Exclusive Interview with Shuttle Pilot Robert Crippen

FUSION

AT THE FRONTIERS OF SCIENCE AND ENERGY

August 1981

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JAPAN Number 1 in Fusion?

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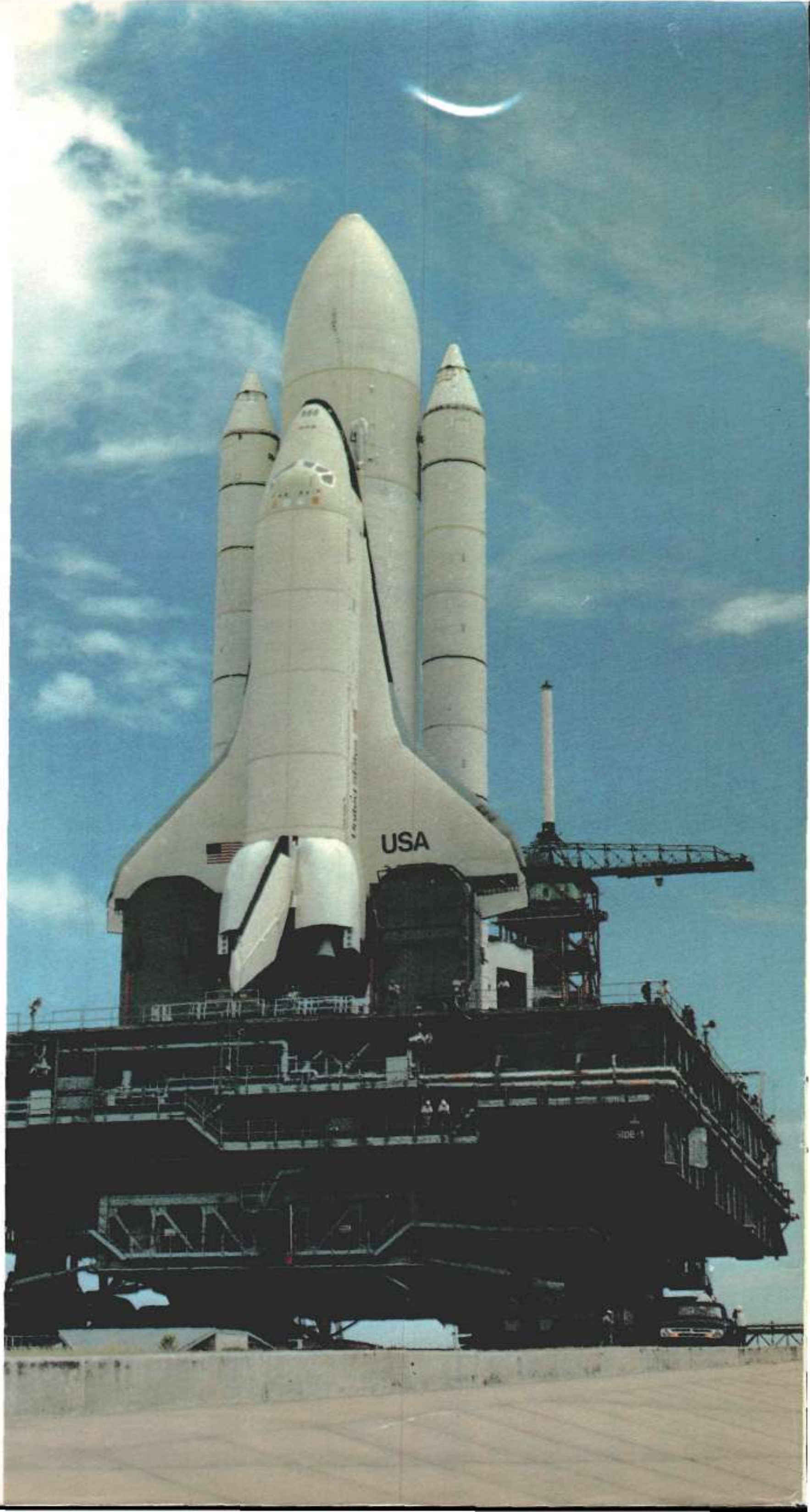
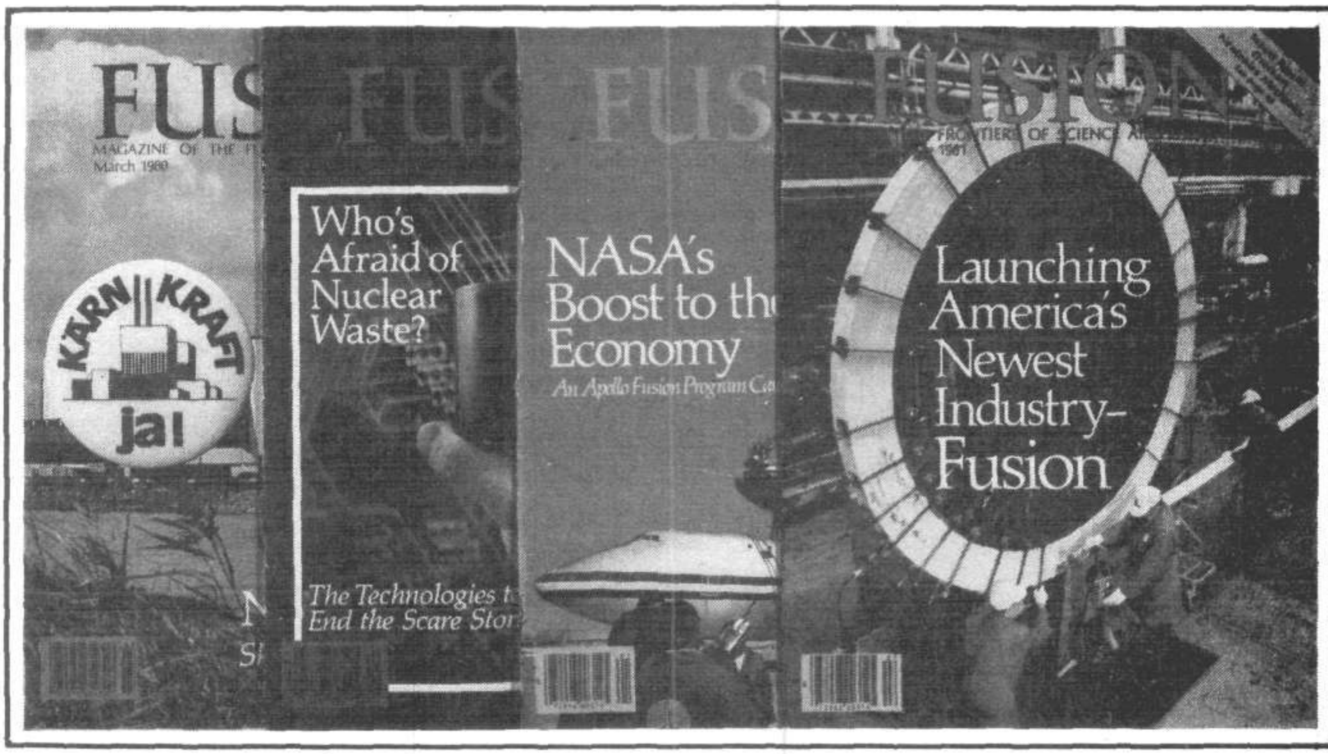


USA

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.

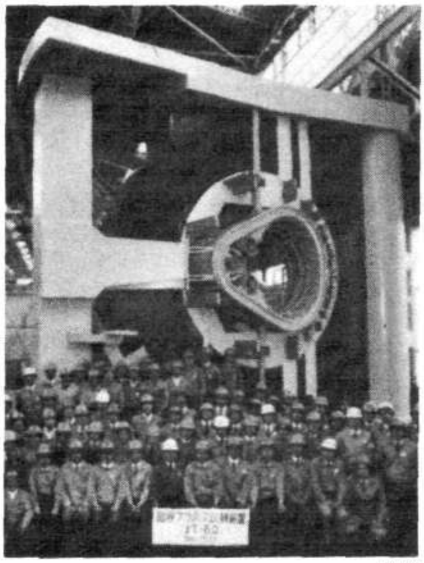
In 1979 alone, more than 22 million dollars was given to zero-growth groups by just six foundations.* Our fight requires this kind of funding—and more. You can help by giving generously to the FEF and supporting some of our special activities.

