FUSION

AT THE FRONTIERS OF SCIENCE AND ENERGY

April 1981

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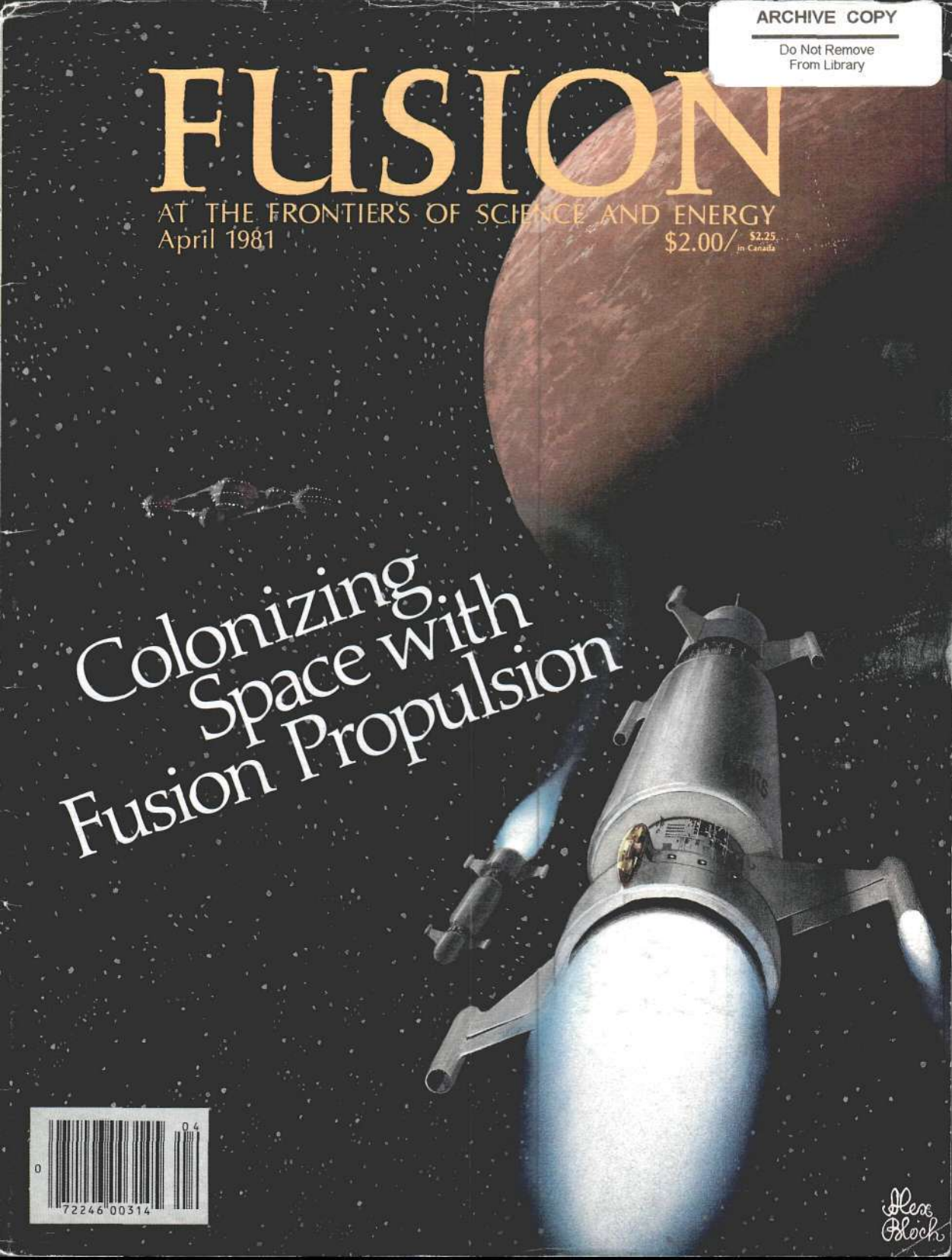

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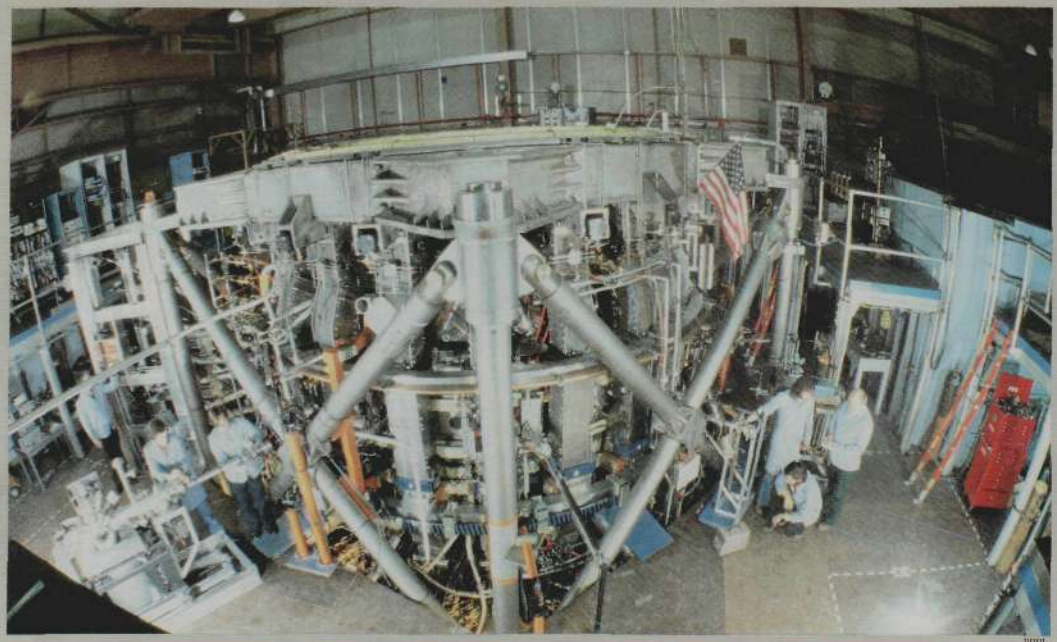
Alex Block

We stand up for you and America.



PPPL

Join the **Fusion Energy Foundation**

Fourteen thousand Americans last year invested from $75 to $1,000 each in the future of America's scientific and industrial leadership by joining the **Fusion Energy Foundation,** the nation's largest scientific membership organization.

With this kind of clout, we waged a vigorous educational campaign nationwide and on Capitol Hill, culminating in what Congressman Mike McCormack called "the most important energy project undertaken anywhere by anyone"—the Magnetic Fusion Energy Engineering Act of 1980. As the first national organization to support an Apollo-style fusion program for America, we and our 14,000 members are proud to take credit for creating the environment in which Congress and the president have mandated fusion as the energy source of America's future.

Now we're aiming for 50,000 new members who believe in progress and growth. Our goals for 1981 are just as important as 1980's fusion legislation:

(1) Eliminate the obstruction of progress by the Environmental Protection Agency.

(2) Launch an unprecedented program of scientific education for our children.

(3) Assure the funds to develop fusion power in the manner mandated by the 1980 fusion act.

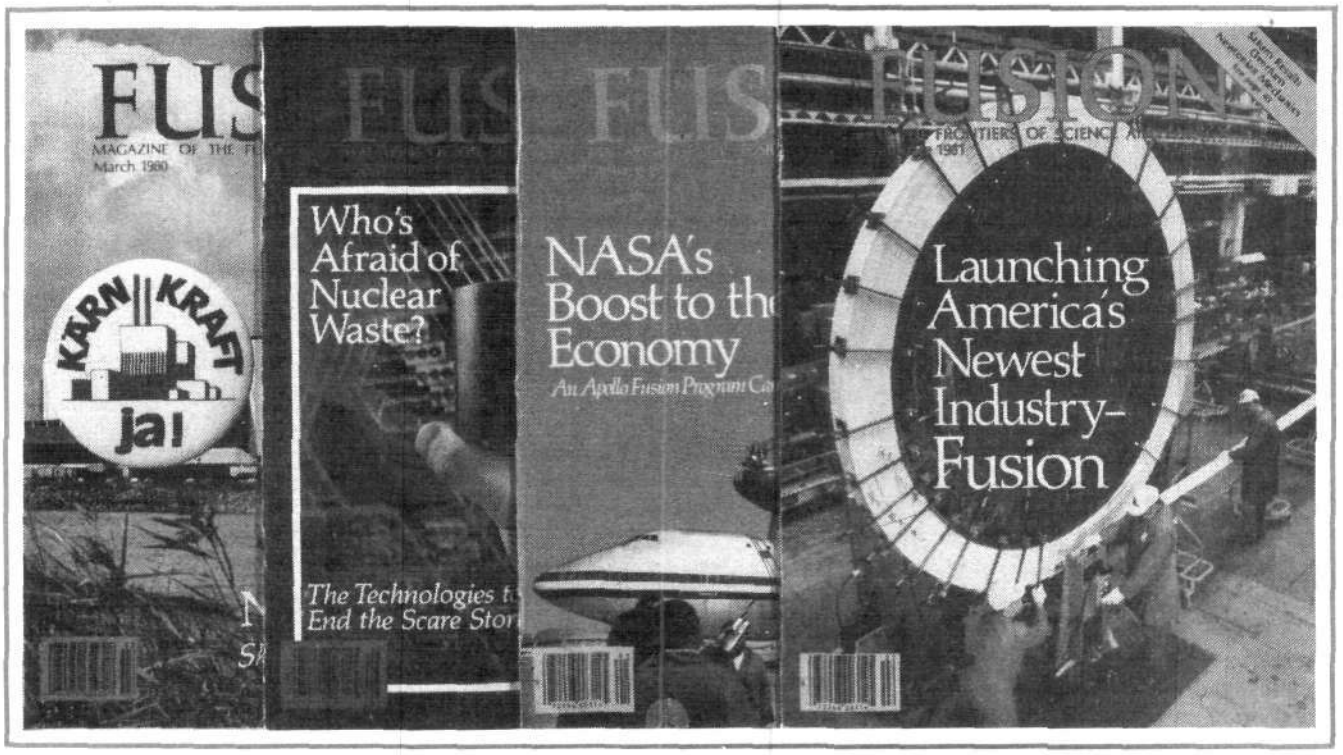
With your active support, we can make 1981 the year that environmentalists cease determining U.S. policy. We can eliminate the artificial impediments to nuclear energy and put an end to the Malthusian politics of austerity and scarcity.

Join the **Fusion Energy Foundation** now. We work for you all year long.

Fill out the membership card opposite this page.

We're making progress!

Literally. Because, as the Fusion Energy Foundation goes, so goes the nation. Think about it. Our rapid growth in 1980 meant that the McCormack fusion bill became law and made possible America's renewed commitment to scientific progress.



But making progress costs money.

The FEF and the United States face greater challenges in 1981. And as we grow and expand our activities, we can ensure that the new administration fulfills its mandate for economic growth.

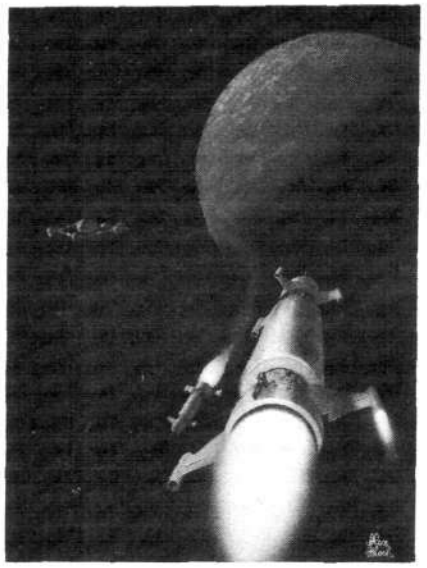
In 1979 alone, more than 22 million dollars was given to zero-growth groups by just six foundations.* Our fight requires this kind of funding—and more. You can help by giving generously to the FEF and supporting some of our special activities.

- Become a corporate or lifetime member of the FEF ($1,000).
- Sign up your friends and colleagues as members.
- Sponsor bulk subscriptions to *The Young Scientist* in your area's schools.
- Purchase the FEF slide show on fusion to educate your friends and community.

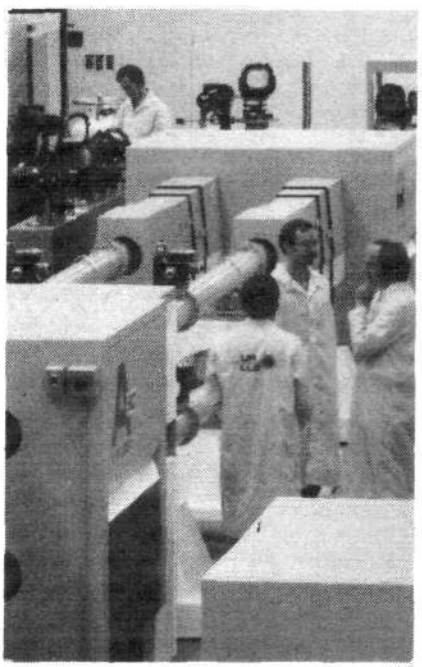
1980 was a year of progress for the FEF and the nation. With your continued support, we'll both do better in 1981. Contributions to the Fusion Energy Foundation are tax-deductible.

For more information, contact Harley Schlanger, FEF Membership Director,
888 Seventh Avenue, Suite 2404, New York, N.Y. 10019, (212) 265-3749.

*See *Fusion*, March-April, 1981, p. 37.



Mining the Moon and other planets may help solve future resource shortages and, as Dr. Winterberg shows, fusion propulsion is the only way to get there. *See page 21.*



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Both the classified and unclassified approaches to inertial fusion are nearing final scientific testing, as shown in the broad review of the inertial fusion program by Gregory H. Canavan, director of the U.S. inertial fusion program, and the fusion report by editor Charles B. Stevens on some recent developments. *See pages 30 and 12.* *Above: The Omega laser at the University of Rochester Laboratory for Laser Energetics.*

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News

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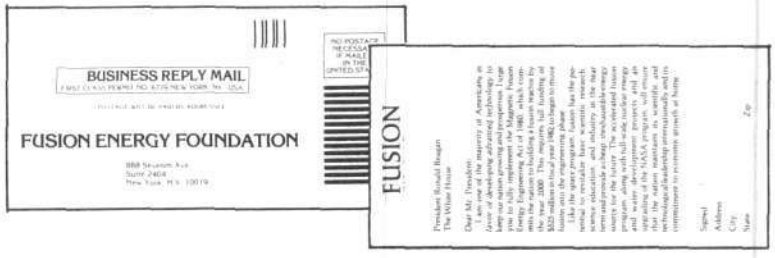

From the Editor's Desk

Signing and mailing the postcard to President Reagan is the first step readers can take to ensure that the magnetic fusion energy program gets into the engineering phase this year.

The postcard campaign is just one of the ways the Fusion Energy Foundation intends to shape national science and energy policy in 1981. This issue's editorial presents in broad outline the tasks required in the Reagan administration's first 100 days to put the nation back on the path of progress. Other articles here and in future issues take up specific policy questions in more detail. For example, this month's Viewpoint by the executive director of the National Science Teachers Association and a review in the science update section of the recent presidential report on science education both discuss the necessity for upgrading U.S. science education, a major FEF goal for 1981.

Readers are encouraged to attend the regional FEF membership meetings this month and next. See the FEF News section for details.

Marjorie Mazel Hecht

Marjorie Mazel Hecht
Managing Editor

FUSION
AT THE FRONTIERS OF SCIENCE AND ENERGY

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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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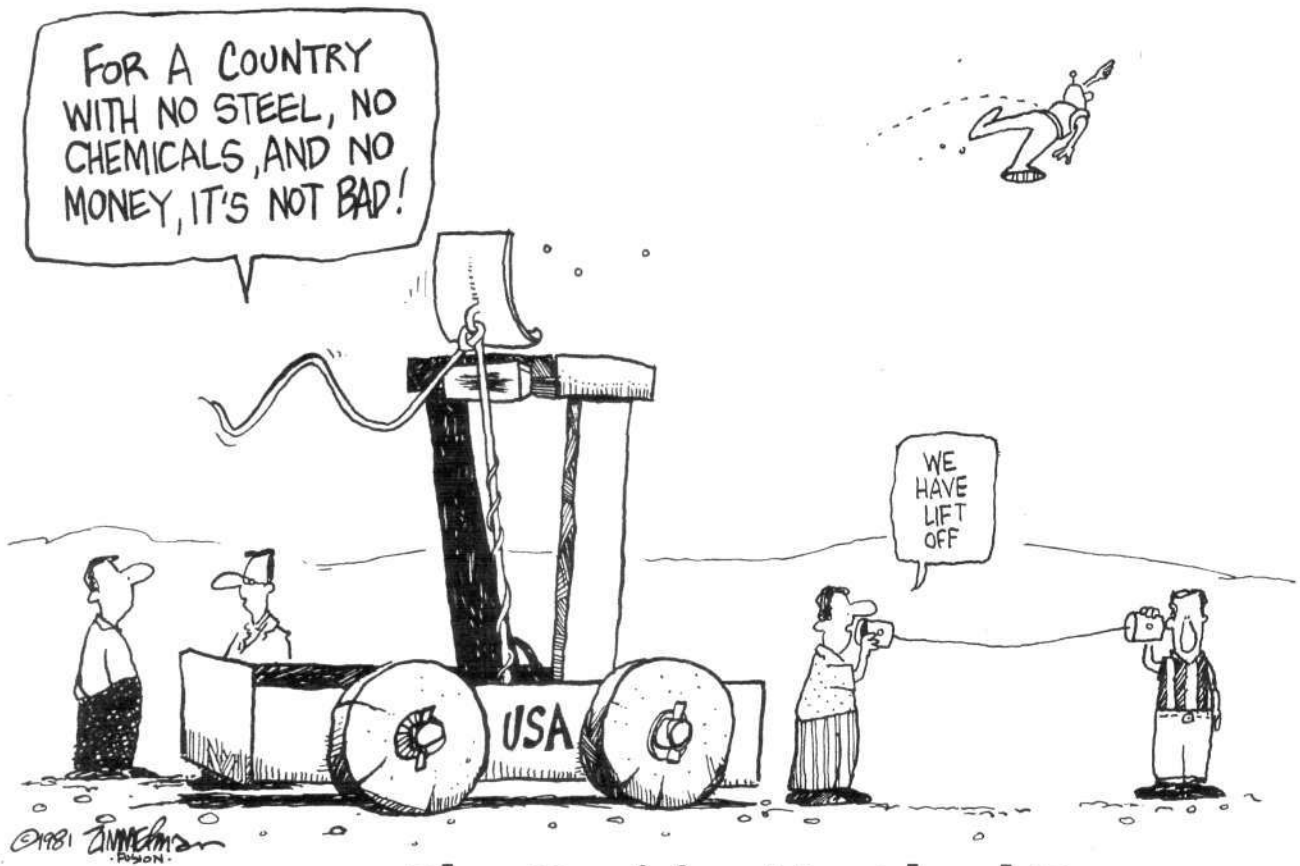


The Decisive Hundred Days

With the inauguration of President Reagan, the United States now embarks on one of the most important three-month periods in its history. The policies enacted or initiated during the first hundred days of the Reagan administration will determine the situation for the decade of the 1980s.

Although there are many pressing issues to settle, ultimately history may well record that the fate of the United States was decided by its science policy. In the year 1980, the fabulous results of the Voyager mission to Saturn, the passage of the McCormack fusion bill, and the awarding of the Nobel Prize in chemistry for the pioneering efforts in recombinant DNA research demonstrated that humanity is capable within the next century of transforming the entire solar system into a springboard for colonization of the entire galaxy. If the nation proceeds from this perspective, there is no present problem that cannot be solved.

The most immediate challenge is to set a new course in economic and foreign policy. If the Reagan administration acts boldly and decisively at the outset to set up massive oil-for-technology deals, in concert with Western Europe and Japan, then the way will be open to provide security, stability, and economic development to the entirety of Latin America and the Mideast.

The United States then need only take a coordinated series of steps to get the economy moving back toward a healthy condition. First, the high interest-rate policy of Federal Reserve head Paul Volcker must be abandoned once and for all, and along with it all other vestiges of monetarist and austerity policy, to be replaced by a competent monetary, banking, credit, and taxation system. Basically, this involves U.S. participation with Western Europe in a beefed-up European Monetary System that channels hundreds of billions of Eurodollars and petrodollars away from inflationary speculation and back into productive investment in the advanced and developing sectors.

In turn this requires replacing the power of the antiindustrial Federal Reserve with an expanded Export-Import Bank working with the European Monetary System and with regional and local banks throughout the country. Finally, interest and taxation rates must be set to reward productive investment and R&D while putting heavy levies on speculative, nonproductive activities.

Within this framework of economic policy a sound national energy and science policy becomes possible and, indeed, indispensable to the nation's future. We outline here the basic principles of policy for both energy and science, as well as some of the most important programs.

A Policy for Energy Growth

Energy policy should proceed from two basic premises: First, it is economically necessary to improve energy efficiency by using increased energy flux density sources and greater energy intensity in order quantitatively and qualitatively to increase productivity in industry and agriculture. Second, the world will have 6 to 7 billion people in the early part of the 21st century.

These two factors, combined with the array of possible raw materials and refining and combustion technologies, provide benchmark figures for global and U.S. energy production over the next several decades.

If we set the goal of undertaking global economic development on the required scale, one that provides an average standard of living equivalent to the level of semiskilled workers in Europe (this would be accomplished through a number of strategic development projects), then energy production by the year 2000 must increase by a factor of more than 3. That requires a global energy growth rate of about 6 percent, composed of rates of approximately 4 percent in the advanced sector and 10 percent in the developing sector.

This can be achieved if several thousand gigawatts of nuclear-generated power of various types are put on line globally by that time. Overall, the mix of energy sources would evolve in such a way that while fossil use significantly increases, the percentages of nuclear and fossil would become more nearly equal.

This growth-and-development oriented energy policy requires these specific measures:

(1) Fusion. The Magnetic Fusion Energy Engineering Act of 1980 to develop a commercial fusion power plant prototype by the year 2000 should be fully funded, to set the stage for the onset of fusion-based technologies in the 21st century.

(2) Fission. The full nuclear fuel cycle must be closed, including spent fuel reprocessing, waste storage, and development of new technologies for fuel enrichment (for example, laser-isotope separation) and breeding. All forms of breeding, from the liquid metal fast breeder and high-temperature gas-cooled breeder to the fusion-fission hybrid and relativistic beam breeders should be experimentally developed and tested for commercialization and economic feasibility.

We must build thousands of nuclear plants for domestic use and export under standardized codes of licensing and safety that permit construction in less than five years.

(3) Fossil. Companies in this field should be provided with economic incentives to maximize production under high-technology conditions and to reinvest significant amounts of surplus into next-generation primary technologies. Advanced exploration and mining techniques should be encouraged, along with a major R&D effort to develop prototypes for magnetohydrodynamic combustion of various fossil fuels, as well as nuclear MHD.

The only "synthetic" fuel R&D deserving of large-scale government support is the production of hydrogen from high-temperature fission and fusion reactors and some development of methanol production in conjunction with high-technology steel production. Before there is large-scale commitment of resources to any synthetic fuel technology, there should be a thorough review of technological feasibility and economics by a blue-ribbon scientific panel.

Continued on page 6

The Lightning Rod

My dear friends,

Recently I heard the following story which, I am told, is making the rounds in Washington, D.C. It seems that two congressmen were discussing the performance of Jimmy Carter with a journalist. One legislator ventured the opinion that history would assess Carter as the USA's worst president.

"Worse than Harding?" the incredulous journalist exclaimed.

"Harding didn't do anything," Congressman A replied.

"Worse than Grant?" the journalist persisted.

"At least under Grant, we built the railroads," Congressman B pointed out.

The story reminded me that Grant, whose presidency was indeed a financial disaster for the United States, by reason of some particularly nasty operations run against the president from the inside of his own Republican Party, deserves to be better remembered as one of the men who saved the nation in its darkest hour. And as anyone familiar with his remarkable memoirs can confirm for themselves, Grant was thoroughly committed to the American idea of progress.

There is a story told by Grant in his memoirs which sums up in a nutshell the weakness of recent administrations in the face of the relative handful of persons and institutions of a "zero-growth" persuasion who have succeeded in manufacturing the myth of an all-powerful "Environmentalist Lobby."

The story concerns one of Grant's experiences as a young officer in Texas, many years before the Civil War. Grant and a fellow soldier were compelled to make a journey through a wild and uninhabited territory.

As Grant tells it, "On the first day out from Goliad we heard the most unearthly howling of wolves. The

Continued on page 6

Editorial

Continued from page 5

All of the recommended forms of present and future energy sources will be the basis for large-scale industrial, agricultural, and urban development, in the form of present types of generating stations, as well as in the form of future energy parks and agroindustrial complexes (nuplexes) that are the basis for economic development in regions with populations of millions.

A Policy for Science Research and Education

If our basic criterion is to increase the population potential of our species, to upgrade its living standards, health, and productivity, and to improve its cultural level and positive sense of human identity, then a broad program of basic research and education is indispensable.[8]

During recent years there has been a remarkable series of experimental results in practically every branch of science, for example, high-energy nuclear physics, astrophysics, plasma physics, high-temperature superconductivity, cell biology, neurophysiology, and DNA dynamics, which have explicitly demonstrated the qualitative changes in the organization of matter and energy that underlie all fundamental processes. Science now faces the challenge of developing the conceptions that will permit comprehension and control of this vast new array of complex phenomena. As the FEF has stressed many times and will develop in a forthcoming book, to succeed in producing the needed breakthroughs requires that we re-create the tradition of Riemannian mathematical science.

Just a few of the crucial, strategic areas of research that must be intensified are:

- Plasma physics in fusion, MHD, astrophysics, atmospherics, and space propulsion
- Space science, from geophysics and celestial mechanics to cosmology
- Accelerator and beam physics
- Recombinant DNA in agriculture and medicine
- Basic research in hydrogen production and the chemical physics and hydrodynamics of desalination
- Advanced cancer and neurophysiological research

In future issues of *Fusion* we will continue to discuss the theoretical and practical implications of these and many other areas of science and technology where the nation's scientists stand on the threshold of great breakthroughs. We can already see the outlines of tomorrow's world of space colonization, fusion power, superconducting energy transmission, supercomputers, climate control, abundant fresh water and food, hydrogen fuel, medical control of aging, and global scientific renaissance. It is equally necessary to visualize concretely the world of continuing economic and cultural decay, instability, and war danger if the nation and the world continue to be run by the principles of Malthusianism, or even by a compromise with the basic evil of zero-growth.

The first hundred days must be instead a time of great victory for the principle of progress.

Unabashed Support For Progress

To the Editor:

I have now been subscribing to your magazine for about a year. As an engineer who is committed to modern technology and who has worked in the aeroengine and nuclear industries and is now involved in the magnetic fusion effort, I am pleasantly surprised at the advocacy of advanced technology that your magazine unabashedly and consistently espouses. Although I am certain that a majority of the American people favor advanced technology solutions to our problems, the elite in this country and in both the major political parties, for nostalgic and other reasons, wishes to return this country to a pastoral and supposedly simpler lifestyle of a previous century. I commend you for taking an unpopular but what I think is a right position.

As an American who was born in the Indian subcontinent, I am pleased that you have taken a positive view of India's efforts at industrialization, especially its nuclear energy program. As you well know, in encouraging India's industrialization, especially its quest for diversified energy sources, you are in a definite minority, among the not so well intentioned elite. As a result of the initial push given by Jawaharlal Nehru, the first prime minister of India, India is one of the few countries in Asia and perhaps the only

The Lightning Rod

Continued from page 5

prairie grass was tall and we could not see the beasts, but the sound indicated they were near. To my ear it appeared that there must have been enough of them to devour our party, horses and all, at a single meal. Benjamin kept on toward the noise unmoved. I followed in his trail, lacking the moral courage to turn back.

"When he spoke it was to ask, 'Grant, how many wolves do you think there are in that pack?' Determined to show my acquaintance with the animal by putting the number below what could possibly be correct, I answered, 'Oh, about twenty.' He smiled and rode on. In a minute we were close upon them. There were just *two* of them. Seated upon their haunches, with their mouths close together, they had made all the noise we had been hearing."

To borrow a phrase from the General, the zero-growthers are like the wolves—"There are always more of them before they are counted."

Your obt. svt.

Benj. Franklin

one outside of Japan which has both a mature industry and a semblance of democracy. But the "small is beautiful" forces are gathering strength even in India, just as the momentum built up by Nehru is running out of steam. You owe it to yourself and to future generations of a large proportion of humanity to continue to advocate the initially difficult but in the long run only solution to world poverty—the adoption of advanced technologies.

I am amazed also that I am in agreement with your magazine in other areas, such as the relevance of the Göttingen tradition in science and mathematics in today's world, and the undue and harmful influence exerted by British pseudoscientific thought on developments in the 20th century. What is indeed surprising is that there should be such convergence of views between somebody brought up in the Vedic traditions of India and your editorial opinions, which I presume are the inheritors of Greek philosophical thought and the European renaissance.

Kosla Vepa
Pleasanton, Calif.

The Editor Replies

Many thanks for your comments.

During my stay in India this year I had the opportunity to meet with a number of Indian scientists. One of the most interesting things to me was the fact that although many scientific institutions and scientific training in general were modeled after British institutions, both the type of attitude toward science and the methodological approach of the best Indian scientists clearly are not British in character.

I had several discussons about the actual "metaphysical" background of Indian science, which led to discussion of the Vedic tradition in Indian science. This tradition defines an astonishing, virtually unbroken continuity going back to the second millennium BC—or even to the third millennium.

To satisfy my desire to understand this more clearly, I have begun to study the Vedic tradition, particularly in mathematics and geometry. I plan to report on the results of this study in a forthcoming issue of *Fusion*. Meanwhile, I would appreciate hearing from you and other readers who are familiar with the Vedic tradition.

Uwe Parpart
FEF director of research

DES Studies 'A Sham'

To the Editor:

In the Jan. 1981 issue of *Fusion* I noted a letter by a concerned, bewildered and somewhat bereaved Sara L. Bouge about the "DES scare." The reply by Susan Cohen I thought was appropriate. However, one item seems to have escaped the public at large, the majority of the medical community, and both Ms. Bouge and Ms. Cohen. The initial studies implicating DES in vaginal carcinoma of the daughters of women exposed previously is and was a sham.

While this was a very popular drug during especially the 1950s and 1960s, there would be little surprise in finding a high percentage of yes responses to the question of women with vaginal carcinoma "did your mother take DES?" The percentage undoubtedly was quite high. However, have these researchers who, in all honesty, do not deserve the title, additionally asked the question "did your mother consume saccharin during her pregnancy to keep her weight in control?," or "did your mother consume vitamins?" (The dye in a number of vitamin preparations very commonly used in the gestational period of American women has demonstrated oncogenic and teratogenic potential.)

In brief, what I am saying is that the researchers who have implicated DES have failed a basic premise of scientific study and have not addressed the question of "what else did your mother take during her pregnancy?" The oncogenic potential of saccharin is well known. The number of pregnant women consuming saccharin I suspect far exceeds the number of women who ever consumed DES. Frankly, in reviewing all the literature implicating DES, I find *no* evidence that, on a scientific basis, implicates DES in the slightest.

Please take special note of the fact that I am in no way associated with any drug industry interests. I am merely trying to encourage the use of more scientific acumen.

Donald R. Steele, M.D.
Newport Beach, Calif.

Speciation

To the Editor:

Generally, I enjoyed Ms. Cleary's review of Dr. Colp's book on Darwin [*Fusion*, Jan. 1981, p. 82]. . . .

She states that "Modern science is only beginning now to unravel the processes involved in higher evolution, of which random mutations are a secondary, not primary, aspect of speciation." . . .

A report from Ms. Cleary that documents the primary "aspect [cause?] of speciation" . . . would thrill this reader.

Robert G. Gard III
McLean, Va.

The Editor Replies

Your thrill awaits you on page 45 of this issue. For a more extensive explanation, see Carol Cleary's "Evolution: A Riemannian Approach to Biology," *Fusion*, March 1980, p. 38.

