this and gave it to the Soviet embassy. The Soviets are very cooperative with us," she said. "This message got through to Andropov and he announced a complete ban on antisatellite weapons."

According to ISCOS legislative director Judith Schnidmann, the institute not only had significant input into the development of the Brown-Coughlin amendment, but also did "a pretty comprehensive sweep" of Congressmen to line up support for it.

The Space Policy Working Group

Rosin's main vehicle for getting Congress behind the Kremlin's policies is the Space Policy Working Group, an informal Capitol Hill caucus that Rosin set up in January 1983.

The working group draws staffers from the offices of congressmen Moakley, Levine, Brown, John Seiberling (D-Ohio), Pat Schroeder (D-Colo.), Les Aspin (D-Wisc.) and Spark Matsunaga (D-Hawaii), among others. Rosin says the group has helped produce such key pieces of legislation as the Mel Levine-George Brown HJR 531, which calls for the maintenance of the 1972 ABM Treaty, and HJR 536, also sponsored by Levine and Brown, which calls for "cooperative ventures in space" instead of an "arms race in space."

The latter is a result of direct KGB orders to Rosin. She revealed that the Soviet embassy told her it was "more effective" to undermine the beam-defense program by counterposing the "positive" approach of "cooperation in space" to an "arms race in space," rather than simply attacking it head-on.

Rosin disclosed that she is now personally trying to sell this ploy to various pro-beam-weapon scientists, and is "trying to get some of them to meet with the Soviets" on it. An aide to Rosin collaborator Spark Matsunaga, primary sponsor of a Senate resolution calling for "cooperative ventures in space," recently told a reporter that "there is a lot of potential for this as an alternative to Star Wars."

The ISCOS Network

Rosin's claim that ISCOS conspires with the Soviets is no idle boast. Earlier this month, Rosin sponsored two private têtes-à-têtes that brought together members of Congress—including Representatives Brown and Levine and Senator Pell—and representatives from the U.S. media, defense industry, and military to confer with a group of high-level Soviet officials. The Soviet group included Georgii Arbatov of Moscow's USA/Canada Institute, Yevgenii Velikhov, a leader of the Soviet beam-weapon program and vice-president of the Soviet Academy of Scientists, and Roald Sagdeev, the Soviet laser expert, all of whom were in the United States to campaign against U.S. beam defense development.

During one event, a reception at Senator Pell's palatial residence where the "problem" of the U.S. strategic defense project was discussed, Rosin and Sagdeev agreed to coauthor a book on U.S.-Soviet joint space ventures.

Rosin, who advertises herself as a protégé of the now deceased scientist Werner von Braun, interfaces with a wide variety of groups, including the rabidly anti-beam-defense Federation of American Scientists, the cultist L-5 Society, and the Heritage Foundation—home of Gen. Danny Graham's low technology ABM plan, High Frontier.

ISCOS's board provides an instructive look at how deeply the Soviets have been able to penetrate the U.S. defense establishment. Sitting side by side with such kooks as "Aquarian Conspiracy" leaders Barbara Marx Hubbard and Willis Harmon, Jim Hickman of Esalen's East-West Institute, and Alla Massavich, a Soviet "stellar expert," are Ed Winchester, controller of the Pentagon, and Bill Johnson, vice president of Fairchild Industries, a major defense contractor. The board also includes Robert von Pugenhardt, professor at the Naval Post-Graduate Institute, and Jim Channon, a leader of the Delta Force cult, which has penetrated to the highest levels of the Pentagon bureaucracy.

—Kathleen Klenetsky

THE PRITKIN FRAUD

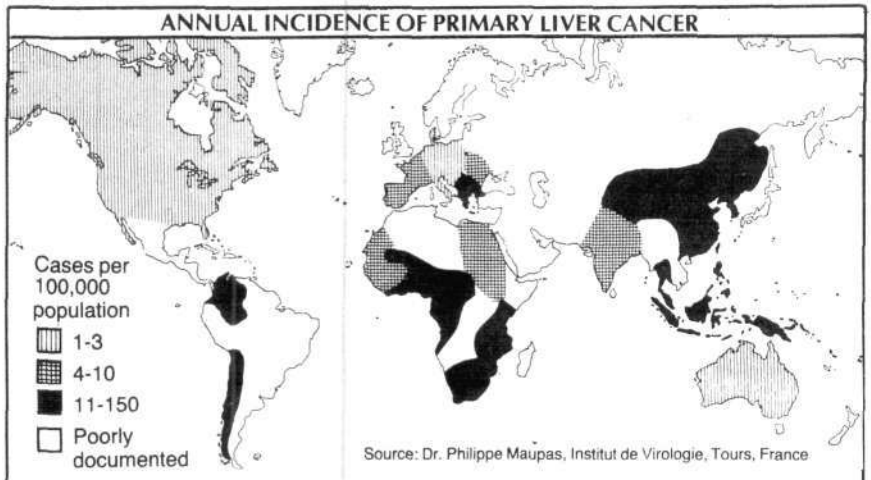
Promoting the Cult of Protein Deprivation

One of the major targets of the Club of Rome and Global 2000 Malthusian networks has been the world food supply, in particular U.S. agriculture. In addition to actions to collapse food production and enforce population reduction by starvation, there are ongoing complementary operations to create a psychological acceptance of reduced food supplies, especially animal protein. Any such reduction in protein consumption will have an effect that is measurable in life-and-death terms: America with an average daily consumption of more than 100 grams of protein, of which 70 grams are animal protein, has an average life expectancy of 73 years, whereas Africa with an average daily consumption of 55 grams, of which less than 10 grams are of animal origin, has a life expectancy of 42 years.

The newest American chapter in the ongoing attack on the food supply has been written by Nathan Pritikin, author of *The Pritikin Program for Diet and Exercise*. This low-fat, low-protein, high-carbohydrate diet, accompanied by jogging, is promoted by a number of community-based Pritikin Better Health Programs and a "Longevity Center" in Santa Barbara, Calif. The distinctive features of the diet are a severe restriction of all fats and a warning against protein, especially animal protein. The basis of this attack is the supposed freedom from certain diseases in the protein-deprived areas of the Third World.

Lie No. 1: Protein Causes Cancer

If one examines these areas of the world, such as Africa, one finds populations that have a lower incidence of certain cancers, such as colon, breast, and prostate, and of certain conditions such as atherosclerosis and hemorrhoids. However, one would expect the incidence of these diseases, which tend to occur in older individuals, to be lower in a population with an average life expectancy of 42 years than in a population with an average life expectancy of 73 years. Moreover, the



Protein Deprivation Provides Breeding Ground for Plagues

In its extreme form, protein deprivation leads to death, but for those who survive, the suppression of the immune system that is induced by malnutrition leads to outbreaks of new plagues.

The killer disease AIDS, Acquired Immune Deficiency Syndrome, is an example of one such new plague. AIDS now appears to be endemic among parts of the African population. The *New England Journal of Medicine* reported Feb. 23, 1984 that there were 23 cases of AIDS among patients from Central Africa who were hospitalized in Belgium between May 1979 and April 1983. They had no history of blood transfusions, intravenous drug use, or homosexuality—the usual case with AIDS victims in the advanced sector. Ten of them have died from the disease.

All of these patients were of upper socio-economic status, but either were living in Africa at the onset of illness or frequently traveled there. This indicates that the infectious agent is present in the African population and spreading from the more obviously malnourished and immunodepressed members of the population as the internal situation in Africa continues to collapse under the murderous austerity policies of the International Monetary Fund.

Kaposi's sarcoma, one of the cancers that occur in AIDS patients, has been a well-known disease in sub-Saharan Africa for many years, along with other immune system cancers such as Burkitt's lymphoma. These diseases are abnormal reactions of the immune system to chronic parasitic infection and malnutrition, especially protein deficiency. Primary liver cancer is another tumor common in the protein-deprived areas of the world.

The *New England Journal of Medicine* commented: "It is possible that AIDS has always been present but unrecognized in Africa. However, we are struck by the increasing number of patients who have come from Zaire or Rwanda to Belgium during the past four years to seek medical care. We believe that AIDS is a new disease that is spreading in Central Africa."

As the collapse continues, these diseases will spread beyond their confines in the targeted populations and pose a general health threat.

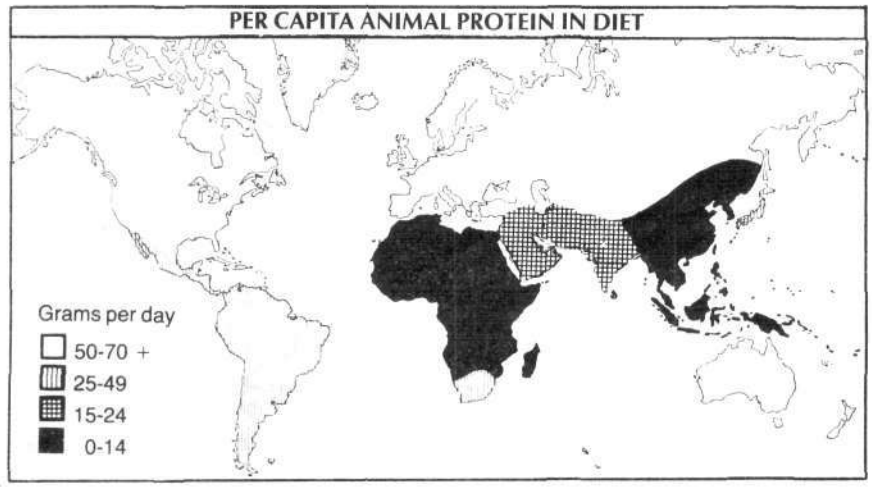
assertion that cancer is rare in these countries is simply untrue. As a recent World Health Organization report documents, cancer is more prevalent in the developing sector than in the industrialized countries, and it now surpasses infectious disease as the leading cause of death.

Primary cancer of the liver, one of the most prevalent cancers in the world, is almost unknown in the United States but is common in those areas with the lowest intake of animal protein. It is associated with widespread infection of the population by hepatitis virus. This is only one of many manifestations of chronic infection in protein-deprived populations. In addition, cancers involving the immune system, such as lymphomas and Kaposi's sarcoma, are endemic in these areas and correlate with widespread immune deficiency as a consequence of the low-protein, low-fat diet advocated by Pritikin.

Pritikin cites the usual collection of case histories. One can read similarly impressive results in other books, such as those of Irwin Maxwell Stillman and Samm Sinclair Baker, and Robert C. Adkins, including reductions of cholesterol and serum lipid (fat) levels. These are high-protein, high-fat, and low-carbohydrate diets, which are diametrically opposed to the Pritikin diet. If one wishes to say that these physicians (Pritkin is not a physician) are lying or incompetent, then one still has to deal with scientists such as the Mexican cardiologist Demetrio Sodi-Pallares, who has produced significant regression in symptoms of arteriosclerotic heart disease and reduction of serum lipids on a diet that provides over 50 percent of its calories as fat!

The common denominator in the Pritikin diet and in Sodi-Pallares's diet is restriction of sodium and highly refined sugar. It is this, and not restriction of fat and protein, that is the most likely cause of the improved blood chemistry in Pritikin's clients. Weight reduction in the obese will lower serum lipids regardless of the diet. Likewise, moderate exercise reduces cholesterol levels, helps normalize body weight, and maintains muscle tone and fitness.

Restriction of fat, and even of protein, in obese individuals will be tolerated as long as the body's own stores can make up the deficit. In the case of protein, this means reduction of muscle mass, and, more ominously, shrinkage of immune system tissue such as the the lymph nodes and thymus. It is not uncommon for cold sores and other minor infections to flare up in people who go on severe crash diets, because of transient immune suppression.



In the Third World, where whatever economy that still exists is based on manual labor, the effects of protein deprivation are most blatant. The populations barely exist at an animal level of subsistence, with short life spans and hideous infant mortality rates. In the severe states of malnutrition, the immune system is so depressed that there is absence of some symptoms produced by the immune response. Health researchers for various organizations connected to the World Bank and the International Monetary Fund have actually argued that this indicates that starvation has a beneficial effect on these people!

Pritikin recommends the same restrictions of fat and protein for growing children. If one looks at populations in which severe lack of fat and animal protein are common, one sees stunting of growth and decreased resistance to infectious disease. Low cholesterol intake in an infant is particularly devastating because a large component of the brain's biochemistry is cholesterol. Permanent effects on brain development can result from fat restriction in early infancy.

When this is compounded by debilitating chronic infections, the potential for anything approximating human existence is very low. To argue that such a diet is healthful is to imply that the devastating effects are the fault of some defect in the victim. This is racism, pure and simple. To idealize this sort of existence as benign and uncomplicated is the worst sort of cultural relativism.

Lie No. 2: Vegetable Protein *Is As Good As Animal Protein*

Next comes the issue of animal versus vegetable protein. True, it is possible to combine a number of grains and nuts to make a relatively complete protein that approximates the amino-acid content of meat. The problem is that not only must the elements be consumed together, but a variety of such foods must be available. This is not the case in most Third World countries, and studies on response to immunization in children show that children with a high proportion of animal protein in their diet produce better antibodies than those who consume a high proportion of vegetable protein, even though the total protein intake is the same. In addition, nuts and beans, which are major sources of vegetable protein, can become heavily contaminated with aflatoxins, the most potent carcinogens known.

Pritikin contends, along with certain World Bank supporters, that protein deficiency is in fact just calorie deficiency, and that additional caloric intake will cure the condition. But the fact is that kwashiorkor, a grave affliction in Africa, is a protein deficiency and responds to protein supplementation, especially milk powder, and does not respond to simple caloric in-

World Protein Supply: Going Down

The total tonnage of food produced per capita worldwide is rapidly decreasing. In Africa, starvation has reached holocaust proportions, where food available per person has decreased for the last 11 years. Given the current rates of decreases in production, food shortages are likely to appear even in the advanced sector nations by as early as 1985.

Overall there are about 1.5 billion tons of grain produced worldwide each year, a figure that has grown very little in the past few years. This means there are about 16 bushels of grain per person each year, compared to the 24 bushels of grain per capita that would be required to provide sufficient feedgrains for meat, milk, and other animal proteins for a healthy human diet. World grain output needs to be doubled at least, and the feedgrains component needs to be tripled.

Instead, policies are underway in the United States and Europe—the nations that account for 50 percent of all world corn produced, more than 50 percent of the world's milk, and high percentages of other feed and food stocks—to drastically reduce farm output. And production declines in parts of the developing sector have reached collapse conditions.

Last year the Department of Agriculture's PIK (payment-in-kind) program, unprecedented in U.S. history, took 83 million acres out of production—one third of U.S. grain and cotton base acreage. In one season, the world's wheat acres in production dropped by almost 5 percent. Under the 1980 PIK program and the worst drought in 50 years, U.S. grain output dropped by 50 percent in corn and 33 percent in soybeans—key elements in the animal protein cycle. The U.S. national livestock herd, dairy herd, and poultry production have all declined under the impact.

In 1984 the infamous PIK plan, plus conservation programs will take 20 million wheat acres out of operation—5 percent of the world's total wheat lands.

Instead of this agricultural rout, the United States and Europe should be gearing up to specialize in energy-dense food output—meat, milk, eggs, fish—for exporting food, breeding stock, and technologies around the world to upgrade nutrition levels and health. In the developing sector, large-scale infrastructure projects are needed—road networks, water management, and bulk storage and port facilities—that will vastly increase the productivity of farming and international grain production.

With the exception of India and some other points of progress, production is declining or collapsing in the developing sector. In Bolivia farmers were forced to eat their seed potatoes in 1983. The government is pleading for emergency food aid, which the U.S. State Department, in collaboration with the International Monetary Fund, has denied. In Mexico, 25 percent of the national dairy herd has been eliminated under the austerity program demanded by the IMF. In Africa, 150 million people in 22 nations are literally facing starvation.

The IMF, World Bank, and related institutions and world food trade cartels (Cargill, Continental, Nestles, Bunge, and others) recommend further cuts in production, using the rationalization that this will "conserve" world soils and resources.

—Marcia Merry

crease of protein deficient foods such as rice or cassava.

Although conceding the necessity for enough protein intake to maintain nitrogen balance, Pritikin contends that anything exceeding this level is positively harmful. The problem is that the amount of protein requirement is significantly increased under certain circumstances, including the vigorous exercise Pritikin recommends. For ex-

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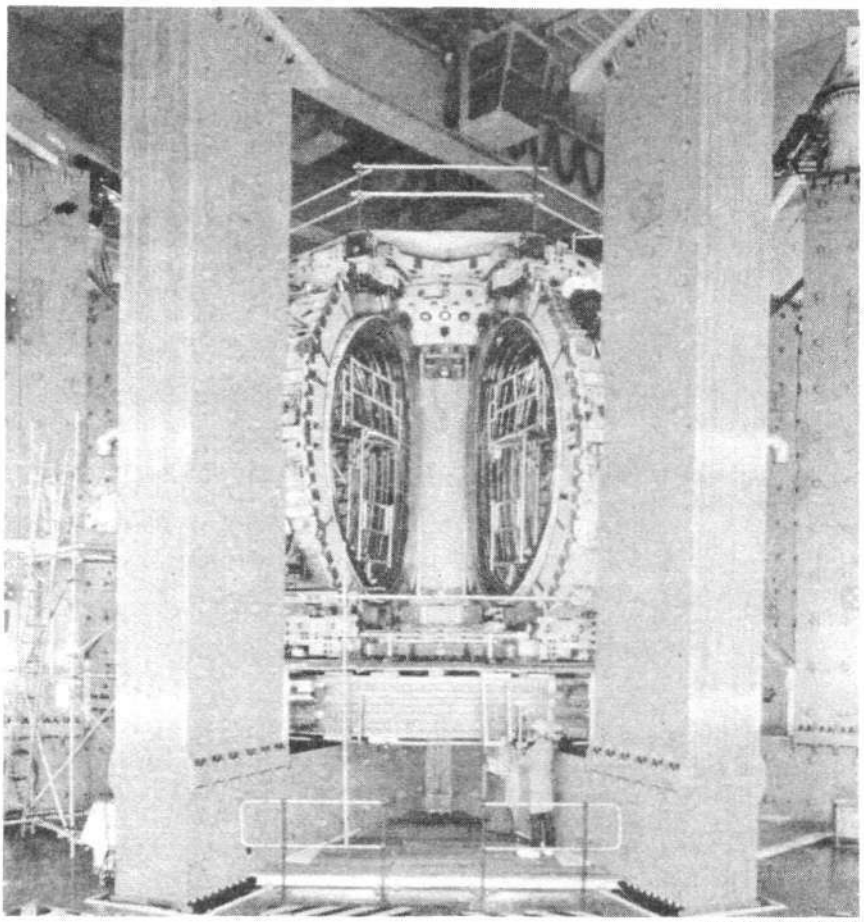
WORLD'S LARGEST TOKAMAK

JET Begins Phase 2 of Experiments

The world's largest experimental fusion reactor, the Joint European Torus, JET, is now in its second phase of operation in Culham, England. The JET reactor, a cooperative project of the European Economic Community, inaugurated the second of four stages of experiments in May 1984, leading up to the projected achievement of energy breakeven by 1988. By that date, JET's fusion plasma is expected to release more energy than was required to create the plasma.

Although the U.S. Tokamak Fusion Test Reactor (TFTR) reactor at the Princeton Plasma Physics Laboratory may achieve breakeven somewhat earlier, JET's larger plasma volume, larger power output, and greater flexibility will greatly add to the harvest of scientific and technological knowledge from history's first genuine controlled fusion reactors. The successful operation of the JET facility, whose detailed planning goes back to 1973-1975, demonstrates the commitment of the Western European nations to the commercial realization of fusion energy.



JET Joint Undertaking

The Joint European Torus is expected to reach energy breakeven by 1988. A cooperative project of the European Economic Community, JET demonstrates the commitment of the European nations to the commercial realization of fusion energy. Above: JET's reactor chamber.

In order for a fusion reactor to effectively produce energy, three main conditions must be fulfilled:

First, the fusion fuel, a mixture of the hydrogen isotopes deuterium and tritium, must be brought to a temperature of at least 100 million degrees Celsius. At this temperature the fuel is in the form of a highly energy-dense ionized gas known as a plasma. The high temperature produces a pressure several times that of ordinary atmospheric pressure within the reaction chamber.

Second, a plasma density of about 100 trillion (10^{14}) particles per cubic centimeter must be maintained; this is 100,000 times less dense than ordinary air in a room.

Third, the plasma must be maintained in the above conditions for at least 1 second in order for the fusion reactions between energetic deuterium and tritium ions to release more energy than was deposited in the plasma by the heating systems.

How JET Works

The JET experiment operates on the tokamak principle, which was first developed in the Soviet Union and brought to a high degree of perfection in U.S. experiments. Tokamak reactors utilize a system of powerful magnetic coils to create a "magnetic bottle" capable of containing the hot plasma. These coils are grouped around a torus- or donut-shaped vacuum chamber in which the ring-shaped plasma column is located. The plasma particles, which are positively charged ions and electrons, are "trapped" within the magnetic field induced by the coils.

The vacuum chamber of JET is immense—large enough for two men, with one standing on the shoulders of the other! The volume of the plasma column in the JET is 180 cubic meters, six times larger than the second biggest tokamak reactor in the world, the TFTR.

The JET has two coil systems (see figures). First, there are 32 D-shaped main

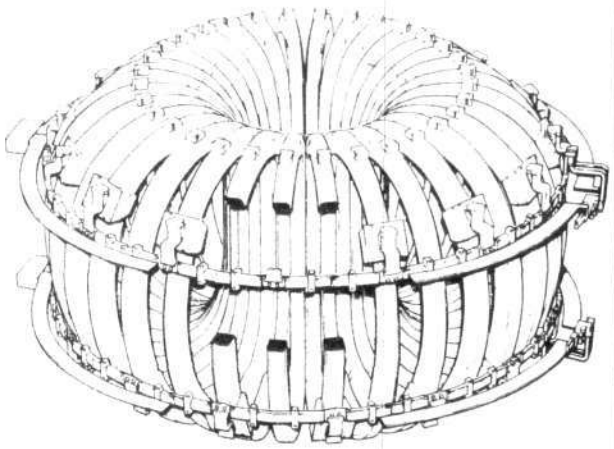


Figure 1
TOROIDAL COIL SYSTEM
JET's 32 D-shaped toroidal coils generate a powerful magnetic field whose field lines run parallel to the axis of the torus.

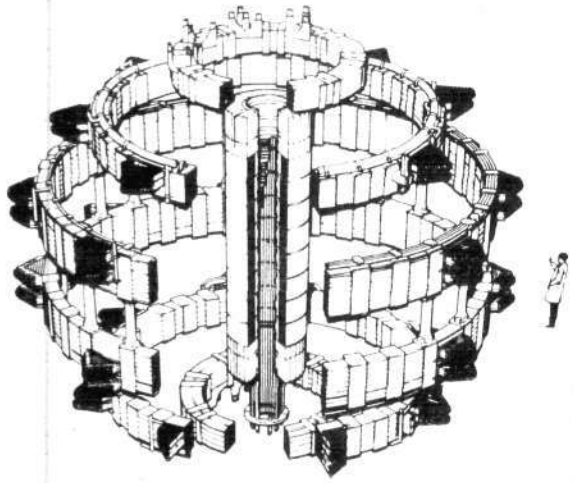


Figure 2
POLOIDAL COIL SYSTEM
JET's poloidal coil system consists of an inner coil system—the eight inner coils on the central axis of the torus—and a secondary coil system going the long way around the torus.

field coils, each weighing 12 tons. These coils generate a powerful toroidal magnetic field, whose field lines run parallel to the axis of the torus. This field forms the most important component for containing the plasma.

Second is the poloidal field system, which consists of an inner and an outer coil system. The eight inner coils on the central axis form the primary winding of a transformer. With the plasma ring itself as the secondary winding, this is used to generate a powerful electric current of 2.6 to 4.8 million amperes in the plasma. This plasma current, in turn, generates a poloidal magnetic field, running in the circular direction around the plasma column. The poloidal field forms the second principal component of the "magnetic bottle."

At the same time, the induced current helps to heat the plasma. The outer poloidal coils regulate the position of the plasma column within the reactor chamber and prevent the hot plasma from breaking out of the bottle and touching the walls of the chamber.

25 Megawatts of Heating Power

JET uses three separate heating systems, based on different principles, to bring the reactor plasma to the required ignition temperature of 100 million degrees. In all, a total heating power of some 25 million watts will be applied in the ignition experiments planned for mid-1988.

The first stage of heating, common to all tokamaks, is known as Ohmic heating. At the beginning of the experiment (called a "shot" by experimenters), cold gas is puffed into the reactor chamber. Next, a powerful surge of current in the poloidal transformer induces an electric field in the chamber, causing the gas to become ionized and generating a current in the ionized gas.

This current then heats the plasma to temperatures of up to 10 million degrees by a physical mechanism similar to that of electric heaters: The electrical resistance of the plasma causes a portion of the current energy to be converted into heat.

Because the plasma resistivity decreases with increasing temperature, however, additional heating systems are required. One of these systems, which has proven very successful in earlier experiments, is called neutral injection heating. In this method, hydrogen or deuterium ions are accelerated to very high energies. Since the magnetic fields of the tokamak bottle would block these charged particles, the accelerated beams of ions first pass through a chamber of hydrogen gas, where they neutralize themselves by "stealing" electrons. The successfully neutralized ions then pass through the magnetic field into the plasma and heat it up.

These neutralized ions reach 80,000 electron volts (about 80 times the energy of the ions in the plasma), depositing a considerable amount of it in the plasma—10 megawatts when JET is operating at full power. However, the limited efficiency of this heating method—almost 100 megawatts of power is consumed by the JET's neutral heating system, compared to the 10 megawatts "end-effect"—and the difficulty of reaching the core of the plasma given the limited penetrating power of the neutralized beams, dictated the need for an additional heating system. This is provided by so-called high-frequency heating.

This method exploits the fact that a plasma, a complex electromagnetic system of ions and electrons coupled by electric and magnetic fields, is capable of numerous types of oscillations. High frequency radio waves, if tuned to any of the characteristic resonant frequencies of the plasma, can effectively couple their energy with that of the plasma, thereby heating it in a highly selective manner. In JET, the so-called ion cyclotron resonance is used. High frequency electromagnetic radiation is fed into the plasma by means of antennae located just outside the

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Sandia Achieves Breakthrough In Particle Beam Focusing

Sandia National Laboratories announced May 17 that it had demonstrated that beams of subatomic particles can be focused just like beams of light. The Sandia group, under the direction of David J. Johnson, succeeded in focusing a proton beam generated by the Proto I accelerator down to a spot size with a radius of 0.65 millimeters. Proto I is a high power, short pulse accelerator in Sandia's particle beam fusion accelerator program. The accelerator now focuses on a spot less than half the size of a pellet of fusion fuel.

The breakthrough was achieved by applying geometrical optics to remove astigmatism from the beam (see below). Electrodynamic effects that many had assumed must always tend to defocus the beam were completely "tamed" by changes in the curvature of the beam-emitting anode "lens."

Particle beam focusing, a much discussed and little understood problem, is necessary in order to concentrate a beam on a target to produce nuclear fusion. The problem is to design the beam-generating equipment, especially the diode, so that the beam converges at the same spot at the same time. In previous experiments, the spot size of the focus was "blurred," so it was larger than the size of a pellet of fusion fuel; that is, too large to be of use in achieving fusion energy.

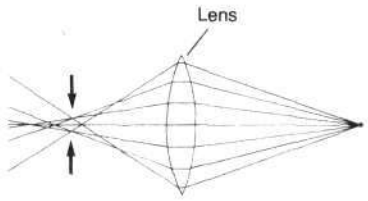

Figure 1
OPTICAL ASTIGMATISM
Because of the shape of the lens, light does not focus at a single point, but at several points along the focal plane, producing astigmatism.

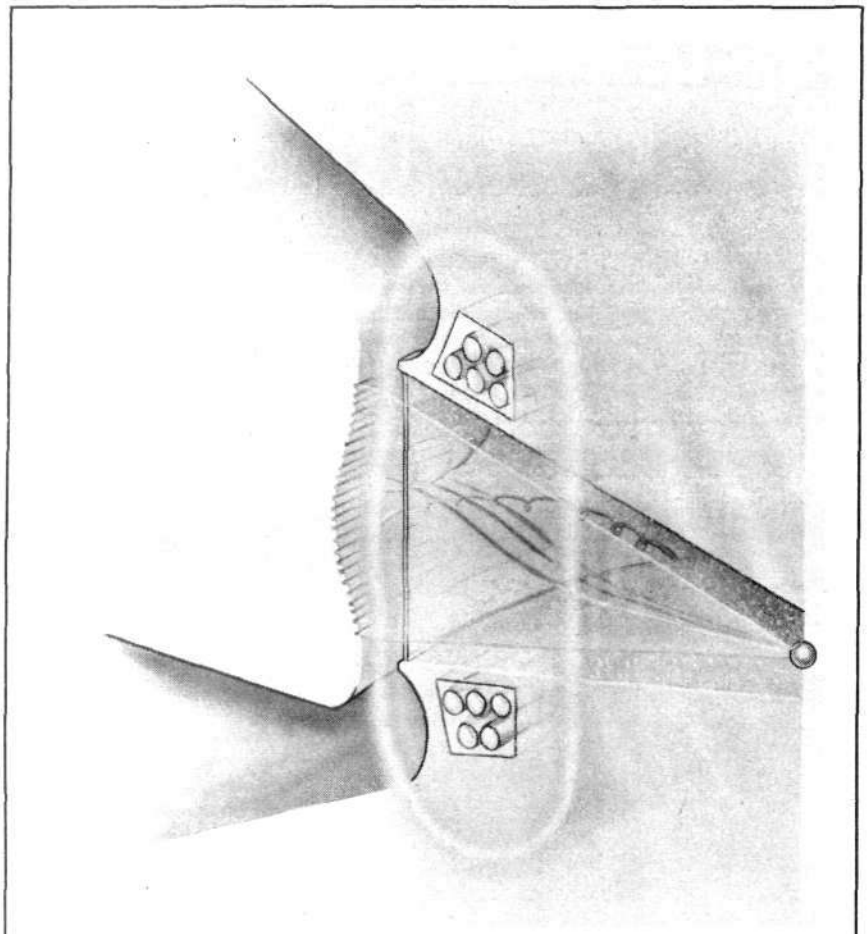

Figure 2
NEW DIODE USED BY SANDIA NATIONAL LABORATORIES
At left is the ion-emitting anode surface, whose curvature is the critical element in producing a focused beam. At right is a fusion fuel pellet.

Some physicists, such as Kosta Tsipis of the Massachusetts Institute of Technology, argue that electrodynamic properties of particle beams of all types make it impossible to produce a focused beam: The spreading of the beam out from its source is inevitable, Tsipis and others say, in their arguments against a beam weapon defense. The Sandia group has refuted this, although on a small scale.

The Only Remaining Problem

Particle beam fusion and laser fusion are the two principal methods being pursued to demonstrate inertial confinement fusion energy. In inertial confinement, intense beams of either ions (charged atomic particles) or laser light irradiate, heat, and compress pellets of deuterium and tritium (isotopes of hydrogen). This work is pursued for two immediate purposes: the development of controlled nuclear fusion for electrical power production, and the study of small "thermonuclear" explosions for weapons-physics research.

Focusing was the only remaining problem before Sandia could scale up its existing equipment to meet its goal of demonstrating fusion in 1988 with a more powerful machine now under construction.

Commenting on the breakthrough, David Johnson said: "For the first time, we were able to show that intense ion

beam diodes behave like optical elements. A small change in the lens curvature [the curvature of the ion-emitting, anode surface] produces a precisely defined change in the focal spot."

Johnson is referring to the relationship between lens curvature and focus in an optical system. Figure 1 shows how a bad lens may focus light at several positions along a focal plane, producing what is called astigmatism. This is precisely what plagued the Sandia particle beam diode.

Correcting Astigmatism

Figure 2 shows the Sandia device that corrects this astigmatism. In beam generation, a pulse of energy moves down transmission lines from the left toward the striated curved surface in the center of the figure, the anode. The pulse creates a plasma on the anode. This then emits the beam of positively charged nuclei, or ions, across a gap through the cathode, a cloud of electrons, toward the fusion fuel pellet at the far right.

Prior to the breakthrough, the beam was not converging as one on the pellet but separate "strands" were converging, some in front of the pellet and some behind it—as Figure 1 shows in the case of light. Johnson simply changed the curvature of the anode to achieve simultaneous focus of the entire beam on the target.

The development of a new diagnostic procedure helped produce the breakthrough because it permitted Johnson to examine the focusing of the beam more directly. "Different parts of the beam focused at different positions and did so every time," he said. "The surprise was that the beam was so reproducible from trial to trial. . . . It was like trying to focus light through a bad lens, so I changed the curvature of the ion-emitting surface to correct the astigmatism."