- 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.



JAERI

Japan's JT-60 tokamak is a reactor-scale machine designed to achieve breakeven plasma conditions. Here is a mock-up of the JT-60 with some of the project's staff. The huge tokamak is scheduled for operation in October 1984.

Features

Japan: Number 1 in Fusion?

The secret of Japan's success as an industrial nation is revealed for the first time in this exclusive report. The fusion program proposed in March 1981 by Japan's top scientists is the most aggressive in the world for developing fusion energy: It will put a demonstration power reactor on line by 1993. The Japanese are convinced that fusion is the key to their nation's survival—*no matter what* is the fate of the U.S. fusion budget. As one Japanese fusion scientist put it, "If the United States won't do it, we will."

News

NASA

This issue's exclusive interview with Capt. Crippen will be part of a 24-page Fusion *report "Conquering Space to Develop the World," available from the FEF at $10 for 10 copies, postpaid (minimum order).*

Departments

Carlos de Hoyos

Former congressman Mike McCormack addressing the FEF conference on fusion and national security May 13.

From the Editor's Desk

The presidential victory of French Socialist Party candidate François Mitterrand May 10 is an unexpected setback for the supporters of nuclear power and economic growth. Already there are reports that Mitterrand plans to stop construction on five nuclear plants. In this issue (page 51) Pierre Aigrain, former French secretary for research, presents the view of French science that prevailed under Valéry Giscard d'Estaing, Mitterrand's predecessor. *Fusion* will continue to cover the energy and science issues in France, and we are expanding the French-language newsletter, *La Lettre de Fusion,* as well as organizing activities in France.

Other items of note: Don't miss the report on the DOE's Fusion Power Coordinating Committee (page 11); Interior Secretary Watt's testimony on strategic minerals (page 15); a *Fusion* interview with the not-so-impartial Congressional Office of Technology Assessment (page 50), Friedwardt Winterberg's latest comments on the X-ray laser (page 54), and a new column, Inside Energy, by William Engdahl (page 47).

Coming up in September is a cover story on why the world needs more people—10 billion, according to *Fusion* editor-in-chief Dr. Steven Bardwell. Also, a full report on the FEF conference on fusion and national security May 13.

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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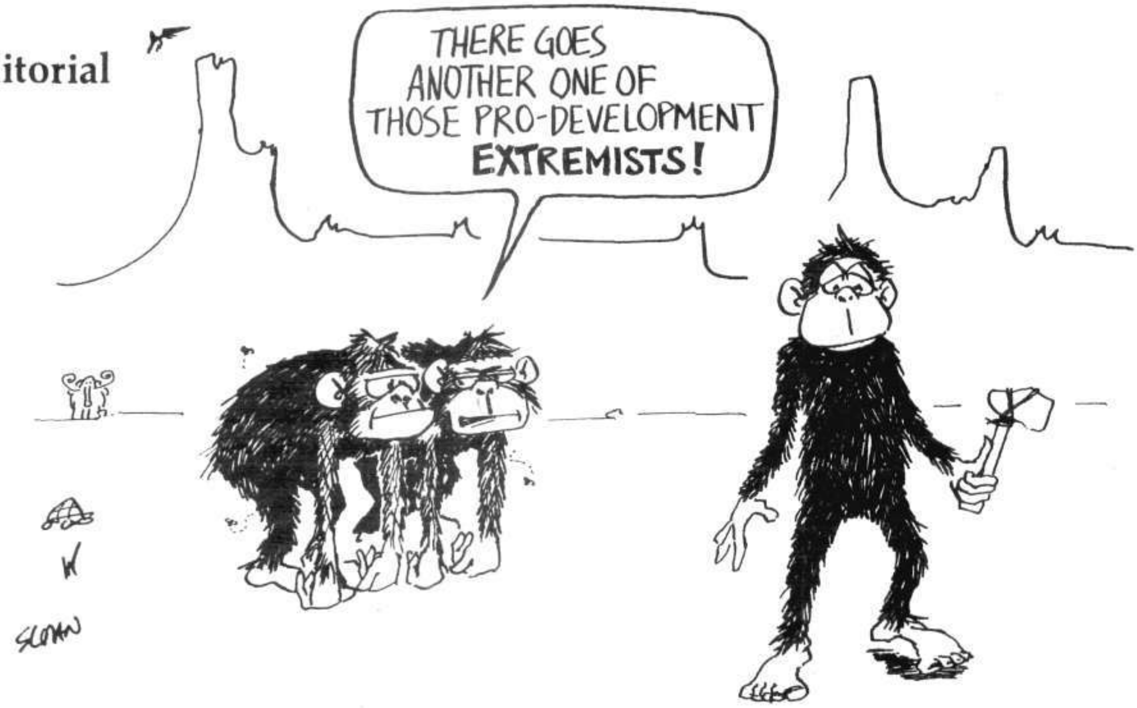
Editorial



Development and Extremism

In the mid-1970s, when most governments were discussing energy conservation as a way of dealing with the oil embargo, Japan's scientists, business leaders, and politicians decided that fusion was the "energy of the 21st century" and, therefore, that Japan should develop it. Just as Japan in the 1960s and 1970s had pioneered in textiles, shipbuilding, automobiles, steel, and electronics, and had termed the 1980s "the decade of technology," concentrating on computers and industrial robots, so Japan saw the 1990s as the fusion technology decade.

This March, based on their evaluations of fusion research worldwide, leading Japanese scientists proposed a program to develop fusion as quickly as possible, putting an Experimental Power Reactor on line as early as 1993. It is a proposal the Japanese government is certain to adopt, according to Japanese scientific sources; and it is equally certain to leave the United States trailing behind in fusion.

An American Tradition

The Japanese have taken the American tradition of progress seriously. Although few Americans today know it, the leaders of the Meiji revolution in the late 1800s built the foundations of modern Japan on the economic model of Alexander Hamilton and Henry Carey. Unlike today's nonsensical "free enterprise" philosophy, the American System adopted by the Japanese was dirigist—the government stimulated the establishment of industry and infrastructure that were too big for individual companies to handle at the pace necessary for national development.

Today's Japanese leaders continue to build on that foundation, moving the economy forward with "frontier industries" as the cutting edge. And unlike their American counterparts who have become obsessed with the fraudulent cost-accountant mentality of cutting today's budget—no matter what happens tomorrow—the Japanese are thinking now of what must be done to ensure growth and prosperity in the 21st century. Japan, for example, spends 50 percent more per capita on fusion research than the United States.

The consequences of going slow on a program like fusion are not just the loss of a few years in the development of an energy source that will be cheap, clean, and virtually unlimited. "Going slow" on development will be measured in dead bodies—the number of people, particularly in the Third World, who will die because the advanced sector chose not to export the advanced technology to provide the energy to grow the food required to feed them at above-starvation levels.

The Question of Extremism

This brings us to the question of extremism. Interior Secretary James Watt has been branded "a prodevelopment extremist" by environmentalist groups like the Sierra Club because he sees the development of the nation's resources as essential to the continuance of progress.

In the same way, former French President Giscard was castigated by U.S. officials and nominally conservative think tankers—who went so far as to support his opposition—because they thought Giscard was going too fast with nuclear power, especially exports to the Third World. Giscard had promised 8 to 10 nuclear reactors to Africa and a full nuclear fuel cycle to Mexico as part of his plans, along with West German Chancellor Helmut Schmidt, to rebuild the world economy.

If François Mitterrand, the newly elected Socialist President of France, reverses Giscard's aggressive nuclear development policies, the consequences will be mass starvation and death. This not only means immediate deaths in *the developing nations; there will be casualties in a France whose* living standards will drop as the economy becomes more labor intensive and less capital intensive. There will also be another kind of casualty—the destruction of human minds and morality that inevitably accompanies social policies that disconnect societies from the idea of progress.