Bucking the Enemies Of Progress

To the Editor:

I am a layman subscriber to your periodical. I therefore must reread your technical features many times. . . . I would like to tell my friends and neighbors what fusion is all about. . . . If you have a leaflet that would introduce my friends to the subject in everyday language, I will be able to have it published in my local newspaper. . . . I think this is a very important method of educating the public and thereby building support for the cause. Without a grassroots movement, who can buck the erudite-seeming enemies of progress? . . .

My commentary on the Republican landslide was that Mr. Carter neglected the energy problem. The only way to lick inflation is to provide an alternate source of energy—fusion. Mr. Carter ruined our country by his dilatory tactics on the breeder reactor

and allowed a number of European nations to leap a few years ahead of this country that invented nuclear energy.

Jack Sprinzen
Putnam Valley, N.Y.

The Editor Replies

The FEF has prepared a 1981 series of seven books including basic articles on fusion and other frontier areas of science, as well as a slide show, "The ABC's of Fusion," explaining fusion in layman terms. (See the ad on page 14 of this issue.) We are also available to write newspaper articles, give interviews to the press, and speak at community meetings.

An Ardent Convert

To the Editor:

I am an enthusiastic new subscriber to your magazine. . . . Being a converted antinuclear advocate, I failed to appreciate the importance of your magazine and discarded my October issue before properly digesting it. Now I would like another copy and have a special interest in the special report on reindustrialization in that issue.

I will be grateful if you would send me a second October issue and also advise how I may obtain reprints of articles.

Harry M. Barker
Chicago, Ill.

The Editor Replies

Reprints of some feature articles and special reports are available at $1.25 each postpaid. The Best of Fusion, the FEF's 1981 book series, includes reprints of many significant *Fusion* articles as well as groundbreaking new work.

Correction

In the article "Mapping America's Vast Oil and Gas Wealth" (*Fusion*, Feb. 1981, p. 35), electrical logs of proven oil wells were misidentified as seismic charts in photographs on page 38 and the bottom left of page 43. In the bottom right picture on page 43, Hilda Talbert was shown transferring information from electrical logs to a map.

Viewpoint

U.S. Secondary School Science Education: Approaching the 'Dark Ages'

by Bill G. Aldridge

By 1990, secondary science education in the United States will be insignificant and lacking substance unless there is a substantial intervention now at state, local, and, particularly, national levels. There will be few qualified science teachers left and essentially none being trained. In that same year there will begin another great change in our population. From 1990 to 2000, the 14-17 age group will increase by 26 percent, with a corresponding surge in secondary school enrollments—at the very time when the number of qualified science teachers is at its lowest point in 30 years.

One can only offer conjectures as to the effects of the next 20 years of "dark ages" in secondary science education on science and engineering education at the postsecondary levels. It might well be, however, that an inadequately prepared citizenry in a highly technological world could help reduce the United States to third-rate status well before the year 2000.

The low priority given science in our schools is not merely a local or state phenomenon. A major share of the responsibility rests with the scientific community, its scientific societies, and the federal agencies which fund science and scientific research.

Over the past 15 years, our leading scientists have been instrumental in assuring that support for science education was systematically and drastically reduced, while support for research was increased. Even in the National Science Foundation's (NSF) science education program, that part devoted to secondary science education was long ago reduced to negligible proportions.

Those few funds directed at problems of science education at the secondary level have been, in reality, grants to colleges or universities, where some "trickle effect" is assumed to benefit secondary school science. This gross negligence of secondary school science education by the "experts" in science can offer little encouragement to local or state governments or agencies to value science in secondary schools more highly.

Some Recommendations

The recent report to the president on science and engineeering education by the NSF and Department of Education includes many recommendations that, if implemented, would substantially improve secondary school science education. However, the large number of recommendations made, and the fact that they have *not* been arranged by priority, reinforce the likelihood that sec-

ondary science education will continue to be neglected.

Unless this educational component is recognized as a serious problem area, it will not be able to compete for scarce federal funds. This is especially true given the fact that the framers of this report have a strong vested interest in meeting "needs" associated with university research departments and little concern for science education below the PhD level. The lack of specificity of the recommendations also encourages their neglect.

These specific recommendations will better address the problems of science education at the secondary level:

(1) Fully implement the recommendation of the report that calls for summer institute programs and short courses. But this effort *must* include stipends, tuition, and subsistence expenses for teachers involved in the programs. These programs should offer a balance of science and technology subject matter, teaching methodology, and exposure to new materials.

(2) Create a distribution system for inexpensive instructional materials for secondary school teachers through grants to local agencies, school systems, and other qualified groups.

(3) Provide funds to colleges and universities to set up in-service programs to prepare science teachers to teach science at several levels within the school system. This would help us to retain science teachers by enabling them to teach some science at the elementary school levels during the K-6 growth period of 1983-1990 (when grades 7-12 enrollment will drop by as much as 50 percent in some states). Then when the 7-12 growth period occurs again in 1990-2000, these teachers could move back into full-time teaching in the high schools.

(4) Provide funds to secondary schools for science apparatus, particularly in computing and modern electronics. These funds could be in the form of grants provided in a competitive program.

(5) Provide funds to enable modification and dissemination of technician-oriented and applications-oriented programs, including some previously supported by NSF.

We badly need to *restore* to our courses consideration of the *applications* of science, an aspect systematically purged by *scientists* in the late 1950s and early 1960s as they recreated secondary science curricula to reflect the work of research scientists. The disastrous enrollment consequences of those abstract and somewhat elitist programs are obvious to all of us who taught in the secondary schools during that period.

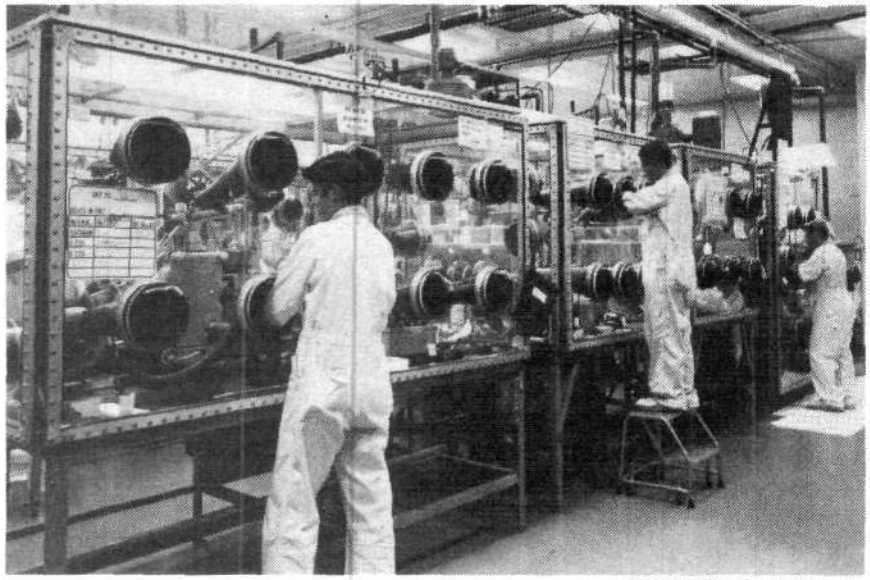
Let's End the Misconceptions

We as a nation must recover from the fiction that secondary-level science education in the United States was given a tremendous boost after Sputnik by the NSF and National Defense Education Act programs. In fact, efforts to strengthen science teaching were neither as substantial nor as pervasive as we tend to believe. Support for science education never achieved the level given vocational education, for example, which serves fewer students. What is worse, there is a persistent misconception that NSF continues to provide substantial support for secondary science education, even though that assistance vanished long ago.

There are at present dozens of federally funded programs in secondary schools in areas other than science. The budget for bilingual education is twice as large as NSF's entire allocation for science education, for example; and support for vocational education alone totals some $750 million. Indeed it is ironic that science content is *not* eligible for support under the vocational education acts, even when taught as specialized technical courses exclusively for vocational programs.

Secondary science education does indeed "fall between the cracks" of a variety of federal programs. But this lack of recognition of its importance, this ongoing condition of neglect, must change or our society will face irreversible problems. We must come to realize that the United States cannot afford to offer its young people an inferior education in science.

Bill G. Aldridge is executive director of the National Science Teachers Association. This Viewpoint is excerpted from his analysis of the NSF-Dept. of Education report to the president.



Babcock & Wilcox Co., Lynchburg, Va.

"An inadequately prepared citizenry in a highly technological world could help reduce the United States to third-rate status well before the year 2000." Here a 1970 photograph of technicians at the Babcock and Wilcox plutonium laboratory.

News Briefs

ANNOUNCE CORPORATE GIFT PROGRAM FOR THE YOUNG SCIENTIST

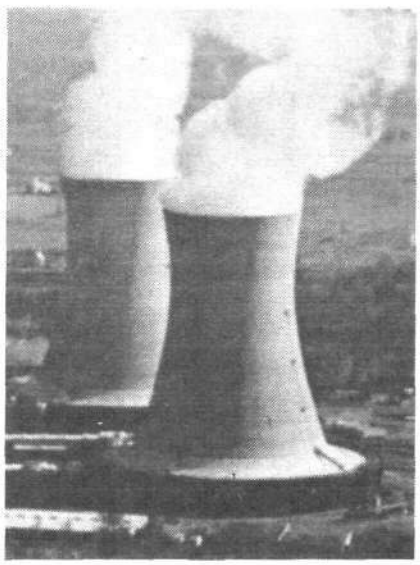
Dr. Morris Levitt, executive director of the Fusion Energy Foundation, announced that the FEF had established a corporate gift-giving program for *The Young Scientist* magazine to enable corprations and businesses to sponsor bulk subscriptions for school systems. "The initial response to *The Young Scientist* magazine," Levitt said, "convinced us that this would be an ideal way for companies to support excellence in science education and for budget-strapped school systems to bring high-quality science teaching materials into the classroom." Interested corporations and school personnel should direct inquiries to Patricia Levitt at FEF's New York office.

The Young Scientist, now published bimonthly, plans to go monthly next September, with a teachers guide, Dr. Levitt said. Young Scientist Clubs are also getting off the ground, with tours for members of scientific laboratories and museums.

ISRAELI SCIENTISTS PRESS FOR NUCLEAR OPTION

Summing up the Dec. 4-5 annual conference of Israeli nuclear societies, Nuclear Society head Shimon Yiftah told his colleagues: "What makes this year's conference different is that we will be discussing practical options for how and where to build reactors in Israel. We feel that the country is finally moving toward nuclear energy and that gives our deliberation new practical importance." A government commission is scheduled to announce its recommendations in April about whether Israel should build nuclear reactors.

Leading Israeli scientists are now mobilizing to ensure that Israel builds two or three new reactors during this decade to meet its future energy needs. The consensus that emerged at the conference, held at Ben-Gurion University, was not only that the nuclear option is necessary for Israel, but that the change of administration in the United States would bring an end to the ban on nuclear exports. This is particularly important for Israel, several participants stressed, because the country was promised two Westinghouse reactors by the Nixon administration that were never delivered by the Carter administration.



TMI: Suing the NRC for $4 billion.

GPU SUES NRC FOR $4 BILLION IN TMI DAMAGES

A $4 billion claim stemming from the nuclear reactor incident at Three Mile Island in March 1979 was filed Dec. 8 by the General Public Utilities Corporation (GPU) and its three operating subsidiaries against the Nuclear Regulatory Commission (NRC). The suit charges the NRC with negligent performance and omissions of its operational functions; negligent failure to comply with its own regulations; negligent failure to give warning based on the (Toledo Edison) Davis-Besse incident that occurred in Sept. 1977; negligent implementation of review and approval requirements; and negligent review and approval of Babcock & Wilcox Co. topical reports and generic designs.

In a statement to the press, William G. Kuhns, GPU chairman and chief executive officer said, "We have based our actions on extensive investigations into the causes of the accident that were conducted by both GPU and its legal counsel, as well as various independent studies and the NRC's own findings and reports. . . . If the NRC had acted with due care, this accident would not have occurred."

SIBERIA HAS 15-TRILLION-BARREL OIL RESERVE

A report by the Swedish oil consulting firm Petrostudies that a Soviet oil discovery in western Siberia exceeds the entire world's known reserves of petroleum has been refuted by Western oil experts and the Soviet Academy of Sciences. However, according to a Soviet geology expert with the U.S. Geological Survey interviewed by the weekly *Executive Intelligence Review,* there are nearly 15 trillion barrels of unrecovered oil in western Siberia, in the vicinity of two now-exploited fields in Salym and Samotlar. An Oct. 4, 1979 underground nuclear explosion near Salym, he said, may be an indication that the Soviets are planning to exploit the additional source-rock potential. The Soviets maintain a "very active" peaceful nuclear explosion program that

could be applied to oil, mineral, and water resource recovery. Experts believe that the 1979 peaceful nuclear explosion may be linked to experimental stimulation of the untapped oil reserves by extensive fracturing of the shales.

NASA TO LAUNCH SATELLITES FOR INDIA

The Indian Department of Space and NASA signed an agreement Nov. 18 for the launch of two communications satellites, called INSAT, in 1982 and 1983. The two domestic satellites will link more than 600 million Indians to the nation's culture, news, education, and world events.

Ford Aerospace Corporation is building the two INSAT satellites at a cost of $60 million. The satellites will include instrument packages for TV and radio transmission, meteorological data transmission and observation, and other data and voice communications. The two geosynchronous satellites will cover an area of more than 1 million square miles from 220,000 miles above the subcontinent. A spokesman for Ford Aerospace explained that this system has the capability to upgrade India's economic position by bringing culture and education to the most remote parts of the country. Each village and rural region will need only one TV set to have access to the national program.

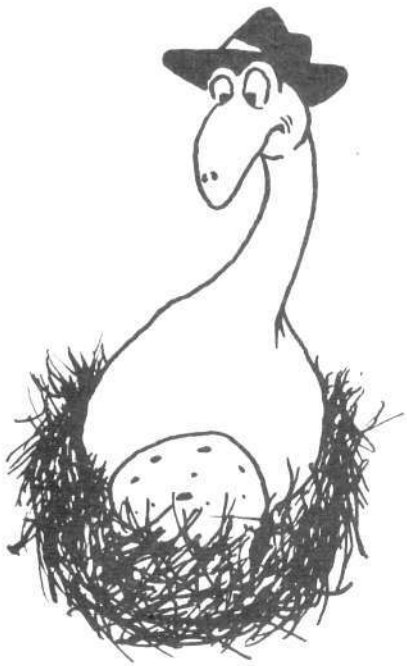
50 ATTEND FEF MEMBERSHIP MEETING IN HARTFORD

"The biggest problem facing the reindustrialization of the United States is an educated workforce; without adequate science education reindustrialization is simply impossible." This was the main theme of Dr. Steven Bardwell's presentation at the FEF membership meeting in Hartford, Conn. Dec. 12. Bardwell is the FEF director of plasma physics research and a contributing editor of *Fusion* magazine. The 50 persons attending the regional meeting were particularly interested in the role of *The Young Scientist* magazine in turning the educational situation around. FEF membership director Harley Schlanger also addressed the meeting on the organization's campaign for 1981. This was the first in a series of membership meetings planned nationwide.

Bardwell addressing the Hartford FEF meeting.

INVESTORS EXAMINE BEAM ENERGY WEAPONS

The chief investment officers and representatives from 35 major institutional investors met in New York Nov. 25 to investigate the technological possibilities of space-based laser beam and particle beam weapons systems. The meeting was addressed by senior Defense Department officials, senior officials from the Defense Advanced Research Projects Agency, and Senator Malcolm Wallop, a Wyoming Republican. According to a representative of First Albany Corp., an investment firm that hosted the meeting, "It is important that we do this because a lot of these emerging technologies are not very well understood by the investment community." Senator Wallop discussed the implications for defense of going ahead with a space-based laser system. He described the current status of the technology as well as the implications for strategic balance of launching such a weapons system. "What emerged, at a minimum, was an education as to what this somewhat esoteric emerging technology is all about, as well as a sense that there is a growing consensus that we should proceed fairly soon with the development of the technology of space-based lasers and particle beam weapons," a spokesman said.



LOUSEWORT LAURELS TO BRUCE STOKES OF WORLDWATCH

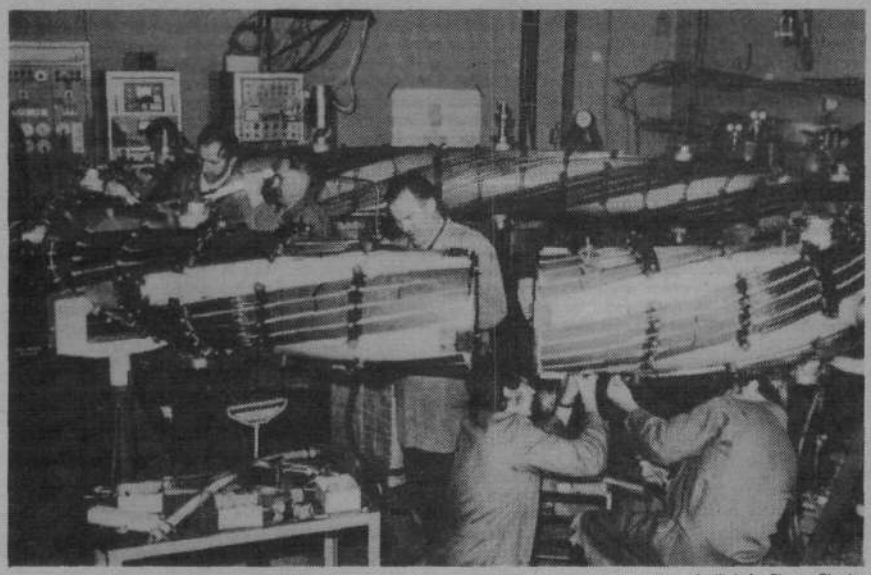
Worldwatch Institute, a leading zero-growth think tank, wins this month's lousewort laurels award for yet another study on preventing "overpopulation." Bruce Stokes, a Worldwatch researcher, has authored a just-released report on the role played by men in irresponsibly bringing more and more children into the world. "Society can ill afford to have men play this peripheral or negative role in family planning," says Stokes. The United Nations-funded study criticizes the societal neglect of men in birth control planning and urges the widespread use of sterilization, condoms, and withdrawal for successful population control. A previous Worldwatch study won the lousewort award in August for its analysis that scientific ideas were running out and that there should be laws against "conspicuous and excessive consumption of energy and food."

The APS Annual Plasma Physics Meeting

Some Inertial Confinement History Declassified

More than 2,000 fusion scientists, engineers, and industry representatives from around the world attended the 22nd Annual Meeting of the Division of Plasma Physics of the American Physical Society in San Diego Nov. 10-14. With its more than 1,385 contributed papers, this conference continues to be the world's largest and most informative annual fusion science meeting.

Many new results and continued, broad-based progress in ongoing fusion programs were reported on in the formal proceedings, which will be briefly summarized here and will be reviewed at greater length in subsequent issues. This report, however, will focus on the background of the inertial confinement program based on historical information presented for the first time at the APS meeting.



Institute for Plasma Physics

Workers assembling the vacuum vessel of the West German stellarator Wendelstein VII. Recent results on the Wendelstein indicate that the stellarator may prove superior to the tokamak.

Here are some of the current developments that were reported on:

• Dr. G. Grieger of the West German Max Planck Institute reviewed the current status of the donut-shaped magnetic bottle known as the stellarator, a U.S.-developed concept that preceded the Soviet-conceived tokamak. (The stellarator is designed so that all components of its confining magnetic field are generated by electrical circuits external to the fusion plasma. In the tokamak, the poloidal part of the magnetic field is produced by the internally induced plasma electrical current.)

Ironically, the United States gave up mainline stellarator research to pursue the tokamak. Today, both West Germany and the Soviet Union have large stellarator programs, and, as Grieger demonstrated, recent experimental results continue to indicate that the stellarator configuration may prove superior to the tokamak.

• The PDX tokamak at the Princeton Plasma Physics Laboratory continues to achieve good results. The magnetic field geometry of this poloidal divertor device permits the removal of plasma impurities. Confinement of the plasma in the PDX is comparable with the best results attained in the Princeton PLT tokamak.

• The ISX-B tokamak high-beta experiments at Oak Ridge National Laboratory were reviewed and analyzed by Dr. D.J. Sigmar. Although further experiments are needed to confirm the ISX results, there is strong evidence that the ISX has already exceeded the theoretical stability limits for containing high-beta plasmas without the observation of any instability. This is a very promising result since high betas mean that the confining magnetic fields are more efficiently utilized.

• New proposals for using "exploding" wires—wires through which a large electrical current is passed—for a combined magnetic and inertial-fusion system were presented.

• New designs for technologically more simple tokamak reactors were presented by Dr. Dan Jassby of Princeton.

• The latest, encouraging results on the TMX, the Tandem Mirror Experiment at Lawrence Livermore National Laboratory, were presented and detailed in a number of talks.

• Sandia National Laboratory reports bringing its Particle Beam Accelerator Facility I up to outputs of 1 million joules.

• Dr. Winston Bostick and his colleagues at the Stevens Institute of Technology in New Jersey reported their detailed experimental findings showing that electron beams form into vortex structures. This work could be quite crucial for beam propagation.

Historical Developments In Inertial Fusion

It has been more than four years since Leonid Rudakov of the Kurchatov Laboratory in Moscow first presented the idea of using soft X-rays for compressing and igniting inertial

targets (laser, ion, or electron beam) in a talk at Lawrence Livermore in July 1976. In his invited talk to the APS meeting on the "Physics Requirements for High Gain," Dr. Stephen Bodner of the Naval Research Laboratory's laser fusion program in Washington, D.C. revealed for the first time that Lawrence Livermore is using the idea that Rudakov made public in 1976—the conversion of laser light to soft X-rays in high-density target designs. This revelation comes as a result of the limited declassification of the work by the Department of Energy after the 1979 *Progressive* magazine court case. As a result of the information discussed at the San Diego meeting, *Fusion* is now able to report for the first time on the actual history of inertial fusion since 1950.

The Beginning

Using the work of the Riemannian-based German hydrodynamic schools such as that of Prandtl, Stanley Ulam and Edward Teller designed the first U.S. hydrogen bomb. This device used the shock wave from an uranium fission bomb to compress and ignite hydrogen fusion fuel; lithium hydride was used in later models.

In the middle to late 1950s, U.S. scientists developed a more sophisticated approach. Instead of utilizing the shock wave from a fission explosion, it uses the X-ray output from a fission chain reaction. The X-ray output passes through a series of different filtering materials and is deposited into a blackbody cavity.

There, the electromagnetic X-ray waves interact with the cavity material to become a very "smooth" spectrum and pulse of radiation, consisting of soft X-rays. Soft X-rays are ideal for driving the most efficient types of implosions of fusion fuel to high densities—isentropic implosions. They deposit their energy in a very symmetrical manner, preventing the development of hydrodynamic instabilities such as the Rayleigh-Taylor instability; and a high proportion of the soft X-ray energy is converted into compression motion.

The development of this method of igniting fusion fuel in the 1950s laid the basis for much smaller thermonuclear warheads needed for submarine-based missiles. Later research led to the development of the neutron and Reduced Residual Radiation (clean) hydrogen bombs. It also provided the basis for "classified" laser, ion, and electron beam inertial fusion targets. In these laboratory devices, the beam energy is first converted to X-rays and then introduced into a blackbody cavity.

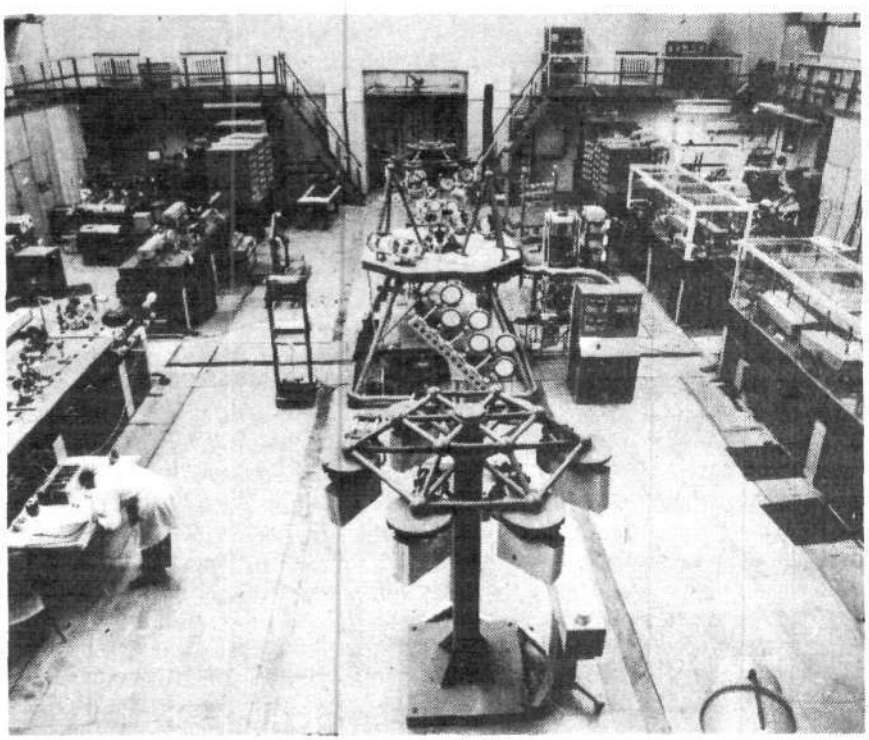
Unclassified Targets

Originally, inertial-confinement fusion was not based on classified-type blackbody X-ray targets. Laser and later particle beam and impact projectile inertial fusion were developed primarily to provide a means of harnessing fusion energy for electric power production through the generation of microscopic fusion explosions on a scale close to that found in the internal combustion engine.

A secondary objective of the program was to simulate the physical effects of thermonuclear weapons on a microscopic, laboratory scale, with both classified and unclassified targets. The unclassified targets used the beam energy to directly drive the implosion of very simple fusion fuel targets.

In the early history of inertial-confinement fusion, U.S. scientists believed that to be economically competitive, very simple, unclassified fusion fuel targets, consisting of a spherical drop of frozen hydrogen (D-T), would have to be used. Therefore, U.S. researchers concentrated on beams with high power fluxes, greater than 10^{14} watts per square centimeter. If these simple targets proved incapable of achieving high energy gains—gain equals fusion energy output divided by beam energy input—then provision was made for developing hollow spherical targets that were capable of being imploded with lower beam power inputs.

The Soviet inertial fusion scientists argued from the early 1970s on that beam-plasma instabilities would limit beam power fluxes to below 10^{14} watts per square centimeter and that, therefore, very thin-shelled targets would be needed for high fusion energy gains.



The Soviets may have achieved a breakthrough in understanding how thermonuclear burn shock-waves work. Here, the laser fusion laboratory of N. Basov at Moscow's Lebedev Institute.

Fusion Report

The U.S. scientists adamantly countered that the very thin-shelled targets were subject to hydrodynamic instabilities such as the Rayleigh-Taylor instability, and that, in any case, Soviet projections for ignition and burn in such targets would not work.

As laser-plasma experiments proceeded in the 1970s, the Soviets were proven correct as a number of instabilities were encountered in the laser-plasma interaction. These instabilities, such as the Brillouin backscatter and resonant absorption processes, led to decreased laser light absorption, asymmetries that generated hydrodynamic instability, and superthermal electrons and X-rays that penetrated the fusion fuel before implosion was completed. (These "hot" electrons in particular prevented the achievement of isentropic implosion.) The only way to avoid these instabilities was through the use of lower beam power flux levels and higher laser light frequencies.

With the increase in energy costs since 1973, laser fusion researchers in the United States now believe that they may be able to make energy economically with classified X-ray targets. And there is now mounting evidence that the Soviets based their original thin-shelled target projections on soft X-ray type targets.

Furthermore, the most recent Lawrence Livermore laser-plasma experiments on the Argus laser confirm that in the case where laser light is being converted to soft X-rays, the original Soviet projection for beam power fluxes is also proven correct. That is, at beam power fluxes between 10^{13} and 10^{14} watts per cubic centimeter, the highest percentage of laser light is converted to X-rays without the generation of hot electrons.

U.S. researchers now agree that when using soft X-rays, questions of absorption and symmetry are no longer important, and thin-shelled targets can be utilized. What remains in dispute is how ignition and burn of the fusion fuel proceeds. There are strong indications that the Soviets may have achieved a breakthrough in the comprehension of how thermonuclear burn shock waves work. Furthermore, it is likely that this new insight was a part of the original Basov superthin-shelled target design.

—*Charles B. Stevens*

Cuts Expected in W. German Fusion Budget

The future of the Zephyr fusion ignition experiment in West Germany is on the line as a result of the plans by the country's Ministry for Research and Technology to cut back the 1981 research budget of the Institute for Plasma Physics (IPP) in Garching. A final decision on the budget cuts, which would reduce the budget from a planned 18 million DM ($9 million) to 10 million DM, is expected to be made by the West German government Dec. 16-17. The cuts will mean that the Zephyr, which went into design phase a year and a half ago, will be totally abandoned.

A Bridge to the 1990s

In the Zephyr experiment, an ignited plasma is to be studied during a 10-second pulse to get more information about plasma heating, the behavior of alpha particles, and other phenomena. The experiment is considered a useful bridge between the coming Joint European Torus/Tokamak Fusion Test Reactor generation of fusion devices and the engineering test facilities expected to come on line in the 1990s. Zephyr was scheduled to start operation in 1986-87.

The probable cutback in the IPP budget is severe but not unexpected. Adjusted for inflation, the IPP's overall budget was far less in 1980 than in 1970. This budget stringency has led to severe restrictions in major areas of fusion research: The IPP's work on laser fusion has been almost entirely given up, a large version of the Wendelstein VII stellarator could not be built, and a successful high-density tokamak was shut down. If the planned cuts continue beyond 1981, the IPP's stellarator work, which made major advances this year, will run up against financial prohibitions.

Reagan's Energy Policy Taking Shape

Production and Consumption Stressed

We reject the notion that the energy dilemma can be solved only by halting the use of energy. Energy resources are valuable only if they are produced and consumed.

—Halbouty task force report to the president-elect

The Reagan energy policy task force, headed by petroleum geologist Michel Halbouty, submitted a report to the president-elect Nov. 5 outlining its proposed guidelines for energy policy. Although the report is not specific in its projections of production or funding and does not deal with the question of fusion, the philosophy of the task force is clearly stated—and is clearly opposed to the no-growth, conservation focus of the Carter administration:

"It is our great fortune to be one of the richest energy nations in the world. Yet, judging by our current economic condition, who would know it? In this land of energy plenty, why have we fallen with the energy poor, rather than prospering with the energy rich? It is not because energy has been ignored. . . . Much has been done. But what has been done is to impede production and curtail consumption. The government has acted on the principle that the way to deal with energy is to do away with it. Instead of unleashing the resources of a wealthy nation, we have, in the name of saving energy for some unspecified future time, tucked energy away like a rare bottle of wine.

"We reject the notion that the energy dilemma can be solved only by halting the use of energy. . . . Energy resources are valuable only if they are produced and consumed."

Unlocking Fossil Fuels

Mixing a free market nongovernment intervention view of energy production with a commitment to move ahead with the technologies for tomorrow, the report's introduction states: "Specifically, we call for decontrol of oil and gas, opening up public lands for exploration and development, placing environmental policy on a scientific cost-benefit basis, encouraging research and development of new energy technologies, building a substantial emergency petroleum reserve, and encouraging the production of energy throughout the world."

The fossil fuel (oil, coal, and gas) proposals outlined by the task force report focus on ending all government obstructions to production and include proposals for the decontrol of resources and rail transport. The report recommends either the repeal of the windfall profits tax on oil or at least a plow-back provision to put the tax into expanded production, something the previous Republican minority in the Senate was not able to win in the last session of Congress.

The report also strongly recommends unlocking Alaska and other federally protected lands, the Outer Continental Shelf and other restricted areas, and unblocking coal reserves that have been restricted for spurious environmental reasons.