Before this discovery it was thought that beam spreading was caused by a number of different effects, and that extensive changes would be required to improve the device. This previous hypothesis was presented by Johnson and his colleagues at the Beams '83 conference in San Francisco in September 1983.[1] The Sandia group asserted there that beam focus was depen-

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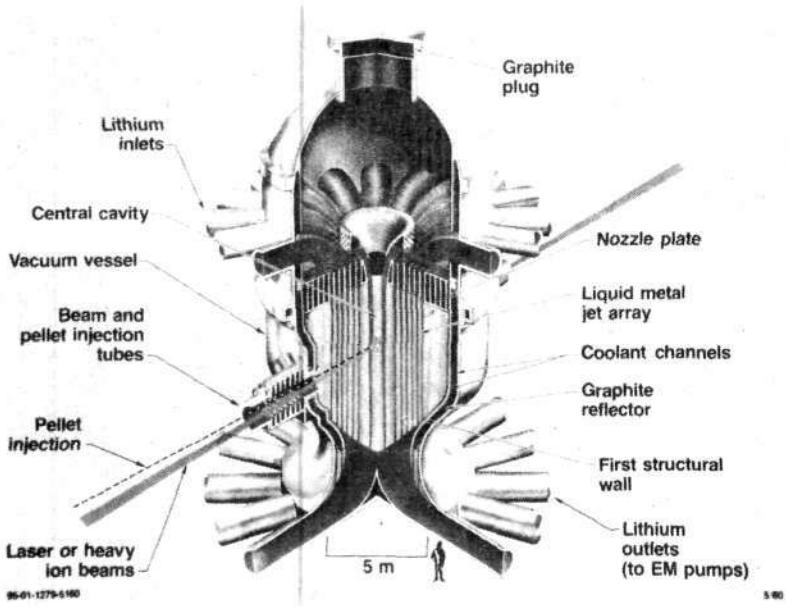


HYLIFE FUSION REACTOR CHAMBER

This fluid-shielded laser fusion reactor is approximately the same size and same power as a light water fission reactor, thus leading to considerable savings in the cost of the power produced. In general, without fluid shielding, fusion reactors are much larger than fission reactors. The shielding provides substantial protection for the reactor wall from neutron damage.

Hylife uses a shower bath of lithium jets. The laser beam is injected to the fuel pellet through openings in the pattern of jets.

Livermore Study Shows Fusion Will Be Cheapest Energy Source

Fusion has the ultimate economic potential of generating electricity for half the cost of the currently cheapest methods—nuclear fission and coal. This is the revolutionary conclusion of a new analysis of fusion's economic prospects by Dr. John H. Nuckolls, associate director for physics at Lawrence Livermore National Laboratory's Inertial Confinement Division.

Nuckolls used new results from recently completed advanced reactor designs to make this point to the European Laser-Matter Interaction Conference held in London, England, in October 1983. "Relative cost escalation would increase this advantage," Nuckolls said. Fusion's potential economic advantage derives from two fundamental properties: negligible fuel costs and high quality energy (which makes possible more efficient generation of electricity)."

All previous fusion reactor studies have come in with projected costs 25 to 100 percent greater than fossil and fission. As Dr. Nuckolls concluded in his report, "This is a remarkable and exceedingly important result. . . . This low cost economic potential would provide strong commercial incentives to accelerate the pace of fusion development in the near term, and to install a fusion energy system in the long term."

Although Nuckolls primarily focuses on inertial confinement fusion, the type of fusion he helped pioneer, he noted: "These remarks about the economic potential of fusion apply to all of fusion not just inertial fusion." Nuckolls concluded that development of both general approaches to fusion to should be accelerated.

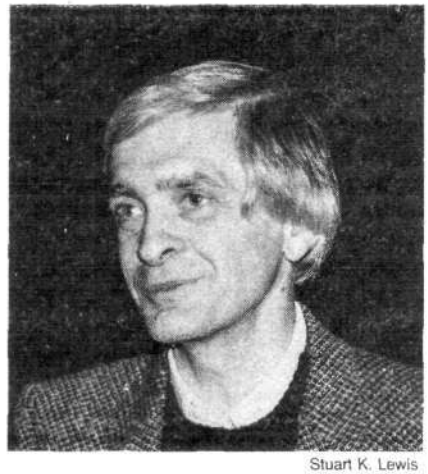
In describing the scientific prospects for inertial confinement, Nuckolls identified the crucial benefits of polarizing fusion hydrogen fuel. This

can lead to a threefold decrease in the laser energy required to achieve inertial confinement and to the development of entirely new approaches to inertial confinement target design. *Fusion* magazine was the first to point out the unique applications of polarized fusion for inertial confinement in a special issue in September 1982.

In his economic analysis, Nuckolls showed that spending a few billion dollars to accelerate the development of fusion now will pay off in the tens of trillions of dollars in the 21st century in the world energy market and will guarantee the technological preeminence of U.S. industry. Nuckolls concluded that because of this tremendous payoff, the United States "has strong incentive to accelerate fusion research—other nations have similar incentives."

In addition to developing the new analysis of the economic potential of inertial confinement, Nuckolls also reviewed its current scientific and technological status: "Inertial fusion must demonstrate that the high target gains required for practical fusion energy can be achieved with driver energies not larger than a few megajoules. Before a multi-megajoule scale driver is constructed, inertial fusion must provide convincing experimental evidence that the required high target gains are feasible. This will be the principal objective of the Nova laser experiments. Implosions will be conducted with scaled targets which are nearly 'hydrodynamically equivalent' to the high gain target implosions. . . ."

"Since the inception of the first experimental laser fusion program at Livermore in 1963," Nuckolls wrote, "the long range strategy has been to build a sequence of successively larger lasers until thermonuclear ignition is finally achieved. Beginning with the few-joule laser in 1966, we have progressed to the 10-kilojoule Shiva laser in 1978 and the 10-kilojoule Novette short wavelength laser which was completed last year. Next year the 100 kilojoule Nova laser will become operational. Each laser in this sequence has been used to conduct critical experiments, and to develop new technologies, which made possible building of the next tenfold-larger laser. Beyond Nova, a multi-megajoule driver will be required to demonstrate that high gain targets required for practical energy applications are feasible."



Stuart K. Lewis

Dr. John Nuckolls

In formulating his economic analysis, however, Nuckolls utilized only the most conservative estimates for target gains, pointing to the more advanced possibilities, such as polarized fusion, as providing a general backup.

Why Fusion Is Cheaper

In his economic study Nuckolls takes nuclear fission, which is significantly cheaper than coal, at its best—that is, assuming an infinite fuel supply, possibly provided by a fission-fusion hybrid breeder, and with an advanced reactor design that can be constructed in five years: "Fusion has two principal assets which could potentially confer a factor-of-two advantage. First, the typical fuel cycle cost for a light-water [fission] reactor is approximately 20 percent of the total busbar cost [cost at the point of transmission] of fission energy. With the hybrid 20 percent escalation factor, the fission fuel costs would give fusion a 40 percent advantage since its fuel costs are negligible. Second, there is another possible 40 percent advantage which derives from a combination of two factors: the high quality of fusion energy and the fluid insulation of fusion reactor walls [the magnetic fields in magnetic fusion reactors and liquid jets of lithium in inertial confinement reactors]. These two factors taken together make possible a 40 to 50 percent increase in the electrical generating efficiency. Multiplied together, fusion's two 40 percent assets provide a twofold advantage over fission."

The most important new point Nuckolls raised in his London presentation is that inertial fusion can utilize the far more efficient magnetohydrodynamic, or MHD, method of electricity generation in a manner that is not only technologically feasible but also simultaneously successful in overcoming the difficulties inherent in high energy neutrons produced in deuterium-tritium (DT) fusion. MHD directly converts the heat from a fusion reactor into electric power with no moving parts.

It has often been pointed out that if some process for directly converting high-temperature fusion energy output into electricity existed, then efficiencies of 99.99 percent could be achieved. Nuckolls described a process that can attain at least 70 percent efficiencies and thereby double the potential electrical output of an inertial fusion reactor. In this process Nuckolls and his collaborators at Lawrence Livermore have turned the neutron damage problem on its head. The solution is to surround inertial confinement exploding pellets with a pill-shaped mass of solid lithium. The fusion-generated neutrons are then captured within this solid mass, causing it to blow up. But because neutrons deposit throughout the volume of the lithium pillbox, the second explosion can be shaped by properly arranging the geometry of the pillbox.

For example, the neutron deposition can be made to generate converging shock waves. And the energy density of the neutron deposition is still sufficient to transform the pillbox lithium into a high temperature plasma. The final result is that the vast majority of the fusion energy output can be transformed in straightforward manner into directed plasma jets.

High-temperature plasma jets greatly simplify MHD electricity generation. And, in general, plasma jets are ideal for all kinds of energy transformations, such as microwave generation. The reasons are easy to describe in the specific MHD case, but it should be noted that the general point of transforming a high temperature "thermal" fusion output into a slightly lower temperature "directed" plasma jet has profound theoretical implications.

—Charles B. Stevens

A REVIEW OF NEW DEVELOPMENTS

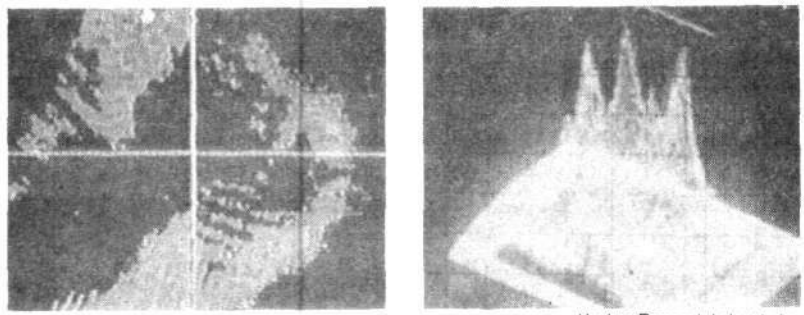
Lasers Can Propagate Through the Atmosphere

Recent developments in laser technology have disproved those scientists who claim that lasers cannot propagate through the atmosphere. Although most of the scientific work is classified, these breakthroughs in laser propagation are undoubtedly what informed presidential science advisor George Keyworth to state publicly that beam weapon defense was feasible based on "very recent advances that *permit us to compensate for atmospheric break-up of laser beams.*"

This report on optical phase conjugation of laser beams has been compiled from a survey of the unclassified literature[1] and discussions with scientists at the national laboratories.

At the May 1983 Conference on Lasers and Electro-Optics (CLEO) in Baltimore, R.C. Lind and G.J. Dunning of Hughes Research Laboratories reported the first demonstration of the dynamic correction capability of optical phase conjugation in the face of severe distortions produced by atmospheric turbulence.[2] More recently, the June 1984 *Science Digest* reported that scientists at Hughes had told them that conjugated laser beams can propagate 60 miles through the atmosphere—in other words, a distance sufficient to reach space-based orbiting mirrors that can redirect such a beam onto a ballistic missile target.

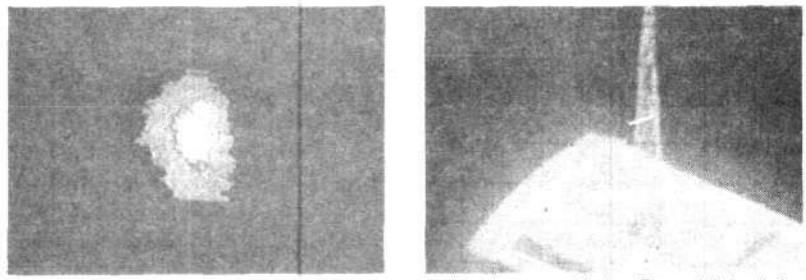
In the Hughes experiment, Lind and Dunning double-passed a beam produced by a 20 milliwatt dye laser through a 100-meter range of turbulent atmosphere. After the first pass through the range, the probe beam displayed high frequency phase errors, severe wander, and intensity nulls on its axis (Figure 1). The beam was then directed into the conjugator. The conjugated beam returned over the range and the corrected beam was picked off at the transmitter. The corrected beam was nearly identical to the 1 × 2 cm elliptical profile of the original probe beam (Figure 2).



Hughes Research Laboratories

Figure 1
BEFORE PHASE CONJUGATION: ABERRATED BEAM

Hughes Research Laboratories has demonstrated that optical phase conjugation can solve the problem of laser beam aberration in propagation through the atmosphere. At left is the computerized profile of a laser beam after being passed through 100 meters of turbulent atmosphere. At right is the computerized isometric projection of the beam.



Hughes Research Laboratories

Figure 2
AFTER PHASE CONJUGATION: CORRECTED BEAM

Phase conjugation sends a beam of light back in exactly the same path it had traveled. The result is that a divergent beam is reflected convergent, or focused. At right is the computerized profile of the laser beam shown in Figure 1, after being conjugated and passed back through the 100-meter range of turbulent atmosphere. The isometric projection at right shows a finely colimated beam.

The field of optical phase conjugation, it should be noted, was founded by Soviet scientists and continues to be dominated by Soviet investigators. In a recent review paper, approximately one-half of the 183 references were to Soviet journals.[3]

How Optical Phase Conjugation Works

Optical phase conjugation involves the use of nonlinear optical effects to precisely reverse the direction of propagation of each plane wave in an arbitrary beam of light, thereby causing the return beam to retrace exactly the path of the incident beam.

Phase conjugators, also called phase conjugate mirrors, do not reflect a beam the same way a conventional mirror does (Figure 3). When a beam

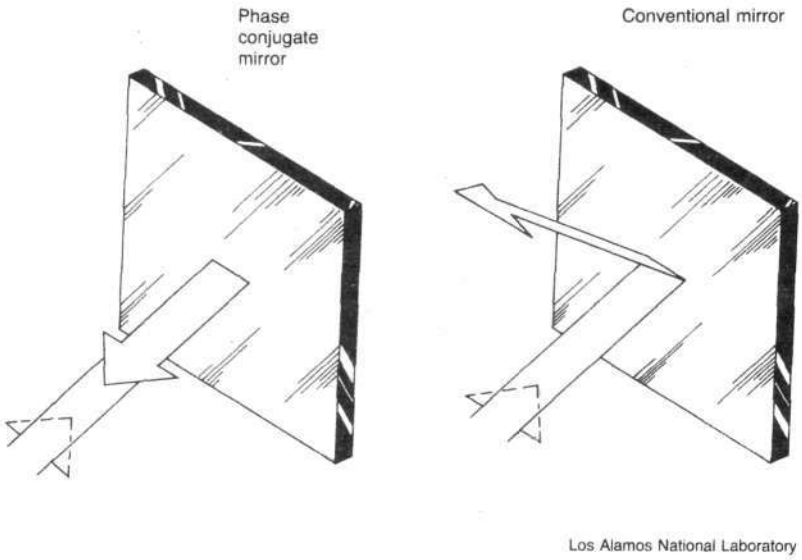


Figure 3
CONVENTIONAL VS. PHASE CONJUGATE MIRROR
When a conventional mirror (right) reflects a beam, the angle of reflection is the complement of the angle of incidence; a diverging beam continues to diverge after reflection. When a phase conjugate mirror (left) reflects a beam, it sends it back in the same direction it came from, and makes a divergent beam convergent, or focused.

is reflected from a conventional mirror, its angle of reflection is the complement of its angle of incidence, and if the beam is at all divergent it continues to diverge after reflection. Since a conjugator sends the beam right back where it came from, the angle of reflection equals the angle of incidence and a diverging beam becomes convergent upon reflection. If it were possible to take a moving picture of the process, the behavior of the conjugate wave would be portrayed by running the film backwards.

This effect occurs despite any beam interference from an aberrator, such as a broken piece of glass or turbulent atmosphere. In other words, conjugation can enable a designer to get around imperfections in an optical system or turbulence in the atmosphere. For beam conjugation to be helpful in producing a focused beam on target, it is necessary for the response time of the conjugator to be faster than that of the aberrator; that is, if the atmosphere has time to change during conjugation, the conjugated beam may not emerge from it focused. Lind and Dunning found atomic sodium to be a successful conjugator because of its rapid 10 nanosecond response time.

In general, the scientific community does not understand how optical phase conjugation works. The process involves the relationship between matter and energy in the most fundamental way. In every case of optical phase conjugation, energy pumped into a liquid, gas, or solid excites that medium to reflect the conjugate of an incident laser beam. The material medium used will conjugate only specific wavelengths. More than 300 materials have been identified as appropriate as conjugators across a spectrum of wavelengths from 10.67 to 0.25 microns and materials that vary from water to crystals to gaseous mercury.[3]

Optical phase conjugation "works" because of the underlying physical continuity between matter and energy, the harmony between substance and light. These are the most fundamental issues of quantum physics—issues that most physicists do not comprehend.

Beam defense advocate Lyndon H. LaRouche, Jr. addressed these fundamental issues before a Washington audience in April 1983: "If we concentrate even a fairly small quantity of wattage on a sufficiently small area, the concentration of energy can be made sufficient to 'boil,' so to speak, any material. . . . This is described more accurately by reporting that each range of the upper electromagnetic spectrum (that is, ranges of shorter wavelength) has very distinct qualities of harmonic resonance."

Some History

There are two forms of optical phase conjugation investigated today: back-

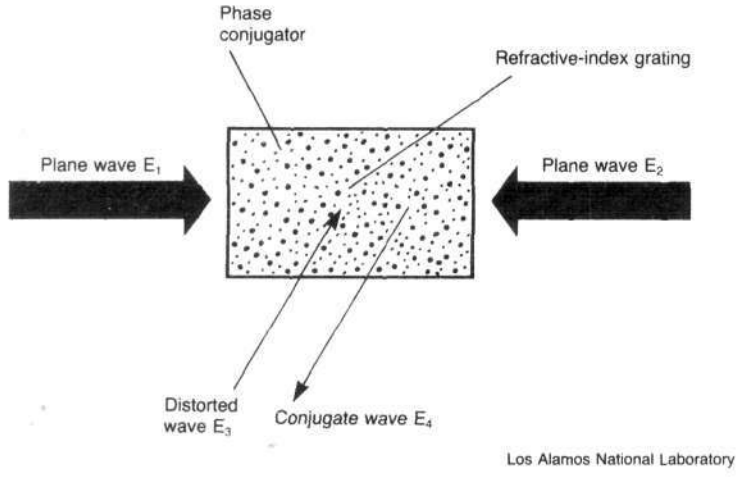


Figure 4
PHASE CONJUGATION WITH FOUR-WAVE MIXING
In degenerate four-wave mixing, two pump beams E_1 and E_2 interact with a distorted probe beam E_3 in a nonlinear material or conjugator to produce, for example, the convergent conjugate of an originally divergent probe beam E_4.

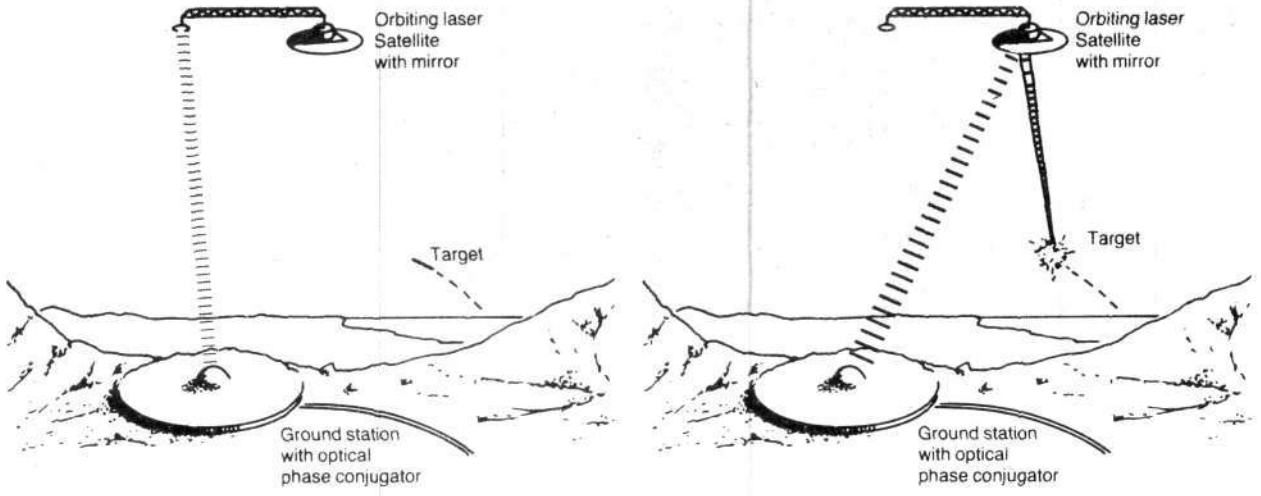


Figure 5
BEAM DEFENSE DEVICE USING PHASE CONJUGATION

This FEF design for an application of phase conjugators eliminates the need to orbit large laser amplifiers in a space-based laser defense system. To destroy a ballistic missile target, a satellite equipped with a mirror and a small laser directs its beam toward the laser amplifier/phase conjugator facility on Earth. The ground-based facility conjugates the beam and amplifies it to the power required to destroy the target. The amplified beam is then reflected off the orbiting mirror to the target.

ward stimulated Brillouin (or Raman) scattering and degenerate four wave mixing (DFWM). In 1972, B. Ya. Zel'dovich, V. I. Popovichev, V. V. Ragul'skii, and F. S. Faizullov of the Soviet Academy of Sciences demonstrated phase conjugation with Brillouin scattering.

In backward stimulated Brillouin scattering, an intense laser beam in a fluid produces a sound wave. The shock front of this wave backscatters the incoming beam as its conjugate. This outgoing laser beam has a frequency downshifted from the incoming laser beam by an amount equal to the frequency of the sound wave created—approximately a 0.01 percent change in frequency. (This is an illustration of sound as another form of electromagnetic radiation, a concept proposed by Lyndon LaRouche.)

B. I. Stepanov, E. V. Ivakin, and A. S. Rubanov first demonstrated distortion correction with degenerate four wave mixing in 1970. Lind and Dunning also used a DFWM conjugator in their experiment. In degenerate four wave mixing, three beams of the same frequency interact in a nonlinear medium to produce a fourth beam, which is also of the same frequency, and is the conjugate of one of the others. Two beams "pump" the medium from exactly opposite planar directions (Figure 4).

The third beam (the probe) is the beam to be conjugated; it enters the medium at the required angle and interacts with it and the pumps so that its conjugate is produced. In DFWM, the power of both the pumps and the probe determines the power of the output conjugate beam. Therefore, it is possible by combining high-power pumps and a low-power probe to achieve a "reflected" conjugate of greater power than the probe. So far, conjugates have been produced with powers 100-fold greater than their probes.

Applications of Phase Conjugation

Optical phase conjugation can be used for any laser application that requires long-distance transmission through inhomogeneous media; for example, laser communications with submarines or directed energy beam weapons. In one scenario the FEF has proposed, the attack sequence against a ballistic missile in its boost phase is initiated by a small laser aboard an orbiting mirror spacecraft (Figure 5).

First, the spacecraft directs its beam downward through the atmosphere to the Earth-bound conjugator and amplifier.

Second, on the ground, the arriving pulse passes through a laser amplifier enroute to the conjugator. The pulse is conjugated and amplified on its second pass to missile-kill intensities.

Third, the pulse travels upwards to deflect off the orbiting mirror at the appropriate angle to intercept the target.

There are other characteristics of optical phase conjugation useful for directed energy beam weapons and other systems. For example, since the output conjugate beam follows the probe beam exactly, the conjugate beam can remain locked on a target (such as an orbiting mirror) without the use of complicated pointing and tracking mechanisms.

—Robert Gallagher

Notes

1. Readers are referred to C. R. Giuliano, "Applications of Optical Phase Conjugation," *Physics Today*, April 1982, p. 27-35; and Barry J. Feldman, et al., "Through the Looking Glass with Phase Conjugation," *Los Alamos Science*, Fall 1982, p. 9-17.
2. A report on Lind and Dunning's presentation at the CLEO meeting can be found in *Laser Focus/Electro-optics*, September 1983, pp. 12-14.
3. Robert A. Fisher, "Phase Conjugation Materials," to appear in *CRC Handbook of Lasers*.

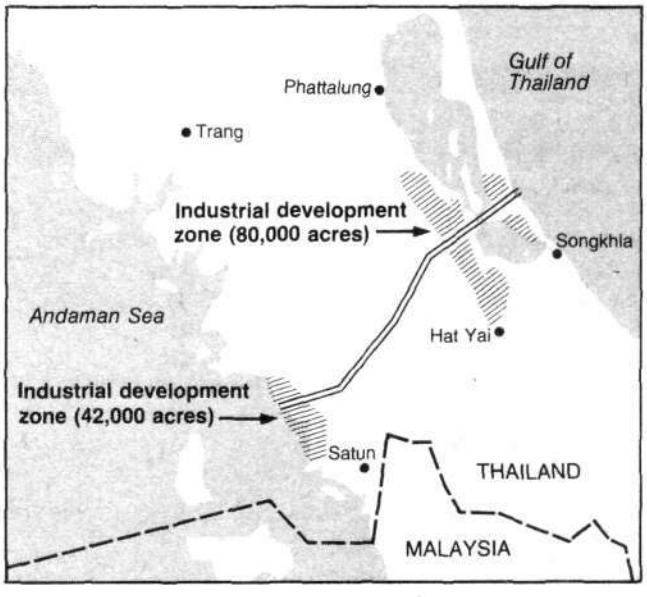
KRA CANAL
Cornerstone of Asian Development

by Uwe Parpart Henke

EDITOR'S NOTE

A year ago, in July-August 1983, Fusion Energy Foundation research director Uwe Parpart Henke and board member Lyndon H. LaRouche, Jr. made a fact-finding tour of Japan, India, and Southeast Asia. At that time, LaRouche proposed a 50-year "Great Projects" global infrastructure building program to transform the economies of the Pacific and Indian Ocean basins. A key feature in the plan was the construction of a sea-level canal across the Isthmus of Kra in Thailand.

In September 1983, a conference to discuss the details of this "Great Projects" development program, cosponsored by the FEF and the weekly magazine *Executive Intelligence Review*, was held in Washington, D.C., and attended by 500 representatives of the diplomatic community, government agencies, industry, and Asian organizations. This was followed by a conference in October on the Kra Canal in Bangkok, cosponsored by the FEF, EIR, and the Thai Ministry of Communications.



The Kra Canal Project – Proposed Route 5A

The Kra Canal would save about 1,200 miles in shipping transport in Asia. It would also link the Indian Basin, which includes Sri Lanka, Pakistan, India, and Bangladesh, with the Pacific Basin nations. India now has very little trade with Asia, with the exception of Japan. It is essential to link up India's skilled scientific manpower and capital-goods production with the fastest growing region in the world.

Today, in June 1984, interest in the Kra Canal project is at its highest level since 1973, when the original engineering studies were submitted to the Thai government. On March 19, 1984, the FEF and EIR presented a study of the financial and economic feasibility of the Kra Canal to 40 top corporate executives, government officials, and military observers, who gave the study a very favorable review. Corporate participants included the three top shipping firms in Asia, Maersk Lines, East Asiatic, and Sealands; Bangkok Bank, Thai Farmer's Bank, and Chase Manhattan Bank; and interested Japanese firms, Mitsui and Mitsubishi.

Here we present an overview of the Kra Canal project along with excerpts from the FEF/EIR study on the use of peaceful nuclear explosives to construct the canal.

* * *

As far back as 1793, the younger brother of King Rama I of Thailand (Siam) had proposed to dig a canal across the peninsula of Thailand south of the Isthmus of Kra, connecting the Lake of Songkhla and the South China Sea with the Indian Ocean. The motivation at the time was to facilitate military and naval operations against frequent Burmese invasions. However, in spite of numerous military and, even more important, commercial advantages, no such canal has been constructed to date as the project remains a subject of political controversy.

From the standpoint of facilitating greatly increased trade and rapid ocean transport between the Indian Ocean basin and the Pacific Ocean basin and, more broadly, between the Western world and the countries of Southeast and East Asia, there is, however, no question about either the urgent need for the Kra Canal or its pivotal role in the economic development of Thailand and the entire region. The Straits of Malacca, which now handle most of the relevant traffic, are highly congested and will become quite inadequate by the end of this decade based on even modest projections of increased trade flows.

A relatively recent feasibility study for the Kra Canal, commissioned in the early 1970s by Mr. K.Y. Chow of the Thai Oil Refining Company, can serve as an excellent basis for initiating the project as soon as Thai government approval is secured. Of course, the feasibility study in question, carried out by engineers and planners of Tippetts-Abbett-McCarthy-Stratton (TAMS) and Robert R. Nathan Associates, Inc. (RRNA), in collaboration with Lawrence Livermore National Laboratory of the United States and submitted in September 1973, is now dated and requires extensive

Shipbuilding in South Korea.

ASIA: CENTER OF GRAVITY OF WORLD TRADE

The Indian and Pacific Ocean basin is already the center of gravity of world trade, as the map indicates. The trade volume for exports and imports, shown here in millions of metric tons, was compiled from the United Nations country statistics for 1980.

Over the past 20 years, the tonnage of imports in this area increased from 171.6 to 912.9 million tons, while exports went from 81.8 to 540 million tons. The compounded rate of growth of two-way trade for this period was 9.1 percent per year. The per annum growth rate in trade in this period is 80 percent higher than the rest of the world's, 90 percent higher than that of the United States, and 150 percent higher than that of West Germany.

A few more statistics make the point: 49.9 percent of all iron ore shipped in the world goes to Asia, (42.5 percent of it to Japan), 44.5 percent of all coal, and 33.9 percent of all grain. In all, 2 out of every 5 metric tons moving in the world are going to Asia.

Indian Exports

U.S.	0.2
Europe	12.2
Asia	25.3
Mideast & Africa	19.4
S. America & Oceania	0

Indian Imports

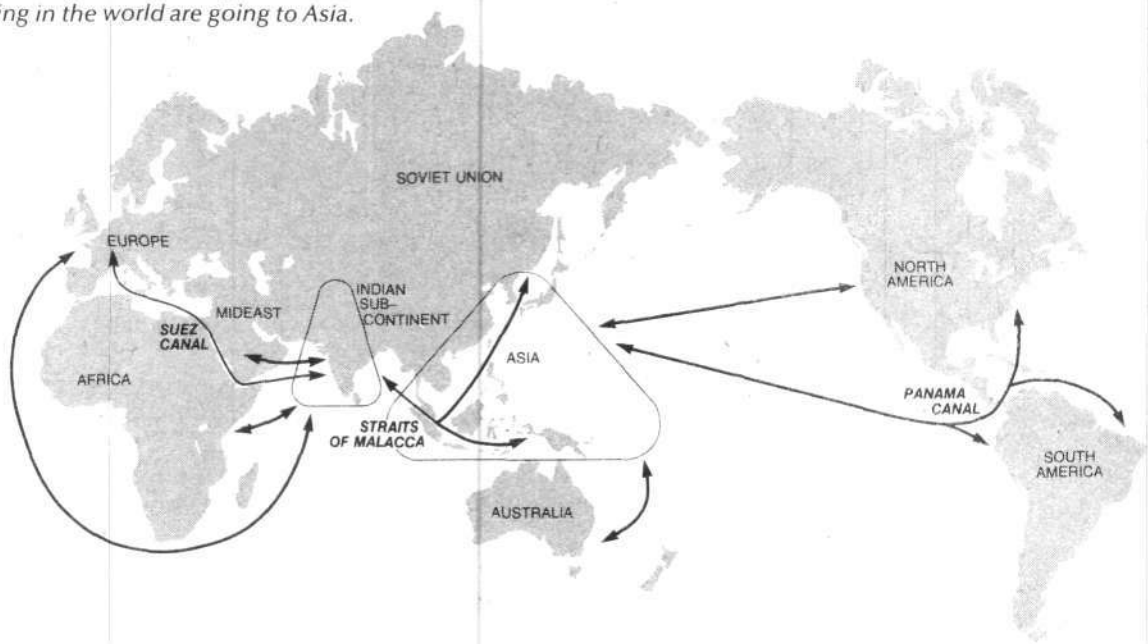
U.S.	5.4
Europe	4.0
Asia	8.9
Mideast & Africa	30.8
S. America & Oceania	1.6

Asian Exports

U.S.	43.4
Europe	23.2
Asia	175.3
Mideast & Africa	31.9
S.America & Oceania	20.5

Asian Imports

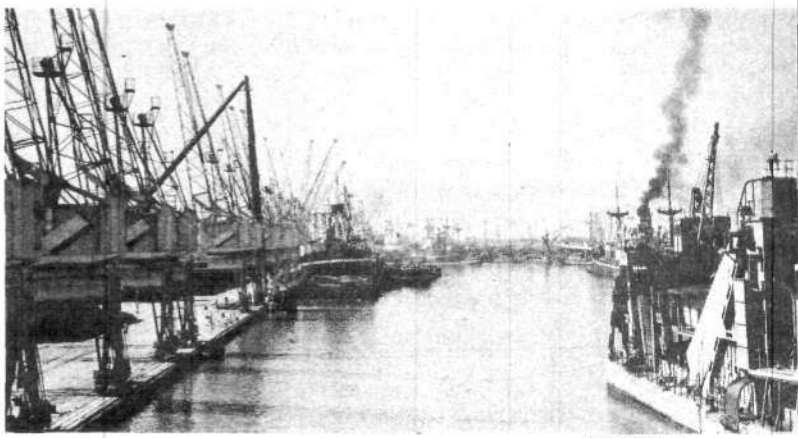
U.S.	126.6
Europe	12.2
Asia	194.4
Mideast & Africa	313.6
S. America & Oceania	202.9



review. Such review would principally have to evaluate economic feasibility and financing proposals. The engineering conclusions of the TAMS-RRNS study, in the view of this writer, remain valid, though in certain instances very recently developed technologies could shorten construction time and improve final performance.