On the world scale, not to develop industry, resources, and new technologies and not to explore the universe is to follow the depopulation scenario of the *Global 2000 Report,* now praised not only by the environmentalist groups but by many figures in the U.S. government. On a national scale for the United States, or France, or Japan to give up a policy of growth and development would be suicide. And suicide is about the most extreme solution to a solvable problem that we can think of.

The Lightning Rod

My dear friends,

A most strange tale has reached me, of a bizarre journey undertaken by an acquaintance of mine, who, until his recent trip, proclaimed himself a devout conservationist and argued a constant opposition to human interference with nature. Here is his account.

I believe I was dreaming when I suddenly awoke to find myself in the middle of a Dark Wood, where the main trail was unmarked (so he be*gan). But when I reached for my* compass, a sepulchral voice at my shoulder intoned,

"Abandon all things artificial, ye who enter here."

Who, then, should I see beside me as I peered through the drear light, but the gaunt form of old Parson M------, who informed me that he was to be my guide through this Pure Wilderness.

Not long after setting out, as the wood deepened, we encountered *two groups of shades, one hissing and* spitting at the other, which answered with a horrid weeping and groaning. As I drew closer, I noted that the hissing noises were caused as the first shades rapidly rubbed two sticks together in a vain attempt to start a fire, for no sooner did the wood begin to catch and smoke than the spark would sputter and die.

"These are the souls of those who urged that oil and gas and nuclear *power be replaced by wood-burning,"* my guide pointed out. "See what a jolly time they're having."

"But who are those opposing them with their weeping and wailing," I inquired.

"Ah," said the pinch-cheeked parson with a sigh of satisfaction, "those are the legions of the Save the Greenwoods Society, whose tears fall constantly on the trees and twigs so that the others may not start their fires."

Soon thereafter we came to the *banks of a great marsh, clogged and* swollen with a pale sludge and reeking with the foulest odor imaginable. Here we observed another band of shades slogging their way through the peculiar whitish ooze. Blades of tall grass stabbed and slashed at their bare legs with the searing agony of a thousand razors, so that it seemed the poor souls positively grinned with re*lief whenever a chance step caused* them to sink to the waist in the sticky, vile-smelling soup.

At the center of the marsh, the point toward which all appeared to be converging, we beheld a giant gray and white bird, flapping its wings but mired in the dismal swamp and unable to fly. From its nether regions we saw streaming gallons of the whitish goo so unpleasant to the touch and offensive to the nostrils.

"Here we are at the Guano National *Wetlands Preserve," observed Parson* M------, rubbing his hands with glee. "These virtuous souls objected to the draining of a swamp to build an airport, and named a seagull as endangered-species plaintiff in a class action suit against the developers. For their reward, they shall spend eternity with Big Bird here."

Hardly had we passed away from the marsh—myself having refused with some abruptness my guide's invitation to "get your feet wet"—than we found ourselves on the edge of a boundless desert, on which the Sun beat down with the force of hammer on anvil. To my astonishment, I witnessed hundreds of souls broiling underneath it like so many wieners on a rotisserie, the resemblance even extending to a mechanism that gave them a quarter turn every few seconds so that their blistering should *proceed with perfect evenness.*

Continued on page 6

Lightning Rod

Continued from page 5

"Isn't this a bit far to travel for a tan?" I asked with a flippancy of phrase which could not disguise the trembling in my voice.

"These sun-worshippers had the high principle to oppose at all times and places the construction of dams, canals, irrigation ditches—in fact, anything wet from a backyard pool to an artificial lake," the parson replied. "They showed a remarkable consistency, for which they receive this even treatment in the solar cooker as recompense."

By this time I was near to pleading with my guide if there were not some shortcut back to civilization we might employ. As if he read my thoughts, he asked if perhaps I might accept a mode of transportation which "helps everybody get where they're all going faster."

No sooner had I given my eager assent, then I found myself strapped into a device that looked something like this:

And to my unspeakable horror, it appeared very much as if a burning fuse were attached to the "business end" of this infernal machine.

"My God, parson! What have you got me into?" I shrieked.

"It's the Population Bomb," he replied.

At that instant, a deafening explosion filled my ears. . . . and I found myself dazed but unhurt, slumped in front of the television set where I had apparently dozed off.

That very day, however, I tore up my Sierra Club membership card and canceled my subscription to *Natural History*, and now when I spot a patch of green on one of my walks through the city, I make sure it stays on the other side of the street from my person.

So ends my friend's cautionary tale.

Your obt. svt.,

Benj. Franklin

Letters

Government Funding And the National Interest

To the Editor:

We are asked as members [of the FEF] to demonstrate our opposition to cuts in government funds favoring nuclear energy and science education projects.

I think that our opposition may make matters worse by irritating Mr. Stockman and his committee. The cuts amount to 15 to 20 percent of the funds, which is fair compared to some other programs which are scheduled to be eliminated altogether.

I am surprised, furthermore, to hear that our association, an opponent of socialism and government intervention in private affairs, speaks for government funding.

Onofrio L. Olivieri
President
Rotomec America, Inc.
South Windsor, Conn.

To the Editor:

I was very displeased with your stand regarding "Stockman's cuts threaten national disaster." You cannot have regulation and not have regulation. If you are going to have big government you will have regulation of all phases of life. The major problem, in my opinion, today with our nuclear energy progress is that we have kept the free market from developing the cheapest and cleanest source of energy—nuclear. . . .

As much as I am in favor of scientific effort of all types, I believe that the private sector is more equipped to select the projects and to fund them through corporate and other resources. I do not think in general the government should be making all these decisions.

Therefore, I implore you to recognize that your short-term reaction to the loss of such funds is 180 degrees

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News Briefs

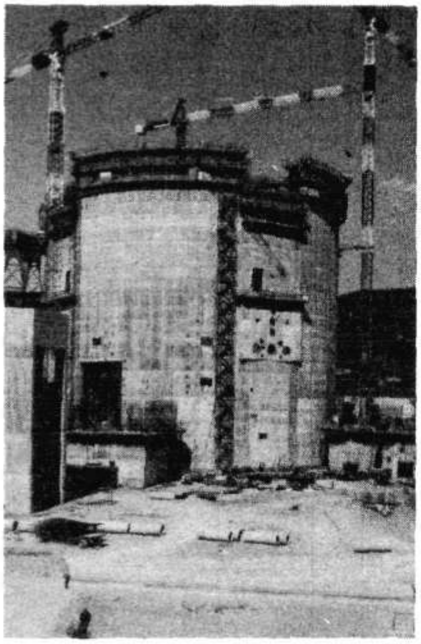
FRANCE'S NUCLEAR PROGRAM AFTER GISCARD: DOWNHILL?

The unexpected victory of Socialist Party leader François Mitterrand in the French presidential election May 10 has placed a question mark over the future of France's nuclear energy program, the most ambitious in the world.

Mitterrand has said that the program—which was the centerpiece of the independent economic and foreign policy of the government of former president Giscard d'Estaing—"is too costly and uncertain." While campaigning, Mitterrand called for a moratorium on new nuclear plants after those under construction are completed. He has proposed holding a nationwide referendum on nuclear power in France, but would have to change the constitution to do so, because the French constitution does not allow for referenda on questions of government policy.

Mitterrand also opposes France's fast breeder program. His election occurred just after the main support base for the 1,200-megawatt SuperPhenix fast breeder was set in position at Creys Malville. As of this spring the SuperPhenix was on schedule for a 1984 completion. Now, however, its future is uncertain.

Mitterrand, who was elected with the support of France's ecology movement, has promised to revamp France's energy priorities: The new priorities are conservation, coal, and new energy sources such as solar, which Mitterrand predicts will be a "major element of the 21st century." After Mitterrand's election, a source at the Council on Foreign Relations in New York predicted another change in French policy: compliance with the nuclear nonproliferation concept drafted by former secretary of state Cyrus Vance, a council member, and no more sales of nuclear reactors abroad.



EDF

France's SuperPhenix fast breeder reactor under construction at Creys Malville.