Environmental protection must be reformulated on a scientific and economic basis, the report says.

Revitalizing the Nuclear Industry

The new administration's most intense battle in terms of turning back the 10-year sabotage of economic and energy growth will be around the question of nuclear power. All signs indicate that the incoming administration will not follow any of the radical proposals being put forward by the Heritage Foundation and others to divest the federal government of responsibility to assure the nation a secure nuclear future.

Rather, it is likely that the administration will move cautiously but deliberately to revitalize the nuclear industry.

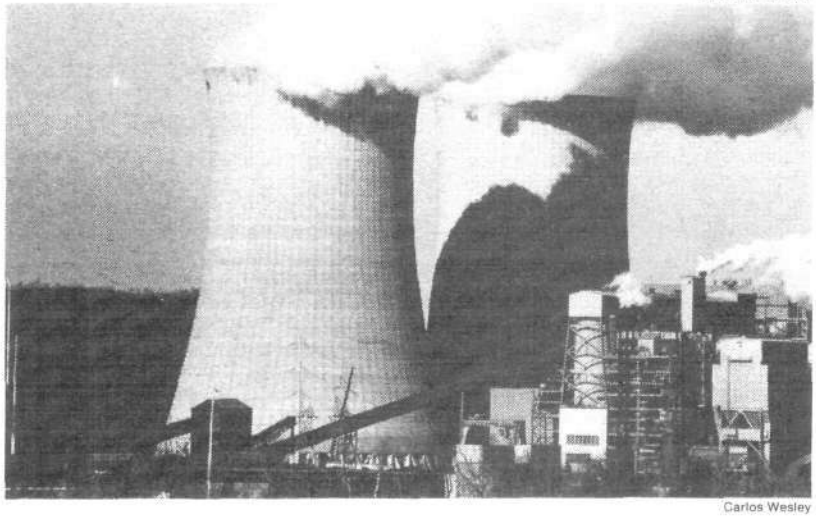
"Revitalization of the essential nuclear power program requires top-level national leadership which itself can substantially strengthen public support and facilitate necessary legislative changes," the task force report states.

Singling out the absurd nature of

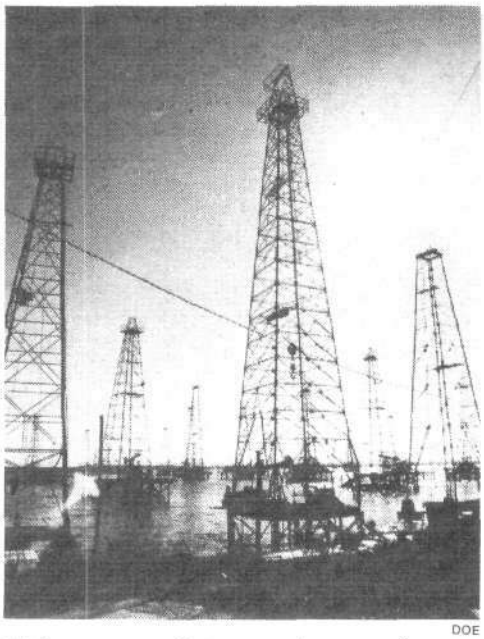
Reagan's Energy Policy Task Force

The members of the task force, headed by Michel Halbouty, are as follows: Petr Beckman, University of Colorado; John Bookout, Shell Oil Company; W.J. Bowen, Transcontinental Pipe Line Company; W. Kenneth Davis, Bechtel Power Corporation; H.J. Haynes, Standard Oil Company of California; Hollis Hedberg, Princeton University; Edward G. Jefferson, E.I. du Pont de Nemours and Company; George O.G. Lof, Colorado State University; John J. McKetta, University of Texas; Edward J. Mitchell, University of Michigan; Thomas G. Moore, Hoover Institution; Bernard J. O'Keefe, EG&G Inc.; Robert H. Quenon, Peabody Coal Company; Joseph R. Rensch, Pacific Lighting Corporation; Fred J. Russell; and Philip K. Verleger, Jr., Yale University.

Boston Edison Co



Carlos Wesley



DOE

"It is our great fortune to be one of the richest energy nations in the world." Above: offshore oil rigs on the Texas-Louisiana coast; top left: Pilgrim State Unit 1 nuclear reactor in Plymouth, Mass.; opposite: a coal-fired generator, Delaware River, Pa.

the licensing procedure, which prevents utilities from building power plants, the report states, "Reducing the licensing time for nuclear power plants by focusing on substantive issues only will enhance safety—not compromise it—and speed the time of United States energy security."

Specific Nuclear Goals

The new administration's goals for nuclear power were even more specifically laid out in a press conference Nov. 25 by Senator Jim McClure (R-Idaho), now the majority leader of the Senate Committee on Energy and Natural Resources. The new administration should seek to "implement nuclear regulatory reform . . . with the objective of reducing the amount of time required to license nuclear plants from 12 years to 6 years, as is the practice in Europe and Japan."

With little fanfare, the Halbouty task force report also asserts that licensing changes must be made for spent fuel reprocessing plants—plants the Carter administration has stopped in midstream. Away-from-reactor spent fuel storage facilities should be posed only as a way to "accommodate the transition period between now and the time when the nuclear fuel cycle is closed," the report says.

In addition to including development of the breeder reactor in the closing of the nuclear fuel cycle, the report scores the Carter nonproliferation policies, calling for a review to reverse the collapse of U.S. nuclear exports and the sabotage of the breeder and reprocessing.

One of the most striking differences between this report and the Carter administration's energy package concerns a proposal in each for "fast-track" legislation. The Carter energy package specifically excludes nuclear in its definition of major energy projects and directs all attention to costly and inefficient synthetic fuels projects. In contrast, the Halbouty report suggests that federal "fast-track" legislation is needed that avoids infringement on state and local prerogatives, "yet provides an effective mechanism for coordinating and expediting decisions on high priority major energy projects, including specifically coal-fired and nuclear power plants."

The 'Free Enterprise' Question

The task force report stresses the need for the government to work with industry to develop the nation's energy wealth. For example, the administration will probably consider a proposed nuclear standardization and

licensing reform concept being developed by the General Electric Company. The fact that Richard Kennedy is leading the Nuclear Regulatory Commission transition team will make that kind of change possible, since he combines a background in economics with years of experience on the NRC. A major concern is to end the adversary relationship that has developed over the past four years between the industry and government.

As for the extreme "free market" proposals by the Heritage Foundation, there is little indication that these will be adopted by the new administration. In the report of its energy project team Oct. 28, the foundation called for the abolition of the Department of Energy within 15 months. No one outside the Heritage Foundation seems to think this is a rational proposal.

The report, authored by a team led by Heritage staffer Milton R. Copulos, recommends that the Strategic Petroleum Reserve be filled with oil purchased by U.S. commercial firms and that federal power marketing authorities such as the Tennessee Valley Authority be sold off to private utilities.

The Heritage report suggests further that the government take no responsibility for planning the nation's energy future and should not "enforce any particular level of energy use or mix of energy sources." The most important priority for the DOE in the next six months is to determine how to eliminate itself, according to the Heritage Foundation.

The Fusion Future

Neither the Halbouty energy task force nor the Republican leadership in the Congress has included any statements about the new administration's policy proposals for fusion, advanced energy conversion technologies like MHD, or other basic science programs. These critical areas have been ceded to the Reagan team's scientific advisory board.

Yet, whether the new government recognizes that its major responsibility for the future is to support science and engineering programs in fusion and advanced technologies today will determine who wins the energy fight—the Milton Friedman cost-benefit analysis extremists or the pro-growth American System faction in the Reagan camp.

Although the report prepared by Reagan's scientific advisory panel has not yet been made public and panel members are reluctant to discuss their recommendations, there are indications that the transition team is keeping its ear open to the voices of the scientific community.

According to the DOE Office of Fusion Energy, a brief meeting with transition team representatives in early December proved positive. The fusion office posed the question: Will the new administration follow through on the mandate of the 1980 fusion legislation and the positive review of the magnetic fusion program by the DOE's Buchsbaum Committee?

The transition team representatives replied that such follow through had been assumed. The real question to ask, they said, would be how to meet the legislative and executive mandate already in place.

The fusion community is hopeful that the reviews last year by both the DOE and Congress of the fusion program will be an adequate basis for the administration to move forward with the funding and top-level executive commitment for an Apollo-style fusion program without delay.

Suzanne Klebe/NSIPS

Outstanding leadership: Hirsch (l) and McCormack.

Hirsch, McCormack Receive Fusion Leadership Awards

Dr. Stephen Dean, the president of Fusion Power Associates, presented awards on behalf of the industry group to former U.S. fusion director Dr. Robert Hirsch and Democratic Congressman Mike McCormack for outstanding leadership in the fusion program.

Hirsch received his citation at the annual meeting of the American Nuclear Society (ANS) in Washington, D.C. Nov. 18, while McCormack received his two days later at a symposium on industry's involvement in the fusion program.

In presenting the award to Hirsch, with whom Dean worked in the government fusion program for close to a decade, Dean reviewed Hirsch's role in the fusion program: "In the late 1960s Bob was convinced that inertial fusion was a possibility. He and John Nuckolls at Lawrence Livermore Lab produced a report which led to the commitment by the government to an inertial confinement program.

"In 1969 at the fusion conference in Novosibirsk [Siberia], Hirsch became convinced that the United States should stop building stellarators and

begin to work on tokamaks. He badgered the U.S. scientists to start work on tokamak experiments. Bob Hirsch is one of the few people who always believed that we could get to fusion by the year 2000."

Dean concluded the presentation by showing a viewgraph from the Energy Research and Development Administration, the DOE's predecessor, that had a year-2000 timetable developed by Hirsch.

"My activities in fusion have been the high point of my professional career," Hirsch said in accepting the award. Hirsch then opened the ANS panel on fusion, which he was chairing, by stating that the real problem now is "the political will and commitment . . . to make the large investment necessary in fusion."

Hirsch described this next step into the engineering feasibility for fusion as the "single most important political step since the beginning of the program."

McCormack: Winning a Long Fight

Congressman Mike McCormack also reviewed some fusion history when he accepted his award. McCormack, a Democrat from Washington and former engineer at the Hanford nuclear research reservation, was the author and prime organizer of the Magnetic Fusion Energy Engineering Act of 1980, signed into law Oct. 7, 1980. The act commits the nation to demonstrate commercial fusion by the year 2000.

Noting that he was sharing the honor with Bob Hirsch, McCormack related their several-year fight for the fusion program: "Bob Hirsch and I started conspiring to move the fusion program forward in 1973, when I was on the Joint Committee on Atomic Energy. We did an end-run around the resistance and obtained $20 million more for fusion in fiscal year 1974. We poured on the heat for money and a more aggressive program. When the Joint Committee was disbanded, the fusion program came under the jurisdiction of my subcommittee on the Committee on Science and Technology.

"Bob and I set up the fusion advisory panel to the subcommittee when the committee took over the program."

McCormack then briefly reviewed the results from the Hirsch panel and the fact that the "aggressive, Apollo-like program with specific dates" and milestones in the McCormack Act came out of his collaborative effort with Hirsch.

The award really paid tribute to many people involved with the program who have also helped to "blaze a trail for other countries," McCormack said, hoping to develop the unlimited energy potential of fusion. The development of the fusion-fission hybrid and the hydrogen economy as the fusion program accelerates are essential, McCormack said, and no matter how much we already know it, we must "keep telling ourselves that fusion is the ultimate energy source for the world."

Also receiving the Fusion Power Associates leadership awards were Dr. Solomon Buchsbaum, who headed the DOE's fusion review over the past year, and Senator Paul Tsongas (D-Mass.), the Senate sponsor of the McCormack fusion bill.

The AIF Annual Conference: **A No-Win Nuclear Strategy**

At the Atomic Industrial Forum's annual conference in Washington, D.C. Nov. 17-19, the industry trade association once again left its members with a no-win strategy.

Most of those present at the conference were excited by the mandate for change that elected Reagan Nov. 4, and most anticipated a turnaround in the stalemate in the nuclear fight.

Some of the speakers reflected this sentiment. Michel Pecquer, for example, the head of the Atomic Energy Commission of France, insisted that even the energy-rich United States would have to develop nuclear power. And John Moore, head of the U.S. Export-Import Bank, warned the AIF audience that the nuclear industry would have to be on guard against the "balance the budget" tendency in the new administration, which could curtail Ex-Im support for nuclear exports.

But the main presentation at the AIF conference, the keynote address on policy, was left to Senator Paul Tsongas, a Massachusetts Democrat and a former antinuclear advocate. While it may be fine to have a "convert" address a conference, it is quite another thing to have such a person lead off an annual three-day meeting presumably planned to give the nuclear industry some direction for political action in the year ahead.

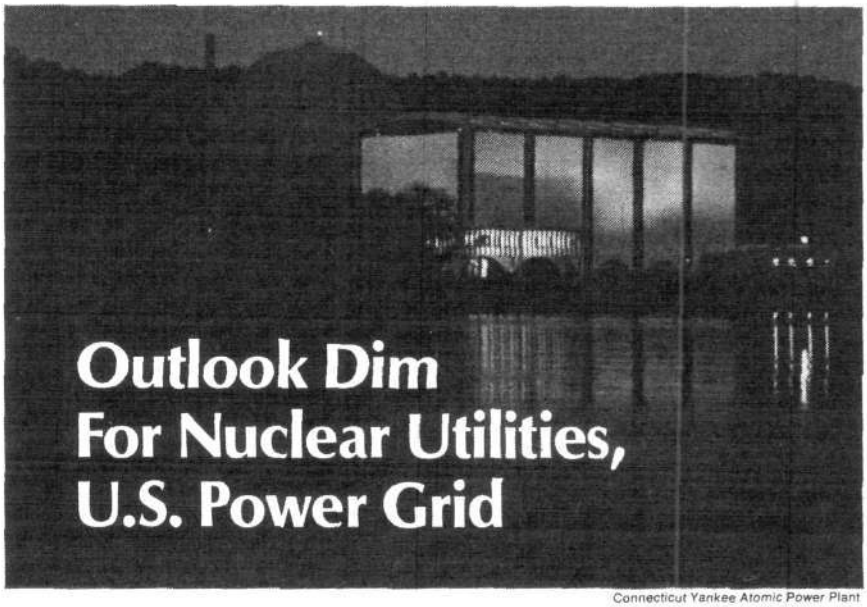
Tsongas: Learn to "talk to the environmentalists"?

The content of the Tsongas speech makes this point all too clear.

The senator scolded the industry for being "too aggressive" in pushing nuclear power. The industry should learn to "talk to the environmentalists," he said, and the utilities should promote conservation rather than the continually growing consumption of electric power.

Tsongas also claimed that the liquid metal nuclear fast breeder promotes weapons proliferation and that the industry has not faced up to the real danger of nuclear power.

A breeder option should, however, be kept open, Tsongas said. Why? Because, the Senate sponsor of the McCormack fusion bill stated, fusion may not work! We now plan to have so little civilian nuclear power in the next two decades that we have plenty of time to decide a decade from now whether we need a breeder, or what kind it should be, he said.



Outlook Dim For Nuclear Utilities, U.S. Power Grid

Connecticut Yankee Atomic Power Plant

U.S. nuclear utilities: pushed into the sunset?

Despite President-elect Reagan's positive attitude toward nuclear energy, the financial decisions being made today by the nation's institutional investors and investment bankers are jeopardizing the expansion plans of nuclear-based utility companies and, with them, the future reliability of the U.S. electric power grid.

The new administration will have to take some swift and decisive steps to reverse the perception of risk now associated with investment in nuclear companies and heavily nuclear-dependent utilities, or the companies will not be able to raise the capital they need at affordable costs to meet even pared-down construction schedules. Furthermore, the new administration will have to reckon with the present DOE projection that the nation won't need an expanded power grid because it will be in an economic depression.

In his speech before the Atomic Industrial Forum's International Conference in Washington, D.C. Nov. 16-19, William S. Lee, president of Duke Power Co. in North Carolina, riveted attention on the deteriorating financial condition of the electric utility industry and the economic implications for the nation. Utility company shares are currently selling at a 25 percent discount from their book value on average, he said. This, together with the perceived risk now involved in investment in utilities, is precluding many companies from raising new capital on the equity markets.

Some analysts are even comparing the financial plight of the utilities to that of the nation's steel industry, which has long been shut out of the equity market and is now considered the model "sunset" industry.

According to the Duke Power president, interest rates would have to drop to 6 percent and inflation to 3 percent for the electric utilities to raise the funds they need to carry out needed expansion programs. Short of this, they will need rate increases or, as a last resort, government subsidies, if they are to fulfill their mandate to keep the nation supplied with an adequate and reliable supply of electric power.

The Rating Game

As the utilities have been beset by mounting financing problems, the investment community has rubbed salt in the utilities' wounds. During 1980, Moody's and Standard and Poor's, the leading investor rating services, downgraded the credit ratings of the debt issues of 16 and 27 electric utilities, respectively. For an industry that is two-thirds dependent on borrowed funds for its construction and maintenance programs, the loss of a preferred credit rating immediately translates into higher long-term borrowing costs and in some cases withdrawal of debt issues and cancellation of plants. Of the 129 nuclear units that were scheduled to come on line by 1990, 22 units have been delayed and 33 units have been postponed indefinitely or canceled, in large part because of financial problems.

For example, Virginia Power and Electric Company (VEPCO) announced Nov. 25 that it had decided to go ahead with construction of a fifth nuclear-generating unit but to scrap plans for a sixth, after weighing anticipated future demand and the superior economics of nuclear-generating capacity against the political and financial uncertainties associated with nuclear energy here.

Yet, given the superior, long-term economics of nuclear energy—VEPCO just instituted rare decreases for all of its Virginia customers in anticipation of the December opening of its North Ana II nuclear unit—the perception that investment in nuclear utilities is risky is clearly shortsighted.

"The long-term prospects may be favorable, but because of short-term factors, we can't continue a preferred rating," commented Peter Jadrosich, an officer of Moody's. "Maybe people are willing to pay for the peace of mind of having coal instead of nuclear," he added, leaving little doubt as to the bias of at least one officer of the influential rating service.

And the influence of the rating services goes beyond their effect on the borrowing costs a utility must pay. In applying to the Nuclear Regulatory Commission for a construction license to build a nuclear unit, a utility must, among other things, demonstrate "financial ability." According to Moody's Jadrosich, staff members of the NRC regularly get in touch with him when they evaluate the financial condition of license applicants.

Double-digit borrowing costs are a major factor fueling the self-feeding

financial crisis of the nation's electric utility industry. The industry could have borne the costly regulatory delays involved in constructing nuclear facilities; and those utilities making large nuclear investments were well-positioned to absorb rising fossil fuel costs. However, the spiraling of inflation and interest rates over the last few years was more than the industry could handle.

A number of utilities are now in danger of having their revenues fall below the two-times-debt-service coverage normally required before a utility can issue new senior securities, according to the National Electric Reliability Council. Exemplary of the problem, when Commonwealth Edison, the heavily nuclear-based Chicago utility, was denied its request for a rate increase in October 1979, it was forced to stop construction on its Braidwood nuclear facility because of a revenue deficiency. Construction resumed on the $2.6 billion unit in Feb. 1980, when the utility was granted a 14 percent rate increase.

The cost of delays such as this one runs in the hundreds of millions of dollars. The Illinois Commerce Commission completed a study last fall showing what it would cost to delay the construction of Commonwealth Edison's Braidwood unit and a second nuclear facility at Byron, Illinois. Taking into account the additional construction costs, carrying charges, and fuel costs to provide power by alternate means, the cost of a four-year delay would be $904 million figuring a 4 percent load growth; $618 million with a 2 percent load growth; and $402 million with no load growth.

Other utilities have not been as fortunate as Commonwealth Edison, which was able to go ahead with the construction of Braidwood. Boston Edison is still awaiting a construction permit from the NRC to break ground on Pilgrim II; and other smaller utilities around the country, such as United Illuminating Co. of New Haven, are being shut out of the capital market by lowered credit ratings.

The postponement and cancellation of plants today have serious consequences for future electric power supplies. The capacity coming on line at the present time was actually planned in the early 1970s, when projected growth in electrical demand was still in the 6 to 7 percent annual range. As of its Aug. 1980 10th Annual Review, the National Electric Reliability Council was projecting a 4.1 percent annual average electricity consumption growth rate for the 1980s—compared with an annual average of 5.2 percent for the 1980s projected in 1978—and the council still foresaw a serious erosion of reserve margins and power shortfalls.

According to the study, about 50 gigawatts of generating capacity, nuclear and coal-fired, previously scheduled to come on line by 1990 will not, because of regulatory delays. The council projects that in 1990 only three out of nine regional electrical grids will have reserve margins that are considered adequate—20 percent or higher. The Southwest Power Pool, which includes Kansas, Oklahoma, Arkansas, and parts of Texas and Mississippi, will have a *negative* reserve margin, because it is the fastest growing economic region. Three other regions will have reserve margins of under 10 percent.

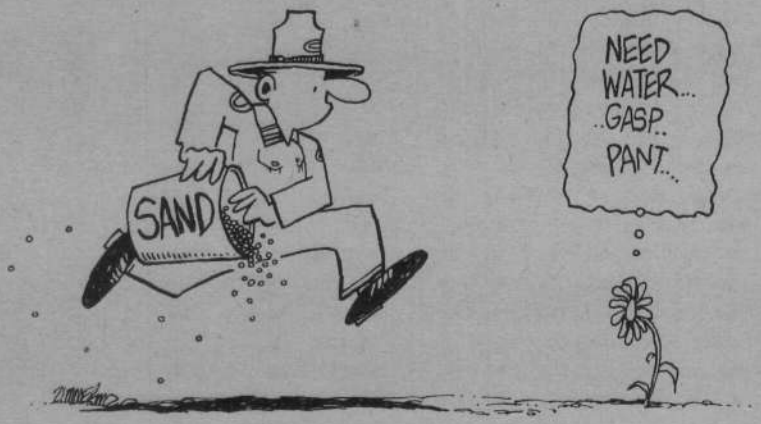
A No-Growth Outlook

An Aug. 1980 study by the Congressional Research Service, "Will the Lights Go On in 1990?" considered a scenario in which electricity demand grows by only 3.3 *percent* per annum during the 1980s, in which case reserve margins will stay above 15 percent in each region of the country.

A concurrent report by the Department of Energy projected that reserve margins would be adequate only if load growth is held to between 2.1 and 2.9 percent per annum over 1980-1983. The DOE based this depression growth rate on "anticipated economic conditions, conservation activity and projected increases in the cost of electricity."

In other words, the only scenarios under which the United States is expected to have adequate electrical-generating capacity over the next decade are those predicated on prolonged economic depression.

—Lydia Schulman



California Desert Plan: Turn Back the Clock

The California Desert Conservation Area plan, scheduled to go into effect in Dec. 1980, has been hailed by leading California environmentalist L.W. Lane as the "most significant conservation move since the passage of the National Parks Act in 1916."

In fact, the desert plan may be even more significant; it may stop agricultural development.

The long-incubating plan, first issued by the U.S. Interior Department's Bureau of Land Management (BLM), was mandated by Congress under the Federal Land Policy and Management Act of 1976. Putting a 40,000-square-mile area of California—one-third of the state—under permanent federal regulation, the

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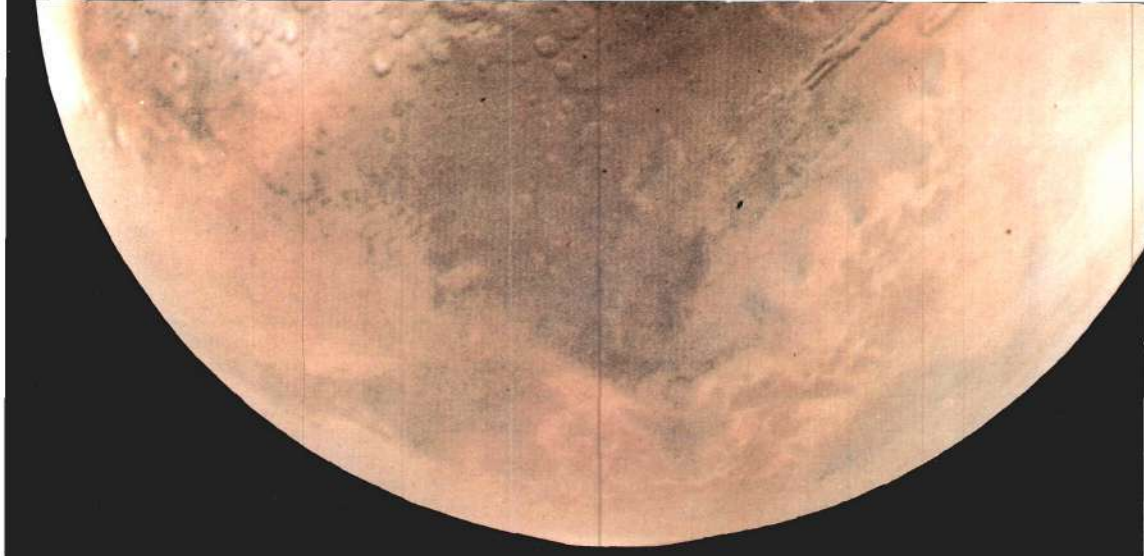


Colonizing Space With Fusion Propulsion

by Dr. Friedwardt Winterberg

Chemical rockets can take man to the Moon but not beyond. But with fusion-propulsion rockets, man will be able to colonize distant planets and, one day, the entire galaxy.

The four great technological breakthroughs of the 20th century are manned flight, the discovery and harnessing of nuclear fission, the development of the space rocket, which led to the 1969 Apollo Project Moon landing, and controlled thermonuclear fusion. The first three breakthroughs have already been accomplished; the harnessing of fusion power will be accomplished during the remainder of the century, probably not later than 1985.

I do not consider myself a practitioner of the pseudoscience of futurology, which attempts to predict the future by making extrapolations from present trends. Such an endeavor is difficult, to say the least, because the future is determined largely by inventions and discoveries that have not yet been made.

But as relativity theory tells us, the past, present, and future are closely connected to each other. And if we know something about the present, we should be able to know something about the future.

Our present state of scientific knowledge and technological advancement tells us something about the discoveries and revolutionary technological

advances man can expect to achieve during the rest of this century and beyond it.

The importance of achieving controlled thermonuclear fusion ranks with the invention of fire. But fusion is a new kind of fire; it is the ignition of a small star on Earth. In contrast to ordinary chemical fire, fusion requires temperatures of 100 million degrees, like those that exist in the center of stars, like our Sun.

The Discovery of Thermonuclear Energy

One of the great problems that engaged scientists during the last century was to explain how the Sun could have shined the billions of years necessary to have made evolution possible. At the turn of the century, Lord Rayleigh told Darwin, I have given you only a few million years for your evolution to take place, because that is as long as the Sun could have given off heat by slowly shrinking in size. No other process to do that was known at the time. But Darwin knew that he would need billions of years to explain evolution. There was a great deal of anxiety in scientific circles about the problem, and when radium was discovered, giving the first clue about nuclear energy, some scientists speculated that the Sun might be made out of radium. But, of course, it is not.

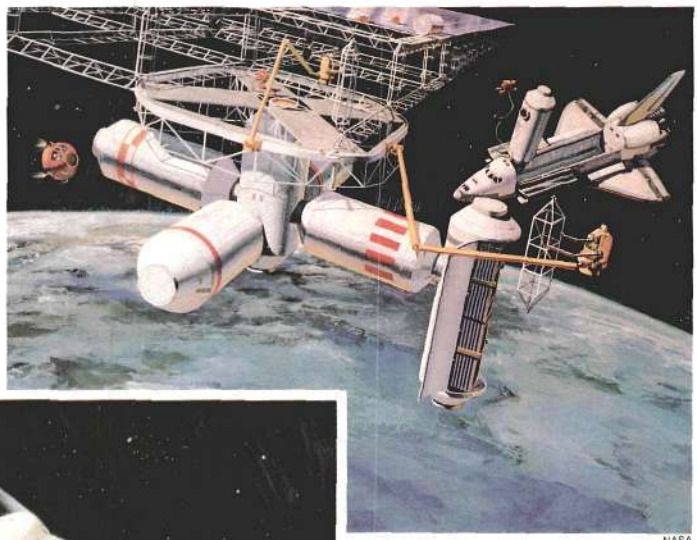
Then, when the Special Theory of Relativity was discovered by Einstein and Poincaré, in which $E = mc^2$, and we learned that there was an enormous amount of energy in matter, the question then became, how is it released? That problem was subsequently resolved in 1928, when it was shown that at extremely high temperatures, certain light nuclei reacting through thermonuclear reactions would produce large amounts of energy. Even so, two years later at a famous conference of physicists, England's Lord Rutherford maintained that the idea of releasing thermonuclear energy on Earth was totally in the realm of fantasy and would never be realized. A few years later, thermonuclear fission was discovered.

One can see from this account how fast knowledge progresses. Futurologists should be careful in making their predictions.

The discovery of fission provided man with two great benefits: an unexpected source of energy and a "match" big enough to light a much larger thermonuclear reaction—fusion. A great deal has been said about the use of fusion energy for the generation of electrical power. Power generation, however, is only one application of fusion; another major application is its unique significance for spaceflight.

Rocket Propulsion

The great challenge that future spaceflight poses is the development of rocket-propulsion systems that can carry large payloads at extremely high speeds, thereby making possible manned spaceflight to distant planets. The Apollo program demonstrated that we are able to land man on



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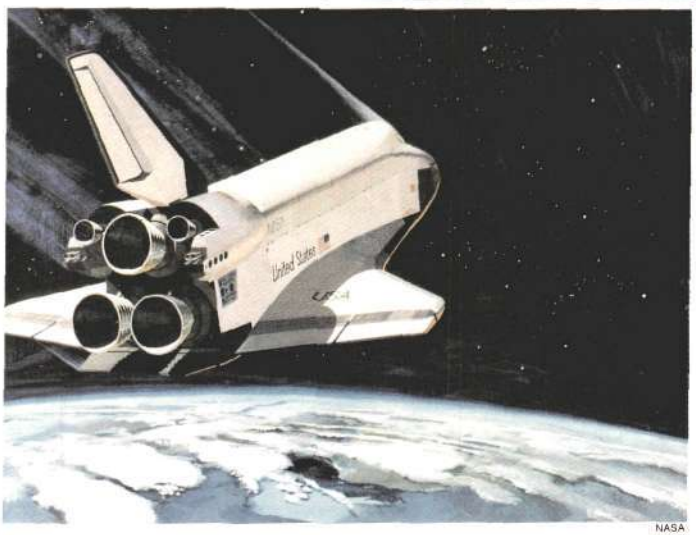


NASA

Above: Artist's depiction of activity at a modularized space station in Earth orbit. The components of the station would be transported to Earth orbit by the space shuttle. Left: Artist's rendition of the Orbiter space shuttle leaving Earth's atmosphere for orbital flight.

another planet in the solar system, but not with a very large payload. The Moon is relatively near to the Earth. If we were to attempt to go to Mars with chemical propulsion, it would take years, and the astronauts would have to travel in a spacecraft not much bigger than the interior of a bus. Making sure that nothing would go wrong in such a small vehicle traveling for years would be very difficult. Such an environment is clearly not practical for long-term space travel.

Chemical propulsion is adequate only for unmanned space probes. However, unmanned probes for scientific reasons alone are neither desirable, nor can they lead to the goals that we must accomplish. What will we find on Mars or elsewhere in the solar system? Only man, with his versatility of mind, is able to respond to totally unexpected experiences. Preprogrammed robots cannot do that.

It is only with fusion propulsion—fission is also inadequate—that manned spaceflight to distant planets will become practical. And man not only will be able to explore the solar system; he will be able to colonize and industrialize it. This is one reason why everyone working with fusion is so excited.