The Kra Canal Project, as detailed in the TAMS report, differs conceptually from earlier major canal projects with which it would reasonably be compared, for example, the Suez and Panama Canals. The transport distance saved by building the Kra Canal—about 900 miles—would not by itself appear to justify the large expenditures in excavation and operating costs. There are two other principal factors which define the overall importance and viability of the project. These are: (1) the already mentioned growing *inadequacy of the Straits of Malacca*, and (2) the *industrial development potential* based on construction of *deep sea ports* at one or both of the canal outlets.

The Straits of Malacca are used by well over 50,000 ships a year and further significant increases in traffic are inevitable. Thus the Kra Canal could be expected to attract all excess traffic from the Malacca Straits as well as traffic which



United Nations

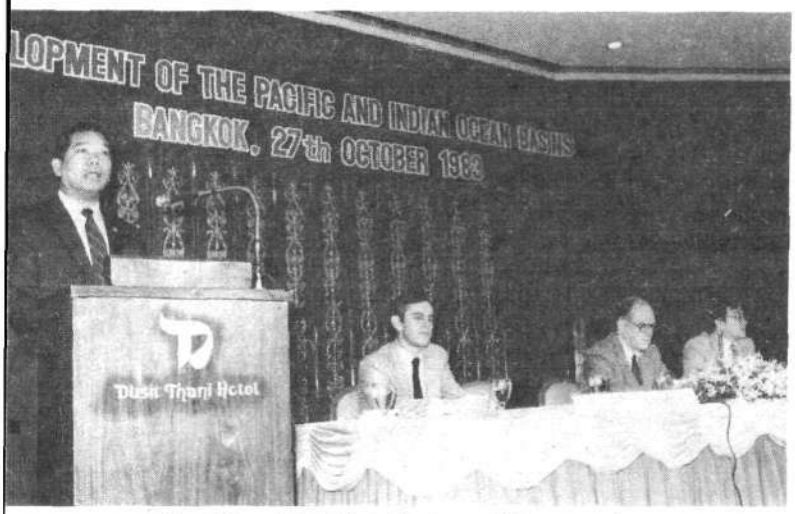
Electric cranes lined up in the port of Calcutta, India.

assigns a premium to speed. Emphasis on speed, as will be explained below, is a major reason why the TAMS study selected a canal route well south of the actual Kra Isthmus. This route, labeled 5A (see map), makes possible the construction of a *sea-level canal without locks* through which

even large (up to 500,000 dead weight ton or dwt) tankers could pass at normal speed. The integration of one (or possibly two) deep sea ports and associated industrial development zones with the Kra Canal proper can be expected to become the single greatest long-term economic asset of the entire project.

Taking the experience of the "Europort" of Rotterdam at the mouth of the Rhine River as a model, an "Asiaport" conjoined with the Kra Canal could become not only a major trade center for Southeast Asia, capable of eclipsing Singapore, but also has the potential—as proved by the Rotterdam and similar examples—of serving as a focal point for major industrial development.

A major included *strategic factor* also deserves the attention of Thai policy makers. Contrary to some reported opinion and concern that a canal through the southern part of the Golden Peninsula would have negative security implications, severing the ethnically and religiously ill-integrated southernmost part of the nation from the rest of the



The FEF and the Thai Ministry of Communications cosponsored a conference on the development of the Pacific and Indian Ocean basins in Bangkok. At the podium is Communications Minister Samak Sundaravej. Seated (from left) Uwe Parpart Henke, Lyndon H. LaRouche, Jr., and Pakdee Tanapura.

country, the opposite consequence would be the projected outcome. The canal complex as a major industrial growth-spot would function as an integrating and unifying factor, joining together the southern, central, and northern provinces in a large common endeavor capable of inspiring the entire nation, uplifting the economic condition of the southern population, and thus reducing the potential for dissatisfaction and dissension, while putting Thailand into a potentially commanding strategic position vis-à-vis its South and Southeast Asian neighbors.

Route Selection and Canal Specifications

Any canal-design study must give at least a preliminary answer to two basic questions: First, what size ships and what maximum volume of traffic are to be accommodated? Second, given preliminary answers to these questions, and given the geographical and geological constitution of the general area under investigation, what is (are) the optimal canal route(s) from the standpoint of these considerations.

(1) Ship sizes and traffic volume projections. It is clear that tankers of at least 500,000 dwt must be accommodated, and handling of larger tankers may be desirable. Maximum safe canal transit speeds with respect to the land of about 7 knots (13 km/h) for ships of this size represent the presently established international standard; in the view of this writer, which differs from that of the TAMS study, a two-lane canal is necessary. The assumption that one lane, handling mainly west to east traffic, is sufficient is based on the untenable premise that for a long time to come the export potential of the East and Southeast Asian nations will be small relative to Western imports.

The canal should preferably be sea level without locks, must accommodate drafts of at least 100 feet (fully loaded supertankers); that is, be at least 110 feet deep, and have a bottom width of approximately 500 meters. The alternative to one rather wide two-lane canal would be two one-lane routes of about 200 meters width each.

(2) Route selection. Extensive geographical and geological investigations have been carried out to find the optimal route for a sea-level canal of the above design specifications. Included in these investigations were considerations concerning required canal crossings for railroads, highways, and utilities. Relative excavation costs and, in particular, the feasiblity of nuclear excavation methods were prominently taken into account.

The preferred route settled upon by the TAMS-report (route 5A—see map) would extend from about 30 km north of the city of Satun to the Gulf of Thailand. The total canal length through land for this route is 102 km, with sea approaches of 50 km in the west and 70 km in the east respectively. This is the shortest possible route for a sea-level canal, minimizes excavation costs, and provides for the best possible sites on either end for harbor and industrial development. Construction time for route 5A using conventional excavation methods is estimated to be 10 to 12 years; partial use of nuclear excavation would cut both construction time and cost by at least 40 percent.

'Asiaport' and Industrial Zones

The construction of major deep sea port facilities and associated industrial development zones at either end of the Kra Canal is both feasible and highly desirable. However, phased port and industrial development, concentrating initially on the eastern canal outlet, appears to be the best strategy at this point.

This involves, in particular, a most interesting concept first proposed in the early 1970s by Mr. K.Y. Chow. Since most Southeast and East Asian ports with the exception of Hong Kong and Singapore are, at present, ill-equipped to handle large cargo vessels and could only be enlarged at very high cost, a port facility at Songkhla could rapidly develop into a major transshipment center for the entire region, capturing a very substantial portion of transshipment now handled by Hong Kong and Singapore.

This development, however, would only be phase 1 and should rapidly be followed up by construction of a compa-

Canal size (dwt)	Canal type (lanes)	Method of Construction	Cost (billions of US $1983)
500,000	2	nuclear	14.53
500,000	1	conventional	13.20
500,000	1	nuclear	8.37
250,000	2	conventional	19.51
250,000	2	nuclear	10.40
250,000	1	conventional	9.93
250,000	1	nuclear	6.38

Table 1
COST COMPARISONS FOR KRA CANAL BY SIZE AND CONSTRUCTION METHOD
The excavation and construction costs were taken from the 1973 TAMS study and put in 1983 constant dollars. The results led the EIR/FEF team to reject the previous preference for the 500,000-dwt ship size in favor of a 250,000-dwt two-lane canal, using PNE methods of construction.

rable facility at the western canal outlet. Even in the initial planning stage, both ports must also be laid out to handle not only transshipments, but also the subtantially greater berthing requirements that will arise out of area industrial development. The pattern of such industrial development requires intensive detailed study to be coordinated with existing Thai government plans for eastern seaboard development and construction of a deep sea port at Sattahip.

One possible outline pattern of industrial development for the Kra Canal Complex would look as follows:

(1) Initial development of industries and servicing facilities supportive of the canal and transshipment port projects. This would from the outset have to involve dry-dock and shipbuilding facilities, building a modern fleet of rapid feeder vessels as specified above. Phase 1 development must also take into account the immediate as well as long-term power requirements of the Canal Complex. If nuclear excavation is used, then the right kind of expertise would already be assembled in the region to consider construction of one or several nuclear power plants. Ideas going back to the mid-1960s for nuclear-industrial complexes should be reviewed in this context.

(2) Phase 2 should envisage the development of large and basic heavy industries developed both as an offshoot of the canal construction itself and as back-up for the proposed shipbuilding project—iron and steel as well as basic capital-goods industries as indicated.

(3) In an environment already shaped by nuclear excavation and power plant development, having assembled the required advanced engineering and scientific manpower, the exciting possibility arises of developing a modern nuclear-based high-technology complex. Lawrence Livermore National Laboratory experts have suggested that the world's first nuclear isotope separation plant of a significant scale might become associated with the Kra Canal Complex. Recent developments in laser technology would in that same context point to the possibility of developing new high-energy laser-based industries.

Financing the Kra Canal

At a March 19, 1984 meeting in Bangkok with government, financial, and corporate representatives, representatives of the EIR and FEF presented their joint study of the canal project and proposals for financing. A six-point, two-level financing package was suggested. The first level involves multilateral funding institutions like the World Bank and the Asian Development Bank and interest-free loans from the United States and Japan, the two primary foreign beneficiaries of the canal. The largest share in this category would have to come from the import-export banks of the leading advanced-sector countries and commercial banks. Ultimately, commercial banks would be expected to provide 40 to 50 percent of the total value of the project.

Type of Trade	Projected Compounded Annual Growth
Japanese oil imports	5%
All other Asian nation oil imports	8%
Bulk traffic (raw materials, grain, etc.)	8%
Cargo traffic (manufactured goods, capital goods, etc.)	10%

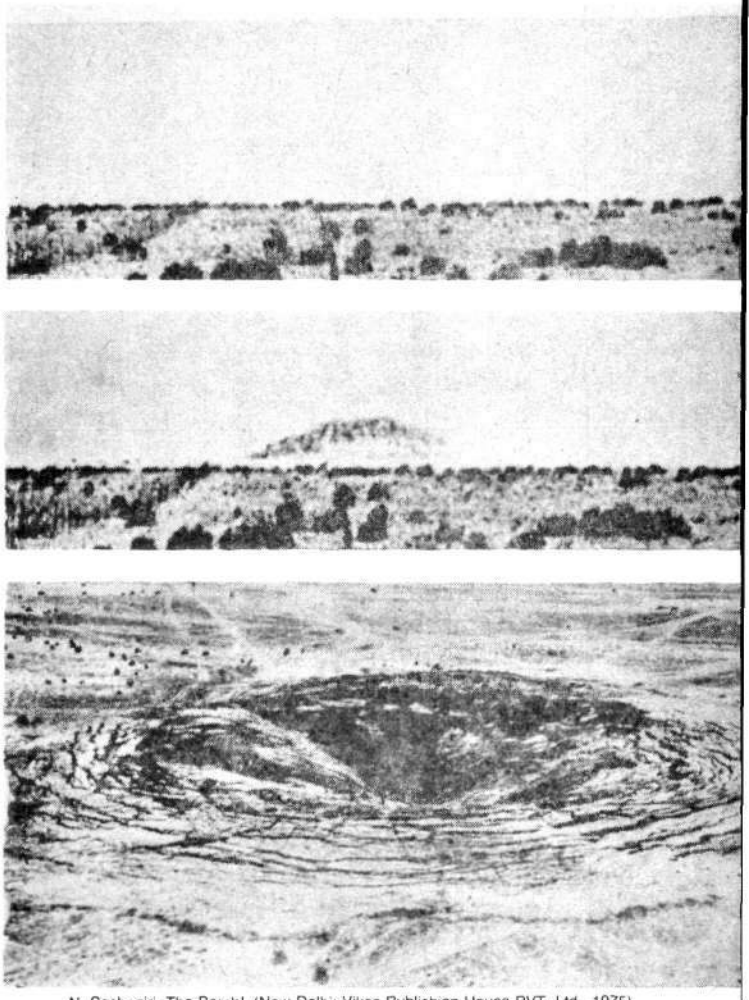
Table 2
ANNUAL PROJECTED GROWTH RATE OF TRADE PASSING THROUGH THE MALACCA, SUNDA, AND LOMBOK STRAITS
The EIR/FEF study anticipates a dramatic increase in general cargo traffic moving westward toward the Indian Ocean and Europe, whereas the 1973 TAMS study predicted a significant increase in eastward-bound oil traffic from the Middle East—that is, toward Japan and the United States. This difference argues for a two-lane canal.

The second level would come from regional and Thai sources, preferably both government and private, and government-sponsored preferential participation in construction contracts for Thai companies.

In commenting on the FEF/EIR study, Dr. Nimit Nontapunthawat, vice president and chief economist of the Bangkok Bank and manager of the bank's Economic and Marketing Research Center, reviewed the increased debt burden to Thailand over the decade required for canal construction and other infrastructural commitments. His conclusion was that after 10 years, Thailand's debt-service ratio would be about 2 or 2.5 to 1, based on an estimated total debt of $38 billion and an export-earning potential of about $15 billion. This is dramatically better than other countries in the region, such as the Philippines, where the debt-service ratio is 5 to 1.

Using Nuclear Explosives For Construction

by Dr. Steven Bardwell
and Charles B. Stevens



N. Seshagiri, The Bomb!, (New Delhi: Vikas Publishing House PVT, Ltd., 1975).

Three views of the Pokaran landscape in India's Rajasthan Desert, site of the May 18, 1974 PNE explosion. Top: Before the explosion; center: a new hill on the horizon seconds after the explosion; bottom: aerial view of the crater.

The development program for the Pacific and Indian Ocean basins intersects a global economic development process that is the advent of an industrial revolution at least as great as the industrial revolutions of the past. This is an industrial revolution based on new physical principles, high-intensity electromagnetic radiation, coherent forms of that radiation, and plasmas and their various technological spin-offs.

The fact that it coincides with the industrialization of the Pacific Basin gives that industrialization process a new unique advantage in the history of human economic progress. This process in the Pacific Basin does not need to replicate the stages of technological development that went on in the United States or Europe. Rather, that development can skip over a number of those stages and take advantage of the most modern, most efficient technologies, without having to go through the intermediate steps of different forms of more primitive industrial technology.

This is especially true of these large infrastructure projects proposed by the Fusion Energy Foundation and the *Executive Intelligence Review*. Here we describe the equivalent in terms of earth-moving technology of lasers for cutting metal or plasmas for refining metal—the construction equivalent of those new technologies.

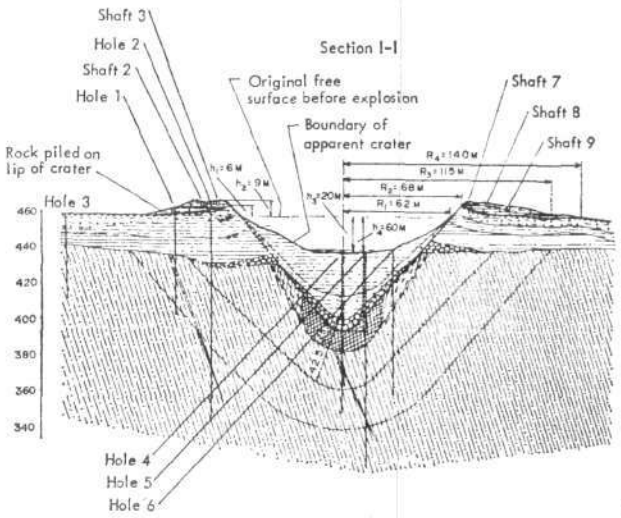
In the most general sense, what characterizes present industrial technologies is that they are all based on matter moving or shaping other matter. In the simplest sense, we have not moved much beyond the potter's wheel in terms of shaping metal. The lathe, the milling machine—all these are devices which turn matter and have other pieces of matter rub against the turning matter to cut it, shape it, to turn it into some useful form. The ideas on which the plasma and laser are based are *using energy to cut matter.* Matter never touches matter to turn it into a different shape; a beam of energy accomplishes that job.

In the area of construction technologies, the equivalent is the use of high-energy explosives to move earth, rather than a bulldozer or steam-shovel. This is using very highly organized, highly directed blasts of energy to move that earth.

The basic idea is to bury, at a precisely determined depth, a small, precisely determined size of nuclear bomb. The depth and size depend on how big a hole you want, how much dirt you want to move, and what the soil and water conditions of the ground are. This device, because it is so intense, generates a very precisely calculable series of shock waves that do not merely blow things up, but in a very precise way, move earth from one place to the other. The idea then is not only to get dirt out of the way, but to use it as part of the construction material. The final form created is a crater, not just a hole, in which part of the ejected material forms a higher side of the crater; thus the result is not only a hole, but the sides of a hole that are desired, created by this precisely shaped explosive charge.

This idea is one that has a tremendous number of other applications in laser fusion, and other more exotic advanced industrial technologies—using focused pulsed power to create new forms of matter.

One of the few tests done that is in the open literature, a 50 kiloton blast 15 years ago, resulted in a very neat looking piece of work. In the middle of a desert at the Nevada test site, where weapons experiments are done, it looks from



TYPICAL PEACEFUL NUCLEAR EXPLOSION

Cross-section of a typical peaceful nuclear explosion showing the crater and its geologic make-up. The blast in this Soviet experiment exceeded 100 kilotons (TNT equivalent explosive power) at a depth of 200 meters.

Legend

- Holes bored, preshot
- Holes bored, postshot
- Shafts
- Datum marks to study subsidence
- Boundary of fallback of ejected rock
- Clay
- Soil and plant layer with loam
- Grey-green and brown clay
- Grey-green clay
- Brown clay
- Siltstone
- Diabasic porphyrites
- Clay with chips of siltstone (more than 30%)
- Fractured siltstone
- Crushed zone
- Lower limit of zone of intense fracturing
- Lower limit of zone of block fracturing

Scale 0 20 40 60 80 100 M

Source: Milo D. Nordyke, "A Review of Soviet Data on the Peaceful Uses of Nuclear Explosions," *Annals of Nuclear Energy*, Vol. 2, p. 657 (1975).

the air like a big ant-eater has been there. These blasts drill very precise conical holes with perfectly formed lips around them.

The application of this technology to moving massive amounts of earth has been much studied, and the economic impact of that technology is absolutely phenomenal. In all the studies done so far, it is uniformly shown that the cost of moving large amounts of earth can be decreased by a factor of four. That is, it costs about one-quarter as much to move earth using nuclear explosives as using bulldozers, and it takes about one-half the time. Most of the time it takes to do nuclear excavation is spent waiting for the right weather—in order to keep the blast from blowing in directions that it shouldn't. The time is spent waiting for what they call "blast days," days when one of these explosives can be set off and the results will be predictable.

The applications of peaceful nuclear explosives, besides earth-moving, include: extracting oil from oil shale; stimulating natural gas deposits; creating underground storage cavities for gas, oil or nuclear wastes; in situ mining of low-grade ore through nuclear rubblization and chemical leaching; stimulating the flow of oil fields; extracting ore from tar sands; deep seismic sounding to determine geological strata; deep coal and other mineral mining; extinguishing oil and gas-well fires; stimulating geothermal reserves; generating high-pressure steam for the production of electricity, fusion, and fission fuels; and stimulating underground water resources.

However, the main application currently discussed is for excavation of earth.

The only place this has been done on an industrial or commercial scale is the Soviet Union. A map taken from a Soviet publication shows a major water-diversion project, which is going to take one of the many water systems that runs from north to south in the Soviet Union and reverse that direction. A map was prepared by Lawrence Livermore National Laboratory and shows the sites at which known experiments using PNEs in the Soviet Union were done between 1965 and 1979. Most of these experiments were for the purpose of water diversion. In Siberia, the Soviets have been conducting a very extensive series of tests using PNEs to stimulate natural gas production. About 100 PNE experiments have been conducted there over the past 15 years for various purposes. This is a very real, economically viable technology in use in the Soviet Union, but not in use in the United States, purely for political reasons.

Prospects for the Pacific Basin

The original studies for both the second Panama Canal and the Kra canal, using PNEs, were done more than 10 years ago, and were based on the state of the art in PNEs at that time. In the intervening period, there have been tremendous advances, including vast reduction in the amount of radiation released. The amount of radiation released by a PNE can now be reduced by a factor of 100, which means that these explosives can be employed in relatively populated areas. If the size of the explosions can be reduced to the point that has been done in weapons tests today, this is in the ballpark of being able to construct in very precise ways, small craters or series of small craters.

The neutron bomb and the reduced-radiation weapon are weapons technologies that are also the key to the small, cheap, and clean nuclear explosives that will revolutionize construction technologies over the next 20 years.

What is most striking in the Panama Canal proposal is the spaced craters that are formed in the first phase of construction. After this first set of craters is formed, it would without doubt be one of the most remarkable feats of human engineering to watch the completion of that canal in the period of half an hour as the second series of explosions goes off. There would be a plume, the earth would subside, and then, out of nothing, a complete canal would be created—literally in half-an-hour's time.

Steven Bardwell was formerly editor-in-chief of Fusion *magazine and Charles Stevens is the fusion technology editor.*

France Takes the Nuclear Lead

by Laurent Rosenfeld

EDF

Since July 1983, more than half of France's electricity generation has been produced by nuclear power, a figure that puts France in first place among the world's nations in terms of the share of electricity coming from nuclear energy. Belgium is second, with 45.9 percent; then Finland with 41.5 percent, Sweden with 36.9 percent, and Taiwan with 37 percent. Trailing behind are the large industrial countries whose size and population are comparable to France, such as West Germany, the United Kingdom, and Italy, as well as the industrial giants, such as the United States, the Soviet Union, and Japan.

France is not only number 1 in terms of the share of energy coming from nuclear power, but also in terms of its nuclear growth rate. During the first quarter of 1984, the nuclear share represented 54.6 percent of France's overall electricity generation, and it is expected that the annual figure for 1984 will be on the order of 55 percent. In addition, this heavy share of nuclear energy makes France's electricity one of the cheapest in the world, surpassed only by those countries, like Norway or Quebec, where the electricity comes chiefly from inexpensive hydroelectricity.

The key to the French nuclear success is the high level of standardization of the French nuclear program. During 1981, 1982, and early 1983, an average of six nuclear units were connected to the power grid per year—one every other month. Except for a few minor details (for example, open or closed cycle water cooling), all these plants were identical. The reactors and steam generators were all constructed by the same company, Framatome, while the conventional parts of each unit—the thermodynamic cycle equipment, turbines, and alternators—were all built by Alsthom-Atlantique. In other words, the two companies were able to build the heavy mechanical engineering and the electromechanical parts almost on an assembly line basis.

While a web of regulations and environmentalist delays strangles the U.S. nuclear industry, France's nuclear safety regulations, although modeled on those of the U.S. Nuclear Regulatory Agency and just as stringent, are organized to get nuclear plants on line quickly and efficiently. For example, once a particular design for a nuclear reactor has been approved, each subsequent reactor of that same design does not have to be resubmitted for approval. The only things that have to be approved are any eventual engineering modifications, any new parts that replace elements that have been found to be defective, and any environmental specifics, such as the type of cooling or cooling towers used or the particularities of the river or seawater used for cooling. As a result, commissioning new reactors takes only a couple of months. In addition, the reactor constructor and the utility company are not compelled to retrofit already existing equipment to new regulations, and there are no lengthy juridical contests.

The effect of this streamlined regulatory process is that France's nuclear plants have a construction time of 6 years,

Four nuclear units at Dampierre, France. France's nuclear plants have an average construction time of 6 years, and in some cases as little as 55 months; this is less than half the time it takes to put a nuclear plant on line in the United States.

and, in some cases (Gravelines 4 and Blayais 4) only 55 months. This is less than half the construction time of many other countries, including the United States. Of course, the financial cost of the investment is correspondingly reduced. This advantage, added to the standardization of production, makes the investment cost per nuclear unit far less costly than it is anywhere else in the world. At present, the total investment cost for a 1,300-MWe nuclear unit is about $600 million—5 billion French francs. The corresponding figure in the United States is two to three times as large.

How France Took the Lead

How is it possible that France, which is about the size of Texas, which has one-fifth the population of the United States, and which began its industrial development relatively late, is so far ahead of the United States in developing a crash nuclear program with a complete nuclear fuel cycle?[1] The answer lies in Charles de Gaulle's dirigist view of the relationship of science and advanced technology to national independence and security.

De Gaulle set up the French Atomic Energy Commission (CEA) immediately after World War II as a crucial part of his independent *force de frappe* (strike force) military policy. De Gaulle's philosophy was explained by Pierre Cognard, a Gaullist involved in the five year plan (1966-1970) of the dirigist French Planning Commission, in a September 1964 issue of *Le Progrès Scientifique*, a government review:

> It would be most grievous if national independence, which is assured on the military plane, should be insidiously destroyed in the scientific domain. . . . Let us feel assured that the objective of the plan is that the nation, with the support of all, will be able to guard its scientific and technical independence, the keystone to the development and independence of a modern nation.

This five year plan doubled national expenditures in R&D in the civilian sector and also doubled the number of research scientists. It encouraged every area of advanced technology—including an ambitious space program—that bore on the development of advanced and independent military capability.

To prevent this crucial policy from being sabotaged by the scissors-wielding finance minister, de Gaulle placed the CEA directly under the prime minister's control. Labor and private industry were coaxed into compliance with the CEA and its subsidiaries through favorable financial arrangements. At each point in the development of the French nuclear program, the population was organized from the top down, starting with the president himself, to support the nuclear policy on the basis of French independence and sovereignty as well as its fiscal soundness as an inexpensive source of energy. The rapid development of breeder technology—which the United States has kept on a perpetual back burner—facilitated this militarily necessary energy independence.

The forcefulness of the de Gaulle policy has prevented any antinuclear environmentalist movement from destroying the French nuclear program, as the U.S. antinuclear movement has done in the United States. In 1972, for example, when the U.S. antinuclear movement tried to gain a foothold in France, the nuclear industry placed preemptive ads in the newspaper of the Communist trade union, the CGT, explaining that the economic future of skilled workers, as well as the nation as a whole, was tied to an aggressive expansion of nuclear energy. The antinuclear movement failed to take hold, gaining adherents only among

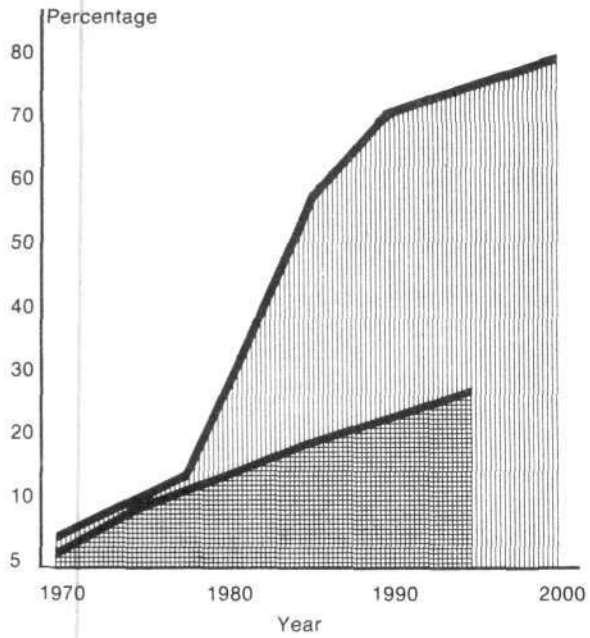


Figure 1
NUCLEAR AS A PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION
France Compared to the United States

By the year 1990, nuclear power will produce about 70 percent of France's electricity; by the year 2000, 80 percent. By contrast, nuclear power accounted for 12 percent of the U.S. electrical energy generation in 1981-82. Furthermore, the U.S. Department of Energy is revising its projections downward and has no figure for 2000.

The United States produces more nuclear energy in absolute terms than any other country, although the percentage of nuclear-generated electricity to total electricity production is smaller. U.S. nuclear capacity installed in 1980 was 55.0 gigawatts, compared to France's 16.1. By 1990, nuclear capacity installed will jump to 56.0 GW in France, 116.2 GW in the United States.

The rate of growth of electricity demand has collapsed 8 percent per capita in the United States since 1980. In France, although industrial demand slowed from the 1960s to the 1970s, the demand from households increased.

Source: North American Electric Reliability Council, *Electric Power Supply and Demand*, 1982-1991, Aug. 1982; Memento sur l'Energie, French Atomic Energy Commission, DPG, 1979; Department of Energy; *Nuclear Power in an Age of Uncertainty*, (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-E-216, Feb. 1984).

François Mitterrand's Socialist Party and its CFDT trade union.

The Scope of the Nuclear Program

French industry initially developed its own successful design for nuclear plants, the so-called UNGG, or natural uranium-fueled, graphite-moderated, gas-cooled reactor. However, after a bitter political battle, it was decided in the early 1970s for commercial reasons to shift to the pressurized water reactor, the PWR, which was licensed by Westinghouse and which at that time dominated the world nuclear market. In March 1974, in the aftermath of the oil crisis, Pierre Messmer, then prime minister under Georges Pompidou, launched an ambitious nuclear program that included the construction of 12 nuclear units and possibly 4 more. Under President Valéry Giscard d'Estaing, this program was accelerated.

The first 34 PWR units, some of which are still under construction, were 900 MWe reactors on nine different sites. In the late 1970s, the size of these units was scaled up to 1,300 MWe. These larger reactors are designed entirely by French industry and Framatome, which is now the largest nuclear reactor constructor in the world. (In fact, Westinghouse is now buying licenses from Framatome.)

At the pace established in the 1970s, six reactors came on line every year during the early 1980s. As of May 1984, the French utility company, Electricité de France, is operating 36 nuclear power plants (see map): 28 PRWs, 6 UNGG reactors, 1 gas-cooled heavy water reactor (the Monts-d'Arrée unit in Brennilis), and 1 liquid metal fast breeder (the Phenix in Marcoule). In all, the 36 power plants represent a total power of 25,000 MWe, or 25 GWe.

In addition, 28 other units are now under construction, representing another 33 GWe. In total, by the end of the decade, France expects to have a nuclear power capacity of 56 GWe, taking into account the decommissioning of a few of the older UNGG units, which will no longer be operating then. In 1990, nuclear power will produce about 70 percent of France's electricity, thus providing approximately 30 percent of the country's overall primary energy consumption.

Mitterrand and the Environmentalists

All is not rosy in the French nuclear picture, however. The Socialist government of François Mitterrand has decided to reduce the pace of nuclear starts to five units for the two years 1984-1985, and is likely to try to reduce it further in the years to come. This "go-slow" approach of the Mitterrand government creates problems for the companies that build the power plants, which have investments that outweigh the reduced number of prospective orders in France and also in the depressed foreign market. Both Framatome and Alsthom-Atlantique are still making profits, but the situation is expected to worsen in the next two to three years. Framatome's profits have dropped significantly, and the firm is no longer able to fill the gap created by the huge losses in other sectors of its mother company, Creusot-Loire, which is now verging on bankruptcy.

Before coming to power, Mitterrand and his party had published a white paper attacking nuclear energy. Once in power, however, they were unable to carry out this policy fully because of factional fighting within the party and because of considerable popular support for nuclear energy. Polls showed that 60 percent of the population backed a strong nuclear policy, with 20 percent against it and 20 percent undecided.

In 1981, when Mitterrand attempted to halt the construction of a four-plant nuclear project in Cattenom, a "Committee to Save Cattenom" was formed and waged an aggressive campaign to continue the project and to discredit the antinuclear environmentalists as Malthusian dinosaurs. The committee, which succeeded in reversing the government attempt to stop Cattenom, was initiated by the French affiliate of the Fusion Energy Foundation, the European Labor Party, and the Metz branch of the Young Giscardians, and it was soon joined by the Gaullist mayor of Cattenom and the head of the Republican Party of the Moselle region. Today, construction is proceeding on the fourth Cattenom reactor, and soon four 1,300-megawatt reactors will export energy to the coal and steel regions of Luxembourg and the Saar district of West Germany.

Much of the antinuclear movement in France continues to be orchestrated from the outside, by such groups as the Natural Resources Defense Council and Friends of the Earth in the United States and Ecoropa and the West German Green Party in Europe. All of these groups sent organizers into France in the late 1970s to try to slow down the pronuclear momentum. In particular, when these groups tried to rally protesters in 1977 against the Superphenix fast breeder at Creys-Malville, they found no support from the surrounding population. More recently, in January 1982, a greenie group lobbed five Soviet-made rockets at the Creys-Malville site, in the name of "écologie pacifique." Needless to say, such "peaceful" activity gained the environmentalists no local support.