'TMI' INCIDENT HITS JAPAN

Japan is suffering a minor "Three Mile Island" nuclear scare, after a small amount of radioactive waste leaked into the surrounding grounds and waters of a nuclear reactor operated by the Japan Atomic Power Company. The amount of radioactivity released is under dispute and is claimed to have been as low as 15 millirems per day over several days or as high as a total of 150 millirems. In neither case is this a significant amount. One normal chest X-ray, for example, is about 50 millirems.

According to Japanese press accounts, on March 8 a worker "carelessly forgot to turn off a valve" for 3 hours in the waste treatment section of the plant. Fifty-four workers then cleaned up the overflow with mops and buckets and reportedly dumped the waste down a manhole drain, allowing the waste to flow into surrounding sea waters.

Japan's Ministry of International Trade and Industry (MITI) was not informed of the March 8 incident by Japan Atomic Power, but found out during routine tests of radioactivity levels in the surrounding grounds and waters. This negligence greatly alarmed MITI, as did the fact that the illegal dumping of waste into the rain water drain led to the contamination of fishing waters. MITI regulations specifically require careful isolation of the drain leading to the sea to avoid this possibility. MITI has temporarily suspended fishing in the area and intends to prosecute the plant managers and company executives.

As with the Three Mile Island incident in the United States, circumstances point to the possibility of sabotage. The incident took place just after the government had approved the first nuclear plant licenses in Japan since TMI. Second, the accident started when a worker carelessly forgot to turn off a valve—the same pattern as in the U.S. incident. Third, Japan has extremely lax security procedures for hiring workers in nuclear plants. Particularly in the clean-up operations, workers are often local fishermen who are hired on a temporary basis—"nuclear gypsies," as they are called. It is not yet known whether the worker who did not turn off the valve was a nuclear gypsy or possibly an environmentalist. However, the Japanese Socialist Party, which opposes MITI's strong pronuclear orientation, has called for the immediate shutdown of all nuclear plants until their safety can be confirmed.

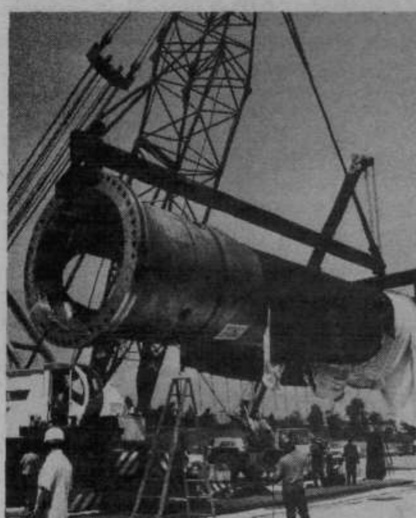
Wide World

An antinuclear rally in Tokyo in April 1979. The demonstrators' signs drew attention to the recent TMI incident in the United States.

SENATE RESTORES SOME NASA CUTS

The Senate Commerce Committee voted May 6 to add $100.7 million to the $6.1 billion budget proposed for NASA in fiscal year 1982. This addition does not come near to restoring the budget to the original $6.7 billion level requested by the Carter administration. However, like the budget authorization voted up on the House side in April, the Senate budget restores funding to the most critical parts of the program that were axed by Office of Management and Budget Director Stockman.

Of the $100.7 million add-on, $55 million will go to NASA's aeronautics research programs and the remaining $45 million to its space programs, including the Upper Atmospheric Research Program, materials testing in space, and the Spacelab that will be put into orbit by the Shuttle. This is still an austerity budget for NASA, but the language in the committee's report leaves open the possibility for a fifth Shuttle orbiter, the resumption of the international Solar Polar Mission, and the funding of other important NASA space programs—when and if the current budget cutting fever subsides.



Breeder Reactor Corp.

The second intermediate heat exchanger being delivered to the Clinch River breeder reactor site, September 1980.

HOUSE COMMITTEE VOTES TO KILL CLINCH RIVER BREEDER

The House Committee on Science and Technology passed an amendment to the Department of Energy's fiscal year 1982 budget May 7 that would terminate the Clinch River fast breeder reactor project. The 21 to 19 vote was the result of an alliance of Democrats who are long-standing foes of the breeder project and austerity-minded Republicans. In previous years, the Republicans on the committee had voted overwhelmingly for the breeder, but this time there were eight desertions to the antibreeder camp.

The committee vote, although a foreboding setback, does not inflict final defeat on the embattled U.S. breeder project. The probreeder forces on the House Science and Technology Committee now have the options of convincing the committee to reconsider its vote or of bypassing the committee and attaching an amendment to the budget on the floor of the House. The Senate, meanwhile, is expected to fully fund the project.

After the House committee vote, Senate majority leader Howard Baker (R-Tenn.) commented, "This is the first vote. But it is not the final word on this project. During the four years of the Carter administration, it was an endless battle to keep enough funds in the budget just to keep the Clinch River breeder project alive. With the commitment by President Reagan to complete this project, I am confident that we will be able to restore a funding level that will clearly demonstrate this administration's goal of moving ahead with the breeder reactor process."

CDIF GENERATES ITS FIRST MHD ELECTRIC POWER

On May 4, the Component Development and Integration Facility (CDIF) in Montana, the only fully integrated test facility in the United States using magnetohydrodynamics (MHD) energy conversion, produced its first amount of electrical energy. The facility was dedicated less than a month earlier on April 24 (see Washington news). Four hundred kilowatts of electricity were generated on this second test run. The CDIF is designed to produce 50 megawatts of power when fully operational. The MHD process converts the gases from combusted fuel directly to electricity without using steam turbines.

MEXICO PREPARES TO DOUBLE SCIENTIFIC TRAINING BY 1986

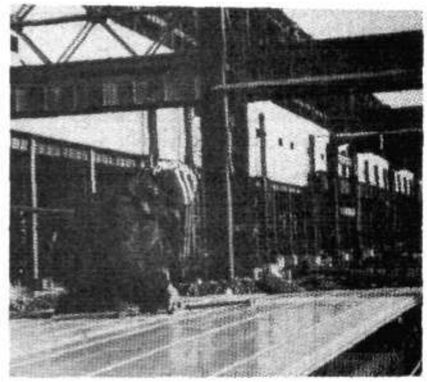
Mexican Undersecretary for Education Elisco Mendoza Berrueto announced April 15 that a new government plan for higher education will more than double the number of students engaged in higher education studies in Mexico over the next five years. There are currently 800,000 students enrolled in higher education, he reported. Under the new plan now being drawn up, the number will rise to more than 2 million by 1986. "It is urgent to correct errors and make serious efforts to reach an acceptable level of scientific and technological research," Berrueto said.

SUPREME COURT RULES AGAINST ENVIRONMENTALISTS

The U.S. Supreme Court decided two cases April 28 that promise to significantly reduce the number and impact of environmentalist lawsuits that have crippled the U.S. economy for more than a decade. In *California v. Sierra Club,* the Court ruled unanimously that private citizens and organizations have no standing to sue under a federal law protecting rivers and wetlands; only the federal government has statutory authority to enforce the law.

At issue in this case was one of the largest water-diversion projects in the country, the 42-mile Peripheral Canal planned to siphon water from northern California for use in the chronically water-short southern part of the state. This project has been held up for more than a decade by the Sierra Club and its allies, who sued the state of California under the federal Rivers and Harbors Appropriations Act, charging that the canal would pollute northern California's fresh water with salt water. The Court's decision not only will permit the project to go forward, but will stymie a favorite environmentalist tactic—the filing of legal actions by assorted private individuals and organizations and class action suits on behalf of anything that walks, flies, swims, or crawls.

In a separate water-pollution case, the Supreme Court decided that the state of Illinois could not impose more restrictive clean-up measures upon the city of Milwaukee than those of the federal Environmental Protection Agency.



Atommash in the Soviet Union, the world's first mass production facility for nuclear reactors.