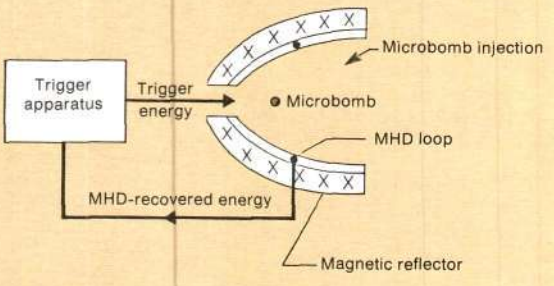


Figure 1
NUCLEAR MICROPROPULSION UNIT

This schematic depicts Winterberg's 1970 design for a fusion-propulsion unit by which large payloads could be moved at great speed (10^3 kilometers per second) within the solar system. The thermonuclear microexplosions would take place in the focus of a concave magnetic reflector. The magnetic field required for the reflector could be generated by superconducting magnetic field coils. A magnetohydrodynamic loop could there pick up a fraction of the explosively released energy to charge up the capacitors for the energy pulse that triggers the following microexplosion.

The crucial problem in rocket propulsion is to achieve a very large exhaust velocity. The key performance parameter is specific impulse or the impulse per unit weight of the rocket propellant, measured in seconds:

$$ma(\Delta t/mg) = \Delta v/g.$$

The hotter the gas, the greater the motion of the gas molecules and hence the exhaust velocity of the gas. Therefore, the extremely high-temperature and high-velocity products of a fusion reaction—10^6 meters per second—give fusion propulsion systems a very large potential specific impulse of 100,000 seconds. Chemical rockets have maximum specific impulses of less than 450 seconds, and fission systems less than 1,000 seconds.

When a chemical fuel is burned, the gas molecules and hence the exhaust reach a velocity on the order of a few kilometers per second, at best 3 kilometers or about 2 miles per second. Such a fuel, composed of hydrogen mixed with oxygen, is the most powerful rocket fuel we know and was used in the upper stage of the Saturn rocket.

As we know from rocket theory, rocket velocity can be increased to as much as three times more than exhaust velocity using a three-stage rocket system. In fact, to escape the Earth's gravitational pull, it is necessary to attain a rocket velocity of about 12 kilometers per second, which can be accomplished only with a multistage rocket. Each stage can attain a velocity of about 3 kilometers per second; and when three stages are put on top of each other, the spaceship can escape the Earth's gravitational field and head for the Moon. However, the maximum velocity that can be attained with chemical propulsion is 10 to 20 kilometers per second.

Chemical propulsion, adequate for escaping the Earth's gravity, thus does not permit us to travel to Mars in a time less than years. The trick of getting to Mars in a short time, possibly only weeks, is to use a higher exhaust velocity. This requires a propulsion fuel that has a much larger energy density and thus higher combustion temperature.

The answer is thermonuclear propulsion. In a thermonuclear reaction, the temperatures are not a few thousand degrees, as in chemical combustion; they are typically a hundred million degrees. Using fusion propulsion, we can get an exhaust velocity on the order of not just a few kilometers per second, but a few thousand kilometers per second.

The idea is to launch a fusion space rocket that would be assembled in orbit, where there is no gravity and it is therefore possible to build much larger structures. All of the different parts and materials for the space rocket would be carried up into orbit by chemically propelled space shuttles (to go from a planetary surface to an orbit, chemical propulsion is always the most convenient means). The rocket constructed in this fashion could carry a payload of thousands or even millions of tons, which it would take from an Earth orbit into an orbit around Mars. Then man would descend onto the surface of Mars, using chemical rockets.

Thermonuclear Microexplosions

The kind of fusion reaction that would propel this rocket would consist of many microexplosions, small releases of nuclear energy many orders of magnitude smaller

than from a hydrogen bomb. This is the fusion process known as inertial confinement. Magnetic fusion, for reasons I will not go into here, is not very suitable for rocket propulsion; but inertial-confinement fusion, fortunately, is ideally suited for it. In inertial-confinement fusion, lasers or other types of beams ignite thermonuclear explosions that are small enough to be confined in a container for power production or to be used for rocket propulsion.

Rocket engineers have always dreamed of a rocket propulsion system that had both a very high specific impulse—a very high exhaust velocity—and a very high thrust. For example, in a chemical propulsion system like the Saturn rocket you have a very high thrust, several thousand tons, but the exhaust velocity is only 1 or 2 kilometers per second.

Another system that has been under investigation is ion propulsion, in which the spacecraft is propelled by a beam of accelerated ions. Such a system would have a high specific impulse, but its thrust would be very small. Thus, using ion propulsion would again take years to travel to Mars, because it would take such a long time to accelerate the spacecraft to a large velocity.

The specific impulse, measured in seconds, is the impulse per unit weight—the higher the specific impulse, the more efficient is the power source. The thrust is the force produced by the exhaust. Only with a microexplosion fusion propulsion system do you have *both* high specific impulse *and* very high thrust. In its capabilities relative to ordinary chemical propulsion, fusion propulsion is like going from a rowboat to a steamboat.

In a fusion-propulsion system, the beams of photons or particles would ignite fuel pellets, each the size of an aspirin tablet, which on explosion would typically produce the energy equivalent of 10 tons of TNT. The microexplosions would take place in the focus of a concave magnetic mirror, whose magnetic field would be generated by superconducting magnetic field coils. As the sequence of microexplosions takes place, perhaps one per second, the fireball of each microexplosion would be reflected by the magnetic mirror, resulting in the thrust that would propel the spacecraft. (See Figures 1 and 2.)

We see that the development of fusion rocket systems requires the combination of two technologies: fusion, which takes place at extremely high temperatures; and superconductivity, an extremely low-temperature technology. The fireballs of the microexplosions are so hot that they cannot be allowed to come in contact with the spacecraft. This problem is solved very elegantly by shielding the spacecraft with a magnetic field generated by superconducting magnets, which are cooled using liquid helium. It should be added that in the case of travel within our solar system, the exhaust velocity of a fusion rocket may get too high, and we may want to reduce it by adding propellant hydrogen to the exhaust.

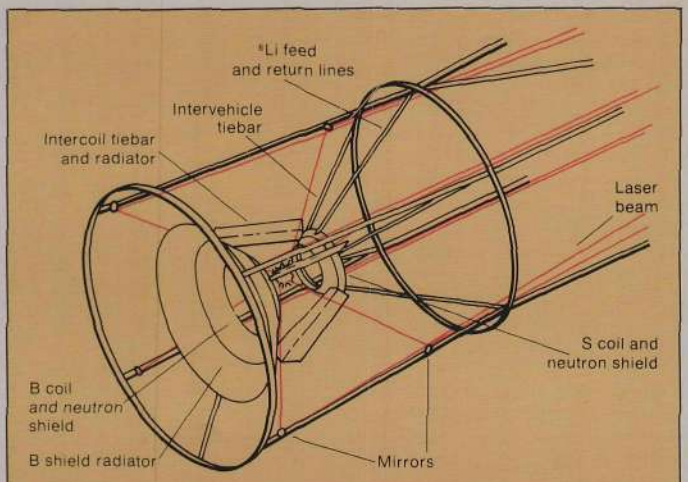


Figure 2
EXTRATERRESTRIAL LASER-POWERED SPACECRAFT
Laser-induced microexplosions in the reactor chamber (open to space vacuum) produce charged plasma debris that is directed by the magnetic mirror system through the larger mirror-loss cones out the rear of the spacecraft.

The idea of propelling a rocket by a sequence of explosions is a very old one. The idea was proposed by an engineer by the name of Ganswindt around the turn of the century in Berlin. However, he was not a physicist and could not correctly analyze his conception. Around the same time, an Austrian physicist working at the University of Lemberg in Czechoslovakia (now in the Soviet Union) analyzed the concept and showed that the chemical explosives known at the time would not be strong enough to propel a space rocket. However, Ganswindt prophetically predicted that one day man would find a propulsion explosive that would be large enough. In fact, less than 40 years later, such a powerful explosive was discovered by Hahn and Strassmann, in the form of nuclear fission.

After fission was discovered, scientists at Los Alamos National Scientific Laboratory pointed out that one could propel a rocket by a sequence of exploding atomic bombs. This approach to rocket propulsion was extensively studied in Project Orion, but it was eventually abandoned because it was considered very adventurous to use a sequence of atomic bomb explosions to propel a spacecraft. Looking back, the project does not seem overly adventurous, and many people think it was a mistake to abandon it.

Nevertheless, for the last 15 years, there has been a much more exciting possibility—that of reviving the project using inertial-confinement fusion—mini H-bombs—which is a much more effective method.

Recall that the hydrogen or fusion bomb is always ignited using an atomic or fission bomb as a trigger, which

then sets off the much larger thermonuclear explosion. Until the mid-1960s, this was the only known method of igniting a thermonuclear explosion. Then scientists theorized that it would be possible to ignite a hydrogen bomb in other ways and also to ignite miniature hydrogen bombs. These bombs could be so small that they not only could be confined in a reactor, in inertial-confinement fusion, but also could be used for rocket propulsion. This approach is similar to that studied in Project Orion, but instead of exploding a 5 or 10 kiloton atomic bomb every few seconds or so, we would ignite a series of relatively modest explosions, which would produce the large exhaust velocity needed to attain very high vehicle velocities with very large payloads.

Dr. Edward Teller, one of the pioneers in the field of fusion research, believes that this application of fusion will precede the use of fusion in commercial power plants. I am not sure I agree with this prediction. Nevertheless, Teller's viewpoint underlines the nearness of rocket propulsion using thermonuclear microexplosions.

Where do we stand experimentally? The highly publicized laser beams are only one method of igniting thermonuclear microexplosions. An even more promising method uses beams of particles. Particle beam weapons are now under development in the United States and in the Soviet Union. Clearly, if we can produce a particle beam that can be used as a weapon, we can produce a particle beam that will set off a miniature hydrogen explosion. In fact, inertial-confinement fusion must be achieved before the weapons project can even be considered, because the latter requires much more powerful beams. With the beams under development at the Sandia National Laboratory in the United States and at the Angara facility in the Soviet Union, inertial-confinement fusion will soon become a reality.

These facilities will produce high-energy beams of ions or electrons. If these particle beams are shot at a thermonuclear pellet from many sides at once, the pellet will explode. Although this has not yet been accomplished, it should occur in the near future—unless our physics calculations are greatly in error. As soon as we succeed in producing this miniature explosion, a fusion rocket propulsion system will quickly follow.

Mining on Other Planets

Once we have developed fusion-propulsion systems, we will be ready to take many space shuttles up into Earth orbit, carrying the materials needed to construct a fusion-propelled superrocket. Such a spaceship will be able to carry a large crew as well as heavy equipment such as earth-moving machines. This spaceship could travel to Mars. It could also be used as a tugboat to travel to and colonize the Moon. To date, we have only landed on the Moon and inspected a few acres. But with our fusion-propelled superrocket, we would be able to go into lunar orbit, descend to the surface of the Moon with chemical rockets, unload necessary materials, and build a lunar colony. (See Figure 3.)

What would be the point of establishing a lunar colony? Although the Moon has no water, it has a core where very valuable metals are concentrated, metals that may eventually run out on Earth. Retrieving these metals is essential for the future of civilization.

To build and expand a technological civilization, there

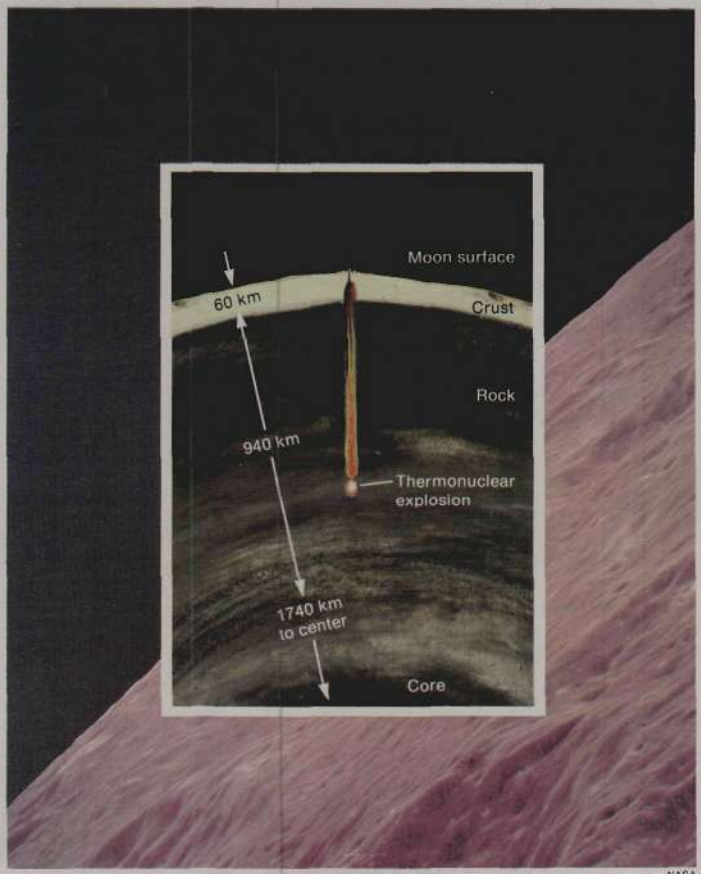
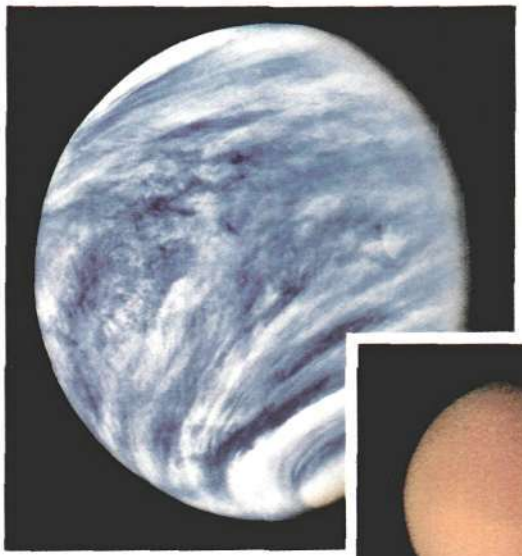
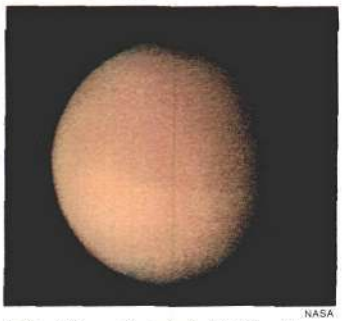


Figure 3
WINTERBERG'S PROPOSAL FOR MOON MINING
Winterberg suggests that a series of nuclear explosions could be used to tunnel to the center of the Moon and extract its valuable metals. In the background is a lunar landscape taken on the last lunar manned flight, Apollo 17 in 1972.





NASA

Left: View of uninhabitable Venus taken from 450,000 miles by Mariner 10 in 1974. The blue appearance is the result of darkroom processing to enhance the ultraviolet markings on the planet's clouds. Above: Clouds covering Saturn's satellite Titan, seen in true color in this Voyager I photo. Titan may be inhabitable.

are basically two things required: metals such as steel and the minerals that go into making them, and other raw materials that can serve as energy sources. The minerals that are available to us on Earth are the small proportion that are in the Earth's crust. But the heavy metals we need have been pulled down to the center of the planet by their specific gravity. Gold, for example, has probably floated up volcanically. In Nevada, many of the gold mine are ancient volcanos, which came up from the interior of the Earth. Concentrations of other more important metals like tungsten are likely to be found in the center of the Earth and other planets.

On Earth, the deposits of these minerals near to the surface may eventually be exhausted. So the question is, where else could we get them? It is impossible to tunnel to the center of the Earth because of the extremely high pressure there—roughly 3.5 million atmospheres.

The situation is different on the Moon. The pressure at the center of the Moon is only about 100,000 atmospheres. Seismic measurements indicate that the Moon also has a core; and it, too, must have been molten at one point, because there are signs on the surface of a great deal of ancient volcanic activity. Thus, there are undoubtedly many heavy elements in the Moon's core, which could be retrieved. And we can drill a tunnel through the Moon, because, technologically, we can sustain the pressure of 100,000 atmospheres.

Drilling a tunnel through the Moon is not a trivial undertaking, nevertheless. We could not simply drill a mine and go down into it. On Earth, if we go down very deep in a mine and hit the wall with a hammer, the rocks that break off are shot into the mine shaft with the force and speed of a gun bullet. This happens because the deeper down we go in a mine, the larger the pressure gradient from the mine shaft into the rocks.

Is there a method by which we can tunnel to the center of the Moon and sustain pressures of 100,000 atmospheres? Yes: We can use nuclear explosions. First, we drill a mine shaft as deep as we can. At the bottom of the shaft, we place a large nuclear explosive and ignite it. The explosion crushes the rocks. The pressure gradient has been released, and we can continue drilling the mine shaft into the crushed rock until we again reach solid rock, where we set off another nuclear explosion. Proceeding in this manner, we will be able to reach the center of the Moon and extract the metals we need. And, as with chemical explosions, we can use nuclear shape charges to direct the explosion and very clean nuclear fuels to avoid contamination. We just have to hope that the environmentalists don't get there first and file a court case prohibiting our drilling.

We can do the same kind of mining on Mercury as on the Moon. The planet Mercury is very interesting, because of all the planets in our solar system, it has the highest specific gravity. That is an indication that Mercury must have valuable high-density metals in its interior. We could undoubtedly conduct similar excavations on Mercury, using 1,000 or possibly 1 million megaton explosions and creating craters through which we could drill deeper and deeper into the planet to obtain its metals.

The Martian Colony

Mars is a much more likely candidate for a large scientific and industrial colony than the Moon because it has water, which contains hydrogen, including the fusion fuel deuterium. But on Mars, water doesn't exist in the form of lakes or rivers, so we must come up with some other means of tapping it.

Nuclear energy is the solution to this problem, too. We can sink a shaft, place some fusion explosives in it, and ignite a very clean explosion with a particle beam, leaving no fission products. In this way, we can release the underground steam in a geyser to the surface, providing a water source for the colony.

Venus, unfortunately, is of little use, because its atmosphere and surface are too hot. We can visit Mercury, on the other hand, because it has no atmosphere. Mars is very cool, but we can always produce enough heat to sustain life—just a few hundred degrees is necessary. To heat a dwelling on Mars from minus 100 degrees Celsius to plus 100 degrees is very easy.

The same reasoning applies to the outer planets. Of course, we cannot land on Jupiter or Saturn, because the gravity is too great. But these planets have moons, and the moons are comparable in size to Mercury—much

larger than the Earth's Moon. Two very interesting candidates for colonization are Titan and Dione, moons of Saturn that were recently photographed by Voyager 1.

The prospect opened up by fusion propulsion is nothing less than the industrialization and colonization of the solar system. Man of the Stone Age knew only the environment around his cave. Man of the Middle Ages could look out on his fields or his lord's castle, but his view was bounded by the horizon. But when the deep-sea vessel was invented at the end of the Middle Ages, along with clear glass that was the foundation for astronomy, man's horizon steadily broadened. And when I was a child, the idea of going to America was still considered a very big event. One had to take a boat on a long trip. Today we jet from one continent to the other in a matter of hours. We are now planetary man. The man of the next century, however, will be man of the solar system. There are even certain recreational aspects of this. Mars has a canyon bigger than the Grand Canyon, so big it would extend from Arizona to New York, and a volcano much higher than anything on Earth. So as far as its scenery is concerned, Mars is a lot more interesting than Earth.

NASA

Olympus Mons, a spectacular Martian volcano, is one of the potential tourist attractions of a colonized Mars.

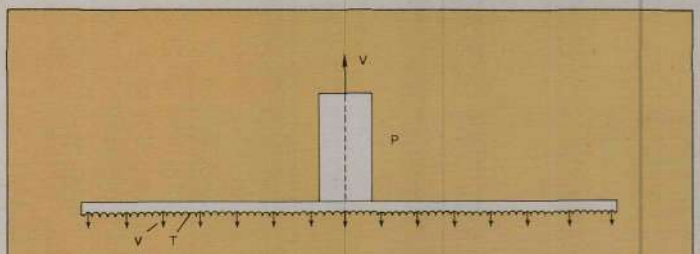


Figure 4
INTERSTELLAR SPACESHIP

Fusion-propulsion systems will one day make even interstellar spaceflight at velocities approximately one-tenth the velocity of light a reality, and eventually lead to the colonization of the entire galaxy. This schematic depicts an interstellar spaceship weighing millions of tons and propelled with about 10,000 microexplosion propulsion units. The dimensions of this spacecraft could be such that it could carry a large crew of thousands of people and a payload of millions of tons to a neighboring solar system in a travel time of several decades. T denotes propulsion units, P payload, and v velocity.

Colonizing the Entire Galaxy

We may leave the solar system, too.

A study was done some years ago by the British Interplanetary Society on using a fusion propulsion system for interstellar spaceflight. Unfortunately, this kind of propulsion system is not as powerful as we would like, and it would take about 50 years to reach a nearby star using it.

But it is conceivable that in a few hundred years from now—or less—we could make interstellar spaceflights by building a spaceship as big as New York City with all the comforts of civilization and propelling it to another solar system (Figure 4). Once there, we would set up a colony on a planet that has Earthlike conditions. We would send unmanned probes or explorer craft ahead of us to tell us that such a planet was there.

Then, I propose the following scenario: The distance between solar systems is about 10 light years, and a fusion craft would take perhaps 50 years to arrive at the next one. Suppose man migrates into the galaxy and travels from the first solar system in all directions to neighboring suns, taking 50 to 100 years to arrive at each. Man remains in each new solar system about 1,000 years, building up a new technological civilization. Then he would move on to the next solar system.

If we propagate about 10 light years each 1,000 years, then we would spread with a migration velocity of one-hundredth of the velocity of light. Since the galaxy has a diameter of 100,000 light years, that means that in 10 million years, man will have colonized the entire galaxy.

Now, the galaxy is approximately 10 billion years old. Our solar system is about 4 to 5 billion years old, and the oldest, "population one" stars like our Sun containing heavy elements are about twice as old. Ten million years is a very short time compared with the age of the galaxy. There has thus been plenty of time for an ad-

vanced technological civilization to spread throughout the galaxy.

Why then has nobody arrived here? All that was needed in this conservative scenario is 10 million years. My answer to this paradox is that we are unique, at least in our galaxy.

Remember that nature always works with enormous amounts of things; nature works with abundance, producing more seeds than are needed. Suppose in every 10 galaxies, there is one technological civilization. Since there are something like 100 billion galaxies, there would be 10 billion coexisting technological civilizations. That there would be more than one technological civilization coexisting in one galaxy would be an exception.

Not only on Earth, but in our solar system, we are definitely unique. The Moon is too small to hold an atmosphere, although it is approximately the right distance from the Sun—virtually the same as Earth. Venus is large enough, approximately the same size as the Earth, but it is too close to the Sun. Radar pictures indicate that it was once like the Earth; it had continents, but then it lost its oceans. Mars is too far away from the Sun for life to evolve—it's too cold.

Thus, there was a very narrow band where life could have evolved. When the Earth evolved, it had a huge land mass in a large ocean. Suppose there was a planet in which there was a small ocean and a huge land mass. There would be much less water, and most of the land would be desert. Then evolution would take not 2 billion years as on Earth, but perhaps 20 billion years. But since the galaxy is only 10 billion years old, the evolution would still be in its first stage. For intelligent life to evolve on a planet in less than 5 billion years, the planet must have favorable conditions.

I think that the Earth-Moon system—which is in effect a double-planet system, because the Moon is not much smaller than Mercury—may have something very important to do with why we are unique. First, given the Earth's correct distance from the Sun, the Earth's ending up with a very large land mass could very well have happened when the Moon was captured. The capturing of the Moon was a very rare event. The only reasonable theory of how the Earth-Moon system came into being says that the Earth captured the Moon. This is the best theory because the chemical composition of the Moon is quite different from that of the Earth.

The capturing must have taken place in an encounter close to the distance that astronomers call the Roche limit. At this distance tidal friction forces are very large. If the Earth-Moon encounter had taken place at a larger distance, there couldn't have been a capture. In the asteroid belt, planets collided. Here we had a close encounter that led to a capture. And that capture probably created the supercontinent Pangea that was essential for the development of intelligent life. (Pangea is Wegner's ancient supercontinent, from which all the present-day continents were created by continental drift.)

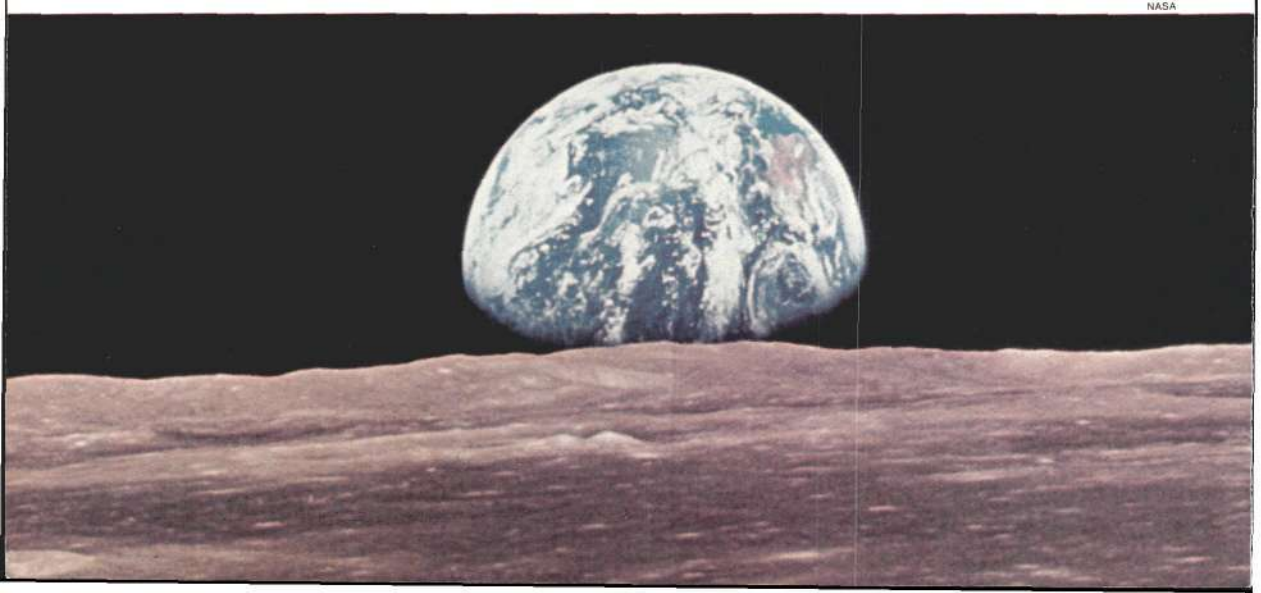
Without the capture of the moon, Pangea may not have formed and everything would have remained under water. On such a planet there could never be intelligent life. Consider also the tides. The tides, caused by the Moon, forced the life in the sea to move onto land much more quickly.

Thinking about the extremely rare conditions that exist on Earth makes one aware of how unique intelligent life on Earth is. If we could persuade political leaders to appreciate this fact—that there is no other life like Earth's in the entire galaxy—perhaps they would take greater responsibility for making political decisions.

Dr. Friedwardt Winterberg, a pioneer in inertial-confinement fusion, is considered the father of impact fusion for his early work in thermonuclear ignition by hypervelocity impact. Now a research professor at the Desert Research Institute of the University of Nevada System, he has long been at the forefront of research on the use of nuclear energy for spaceflight. Winterberg received the 1979 Hermann Oberth gold medal of the Hermann Oberth-Wernher von Braun International Space Flight Foundation for his work on thermonuclear propulsion.

This article is adapted from his speech at a conference on reindustrialization sponsored by the Fusion Energy Foundation in Los Angeles Oct. 15, 1980.

NASA



"The environmentalist-terrorist groups are merely infantry divisions deployed by some of the most powerful political forces in the United States."

—Robert Greenberg
Editor, Investigative Leads

Over the last decade, the United States and other industrialized countries have been under all-out attack by the forces of the so-called environmentalist movement. Radicalized youth, "social-activist" lawyers of the Ralph Nader variety, and "expert studies" have all been combined to convince many that growth and prosperity are things of the past.

Now, *Executive Intelligence Review* is making available a comprehensive study on the environmentalist movement, showing how the movement is controlled from top to bottom by some of the most prestigious power centers in the United States: New York-based foundations and law firms, and federal agencies, under the umbrella of the Council on Foreign Relations.

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A special report prepared by *Investigative Leads,* a research arm of *Executive Intelligence Review.*
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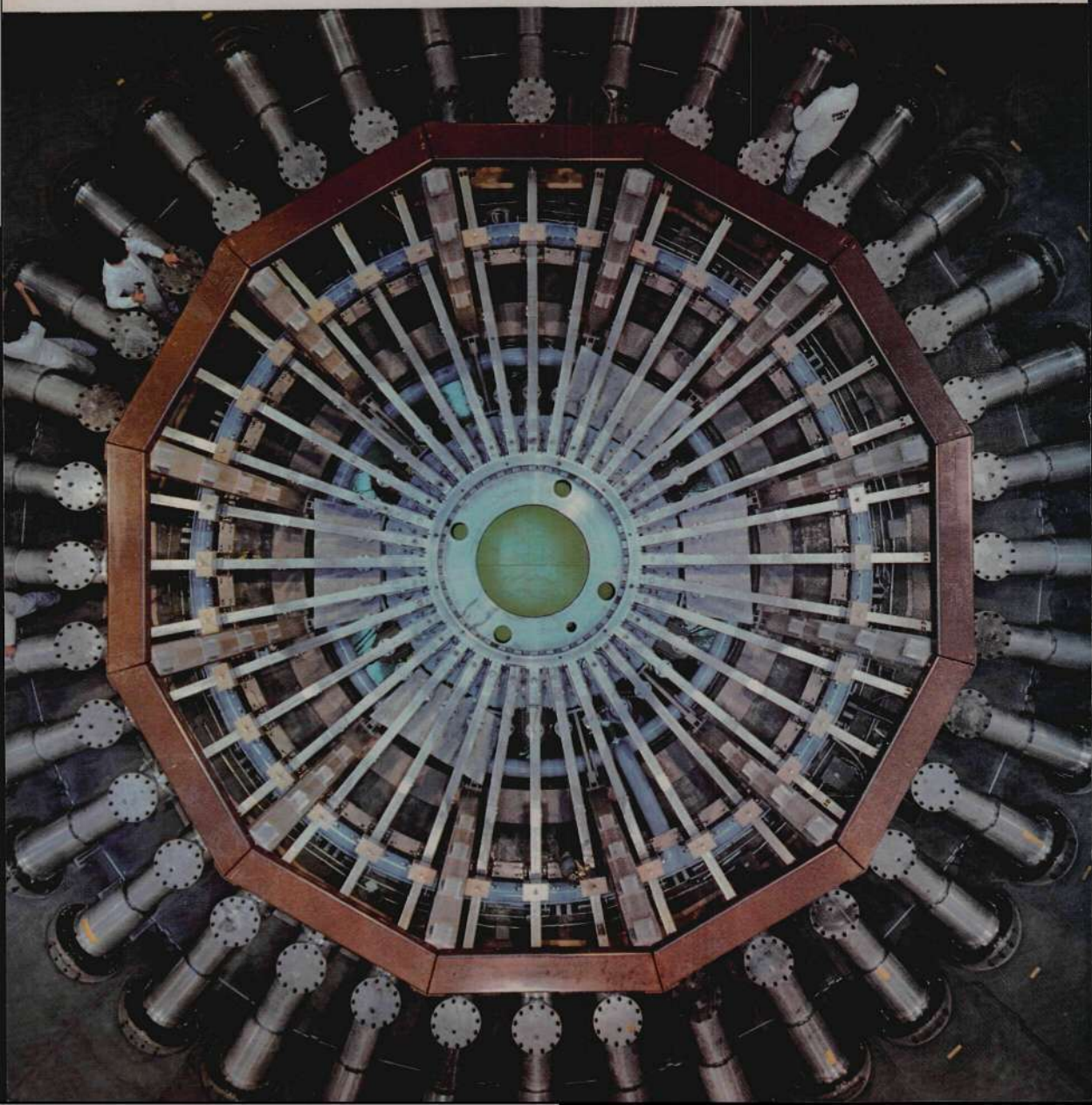
Prospects for Inertial Fusion



The director of the U.S. inertial fusion program reviews how the "number two" fusion approach is gearing up for decisive testing.

by Gregory H. Canavan

The goal of the U.S. inertial fusion program is to develop the full potential of inertial fusion for both military and energy applications. Both applications depend on the ability to burn small masses of thermonuclear fuel efficiently by compression to extreme densities.