Nuclear Energy Develops Flexibility

With more than half of its electricity production coming from nuclear power, Electricité de France, the state-owned utility company, has had to solve the problem of adjusting the power supply to meet the variations of electricity consumption. For example, only one-third of the electricity used at 8 p.m. is used at 4 a.m.; more electricity is used on Sundays than during weekdays; and one-and-one-half times the electricity is consumed in the winter months than in the summer. The low cost of nuclear electricity for home heating has, in fact, accentuated the seasonal variation in consumption.

To solve this problem in the past, the utilities have used the nuclear power plants for 6,000 or more hours per year to provide the "base" of consumption; that is, the bottom-line amount of electricity that is being used at any time of the day, week, or year. The demand peaks have been met by the use of conventional thermal plants as well as hydroelectric dams, which can regulate their production more flexibly than nuclear plants (or than hydro plants with no dams). The utilities have also tried to schedule, insofar as possible, the yearly shutdown of nuclear stations for refueling and overhauling in the periods when little electricity is needed.

In addition, EDF has had import-export agreements with

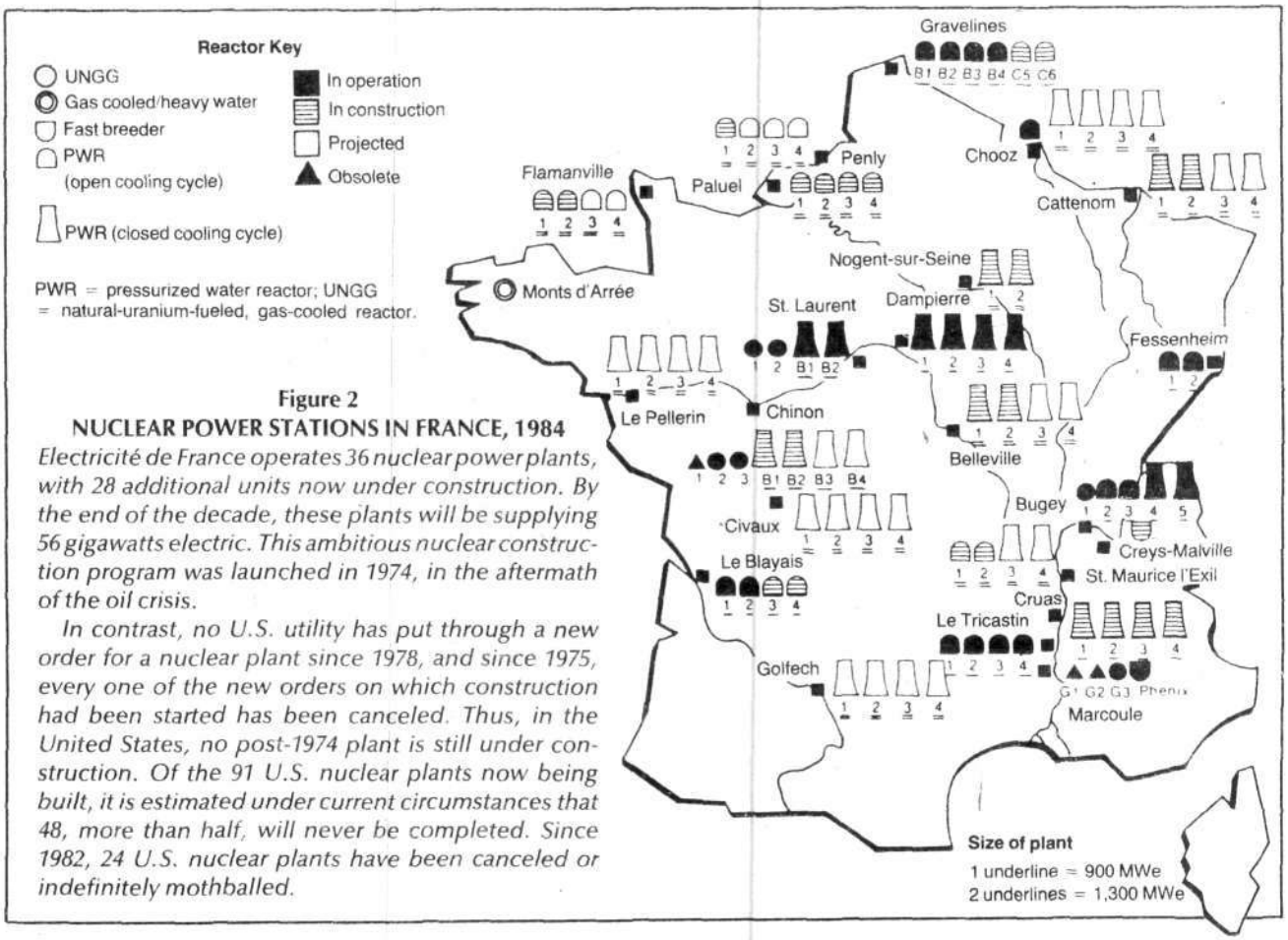


Figure 2
NUCLEAR POWER STATIONS IN FRANCE, 1984

Electricité de France operates 36 nuclear power plants, with 28 additional units now under construction. By the end of the decade, these plants will be supplying 56 gigawatts electric. This ambitious nuclear construction program was launched in 1974, in the aftermath of the oil crisis.

In contrast, no U.S. utility has put through a new order for a nuclear plant since 1978, and since 1975, every one of the new orders on which construction had been started has been canceled. Thus, in the United States, no post-1974 plant is still under construction. Of the 91 U.S. nuclear plants now being built, it is estimated under current circumstances that 48, more than half, will never be completed. Since 1982, 24 U.S. nuclear plants have been canceled or indefinitely mothballed.

other countries that have little nuclear energy or that have peak demand periods at slightly different hours.

Now, with a more sizable share of electricity coming from nuclear generation, these solutions have become insufficient, and EDF has developed what it calls the "gray-mode" piloting of nuclear plants. This gray mode consists of a new type of control rod system (colored gray, hence the name of the system) that allows the energy produced to be regulated very flexibly. EDF is now introducing the system progressively in all operating PWRs and will install the system in all its new units.

Completing the Fuel Cycle

Since its creation by de Gaulle in 1945, the Commissariat à l'Energie atomique, CEA, which is responsible for all research on civilian and military nuclear power, has been working on the complete nuclear fuel cycle. CEA specialists and its industrial subsidiary that deals with nuclear materials handling and processing, Cogéma (Compagnie Générale des Matières Nucléaires, have become among the best in the world in all areas of the nuclear fuel cycle—from prospecting and mining uranium ore, to uranium enriching, fuel pellet and rod fabrication, and spent fuel reprocessing and waste disposal.

The nuclear research centers at Marcoule, Cadarache, Pierrelatte, and other locations have developed a mastery of all these processes over the past 20 years. For example, the CEA has run an isotope separation plant based on gaseous diffusion in Pierrelatte for 20 years. Originally mainly for military use, the plant takes natural uranium, U-238, which contains only about 0.7 percent of fissionable uranium, U-235, and enriches it to contain about 3 percent U-235 in order to make it usable as fuel for a PWR.

Based on this solid experience, the CEA created Eurodif, an international company with Belgian, Italian, Spanish, and Iranian partners to build a large industrial enrichment plant in Le Tricastin. The enormous electrical power required for the plant is supplied by four nuclear units of 900 MWe each, built on the same site. Completed two years ago, the Le Tricastin plant is able to produce 2,670 tons of uranium enriched at 3.15 percent per year—enough to fuel 100 GWe of nuclear power. This production capacity represents about 30 percent of the world production of enriched uranium for civilian use.

Even more important internationally is the mastery CEA and Cogéma developed in fuel reprocessing. Unlike the other nuclear countries, France decided that it was necessary to reprocess its spent fuel for several reasons. First, France wanted to separate the low-level radioactive waste from the more radioactive nuclides. In this way, the quantity of the high-level waste could be reduced to a very small amount—just a few cubic feet per year per plant—making it easily disposable. Second, the spent fuel from fission power plants is of a higher grade than natural uranium and

thus requires less isotopic separation work to transform into new fission fuel. Third, plutonium could be recovered from the spent fuel to be used in fission power plants as well as in breeder reactors. It was also speculated—but not proven—that the military wanted to procure larger quantities of plutonium.

After its experience in running a small-size reprocessing plant in Marcoule for 20 years, which was largely used to extract plutonium for the military, the CEA decided to build an industrial reprocessing plant in La Hague, Normandy. With the possible exception of a plant in the Soviet Union, this is the largest reprocessing plant in the world, having a current reprocessing capability of 800 tons per year—enough to process spent fuel from 35 nuclear units of 900 MWe each. Next year, when the second La Hague unit comes on line, this capacity will double.

The CEA has also developed some important solutions to the waste disposal problem. After the extraction of the useful radionuclides—uranium, plutonium, and some others—from the spent fuel and the separation of the nonradioactive elements, the amount of waste to be disposed of is reduced to just a few cubic feet per year per plant. Most of this is high-activity fission products that have a short lifetime and decay almost completely after a couple of years in temporary storage. The rest of the waste, long-life radionuclides consisting of some fission products and transuranic elements, are then processed in a vitrification plant; there they are vitrified, embedded in melted glass to prevent any leakage. The containers of this glass can then be stored in special geological formations.

Superphenix: Transmuting Matter

The most exciting accomplishment of the French nuclear program is the fast breeder. After having built several research fast breeder reactors with such poetic names as Harmonie, Masurca, Cabri, and Rapsodie (this last breeder reaching 40 MWt), the CEA built the 250 MWe Phenix fast breeder in Marcoule. Phenix produced its first kilowatt hour for the power grid in December 1973, and reached full power in March 1974. In the first six years of its operation, Phenix was the largest fast breeder reactor in the world (until the Soviets put the BN600 on line in Beloyarsk). Based on its experience with the Phenix, the CEA decided to build an industrial-size reactor, the Superphenix, in Creys-Malville. When in operation next year, the 1,200-MWe Superphenix will be the largest fast breeder in the world and the first industrial-size breeder.

The French Superphenix, a commercial-size breeder, cost slightly more than $1 billion; in contrast, the United States has spent $4 billion in the last three decades on breeder development, with an estimated $10 billion more required to develop a commercial prototype.

Although the United States pioneered in breeder reactor development—its Experimental Breeder Reactor I was the first nuclear reactor to produce power in 1951—its breeder program now lags 10 or more years behind France. The Clinch River Demonstration Breeder Reactor Project in Tennessee is practically dead, having been mortally wounded by the Carter administration in the 1970s, and left to die by the Reagan administration, which abandoned the project to "free enterprise."

Visiting the Superphenix in Creys-Malville from Paris, this writer was struck with the fact that one encounters frontier technologies from the very beginning of the trip: The TGV high speed train that links Paris to Lyons travels at 160 mph. As much as this means of reducing the distances between the two cities is a milestone in technology, the Superphenix reactor has even more far-reaching consequences for the nation and the world: The Superphenix will produce more fissile fuel than it consumes (in the form of U-235 and plutonium). The excess fuel is produced by transmutation of uranium-238, which cannot be used for producing energy in conventional nuclear reactors.

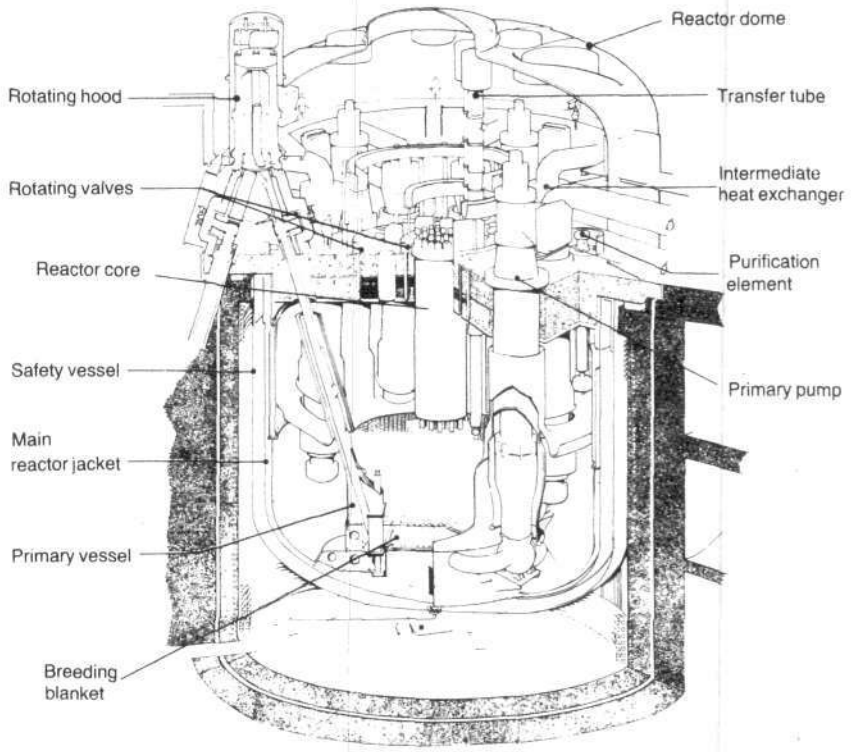
Thus, for the first time, the dream of the alchemists becomes reality—transmuting matter. The Superphenix, however, this philosopher's stone of modern times, will not transform lead into gold as Paracelsus's followers wanted to do. Instead it will transform uranium-238—a metal that would otherwise have no value and could even be considered waste—into plutonium, one of today's very precious metals. At a value of about $6,000 per pound, approximately $410 per ounce, plutonium truly has the value of gold.

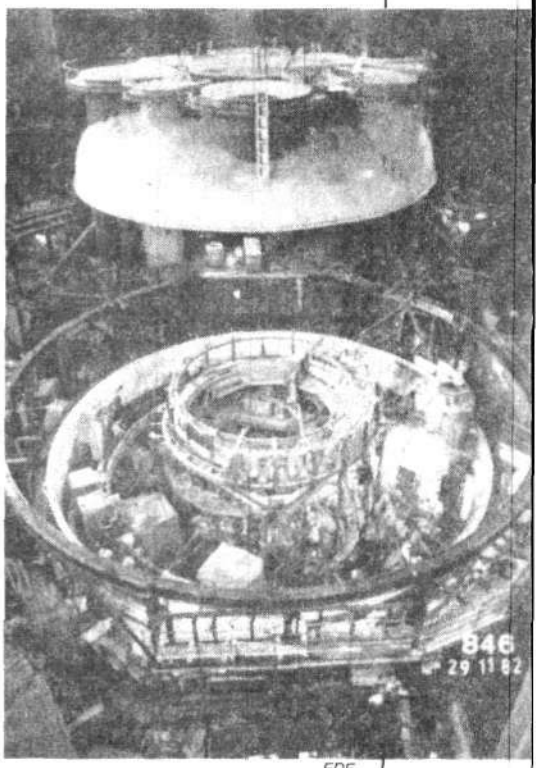
Consider this analogy to the advantages of a breeder. Imagine a man stranded in a mountain refuge during a violent snow storm. Suppose that the refuge has a two-day supply of dry wood for heat. If he carelessly consumes the wood, he will die of cold on the third day. But if he makes sure to pick up wet wood around the chalet and leave it to dry in front of the fire, his wood reserve may last longer. In fact, if he manages to dry as much or more wood than he consumes, his wood reserve might last forever, assuming that there is an unlimited supply of wet wood around his refuge. Our stranded man will have created a "breeder" of burnable wood.

The dry wood of our example is uranium-235, the only fissile isotope of uranium, which represents just 0.7 percent of natural uranium. The rest, the 99.3 percent of uranium that is uranium-238, like the wet wood, is unburnable, at least in ordinary reactors. The task of the breeder is to "dry the wet wood"; that is, to transform the nonfissile U-238, which is 140 times more abundant than the U-235 fission fuel, into a combustible (fissile) material—plutonium-239 for nuclear reactors. This means that there can be no foreseeable energy shortage. If known reserves of natural uranium at a given price allow the production of the equivalent 40 years of the present world electricity consumption, then breeder reactors, at least in theory, can make those same reserves last 140 times longer—5,600 years.

The ABCs of Fast Breeders

All nuclear reactors are based on a chain reaction: A neutron is used to hit a uranium nucleus, and under the shock, the nucleus splits or fissions, usually into two fragments (the fission products) plus two or three neutrons. These neutrons in turn can produce new fissions. In general, U-235 is easier to split with slow neutrons; however, the neutrons expelled by the fission process are fast neu-





EDF

Reactor dome and vessel of the Superphenix in construction.

Figure 3
SUPERPHENIX: WORLD'S LARGEST BREEDER

Superphenix is an integrated or pool reactor; that is, the entirety of the primary coolant loop lies near the core within the vessel, including the heat exchangers and the primary pumps. The core itself is comprised of 364 vertical fuel assemblies, each made up of 271 fuel pins that are 2.7 meters long with a diameter of 8.5 mm. The pins contain fuel pellets, about 15 percent of which is composed of fissile nuclides—uranium and plutonium oxides. In all, the core of the reactor has a volume of 10 cubic meters and contains about 5 tons of plutonium and 108 tons of uranium. The core is surrounded by 233 fertile blanket assemblies of natural uranium or depleted uranium.

Every second, 5 tons of liquid sodium enter the core at 400 degrees Celsius. The sodium circulates among the fuel pins, leaving the core at a temperature of 550 degrees Celsius. This sodium is then pumped by four primary pumps into the four primary loops, each of which has two heat exchangers. Overall, the reactor vessel contains 3,500 tons of sodium, which gives the system a very large thermal inertia. When asked of the significance of this amount of sodium, Gilbert Labat, the chief of operation for the Superphenix and a veteran of the Phenix research reactor, put it this way: "If something happens, you need not have quick reflexes. You can start by smoking a cigarette and figuring out what is actually going on. You have all the time you need [about a half-hour] to think twice before taking action."

Surrounding the main reactor vessel of the Superphenix is a safety vessel containing an inert gas that can contain and recover sodium in the case of a leak. This safety vessel itself is topped by a metallic safety dome. Outside the vessel are the secondary pumps and the barrel used to manipulate the fuel assemblies. All of this is housed in a concrete reactor building. The rest of the Superphenix power plant is purely conventional: The secondary sodium leaves the reactor building to heat up water in four steam generators, which activate two turbo alternators, each with a power of 620 MWe.

trons that usually bounce off the uranium nuclei without triggering fission. In ordinary reactors, a moderator (water, graphite, carbon dioxide, or heavy water) is used to slow down the neutrons. The fast neutrons bounce off the light nuclei of the moderator thus giving most of their original kinetic energy to the moderator and ending up in thermal equilibrium with the medium used. These neutrons are therefore called "thermal neutrons." When their speed has decreased enough, these thermal neutrons become able to trigger new fissions.

In a breeder reactor the fast neutrons are used directly (hence the name fast breeder). Because fission is more

difficult to obtain with fast neutrons, the fuel used in the breeder has a higher concentration of fissile nuclides. Solving the particular problems involved in the breeder produces a series of advantages. First, fast neutrons are able, albeit inefficiently, to fission U-238. In a reactor like the Superphenix, between 10 and 15 percent of the fissions are obtained directly from U-238. Those neutrons that do not cause the U-238 to fission can be captured to create neptunium-239, a radionuclide that decays rapidly into plutonium-239. This process also occurs in PWRs; however, in the breeder these fast neutrons are able to split plutonium.

The main advantage of the breeder, however, is that it breeds new fuel. The reactor core where the chain reaction is maintained can be surrounded with a fertile blanket, walls made of natural uranium or, even better, of the "waste" depleted uranium from an enrichment plant. Bombarded by neutrons from the core of the breeder, the U-238 in the blanket is transformed into plutonium. In this way, the reactor produces more plutonium overall than the plutonium and U-235 that are consumed as fuel in the reactor core. This plutonium product is then reprocessed to serve as new fuel for reactors, thus closing the nuclear fuel cycle.

An additional economic advantage is that the core size of the breeder reactor can be much smaller than a conventional PWR, because it has a higher concentration of fissile fuel and because it does not need a moderator.

The Sodium Coolant

The French nuclear program pioneered in breeder technology and solved one of the problems that the now near-dead U.S. breeder program had set out to solve in the 1970s—designing a steam generator system that does not leak. The steam generator in a breeder system has a very thin, 0.10 inch barrier between two extremely incompatible heat transfer fluids, the liquid sodium coolant and water. If sodium and water mix, a turbulent reaction occurs, in which the sodium burns and hydrogen is produced. Fabricating a large steam generator that does not leak, or leaks rarely, required higher quality materials manufacturing, fabrication techniques, welding methods, and quality assurance methods than previously achieved in the heavy equipment industry.

All breeders today are cooled with liquid sodium, which has been found to be by far the best coolant. Since the core of the breeder has a very high power density, the coolant must have a good thermal conductivity and absorption capacity. A liquid metal is therefore ideal. In addition, the coolant must not moderate or slow down neutrons, which means that it must be made up of relatively heavy nuclei. Sodium fits the bill neatly: The metal melts at 98 degrees Celsius and boils at 882 degrees Celsius, thus providing a very large spread of temperatures in the liquid phase.

The main drawback of the sodium coolant is that under neutron bombardment, it can capture neutrons and become radioactive. Therefore, the breeder reactor has to have a secondary cooling loop to keep the activated sodium within the reactor vessel. This secondary sodium loop, which heats the steam for the thermodynamic cycle of the reactor, along with some sodium purification equipment, increases the cost of the breeder.

A second inconvenience with sodium is, as noted above, that it is a strong chemical reducer with a great affinity for oxidizing substances, specifically for oxygen and water. Because of these chemical properties, any free surface of sodium must be covered with inert gases, argon or nitrogen, and the reactor must have a double wall between the sodium of the secondary (nonradioactive) loop and the water of the thermodynamic loop.

The additional costs incurred by the use of sodium—the extra cooling loop and the use of more stainless steel compared to PWRs—are partially offset by the savings it allows for the reactor. As mentioned above, the reactor vessel can be smaller, because of the high density of the fuel in the core, and thus less costly to build. Also, since the sodium is used at temperatures far from its boiling point, the vessel has much smaller physical mechanical constraints and does not need to be pressurized. Finally, sodium can be operated at a higher temperature, which allows a thermodynamic efficiency of 40 percent, higher than the 30 to 33 percent of the PWR. This in turn allows for a smaller (and thus less costly) turbine and reduces the thermal losses. Overall, however, the kilowatt hour produced by a fast breeder should remain a bit more expensive than that of the PWR, so long as the price of uranium remains level.

After the Superphenix: Will France Keep Its Lead?

The construction of the Superphenix was completed in May 1984. The sodium is in place, and part of the inner core of the reactor is on site. In July 1984, the conventional part of the reactor will be tested with auxiliary heating boilers. By the end of 1984, the fuel will be loaded and other tests will continue over several months. If all goes well, the power plant will supply its first kilowatt hours to the power grid in mid-1985.

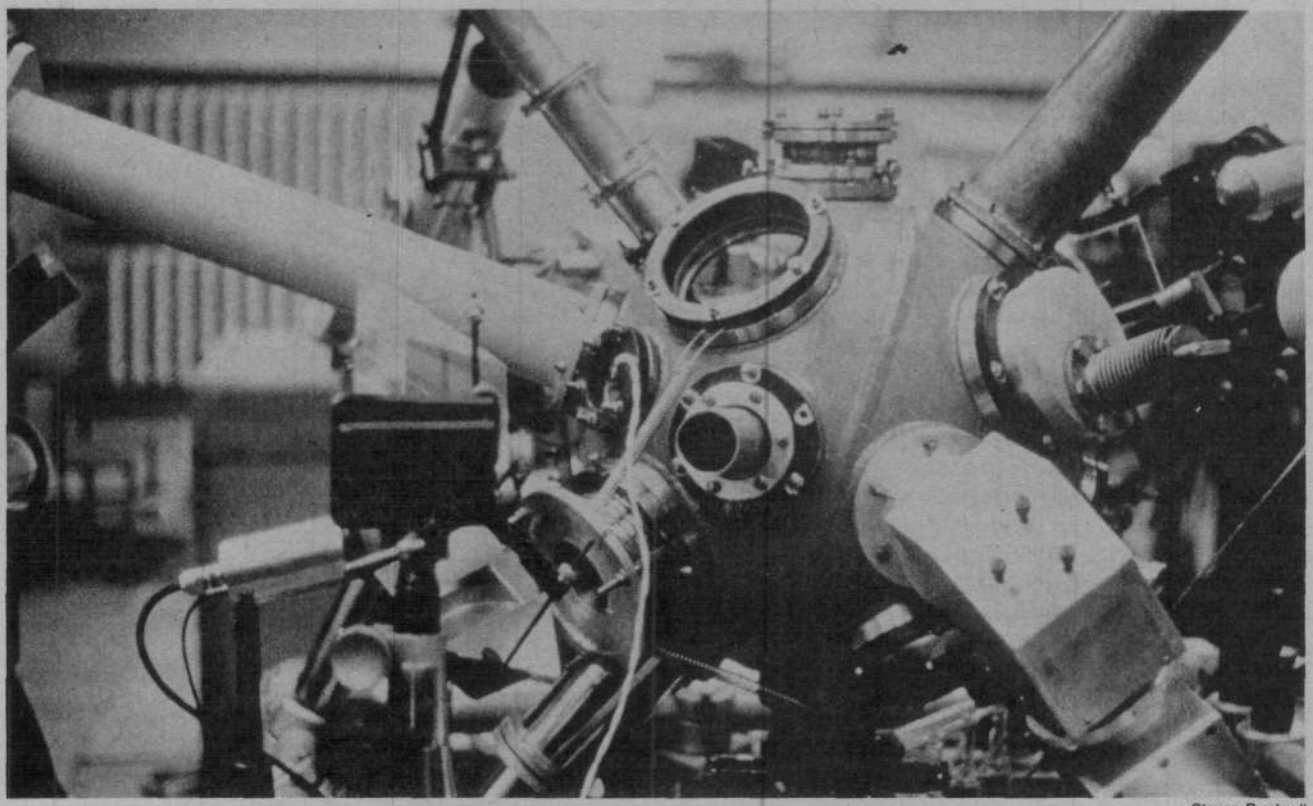
Unfortunately, the French nuclear program has not decided on any follow-up to the Superphenix, although a Superphenix II is under consideration. Claude Aycoberry of Cogéma and Jacques Leclercq of EDF presented a plan for twin breeder reactors, Rapides 1500, in July 1982. Directly derived from Superphenix, these reactors would have minor modifications, such as full power of 1,500 MWe to be reached by optimizing the reactor equipment.

As veterans of the French nuclear program have argued, the world needs fast breeders. We cannot burn our "dry wood" in a few decades without preparing for the future. Even if thermonuclear fusion, and perhaps fission-fusion hybrid breeders will ultimately replace fission energy, we need to fully explore and take advantage of state-of-the-art fission technology if we are to get on with the task of industrializing the world and lifting mankind out of the mud of poverty.

Laurent Rosenfeld is editor-in-chief of the French-language magazine Fusion, *a quarterly publication of the Fondation pour l'Energie de Fusion.*

Note

1. A full history of the French nuclear program can be found in "How France Took the Nuclear Lead," by Dana Sloan, *Fusion*, August 1980, p. 36.



Steven Bardwell

The target chamber for the Kalmar laser, approximately 40 cm in diameter. The various diagnostics (x-ray cameras, calorimeters, and so on) are attached to the portholes around the sphere.

Thermonuclear Laser Fusion In the Soviet Union

by Dr. Nikolai G. Basov

This review of the Soviet laser fusion program by Soviet Academy of Science member Basov appeared in the January 1983 issue of the Russian-language magazine Priroda *(Nature) and is published here with the author's permission. It was translated by Michael Masterov, a student intern with the Fusion Energy Foundation in New York City.*

* * *

At the present time, the volume of physical information collected over the many years of thermonuclear laser fusion research allows us to evaluate this approach as a whole, as well as to analyze the scientific and technical difficulties that must be overcome to realize and utilize controlled thermonuclear reactions. In essence, the time has come, when, on the basis of the analysis of available data, it is necessary to select the most reliable and promising path for further research, using all the strong points of the laser approach to this problem. The research, conducted in ever-increasing volume, is already aimed not only at the search for a feasible variation of thermonuclear laser fusion, but also at the development of the optimal way of solving the problem of obtaining thermonuclear energy.

The Physical Concept of Thermonuclear Laser Fusion

The concept of thermonuclear laser fusion with inertial confinement is that of a fusion reaction initiated at the center of a super-dense plasma, concentrated in an area with a small characteristic diameter (on the order of 100 micrometers), and causing a burn wave to spread from the center over the entire volume of the plasma during a time determined by the inertia of the substance. When this time elapses, the plasma disassembles and the thermonuclear reaction ends. The duration of the inertial "confinement" depends on the size of the plasma and its temperature; for targets with a starting size of nearly 1 mm it is 10^{-10}sec.

The amount of energy created at this time is a function of the plasma density, which, in turn, is related to the characteristics of the target and the parameters of the laser impulse. However, even simple calculations based on the law of conservation of energy (confirmed by exact numerical calculations) lead us to conclude that in order to achieve

considerable energy yields the target must be compressed to densities thousands of times greater than the density of liquid thermonuclear fuel, a mixture of deuterium and tritium.

The spherically symmetrical laser radiation falling on the target heats it and causes it to evaporate. As this happens, the reactive pressure of the disintegrating plasma causes a radially inward impulse in the shell. In the process of the shell's movement toward the center it is important that the temperature of the thermonuclear fuel remain sufficiently low for as long as possible. Otherwise, the compressed plasma will create considerable thermal pressure directed outwards from the center, which will slow down the shell, in this way limiting the maximal density of the plasma core. In this case, the achievement of a high level of fuel compression is the most important indicator of the promise shown by one or another regime of compressing and heating thermonuclear targets.

The hydrodynamic regime of compressing and heating thermonuclear fuel is the basis of the physical concept of thermonuclear laser fusion being developed in the Soviet Union. It is characterized by a continuous pressure change and requires relatively low (to 10^{14} watts/cm^2) laser radiation power densities to be applied to a hollow-type target. With a sufficiently high energy irradiation for targets with aspect ratios (the ratio of shell radius R to shell thickness Δ-R) nearing 100, it is possible to achieve significant compression and heating of the thermonuclear fuel. The comparatively low power density of the irradiation allows us to get rid of some undesirable phenomena, the most important of which is the target preheating by fast electrons, formed when the plasma is heated by laser radiation.

The role of the fast electrons in the absorption of the intense laser radiation by the plasma is illustrated by experiments performed by American researchers at the Shiva laser thermonuclear installation [Lawrence Livermore National Laboratory in California] with the energy of 10 kj. These experiments resulted in a record neutron output (almost 10^{10} neutrons per impulse), which was 4 orders of magnitude below the planned output. This was the result of a high (almost 10^{15} watts/cm^2) radiation energy density applied to the target. The "imploding liner" regime used in these experiments efficiently generated fast electrons which caused a great deal of target preheating, and, as a result, the compression level of the plasma was not great.

The Soviet Concept

At the present time the concept of thermonuclear laser fusion developed in the Soviet Union on the basis of analyzing the vast volume of theoretical and experimental developments and numerical calculations has received universal acceptance. It is based on the following tenets:

(1) Among the many possible regimes of interaction of the laser radiation with the thermonuclear target, the optimal is the hydrodynamic regime of ablation, characterized by the continuous acceleration of the substance and the absence of powerful hydrodynamic disturbances.

(2) This regime may be realized by using laser impulses of the simple triangular form with a pulse duration of several nanoseconds, usually formed in powerful pulsed lasers with a power density on the order of 10^{14} watts/cm^2.

(3) For such parameters of irradiation, the absorption processes and further energy transformation are classical to a considerable degree, which means that the effect of fast electrons on the compression and heating of the target can be ignored.

(4) The hydrodynamic regime of ablation allows us to count on a sufficient stability of these processes even with targets having high aspect ratios (R/Δ-R approximately 10-100).

(5) The conditions for realizing a thermonuclear flash with the hydrodynamic regime of compression can, in theory, be created by profiling the starting structure of the

MAIN CHARACTERISTICS OF LASERS AND TARGETS

Power density of radiation on target	10^{14} watts/cm^2
Pulse length	5-30 nanosec.
Laser energy	10^6-10^7 j
Wavelength	0.3-0.6 micrometers
Laser power	10^{14} watts
Radiation divergence	10^{14} rad
Laser efficiency	5%
Hydrodynamic efficiency	10-15%
Plasma compression (by volume)	10^4
Compression velocity (shell velocity)	2×10^5 m/sec
Aspect ratio (multishell targets)	100
Precision in shell production	1%
Thermonuclear amplification coefficient	1-100

Dr. Basov is head of the Soviet laser fusion program. He won the Nobel Prize in 1984 for developing the maser and laser principle of producing high-intensity radiation.

target. (Depending on the on the amount of applied energy, meaning the expected thermonuclear yield as well, it is necessary to use multilayer pellet targets of various construction.)