ATOMMASH PRODUCES WORLD'S FIRST MASS ASSEMBLY REACTOR

The first pressurized water nuclear reactor rolled off the assembly line at the new Atommash manufacturing plant in the Soviet Union this spring. Atommash is the world's first mass assembly plant for floating nuclear reactors. A total of seven 1,000-megawatt PWRs are scheduled to be produced in the plant's first year of operation. A similar facility planned for the United States, Westinghouse's Offshore Power System, has been in mothballs since 1978, when the administration of New Jersey Governor Brendan Byrne denied state utilities the rate pass-on they would need to amortize the project.

NRC LICENSE DELAYS WILL COST U.S. UTILITIES $15.5 BILLION

U.S. utilities, which currently have 10 new nuclear power reactors at or near completion, estimate that continuing delays in obtaining licenses from the Nuclear Regulatory Commission will cost them $15.5 billion in substitute energy costs. This estimate was given in congressional testimony in March prepared at the request of Rep. Tom Bevill (D-Ala.), chairman of the House Subcommittee on Energy and Water Development. The 10 plants, all scheduled for full operation by 1983, are located in California, Texas, New York, Pennsylvania, Ohio, Louisiana, and the Carolinas.

FATE OF WEST GERMAN FAST BREEDER UNCERTAIN

West Germany's Ministry of Research and Technology approved $200 million in interim funding this spring for the 300-megawatt Kalkar fast breeder reactor project. This commitment will enable Schnell-Brueter-Kernkraftwerks (SKB), the operator, to place new equipment orders and continue construction on the facility for approximately six months. However, industry sources are stressing that the fate of the breeder project is by no means settled. The Belgian and Dutch governments, which together have been contributing about 30 percent of the project's costs, are demanding a ceiling on their contribution, although they have not specified the amount. SKB estimates that the total project will now cost $2.5 billion, three times the original 1973 estimate.

LOUSEWORT LAURELS TO PRINCE CHARLES

This month's Lousewort Laurels award goes to its first royal recipient, England's Prince Charles. Among his many homilies to Americans on his recent trip here, the Prince offered this gem of advice: "We have to learn that the modern way of growing great is growing small, so that man can operate in smaller units."

Viewpoint

America Needs a Total Water Program

by B. Joseph Tofani

With 46 years experience in water resources, I have witnessed many accomplishments. But over the past several years, I have seen our water resources development going steadily downhill. In order to reverse this trend of declining water resource development, we must prepare a total water program.

No matter how you view it, the ever-changing pattern of life in our nation is accompanied by one constant reminder: We require water for many uses, and the uses for water are increasing.

As in the past, we cannot expect to forecast the shifting priorities in water use with a great deal of accuracy, but we can predict that water demand and water use will continue. These uses are bound to generate conflicts. However, such conflicts are to be expected and must be resolved in order to achieve a proper balance in meeting our water requirements and other requirements as well.

Taking a page from our history, we must avoid the mistakes of the past, such as the piecemeal solutions that have been the trademarks of settling every water crisis from the battles in the West over water holes to the devastating floods of the 1920s, 1930s, and 1940s.

We must not only consider future needs; we must continue to improve and provide for existing water needs. We cannot rely solely on conservation, defined by some as less demand and less use. We must adopt true conservation, which is wise use.

Through the years, in carrying out water programs, too much emphasis has been placed on numbers. We failed to establish a program, a goal, or an objective. Instead, we justified each individual project by so-called benefit to cost analysis. Then came the legislative products of the 1960s and 1970s—NEPA, clean water, wild rivers, scenic rivers, trails, fish and wildlife, endangered species, and many others, all accompanied by new ground rules.

There was no benefit to cost analysis here, just total programs with goals and objectives. Why not take a page from these legislative acts—acts that did not develop programs in a piecemeal fashion but by a total program approach, which has been very effective.

Instead of the piecemeal approach to water policy, it would be more logical to develop a water program *and* an agency to implement the policies that such an agency would generate. I believe the best approach in the management process is to designate one agency and assign to it the responsibility for developing a water program for each of our river basins. This should start with an agency that is given nationwide capability to conduct river basin studies, utilizing input from other federal, state, local, and private agencies. A wealth of material and national water assessments is available as starting points.

Within this framework, I suggest a two-phase solution. First, develop a program for individual river basins, since each basin has different requirements. I recommend the Corps of Engineers, which developed a water program many years ago and has the nationwide capability, to do it again. The responsibility of the Corps would be aimed solely at developing the program and not at becoming involved with policy issues.

The second phase, the policy phase, should be developed by an interagency arrangement. There is no doubt that the federal government will continue to participate in one way or another in water resources investment. It naturally follows that the agencies that plan, construct, and operate the projects should be members of the group—like Army, Interior, Agriculture, and EPA. This organization should be headed by an independent chairman appointed by the President and confirmed by the Senate, who would obtain input from states and local governments and regional, interstate, and private organizations. It should also have an advisory group representing the states or regions.

The responsibilities of the organization would be to review the basin programs, set priorities, recommend who should build the projects and who should pay—in short, to make the necessary policies for a total water program. In no way should this organization become involved in the operation of the federal, state, local, or private agencies.

The agency would act as an overall coordinating body. All its programs, policies, guidelines, and priorities should receive the ap-

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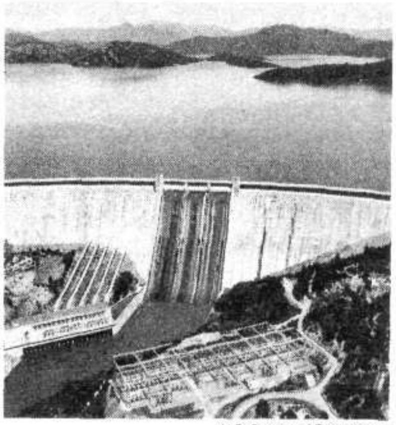


U.S. Bureau of Reclamation

An aerial view of Shasta Dam and Lake on the Sacramento River.

FPCC Quarterly Meeting: 'Moving Ahead with Uncertainty'

Not only is the new administration's policy toward fusion uncertain, there is even "an uncertainty as to who the people are who will be overseeing the program," Edwin E. Kintner told the April 14 meeting of the Department of Energy's Fusion Power Coordinating Committee (FPCC) at the Massachusetts Institute of Technology.

The FPCC is an advisory body to Office of Fusion Energy Director Kintner, and its membership includes the heads of each magnetic fusion program, industry representatives, and consultants.

Kintner noted that in this uncertain situation, one of the major questions being raised about fusion was "its desirability versus a panoply of energy options," including the nuclear fast breeder reactor.