In the simplest case this is accomplished by focusing beams of light or particles onto millimeter-size targets containing milligrams of fuel. The beams heat the target's surface, vaporizing material and causing it to ablate (expand outward) at high velocity, as shown in Figure 1. This produces a strong recoil force that compresses the fuel. If thermonuclear conditions are reached (1,000 times liquid density and 100 million degrees Celsius), the core will ignite. While inertial forces hold the compressed fuel together, thermonuclear burn propagates outward, releasing much more energy than was required to compress the fuel. (This is termed gain.) This energy can then be contained for nuclear weapons physics, weapons effects simulation, or energy production. Weapons effects simulations require a large output energy that translates into a high target gain or extensive propagation of thermonuclear burn. Energy applications require high gains from mass-produced targets that can be driven by efficient laser or particle beams.

There are many engineering advantages to using inertial confinement to produce commercial fusion. The key features of current conceptual designs of inertial fusion power plants are their modest dimensions, conventional liquid-metal power-generation loops, and physical isolation of the inertial confinement driver from the radiation environment of the reactor (Figure 2). These engineering advantages justify the development of inertial fusion as an alternative energy source that may in the long run prove superior to magnetic fusion, although it is currently much less mature.

The progress, planned developments, and ultimate performance required to meet both civilian and military applications are summarized in Figure 3. There are two key experimental parameters: quality of confinement (density times confinement time) and plasma temperature. These parameters put magnetic fusion results on a common basis for comparison with inertial fusion results. Until the last few years inertial fusion concentrated on attaining high temperatures without much compression in order to produce adequate neutron fluxes for diagnostics and to study the coupling of energy into the target. During that period magnetic and inertial experiments produced comparable gains. Since then they have diverged, with magnetic fusion going directly to higher gain and inertial fusion going first to higher density.

In 1979, inertial fusion achieved ablative compressions of 100 times the density of liquid deuterium-tritium, termed 100×. This result, which is within a factor of 10 of the 1,000× required for efficient burn, was achieved without encountering any fundamental barriers to further compression. However, further progress will require use of the higher-energy facilities now under construction. The 100-kilojoule Phase I of Nova, the giant laser at Lawrence Livermore, should reach 1,000× with enough energy left over for heating to produce a like amount of thermonuclear energy. This condition is known as significant thermonuclear burn.

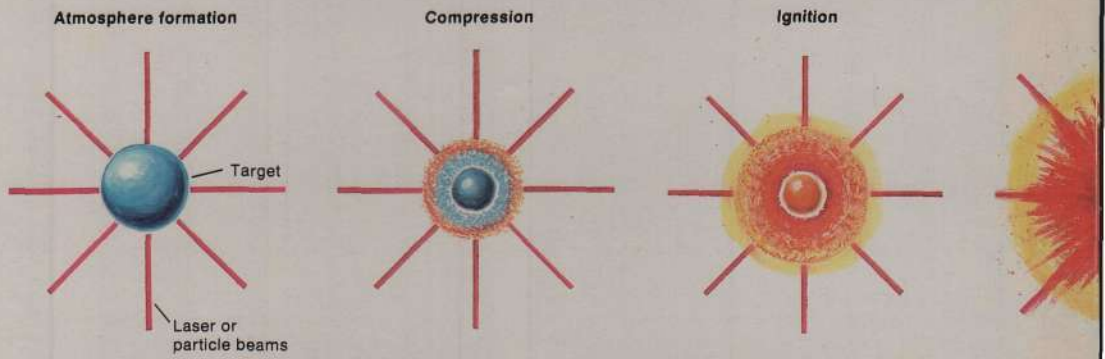
Once Nova is upgraded to 300 kilojoules, it should reach ignition of a "spark plug" of fuel, initially producing an overall fuel pellet gain of about 10 percent. Although magnetic fusion can support energy applications with ignition level gains, inertial fusion cannot. Higher gains are required to compensate for the inefficiencies of driver and target coupling. A facility still larger than Nova will be required to propagate thermonuclear burn through large masses of fuel, achieve high gains, and establish the feasibility of military and energy applications.

Driver Selection

In selecting a driver for the high-gain facility, the two conversion efficiencies shown in Figure 4 must be considered. The first is the electrical efficiency with which the driver converts input energy into laser or particle beam energy. The second is the target coupling efficiency with which that beam energy is converted by compression into fusion energy.

For military applications the latter is dominant. For energy applications the fusion energy must be much larger than the input energy, so the product of the two efficiencies must be high. Thus, the well-developed glass laser's high coupling efficiency makes it an excellent driver for weapons applications, and its efficient frequency conversion makes it a flexible experimental tool, although its low electrical efficiency makes it unattractive as an energy

An overhead view of the central section of Sandia Laboratory's PBFA-I accelerator showing the 36 transmission lines converging on the diode area. The accelerator is being tested in preparation for inertial confinement fusion experiments with ion beam pulses.
Sandia



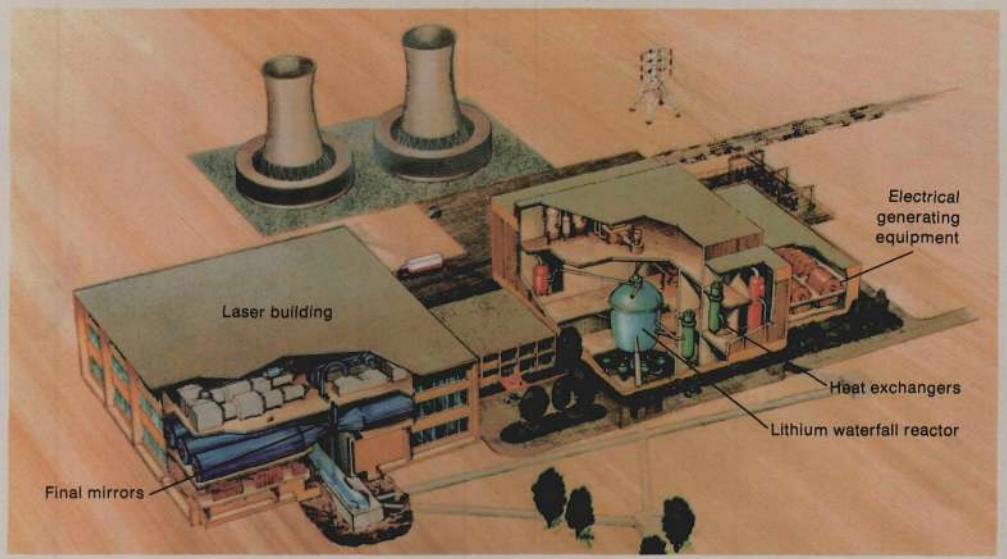


Figure 2
LASER FUSION REACTOR BUILDING

Most of the materials and techniques required for inertial fusion reactor design are within the current state of the art. The lithium waterfall plant shown here was developed by Lawrence Livermore. The fusion reactor is at the center of the building at the right, with the liquid metal pumps, heat exchangers, and electrical generation equipment. The laser system is in a separate building on the left, a separation that leads to lower capital costs and greater ease of maintenance. The laser beams are conducted through underground concrete tubes to the final focusing mirrors that look into the reactor chamber.

The lithium waterfall reactor is a closed system. The neutron and X-ray energy from the implosion of the pellet is absorbed in the liquid metal lithium that forms a thick wall around the center of the reactor. The lithium, circulated through a series of heat exchangers, is also the heat-transfer fluid. Electricity is produced with conventional turbine generators.

Figure 1
INERTIAL CONFINEMENT FUSION—HOW IT WORKS

In inertial confinement, beams of light or particles are focused onto tiny target pellets filled with fusion fuel. First, the laser or particle beams rapidly heat the surface of the fusion target, forming a surrounding plasma envelope. Then the fuel is compressed by rocketlike blow-off of the surface material. With the final driver pulse, the full core of the fuel pellet reaches 1,000 to 10,000 times liquid density and ignites at 100 million degrees Celsius. Thermonuclear burn spreads rapidly through the compressed fuel, yielding many times the energy of the driver input.

driver. On the other hand, the carbon dioxide laser's efficiency is adequate, but its target coupling, which is degraded by plasma instabilities that are excited by its long-wavelength light, may be too low for either application. For that reason, there is considerable interest now in advanced lasers, which, on the basis of limited experiments, appear to combine the high target coupling of the glass laser with the efficiency of the carbon dioxide gas laser to produce an attractive driver for both military and energy applications. For advanced lasers the chief issues are the confirmation of these theoretical predictions and the demonstration that they can be scaled economically to the sizes required.

In addition to laser drivers, there are two particle-beam drivers with great promise. The first uses the simple and well-developed technology of pulsed power to produce beams of protons and other light ions with very high efficiency. Once particle beams get to the target, their deposition is predicted to be classical; that is, they should have none of the plasma instabilities that have degraded laser coupling. The main points here are propagating the beams to the target and focusing the beams down to the size of the target. Significant improvements are required in both. But if those improvements are possible, light ions will produce an extremely cheap and efficient driver that can readily be developed for either military or energy applications. For that reason light ions have been developed aggressively as a high-risk, high-payoff option.

The second driver uses the well-developed accelerator technology of high-energy physics to produce beams of heavy particles very efficiently. Theory and limited experiments indicate that there should be no problem in focusing these beams onto targets or in depositing their energy efficiently. As with advanced lasers, the key issue is scaling. It is necessary to demonstrate the scaling of the accelerators to the orders-of-magnitude-higher currents required for fusion applications.

As Figure 4 summarizes, there are major gaps in the measurements of the all-important target coupling efficiency for each driver option. For two developed drivers, carbon dioxide lasers and light ions, the evaluation is incomplete and inconclusive. For the advanced drivers, optimistic theoretical evaluations require experimental substantiation. All these evaluations must be completed before we can make a defensible choice of a high-gain driver.

Programs Underway

There are several programs recommended to complete the evaluation of the five drivers just discussed: glass lasers, gas lasers, light ion beams, advanced lasers, and heavy ions (Figure 5). The logic is to test each of the five thoroughly before choosing one as the driver for the Single Pulse Test Facility, which is intended to demonstrate high gain and support military applications. There is also a parallel technology program that augments the high-gain demonstration with the developments required to build an inertial confinement fusion Engineering Test Facility and establish the engineering feasibility of energy applications.

I'll briefly review each of these programs.

Glass laser development. The 10-kilojoule Shiva glass laser at the Lawrence Livermore National Laboratory has compressed fuel to 100 times liquid density (100×), providing the first successful test of the type of double-shell targets proposed for ignition experiments on the larger Nova laser experiment. These tests are expected to reach about 400× over the next few years.

Experiments with Shiva on hot electron scaling have shown that the energy transferred to hot electrons decreases as the target size increases. Since it was the unexpectedly high levels of hot electron production that lowered glass laser target performance compared to theoretical predictions over the last few years, the recent measurements lead to predictions of reduced preheat and increased performance from Nova-sized targets. Lawrence Livermore and the University of Rochester have also demonstrated about 70 percent efficient conversion of the long-wavelength red light from glass lasers into shorter-wavelength green, blue, or violet light. This will allow the 100 kilojoules of red light from Nova I to produce 70 to 80 kilojoules of green or blue light for shorter-wavelength interaction experiments. And recent experiments at Lawrence Livermore and KMS Fusion have shown increased absorption, improved conversion, and reduced hot electron energy with green light compared to red, leading to increased confidence that the Nova laser will reach ignition.

This demonstration is pivotal, since it will establish the feasibility of efficiently burning the small spark plug of fuel needed to start propagating burn in a high-gain target. It should permit confident predictions of the size of glass or advanced short-wavelength laser required as a driver for the Single Pulse Test Facility. Construction of the Nova laser bay, target area, and office building are proceeding on schedule. All major optical components for the 10 beams of Nova I have been ordered, with the exception of the laser glass itself. No major technical problems are anticipated; project cost and schedule are within contingency limits.

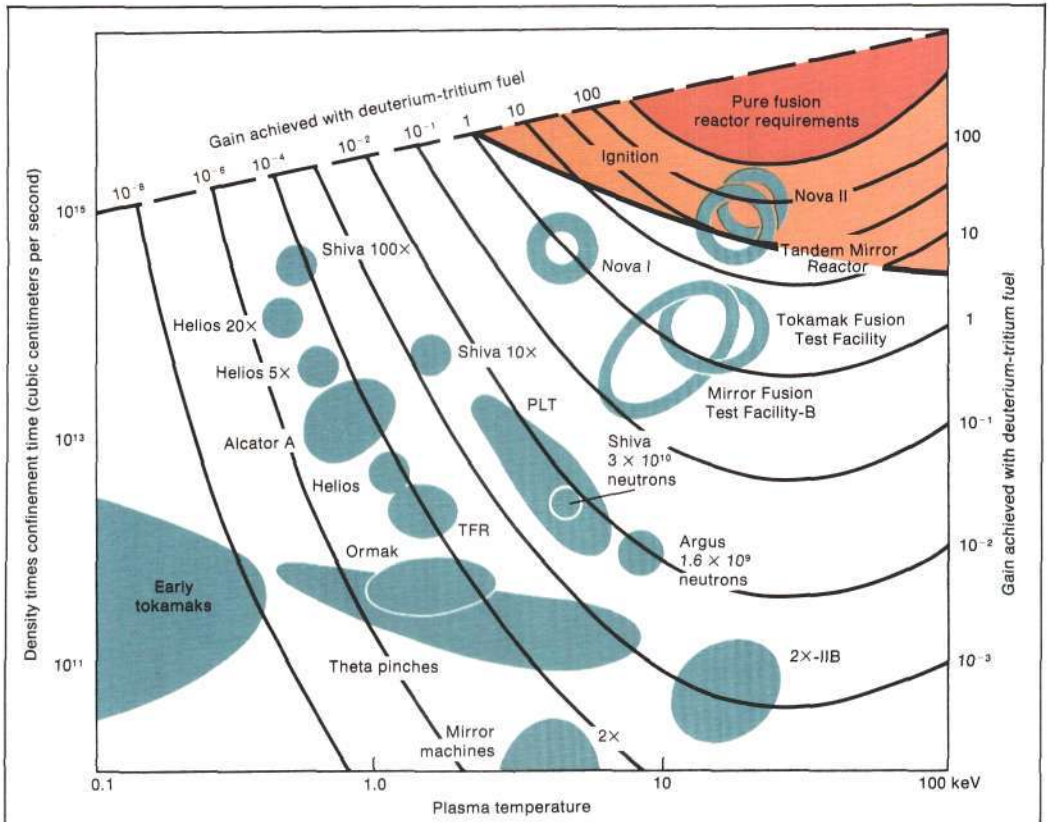


Figure 3
PROGRESS IN INERTIAL AND MAGNETIC CONFINEMENT FUSION

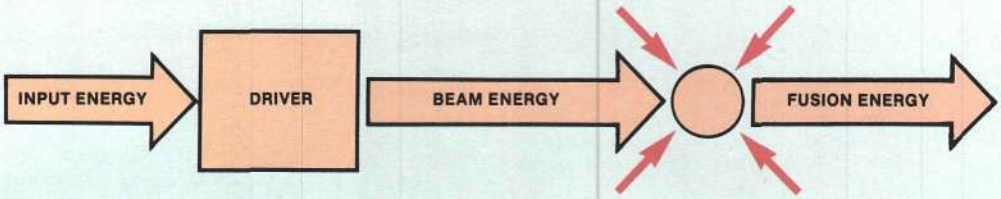
During the last few years, magnetic and inertial fusion experiments produced comparable gains—fusion energy output divided by energy input. But more recently, the results of the two programs have diverged, with magnetic fusion achieving higher gain and inertial fusion achieving higher density. Shown here are major U.S. fusion programs measured in terms of density times confinement time (vertical axis) and plasma temperature in thousands of electron volts or keV (horizontal axis). The figure next to the × in the laser fusion experiments equals the number of times the compression achieved is greater than the density of liquid deuterium-tritium.

Carbon dioxide laser development. The 10-kilojoule Helios laser at the Los Alamos National Scientific Laboratory has produced compressions to 20×. Like Shiva its goal is 400×. Along the way it should resolve many questions about carbon dioxide target coupling. The hot electron problem is much more severe at carbon dioxide frequencies than at glass laser frequencies, and it is uncertain whether going to larger targets will reduce the problem sufficiently to permit high gain experiments.

Helios is now engaged in classified interaction experiments that will evaluate for the first time the efficiency of carbon dioxide lasers in driving such targets. The 40-kilojoule Antares, also at Los Alamos, could produce significant thermonuclear burn, confirming the scaling of carbon dioxide target coupling results with energy. The extrapolation of those results to predictions of requirements for ignition and propagating burn will then determine whether the attractive technology of carbon dioxide can be used for high-gain experiments.

The Antares laser, laser hall, target building, and office complex are complete, and the laser assembly and testing are in progress. The electron beam identified as the high-risk item has been tested successfully at full voltage. The first power amplifier module will enter full system testing in December 1980. Cost, schedule, and performance are all within the revised baselines reflected in the budget.

Pulsed power or light ion developments. During the last year, the Proto accelerators at the Sandia National Laboratory in Albuquerque, New Mexico have demonstrated ion-beam focusing to 1 terawatt per centimeter squared, achieved velocities of 20 centimeters per microsecond with exploding foils, and started ablatively driven foil



Driver	Efficiency	Target coupling
Glass laser	Very low	High, flexible
Carbon dioxide laser	Moderate	Possibly too low
Advanced laser	Moderate	Theoretically high
Light ions	Very high	Possibly high
Heavy ions	Very high	Theoretically high

Figure 4
COMPARISON OF CONVERSION EFFICIENCY OF INERTIAL FUSION DRIVERS

Compared here are the electrical efficiency with which the driver converts input energy into laser or particle beam energy and the efficiency with which that beam energy is converted into fusion energy (known as target coupling). On the basis of limited experiments, advanced lasers appear to combine the high target coupling of the glass laser with the efficiency of the carbon dioxide gas laser to produce an attractive driver for both military and energy applications.

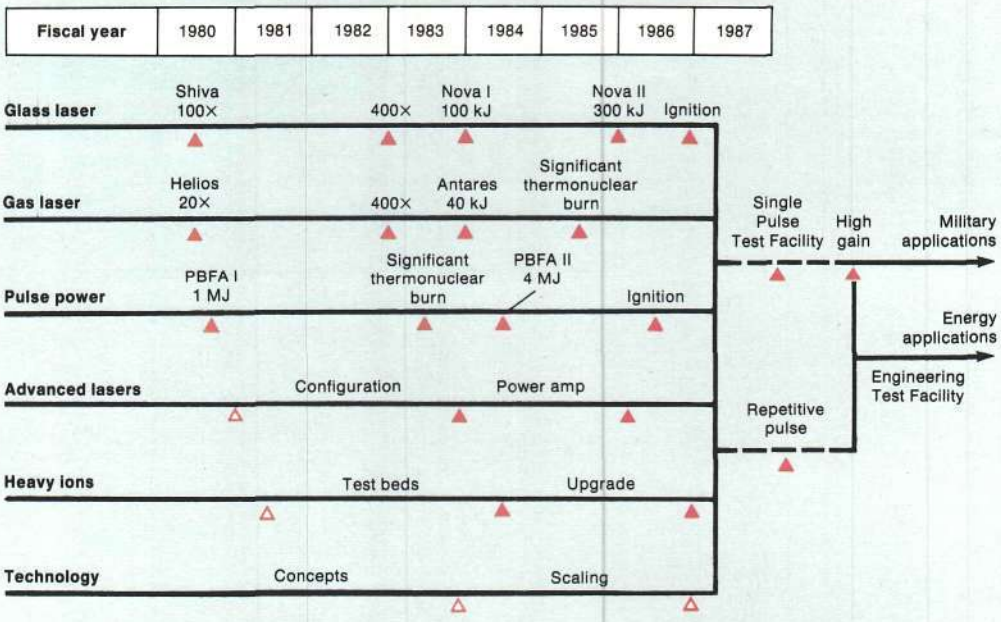
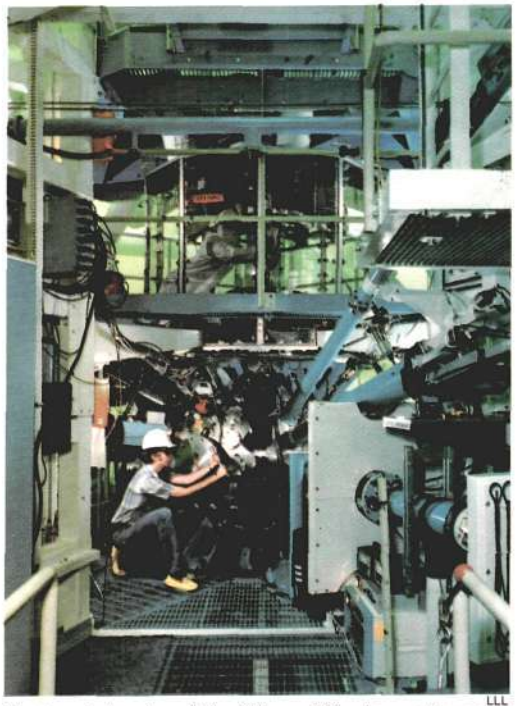


Figure 5
RECOMMENDED PROGRAMS IN INERTIAL CONFINEMENT FUSION

The program goals recommended for the five inertial confinement drivers include experiments required to evaluate each of the five inertial confinement drivers under discussion. The Department of Energy's logic is that each driver should be tested thoroughly before choosing one as the driver for the Single Pulse Test Facility.



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The target chamber of the 40-beam Shiva laser at Lawrence Livermore, showing 10 upper and 10 lower beams entering in nested pentagonal clusters. The Shiva transforms an input of several hundred megawatts of electrical current into a pulse of light with a power level of several hundred trillion watts.

experiments. The 1-megajoule Particle Beam Fusion Accelerator (PBFA I) at Sandia will start experiments in 1981. During 1981 it should demonstrate focusing to 5 terawatts per centimeter squared, the threshold flux required to drive targets. It should achieve significant thermonuclear burn by 1983. PBFA I will then be upgraded in both energy and power to PBFA II, which will perform ignition level experiments providing a thorough evaluation of light ions as a Single Pulse Test Facility driver. This result should be achieved at roughly the same time as the ignition level result from Nova, which will give us a simultaneous evaluation of the tradeoffs between laser and particle beam drivers.

On June 28, 1980, all 36 pulsed power modules developed by Sandia for the PBFA I were simultaneously fired to test the machine on time, performance, and cost. The PBFA I energy storage tank contains enough room to accommodate the authorized PBFA II upgrade, which will be carried out by doubling the energy per module and the number of modules, producing an overall increase in energy by a factor of 4, and further doubling the focusing of the beam from each module, producing a net increase in power of a factor of 10.

Advanced laser development. Over the last few years the inertial confinement program has identified several advanced lasers that operate at short wavelengths, where target coupling is high, with efficiencies adequate for energy applications. The central issue is whether they can be scaled to Single Pulse Test Facility energy levels. The advanced laser program approaches this issue in two stages: First, the testing of the scaling of alternative beamline configurations; and second, the selection of one for the development of a power amplifier module from which a Single Pulse Test Facility could be constructed in a building-block fashion. This program would produce scaling data on cost, schedule, and technology development required for an advanced laser test facility; parallel experiments with the doubled frequency and tripled output of Nova would produce target information. Together the advanced laser and Nova programs will permit a full evaluation of advanced lasers as Single Pulse Test Facility or energy drivers.

Heavy ion development. Heavy ions are predicted to interact as well as light ions and focus much more easily. Again the central issue is scaling. The program involves two stages: first, the evaluation of radiofrequency and induction linear accelerator scaling by the construction of test beds; and second, the selection of one for upgrading to 10 kilojoules for beam focusing and deposition demonstrations. Again, these are primarily tests of accelerator scaling. Parallel experiments on PBFA are required to provide light ion target information that can be scaled to heavy ions to complete their evaluation as Single Pulse Test Facility or energy drivers.

Technology development. In the near term the emphasis in developing the technologies required to meet energy applications is on the identification and analysis of reactor configurations compatible with each driver. As the driver options are reduced, the emphasis shifts to demonstrating the scaling of key components of the main contenders. After the decision on the Single Pulse Test Facility, the emphasis shifts again to demonstrating the repetitive pulse capability of the driver selected for the Engineering Test Facility.

In summary, the recommended program summarized here attempts to evaluate the scaling and coupling of each driver fully before choosing the best one as the driver for the Single Pulse Test Facility. The evaluations are not equally thorough. Those of glass lasers and light ions are fairly complete, while that of carbon dioxide is somewhat slight and those of advanced lasers and heavy ions are heavily dependent on coupling measurements with other drivers. But each is given an adequate evaluation for the Single Pulse Test Facility. In the process, each is also brought to the level of development required to meet downstream energy driver needs. Thus, this program is balanced not only in its evaluation of alternative drivers, but also in its service to military and energy applications.

Gregory H. Canavan is the director of the Office of Inertial Fusion at the U.S. Department of Energy. This article is adapted from a presentation he made at the American Nuclear Society's annual fusion meeting in Oct. 1980.

TMI Two Years Later

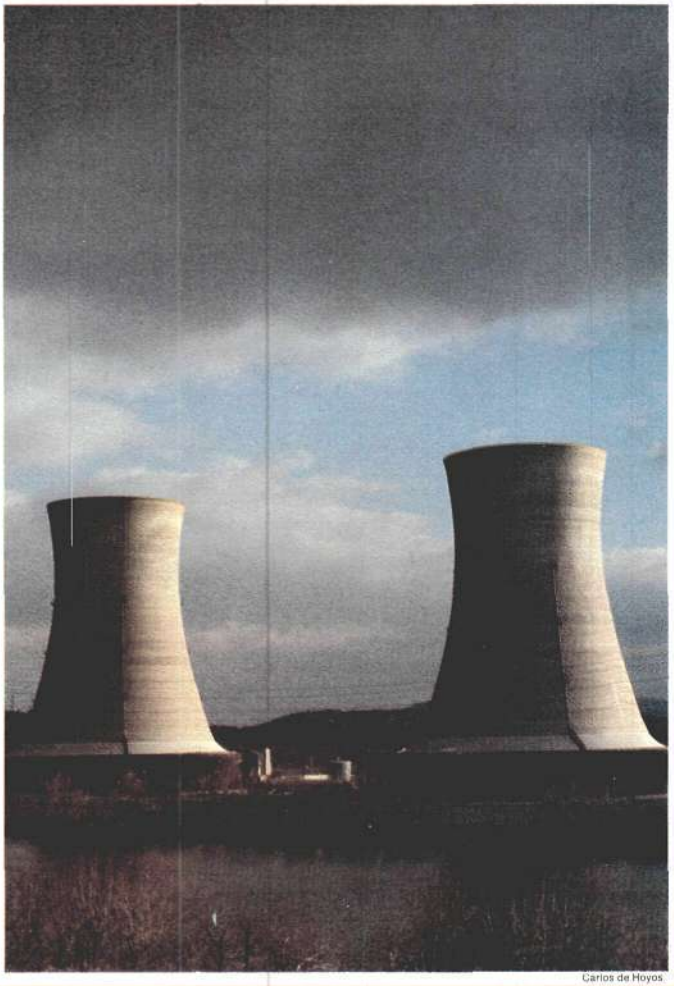
Although the question of "whodunit" is still unanswered, the role of the media and the funders of the environmentalists provides some clues.

On the second anniversary of Three Mile Island, we present two brief documentary articles that deal with the key issues involved. First, a review of the media's role at TMI, compiled by the Independent Commission to Investigate Media Corruption, that documents how the press invented myths at the initial TMI press conferences and turned them into national headlines. Second, a rundown on where the money comes from to fund the allegedly grass roots environmentalist activities.

During the past two years, *Fusion* has published several articles on the TMI events. Our series over a period of five months, "The Harrisburg Hoax" by FEF director of nuclear engineering Jon Gilbertson, won the Freedoms Foundation at Valley Forge George Washington Honor Medal in 1980 for its coverage of TMI.

The award-winning series raised the issue of sabotage and emphasized that the most important question about what caused TMI was not answered by any of the official groups investigating the incident: Who deliberately or accidentally turned off the emergency feedwater valve that triggered the incident?

The highlights from these articles will appear in a forthcoming book published by the FEF, *Nuclear Power and World Development*. A reprint of Gilbertson's "Putting TMI Back on Line: The Big Cleanup," "Radiation: Fact Versus Fiction," and the FEF recommendations for the nuclear industry, all from the April 1980 issue of *Fusion*, is available at $1.25 postpaid from the FEF.



Carlos de Hoyos

A special study of the news media's coverage of the Three Mile Island nuclear incident in March 1979 has charged journalists with willful irresponsibility in their press, radio, and television reports at the time.

The Independent Commission to Investigate Media Corruption, composed of nuclear specialists, journalists, and other concerned citizens, issued part 2 of its report, "The Role of the Media at Three Mile Island," Sept. 5, 1980. Part 1 of the report focused on the activity of the White House, the Nuclear Regulatory Commission, and, in particular, the Federal Emergency Management Agency (FEMA), which appears to have exercised final authority over all information issued about the events at the nuclear plant. That report concluded that Carter administration restrictions on statements issued by Pennsylvania Governor Dick Thornburgh's office and by Nuclear Regulatory Commission personnel made it nearly impossible for an honest reporter to find out what was going on.

The second report documents the charge that many reporters and their editors were far from honest in their treatment of officials' comments and the facts presented to them in the early days of the event.

"Our conclusion is that the investigative techniques employed by the media comprised a willful and gross distortion of reality," the report asserts. "Coupled with the overwhelming ignorance of the media on the issues of nuclear energy, this sensationalism resulted in a news information debacle."

The commission states that "three myths" were created "almost entirely by the media," each bearing no relationship to the actual facts or the facts at their disposal at the time:

(1) the myth of nuclear core meltdown or catastrophic hydrogen bubble explosion;

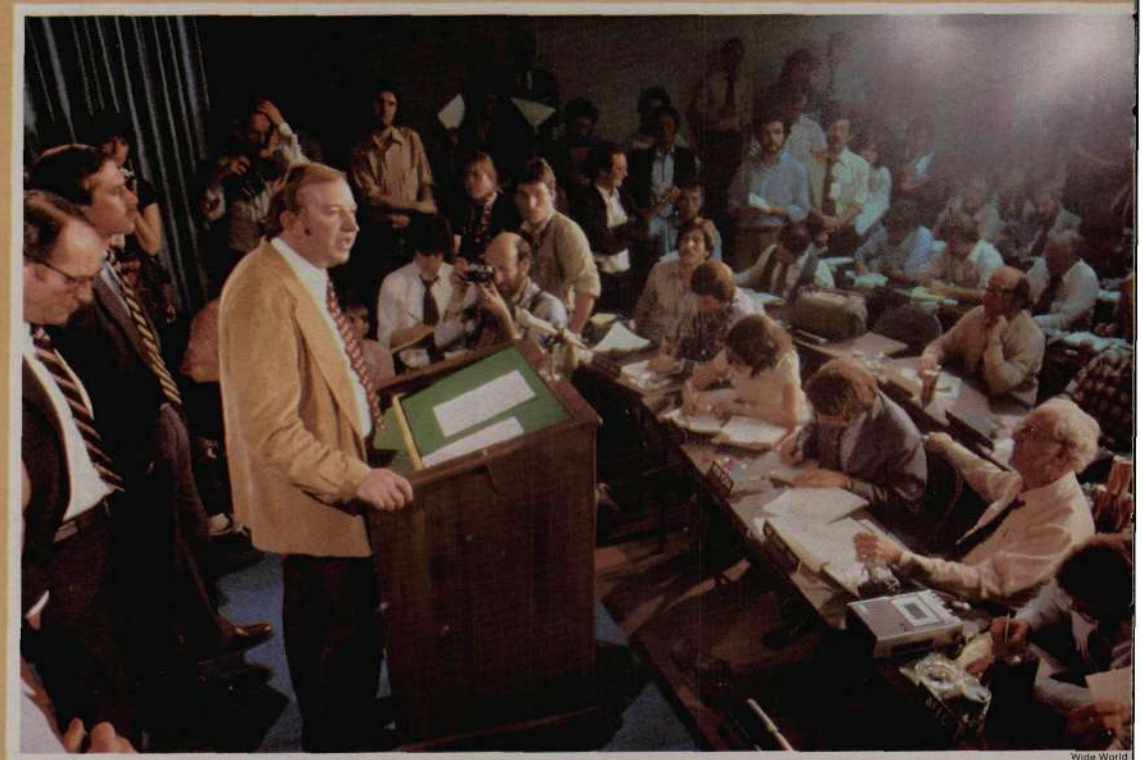
(2) an alleged "three-hour delay" in reporting the occurrence of the accident; and

(3) the "plans for a mass evacuation" which never occurred.