(6) Laser radiation of about 10^6 j with a power of about 10^{14} watts corresponds to a thermonuclear amplification coefficient on the order of 10^2. The question of the optimal wavelength still remains open. From the point of view of the physical interaction between the target and the laser radiation, shortwave lasers are preferrable; however, there exist possibilities (which will be discussed below) where longwave radiation can be used effectively.

Based on the above-mentioned, we can already formulate a fairly clear idea of the criteria for building optimal laser-target systems for various output energies from the lasers directed at the targets and for thermonuclear amplification coefficients.

At the present time there is no doubt as to achieving breakeven in thermonuclear reactions using the laser approach. Calculations, conducted by the Institute of Physics and Applied Mathematics of the Academy of Sciences of the Soviet Union, and the analysis of experimentally collected data, as well as the reliability and relative simplicity of the physical model for heating processes and target compression, which allows us to extrapolate for a higher level of energy, all lead us to conclude that breakeven may be achieved with an energy of irradiation close to 10^5 j and possibly even lower in the case of multiple profiling (that is, simultaneously using impulses of different wavelengths). With this energy level of laser irradiation, a very simply structured target may be used, though the stability problem still causes stringent precision requirements (approximately 1 percent) and symmetry of irradiation requirements.

This way, from the physical point of view, thermonuclear energy "surplus" can be effected with laser energies not exceeding 10^5 j, while the realization of commercially justifiable thermonuclear reactors requires the availability of lasers capable of pulses of several megajoules. At the current stage, the main task for solving the problem of thermonuclear laser fusion is the creation of lasers with irradiation energies of 10^5-10^6 j. As the modern concept of thermonuclear laser fusion is based on the use of several laser beams, the installations of this scale require special modules (each forming a single laser beam) which must be developed to output energies of about 10^4-10^5 j. The development of these modules is the most important task of contemporary quantum electronics.

Lasers for Thermonuclear Laser Fusion in the Soviet Union

The thermonuclear laser fusion research program in the Soviet Union is basically oriented on the glass laser as the one most accepted by industry. In 1981, the Physics Institute of the Academy of Sciences, in cooperation with the above-mentioned concept of thermonuclear laser fusion, established the Dolphin-1 installation and equipped it with a neodymium laser currently capable of 2 kj pulses several nanoseconds in duration.

What are the possibilities of developing other types of lasers? Simple physical considerations (high absorption,

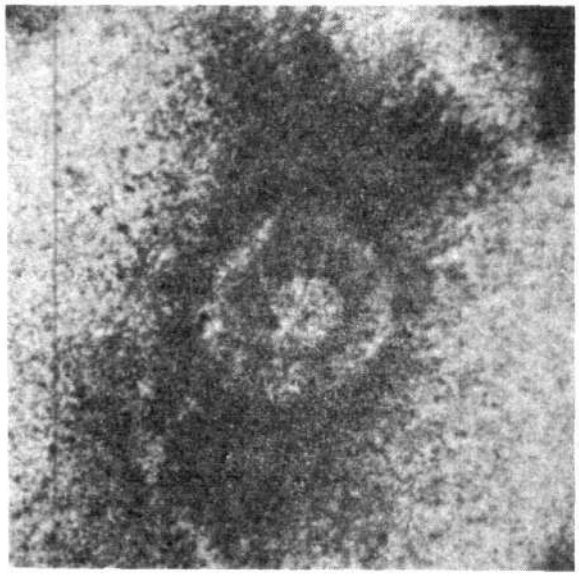


Figure 1
X-RAY MICROPHOTOGRAPH OF A PLASMA
This X-ray microphotograph of a plasma, which is formed when a multishell target is heated. The target is a polystyrene shell (276 micrometer diameter) surrounding a glass shell (97 micrometers diameter). The photograph illustrates the possibility of heating and compressing plasma in complex multilayer targets using the hydrodynamic regime of ablation.

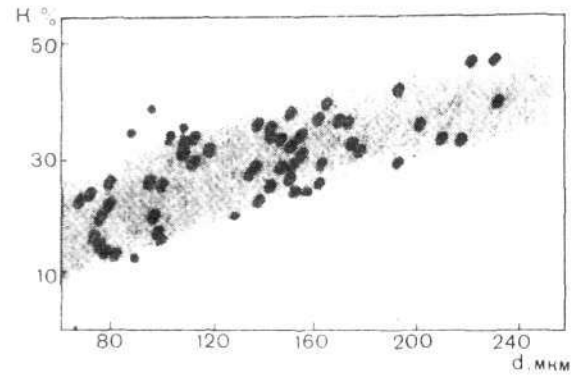


Figure 2
LASER RADIATION ABSORPTION VS. TARGET DIAMETER
The dependence of laser radiation absorption, coefficient K, *on target diameter* d *achieved at the Kalmar installation. Target materials and construction were varied. With diameters of more than 200 micrometers, the absorption coefficient reaches 50 percent. The vertical axis is the percentage of laser radiation absorption and the horizontal axis is the target diameter in micrometers.*

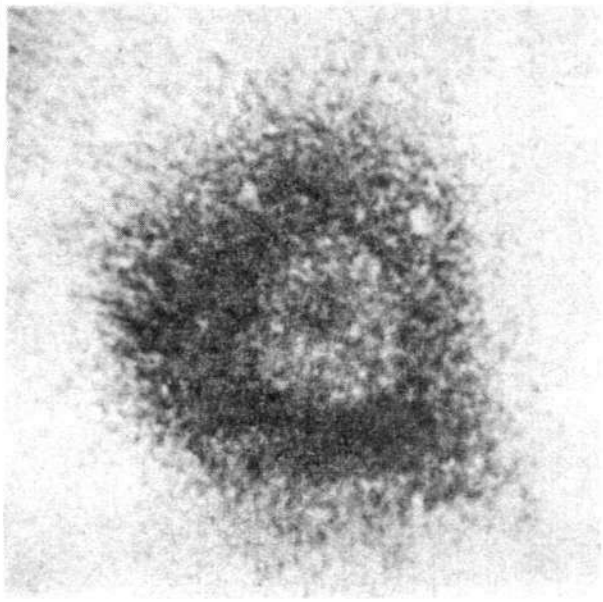


Figure 3
X-RAY MICROPHOTOGRAPH OF IRRADIATED THIN-SHELLED TARGET

X-ray plasma microphotograph, obtained when irradiating thin-shelled glass target (diameter 140 and thickness 2.2 micrometers), filled with gaseous deuterium under pressure (35 atmospheres). We see a core compressed 1,000 ×.

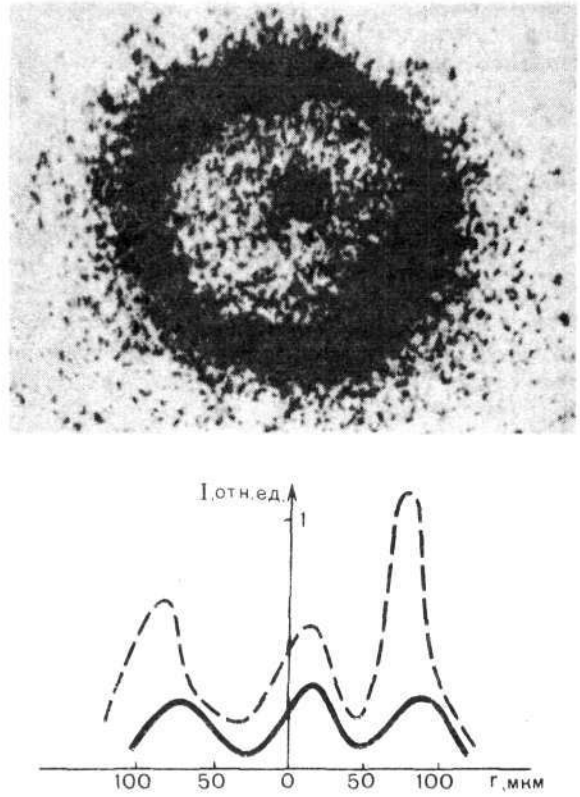


Figure 4
X-RAY MICROPHOTOGRAPH OF ASYMMETRICALLY IRRADIATED PLASMA

X-ray microphotograph of a plasma obtained by asymmetrical (30%) irradiation of a polystyrene target (diameter 179, thickness 6.9 micrometers). Below, the solid line shows experimental and the dotted lines shows the theoretical spread of intensiveness of X-radiation. The asymmetry of irradiation does nothing but move the core in relation to the center, having no appreciable effect on the level of compression.

lack of fast electrons, and rapid ablation, which means a high hydrodynamic coefficient of useful action [efficiency]) require that we give preference to shortwave lasers. However, the question of efficiency and the possibility of generating nanosecond impulses in the shortwave band remain unclear at this time. Apparently, the most promising in this approach are the eximer lasers, which can theoretically achieve an efficiency of about 10 percent if the amplification cascades are optimized. However, the creation of such a laser installation is problematic because of the uniform saturation of the working substance of the laser with electronic beams that have the energy of several MeV and the suppression of the effects of the high-intensity parasitic X-ray radiation on the properties of the optics in use and the active medium.

In terms of efficiency and the frequency of repeating the impulses, the carbon dioxide lasers appear to be the best, but the data existing today on how the carbon dioxide laser radiation interacts with the substance of the target seem to indicate the tendency to form fast electrons. This effect is detrimental to laser ablation and requires the use of "thick" protective layers. As calculations have shown, there is a theoretical possibility of designing an external layer of the target in such a way that the regime of a "collapsing shell" can be implemented as a result of preheating by fast electrons.

Main Physical Results

Let us mention the main experimental results justifying the aforementioned concept of thermonuclear laser fusion. The main problems facing researchers trying to determine the optimal regime of compressing and heating thermonuclear targets are the following:

(1) Determining the laser radiation absorption coefficient in thin-shelled targets in the power density range of 10^{13}-10^{14} watts/cm^2;

(2) Researching hollow shell target compression stability with various aspect ratios;

(3) Determining the effect of nonuniform irradiation (unequal intensity of radiation over the target surface) on the maximal level of compression;

(4) Studying the fast-electron-generating mechanisms in a plasma under the effects of powerful laser radiation, and

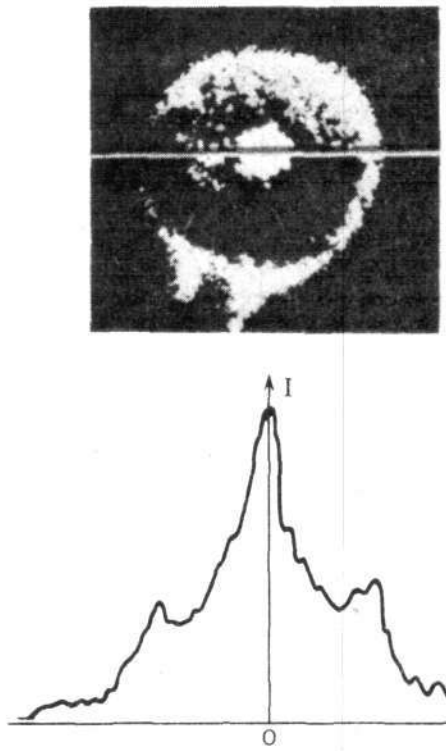


Figure 5
X-RAY MICROPHOTOGRAPH OF TARGETS WITH HIGH ASPECT RATIOS

X-ray microphotograph illustrating the compression of hollow targets with high aspect ratios. Below, an intensity spread chart of X-ray radiation in a cut across the diameter of a glass target (shown by the line in the photograph. The diameter of the target is 534 micrometers, the thickness 1.1 micrometers).

the effect these electrons have on the dynamics of target heating and compression.

Besides this, the search for the optimal target construction that could serve as a prototype for thermonuclear targets, as well as many other problems are as important.

Until the end of the 1970s, the main thermonuclear laser fusion research in the Soviet Union was conducted at the 9-channel laser installation Kalmar, which allowed the realization of compression and heating of spherical targets using a hydrodynamic regime of ablation, with the laser radiation that hits the target on the order of 100 j. As a result of this research, the main tenets of the concept outlined above were confirmed. It was shown that in the power density range corresponding to the hydrodynamic regime, the laser radiation absorption coefficient may reach 50 percent. In these same experiments, a thousandfold gas compression was reached for a target with an aspect ratio of about 35. It was also determined that when the irradiation asymmetry does not exceed 30 percent, there is no appreciable change in the compression level, which indicates the stability of this regime. Measuring the separation of electrons by velocity showed that with a radiation power density corresponding to the hydrodynamic regime of ablation, the amount of fast electrons is several orders of magnitude less than the amount, observed in experiments conducted in the Lawrence Livermore National Laboratory with power densities on the order of 10^{15} watts/cm^2.

When determining the promise for thermonuclear laser fusion of hollow shell targets, one of the most important problems is the problem of compression stability of targets with high aspect ratios (R/Δ-R greater than 100). The use of such targets allows us to considerably increase the amount of laser radiation that hits the target and is converted into the energy of a substance moving toward the center (hydrodynamic efficiency) and the velocity of the shell. This will in turn increase the level of compression of the thermonuclear fuel.

Experimental research into the possibility of stable compression of hollow shell targets with aspect ratios greater than 100 was performed at the Dolphin-1 installation with the laser radiation energy at the target equaling approximately 2 kj. In these experiments we were able to register stable compression of simple hollow glass targets with starting radii in the area of 200 micrometers and shell thicknesses of 0.7 to 1.7 micrometers.

Registering the compression level was achieved using X-ray microscopy, by determining the spatial spread of the plasma emission density in the X-ray portion of the spectrum. Simultaneously, X-ray electrooptics were used to measure the shell velocity toward the center. (Maximal compression by volume exceeded 3×10^3, at which times the shell velocity reached 1.6×10^5 meters per second.)

Experiments performed on the Dolphin-1 installation allowed us to discover the filamentation phenomenon (the formation of string-shaped clots), indicating the formation of instabilities in the plasma corona, the thickness of which increases with the increase in the laser radiation energy. These string-shaped formations are seen most clearly in plasma photographs made by the plasma's own X-rays, most prominently in the plasmas of low-density targets (polystyrene). Analyzing the experimental results shows that despite the filamentation, it is still possible to achieve high target compression.

Laser Thermonuclear Reactors

Within the boundaries of the controlled thermonuclear fusion research program in our country, in the last few years some projects were also developed for a laser energy re-

MAIN PARAMETERS OF THE DOLPHIN-1 INSTALLATION

Radiation energy	2×10^3 j
Impulse duration	2 nanoseconds
Energy absorbed	1×10^3 j
Target aspect ratio (glass shell)	100-200
Plasma corona temperature	1 keV
Shell velocity	1.6×10^5 m/sec

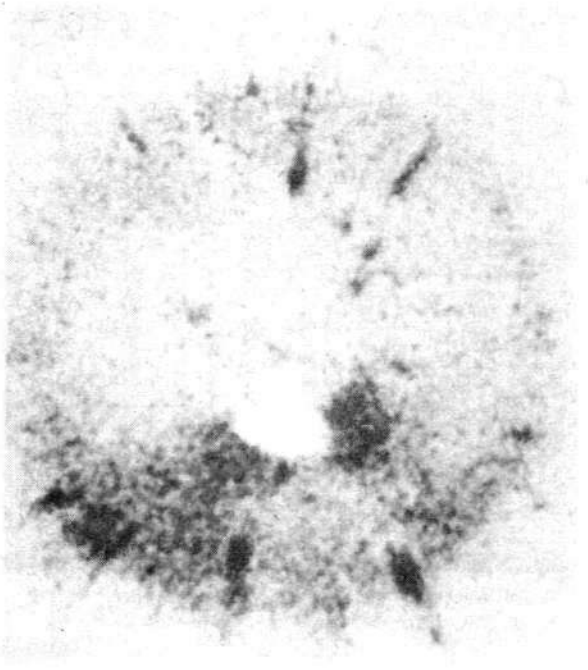
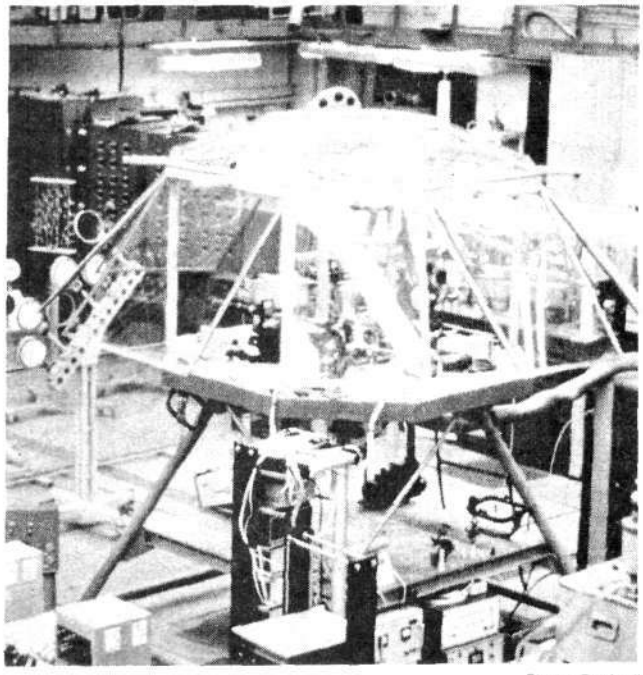


Figure 6
MICROPHOTOGRAPH SHOWING FILAMENTATION IN A HOLLOW POLYSTYRENE TARGET
X-ray microphotograph of a plasma from a hollow polystyrene target. String-shaped formations are visible, indicating that a filamentation phenomenon is developing in the corona.

CHARACTERISTICS OF LASER TARGET SYSTEMS FOR THERMONUCLEAR REACTORS

Radiation energy	[1-5] × 10^6 j
Power	10^{14} watts
Radiation Divergence	10^{-4} rad
Repeat frequency	1-10 Hz
Laser to target distance	Greater than 50m
Diam. multilayer cryogenic target (D-T ice)	0.5-1.5 cm
Thermonuclear amplification coefficient	10-100
Neutron output	10^{17}/impulse



Steven Bardwell

Basov's laboratory and the Kalmar laser in 1980. The laser and amplifier rods are along the back wall of the laboratory. In the center is the target chamber protected with a plastic dust cover.

actor. As a result of these developments, requirements for the laser-target system for an energy reactor were formed.

Projects exist for three types of reactors: the "pure" reactor (which uses only fusion energy), the hybrid (fusion and uranium fission in a blanket), and the breeder reactor, which creates more fuel for standard atomic power plants and would be built together with a fission plant to form a single power complex.

The most difficult to realize is the "pure" reactor, as it requires a laser with sufficient efficiency (about 5 percent) and a target with a thermonuclear amplification coefficient greater than 10. Furthermore, even if the aforementioned requirements are met, the cost of electricity in the "pure" power plants would be twice as high as in the second and third possibilities. Economic calculations show that the cheapest electricity is obtained from the laser-target system for producing nuclear fuel to be used in an atomic power plant. In this case the laser efficiency can be as low as 0.5 percent.

It is interesting to note that the laser cost is no more than 10 percent of the electricity costs (with lasers costing 100 rubles per joule, an efficiency of 5 percent, and a capability of something on the order of 10^8 impulses per year).

The closest to reaching the aforementioned parameters is the electroionizing carbon dioxide laser. Another possible candidate is the eximer laser. Looking at the problem optimistically, it is necessary to note that the creation of technologically applicable and commercially useful megajoule lasers is a very difficult task.

In conclusion, I would like to mention that the progress in understanding the physics of thermonuclear laser fusion was achieved with the efforts of scientists from many countries. When developing megajoule lasers (under conditions when the optimal type of laser is still difficult to pick and the creation of laser thermonuclear installations as a whole requires great effort and expenditure) it is difficult to get along without widespread international cooperation. This cooperation in the boundaries of member nations of [the Soviet bloc] or even on a wider scale (as this is already taking place in the case of thermonuclear installations with magnetic confinement) will allow a significant acceleration in realizing the thermonuclear laser fusion program.

Why I Must Attack Albert Einstein

by Lyndon H. LaRouche, Jr.

Photo by Johan Hagemeyer, Bancroft Library, courtesy of American Institute of Physics, Niels Bohr Library.

Dr. Albert Einstein, circa 1930.

EDITOR'S NOTE: An "Einstein debate" emerged after the 100th birthday celebration of Einstein in 1979, in which the name Einstein has been repeatedly misused solely to strengthen cultural pessimism and the antiwar movement. This article contrasts sharply with the so-called Einstein debate, and treats with scientific precision the question of morality in scientific work.

The origins of the ugly Einstein debate are as follows: In November 1980, an essay by the West German physicist Unsöld pinned on Einstein the blame for atomic weapons, and therefore all modern warfare. Writing in the official publication of the German Science Association, Unsöld vented his anger over the just-concluded "Einstein Year" celebration: "[H]ardly anyone dared to remind us," he wrote, "that Einstein's name is also closely associated with with atomic bomb. . . . Much has been said in 1979 about the 'responsibility of scientists.' But of Haber's poison gas and Einstein's atomic bomb . . . we hardly heard a single word." (The year 1979, it should be noted, was the year NATO made the bilateral decision to station middle-range missiles in Western Europe.)

The green and peace movements immediately put Unsöld on their lecture circuit, giving him the opportunity to spread his ideas on "scientists' responsibility" throughout West Germany. His speeches against Einstein soon provoked an international outcry, including charges that Unsöld's attack was motivated by antisemitism. The British magazine *Nature*, for example, reported April 16, 1981 that "Unsöld, a theoretician, now 75, appears to have begun his attack on Einstein at a [university] symposium . . . when he said that Einstein was guilty of crimes, no less serious than those of Hitler. . . . Unsöld has been charged with antisemitism." Why the peace movement would so zealously rely on Unsöld's view of "scientists' responsibility," becomes clear from the following citation from the abovementioned Unsöld article against Einstein:

> Man's psyche apparently possesses *two regions*, which operate according to quite different rules. . . . The deliberative, goal-oriented and critical activity of our "I" resides . . . in the neocortex. . . . Opposed to this is the genetically more ancient limbic area, or brain stem, which is where the instincts, the "Id," reside. This latter portion has remained unchanged since the stone age. Thus we understand that, even in humans with extremely differentiated thinking and investigative capacities—people with "exceedingly high intelligence"—the old stone-age instincts are lurking in the background, instincts primarily aimed at acquiring power, acclaim, etc., and which would not hesitate to destroy anything which could get in the way.

In Unsöld's twisted and antihuman view of man—as in that of the green and peace movements—there is no place for moral or statesmanlike activity, and no notion of how science and technology enable mankind to not only survive, but to develop. The Einstein debate spurred by Unsöld promoted nothing useful scientifically; it served only to promote the European peace movement's simple-minded formula that "Science = Weapons."

With great personal reluctance, I find myself obliged to attack certain features of the work of the late Albert Einstein publicly. This reluctance bears upon Einstein as a man, not as a physicist. Although I am not a physicist or mathematician as such—chiefly because I early abhorred, morally, certain leading features of contemporary textbook and classroom mathematics—I am not awed by Einstein's reputation in science. I know enough of the absolute fundamentals of scientific work to know with certainty that important aspects of Einstein's work depend upon childishly outrageous blunders of assumption and method. What I like about Einstein is that, although he permitted himself to be used and corrupted to a certain degree, he drew the line beyond which he would not permit himself to be used for corrupt purposes. For that latter reason, and for reason of certain important issues on which Einstein was morally on the right side, I would prefer to defend him, than to be obliged to attack his memory.

My motives for attacking Einstein's memory are eminently, urgently practical ones, reasons he would admit are of an obligatory moral as well as practical character. Briefly, the threat of a new general war, this time probably a thermonuclear war, and the threatened collapse of the world's economy—unless a technological revolution intervenes—require a very special kind of "crash-program" effort in development of three interrelated areas of scientific investigation and technological applications. These three areas are: (1) controlled thermonuclear fusion and related aspects of relativistic physics; (2) a general, radical revision in the theory of quantum electrodynamics, with emphasis on the need for a comprehensive and coherent doctrine of coherent radiation—new, rigorous distinctions between *energy* and *work*; and (3) revolutionary breakthroughs in biophysics, centered upon control of aging of tissues within the whole processes of human bodies, a fundamental breakthrough in the physical definition of the word *life*. These three breakthroughs cannot be accomplished without throwing overboard the *axiomatic notions* of a statistical theory of heat, axiomatic notions embedded in much of Einstein's work, and the root of every major error in his work.

In these matters, my own special variety of competence lies both in my mastery of empirical principles of economic science, and a life dedicated chiefly to mastery of what is best described as "the third level of scientific hypothesis," what Plato's writings define as the notion of an *hypothesis of the higher hypothesis*. In my own case, my susceptibility to the Platonic (or, Neoplatonic) viewpoint was an outgrowth of a childhood and youthful saturation with matters of theology, most emphatically that of the Gospel of St. John. It was consistent that during my 13th and 14th year, I should have been won totally to the methodological outlook of Gottfried Leibniz, most emphatically the Leibniz of the Leibniz-Clarke correspondence and the *Monadology*. This theological point of entry into scientific work has been no defect, as the instances of St. Augustine, and the founding of modern science by the 15th-century Cardinal Nicholas of Cusa best indicate the connections to be noted.

What turned me away from mathematics, as I encountered taught mathematics in the textbooks and classrooms

of my youth, was the recognition that the lattice structures of a logically consistent mathematical edifice depend upon the validity of the axiomatic and postulational assumptions which underlie all mathematical systems. It has always appeared morally indefensible to me to assert that anything is true mathematically merely because of plausible empirical consistency with mathematical schemas. If the underlying assumptions are in error, then the entire edifice of existing mathematics collapses. Perhaps, at any given point in progress of knowledge, it may not be possible to settle these problems respecting underlying assumptions, and scientific work must not be halted merely because we know some more or less pervasive defect to exist in given mathematical physics. Yet, at the same time, it is morally wrong, and ultimately destructive of scientific work, to pretend that the existing mathematics is self-evidently right as to principles when it is demonstrable that some underlying assumptions are of a dubious character.

This doubt proved most fruitful. The Wiener-Shannon doctrine of "information theory," derived from the statistical theory of heat, expresses the most immoral features of existing scientific opinion, depending most directly upon assumptions which are provably absurd, assumptions conclusively proven absurd long before the work of Boltzmann, Gibbs, et al. *Negentropy*, it appeared to me during late 1947 and early 1948, when I first encountered the Wiener-Shannon dogma, is characteristically the quality of living processes. *Life* as an active, efficient principle, must be adduced directly, empirically, from living processes. It was my preferred argument then, and still today, that the professor who undertakes to discover whether or not life is possible, from the standpoint of the statistical theory of heat, or the mechanistic standpoint otherwise expressed, is posing actually the question whether he himself exists to have the power to express an opinion on any matter of inquiry. Therefore, I was led through the work of Nicholas Rashevsky on mathematical biophysics, to challenging Rashevsky's methodological assumptions. This led ultimately to a year of wrestling with Georg Cantor's notion of transfinite orderings, a vantage point which made the essential, underlying features of the work of Bernhard Riemann directly accessible. My own fundamental discoveries in economic science, dated from 1952, were the result of that.

Energy unquestionably exists, to the effect that increase of measurable energy-flux density of processes is the proper first-approximation measure of work accomplished by thermodynamic processes. Yet, "energy" and "work" are not the same thing. Work produces energy, and the conversion of energy into work is the crux of the matter. It is the comparison of the work gained with use of energy against the work required to produce energy in the form required, which is the essential definition. This recognition, and its bearing upon the measurability of technology as such, was the basis for my original discoveries of 1952, a discovery which has undergone a radical improvement in depth and scope during the recent five years—chiefly due to my collaboration with Uwe Parpart Henke, Dr. Jonathan Tennenbaum, and others, who have enabled me to locate my earlier conceptions within the broader range of fundamentals of mathematics and mathematical physics.

The most recent developments in my own work began during 1980. The LaRouche-Riemann method of economic forecasting has proven itself the only competent forecasting method in existence today, but there are shortcomings within the present form of the forecasting practice, such that the method is of the highest accuracy presently available for short-term general forecasting, but not satisfactory to the same degree for short-term forecasting of subsectors of the same general economic process. Therefore, a constant improvement, refinement, in the program has been characteristic of the work since it was launched in December 1978.

The direction of these continuing refinements took a wrong turn during mid-1980, a wrong turn I recognized to be disregard for the deeper implications of the "delta" in Leibniz's formulation of the differential calculus. This, I warned my associates then, obliges us to emphasize the fact that the notion of a quantum-value in physical processes is nothing but Leibniz's notion of the fallacy of "infinite divisibility," one of the points upon which he based his (accurate) argument, that Newton's form of the calculus was useless and false to physical reality. To solve certain tasks of refinement in economic analysis, I concluded, it is indispensable to brush aside prevailing, accepted interpretations of the quantum-notion and to derive the necessity of this notion from the same basis as Leibniz's approach, rejecting the assumptions underlying what is called quantum mechanics. When my associates failed to effect quickly enough the breakthrough of the form I saw necessary, I mobilized myself to set the required solution into motion, demanding that we examine the matter from the standpoint of a rigorously synthetic-geometrical approach to construction and interpretation of conical (complex) functions.

This program began, during 1981, with an attack on the simplest phenomenon of all conical functions: the determination of the correct, well-tempered values for the musical scale as an elementary exercise in differential geometry, as completed by Jonathan Tennenbaum and Ralf Schauerhammer during autumn 1981. This led, further, Tennenbaum's reconstruction of Minkowski's doctrine of special relativity through use of paired cylindrical functions, in respect to which I insisted this must be corrected by an additional, crucial step, of substituting conical functions for the cylindrical. This led to Tennenbaum's discovering a fresh view of Gauss's arithmetic-geometric mean. Through the collaboration with Tennenbaum, I pointed out that the view of generalized elliptic functions, as subsumed by Gauss's derivation of the arithmetic-geometric mean, was the basis for both Riemann's famous 1854 habilitation dissertation, "On The Hypotheses Which Underlie Geometry," and the proper basis for defining both the principle of the quantum and Leibniz's "delta."

The outgrowth of Tennenbaum's continuing work on this matter gave us a much more powerful apparatus than I had previously employed for economic science. This, and its general implications, I reported to the July 3-4 [1983] conference of the International Caucus of Labor Committees in Reston, Virginia. The included judgment is that a "general theory of relativity," as distinct from "special relativity,"

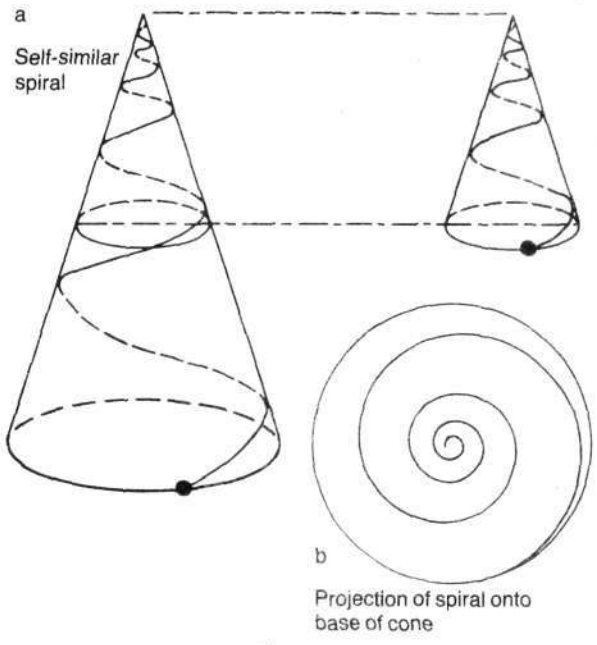


Figure 1
SELF-SIMILAR SPIRAL ON A CONE

A self-similar spiral (a) is the proper mathematical definition of work. The self-similar characteristic of the figure is that a cut made anywhere parallel to the base of the cone produces a smaller cone and spiral identical to that of the larger cone, except for its scale and rotation. Each cycle of the spiral defines a circular cross section of the cone.

In projection (b), the spiral on the cone becomes a two-dimensional spiral.

does not exist, that the search for a unified field within the scope of a supposed general relativity is a result of wild, unrecognized fallacies embedded in an incorrect formulation of what is called "special relativity." This argument does not depend upon any complex analysis of the matter; the errors are entirely of the most elementary kind, the most primitive errors of assumption, which therefore admit of direct, simple demonstration.

I summarize the bare essentials of the case which I presented to that conference, beginning with a definition of the notion of an hypothesis of the higher hypothesis.