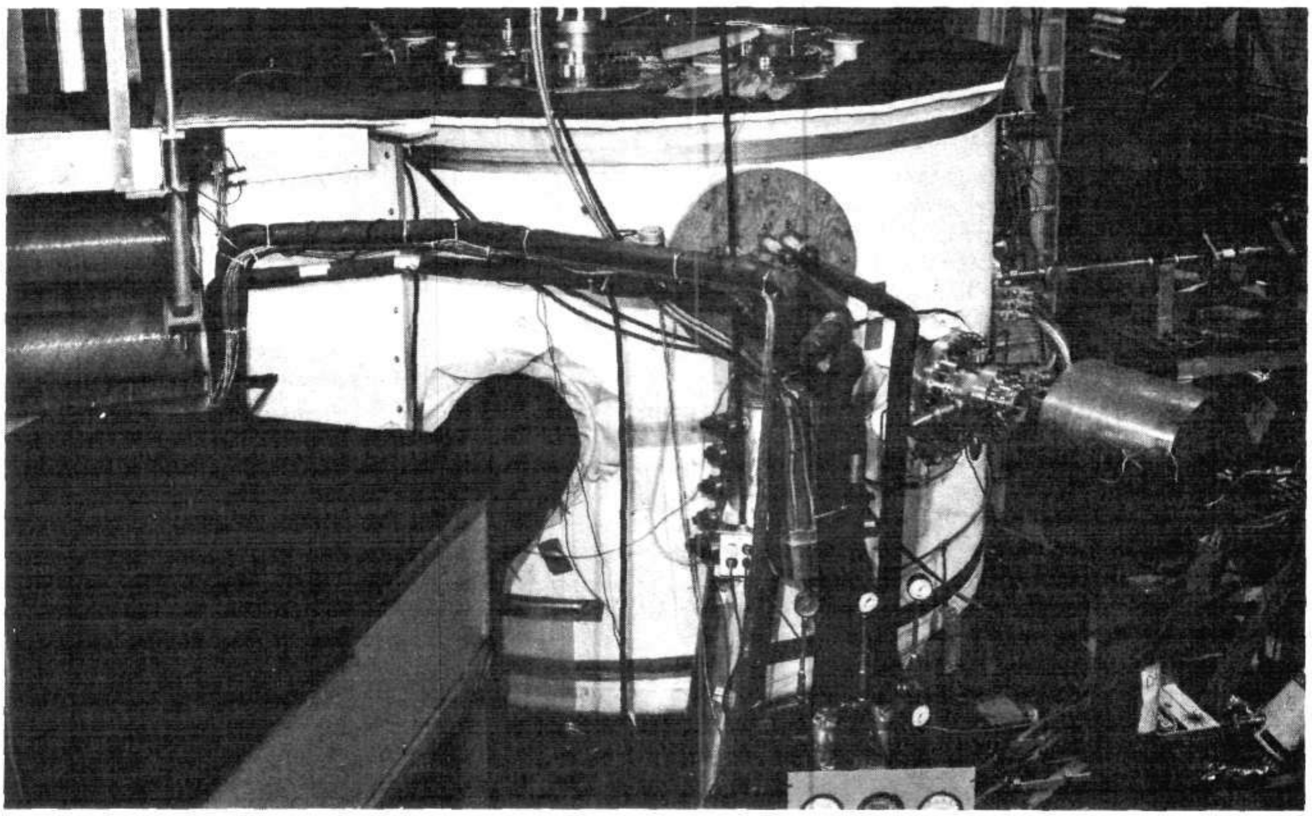
"We have to work hard for the next decade," Kintner said, "to settle the questions of the technology, costs, and environmental effects of fusion vis à vis all the others. Fusion is the last known energy source for mankind."

The first day of the open meeting was spent reviewing the results and progress in the fusion experiments at the MIT laboratory. After a summary of MIT's energy and fusion facilities by Dr. Ron Davidson, head of MIT's plasma physics program, the most recent results on MIT's Alcator-C tokamak device were reviewed by Dr. Ron Parker, who directs the Alcator program.

For the past year, the Alcator has shown a disturbing leveling off in predicted confinement of the fusion plasma, Parker said. It had been predicted that the time the plasma could be confined would increase in a linear relationship to the increase in the plasma's magnetic field strength and density. However, at the point that the key fusion parameter—the density of the fusion fuel multiplied by the time that the plasma is confined—has edged toward the region of 10^{14} particles per square centimeter per second, the experimental results have refused to progress further.

A Physics Challenge

Various experiments have been performed to make sure that impurities in the plasma from the wall of the



MIT

The Alcator-C tokamak fusion experiment at Massachusetts Institute of Technology. The past year's experimental results have raised new questions about the relationship between energy confinement and density.

vacuum vessel are not causing the fusion plasma to cool off, but the plasma has been found to be relatively "pure."

An important clue to the nature of the problem, however, has been a measured difference of an order of magnitude between the ion and electron temperatures as the density has increased. This loss of thermal energy in a reactor has led some scientists to question the accuracy of measurement both of the ion and electron temperatures.

Parker reported that new diagnostic instruments are under development to more accurately measure the ion and electron temperatures. But he asked the scientists present from around the country to help solve a problem that might otherwise prevent the high magnetic field Alcator tokmak from reaching the near breakeven density and confinement time required to go forward with the next generation tokamak experiments.

Density Scaling

Some of the participants at the FPCC meeting were confident that existing theories could account for the seemingly anomalous energy confinement results from recent experiments. Several researchers at the MIT Alcator laboratory have indicated that the scaling relationship between energy confinement and density has not been violated, but that this relationship was more complicated than it appeared in the usual, empirical form.

In fact, these researchers point out that the theoretical form of the scaling law has always shown a sensitive dependence on the density and current profile *within* the plasma (not just the average density), and this profile dependence goes a long way toward resolving the anomaly. According to these researchers, the profile dependence of the scaling law gives researchers a much wider range for experimentation and more flexibility in the design of tokamak reactors.

The most exciting reports given during the meeting were those on new experiments coming on line and new ideas that expand the dimensions of the experimental work in magnetic fusion research.

For example, Dr. Harry Dreicer from the Los Alamos National Scientific Laboratory in New Mexico reported on the preliminary results obtained on a new reversed field pinch device at LASL, which began plasma discharge Feb. 18. Dr. Tahiro Ohkawa from General Atomic Co. in San Diego then reported that General Atomic's new reversed field pinch experiment also began operations in February and that it looked as if the machine would be as successful as the established ZT-40 device at Los Alamos.

One of the most intriguing discussions was by the new director of the Princeton Plasma Physics Laboratory, Dr. Harold Furth. Furth has been thinking about the possibility of combining the best aspects of the traditional tokamak and the older stellarator idea. Although pioneered in the United States in the 1960s, the stellarator is not under current development here.

A stellarator is a donut-shaped fusion device, which, unlike the tokamak, does not have an electrical current flowing in the plasma. All the magnetic fields that contain the stellarator's fusion fuel are outside the vacuum vessel, and the plasma is contained by nonsymmetric helical magnet windings.

Furth suggested that it might be possible to develop a combined tokamak and torsitron (a type of stellarator) called a tokatron. Using a series of hand-drawn sketches, Furth sparked the curiosity of the FPCC scientists with this unusual combination.

Impressed with the progress in the experimental results, the new ideas generated by a "better understanding of the physics of fusion," and the challenging questions raised in the MIT program, fusion director Kintner told the open FPCC session that in the near future "we need a machine that produces enough fusion energy to answer all of the questions."

The Stockman Budget

During the second day of the meeting, Dr. Paul Gray, president of MIT, gave a brief welcoming speech to the FPCC. Gray said he had just come from a meeting of the Association of American Universities in Washington with two cabinet members and the head of the National Science Foundation. He reported that during dinner "OMB director David Stockman gave a one-hour discourse on the budget-making process for 1982-84. The AAU members were very gloomy."

"There was unanimity among university presidents," Gray said, "that this would gradually disassemble the ability of America to meet the demand for engineers and scientists."

—*Marsha Freeman*

ASDEX Runs Clean

Major Advance in Tokamak Impurities

Fusion scientists at the Max Planck Institute for Plasma Physics in Garching, West Germany, have achieved a major advance in controlling the impurities that plague efficient magnetic-confinement plasmas with their ASDEX (Axial Symmetrical Divertor Experiment) tokamak, according to sources in the U.S. fusion community. The ASDEX has successfully produced a virtually pure hydrogen plasma with an effective Z of 1; that is, no impurities.

The problem of impurities is a major one for magnetic-confinement fusion, since these heavier elements drawn from the walls of the tokamak cause rapid cooling and thus energy loss through electromagnetic radiation. The ASDEX was built to produce the purest plasma possible using poloidal divertor fields. The magnetic divertor is a sort of "hole" in the magnetic bottle that contains the plasma, which diverts part of the plasma out of the tokamak so that the impurities can be removed. The first experiments in May 1980 showed a clear decrease in plasma radiation with an exceptionally long plasma discharge time of 3 seconds, using ohmic heating alone.

Now that the ASDEX has been upgraded with neutral beam heaters and 8 megawatts of heating, the initial results seem to be completely successful. ASDEX has now operated with its divertor removing the impurities, and a special predischarge cleaning procedure has also been used successfully. This involves putting a thin film of titanium on the reactor chamber wall, "titanium gettering."