Transcripts of both official press briefings and subsequent newspaper accounts contained in the commission report reveal that the "three-hour delay," the "mass evacuation," and the "core meltdown" or "China Syndrome" scenarios were all initially introduced by reporters themselves, not by the officials giving the briefing. News reports then distorted facts and statements to make them conform to the fantastic scenarios invented by reporters.

Fay Sober

The Media Role in Creating



Wide World

For example, at the first press briefing held by Pennsylvania Lieutenant-governor William Scranton, a reporter asked: "Was there ever anything approaching, or was there ever any possibility of the China Syndrome? Have you seen the movie?" Scranton's "no" answer was reported as an evasion of the question.

At the same briefing, the following line of questioning occurred:

Reporter: When was the Pennsylvania Defense Emergency Resources (DER) agency informed?
DER official: We were informed through Civil Defense at 7 a.m.
Reporter: Three and a half hours after the accident!?
DER official: About three hours afterwards, yes.
Reporter: Is that considered communications. . . .
DER official: We don't know what the situation was at the plant in the interim. . . .
Reporter: Initially you thought that it was a serious situation and I ask you now, does it bother you that it took three hours to tell you what was going on?
DER official [after answering that no indication existed of any serious mishap prior to that time]: If I had gotten a call at 4 a.m. which told me our number two unit has just automatically shut down, we don't know why, but we're worried, this would not have helped me a hell of a lot.
Reporter: But they said this was a serious incident!
DER official: No, not at 4 a.m. . . .

Nevertheless, news reports implied and in some cases stated that for the first three hours, the Metropolitan Edison utility and state officials had tried to cover up the accident.

A similar line of leading questioning was employed by Westinghouse network TV senior reporter Sandy Starobin at the lieutenant-governor's second press briefing March 28.

Starobin: Why did it take three hours between the time of the accident and the time of the report?
Scranton: The officials from Met Ed said that when the first incident occurred, which was outside the nuclear part of the reactor, that began a process which slowed down and cooled down the reactor and there was no detectable incidence of abnormal radiation leakage within the reactor until ten minutes of seven. . . . that is when they are supposed to call the Civil Defense and they did it at that time.
Starobin: Doesn't that indicate some kind of failure in the design, some kind of negligence in the design of the alarm system, at least?
Scranton: If the alarm system were formed to detect radiation and radiation did not begin to leak until ten minutes of seven, it does not.
Starobin: But the point of it is, if there was an inevitability of leakage of nuclear radiation at the time the system. . . .
Scranton: There was not. According to the people at Met Ed, there was not an inevitability. It occurred due to a malfunction and later on after the first stoppage of the turbine. . . .
Starobin: We were told that some of the people working there were contaminated. Can you tell me how many and to what extent?
Scranton: The company told us that there were some contaminants in clothing, contaminants that have been discarded, and they are going through the normal health procedures. . . . There is no evidence of any permanent health damage. . . .

Another reporter from UPI quickly joined in Starobin's quest for a "cover-up" story:

Reporter: Why don't you know how many employees were there and what's being done to see if they've been contaminated?

The Harrisburg Hoax

NSIPS

Left: The NRC's Harold Denton briefing press in April 1979. Gov. Thornburgh is standing second from left. Above: Ira Seybold, a nuclear dosimetry expert and member of the Independent Commission to Investigate Media Corruption, at a press conference Sept. 15, 1980 in Philadelphia, where the commission released part 2 of its report on the role of the media in the TMI incident.

Scranton: That is the company's concern . . . and this is a normal procedure.
Starobin: Is there any evidence so far of negligence on the part of the company?

The commission report, quoting this transcript, pointed out that Starobin and his junior colleagues not only are not seeking to discern the facts of the situation in the plant at the time or how the accident had actually occurred; but also are eliciting and repeating distorted versions of what was being said. The report notes: "Contamination of the special protective outer garments and equipment used by nuclear plant personnel occurs routinely in the operation of a nuclear plant. The press chose instead to exploit the meaning of words like 'radioactive contamination' for their emotional impact."

'Pack Journalism'

Commission member Ira Seybold pointed out at a press conference when the report was released that there was a remarkable uniformity in reporters' lines of questioning at all press briefings—whether the reporter was from UPI, AP, the Westinghouse network, the *Philadelphia Inquirer*, or any other press outlet. Seybold, a nuclear engineer, was called in to direct the dosimetry unit of the TMI cleanup team. "After our Harrisburg press conference," Seybold said, "we went to the press room and it immediately struck me—something I was a little bit ignorant of—that all these people are working out of the same place. . . . I would assume that they had sat down and cooked the thing over. . . . It's 'pack journalism.'. . . A senior reporter like Walter Cronkite or Sandy Starobin 'led the pack' . . . and is looked to by all the other press for how to 'play' a story."

The same sort of "pack journalism" described by Seybold was used to promote myth number three—the scenario for "mass evacuation" that reporters, not officials, raised at Gov. Thornburgh's March 30 press conference. The commission quotes a conference transcript to make the point:

Reporter: Governor, are you concerned that a sense of panic may have set in here?
Thornburgh: I hope not. . . . We are assessing the situation constantly to satisfy ourselves what is rumor and what is fact. . . .
Reporter: Governor, do you have some type of security set up in these areas that you're going to evacuate?

The commission notes that no one had mentioned evacuation until this question was raised by the reporter.

Thornburgh: They are not being evacuated.
Reporter [UPI's MaCleod]: Are the cities of Harrisburg, York, Lancaster, and Lebanon involved in this potential evacuation alert area?
Thornburgh: There is no potential evacuation alert area.

"There was no competent briefing to the press after Metropolitan Edison was officially gagged by the White House, on the request of Governor Thornburgh."

Reporter: But you're saying that you're monitoring the situation and that there could be evacuations.
Thornburgh: I didn't say that at all. I said there is no evacuation order at this time.
Reporter: But you used the word potential, Governor.
Thornburgh: No, I didn't.

It was after this press briefing that newspapers began to fill up with pictures of "pregnant women" evacuating the area voluntarily, or the notorious photograph run in the *Philadelphia Inquirer* of an allegedly deserted Goldsboro, Pa. township street. The picture was taken after photographers and newsmen "asked the residents to clear both street and sidewalk," the commission report states.

The report of the Independent Commission to Investigate Media Corruption singles out the *Philadelphia Inquirer*'s coverage of the TMI incident as especially distorted and corrupt and remarks on the irony that the *Inquirer* won the Pulitzer Prize for such distortion. The report states:

> The *Inquirer*'s series abounds with headlines like the large type, boldface paragraph introducing part seven of the series: "The plant posed a danger both lethal and invisible, and suddenly the potential became even more horrifying with the twin threats of 'meltdown' and a 'bubble'."

Neither threat, the report points out, ever existed, nor was there any basis to have assumed they existed. "One of the accompanying feature articles to the series," continues the report, "was headlined: 'A Child's Fears: "The Big Ball Killed Everybody".' "

In addition, says the report:

> The investigative and news reporting techniques of the *Inquirer* team also included illegal monitoring of the secret security radio band communications between plant operators and state and federal personnel. Illegal taps were the cause of more than one inaccurate and irresponsible *Inquirer* report based on conversations and speculations overheard. The *Inquirer* reporters also "bugged" a private meeting of Metropolitan Edison officials, by eavesdropping on their discussion to produce part ten of the series, entitled "A Secret Utility Meeting About Public Relations—Company Officials Meeting Behind Closed Doors to Discuss How to Keep the Facts Hidden."

Another *Inquirer* article cited in the commission's report is by "medical writer" Donald Drake, who talks about nuclear radiation under the headline: "The Potential Time Bomb Ticking Within."

Drake begins:

> There is good reason to fear radiation. . . . When it strikes its victims, neither sound nor pain betrays its presence. Yet it can cause lethal forms of cancer that will not be-

come apparent for decades, or serious birth defects that will not occur for generations.

Only halfway through the lengthy article, the report points out, does Drake mention the fact that "scientists consider the levels of radiation emitted from TMI so low that they cause no damage. . . ."

In an excerpt from part three of the *Inquirer* series, "State Officials Get the Word: 'Emergency,'" the commission report quotes the following:

> The NRC's Darrell Eisenhut is, at once, propounder of a system of reason that contends: All things are at bottom intelligible . . . [and] he who understands, controls. . . . Eisenhut is the complete nuclear man.
>
> He is deputy director of the operational reactors division of the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission. All this he says in a breath, unhesitatingly. He is 35, a fact which he produces only after a long pause for thought. "It is not something I compute everyday," he explains. "It is not a useful piece of information."
>
> Eisenhut and his boss Victor Stello are sitting in Stello's office. . . .
>
> It is an office filled with Eisenhuts—with men, mostly young, who subscribe to this code of reason and who invariably respond to the question "How did you feel" with another question: "What do you mean?"
>
> Stello takes a call. It is terse, formal, firmly within the bounds of permitted communication between and among these men. "Event at Three Mile Island. . . . Team from region one on its way. . . observed radioactivity. . . . Incident response center activating. . . ."
>
> Stello hangs up and tells Eisenhut. There are no comments, not even a meaningful glance between them. . . .

The independent commission's report comments: "The *Inquirer* series abounds with descriptions like this."

The independent commission's findings, however, do not place sole blame on the news media. Its first report, issued July 15, 1980, quoted one correspondent in Harrisburg:

> There was no competent briefing to the press after Metropolitan Edison was officially gagged by the White House, on the request of Governor Thornburgh. There were no written technical statements and no technical advisors were allowed to get near reporters to explain what was going on. . . . Small shreds of evidence given to the reporters in small doses, they had to elaborate into 500 and 1,000 word articles. . . . The honest reporters did not have a chance to find out the true story.

The "gag order" to the utility cited by this reporter originated with Jack Watson of the National Security Council (NSC), who was then advisor to President Carter on intergovernmental relations. Watson, who sat on the Executive Management Committee in the White House with NSC chief Zbigniew Brzezinski and Federal Emergency Management Agency (FEMA) chief John Macy, later admitted to a UPI reporter that they had "managed the flow of news" throughout the TMI events.

"The honest reporters did not have a chance to find out the true story."

The Role of FEMA

FEMA was created by Presidential Review Memorandum 32, an executive order, and was scheduled to go into operation April 1, 1979. However, without explanation, FEMA became operational one day before the Three Mile Island incident occurred, March 27.

Centralizing all "emergency" functions previously exercised in a half-dozen government agencies, FEMA operated during the TMI incident with powers above the Constitution and the Cabinet. The commission report notes that the fashion in which FEMA and the Pennsylvania Emergency Management Administration (PEMA) denied competent technical briefings to the media and circulated or allowed to be circulated rumors about "hydrogen explosions," "meltdowns," etc., seemed designed to *promote* panic to study the results.

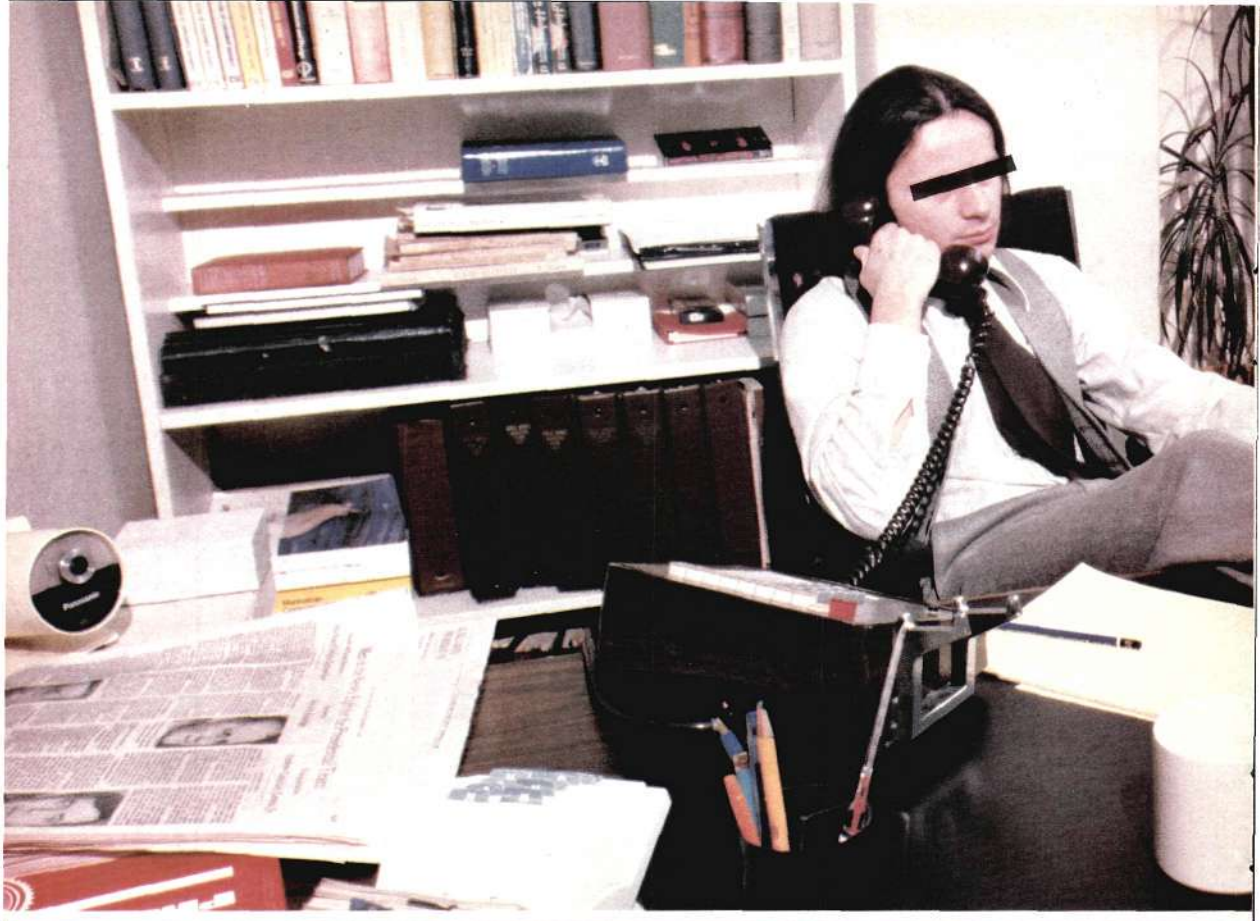
The commission also points out that "Governor Thornburgh . . . was a veteran of the Justice Department and its Criminal Justice Division, with extensive training and experience in civil disorders and natural disaster management. . . . Under his administration at the Justice Department's Criminal Division in 1976, a report on the handling of civil disorders, natural disasters, and terrorism was prepared."

Part 1 of the commission report quoted the Thornburgh document as follows:

> Of greatest importance to law enforcement and local authorities are those conditions that are most conducive to creating panic situations. . . . The threat must be sudden and unexpected, posing a danger that would be sufficient enough to cause immediate and intense fear. The threat must be direct. . . . The population must believe that there is a danger for which they are unprepared and which is beyond the capacity of normal behavior response to adequately treat. Elements of novelty and incomprehensibility increase the tendency to panic. Confusion with respect to the general situation and specifics such as escape, avoidance, and counter action, directly impact on the likelihood of community panic. Finally, not only must the population be aware of their helpless situation, no escape, no information, bewildering uncertainty, the community leadership in the form of authoritative realistic response must be absent.

"This," comments the report, "is exactly what happened at Three Mile Island."

Fay Sober is a member of the Independent Commission to Investigate Media Corruption.



Who Funds the Environmentalists?

EDITOR'S NOTE

A showdown over the nation's nuclear policy is on the agenda in the next few weeks as the new Reagan administration works out its energy policy. This article addresses one of the chief issues in the nuclear debate: How is a small minority of environmentalists able to wield such power against the nation's industry?

Compiled by Robert Zubrin of the FEF staff, the survey documents who funds the environmentalist groups and what their connections are. Examined here are the grants from six major tax-exempt foundations to environmentalist groups and the affiliations of the top foundation directors: the Ford Foundation, the three Rockefeller foundations, the Atlantic Richfield Foundation, and the Stern Fund. Their grants to environmentalist groups total $22,257,000 for the year 1979.

As you can see, the foundations reviewed have close ties to leading policy-making institutions; namely, the New York Council on Foreign Relations (CFR), the Trilateral Commission, the Aspen Institute, and the Club of Rome. The details of the zero-growth and "controlled disintegration" economic policies of these institutions have been presented elsewhere and are a matter of public record. (See, for example, "The 1980s Project: The CFR's Blueprint for 'Controlled Disintegration,'" *Fusion*, Oct. 1979, p. 36.)

Similarly, the goals of the funded groups are a matter of public record. The board of directors of the Sierra Club, for instance, one of the most heavily funded groups, set the following as their top priorities for the year 1980: (1) enactment of the Alaska National Interest Lands Bill to seal off some 125 million more acres of land from any development; (2) prevention of siting of nuclear waste facilities; (3) prevention of siting of nuclear power plants and the phasing out of existing plants; (4) opposition to the Foley Bill in order to prevent some 50 million acres of federal land in the West from being opened to development; (5) prevention of coastal development; and (6) prevention of the completion or initiation of some 200 water projects.

Jack Abraham

FORD FOUNDATION

President: McGeorge Bundy, CFR
Vice-president: David E. Bell, CFR
Andrew F. Brimmer, CFR, Trilateral Commission
Hedley Donovan, CFR, Trilateral Commission
Robert S. McNamara, CFR
J. Irwin Miller, CFR
Irving S. Shapiro, CFR
Glenn E. Watts, Trilateral Commission, Aspen Institute

Grants to environmentalist organizations in 1979:

Alaska Native Foundation	$ 20,000
American Friends Service Committee	75,417
Aspen Institute	29,395
Center for Law and Social Policy	12,000
Conservation Foundation	25,000
Council on Foreign Relations (for "1980s Project")	167,000
Environmental Defense Fund	250,000
Fund for Peace	150,000
Hawaiian Coalition for Native Claims	25,000
INFORM	12,000
Institute for Democratic Socialism	5,000
Institute of Research on Public Policy	450,000
International Committee on Management of Population Programs	25,000
Keystone Center for Continuing Education	50,000
Massachusetts Audubon Society	10,000
Native American Rights Fund	600,000
Natural Resources Defense Council	1,740,000
New York Lawyers for the Public Interest	15,000
New York Alliance to Save Energy	15,000
North Carolina Center for Public Policy Research	25,000
Population Council	2,408,000
Scientists Institute for Public Information	25,000
RESOLVE	15,000
Sierra Club Legal Defense Fund	170,000
Survival International	60,000
Trilateral Commission	18,400
United Indians of All Tribes Foundation	25,000
Urban Environment Conference Foundation	106,000
Washington University Center for Biology of Natural Systems	79,443
Wisconsin Center for Public Policy	100,000
Youth Project (Institute for Policy Studies)	10,000
World Wildlife Fund	25,000

ATLANTIC RICHFIELD FOUNDATION

Director: Robert O. Anderson, CFR, Trilateral Commission, Club of Rome, Aspen Institute
Director: Thornton Bradshaw, CFR, Club of Rome, Aspen Institute

Grants to environmentalist organizations in 1979:

Aspen Institute	$1,186,000
California Conservation Project	15,000
Center for International Environmental Information	10,500
International Institute for Environmental Information	20,000
National Wildlife Federation	50,000
Nature Conservancy	162,000
RESOLVE	1,033,000
Sierra Club Foundation	30,000
U.S. Association for the Club of Rome	5,000
Wildlife Society	15,000
World Wildlife Fund	10,000

ROCKEFELLER FOUNDATION

David Rockefeller, CFR, Trilateral Commission
Theodore Hesburgh, CFR
Robert V. Roosa, CFR, Trilateral Commission
W. Michael Blumenthal, CFR, Trilateral Commission
James P. Grant, CFR
Lane Kirkland, CFR, Trilateral Commission
Bill Moyers, CFR
Victor Palmieri, CFR
Henry B. Schacht, CFR, Trilateral Commission
Clifton Wharton, Jr., CFR

Grants to environmentalist organizations in 1979:

American Civil Liberties Union	$ 13,500
Aspen Institute	313,000
Canadian Arctic Resources Committee	5,000
Conservation Foundation	15,000
Foxfire Fund	6,870
INFORM	6,116
Institute for Policy Research	109,000
International Center for Aquatic Resource Management	1,057,000
International Council of Scientific Unions	108,000
International Institute of Applied Systems Analysis (Club of Rome)	108,000
International Union for Scientific Study of Population	23,000
John Muir Institute	24,310

Lindesfarne Association	35,000
Massachusetts Audubon Society	34,000
Nature Conservancy	100,000
Population Council	2,365,000
Population Resource Center	200,000
Royal Institute for International Affairs (project relating to nuclear power)	150,000
Institute of Environmental Studies, *University of Toronto*	60,000
Office of Environmental Mediation, University of Washington	64,000
Worldwatch Institute	35,000
Zero Population Growth Foundation	37,500

ROCKEFELLER BROTHERS FUND

Henry Kissinger, CFR, Trilateral Commission
Dana S. Creel, CFR
William M. Dietel, CFR
William McChesney Martin, Jr., CFR
David Rockefeller and other family members

Grants to environmentalist organizations in 1979:

American Civil Liberties Union	$ 50,000
American Friends Service Committee	25,000
Aspen Institute	30,000
Caribbean Conservation Association	10,000
Center for Law and Social Policy	75,000
Conservation Foundation	50,000
Foundation for PRIDE (Florida)	45,000
International Federation of Institutes of Advanced Studies (Club of Rome)	60,000
HOSPICE	20,000
National Center for Policy Alternatives	70,000
Natural Resources Defense Council	50,000
New Alchemy Institute	120,000
Population Council	3,650,000
Survival International	25,000
Zen Center (San Francisco)	50,000
Northern Rockies Action Group	95,000

ROCKEFELLER FAMILY FUND

Rockefeller family members are trustees; all are CFR members at various times.

Grants to environmentalist organizations in 1979:

Alaska Trustees	$ 25,000
Pacific News Service	25,000
Citizens for a Better Environment	20,000
Conservation Foundation of New England	50,000
Environmental Action Foundation	20,000
Environmental Defense Fund	30,000
Environmental Law Institute	5,000
Environmental Policy Institute	40,000
Foxfire Fund	10,000
INFORM	15,000
National Audubon Society	25,000
National Wildlife Federation	20,000
Natural Resources Defense Council	35,000
Public Lands Institute	10,000
River Conservation Fund	10,000
Sierra Club Legal Defense Fund	75,000
Wilderness Society	25,000

STERN FUND

Jerome Wiesner, CFR
David Hunter, Ford Foundation

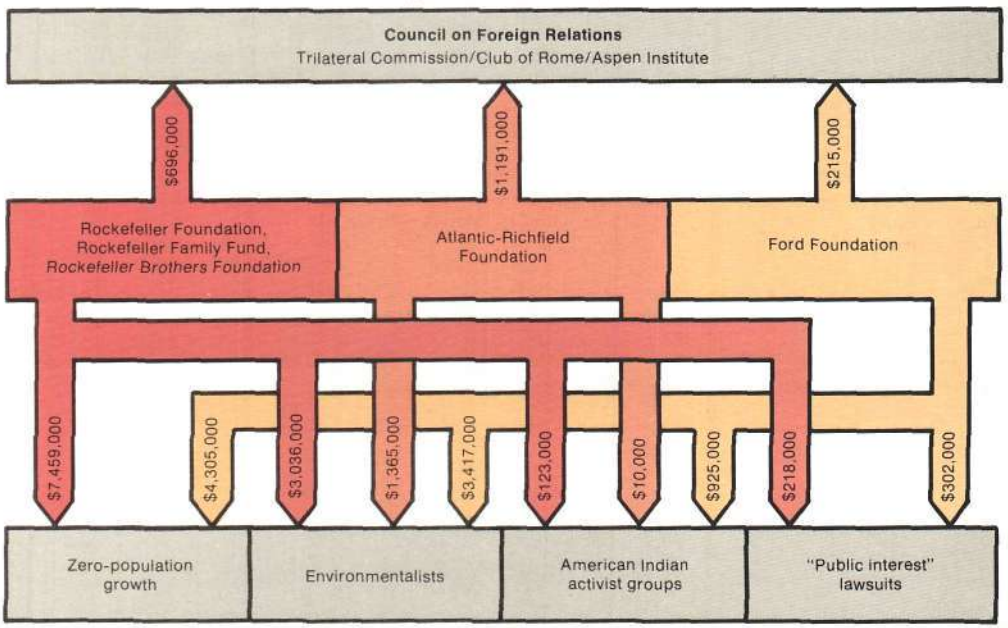
The Stern Fund, channeling the bulk of its *monies directly to the "street level" or* "direct action" environmentalist groups, made the following grants in 1979:

Alaska Public Interest Research Group	$ 20,000
American Civil Liberties Union	45,000
Clamshell Alliance	5,000
Crabshell Alliance	5,000
Environmental Policy Institute	15,000
Environmentalists for Full Employment	20,000
Institute for Policy Studies	20,000
Mid-Peninsula Conversion Project	5,000
Mobilization for Survival	15,000
Movement for Economic Justice	15,000
National Conference on Alternative State and Local Public Policies	25,000
National Land for the People Foundation	30,000
New England Coalition on Nuclear Pollution	15,000
Nuclear Information and Resource Service	15,000
Scientists Institute for Public Information	20,000
Southwest Research and Information *Center*	25,000
"Vermont Alliance" of the Youth Project (Institute for Policy Studies)	35,000

Source: *Foundation Grants Index*, 1979

WHO FUNDS THE ENVIRONMENTALISTS?

(Figures are for 1979 only.)



Coup Against Darwin's Dogma Opens Way for Biology Breakthroughs

The fundamental tenets of Darwinian evolutionary biology are inadequate in light of current scientific findings. This was the conclusion of 150 leading evolutionists attending an international conference in Chicago in late October.

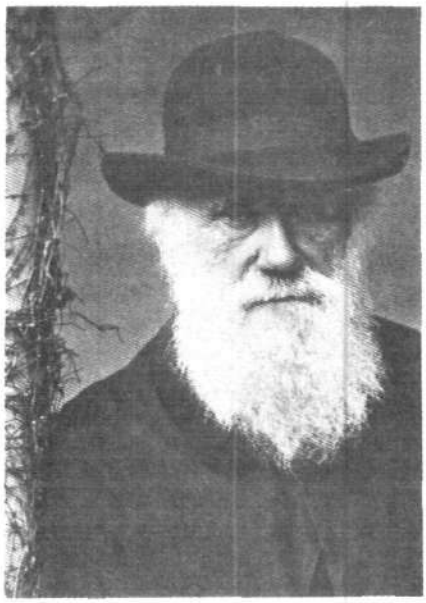
Citing much of the same data reviewed in Fusion *over the past three years, the conference participants stated that hypotheses based on Darwin's Malthusian ideology cannot account for evolution. If the implications of these findings are properly evaluated, we can expect to see some long overdue breakthroughs in biology.*

* * *

For 40 years, biology has been dominated by a form of molecular Darwinism called the *Modern Synthesis,* a term coined in 1942 by Julian Huxley.

According to the Modern Synthesis, random mutations at the gene level create genetic variation within a species population. Scarcity of available resources enables only what are called the most fit to survive and procreate. This survival of the fittest creates gradual shifts in the frequency of various genes in the population, called *microevolution.* And the gradually accumulated small genetic shifts then lead to speciation—that is, to the appearance of genetically distinct, reproductively isolated individuals.

The Modern Synthesis, promoted by Julian Huxley from 1942 on, emerged formally at a conference on the biological sciences held at Princeton University in 1947. E. Boesige, C.D. Darlington, T. Dobzhansky, E.B. Ford, V. Hamburger, J. Huxley, M. Lerner, E. Mayr, B. Rensch, G.G. Simpson, L. Stebbins, and A. Weinstein arrived at the theory as a consensus, thus sweeping away the intense prewar controversy on evolution that had dominated the late 1930s.



Charles Darwin: His theory doesn't work.

Despite 40 years of ideological dominance, the continuous efforts to force biological data and accumulated experimentation into the random-mutation—survival-of-the-fittest tenets of the Modern Synthesis have led to increasing frustration in the biological community and, finally, to what might be called a coup.

Microevolution Vs. Macroevolution

The coup was carried out by 150 leading evolutionists at a four-day October conference on macroevolution at Chicago's Field Museum of Natural History. The microevolution of the Modern Synthesis does not, they concluded, lead to macroevolution—the evolution of major differences that result in higher-ordered (taxonomic) evolutionary patterns.

The paleontologists played a leading role in this anti-Darwin coup, backed by an increasing amount of experimental evidence from genetics and other areas of the biological sciences.

Paleontologists have long insisted that species remain unchanged throughout most of their existence and then abruptly change morphologically, creating a distinct discontinuity in the fossil record. Charles Darwin countered the leading paleontologist of his day, Louis Agassiz, by claiming that the fossil record was very shoddy; Very gradual morphological evolution was occurring, Darwin insisted; paleontologists had simply failed to find the "missing links."

Chromosomal Shock Waves

"Certainly the record is poor, but the jerkiness you see is not the result of gaps, it is the consequence of the jerky mode of evolutionary change," argued conference participant Stephen Jay Gould of Harvard University.

"I'm tired of hearing about the imperfections of the fossil record; I'm more interested in hearing about imperfections of our questions about the record," said John Sepkoski of the University of Chicago.

"The record is not so woefully incomplete," claimed Steven Stanley of Johns Hopkins University. "You can reconstruct long sections by combining data from several areas." Last year, Stanley authored a book, *Macroevolution: Pattern and Process,* documenting the extensive paleontological evidence against Darwinian evolution.

This paleontological view is actually a return to the theory developed by Richard Goldschmidt in the 1930s. Goldschmidt stated that speciation emerges not out of a Darwinian mode, but out of a natural discontinuity that arises only through sudden changes on the chromosomal level. Random variation and natural selection, Goldschmidt said, produce only trivial population variation within a species—microevolution—not new speciation or higher taxa—macroevolution.

The paleontological barrage supporting Goldschmidt was backed by Richard Lewontin, a Harvard geneti-

cist. "Most conceivable organisms don't exist. Why are there no organisms with wheels? Why are there no six-legged vertebrates?" Lewontin expressed the skepticism of many at the Chicago meeting that random variation and natural selection can account for the apparent *directedness* of evolution.

Then Guy Bush, a geneticist from the University of Texas, presented extensive evidence for chromosomal evolution. Chromosomal rearrangement could prosper in species organized in harems, he said, in which such changes could be reproduced in a large number of offspring, some of which might later interbreed. "Such favorable social organizations are relatively common," said Bush, "in horses, many primates, and rodents, for instance."