The Three Levels of Hypothesis

In scientific work, there are three levels of hypothesis:

(1) *Simple hypothesis.* The underlying assumptions of prevailing scientific knowledge are assumed to be valid, both for scientific work generally, and also for the particular area of inquiry to which some experimental hypothesis is addressed. The assumption of consistency with existing structures and underlying assumptions of scientific work, especially mathematical physics, is the basis for design and testing of the experimental hypothesis.

(2) *Higher hypothesis.* This is an experimental hypothesis addressed to the question whether evidence requires us to overthrow one or more of the fundamental assumptions underlying contemporary scientific work. A successful higher hypothesis produces a greater or lesser scientific revolution, and, by implication, greater or lesser technological revolution.

(3) *Hypothesis of the higher hypothesis.* This presumes that a succession of scientific revolutions represents an orderable series of higher hypotheses, on the condition that the succession correlates with an increase in the potential per capita power of society over nature. This poses the question, whether a succession of higher hypotheses meeting that requirement is demonstrably the result of some common principle of discovery. In other words, is there some principle of discovery which can be successively applied to successive scientific revolutions to generate the next scientific revolution in that series? Experiments which test hypothetical principles of discovery of this sort define the notion of an hypothesis of the higher hypothesis—*the third level of hypothesis.*

There is a current of modern science, beginning with the discovery of the *isoperimetric principle* by Cardinal Nicholas of Cusa during the 15th century, which insists that all of the fundamental questions of scientific knowledge exist for comprehension only on the third level of hypothesis. This current of science is typified by Cusa, Leonardo da Vinci, Johannes Kepler, Gottfried Leibniz, the Carnot-Monge Ecole Polytechnique, Karl Gauss, and Bernhard Riemann—a current sometimes identified in English literature as "continental science." This is the current to which this writer adheres.

This adherence takes the practical form today of the writer's specifications for design of a needed "crash program," both to implement the President's strategic doctrine enunciated first on March 23, 1983, and to cause that work in military technology to spill over efficiently into the world's civilian economy, to foster a general explosion in economic growth. The designs proposed by this writer are modeled, as a matter of reference, on the combined military, scientific, and educational work of the Ecole Polytechnique under Lazare Carnot and Gaspard Monge. Otherwise, the writer situates within that model of reference the question of a governing administrative-methodological principle approach to make such a social instrument of "crash-program" work effective for the specific objectives in view today.

The importance of this approach is most readily demonstrated from a military standpoint. In opposition to those "systems analysts" whose influence has ruined the defenses of the United States, military technology defines a domain of accelerating technological attrition. The best measures deployed today produce countermeasures, countermeasures which require more advanced measures to overcome them. The succession of measures and countermeasures so defined is sometimes named "technological attrition," and is sometimes called an "arms race." There is no alternative to such an "arms race," but to prepare to lose the next war.

The same principle of "competition" exists in the nonmilitary economy. However, one may ignore this principle of "competition," on the assumption that a nation may survive national economic bankruptcy, but might not survive

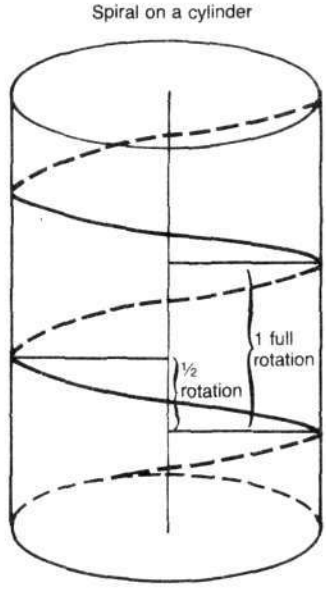
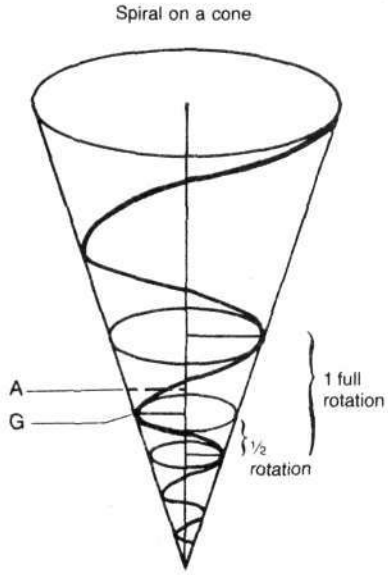


Figure 2
IDEAL REPRESENTATIONS OF ENERGY AND WORK

At left, a spiral on a cylinder, the ideal mathematical representation of energy. Half the spiral's rotation occurs at a point on the cylinder that is one half the height of a complete cycle of rotation.

At right, a spiral on a cone. At one half-rotation, the spiral has reached a height, measured along the central axis of the cone, that is less than one half the height of a complete cycle of rotation. The height of the spiral after making a half-rotation will be the geometric mean (G) between the height at the beginning and end of the cycle of rotation. The arithmetic mean (A), the midpoint of the vertical distance traversed by the total action, is at a point more distant.



losing a war. Hence, it is the unfortunate reality of modern history, that great advances in technology of civilian economies have often been a by-product of mobilization for wars. It is not that war is the indispensable instrument of progress—usually it is not; it is that nations refuse to do what they should have done in pursuit of peace, until the hot breath of war is upon their necks.

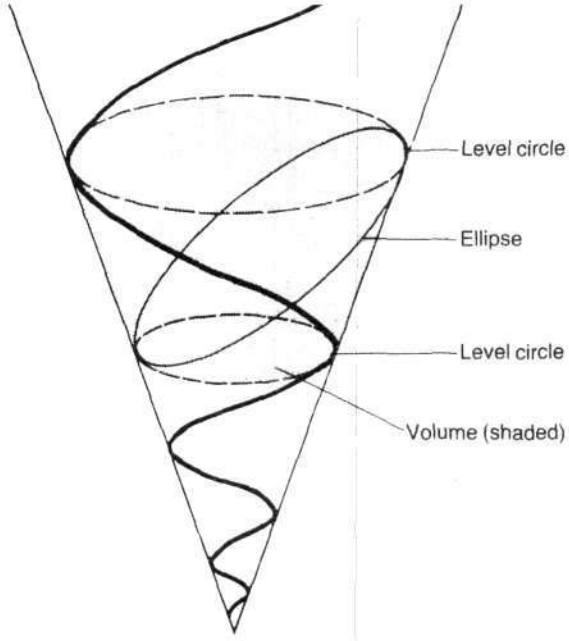


Figure 3
ELLIPSE CHARACTER OF CONICAL ACTION

The path of the spiral up the cone defines the first integral of the complex variable. The shaded area between the two circles represents the volume and defines the second integral, net work. The character of this volume is the ellipse cut between the two level circles.

Technological attrition converges upon the notion of successive scientific revolutions, at least, successive technological revolutions. The distinction between the two is that a technological revolution is a scientific revolution put into practice—too often, belatedly. The idea that there exists a "world-line" based on successively ordered series of scientific breakthroughs, or technological breakthroughs, is the implied feature of technological attrition, and therefore the implied feature of all "crash programs" resembling that which we have proposed. This represents the ideal case for direct application of the third level of hypothesis.

Conical Functions Defined

The fundamental fallacy of the work of Einstein—and many others—was his refusal to accept the fundamental principle upon which the preceding development of European science depended: the treatment of the implications of the five Platonic solids from the vantage point of Cusa's rediscovery of the isoperimetric principle: the principle that the *action of circular rotation*, Leibniz's Principle of Least Action, is the only form of action self-evidently existing in visible (Euclidean) space. All of Einstein's major errors are derived from this consideration, including his misinterpretation of Riemannian physics.

Briefly, circular action in a measureless, formless void, creates a circular area of measureless extent. The repetition of this same action upon that circular area creates the straight line, and also creates the first degree of measure: division of circular rotation by one-half. This is the only definition of a straight line permitted within a rigorous mathematical physics. The same circular action repeated upon a semicircle creates a point. From circular action, and the line and point created by circular action (singularities), all forms constructible in visible (Euclidean) space are constructed, using no other means but the hereditary principle of con-

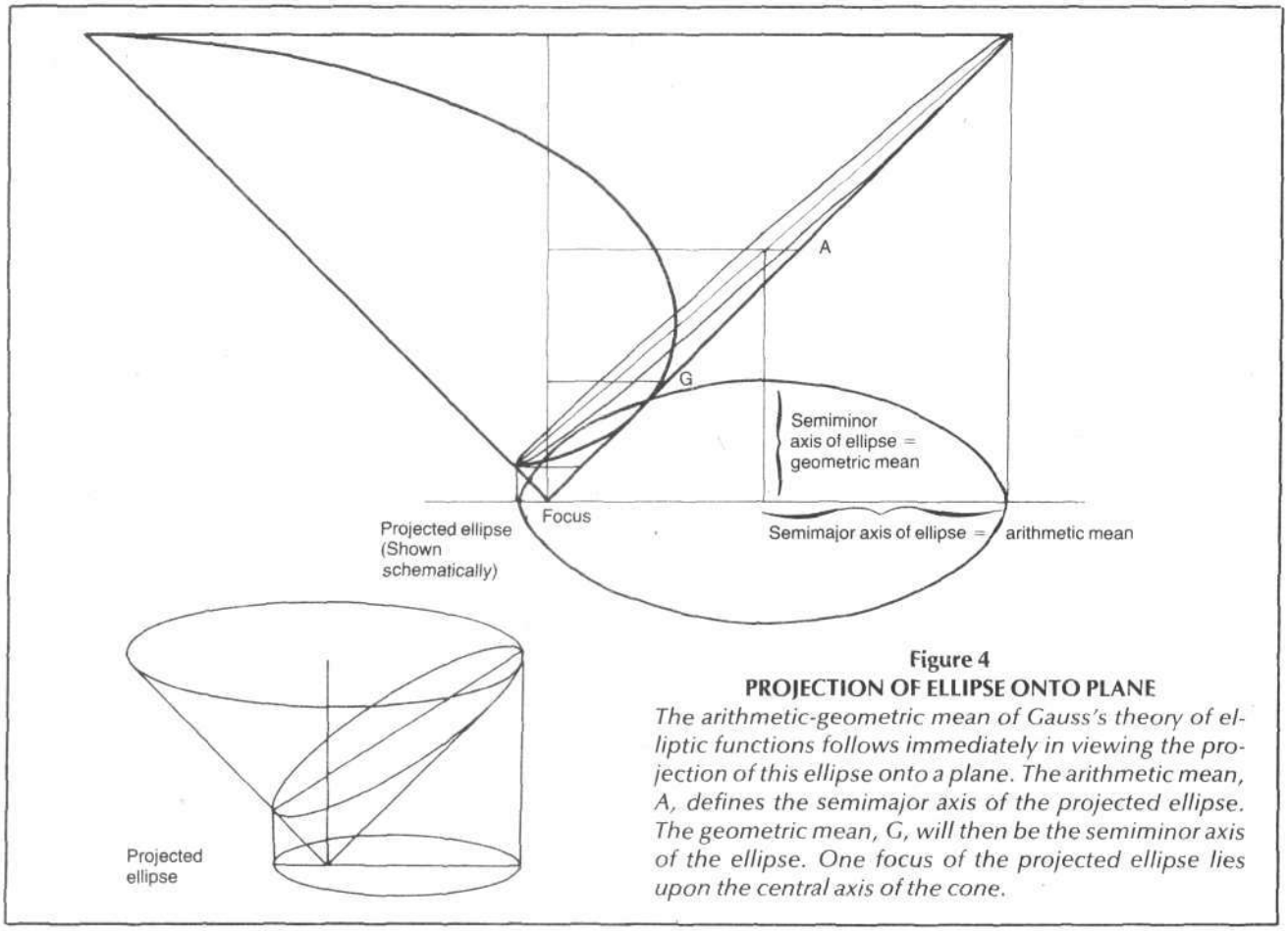


Figure 4
PROJECTION OF ELLIPSE ONTO PLANE
The arithmetic-geometric mean of Gauss's theory of elliptic functions follows immediately in viewing the projection of this ellipse onto a plane. The arithmetic mean, A, defines the semimajor axis of the projected ellipse. The geometric mean, G, will then be the semiminor axis of the ellipse. One focus of the projected ellipse lies upon the central axis of the cone.

struction from the starting-point of circular action. No axioms or postulates are permitted in rigorous mathematical physics, or geometry.

The limitations upon construction in visible space are two. First, only five kinds of regular polyhedra can be constructed in visible space—the five Platonic solids. All of these solids (4, 6, 8, 12, and 20 sides respectively) reduce to one elementary such solid, the 12-sided dodecahedron whose sides are equal, regular pentagons. The pentagon and the dodecahedron are both constructed on the basis of a harmonic characteristic called the golden section. Nothing can be constructed in visible space except by reference to the unique feature of the golden section. The second, ultimately identical limitation, is the fact that certain classes of occurrences within visible space cannot be constructed within visible space, those constructions which depend upon transcendental functions—including the regular heptagon.

However, all existences within visible space can be constructed as projections of continuous, conical functions upon visible space. These conical constructions have the elementary form of a self-similar spiral on the outer surface of a cone. This spiral has the 2-space projection of an Archimedes spiral whose characteristic proportion is the golden section. Each cycle of the spiral defines a circular cross-section of the cone. All existences in visible space are thus defined by transcendental conical functions. *The conical self-similar spiral of the reflected continuous manifold is the only self-evident form of physical action in the universe* (Figure 1).

This is the foundation of all rigorous forms of mathematical physics. This is the elementary root of the third level of hypothesis for mathematical physics.

Pacioli, da Vinci, and Kepler emphasized that all living processes have the morphological characteristics of growth and function of the golden section. *Functions with such characteristics are negentropic functions.*

Kepler proved, and that conclusively, that the Platonic harmonic system, as presented by Plato's *Timaeus*, is the basis for the universal laws of astronomy. With aid of corrections supplied chiefly by Karl Gauss, Kepler's astronomy is valid to the present date, whereas all opposed doctrines are not.

The most fundamental breakthrough in science after Kepler and Leibniz's, was the discovery of the arithmetic-geometric mean by Karl Gauss. Without this discovery, no fundamental discovery of post-1830 European sicence would have been possible (after Legendre, Fourier, and Poncelet). This is what Einstein rejects implicitly.

The most elementary complex variable is the stretching of a rotating radius-line as the radius rotates around the axis of a cone. The simplest case is that in which the radius increases by a fixed ratio as it rotates, such that, after each complete rotation, the radius has increased by the ratio of some fixed number. If the ratio of the radius's increase is "1," the result is a constant spiral on the outer surface of a

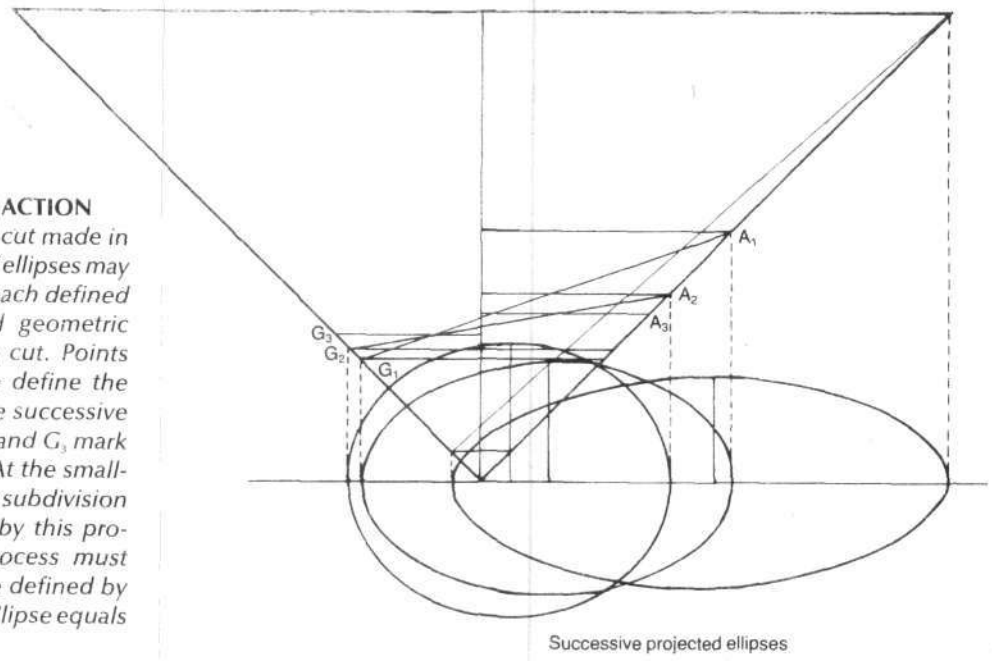


Figure 5
THE QUANTUM OF ACTION
Following the elliptical cut made in Figure 3, a succession of ellipses may be cut from the cone, each defined by the arithmetic and geometric means of the previous cut. Points A_1, A_2, A_3 on the cone define the arithmetic means of the successive ellipses; points G_1, G_2, and G_3 mark the geometric means. At the smallest possible self-similar subdivision of the spiral achieved by this process, the recursive process must stop. Here, the volume defined by the two foci of the last ellipse equals the quantum of action.

cylinder, the ideal representation of *energy*. If the ratio is greater than "1," the result is a self-similar spiral on the outer surface of a cone, the ideal representation of *work* (Figure 2).

In the second case, the Gauss arithmetic-geometric mean follows immediately.

The first integral of such an elementary complex variable is the spiral-action (for an interval of time). The second integral (for our purposes here) is the definite integral of the spiral-action for one completed cycle of rotation: the volume defined by two successive circular cross-sections of the cone, at the beginning and end of that cycle. The characteristic of this volume is the ellipse defined by any diagonal cut of the volume by a plane (Figure 3).

If the volume is cylindrical, the spiral rotates half its rotation at the midpoint of the volume: The geometric and arithmetic means are coincident. The elliptical cross-section defines energy, but not work.

If the volume is conical, the spiral rotates less than half the distance along the central axis of the cone during the first half of the rotation. In this case, the geometric mean lies below the arithmetic mean; the two are not coincident.

Imagine the cone standing on a plane and project the boundaries of the spiral down to the plane. The distance between the two points on the plane defines the major axis of an ellipse in the plane. The vertex of the cone forms one focus of this ellipse (the position of the sun in the Earth's orbit). The semimajor axis of the projected ellipse has the same length as the radius of the circle that is located at the arithmetic mean on the cone. The semiminor axis has the length of the radius of the circle located at the geometric mean (Figure 4).

Let us imagine that the ellipse on the plane is projected from an ellispe located in a cone. We can generate a series of similar ellipses, each bounded by the arithmetic and geometric means of the previous ellipse. Repeat this operation a large number of times. The question is: When does one stop this recursive process? This is the kernel of Gauss's theory of elliptic functions.

At whatever point the recursive process ceases, the remaining volume defined by the two foci of the last ellipse defines a degree of rotation of the spiral generating the cone, and also defines a relative value for an interval of displacement along the central axis of the cone. In a universe whose metric is the speed of light, this will correspond to a wavelength, a frequency. If this is determined in some necessary way, we have Leibniz's "delta" and the notion of the quantum of action (Figure 5).

The physical significance of this was first established in available scientific literature, by Riemann's 1854 habilitation dissertation, "On The Hypotheses Which Underlie Geometry." Assume the prior self-elaboration of the universe as a whole, or some phase space to correspond to some well-defined number N, such that the singularity of the Gaussian elliptic-function series for the conical interval represents $N+1$. This means that action corresponding to a well-defined notion of work acts upon the universe (or phase space) as an entirety, such that that action is bounded uniquely, in scope and division of itself, by the relationship implied by values $N+1$ and N. This defines a smallest division of action, below which only a singularity in physical space can occur. That is a quantum of action, a value which varies relativistically as the universe evolves to higher states, or as the phase space evolves similarly.

That is what the quantum represents from the standpoint of the third level of hypothesis: a smallest wavelength of continuous action, below which only a singularity can exist.

This was the basis for Riemannian electrodynamics, in which retarded potential, rather than notions of the statistical theory of heat, is characteristic. This has been the underlying issue of the factional furor within physics for more than a hundred years.

However, this quantum can be measured empirically not only as a smallest wavelength of a continuous (for example, electromagnetic) function. Changes in the value of the quantum, relative to functional notions associated with N and $N+1$, also correspond to relativistic metrical changes in the characteristic rates of action within the phase space concerned, as Riemann specifies. This, from the standpoint, again, of the third level of hypothesis, defines relativistic physics.

Contrast to Newton and Maxwell

Any system for describing physical processes which is modeled upon the syllogistic system of Aristotle, eliminates representation of such forms of action as "create" and "cause" within the mathematical system itself. The use of the equal-sign or inequality-signs has the same function as the middle term in the Aristotelian syllogism. Hence, mathematics usually confronts us with the ludicrous spectacle that we speak of creation of the universe, and speak of and observe causal relationships in physical processes, but can find no expression of either in conventional mathematical schemas.

The paradox does not exist in a rigorous geometry of the sort we have indicated here. Circular action, as the mirror of conical-self-similar action, is the form of the verb "to create," and also the description of action congruent with the verb "to cause." Creation and causation are one and the same, at least essentially. This requires, of course, that we cast aside all of the axioms and postulates of Euclid's *Elements*, or anything resembling them, and replace entirely the syllogistic lattice-work of deductive theorems by the "hereditary principle" of rigorous construction of synthetic geometry from the unique principle of circular (conical self-similar) action, Leibniz's Principle of Least Action.

Most of the formal fallacies which afflict mathematics and mathematical physics are derived not from physical experiments as such, but from substituting an axiomatically algebraic mathematical structure used to describe physical processes for those processes themselves. In a word, *nominalism*. Since such mathematics does not tolerate the existence of a creation, such as our universe, and prohibits specification of causation as a term of description, it should not be surprising that such mathematics is often inappropriate means for studying principles of causation in a created, existing universe. Such mathematics has merit as a language of description, but it is a fool's enterprise to attempt to wring out of such mathematics any evidence bearing upon causation: one would have better luck attempting to wring blood from a stone. When one uses such a language of mathematical description, one must be aware at all points of what this mathematics can and cannot accomplish, and not employ it for the sort of analysis which it prohibits on axiomatic principle.

The same general problem arises in connection with notions of probability. The same word, probability, has mutually exclusive meanings from the standpoint of Gauss on the one side, and Descartes or LaPlace on the other. In Gauss, it signifies the necessarily determined division of action according to principles of a conically defined continuous manifold. In LaPlace, it has a mechanistic-numerological interpretation. In the latter connection, we locate the intrinsic fallacies of assumption underlying popularized notions of a statistical theory of heat, and of related notions of statistical dynamics, quantum mechanics. There is no doubt that the action described probabilistically occurs as a phenomenon in more or less the form described. The issue is that of what sort of causal notion one might wring out of the two, mutually exclusive modes of description—Gauss's versus LaPlace's, for example. The latter prohibits incorporation of causation into mathematics: Lo and behold! Such mathematics argues from examining its own probable navel, that causation does not exist!

Admittedly, the sort of notions we have described for the third level of hypothesis do not provide us an elaborated physics. They provide only what that level of hypothesis is defined as providing: principles of discovery. However, the process of experimental refinement of such principles of discovery converges upon the underlying principles of lawfuness of the universe in general, and thus constitutes as much as we can know respecting the fundamental laws of that universe. Not only does this level of hypothesis define a *method*, it also defines as much as we can know respecting the lawful *ontology* of the universe as a whole. Not only is science fundamentally *methodologically transfinite*; the universe explored is itself *ontologically transfinite*.

This addresses an issue which much occupied German science at the beginning of this century, a shift from the ontologically transfinite standpoint of Cusa, Kepler, Leibniz, Gauss, Riemann, et al., to the only-methodologically-transfinite approach of German science at the turn of the century. This latter represented a limited concession to Helmholtz, Boltzman, et al., the leading enemies, together with Maxwell, Rayleigh, et al., of the rigorously geometrical approach to physics. The geometrical method was degraded from a method of physics, to a method for clever intuitions into matters bearing upon the interpretation of mathematical physics' problems.

The legitimate problem, which the purveyor of statistical mechanics cites against the mechanistic system of Descartes and Newton, is that action in the universe does not conform to the notions of one-on-one interactions among isolated particles in empty space. There are determinations which belong to the manifold as a whole, which override what might appear to be inferred from a mechanistic misinterpretation of space. Probability appears to fill the gap between the two, and, within limits, appears to provide an efficient guide to practice in those matters for which the mechanistic method fails otherwise.

The fallacies intrinsic to statistical mechanics generally, and quantum mechanics in particular, are, therefore, these.

(1) It overlooks the fact that physical reality cannot be constructed within visible space, but that this reality can be constructed only as projections of a continuous manifold upon the discrete manifold of visible space. Our sense-perceptual apparatus is such, that we distort the real universe (the continuous manifold) into the form of the visible (discrete) manifold of sense-perception. The result is as if a distorting mirror were everywhere embedded in space, such that we see only the distorted reflection, not that which is reflected. Therefore all inductive-empiricist method is in-

trinsically false as to principled features of the cause of phenomena.

(2) It assumes that least action is straight-line action as defined by a naive view of the discrete manifold as self-evidentally reality, whereas the only real form of action in the universe is least action defined by the projection of self-similar-spiral conical action as the isoperimetric principle of visible space. Thus, mathematical physics is made intrinsically incommensurable with the action causing the phenomena.

(3) It makes energy and work simply equivalent, and ignores the fact that all action is essentially negentropic work, congruent in principle with increase in the areas of conical cross-sectional circles defined by a self-similar, harmonic conical function. *It confuses mere effects with work*, and therefore distinguishes entropy and negentropy as a mere construct of such effects, rather than properly recognizing that effects are singularities of negentropic or entropic action as primary realities.

These problems vanish once the successive standpoints of Gauss and Riemann are adopted.

This does not signify that we can derive physics simply and directly from the third level of hypothesis. It is merely a method for effecting improvements in physics, and also for judging what is outrightly absurd in existing physics' doctrines respecting fundamental matters. It is simply a rigorous way of thinking about the universe, which means that a physicist employing such rigor is vastly superior to one of equal training lacking such rigor.

Economics and Physics

Popular opinion is so much conditioned to confusing economics with monetary doctrines, that the connection of economics to physics is simply overlooked or violently denied. It is forgotten that modern economic science was founded by Leibniz, who defined economics as "physical economy," as did the founding fathers of the United States (for example, Hamilton's *Report On the Subject of Manufactures*).

What we measure, ultimately, in economy, is the relative increase or decrease of the power of a population to sustain its own existence. This is best described as the potential relative population-density of a society (economy). This measures man's per capita power over nature, and thus defines what changes in behavior correspond to an increase or decrease in man's knowledge of the lawful ordering of the universe.

Those changes in behavior which overcome effects of depletion of natural resources, or which advance mankind's potential relative population-density absolutely, are increases in technology. Thus, the net work accomplished by society is properly defined as the role of work in mediating advances in technology for the practice of the society as a whole. This form of work is intrinsically negentropic, corresponding to the simplest sort of ideal conical function indicated above. That is our proper definition of work, and the proper measure of technology's equivalence to work. This connection was the discovery the writer effected in 1952 on the basis of implications of Riemann's 1854 habilitation dissertation.

In other words, increase of the potential relative population-density of an economy is the unique experimental authority for determining what are in fact valid scientific conceptions. Any purportedly scientific notion which contradicts such criteria is ipso facto scientific absurdity. Any notion, however correct, which cannot account for itself in these terms of reference, is to that degree scientifically illiterate.

This was understood by Leibniz, who developed thermodynamics from the vantage point of his development of economic science: his generalization of the implications of the heat-powered machine for increasing the power of an individual operative to perform work. The fact that two machines, consuming the same amount of coal per hour, contribute differently to an operative's power to accomplish work, is the basis for the notion of technology.

Technology, in turn, reduces, in the case of machines, to the Principle of Least Action: conical functions as we have indicated here. This is generalized for electromagnetic action. Although we have failed to solve this for chemistry and biology, the terms of mechanical and electromagnetic work-action have proven adequate even for biological processes. Today, we reduce the formal aspect of technology to electromagnetic equivalents, and measure increase in productive power per capita in such electromagnetic-geometrical terms of reference for measuring technology.

By correlating technology so defined with the work represented as increase of potential relative population-density, we correlate technology with economic growth, the latter properly defined. Thus, we prove that those principles of discovery generating successive scientific revolutions are consistent with man's increase of per capita power over the universe. That is the ultimate scientific experiment, upon which the authority of all scientific knowledge ultimately depends.

There is much talk of the function of morality in science, a matter which was of great concern to Einstein, but a conception which eluded his grasp, and which thus misled him and his associates into many immoral directions. Reason and love are inseparable qualities of the Logos. A love of reason (the Logos) expresses itself as a love for the improvement of the condition of mankind through technological progress, and a love for that potentiality within each human personality which corresponds to the power to develop, assimilate, and apply technological progress. This is loved not merely because it enables mankind to improve his material conditions of life, but because this improvement relies upon the development of those powers of the human individual which converge upon agreement with the Logos, with the divine.

The problem of Albert Einstein, in matters of science, is that he fell in with such political company as the most evil man of the 20th century, the late Bertrand Russell, as did the "Dr. Strangelove" of the Pugwash Conference, Leo Szilard.

Lyndon H. LaRouche, Jr., an economist, is a member of the board of directors of the Fusion Energy Foundation. He is currently a candidate for the Democratic Party presidential nomination.

Congress Slashes the Fusion Budget

During deliberations on the fiscal year 1985 magnetic fusion energy budget this spring, Congress joined forces with the budget slashers in the Reagan administration to inflict deadly wounds on an already inadequate budget proposal. For the past three budget cycles, the fusion program has been barely treading water, suffering such small increases that it has not even kept pace with inflation.

This is the first year that Congress has not added money to the administration's budget request, but has instead gone wild with cuts. Fusion scientists fear that promising programs already in progress may get axed out of the budget entirely.

"These cuts are an inevitable outcome of the program allowing itself to be pushed into the mode of a 'pure science program,' " commented Edwin Kintner, former fusion director for the Department of Energy.

The administration requested a fiscal year 1985 magnetic fusion energy budget of $483 million, compared to a fiscal year 1984 funding level of $471 million. This increase of less than 3 percent represents a real cut when inflation is taken into account.

The key issue is whether the proposed next-step engineering device, the Tokamak Fusion Core Experiment (TFCX), will be funded. Not only did both the House and Senate committees emphatically reject this next step in fusion development; they also recommended such severe cuts in the administration's request that much of the engineering and technology development already under way will have to be curtailed.

The full Appropriations Committee of the House passed a bill May 15 that included a $64 million cut in the fusion budget request. This is approximately the size of the entire Lawrence Livermore National Laboratory magnetic mirror fusion program. The Senate Appropriations Subcommittee followed this action May 24 with a recommended cut of $27 million.

When the subcommittee mark-up went to the full committee June 5, $14 million of the cut was restored by an amendment offered by Senator Pete Domenici (R-N.M.). The budget will still have to go through House-Senate conference committee deliberations, and a compromise is expected that is somewhere between the $13 million and $64 million cut.

No Fusion Engineering

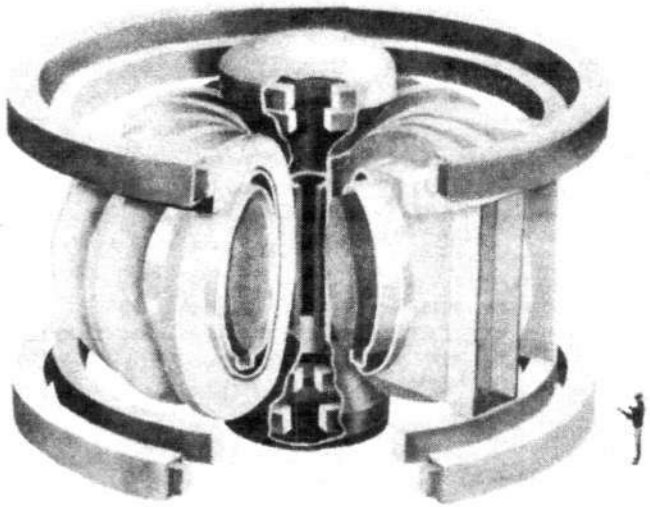
The emphasis of the administration and Congress on science only, as opposed to a crash program to develop fusion as an energy source in the next 20 years, has long been the rationale of the "go-slow" faction that would put fusion development on a 50-year schedule. Three years ago, for example, presidential science advisor George Keyworth told the Fusion Energy Foundation that pushing ahead into fusion engineering would destroy the scientific work of the program.

According to Kintner, scientists in the program did not put up a fight to prevent this return to a fusion "science" program. "Once you prove fusion has no practical end use, you can't justify spending so much money," he stated. Kintner said that the congressional committees have recommended that the DOE "do away with remaining technology development programs."

"I find it surprising and difficult to understand how the fusion program—which has a hope of leading to a practical and useful product—could be cut, while high energy physics and military research and development programs are growing so fast," Kintner commented. "It is also surprising," he said, "that this program, which has contributed so many defense applications, doesn't justify additional budget support."