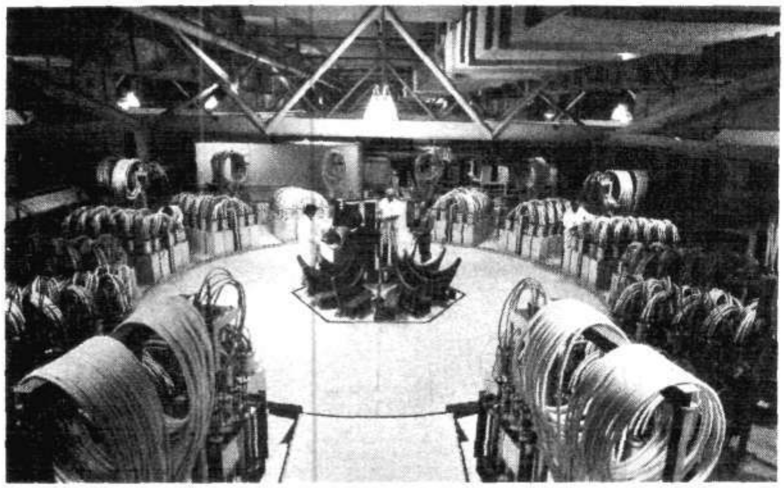
The Impurities Problem

The single most important technological barrier to building a successful prototype fusion reactor like the Fusion Engineering Device or the United Nations' Intor is the problem of impurities. Thus the ASDEX results, if confirmed, will be of great importance in fulfilling the mandate of the Magnetic Fusion Energy Engineering Act of 1980, "to achieve at the earliest practicable time, but not later than the year 1990, operation of a magnetic fusion egineering device based on the best available confinement concept."

ASDEX's effective Z of 1 means that the plasma is of completely ionized hydrogen. The Z of any atomic element is equal to the number of protons it has in its nucleus, which is also the atomic number of that element. When hydrogen, for example, with atomic number 1, or 1 proton, is stripped of its electrons, it has a positive electrical charge proportional to its Z.

Impurities cool the fusion plasmas through radiation, thus decreasing the chances for commercial feasibility. The effect of the impurities is measured in terms of Z, the effective ionic charge of the plasma. The rate at which a plasma radiates away electromagnetic energy is proportional to the square of Z, or the effective Z.

If just 1 atom of iron from the walls of the tokamak is added for every 500 hydrogen atoms in the plasma, the rate at which the plasma loses energy will more than double. This is because iron has a Z of 26, and the square of 26 is 676. The square of 1 is 1 for pure hydrogen, but adding iron's square of 676 to this figure and then dividing by the 501 atoms, increases the effective Z of the overall plasma from 1 to almost 2. This why even minute quantities of impurities have such a devastating effect on the attempt to keep the plasma hot enough to sustain a net fusion reaction.



LANSL

Experimental work in magnetic fusion made significant progress over the last year. Shown here, the ZT-40 device at LANSL.

Los Alamos ZT-40 Pinch Enters Tokamak Range

The Los Alamos National Laboratory's ZT-40, a reversed-field toroidal zeta pinch, continues to make substantial progress, according to a report by Dr. Joseph DiMarco of the Los Alamos Controlled Fusion Division, which was presented to the Fusion Power Coordinating Committee meeting in Boston this April.

The discharge times of the ZT-40 have now been increased to 8 milliseconds. If this proves to be an accurate measure of energy confinement time, the ZT-40 will enter the range of operation of tokamaks, although with much lower magnetic field strength.

These results go far beyond the early-1960s results of the British Zeta, which were not understood at the time.

As reported in the June issue of *Fusion* (page 18), the magnetic structure in a zeta pinch is initially unstable in the form of a twist in the plasma, a kink, that moves around the torus. As the kink reacts with the walls of the vacuum chamber electromagnetically, it causes the outer shell of the confining magnetic field to reverse directions. The kink disappears, setting up a stable magnetic configuration.

The field-reversed nature of the ZT-40 is its most significant feature, allowing the device to explore those plasma regimes that may permit the design of stand-alone plasma field-reversed configurations, where the need for external magnetic coils is substantially reduced. This could lead to very economical magnetic fusion reactors, since a large portion of the total cost of a magnetic fusion reactor involves the cost of the magnetic system used.

The ZT-40 success is creating great interest among all fusion theory and experiment groups since many aspects of this machine's operation are applicable to alternative types of magnetic confinement devices.

Los Alamos scientists also report that the British HBTX A1 reversed field toroidal zeta-pinch experiment has just been brought on line, and results of the first run are expected soon. The HBTX A1, which is at the Culham Laboratory, is slightly larger than ZT-40.

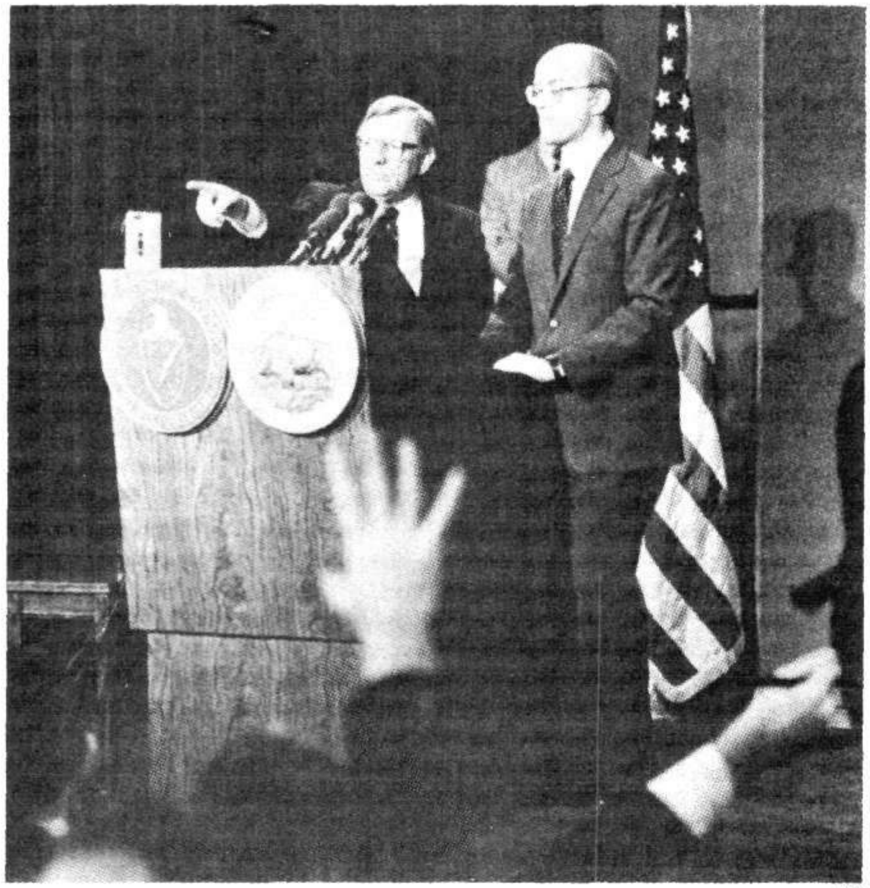
Environmentalists Target Watt: 'A Prodevelopment Extremist'

A coalition of environmentalist groups led by the Sierra Club launched a national campaign this spring to oust Interior Secretary James G. Watt, and hopes to collect 1 million signatures demanding his resignation.

With no identifiable legislative goal, and given the assassination attempt on President Reagan, the "oust Watt" campaign could well create the climate in which the prodevelopment Interior Secretary himself becomes an assassination target, sources in the intelligence community have warned.

A second flank in the campaign against Watt is the "Seaweed Rebellion" in California, which is protesting Watt's efforts to expedite the long-stalled leasing of promising oil and gas tracts off the coast. Citing the plight of California sea otters and other coastal marine life—which need not be uprooted by the stepped-up oil development—environmentalist groups and California Governor Jerry Brown filed twin suits in late April charging that Watt "has taken an unbalanced and unsupported view" of the national interest in recommending some 34 tracts for leasing.

Other lawmakers lining up with the environmentalists are California Senator Alan Cranston and Representative Phillip Burton, both Democrats, who claim that Watt has declared "unconditional war" on their state's natural resources. In his first speech as secretary, Watt emphasized that he in fact advocates the "orderly development" of energy resources and greater access to public parks and wilderness.