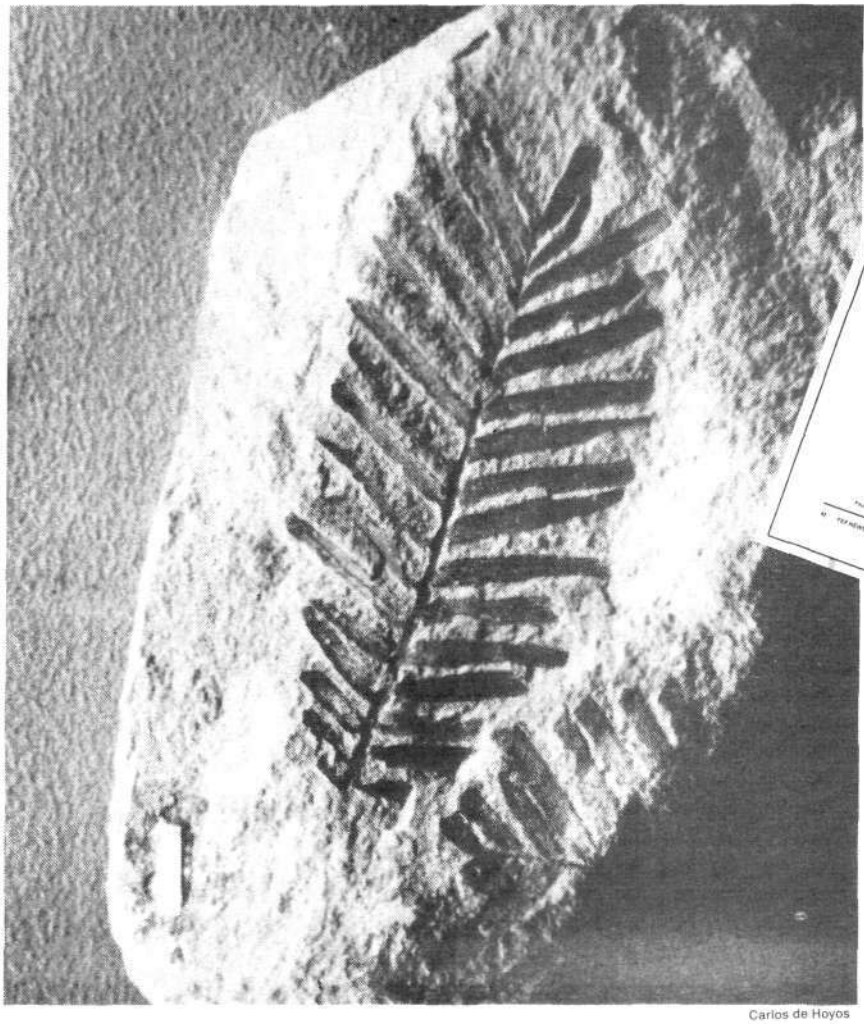
Although many at the conference were intent on attacking the Modern Synthesis, the primary question, that of the underlying causality in biological evolution, was virtually ignored. That question forces the issue well beyond Goldschmidt.

In a March 1980 article in *Fusion* ("Evolution: A Riemannian Approach to Biology"), this author looked at the extensive work of Guy Bush on chromosomal evolution from the standpoint of causality. Rapidly evolving placental mammals and herbal angiosperms like grasses act collectively, as a singularity, that expands and transforms the previous boundaries of the biosphere, generating a more differentiated environment with a net cumulative increase in biological energy flow.

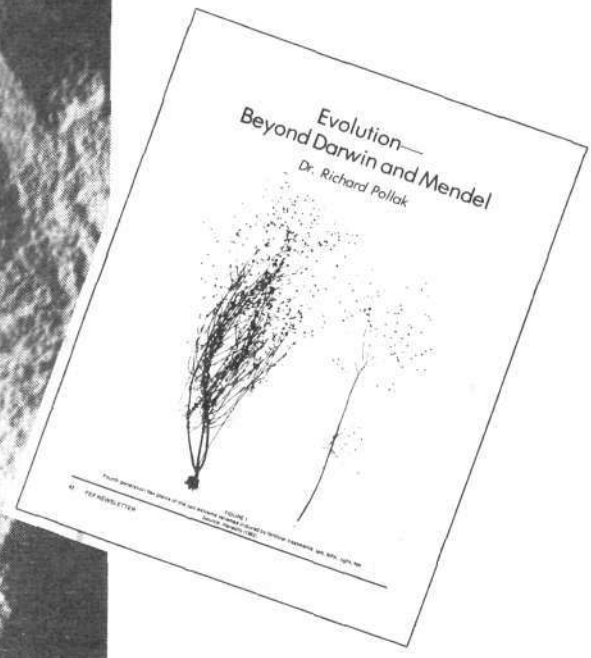
The significance of the permanent, pair-bonded harem from this standpoint goes well beyond its obvious advantage as a mode of perpetuating sudden chromosomal rearrangements. The harem unit, as a form of social organization within this several-species singularity, amplifies in a nonlinear way the associated, general increase in biological energy flow into future generations, both breeding females and their young.

Crucial experiments on flax, for example, indicate that highly favorable conditions, rather than scarcity and survival of the fittest, generate a maximizing metabolic energy flow in flax plants, causing large transitional increases in DNA content per cell nucleus and inherited qualitative transformations in the size of future generations of flax plants. (See "Evolution—Beyond Darwin and Mendel," by Dr. Richard Pollak in the *FEF Newsletter*, May 1977.)

But perhaps the greatest benefit of



Carlos de Hoyos



This fossil of a fern leaf, formed during the Triassic period some 220 million years ago, is part of the extensive paleontological evidence that argues against Darwinian evolution. The inset shows the May 1977 publication of the Fusion Energy Foundation by Dr. Richard Pollak where the flax experiments were discussed in a refutation of Darwin.

approaching biological evolution as a negentropic process is the crucial, causal clue it may provide for attacking clinical problems such as cancer and aging.

As discussed in this author's article cited above, cancer can be approached as the inverse of evolution. While evolution is mediated by chromosomal rearrangements or by qualitative and quantitative transformations in DNA content under negentropic conditions, cancer occurs as chromosomal rearrangements under entropic drops in biological energy throughput. This is suggested both by clinical case studies and by the 20-year studies of the Ehrlich-Lettré-Diploid mouse tumor.

Such a hypothesis has just been epidemiologically confirmed by John Cairns of the Imperial Cancer Research Fund of London. Cairns announced at a recent Washington, D.C. International Symposium on Aging and Cancer that cancer is the result of unrepaired *chromosomal* rearrangements, not random unrepaired point mutations.

This is important not only in terms of finding cures for cancer, but also in terms of ending the fallacious method involved in the Environmental Protection Agency's hunt for carcinogens. For example, Cairns's findings confirm the position advanced in another article by Dr. Pollak ("There Is No Cancer Epidemic," *Fusion*, Aug. 1978) that there is no scientific basis for using the standard Ames test for carcinogens.

Cairns compared the cancer rate of patients with a genetic disorder called Xeroderma pigmentosa—an inability to repair the common point mutations in DNA caused by the ultraviolet radiation in sunlight—and the cancer rate of patients with Bloom's Syndrome, an inability to repair chromosomal rearrangements. Although Xeroderma pigmentosa patients have a higher-than-average rate of skin cancer, they have a normal rate of all other internal cancers.

In contrast, Bloom's Syndrome patients develop all cancers 100 times more frequently than the general population.

At the same conference, George Martin of the University of Washington discussed a similar correlation between high cancer incidence and chromosomal rearrangements among patients with Werner's Syndrome, a rare disease involving premature aging.

This combination of results indicates that a broad basic research program involving studies in cancer, immunology, genetics, cell kinetics and structure, and evolution and using techniques such as recombinant DNA can produce fundamental progress in biology.

—*Carol Cleary*

FAO Clears Herbicide 2,4,5-T

The widely used herbicide 2,4,5-T, under attack by environmentalists in the United States, has been given a clean bill of health by the Food and Agricultural Organization of the United Nations (FAO).

A panel of experts from FAO recently released a report that supported the views of other nations that dioxin (known as TCDD) levels in the herbicide were not found in significant amounts in residue of foodstuffs or water.

"In view of the low level of TCDD in technical 2,4,5-T and formulated 2,4,5-T herbicides (0.1 parts per million), the rate of use of 2,4,5-T, the situations in which it is used and the knowledge that TCDD is readily degraded in sunlight, the panel agreed there was no likelihood of TCDD residues occurring in food," the report said.

Despite reluctance from the Environmental Protection Agency, the FAO also established acceptable human daily intake and residue levels for 2,4,5-T with its trace contaminant TCDD. The FAO and several countries have failed to detect 2,4,5-T residue in samples above the levels of analysis, or 0.1 parts per million.

The EPA is currently conducting hearings on banning the important herbicide.

GAO Reports on Conservation Hazards

Energy conservation may be hazardous to your health. This is the finding of a congressional study by the U.S. General Accounting Office on how various heat-saving energy conservation measures affect the health of individuals in homes, schools, and office buildings.

The GAO's basic conclusion is that various methods of energy conservation result in a substantial increase in the accumulation of potentially dangerous pollutants.

Some of these pollutants are directly produced by conservation measures; for example, urea-formaldehyde foam insulation, which the GAO cited as potentially dangerous. In this case, the GAO report concludes that by creating tax incentives to encourage citizens to better insulate their homes, the federal government has contributed to this problem.

Another cited hazard is that as buildings are better sealed off from the cold winter air, the exchange of air between the inside and outside of the buildings becomes greatly reduced, thereby increasing the residents' exposure to pollutants.

As the GAO summary notes, ". . .in attempting to resolve the nation's energy shortage, the government may very well be advocating solutions which will adversely affect public health."

A Review of the President's Report

Putting U.S. Science Education Back Together

A report commissioned by President Carter in Feb. 1980 and released in Oct. 1980, *Science and Engineering Education for the 1980s and Beyond*, documents the precipitous decline in U.S. science education and offers some directions to return the population to scientific literacy.

Authored by the National Science Foundation and the Department of Education, the report, although flawed in several respects, provides a mandate from the highest levels of the scientific establishment to turn education away from the so-called socially relevant courses toward those that will prepare the U.S. population to meet the challenges of a fast-approaching fusion era.

The opening paragraphs of the report tell the story of U.S. educational collapse in unambiguous language:

There is today a growing discrepancy between the science, mathematics, and technology education acquired by high school graduates who plan to follow scientific and engineering careers and those who do not. Scientific and technical literacy is increasingly necessary in our society, but the number of our young people who graduate from high school and college with only the most rudimentary notions of science, mathematics, and technology portends trouble in the decades ahead. Thomas Jefferson's axiom that an enlightened citizenry is the only safe repository of control over the ultimate processes of society surely includes the necessity for scientific and technological enlightenment. While students who plan scientific and engineering careers are receiving an adequate educational foundation, more students than ever before are dropping out of science and mathematics courses after the tenth grade, and this trend shows no signs of abating.

The truth of this dismal situation can be partially confirmed by looking at the results of standardized college entrance examinations. Figure 1 shows the steady decline of mathematical and verbal skills from 1952 to 1977. The confirmation is only partial because these examinations are taken by students who intend to go to college and therefore are more likely to pursue science and mathematics courses in high school. The general picture is worse.

"The declining emphasis on science and mathematics in our school system is in marked contrast to other industrialized countries."

The presidential report draws several ominous conclusions from the assessment of the current situation:

- *Today, people in a wide range of nonscientific and nonengineering occupations and professions must have a greater understanding of technology than at any time in our history. Yet our educational system does not now provide such understanding.*
- *Students who take no more mathematics and science after their 10th year in school have effectively eliminated, by the age of 16, the possibility of science or engineering as a career. The pool from which our future scientific and engineering personnel can be drawn is therefore in danger of becoming smaller, even as the need for such personnel is increasing.*
- *Increased emphasis must be given to aiding those who have been excluded, for too long, from careers in science and engineering. We stress this imperative both for reasons of equity and to increase the size of the pool of talent from which the nation's scientists, engineers, and technicians can be drawn.*
- *The declining emphasis on science and mathematics in our school systems is in marked contrast to other industrialized countries. Japan, Germany, and the Soviet Union all provide rigorous training in science and mathematics for all their citizens. We fear a loss of our competitive edge.*

The report notes that because of the structure of America's educational system, with its more than 17,000 independent school systems, it is neither possible nor desirable to impose national standards for the quality of a high school diploma. By exercising his leadership, however, the report suggests that the president can significantly direct the shaping of educational policy and the spirit in which students engage in their studies.

To this end the report recommends the creation of a President's Council on Excellence in Science and Technology Education. This body would "provide a vehicle for presidential statements aimed at teachers' organizations, state and local school officials, and colleges and universities about the need to raise science and mathematics requirements for all secondary school students."

What the report omits is that this approach, of course, makes sense only if the administration is committed to technologically vectored programs that inspire popular enthusiasm for science and technology, like the spirit created during NASA's Apollo program. In a climate of austerity and environmental constraints on development, no amount of exhortation could convince people that the future lies in being scientifically literate.

The report's other recommendations to increase general education in the sciences include federal assistance to provide adult education courses and to aid science and technology museums.

It also recommends the development of new teaching materials—with emphasis on electronics and computers—for use in secondary schools. The report suggests that existing fed-

eral programs to aid teachers should be focused on the needs of teachers in science, technology, and mathematics. Furthermore, a special effort is recommended to provide counseling for students about career opportunities in scientific and technical fields.

The report offers no specific criticism of the curricula that led to the need for a vast revision in U.S. science education. However, general remarks sprinkled throughout the report hint at the kinds of curriculum changes that would accompany a major effort to develop the kind of universal scientific education that characterizes other industrialized countries.

The authors point out, for example, that the current trend to develop "basic skills" is inappropriate because it focuses on the attainment of necessary but merely mechanical computational skills in mathematics and does not view science as "basic." At the same time, the report notes, the curriculum development work of the late 1950s and early 1960s led to the widespread use of excellent science course material for professionally oriented high school students that was generally too abstract and too divorced from technological applications to be of much use to others.

It is important to note in this context that the eminent German mathematician and educator Felix Klein, who was largely responsible for the development of rigorous science education in pre-World War I Germany, repeatedly insisted on the unity of pure and applied science and mathematics and the necessity of teaching them as one. One of the major tasks of educational reform will be to develop the most advanced pedagogical techniques, making use of the historical precedents for this task: such as Göttingen University and the Ecole Polytechnique.

Professional Education

A major subdivision of the report is devoted to professional education for engineers, scientists, and technicians.

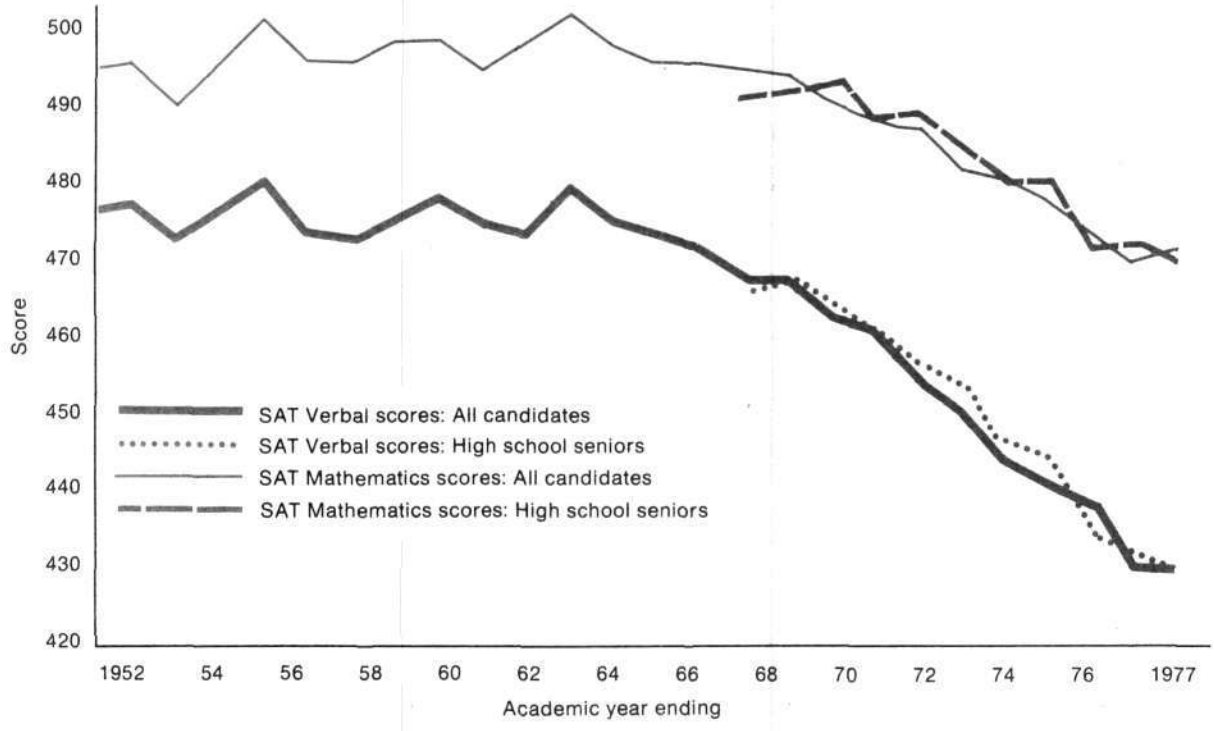


Figure 1
THE DECLINE IN SAT SCORES

The collapse in secondary education has been reflected in a continuing decrease in the scores of college-bound high school students on standard achievement tests, such as the Scholastic Aptitude Test (SAT) scores shown here. According to a recent report by the College Entrance Examination Board, called On Further Examination, *the marked decline in mathematics scores is attributable to several factors. First and foremost, the College Board says that the decline is the result of the introduction of the New Math into curricula. A second major contributing factor cited is the introduction of experimental classroom settings, the so-called open classroom that features very little input from the teacher in the educational process. The College Board also attributes a significant part of the decline in mathematical skills to the rise in functional illiteracy that can be seen in the declining verbal scores.*

In this section, the authors conclude:

There should be adequate numbers of engineers and scientists at all degree levels to fill available positions in 1990—provided *we assume that the nation does nothing different in the future in the ways it trains and makes use of engineers and scientists to address national problems. Since the technological complexity of our society is almost certain to increase, however, we believe that taking that assumption as a given would not be in the best interests of the nation.*

With this caveat, the authors express their disagreement, stated later in the report, with the imposed necessity of relying on econometric projections from current trends to estimate the needs for professional scientific personnel in the future. As they recognize, a zero-growth economy won't create new demands for science professionals.

Judging from the initial report of the Reagan administration's energy task force, the econometric assumptions enforced on this report won't hold, and there are good prospects for economic growth.

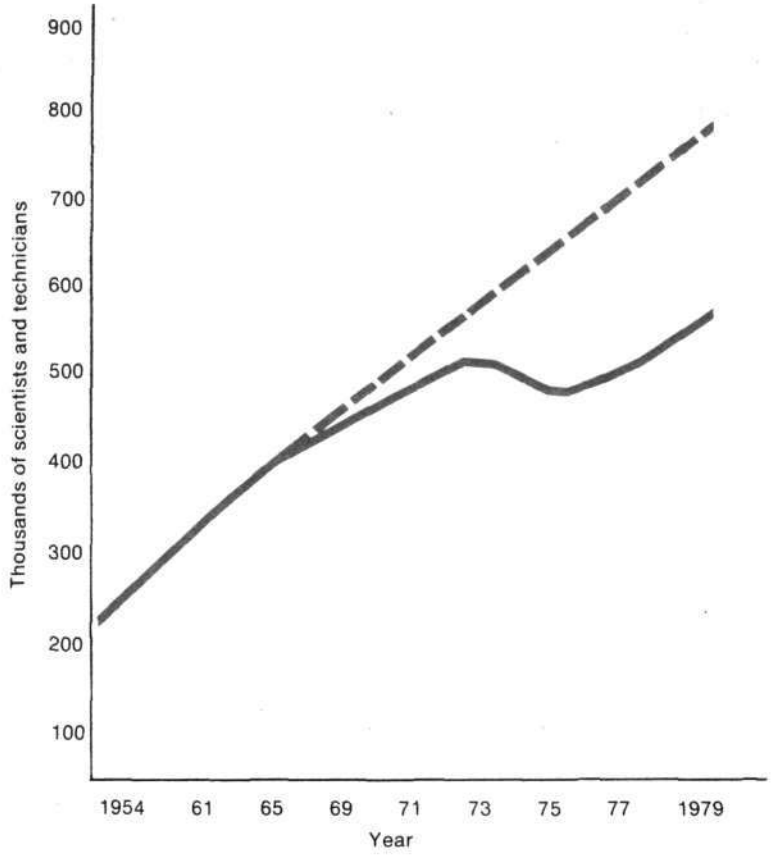


Figure 2
U.S. SCIENTIFIC MANPOWER

The solid curve represents the actual numbers of U.S. scientific personnel for 1954 through 1979, showing a rapid takeoff in the 1960s that flattens out as NASA and other high-technology frontier areas were gutted. The dotted curve shows the numbers of scientific personnel that would exist if the momentum of the NASA years had been maintained. The actual manpower needs for a fusion-based economy would be off the scale of this diagram.

Specifically, the Magnetic Fusion Energy Engineering Act of 1980 makes a national commitment to build a fusion reactor in the next 20 years. In all likelihood, this legislation will be followed by a similar bill to accelerate the inertial confinement effort.

Furthermore, the breeder program and other advanced fission programs are slated to be relaunched now that Carter is out of office.

If these national tasks are combined with the resumption of manned space flights directed toward near-term colonization of the solar system, the rapidly developing areas of microelectronics, genetic engineering, and the technologies that will spin off from these projects—plus the tremendous demand (especially for engineers) to design underdeveloped-sector industrialization schemes—then clearly the nation will have a shortage of all kinds of technically competent personnel to meet its goals.

Figure 2 presents the rate of growth for U.S. scientific personnel in recent years. The extrapolation curve shows how the rapid growth of the 1950s and 1960s was aborted, indicating the shortfall in personnel that must be made up as a base line for further progress.

Although the authors of this report disqualify themselves from making projections for demand under conditions of a recommitment of the United States to scientific and technological excellence, they recommend actions to avert spot shortages of personnel in statistics, computers, and in certain engineering subfields.

These recommendations, of course, are inadequate to meet a significantly higher demand for scientific and technical professionals. To meet the needs of a fusion economy would require a well-thought-out program combining the best aspects of the NSF's 1950s mandate, the National Defense Education Act of 1958, and those parts of the NASA legislation that concern education. Despite its shortcomings, however, this education report provides a starting point for the new administration to turn the situation around.

—Dr. John Schoonover

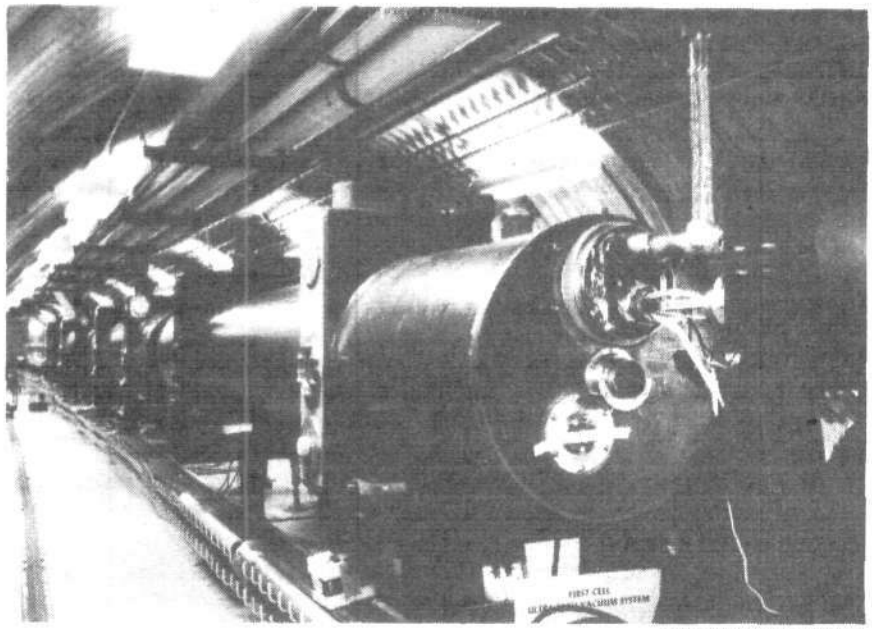
Isabelle Is Alive and Well

To read recent coverage of the construction of the Brookhaven Laboratory's new high-energy colliding beam particle accelerator known as Isabelle in *Science* (Nov. 21) and the *New York Times* (Nov. 28), you would think that the project was one of the worst conceived, most poorly executed adventures ever to have hit the scientific community.

Science magazine's William J. Broad described the accelerator as "teetering on the brink of a technological failure that would set the high-energy physics program in the United States back by many years. . . ."

Walter Sullivan, science editor of the *New York Times*, echoed this gloomy refrain: "It [Isabelle] will probably not be able to reach its most ambitious goal of energizing two colliding proton beams to 400 billion electron volts each."

Spokesmen for the High Energy Physics Group at the Brookhaven National Laboratory have denied these charges, asserting that Isabelle is alive and well, and that its problems are solvable.



Brookhaven National Laboratory

The Isabelle first cell with three dipole magnets and one quadrupole magnet assembled in a prototype tunnel for systems testing.

The Isabelle Concept

Isabelle has been designed to probe deeper into subatomic matter than any previously developed particle accelerator (once known as atom smashers). To do this, it uses the technique of colliding *beams* of highly energetic particles, in this case protons. This technique is much more effective than colliding a beam of particles with a stationary target, since much more energy can be put into the collision, allowing a deeper penetration into the structure of the protons.

To accomplish this task, the designers have made use of superconducting magnets, a frontier technology with many practical potential applications, including loss-free transmission of electricity and plasma confinement in fusion reactions.

The Nov. 21 *Science* article contended that these superconducting magnets would not work properly. "If Isabelle engineers develop weaker magnets that are easier to make, as some outside observers have suggested, the energy of Isabelle's proton beams would fall from 400 to around 300 billion electron volts (GeV), making the machine less attractive for performing experiments."

The Real Story

Brookhaven's associate director for high energy physics, Dr. R. Ronald Rau, has refuted this claim, saying that the latest tests indicate that the magnets are capable of achieving at least 360 GeV. The High Energy Physics Review Panel has indicated that this reduction in energy of up to 10 percent from the original projections is acceptable, and that the machine would still be able to do its job.

Spokesmen for the laboratory expressed shock that such inaccuracies about the project should appear in print. There have been unanticipated and serious problems with the magnets, they said, but these problems are being vigorously worked on and are not considered to be unsolvable, by any means.

According to Rau: "The primary reason we are experiencing this kind of problem at the construction stage, rather than prior to it, is that the superconducting magnet technology has turned out to be more difficult than any of us thought it was going to be. It has pulled surprises on us after we thought that we had demonstrated that it was not going to be all that difficult."

The Funding Problem

Rau continued: "There is a whole other long-range problem, though, that has to do with the funding of research. The funding at Brookhaven started to level off and then decrease in about 1968. This did not allow the laboratory to keep going in the sense of new things for young people to do. A keen edge on the staff that works on accelerator design and construction was lost.

"When we started the construction

of Isabelle, it was after a very long hiatus in construction at Brookhaven. Our people were not really accustomed to construction projects. That is attributable to the fact that the field has been pretty badly funded now for 12 or 13 years.

"By comparison, CERN in Geneva has continued to get new projects, so that their team has not only continued to get larger, but it has kept that keen edge, has kept honed to do new things.

"When we started Isabelle, we began with the people we had here, who were experienced in accelerator design, and we have added to that team. But is very hard to hold good people these days because industry is paying such enormous salaries compared to what we can pay. Many fewer qualified people are being produced. This is true for engineers especially, but also for physicists. Even at this late date we are missing a few very key people for the project."

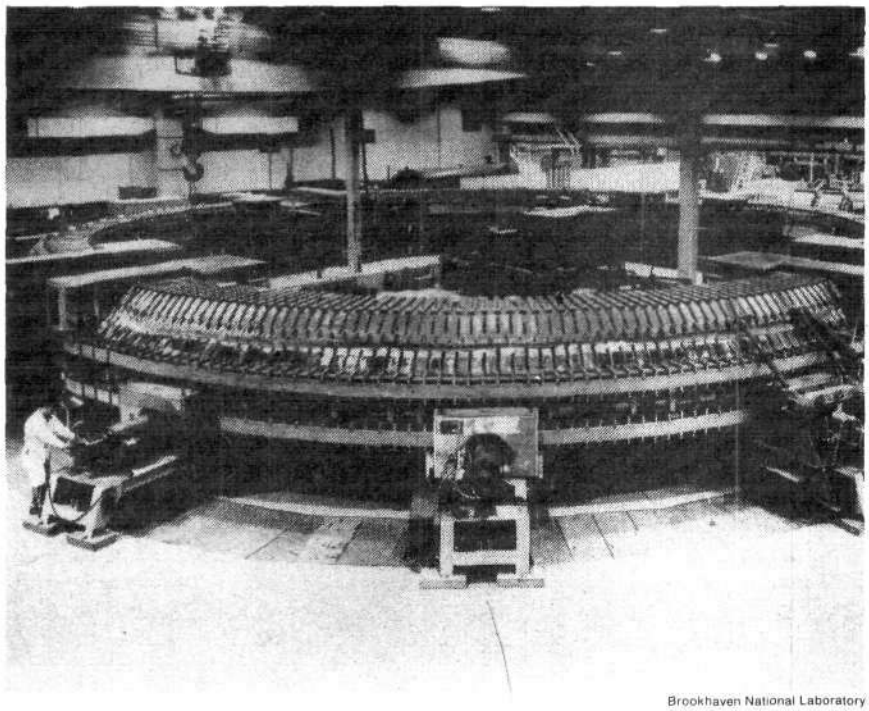
Essential Research

Building high-energy accelerators is not a luxury that we can afford to dispense with. The construction of accelerators provides experimental information of fundamental importance for understanding how matter is constituted and how it can be transformed, and in the process, like spaceflight, it brings forth progress in new and emerging technologies that might otherwise be much more slowly developed.

As Rau pointed out: "Brookhaven has done work with fairly large superconducting magnets for quite some time. We have also been working on superconducting transmission lines. Some of our people, with their experience building large superconducting magnets for bubble chambers, early on contributed ideas and information to the people working on magnets for fusion.

"There is a lot of ongoing exchange of ideas back and forth between the fusion people and the accelerator people. The first really big superconducting magnets ever made were made by high energy physicists for big bubble chambers in the late 1960s and early 1970s. These magnets were an example for the fusion people, who are now building ones that are much bigger."

—Dr. John Schoonover



Brookhaven National Laboratory

A 1960 predecessor to Isabelle: a synchrotron that accelerated protons in a circular path to speeds approaching the velocity of light.

Gilbertson Addresses N.J. Engineers

Jon Gilbertson, FEF director of nuclear engineering, addressed a meeting of 80 engineers, consultants, and contractors at the Dec. 4 gathering of the North Jersey Chapter of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). The subject of Gilbertson's presentation at the Governor Morris Inn in Morristown, N.J. was "Nuclear Power Today and the Future of Fusion Energy."

"Is there anyone present who could supply New York's Indian Point 2 nuclear plant with a good air conditioning system that would keep the Hudson River water out of the reactor's containment building?" Gilbertson asked his audience.

The American System

After describing what actually had happened with the Indian Point 2 water leak—compared to what the antinuclear media have led people to believe happened—Gilbertson told the audience that this was another example of how the zero-growth groups are using the nuclear power issue to stop what he called "the American System of economic development, its commitment to scientific and technological progress."

Gilbertson's presentation focused on the current status of fusion power development and the significance of the Magnetic Fusion Energy Engineering Act of 1980 for achieving commercial fusion power by the turn of the century. Gilbertson also discussed the FEF's role in winning the battle for passage of the McCormack fusion bill, and explained the FEF goals for 1981.

Gilbertson reported that the highlight of the meeting was the rush from the audience to grab up issues of the FEF's newest publication, *The Young Scientist*, after Gilbertson described how this would be a primary weapon in the fight to make America a scientific leader again. The importance of reintroducing children to science and development in the schools needed little explaining to this audience, Gilbertson said, many of whose children come home from school telling them that "nuclear power is dangerous and technology is bad."