The inertial fusion budget, including laser fusion experiments, has been slashed, as well. Eliminating an additional research capability that could contribute to the president's beam defense technologies programs, the administration cut the budget from $170 to $138 million.

—*Marsha Freeman*



PPPL

CUTAWAY VIEW OF THE PROPOSED TFCX DESIGN

The Tokamak Fusion Core Experiment, shown here in an artist's illustration, could be the next-step fusion device—if Congress reverses the budget cuts for the fusion program. The TFCX is planned as a joint effort by the national fusion laboratories, with Princeton Plasma Physics Laboratory serving as the lead organization.

The U.S. Needs a Manned Space Station!

TRW

This TRW design for NASA's space station has a central berthing hub with modules for living quarters and laboratory work, a utility module with solar arrays and thermal radiators, and a replaceable logistics module that provides a renewable supply of food, water, and air.

In his Jan. 25 State of the Union address, President Reagan committed this nation to build a manned space station within a decade. "A space station will not be an end in itself but a doorway to even greater progress in the future, the President said."

The response from the military, and much of Congress and the space science community, however, has been to think small. Manned missions cost too much, these pragmatists say, and besides, man gets in the way of science.

In a report issued in November 1983, the Space Science Board of the National Academy of Sciences stated that it could "see no need for this space station" for space science missions for the next 20 years. The British magazine *Nature* called the Space Shuttle a "disaster" for scientists and said that the space station would be just another "tragedy."

Some space scientists have even made the argument that the manned space missions have stolen money from planetary and other science programs. It was for this reason that Dr. James Van Allen proposed a few years ago that NASA should cancel its manned flights.

However, as NASA Administrator James Beggs emphasized in congressional hearings in May, NASA is totally committed to keeping the space science portion of the NASA budget growing. As the overall NASA budget has been increasing since 1980, he said, the space science budget has been increasing as well. In the previous three budgets, space science funding increased $440 million or 43 percent.

Astronomer Robert Jastrow succinctly answered all those who would prefer man to go backwards instead of into space in a May article in *Science Digest*: "The move of man off the face of the planet is the most important step in evolution of life on the Earth since the fishes left the water 350 million years ago," Jastrow wrote.

'Growing a Space Station

NASA has committed itself to build an $8 billion space station, made up of several separate modules delivered to low-Earth orbit by the Shuttle.

The first set of modules will probably consist of living facilities, laboratories, a supply station, and satellite repair and check-out facilities. To expand the station's capabilities during this decade, international cooperation, particularly with Western Europe and Japan, will likely add more modules, and increase the number and variety of tasks the station can perform. Administrator Beggs has asked the Europeans to consider spending about $2 billion on the station, and the Japanese about $1 billion. These nations are currently shaping out what their contribution to the station will be.

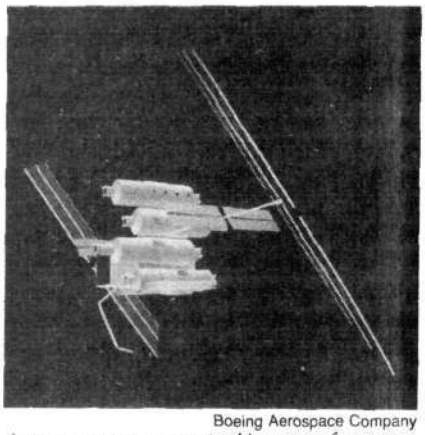
In this way, NASA plans to "grow" the station by making its facilities available to U.S. allies, who in return will add real capabilities to the system. Considering the experience the Europeans have gained by building the Spacelab, which flies inside the Shuttle, it is likely that they will choose to build a scientific laboratory as the module they contribute to the station.

This will open up unimagined frontiers for space science.

Man Versus Science?

One small-minded scientist, John Pike of the Federation of American Scientists, complained, "for most legitimate missions of a space station, people get in the way." Of course, astronauts moving around inside the station might disturb highly sensitive telescopes and other equipment, but as serious space scientists have suggested, such instruments can be contained in small, unmanned platforms that are co-orbital with the station.

Real science can never be independent of the minds that designed the experiment and will interpret the data. And without man in space, of course, repairs would not be possible. As Robert Jastrow pointed out, observatories like the Space Telescope that are planned in the next decades are enormously expensive: "If they stop working, they will never be replaced in our lifetime. Keeping the observatories in service will be one of the space station's greatest contributions to scientific progress."



Boeing Aerospace Company

A computer-generated image of a space station designed by Boeing Aerospace Co. is shown here on a video screen where engineers can modify it quickly to meet NASA requirements. There are four modules, each about the size of a mobile home, plus a hangar that can be used to service spacecraft.

As for other research in space, it should be obvious that experiments in space biology and medicine cannot be conducted without people in the space environment. Treatment for heart disease by lowering the gravitational pressure on the cardiovascular system for the elderly, studying the long-term adjustment of man to zero gravity before he ventures to Mars and even farther away, and producing life-saving pharmaceuticals in space for use on Earth are a small sample of the challenges for these fields of space science.

Can most of these tasks be accomplished by using automated robotic systems rather than man? "A fully automated plant is possible in theory, but experience on the ground shows that automated factories break down and require constant maintenance," according to Jastrow. In fact, astronauts on recent Shuttle missions report that many of the industrial and scientific experiments on board required constant supervision. Alhough a pharmaceutical-producing factory in space would be automated, who would want to wait weeks or months for a Shuttle repair mission if something broke?

Professor Peter Banks from Stanford University is heading a 23-member task force on the "Scientific Uses of the Space Station," which is suggesting station designs to NASA. Banks stated that the station will likely have ten modules, including two that would be devoted to scientific research.

Calling the station "a relatively inexpensive project, compared to other programs," Banks pointed out that the 1960s Apollo program would cost $80 billion in today's dollars. The $8 billion NASA station includes $800 million for the two unmanned plaftorms the task force has recommended for scientific equipment.

Budget-Slashing Congressmen

Opportunistically jumping on the "save space science" bandwagon, a number of congressmen have dictated through the budget process that NASA must spend $15 million next year to study building an *unmanned* platform, instead of a manned space station.

Both the chairman and the ranking Republican on the House Appropriations Subcommittee responsible for the NASA budget have insisted that the station will cost too much and could be replaced initially with an unmanned platform, in conjunction with an extended duration capability for the Space Shuttle. Top NASA officials have made it clear that the point of the Shuttle is to keep it flying and not tied up in orbit, and that the orbiter is an uncomfortable place for people to live for more than a few days.

A manned space station will make it possible to put into space scientific experiments that are at the leading edge of technology because repair services will be available. It will make it possible to continually update the instruments, and replace them with the most advanced, state-of-the-art technique. Man in space will mean that experiments can be altered in real time, and opportunities will not be missed because changes can be made on the scene.

Space science on the station will lay the basis for man and his instruments to travel to the planets and beyond. Like all new capabilities, no one can even imagine what will develop. As Gerry Gray of the American Institute of Aeronautics and Astronautics has replied to scientists who have "no need" for the space station: "people did not know what they would ever use a telephone for before it was available."

—Marsha Freeman

Jet Begins Phase 2

Continued from page 15

plasma column. Experiments in France and the United States have demonstrated heating efficiencies of 50 percent by this method. JET uses 15 megawatts of high frequency heating.

An Ambitious Research Program

The overall purpose of the JET experiments is to generate and study plasmas whose parameters correspond to those of future fusion reactors.

This includes: studies of thermonuclear plasma processes; studies of the interaction of the plasma with the walls of the vacuum chamber (this interaction determines the rate of "poisoning" of the plasma by heavy ion impurities from the walls, whose effect is to greatly increase energy losses by radiation from the plasma); studies of heating system function; and studies of the effect of alpha particles generated by fusion reactions.

The research program of JET is projected to last seven years, and consists of four phases:

Phase 1. Begun in June 1983, this is the "breaking-in" phase in which the reactor was operated with hydrogen or deuterium, using only Ohmic heating.

Phase 2 (mid-1984 to mid-1986). Inaugurated with ceremony in May, this phase will have additional heating systems installed, beginning with a neutral beam injector of 5 megawatts. A year later, a second neutral beam injector will be added, together with the first unit of high frequency heating. At that point, a total of 16 megawatts of heating will be available. If this phase successfully demonstrates the projected performance of the machine, then the go-ahead will be given for actual ignition experiments in the final phase.

Phase 3 (mid-1986 to mid-1988). The full heating power of 25 megawatts will be brought on line in this stage. Hydrogen and deuterium plasmas will be generated under conditions approximating those required for the later ignition experiments with deuterium-tritium plasma. This will set the stage for the most spectacular event in fusion research.

Phase 4 (from mid-1988 on). This is the decisive phase. For the first time, a large D-T plasma will be ignited and, for a short interval of time, significant fusion power will be generated.

It is not yet determined whether JET will be able to reach complete ignition of its plasma. Detailed computer simulations have shown, however, that the required ignition conditions will be achieved at least in the central core of the plasma: a temperature of 120 million degrees, a density of 1.2×10^{14} particles per cubic centimeter, and a containment time of 0.5 to 1.5 seconds.

The projected sequence of events in the JET ignition experiments is as follows: First, 0.05 grams of cold deuterium and tritium gas mixture are puffed into the vacuum chamber at a chamber pressure of one millionth of an atmosphere. Second, the magnetic coil systems will generate a toroidal magnetic field of 3.5 tesla and a plasma current of 5 million amperes.

Third, heating systems will bring the plasma to a temperature of 120 million degrees for ignition. At this temperature, the average pressure of the plasma is 2 atmospheres; the magnetic pressure of the containing bottle field—which must be stronger because of diffusion of the plasma across the field—is about 50 atmospheres.

Ignition

At this point, ignition should occur. The plasma core should rapidly reach a temperature of 350 million degrees, as energetic alpha particles (helium nuclei) are produced by the deuterium-tritium reaction with energies 250 times larger than the original plasma ions.

The investigation of these alpha particles—their generation, containment, and interaction with the rest of the plasma—is the most important goal of the final research phase. This knowledge is crucial for the design of future magnetic fusion power plants, in which the heating of the plasma by energetic alpha particles produced by the fusion reaction must maintain fusion conditions, once the process has been "ignited" by the reactor's heating systems.

The second product of the D-T fusion reactions is high energy neutrons. These neutrons carry away most of the energy of the fusion reactions. In future fusion power plants, the neutrons will be absorbed by a "blanket" of special material surrounding the plasma, thereby generating the heat that will then be converted into electrical energy via heat exchangers and turbines. For the JET, however, which is a plasma research reactor without energy conversion systems, these neutrons are a nuisance. They bombard the structural material of the apparatus and cause it to become radioactive. As a result, advanced remote control robotics will be used to conduct maintenance and repairs once the reactor goes into D-T operation.

JET is expected to produce about 10^{20} neutrons per shot, corresponding to a power output of about 80 megawatts. Since this figure is much larger than the energy pumped into the plasma by the heating systems, JET will therefore be operating in a condition of "scientific breakeven." JET will still be under "net breakeven" conditions, however, since the heating systems consume several times as much energy as they deposit into the plasma. To be economical, future fusion power plants will operate at much higher fusion output levels, with substantial improvements in heating efficiency.

Researchers plan to carry out a total of 10,000 "shots" in the final phase of the experiment.

The Future

JET will lay the basis for the construction and operation of an even larger European experiment, called the Next European Torus, NET, which is already in the early phases of conceptual design. NET is a technology-oriented power reactor designed to test and develop the technologies that will be used in actual commercial fusion power plants. Together with the results of the TFTR and the large Japanese tokamak experiment, JT-60, JET will open the way to harnessing the unlimited potential of fusion energy for mankind.

—Heinz Horeis and Jonathan Tennenbaum

How Plants Grow in The 'Golden Mean' Ratio

by Ned Rosinsky, M.D.

Why do plants grow in the shapes that they do?

This question has fascinated scientists for thousands of years. Although the shapes of plants can become quite complicated, a great deal can be understood simply by considering what the plant needs in order to function. First, it needs to be exposed to sunlight for photosynthesis, so it will tend to grow in a shape with a large surface area exposed to the Sun. Second, it needs room to grow, so it will tend to grow in such a way that one part of the plant does not crowd another part.

These simple ideas, if examined carefully, lead to interesting conclusions about how the plant must be shaped and how the plant must grow into its proper shape. I will show here that the kind of shapes and growing forms that best allow the plant to do its work are all related to a particular mathematical ratio called the *golden mean*, which is approximately 1.62. The golden mean is the ratio in which the smaller part of a quantity is to the larger part of that same quantity as the larger part is to the whole (Figure 1). The quantity can be just a line you have drawn on paper and then divided, a container full of marbles that you divide, or something living, like a plant.

$a/b = b/(a + b)$

Figure 1
THE GOLDEN MEAN RATIO
The golden mean is the ratio of division in which the smaller part, a, is to the larger, b, as b is to (a + b).

To understand the importance of the golden mean, you must first notice that living things usually grow by multiplication, rather than addition. For example, if you start with 1 bacterium, after about 20 minutes it will have divided in half and produced 2 bacteria; after another 20 minutes, 4 bacteria, then 8, then 16, and so on. Every 20 minutes the number of bacteria doubles or, in other words, multiplies by 2.

A series of numbers that grows by multiplication is called a *geometric series*, such as 2, 4, 8, 16, and so on.

Figure 2
SELF-SIMILAR GROWTH
As the spruce tree grows, its overall shape does not change much, only its size. This gives it self-similarity in its shape as it grows.

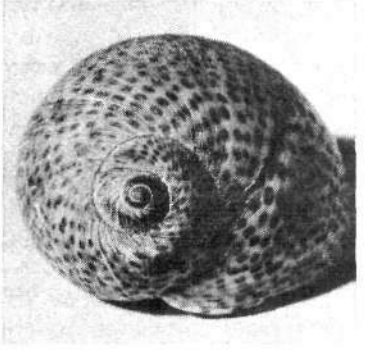


Figure 3
SNAIL SHELL
The snail grows at a rate proportional to its size at any particular time. Therefore, its rate of growth is always increasing. Since the shell is turning as it grows, it produces a spiral shape.

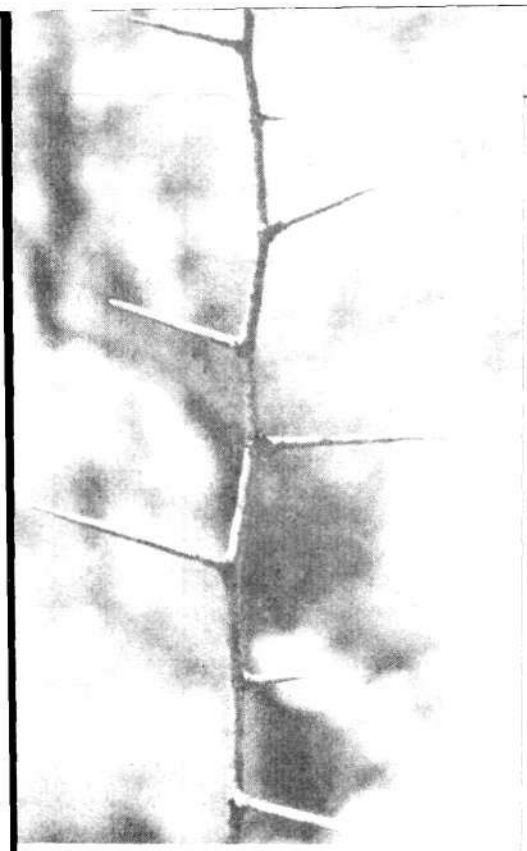


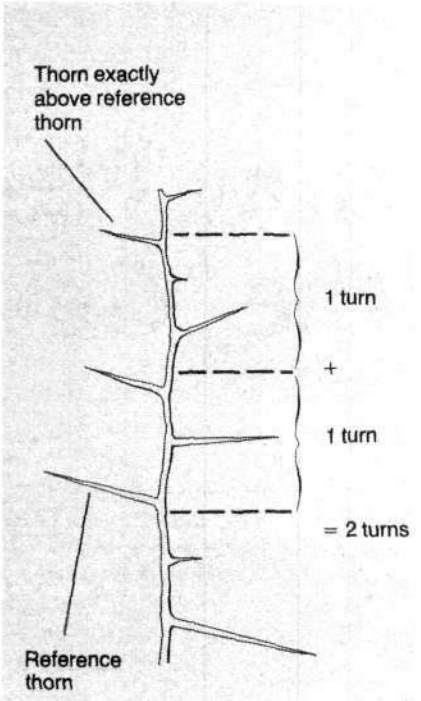
Figure 4
SPIRAL PHYLLOTAXIS

In this plant the thorns are arranged around the stem in a spiral pattern. If you start with a particular thorn, can you see how many thorns you have to pass through above that thorn until you reach one exactly above the thorn you started with?

Source: *Patterns in Nature* by Peter S. Stevens, (Boston: Little, Brown and Company, 1974), p. 158.

Figure 5
THE PHYLLOTAXIS RATIO

In Figure 4 you saw that two thorns that grow at the same position on the plant stem are separated along the stem by a certain number of thorns. The phyllotaxis ratio is the ratio of the number of turns in the spiral you had to make to get from your reference thorn to a thorn growing at the same position on the stem, divided by the number of thorns you passed through. Here it is two turns and five thorns, giving a ratio of 2/5.



In contrast, a series that grows by addition, such as 2, 4, 6, 8, 10, and so on (here, 2 is added each time), is called an *arithmetic series*. The main point is that plants tend to grow by geometric series, and that this kind of growth causes certain kinds of shapes in the plants (see Figure 2).

Self-Similar Growth

The reason that plants grow in geometric series (for example, doubling in size every six months) is that the entire plant is growing as one overall unit. This means that if it weighs 1 pound and it takes a month to grow another pound, then when the plant weighs 2 pounds it will take another month to grow another 2 pounds, and so on. The speed at which it grows increases, and is related to the plant's current size at any particular time. This causes the size to increase as shown in Figure 2. Since the plant is growing overall as a unit, it tends to keep the same shape even though it gets bigger. This is called *self-similar growth*.

If you look at the shape of a snail you can see the same pattern of geometric growth, only now since the shape of the snail is turning as it grows, it produces a spiral (Figure 3). This geometric spiral, also called a logarithmic spiral, is the main kind of shape you see in plants. If you can understand how this spiral works in plants you will begin to see why they are shaped the way they are.

A good example of a spiral in a plant is the way the leaves or thorns are located on a plant stem in many kinds of plants (Figure 4). Look at the overall shape of a spruce tree, which is a cone. The branches of the tree stick out in a pattern that spirals around the tree's cone shape (Figure 2). Now, let us see how this geometric growth connects to the specific ratio of the golden mean.

If you look at various types of plants, you find that the leaves around the stem are arranged in different kinds of spiral patterns. If you pick any leaf and call it a *reference leaf*, and then start counting leaves above it as they spiral around up the plant stem, sooner or later you will find a leaf that is directly above the reference leaf on the stem. You may have to go a number of times around the spiral before you find this leaf.

Now, if you count up the turns around the spiral you made, and divide it by the number of leaves you went through, you get a ratio that is characteristic for each plant species. For example if you made 5 turns and passed 13 leaves, the ratio is 5/13. This is called the *phyllotaxis ratio*. (Phyllotaxis comes from the Greek words for leaf, *phyllon*, and order, *taxis*; the plural of taxis is taxes.) See Figure 5.

The Phyllotaxis Ratio

These phyllotaxis ratios form an interesting series of fractions: 1/1, 1/2, 1/3, 2/5, 3/8, 5/13, 8/21, 13/34, and so on. What is interesting is that all the numbers come from a series called the *Fibonacci series*, named after the 12th-century mathematician who discovered it. The Fibonacci series is formed by starting with 1, adding another 1, and then getting each next new member of the series by adding the previous two members: 1 + 1 = 2, 1 + 2 = 3, 2 + 3 = 5, 3 + 5 = 8, and so on. This forms the series 1, 1, 2, 3, 5, 8, 13, 21, 34, and so on. (See Professor von Puzzle, p. 59.)

The plant phyllotaxes are ratios formed by taking two numbers from this series that are separated by one number; for example 3 and 8 or 5 and 13.

This particular series has some interesting geometrical properties. Take a circle and divide it into a number of parts according to one of the Fibonacci numbers, say, 13. Then count off sections of the circle by the Fibonacci number that is two numbers behind 13, which is 5. This gives you the pattern shown in Figure 6.

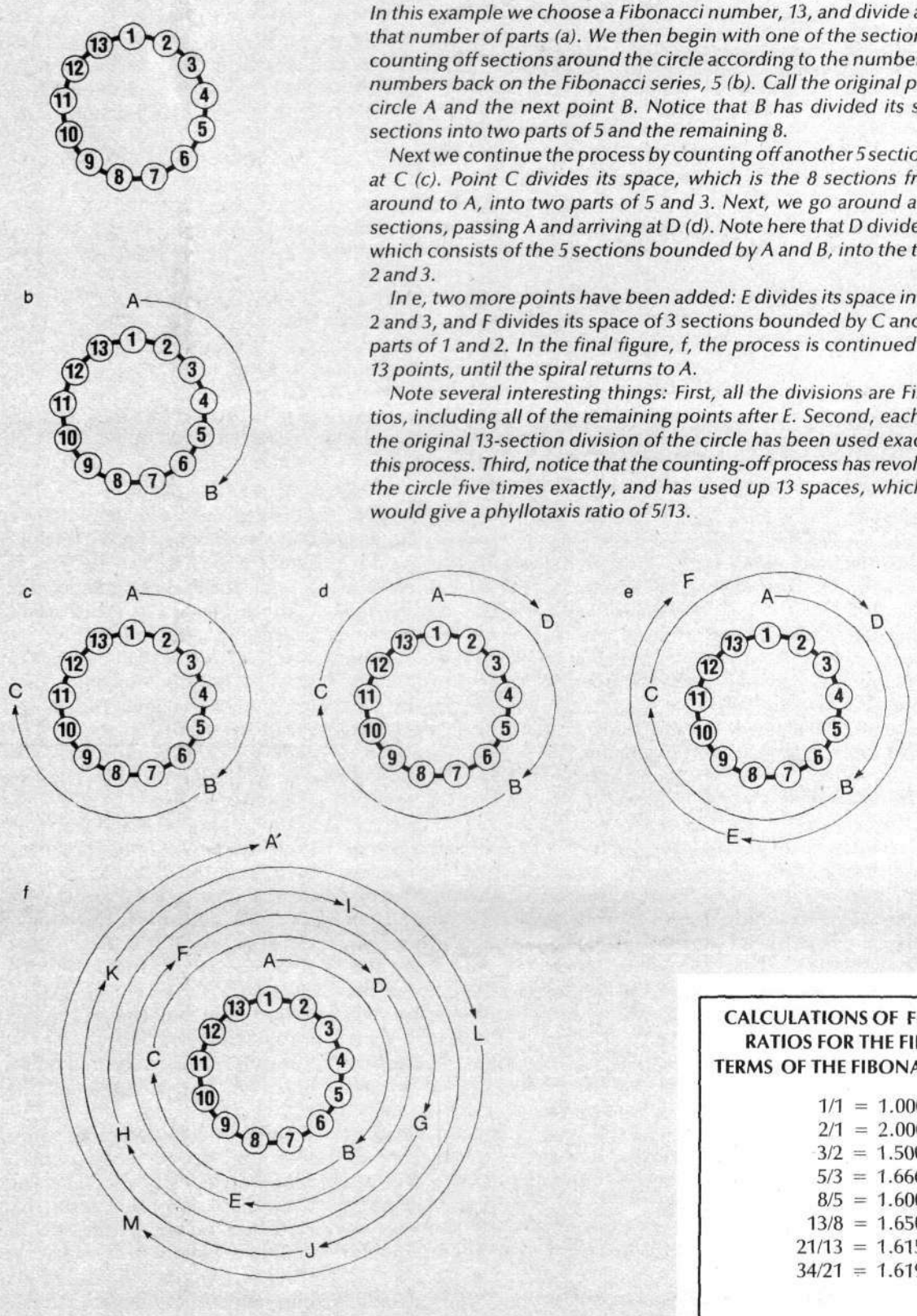
Figure 6
UNPEELING THE FIBONACCI SERIES

In this example we choose a Fibonacci number, 13, and divide a circle into that number of parts (a). We then begin with one of the sections and start counting off sections around the circle according to the number that is two numbers back on the Fibonacci series, 5 (b). Call the original point on the circle A and the next point B. Notice that B has divided its space of 13 sections into two parts of 5 and the remaining 8.

Next we continue the process by counting off another 5 sections to arrive at C (c). Point C divides its space, which is the 8 sections from B back around to A, into two parts of 5 and 3. Next, we go around another five sections, passing A and arriving at D (d). Note here that D divides its space, which consists of the 5 sections bounded by A and B, into the two parts of 2 and 3.

In e, two more points have been added: E divides its space into the parts 2 and 3, and F divides its space of 3 sections bounded by C and A into the parts of 1 and 2. In the final figure, f, the process is continued for the full 13 points, until the spiral returns to A.

Note several interesting things: First, all the divisions are Fibonacci ratios, including all of the remaining points after E. Second, each section of the original 13-section division of the circle has been used exactly once in this process. Third, notice that the counting-off process has revolved around the circle five times exactly, and has used up 13 spaces, which in a plant would give a phyllotaxis ratio of 5/13.



CALCULATIONS OF FIBONACCI RATIOS FOR THE FIRST FEW TERMS OF THE FIBONACCI SERIES

1/1 = 1.0000
2/1 = 2.0000
3/2 = 1.5000
5/3 = 1.6666
8/5 = 1.6000
13/8 = 1.6500
21/13 = 1.6154
34/21 = 1.6191

As you can see, each new place counted off on the circle divides its space into a Fibonacci-type ratio, either 1/1, 1/2, 2/3, 3/5, 5/8, 8/13, and so on. Notice that these ratios are the same as the ones you would have produced if you had counted off 8 spaces going around the circle in the opposite direction. The Fibonacci phyllotaxis can also be obtained by taking two consecutive Fibonacci numbers, 13 and 8 (that is, without skipping a number in the series), and going around your circle in the opposite direction (Figure 7b).

You will obtain a similar picture by starting out with a circle divided into equal parts by any other Fibonacci number, such as 21. (With the circle divided into 21 parts, you would then count off segments in groups of 13.)

Looking Down at the Plant

Now, consider the sectioned-off circle you have drawn as a diagram of a plant, looking down at the plant from the top, with each of the above countings in the circle representing a new leaf sprouting out. You can see that each leaf is dividing its space into a Fibonacci ratio. What can you tell about these ratios?

First, each place you have marked off on the circle divides the previous space marked off on the circle nearly in half. Thus, each new leaf is almost evenly placed between two previous leaves, giving it lots of *space in which to grow*. Second, each leaf also has lots of *space to get sunlight*. In these divisions, the space on one side of a leaf is never more than twice the space on the other side.

Now, calculate the ratios you have marked off as they get farther along in the series, dividing the numerator by the denominator. You can see that the ratios get closer and closer to the ratio 1.62, which is the golden mean (see table). Some plants, in fact, have the golden mean ratio as the angle of the separation of consecutive leaves (Figure 8).

What about other ratios? Let us try an experiment with a ratio that is not from the Fibonacci series. Keeping the 13-divided circle, if you count off by 7 sectors at a time (instead of 8 as in the Fibonacci series) you get within one section of the first leaf after just two leaves, causing unnecessary crowding. If you use 4 to count off, or rotate, you get again within one section of the start within three leaves (Figure 9). You can try this with other numbers of section divisions and rotations.

To see why the Fibonacci numbers work so well, look more carefully at what happens in the above example of a circle divided into 13 sections by counting off 5 (or the equivalent, 8, in the opposite direction). The first counting divides the circle into 8 and 5, which are the two previous terms in the Fibonacci series. The next counting, or rotation, of 5 sections divides the space of 8 sections between the first and second leaves into two portions of 5 and 3, which are the next numbers counting backwards in the Fibonacci series.

Now, the next counting of 5 goes past the first leaf and divides the space of 5 sections between the first two leaves into two portions of 2 and 3. Again, this is done by moving backwards in the Fibonacci series, continuing the process (Figure 6). This is really like an "unpeeling" of the Fibonacci series by subtraction!

Since the Fibonacci ratios get progressively closer to a constant value, the golden mean, the series becomes close to a geometric series in which the golden mean is the constant factor of multiplication. Plants frequently flip from one phyllotaxis to another in the course of early development, or in the evolution of new species of plants. Since the ratios are in a geometric series, this

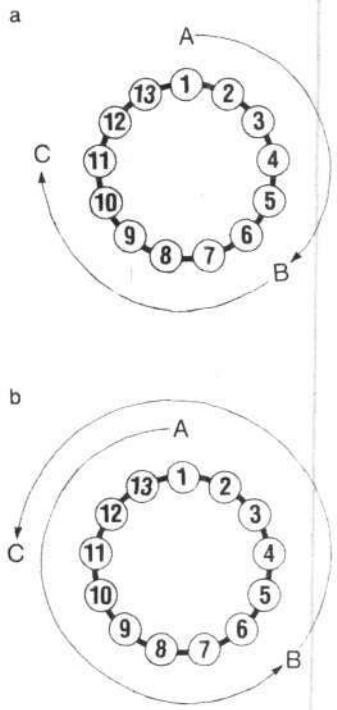


Figure 7
ALTERNATE FIBONACCI COUNTING

In a, the 13-sector circle is counted off in groups of five, giving the points A, B, and C. In b, the same circle is counted off in groups of 8, in the opposite direction, giving the exact same location of the points A, B, and C. We see, therefore, that the neighboring Fibonacci number to 13, which is 8, can be used to give the same results as 5.

If you work out this example all the way, as was done in Figure 6, you will see that all 13 sections are used up. Now, however, instead of 5 complete rotations around the circle, there are 8, giving a phyllotaxis ratio of 8/13.

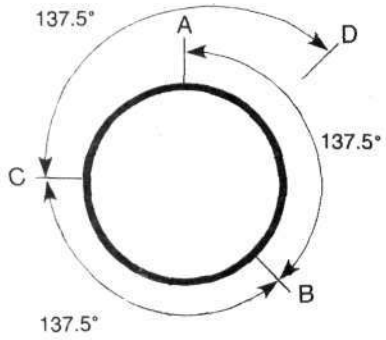


Figure 8
GOLDEN MEAN SEPARATION OF LEAF ATTACHMENT LOCATIONS

Here the circle is divided by the golden mean, which is approximately 1.62 or 137.5 degrees (out of 360 degrees). Notice that the points are located in positions that give them ample room as each is successively laid down.

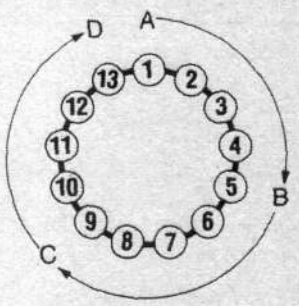


Figure 9
NON-FIBONACCI DIVISION OF THE CIRCLE

Using the circle divided into 13 sections, we try some counting number other than 5 (or the equivalent 8), such as 4. Here the first added leaf, B, divides its space up into 4 and 9, which is less symmetric than the 5 and 8 division. The second leaf added, C, divides its space between B and A of 9 sections into 4 and 5, a good division, but then its next leaf, D, divides its space of 5 sections into 4 and 1, a highly unequal division. Similar highly unequal divisions occur with other choices of the counting number, such as 3 or 7.

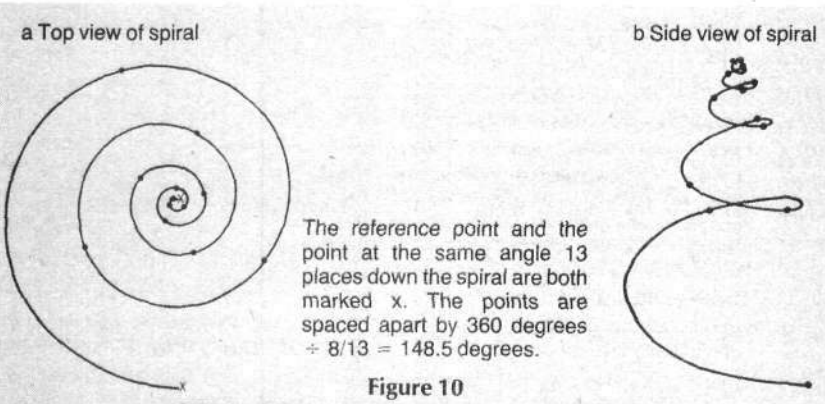


Figure 10
SPIRAL ARRANGEMENT OF LEAF POSITIONS

Here the circle representation is uncoiled to reveal the underlying spiral of leaf arrangement. In this example the 13-section circle becomes a 13-section spiral. After 5 turns above a given point in the spiral, there is another point at the same angle on the spiral. Again, another spiral could have been drawn through the same 13 points but in the opposite direction, This spiral would have had to turn 8 times between the matched points. The top view of this spiral is shown in a, and the side view of the spiral, looked at obliquely, is shown in b.

aspect of evolution is really a geometric jump, from one ratio to another similar ratio. This is another aspect of self-similar growth that is more easily seen in the overall growth of the snail or the overall shape of a tree as it grows.

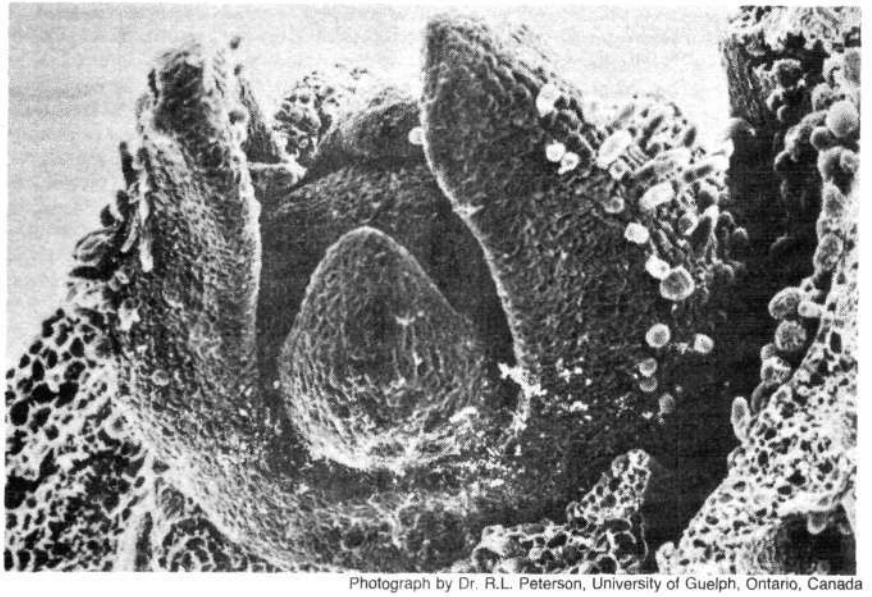
Next, take the circle on which you have drawn the leaves and re-draw it back to its original spiral shape (Figure 10). Here you can see that as the Fibonacci series is "unpeeled," the leaves are spread out vertically, so that neighboring leaves on the circle are far away from each other on the grown plant. The outward growth of elongation of the leaf stems makes sure that the new leaves do not shadow the old leaves, which may be directly under them or near them in the circle model.

This completes the overall picture, showing that the plant is generally shaped like a cone with a spiral of leaves coming out of a central stem. The plant always grows in such a way that it expands into a new size but keeps a similar conical shape.

The Question of Crowding

The same question of crowding applies to the small piece of plant tissue at the growing tip of the plant where the new leaves actually sprout. This tissue is called the *meristem*, and measures less than 1/32 of an inch across. The new leaf buds come out of this tissue at the same angles they will have on the stem as adult leaves. Therefore, the crowding question for growth and sunlight is exactly the same as it is in the case of starting the leaves out with room to grow on the meristem in the first place (Figure 11).

This shows that the question of what the best leaf spacing is for sun-



Photograph by Dr. R.L. Peterson, University of Guelph, Ontario, Canada

Figure 11
HOW BUDS GROW ON THE MERISTEM

The meristem shown here is magnified 250 times, and the outer leaves are cut away to expose the very youngest leaf buds as they begin to form on the surface of the meristem tissue. Notice how close the young leaf buds are to one another.

light, for growth, for growing out in the meristem, and for evolution as well, are all really the same. These problems require the same solutions, and the best solutions are all based on self-similar geometric shapes related to the golden mean.

Some Experiments

In order to look at these ideas more clearly you can do several kinds of experiments. First, do the example described above of dividing a circle into a Fibonacci number of sections and then counting off sequences of sections according to the next smaller Fibonacci number. Notice how the addition of each leaf divides the space for that leaf in a Fibonacci ratio.

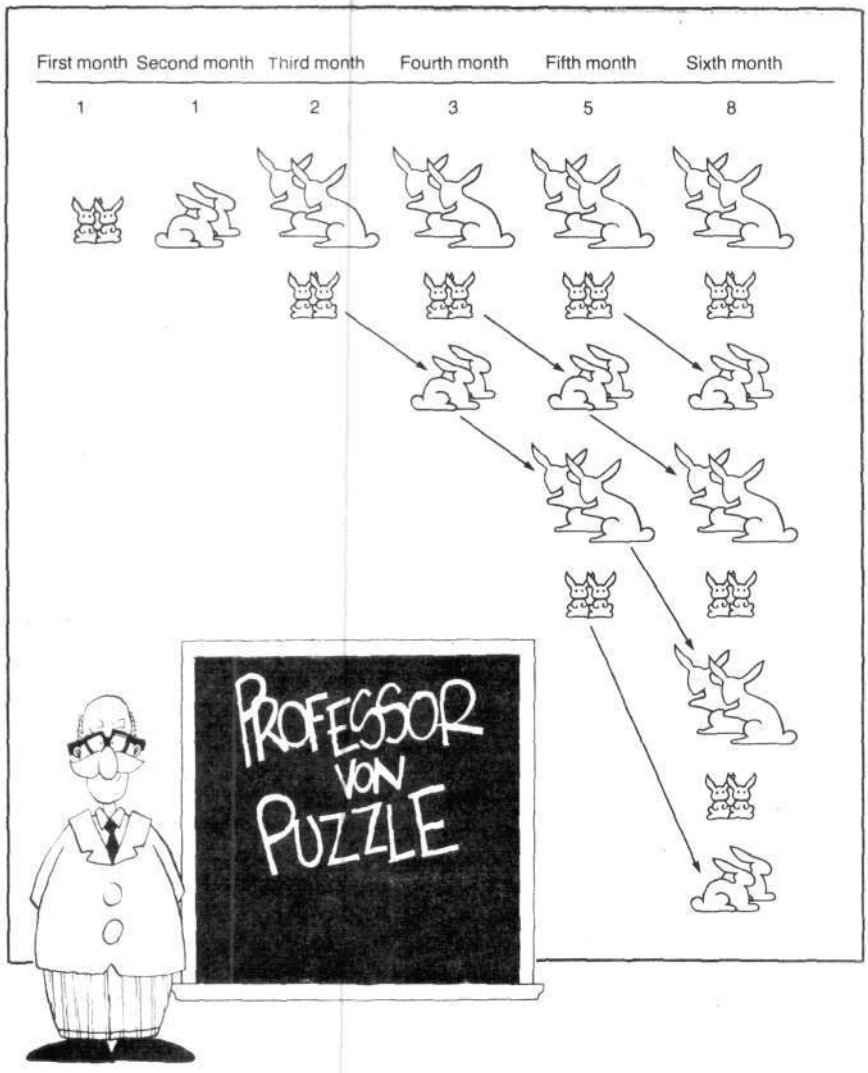
You can try this exercise with other numbers that are not from the Fibonacci series to see whether the leaf spacing is as good.

Second, collect plant samples that have the various Fibonacci ratios in their leaf or thorn patterns around the stem. Examine these specimens from various angles to see the effect of the spacing on sunlight exposure and growth crowding. A few common examples are the 1/3 ratio in beech trees, the 2/5 ratio in oak, the 3/8 ratio in poplar, and the 5/13 ratio in willows.

Third, dissect the meristem tip of a plant under a low power microscope or strong hand lens, to see the pattern of leaf buds and how they form a Fibonacci geometry. Notice the extremely close crowding of growth at the meristem tip.

Fourth, take snapshot pictures of a growing plant every day at the same time from the same place, in order to visualize the growth patterns that follow the self-similar patterns you have outlined.

Fifth, a more challenging experiment would be to investigate why some plants that may start out in a conical shape change to other shapes. I'll give you a hint: The increase in crowding of the plant (its population density) may affect its shape as it attempts to maximize exposure to the Sun or to ground water. For example a lone oak may be wider at its base, but an oak in a crowded forest may be wider on top.



Brother Bonacci's Rabbits

Filius (Brother) Bonacci, who was born in Pisa, Italy, in the year 1170 AD, discovered a unique series of numbers that have ever since borne his name—the Fibonacci series. Brother Bonacci is said to have discovered the series observing the reproduction of rabbits.

Suppose we want to raise rabbits, and we start with a newborn pair—a male and a female. Let's assume for simplicity that each rabbit pair takes one month to mature to the point that it can produce offspring, and that the female carries her young for one month. That means it will take two months from the birth of the first rabbit pair to produce the first offspring. Let's also assume for simplicity's sake that each litter consists of one male and one female rabbit.

Now let's look at the growth of the rabbit population by month. In the first month we have *one pair,* and so also in the second. At the beginning of the third month a new pair is born. Now we have *two rabbit pairs.* At the beginning of the fourth month, that new pair is maturing, and the original pair give birth to another pair. The total number of pairs now *equals three.*

What do you think happens in the fifth month? Let's see. The original pair gives birth to yet another pair, making four pairs. But the pair that was born at the beginning of the third month also has a pair. So the total number of pairs *equals five.*

The chart helps you to see how this growth continues, producing the series named after Filius Bonacci:

1, 1, 2, 3, 5, 8, 13, 21, . . .

This series has two very important

properties. First, any term in the series is equal to the sum of the two previous terms. For example:

$$2=1+1, \text{ or } 13=5+8$$

Knowing this, you can produce the series just beginning with 1 and 1.

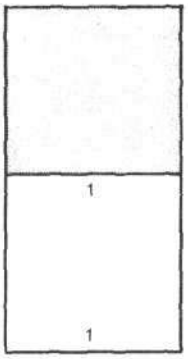
Second, the ratio of any two neighboring terms of the series is almost equal to the number 1.618, which is the ratio of the golden section or golden mean (see "How Plants Grow," p. 54). The higher we get in the series, the more true this is. Try it yourself. Use the first property I have just shown you to write out the Fibonacci series a few terms beyond the highest number (21) that I have given you. Now take any two neighboring numbers and divide them, the higher by the lower. (For example $21 \div 13 = 1.615$). You may use a calculator to facilitate this long division.

You see that the higher you go in the series, the closer it gets to the ratio of the golden section, which is approximately 1.618. This is called *convergence*. The ratio of neighboring terms in the Fibonacci series converges on the golden section.

A Geometric Construction

You can also produce the Fibonacci series by a geometric construction. Start with a square whose sides we consider to be 1×1. Now, you need only follow a simple rule to generate the Fibonacci series. The rule is: Always add a square to the longest side of your figure. Since we begin with a square, no side is the longest; we can add a square to it on any side (Figure 1).

Figure 1



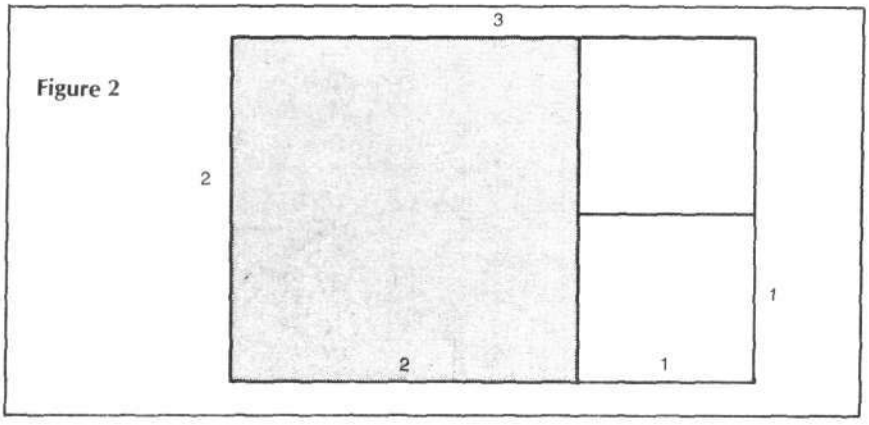


Figure 2

But now we have a figure twice as long as it is wide (2×1). So we add a square to its longest side (Figure 2).

Now our figure is 3×2. As we keep adding squares to the longest side, we get figures of 5×3, 8×5, 13×8, and so on. As the figure grows larger, the proportions of the rectangle hardly change. This is self-similar growth. The size increases, but not the shape. All living things grow this way.

Now for the puzzle: What will happen if you start with any rectangle and construct a square on its long side, making a new, larger rectangle? Repeat the process a number of times. Then make a series of numbers from the lengths of the rectangles you have constructed. What can you discover about these rectangles?

—Laurence Hecht

Tall Tales About Fusion

The Man-Made Sun
by T.A. Heppenheimer
New York: Little, Brown and Company
1984, $19.95

The Man-Made Sun is the only popular book to be written on the important topic of thermonuclear fusion research in many years, and therefore it has attracted much attention. Unfortunately, it muddies an interesting presentation of the science and development of fusion with some tall tales about the people and circumstances of fusion's progress.

In particular, individuals who have made major contributions to the fight for fusion development, and indeed, individuals who assisted author Tom Heppenheimer in the preparation of the book, received inexplicably nasty treatment.

Struggling with Plasmas

On the positive side, one of the highlights in the book is the story of how Lawrence Livermore National Laboratory solved some initial problems in their magnetic mirror fusion program. Heppenheimer recounts how early problems with plasma "leaking" out the end of the cylindrical mirror, made scientists pessimistic about ever being able to design a usable power reactor.

By a series of scientific interventions—including the idea of "plugging" both ends of the cylinder by creating a tandem mirror and developing a thermal barrier to the plasma loss—today's generation of successful mirror configurations was created.

Evident in the story is the commitment of the scientific teams, the constant direction and pressure from the Washington headquarters to meet goals, and the international scope of fusion development that helped solve this and other difficulties the research program faced over its 30-year history.

Unfortunately, Heppenheimer has interwoven this positive story of man's increasing mastery of a potentially limitless and cheap energy source with snide comments about the allegedly near-constant warfare between scientific teams working on competing fusion concepts. Reading his account, one would conclude that the scientists at Livermore and the Princeton Plasma Physics Laboratory spent more time squabbling with each other and competing for funding than doing research. It is as if Heppenheimer views science history as nothing more than an installment of "Dallas" on television.

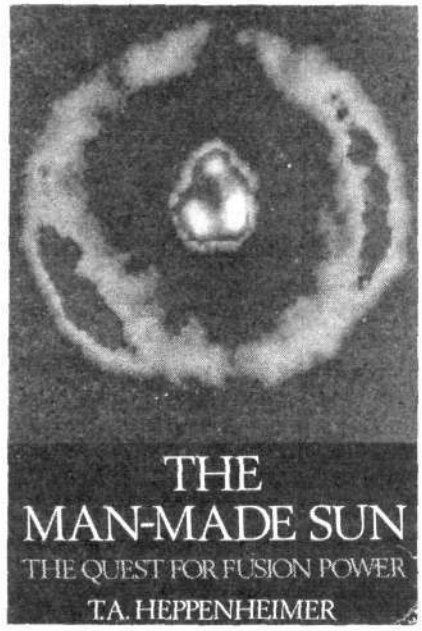
The real life-and-death battle for fusion is the still-ongoing fight with the enemies of progress in this country who think it's fine if the fusion program—along with other scientific advances—is put off until the distant 21st century.

Short Shrift

Particularly disturbing is the short shrift given to crucial figures in the fusion effort like Edwin Kintner, former head of the Department of Energy's magnetic fusion program. Heppenheimer does all but call Kintner, a pioneer in the Nuclear Navy program under Admiral Rickover, a bystander in the war!

As this magazine has documented, Kintner fought hard to maintain scientific momentum in the program and to bring fusion into the engineering stage. Not publicly known is the fact that Kintner was also very supportive of Heppenheimer's efforts in writing this book.

Equally astonishing is Heppenheimer's treatment of *Fusion* magazine and the Fusion Energy Foundation. His one reference to the 10 years the foundation has promoted fusion development and popularized information



about fusion with its 200,000-circulation magazine is limited to one nasty mention of the role the FEF played in 1978 in making the stunning results of the Princeton Large Torus (PLT) into international news.

Heppenheimer refers to the FEF as "a small but well-financed offshoot of the U.S. Labor Party," which of course, as Heppenheimer knows, is not true. The FEF was not small (at that time it had 20,000 members), was not well-financed (it is a member and subscription supported nonprofit organization), and was independent of the former U.S. Labor Party (which was disbanded in 1979).

According to Heppenheimer, whatever legitimacy the FEF may have had, came only from the fact that its first executive director, Dr. Morris Levitt, "would go on to become editor of the well-respected physics journal, *Laser Focus*."

So much for the organization that brought the news of the Princeton PLT breakthrough to scientists throughout the world and whose scientific concepts for laser fusion research have been adopted by researchers in Japan and other places.

In all, this is a disappointing book full of the author's subjective observations. The U.S. fusion program deserves a better history.

—*Marsha Freeman*

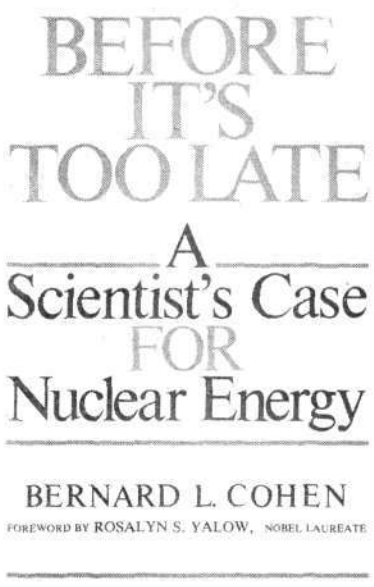
Stopping the Lies About Nuclear Power

Before It's Too Late
A Scientist's Case FOR Nuclear Energy
by Bernard L. Cohen
New York: Plenum Publishing Corp.
1984, $16.95

In a nation choked in a fog of misinformation and outright lies about the safety of nuclear power, Bernard Cohen's *Before It's Too Late* is a much-needed breath of fresh air. Cohen, a long-tenured physics professor at the University of Pittsburgh and an expert in radiation physics, thoroughly demonstrates the negligible risk nuclear power poses to public health as well as the tragic misconceptions the public has about the nuclear power industry.

He uses memorable analogies to allow the layman to visualize the miniscule probability of radiation release from all elements of the nuclear power industry, and he documents authoritatively the much-lied-about impact of low-level radiation on the human body in terms of the risk of cancer and genetic disorders. He also demolishes the great media meltdown myth.

Citing the minor release—1 millirem—of radiation at Three Mile Island as an example of the gross exaggeration of the press, Cohen documents how the human body is subjected to 85 millirems per year of natural background radiation from the Sun and such natural things as the potassium in our bodies. What is the heightened risk of contracting cancer to those exposed to radiation near Three Mile Island? Quantitatively, it's equivalent to taking three puffs of a cigarette.



The media, Cohen says, has consistently ignored the findings of highly respected scientific organizations and, instead, have reported only the discredited works from a handful of antinuclear scientists. According to a poll of over 300 scientists taken by Cohen, these antinuclear scientists so respected by the press have an extremely low level of credibility among their peers.

And how does an American public brainwashed with radiation scare stories regard nuclear power? When Cohen polled a number of college students and members of the League of Women Voters and asked them to choose which of 30 activities held the highest "present risk of death" to the average American, the majority chose nuclear power. Yet, the facts are that risk estimates put the death rate from nuclear power at 10 per year, while driving motor vehicles kills 50,000 per year, and cigarette smoking accounts for 150,000 deaths annually.

Cohen completes the picture with comprehensive scientific evidence that shows how continued use of coal to generate electrical power carries high risk to public health and property, while solar and wind alternatives are unreliable, land-intensive, and much more costly than nuclear power. As for the bugaboo of nuclear waste disposal, Cohen shows that it is a technologically trivial task with essentially no risk to the public.

You Can't Trust The London *Financial Times*

Nuclear Power in the Developing Countries
by Judith Perera
London: Financial Times Business Information, Ltd.,
1984, $75

There are two things about *Nuclear Power in the Developing Countries* that struck me as strange even before reading it. First, it's unusual these days to see any new study coming from one of the industrial nations on the subject of nuclear energy technology export, especially an organization like the London *Financial Times*, not known to be on the side of technological progress.

Second, the author, Judith Perera, is a specialist not in nuclear technology but in Mideast politics. Perera's previous publications include such titles as "A Survey of Chemical and Biological Warfare," and "Can the Arabs Win the Nuclear Arms Race with Israel?"

The purpose of this book, it turns out, is to make the case against nuclear power in the developing countries. Aside from the tedious though well-catalogued mass of impressive looking charts, graphs, and official statistics with which Perera fills the pages of this tome, the bulk of the text is a facile and often brazenly inaccurate rehash of what might pass for a Friends of the Earth primer on the "evils of nuclear technology."

"The developing states have been conducting a strange love affair with nuclear power since the mid-1950s," she writes.

For the most part, Perera insults the intelligence of her readers—especially so since the intended audience for the book is presumably potential nuclear suppliers and financiers. For example, she catalogues the potential for nuclear terrorism, bomb diversion, and the "risks" to industrial nations as the "double-edged sword" of nuclear technology transfer.

Continued on page 64

Political Babe in the Woods

Although Cohen builds a strong case for nuclear power, he is a babe in the woods when he ventures into a discussion of politics—how this country ever got into such an antitechnology mess. For example, he brushes off the media's misrepresentation of facts as simply their quest for "entertaining" scare stories.

As for the irrational antinuclear activists, Cohen lamely says, "Somehow their political philosophy told them that nuclear power is bad . . . ."

Cohen also makes no connection between the antinuclear activists, their legions of attentive reporters, and the ideological outlook that regards mankind as a mere beasts, dominated by the whim of mother nature and seeking only to maximize pleasure without regard for the well-being of generations to come. He fails to look behind these antitechnology puppets at their masters—the international power brokers in organizations like the Council on Foreign Relations, the World Bank, the United Nations, the Club of Rome, and, indeed, the liberal wing of the Democratic Party who are consciously planning a new dark age. In this dark age, not only would nuclear power be destroyed, but also most of the material and cultural advances of Western civilization, and most of the world's people.

Without naming the names of those individuals who are responsible for funding and directing the antinuclear movement and attacking their feudalist worldview, it is of course, impossible to stop the process of devolution.

In all, Bernard Cohen's *Before It's Too Late* is a valuable book that belongs in the library of all who are concerned to stop the lies about nuclear power. It belongs as well in every public library and school library, to counter the reams of yellow journalism churned out of the environmentalist presses. It is certainly a convincing weapon to have in one's arsenal; but if we are to win the battle for progress, readers must be willing to wage a hard political fight to restore the nation to technological progress and to those policies that nurture the well-being and creative potential of human beings throughout the world.

—Kevin Schmidt

Sandia Achieves Breakthrough

Continued from page 17

dent on the curvature of the anode surface A plus three independent effects of magnetic and electric fields in the diode: (1) the bowing of the magnetic field B applied to insulate the anode; (2) the bending of the magnetic field generated by the beam itself S, and (3) the bowing of the electric field E equipotential surfaces with respect to the applied magnetic field.

They formulated this dependence with an equation for the beam focal length with four factors as follows, where L = focal length in centimeters:

$$1/L_F = 1/L_A + 1/L_B + 1/L_S + 1/L_E$$

In fact, only the first term of this equation, anode surface curvature, is relevant.

Sandia's J. Pace VanDevender explained in a laboratory press release that some feared that the electromagnetic effects would be arbitrary: "High current ion diodes [like the one used in the Sandia experiments] have so many electrons and ions running around them," he said, "that scientists had feared that they would slosh around like ocean waves and disrupt the ion focusing."

Instead, although the electromagnetic effects shape the geometry within which the beam must propagate, they do not do so arbitrarily. The result is that changes in the curvature of the anode surface focus the beam in that determinant geometry. Johnson is delighted with the simplicity of the solution and has told this writer that his earlier formulation of the relevance of electrodynamic effects was simply incorrect.

—Robert Gallagher

Note

1. D. J. Johnson, R. J. Leeper, W. A. Stygar, and S. A. Slutz, "Proto-I Axial Focusing Experiments," paper presented at Fifth International Conference on High Power Particle Beams, San Francisco, Calif., (Sept. 1983).

The Pritikin Fraud

Continued from page 13

ample, studies have indicated selective depletion of leucine, an amino acid most easily obtainable from meat, in persons performing vigorous exercise. Leucine also plays a key role in the body's tissue immune system. This accounts for the immune suppression commonly observed in manually laboring populations of the Third World.

The Cult of Deprivation

Pritikin's diet, along with the general promotion of vegetarianism, "natural foods," and sundry attacks on food preservatives, is preparing the cultural conditions for acceptance of a reduction in the quality of the U.S. diet as a consequence of policies that are undercutting the U.S. meat and dairy industry and destroying grain production as well. The consequences of these policies will be more palatable to a population that has been conditioned to believe that a lower-quality diet is in fact healthier. A most effective way to do this is to create a cult that promotes deprivation as a positive value.

Guyana in 1979 banned the import of milk, supposedly in the "national interest," but actually in compliance with IMF loan conditionalities that called for cutting imports to have more cash available for loan repayments. Last year, the United States, along with the IMF, took the additional step of cutting off the remainder of Guyana's food imports.

It is predictable that the incidence of heart disease may decrease as the population succumbs to starvation and infectious disease. However, as when one reads about the decreased incidence of arteriosclerosis found at autopsy in concentration camp victims, it is useful to remember what condition the victims were in when the observation was made.

—John Grauerholz, M.D.

You Can't Trust...

Continued from page 62

Perera sees little role for electricity and specifically nuclear electricity in spurring industrial growth, although recent scientific studies show electricity to be the most efficient "locomotive" for industrialization. "The uncertainties which are apparent when taking a worldwide view of nuclear power are increased several fold with respect to developing states," she writes. "Electricity consumption is bound to increase but it will not be the main priority for development. . . . It is by no means certain, moreover, that nuclear power is the best choice to produce this electricity in developing states. . . ."

In sum, Perera and her editors at the *Financial Times* not only would discourage nuclear power in the developing sector, but also would throw out the enormous opportunity for the economically depressed advanced industrial nations to export the most advanced nuclear technology to the developing world. Do the developing sector nations themselves want to go nuclear? The answer from India, Egypt, Nigeria, Korea, and other countries is a loud "yes." Does the *Financial Times* want the advanced sector nations to export this development? The answer is a loud "no."

Is this book perhaps compiled to give the environmentalists some new targets in those developing countries that understand that technological advance is the only way out of the abyss of misery and starvation?

—William Engdahl

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In This Issue

THE 'GREAT PROJECTS' METHOD

The Kra Canal, this issue's cover story, is one of several "Great Projects" proposed to transform the economies of the Indian and Pacific Ocean basins. This method of using large infrastructure projects as magnets to industrialize an entire region is a sure way out of the world depression: The economy will be revitalized as we gear up U.S. industry to export advanced technology. And the developing sector will establish the infrastructure necessary to industrialize and provide for its growing population.

Most exciting, as FEF research director Uwe Parpart Henke reports, is that the Kra Canal project, discussed for some 200 years, is finally on the verge of becoming a reality.

THE HYPOTHESIS OF THE HIGHER HYPOTHESIS

How does one determine valid scientific conceptions? This is the question Lyndon H. LaRouche, Jr., answers in his provocative article "Why I Must Attack Albert Einstein." The ultimate measure of an economy is the capability of its population to sustain and improve its own existence: man's mastery over nature. It is through advances in science and technology that man progresses, LaRouche says, and he lays out some ground-rules for making such breakthroughs. The method he presents, the hypothesis of the higher hypothesis, is based on restoring the fundamental principles of continental science—principles that Einstein did not accept.

THINKING BIG: THE FRENCH NUCLEAR PROGRAM

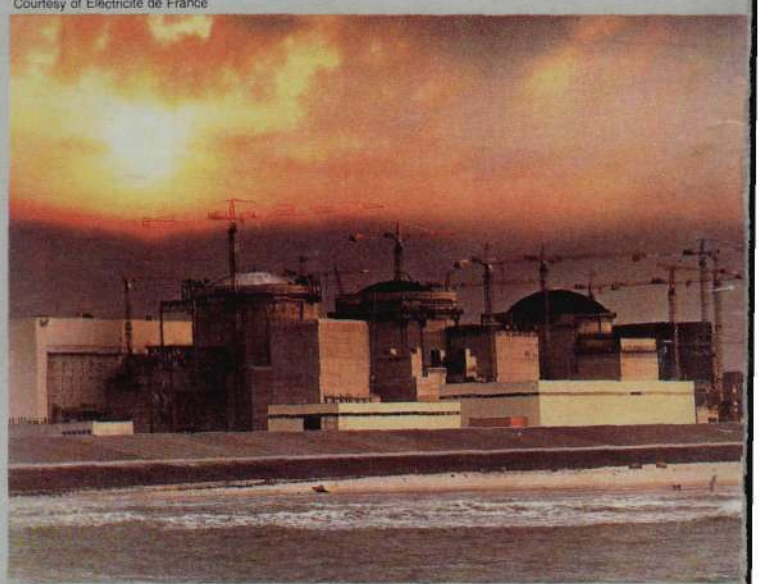
While the U.S. nuclear program is shrinking away, nuclear power has produced more than one-half of France's electricity generation since July 1983. France is now number 1 among the world's nations in terms of the share of its electricity provided by nuclear energy, and has a unique fast breeder program. Laurent Rosenfeld, editor-in-chief of the French-language *Fusion*, tells the story and provides American readers with plenty of ammunition in the fight to keep America out of a New Dark Age.

SOVIET LASER FUSION: FULL SPEED AHEAD

This exclusive review of the Soviet Union's thermonuclear laser fusion program by Academy of Science member Dr. Nikolai G. Basov demonstrates the depth of their inertial confinement program. "There is no doubt as to achieving breakeven in thermonuclear reactions using the laser approach," Basov writes.

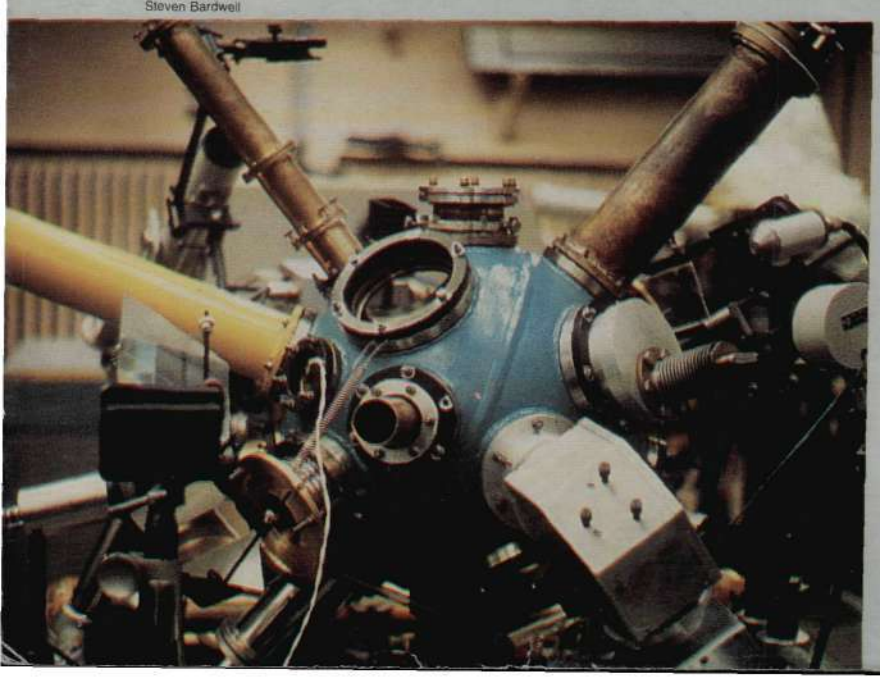
The military implications of this fusion research cannot be overlooked. Basov's certainty of making a scientific breakthrough in laser fusion contrasts sharply with Soviet assertions that similar technological breakthroughs are impossible in the area of directed energy beam defense.

Courtesy of Electricité de France

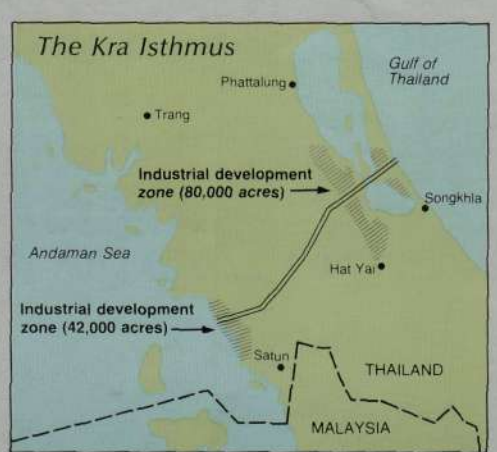


The Gravelines nuclear plants, 4 of the 28 plants now under construction in France. By the end of the decade, France will have 56 gigawatts electric of nuclear power.

Steven Bardwell



(Left) Target chamber of a laser fusion experiment in Basov's laboratory in the Lebedev Institute.



Proposed site for the Kra Canal.