FEF Regional Membership Meetings
(partial listing)

Feb. 5—Springfield, Mass.
Feb. 16—Los Angeles, San Diego, San Jose, Calif.; Richland, Wash.
Feb. 24—Washington, D.C.
Feb. 26—New Haven, Conn.

For more information on these and other meetings call the FEF New York office, (212) 265-3749.

FEF in the News

Times-Call, Longmont, Colo., Nov. 15, 1980
"Hamilton's Economics May Help Reagan," by Marge Easton

Updating Alexander Hamilton's original monetary theories can halt inflation, encourage reindustrialization, provide a stable foreign policy and balance the budget, a New York writer claimed Wednesday in Denver.

Criton Zoakas, editor-in-chief of the weekly *Executive Intelligence Review*, told a press conference that the American System of Economics followed by the first secretary treasurer of the United States is being proposed to the new president, Ronald Reagan, as an alternative to other economic theories. . . .

Zoakas was in town to explain the theory during a conference of the Fusion Energy Foundation, a New York based group interested in reindustrialization and the eventual export of nuclear power to be produced by fusion reactors.

Sentinel, Grand Junction, Colo., Nov. 16, 1980
"Firm Unveils 'Major' Water Diversion Plan"

An ambitious plan to nearly double the amount of fresh water in the United States by channeling runoff from Alaska and the Yukon territory in Canada has been proposed by a nonprofit foundation.

Nick Benton, Western regional coordinator for the Fusion Energy Foundation, said Alaska alone produces 400 million acre-feet of runoff annually—more than that of the entire lower 48 states. . . .

The plan calls for collecting the runoff from a 1.3 million-square-mile area of Alaska and the Yukon Territory, and diverting it to the 500-mile-long Rocky Mountain Trench. . . . Under the North American Water and Power Alliance Plan, designed in 1964 by the Ralph M. Parsons Engineering Co. of Pasadena, Calif., 80 million acre-feet would end up in the United States, and another 80 million would be split between Canada and Mexico, Benton said. . . .

The foundation espouses the plan as a part of its overall scheme to rebuild the U.S. economy through the use of high technology, especially nuclear fusion.

Gazette-Telegraph, Colorado Springs, Colo., Nov. 14, 1980
"Fusion Foundation Outlines Plan to Nearly Double U.S. Freshwater"

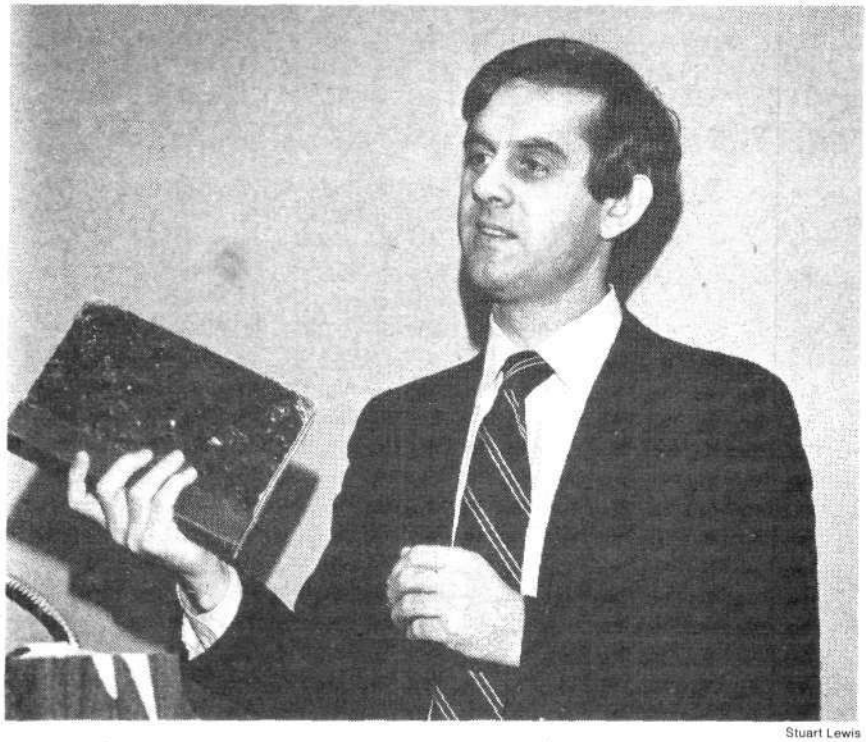
Nick Benton, Western regional coordinator for the Fusion Energy Foundation . . . outlined the scheme Wednesday night at a one-day conference in the Brown Palace Hotel—the fifth of six such meetings in the Fusion Energy Foundation's national conference series.

The foundation espouses the plan as a part of its overall scheme to rebuild the U.S. economy.

FEF Sponsors Riemann Lectures

Uwe Parpart, director of research for the FEF, is giving a series of public lectures in New York City on "The Unity of Mathematics: Riemann's Unknown Program for Mathematical Physics" in December and January. Parpart, who has done extensive research in the Riemann archives in West Germany, is the author of a forthcoming group of books on Riemann's life and work. He is also the codeveloper of the LaRouche-Riemann model.

Nearly 150 people attended the first lecture Dec. 17, where Parpart discussed the line of science development reaching back to Kepler, Leibniz, and the Ecole Polytechnique. He illustrated a summary of Riemann's career with color slides taken on his 1980 visit to West Germany.



Stuart Lewis

Parpart showing a volume of Riemann's collected works in German, most of which are not available in English.

by Harley Schlanger, FEF Membership Director

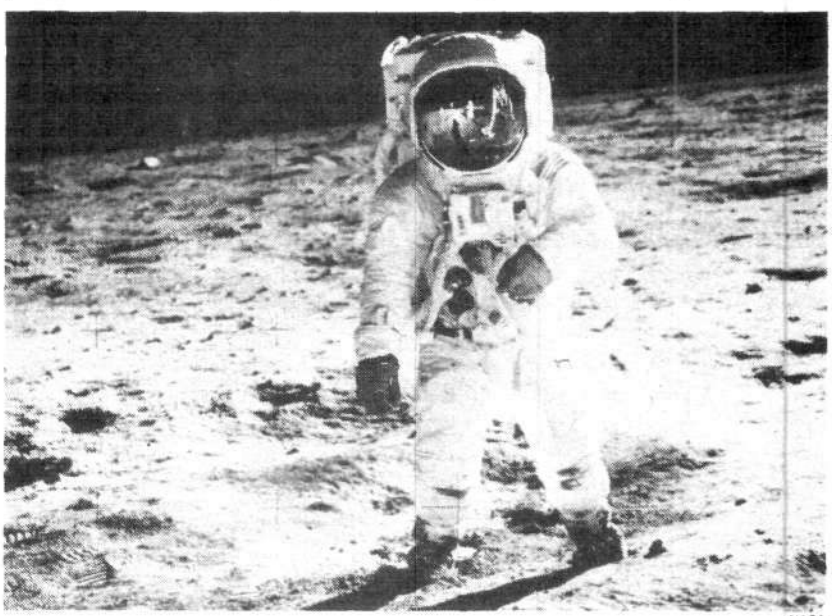
Let's Win the High-Technology Fight

How many investment opportunities offer a return of $14 for each $1 invested? No, I'm not talking about some fast-buck pyramid shell game, real estate speculation, or casino stock, all of which drain real wealth from the economy while feeding inflation. This was the conservatively estimated rate of return for the U.S. economy on the money spent by NASA's Apollo program. For each dollar spent, fourteen dollars were returned to the economy in new jobs, new technologies, and new factories; new industries emerged, and existing industries—such as computers—received a tremendous boost.

The NASA program was not initiated without a political fight. Even today, it is under attack. Some of NASA's liberal critics say that it has been nothing but a boondoggle for "big business," that the money spent should have gone for "social programs." Others complain that it violates the principles of "free enterprise" because it is a centrally directed government program.

Both arguments are ridiculous. They ignore the most outstanding feature of the NASA experience: Precisely the interface between centralized government direction and private-sector initiative has made NASA a success. The nation has been to the moon and beyond and has experienced sound, productive economic growth. It would seem that this success story would encourage other national mobilizations and ease their passage through Congress.

Unfortunately, this has not been the case. As many of you know, it took almost five years of organizing and educating by the FEF, our members, and supporters, working with representatives of industry and the labor movement, to create the support necessary for a small group of Congressmen, led by Mike McCormack, to pass legislation committing the nation to build a fusion energy reactor by the year 2000. Full implementation of this law, which is still an open question, will provide even more benefits to the economy than the NASA program did.



NASA

"The NASA program was not initiated without a political fight"— and that fight is still continuing.

The fight for the fusion legislation was a long and often discouraging one. And the zero-growth, Malthusian energy policy passed by Congress under the direction of the Carter administration only worsened the situation.

But we won this first battle, and we have learned a lot. *Your* participation made the difference. Many Congressmen have told us that the postcards, calls, and telegrams they received from you in support of the McCormack fusion bill convinced them to vote for it. With the electorate's rejection of zero-growth antiscience policies ringing in their ears, you can be sure that the new Congress will be more responsive to the FEF constituency than ever.

We must ensure that this mandate for growth and high technology is put to good use. To do this, we must be organized. We have an important role to play in shaping the direction of the new Reagan administration, especially in the first 100 days.

What You Can Do

Here's what *Fusion* readers and FEF members can do:

- Send in the attached postcard to President Reagan and get your friends to do the same. Call or write us to get more postcards to distribute.
- Attend the FEF regional membership meeting in your area during February. An FEF representative will call members about the time and place.
- If you are not already an FEF member, join now and bring your friends and colleagues to the regional membership meetings. We have close to 15,000 members now, and our 1981 goal is 50,000.

Executive director Morris Levitt, other FEF staff members, and I will be attending these meetings, and we look forward to working with you.

Showing Some Nuclear Spunk

The Washington Public Power Supply System has aroused the ire of local environmentalist groups by distributing a pamphlet that takes them to task for trying to "dismantle this energy system to promote a lower quality of life for all citizens and condemn the less fortunate to a substandard existence."

The pamphlet, "Nuclear Power," was written by R.W. Deutsch of the General Physics Corporation, and the power company is distributing it to schools in Washington state as part of a public education program. A spokesman for the utility said that it will continue to distribute the pamphlet despite complaints from environmentalists, who have branded the plain-spoken description of environmentalist political goals as "paranoia."

Copies of the pamphlet can be obtained from the General Physics Corporation, 1000 Century Plaza, Columbia, Md. 21044, (301) 730-4055.

* * *

Abelson Recognizes Science Crisis

"In comparison with other advanced countries, the United States is becoming a nation of scientific illiterates," Philip Abelson, editor of *Science* magazine, writes in a Nov. 28 editorial. He then describes the situations in Japan, West Germany, and the Soviet Union, where scientific and engineering education are highly valued and promoted.

Using the recently released presidential report, *Science and Engineering Education for the 1980s and Beyond*, as a springboard, Abelson laments the nation's current plight: "Our present policy is moving us toward becoming a colonial supplier of raw materials and food to more advanced countries and is placing us in a position of increasing peril."

(Ironically, this is a policy Abelson has cheerfully advocated in the past for the Third World and even for the United States.)

Instead of posing a positive program to turn the situation around, however, Abelson rather lamely ends his editorial: "Unfortunately, there is no crisis to alert the public. The one positive factor operating at this time is a strong demand for engineering graduates, which is driving up salaries. Overcoming scientific illiteracy will take decades."

* * *

Heritage Foundation Goes Green?

The goals of the environmentalist movement should be incorporated into the American political mainstream, advises an article published in the latest issue of *Policy Review*, the journal of the Heritage Foundation. This Washington-based think tank serves as an advisory body to many pronuclear groups.

"Environmentalism is an expression of 'aristocratic conservatism,' an alliance between 'the shadow aristocracy, the good families,' and the 'college-educated, white collar workers,' " according to author William Tucker, a contributing editor to *Harper's* magazine.

There is, Tucker states, "a hard core of truth in the worries which environmentalists express. It is my feeling that it will be the task of American politics to incorporate the major issues which environmentalists have raised without adopting the conservative and elitist cast which environmentalists have given them."

Readers may note the similarity to Senator Tsongas's speech to the AIF reported on in this issue's Washington section. Who's writing the script?

* * *

Soviets on New Math: 'Verbal Crabgrass'

The late-1960s New Math reform of Soviet secondary school mathematics teaching has come under sharp criticism in *Kommunist*, the magazine of the Communist Party of the Soviet Union. *Kommunist* #14 for 1980 (cleared to the press Sept. 25) carried 15 pages on the intense debate over the efficacy of the New Math curriculum, consisting of a letter by internationally known Academician L. Pontryagin titled "On Mathematics and the Quality of Teaching It" with supporting editorial commentary.

Pontryagin's criticism is aimed above all at the set-theoretical, New Math content of the new courses, which he describes as formalistic, barren, and a bunch of "verbal crabgrass." "Relatively simple, clear formulations" of central concepts like vector, equation, and function have been replaced by "cumbersome, deliberately complicated ones" that are "useless, because they cannot be applied in physics, mechanics, or any

other science," Pontryagin wrote. The deterioration of teaching has reached the point, he said, where graduating students are incapable of passing university entrance examinations and do not have the basic skills for engineering and other technical professions.

Pontryagin's evaluation of the program's flaws and the urgent need to correct them was supported by other leding Academicians, including I.M. Vinogradov, director of the Keldysh Institute of Applied Mathematics. Its publication in *Kommunist* gives it the weight of a party intervention into the situation.

The next issue of Fusion *will feature an analysis of the New Math and the damage it has done in the learning of mathematics.*

Wood That It Were

Wood-burning stoves, the romantic alternative of the U.S. environmentalists, are about as carcinogenic as anything you could imagine. The Nov. 13 issue of the popular British science magazine *New Scientist* lists some of the products from wood combustion in an article titled "Wood Stoves: The Trendy Pollutant."

The pollutants include: benzo(a)-pyrene, dibenz(a,*h*)anthracene, benzo(*b*)fluoranthene, benzo(*j*) fluoranthene, dibenzo(a,*l*)pyrene, benz(a)anthracene, chrysene, benzo(e)pyrene, and indeno(1,2,3-*cd*)pyrene.

Not surprisingly, these are the same culprits suspected of causing lung cancer that are found in tobacco smoke.

California Desert Plan

Continued from page 20

plan applies directly to 18,000 square miles of federal tracts and indirectly to state, county, municipal, and private lands interspersed in the vast area extending from Death Valley southward to the Mexican border.

A "Question and Answer" booklet issued by the Bureau of Land Management, which will oversee the area, noted that outgoing Secretary of the Interior Cecil D. Andrus had "a deep personal interest in this project" to preserve the natural beauties of the California desert and had made it a priority to get the plan implemented.

The final version of the plan divides the 18,000-square-mile area into four categories of use: Half the area is classified for "limited use," with priority given to the protection of the natural ecology. Seventeen percent of the land will be included in the National Wilderness System and given over solely to the promotion of "wilderness values." Twenty-seven percent is classified for "moderate use," including some commercial development. Only 4 percent is designated for "intensive use," in which commercial and recreational use will be the priority.

Put on the defensive by well-organized opposition to the plan, the BLM is maintaining that it has carried out its congressional mandate to draft a "multiple-use" plan—one that would permit both the preservation of unique and scenic ecologies and development of resources. However, all future plans for power plants and utility corridors in the area, including for meeting water requirements for agriculture and residential consumption, will now have to be reviewed by the BLM on a "case-by-case" basis, and will likely meet with regulatory delays or prohibition.

Critics of the plan are particularly concerned that it will block further agricultural development by denying additional water projects to supply the Imperial Valley, one of the nation's most productive farming areas.

Opponents of the California Desert Area plan prominently included State Assemblyman J. Robert Hayes (R-San Fernando) and other members of the "Sagebrush Rebellion." This movement has been trying to force the federal government to relinquish control of millions of acres of resource-rich land in 12 western states so that the land can be developed. The major media ignored the principled opposition and instead featured a motorcycle group called the Phantom Duck, which is fighting the plan as an infringement on their rights to do as they please in the desert.

TMI Cleanup:
Fewer Problems Than Expected

The four manned entries of the Unit 2 containment building at Three Mile Island, carried out last June through November, found that the levels of radiation present were even lower than expected.

The krypton gas released during the first and major venting June 28 through July 10 amounted to 43,000 curies, compared with an earlier estimate of a low 57,000 curies. The venting took place without incident and with the radiation levels beyond the plant boundary far below levels permitted by the Nuclear Regulatory Commission.

The basic goal of the initial phase of the Unit 2 cleanup is to survey the radiation levels and assess whether any damage occurred as a result of the March 1979 incident or during the time in which the equipment has been sitting idle without maintenance.

The Money Barrier

The only potential barrier to continued progress in cleaning up Unit 2 is whether General Public Utilities, TMI's parent company, will be able to obtain the money to complete the job.

Recent estimates put the total clean-up cost at $500 million, which includes the cost of removing the damaged fuel, with completion expected by mid-1983. It will then cost another $260 million to restore Unit 2 to its preincident operation condition, based upon a late 1985 completion date. The assessment after the fourth entry in late November was that the costs might be lower than these estimates, but the expense will be substantially more than GPU's insurance will cover.

The hottest political issue at TMI now involves GPU's efforts to obtain a license to start up its Unit 1 reactor again. This mate to Unit 2 happened to be shut down for refueling when the incident occurred at Unit 2. The reactor is in perfect operating condition and only needs to be turned back on to save central Pennsylvania more than $10 million a month in replacement energy costs. The reopening of Unit 1 would also, of course, give GPU some financial breathing room for proceeding with Unit 2's cleanup.

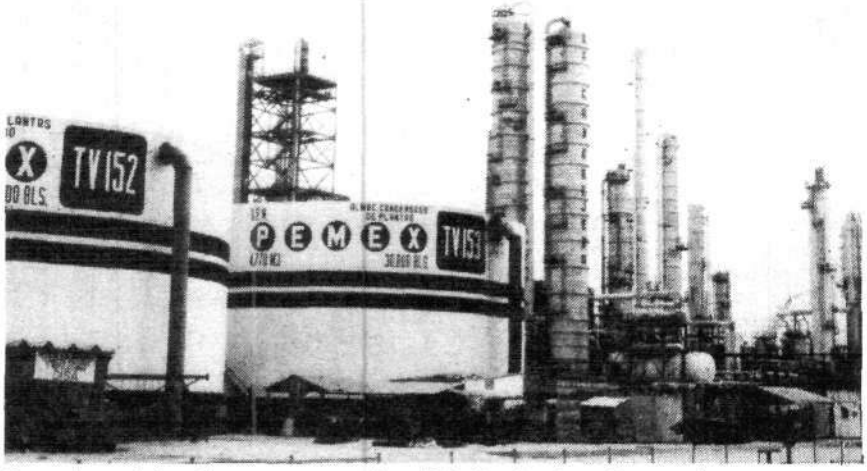
—Jon Gilbertson

Intervenor Funding Stopped

Congressman Mike McCormack reported Dec. 4 that he had succeeded in getting the Nuclear Regulatory Commission to suspend funding of intervenors who have been responsible for delaying nuclear power plant projects. On July 25, 1980 the NRC implemented a program to provide a free transcript and other free services to intervenors "amounting to about $1,000 per day." This program, McCormack stated, "was inconsistent with the legislative history of the fiscal year 1980 appropriations" for the NRC.

In response to his request for an opinion on the matter, the Comptroller General returned a four-page opinion stating that the NRC program was illegal, after which it was suspended.

Mexican Plan Taps Nuclear Alternative



Even though its oil reserves are plentiful, Mexico is going nuclear.

Mexico, a country with massive, new-found oil wealth, recently adopted a new National Energy Plan (PNE) that taps nuclear as the major alternative energy source to oil for medium and long-term energy needs.

"At the international level, [nuclear] seems to be the great option of our time, with its corresponding sequel of the breeder reactor," the plan states. The PNE, which was released last Nov. 18, was prepared by Mexico's National Resources and Industrial Development Ministry, based on guidelines in the National Industrial Development Plan.

The nuclear plan endorses the previously set goal of 20,000 megawatts of nuclear energy by the year 2000 and specifically calls for:

- "one additional unit" of 1,200 megawatts to be completed by 1990 beyond the twin reactor complex under construction at Laguna Verde,
- rapid transition to breeder reactor technology toward the end of the century, requiring "technical cadre of the highest level,"
- strengthening Mexico's program for uranium exploration, and
- use of both light water and heavy water reactor systems in the next stage of development.

The nuclear plan, like Mexico's oil development program, is closely linked with plans for expanding Mexico's capital goods industry; by the 13th or 15th unit of the 20,000 megawatt program, 85 to 90 percent of the components are to be manufactured by domestic industry.

The near-term nuclear projections still reflect a belief in some planning circles, however, that Mexico's plentiful oil provides an adequate cushion. The goal of adding just one more unit beyond Laguna Verde by 1990 means that the main weight of the program is concentrated in the final years.

Mexico's 'Guaranteed' Uranium Reserves

Francisco Vizcaino Murray, director of the Mexican state uranium company, Uramex, took the opportunity of the release of Mexico's new National Energy Plan to reveal that Mexico's uranium reserves have increased to 10,000 tons proven, 100,000 probable, and 500,000 possible. He emphasized that the 100,000 figure, based on uranium contained in phosphoric rock deposits now being exploited by the government in the Baja California peninsula, is virtually "guaranteed."

Looking ahead, the Uramex director concluded: "Mexico, with guaranteed uranium reserves of 100,000 tons, is a country that can pass with comfort from first-generation reactors, such as those of Laguna Verde, to those of the second generation; that is, breeder reactors, or, in the same period, to thermonuclear fusion."

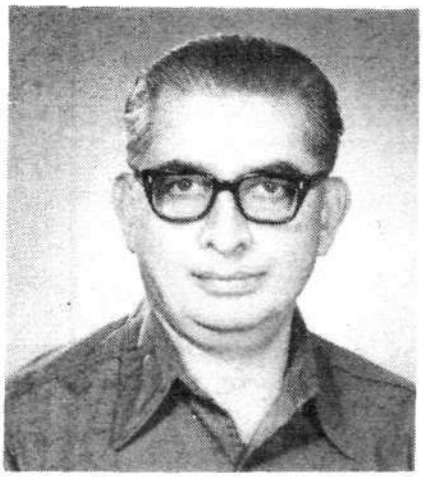
India Looks To the Future

Fusion's West German correspondent questioned two prominent Indians, Dr. M.R. Srinivasan and S.G. Ramachandra, about the future of nuclear energy and industry in their nation. Srinivasan is the director of the Power Projects Engineering Division of India's Atomic Energy Commission and Ramachandra is executive vice president of Kirloskar Electric of India. Here are exerpts from the interviews, conducted during the World Energy Conference in Munich, West Germany in Sept. 1980.

Srinivasan on India's Nuclear Program

Question: In the industrial countries, it is often said that wind, solar, and biomass are the appropriate forms of energy for the developing sector. As a representative of a developing sector nation, what is your opinion?

I am afraid that the importance of solar, biomass, and other such renewable energy sources has been overemphasized by certain energy technologists and economists. I agree that there is a certain scope, a limited scope, to use these, but it seems very clear to me that developing countries *will* not be able to maintain even a



Dr. M.R. Srinivasan

reasonable standard of living, certainly nowhere comparable to the standard of living in Europe today, unless they rely on developing commercial energy sources.

The options now available are limited to coal and nuclear, of course. India has a certain amount of coal, but increasingly there will be pressure to use coal for nonenergy uses. Therefore, in my view, we will have to depend on nuclear energy, initially fission and eventually the fusion cycle. We do hope that in some 30 or 40 years solar energy will also make some contribution to our energy needs.

Question: What is your perspective on possible cooperation between India and Western and Eastern European countries on development of nuclear technology, especially the nuclear technologies appropriate for the developing countries?

We consider it quite important to have cooperative endeavors in nuclear technology. In fact, in earlier periods, our own nuclear program benefited from meaningful cooperation with France, Canada, and the United States, to name a few of the countries involved. We have also had agreements with Britain, West Germany, and, of course, the countries of the socialist group, especially the Soviet Union.

But lately the issue of nuclear cooperation has gotten entangled with political issues such as nonproliferation, and this has undoubtedly impeded cooperation, which would have been helpful to all concerned in ensuring the faster development of nuclear technology.

We would certainly like to see greater cooperation and an easier flow of experience across national frontiers. As far as cooperation with developing countries is concerned, we certainly believe that we should share all the technology we have with other developing countries who could benefit from the advances.

Question: Special work has been done in West Germany on the high-temperature gas-cooled reactor and the thorium cycle. Do you see any possibility of collaboration between Indian and West German scientists in these fields?

We have a very strong interest in thorium utilization, as we have one of the largest thorium reserves in the world. In principle, I think it would be a good thing for us to speak with our counterparts in West Germany on long-term utilization of thorium. There has been some exchange of information already, but I think that this is an area where we could clearly do more in the future.

With regard to the high-temperature gas-cooled reactor, there is certainly a great potential for use of high-grade process heat, especially in steel making and coal gasification. We have not yet done any work in this area, but it is certainly a field in which India has a long-term interest.

Ramachandra on India's Industrial Potential

Question: It is said that India is a "sleeping giant"—that it has a very great industrial potential. What in your view is this potential?

India has a very strong engineering base. It is presently capable of manufacturing most of the energy equipment needed to satisfy its own requirements. India also has a very strong manpower base, which is considered to be the third or fourth largest in the world. Therefore, it certainly has the character, as you describe it, of a "sleeping giant." How long India will continue to sleep depends on whether people in India wake up and make the giant really awaken.

One aspect of industrial development that I would like to comment on is the role of assistance and cooperation from the Western world. We have gotten very large assistance from Sweden, the United Kingdom, other European countries, the United States, and the Soviet Union. However, during the last 15 years, there has not been much of an effort to update this technology.

I would also like to point out that at present India's external trade is hardly equal to 1 percent of world trade. It is necessary to increase this to at least 3 to 5 percent in the near future. This calls for updating our technology and our manufacturing practice, because developing countries do not get any preference from buyers in international trade. Buyers purchase the cheapest equipment and equipment available on credit, and in most cases India is not able to sell equipment on credit.

As for India's trade with other developing countries, most of the developing countries depend on financial assistance from one agency or another to finance imports. India is not able to generate adequate financial surpluses to finance the export of its industrial products.

Question: Besides oil price increases, global monetary disorders have had a serious impact on the economies of the developing sector. What has been the effect on India?

For India, the import of capital equipment for development is very small. The bulk of the country's foreign exchange reserves is currently going for the purchase of oil. If we can intensify our own exploration and development of oil reserves, which we are doing, then we can try to gain an advantage. In the last eight weeks, India has struck oil in certain areas where it was previously not thought to exist, and it is possible that a new industry will develop in India—oil exploration and drilling and allied lines. I think this prospect is in India's short-term future.

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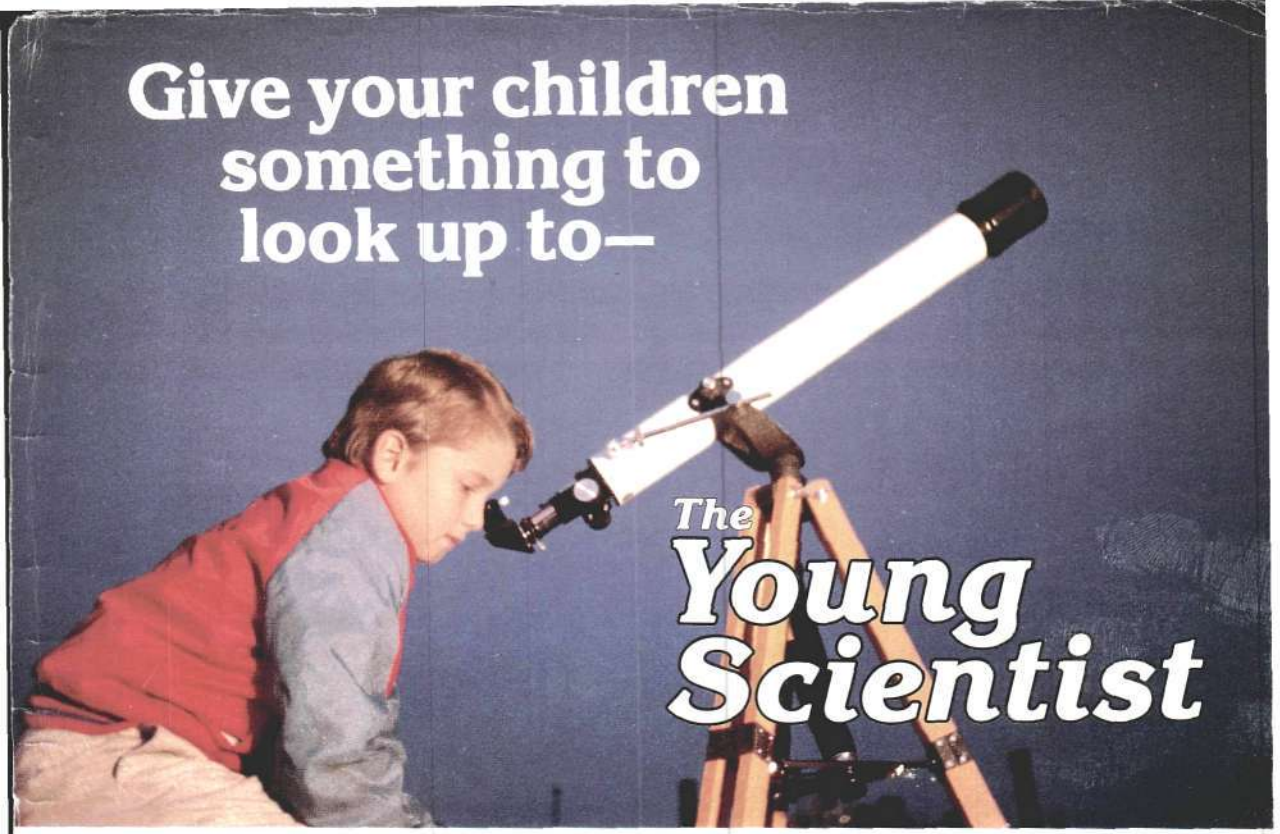

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Here's a sampling of what *The Young Scientist* covered in December:

- The tokamak: bringing the star power of fusion down to earth
- A tour through the Alabama Space and Rocket Center
- Experiments with magnetic fields and moving charges
- Trains without wheels
- An interview with Dr. Stephen Dean —how a fusion scientist got his start as a young man

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Carlos de Hoyos

PUTTING AMERICA ON A HIGH-TECHNOLOGY COURSE

Readers are urged to send President Reagan the postcard inserted in this issue asking him to fully implement the Magnetic Fusion Energy Engineering Act of 1980 and to put the nation back on a high-technology course. As energy editor Lydia Schulman spells out in the *National* section, the situation is critical for nuclear-oriented utilities. Without a turnaround in policy, there won't be enough electricity generated to power any economic growth in this decade. And in the Washington section, editor Marsha Freeman reviews the prospects for such a turnaround in a report on how Reagan's energy policy is taking shape.

INERTIAL CONFINEMENT— FUSION ENERGY ON EARTH AND IN THE GALAXY

Gregory Canavan, director of the U.S. inertial confinement fusion program, reviews the progress and prospects for this "number two" approach to commercial fusion energy. And fusion pioneer Friedwardt Winterberg shows how in the not-too-distant future laser-fusion propulsion systems will take man out to colonize distant planets and perhaps, someday, other galaxies. In the Fusion Report section, fusion technology editor Charles B. Stevens relates some of the recently declassified history of the U.S. inertial program, which for the first time reveals some of the basic scientific problems of inertial fusion.

LANSL

Front cover: Depiction of fusion-propelled spaceship approaching a space station near Mars by Alexander Bloch. At right: The Helios gas laser at Los Alamos National Scientific Laboratory. Above: Public Service Gas & Electric's Salem *Nuclear Generating Station* in New Jersey. Cover design by Christopher Sloan.