DOE

Interior Secretary James Watt (right) and Energy Secretary James Edwards respond to questions at the press conference at which they announced an accelerated five-year leasing program for offshore oil and gas.

Behind the 'Oust Watt'ers'

A look at the roster of environmentalist groups protesting Watt suggests that the motives behind their campaign are other than preserving untouched nature. The "oust Watt" coalition includes the Wilderness Society, the Friends of the Earth, the National Resources Defense Council, the Audubon Society, the Environmental Policy Center, and Environmental Action.

Like the Sierra Club, these groups are all heavily funded with tax-deductible grants from the Rockefeller, Ford, and Atlantic Richfield foundations, on whose boards sit members of top ranking Eastern Establishment institutions like the New York Council on Foreign Relations, the Trilateral Commission, and the U.S. Association for the Club of Rome. These institutions also had major input into the drafting and promotion of the *Global 2000 Report*, whose recommendations on world population control and resource conservation hinge on the premise of finite, dwindling resources. Watt's stance—that there are plenty of resources there, if we will only develop them—pulls the rug out from under the arguments of the *Global 2000* crowd.

The Sierra Club's chief criticism of Secretary Watt, in fact, is that he is "a prodevelopment extremist."

Interior Secretary Watt on The Best Strategic Minerals Policy

Secretary of the Interior James G. Watt testified before the Science, Technology, and Space Subcommittee of the Senate Commerce Committee March 2 on America's growing dependence on foreign sources for minerals vital to national security—so-called strategic minerals. Excerpts from the testimony appear below.

Hearings on this issue and government action are mandated by the National Materials and Mineral Policy, Research and Development Act of 1980. Many State Department officials have used the strategic minerals issue to motivate a U.S. foreign policy of imposing the perspective of the Global 2000 Report *internationally—population control and conservation of all resources—or one of risking U.S. involvement in proxy wars over Africa's supplies of the strategic resources. Watt, on the other hand, argued that the best strategic minerals policy is to develop America's undeveloped mineral-rich lands, as well as the vast, untapped resources that lie in deep seabeds.*

* * *

. . . In the past 10 years, minerals exploration in America has declined. New mine development in this nation has declined. Smelting and refining of American ores on American soil has declined. We are importing from foreign nations the most critical element of our civilization, the universal building blocks of an industrial economy—strategically important minerals.

The National Materials and Minerals Policy, Research and Development Act of 1980 is clearly a congressional reaffirmation of its 10 year old predecessor. It is an effort to end the troubling decline of America's minerals industry. Congress has once again directed the executive branch to "foster and encourage" America's minerals industry. . . .

In your invitation to me to appear before you today, you asked me to describe the [Interior] Department's state of readiness and the steps we are prepared to take to meet our domestic and defense needs if confronted with a foreign interruption of strategic minerals and materials. In the case of an interruption of immediate consequence, there are in place appropriate mechanisms to mitigate the short-term impacts and to provide for appropriate subsequent actions. I have attached to my statement an abbreviated list of possible actions that, depending upon the seriousness of the situation, could be undertaken.

This response capability, including stockpile allocation, relates to defense preparedness in the face of a national emergency. As such, the type and size of stockpile goals reflect a measure of the security of foreign sources. However, while the whole of the emergency process available under the Strategic and Critical Materials Stock Piling Act of 1979 and the amended Defense Production Act of 1950 is intrinsically part of a strategic minerals policy, it is not minerals policy in the sense of a sustained national effort to strengthen this very base of our productive capacity. In fact, the emergency process is necessary in part because we have no minerals policy. . . . The Department of the Interior, through the secretary and through the assistant secretary for energy and minerals, must be, as the 1970 Act intended, the "amicus" for the minerals industry in the court of federal policymaking—not as a representative of private mining interests per se, but

Continued on page 59

Speeding Up the Leasing Process

Since his confirmation as Secretary of the Interior, James Watt has taken some decisive actions to extirpate the Carter administration's legacy of environmentalism and zero growth.

In a joint press conference April 10, Watt and Energy Secretary James Edwards announced they were taking action to accelerate the process of leasing offshore oil and gas tracts. This move will increase the number of proposed Outer Continental Shelf lease sales over 1982-86 from 36 to 42, adding approximately 70 percent of the total acreage available for exploration in Alaska, California, and Gulf of Mexico areas. The U.S. Geological Survey estimates that one of the areas—the Beaufort Sea off Alaska—may contain some 8 billion barrels of recoverable oil and 27 trillion feet of natural gas.

Watt is considering legislation that would promptly open up for multiple use lands that have been determined to be unsuitable for wilderness designation under section 603 of the Federal Land Policy and Management Act of 1976.

He is also reviewing the burdensome regulations blocking strip mining.

Perhaps most politically significant, Watt was instrumental in preventing the team of Carter administration holdovers from returning to the Law of the Sea Treaty negotiations at the United Nations in March. As Watt stressed in congressional testimony March 2 (see accompanying article), the exploration and development of the world's deep seabeads are crucial to both international economic prosperity and security. What Watt did not say explicitly is that the Law of the Sea Treaty under negotiation would put seabed mineral development under the control of a supranational body like the United Nations and squelch development, using the guise of protecting Third World nations' equal access to the resources off their shores.

Will America Take Up

Marsha Freeman

The flight of the Shuttle rekindled the American population's excitement about conquering space, the next frontier. Shown here, zero hour at the Kennedy Space Center April 12.

"The Shuttle will remoralize America," Shuttle pilot Captain Crippen said before the launch of the Orbiter Columbia April 12.

The jubilant reaction of the American people to Columbia's maiden voyage indicates that, indeed, the Shuttle has begun to remoralize America. Now the question is political: Will the nation make the capital investments to expand the U.S. industrial and scientific base here on Earth in order to put civilization into space?

In the period between the manned Apollo Moon program and the recently successful Shuttle flight, the U.S. space program foundered in its initial commitment to spread human civilization throughout the universe.

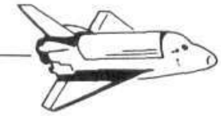
In terms of where man could immediately go in space, the groundwork was laid by the mid-1960s when NASA established the fact that man could survive in space. By the end of the decade, man had landed on the Moon and returned safely to Earth in a remarkable mastery of the science and technology of space flight.

Until the flight of the Columbia, however, the next step—establishing and maintaining a permanently manned series of space stations that would allow Americans to live and work in space to prepare for the next phase of colonization—was not seriously pursued.

This permanent presence of Americans in space is what is now needed.

The scientific exploration of Earth's neighbors in the solar system that are farther away than our own natural satellite, the Moon, proceeded with spectacular unmanned flights over the 1970s. But if we are to ever live in and "Earth-form" these barren worlds, the nation needs an entirely renewed vision and commitment to its space program.

The United States right now does not have any funded programs for space colonization. In real terms, the



the Challenge of the Shuttle?

U.S. space budget has been shrinking since the mid-1960s. If NASA were to have a scientific and operational capability today comparable to the one it commanded at the height of the Apollo program in 1965, it would require a budget of $14 billion. Instead, the fiscal year 1982 budget is just a little over $6 billion.

(By contrast, Soviet space expenditures have been growing at a steady rate of about 5 percent a year for the past 10 years.)

Without a commitment of funding for NASA, for science education, and for industrial growth, the United States will not be able to support a space colonization program. Contrary to the beliefs of those space supporters who are zero growthers, space colonization will not be an escape from an Earth with limited resources; instead, that space colonization will be accomplished only by a society that has used advanced science and technology to expand the resource base here on Earth.

A Vision for America

The vision for America of making space the nation's frontier was articulated eloquently at the time of the Shuttle mission. Two days before the scheduled Columbia launch, for example, Senator Howell Heflin, an Alabama Democrat, submitted a statement to the *Congressional Record* that summarized the economic benefits of the NASA program in detail. Heflin concluded:

"In my judgment, we must unleash the creativity, the imagination, and the technological innovation of these superb teams of scientists in our space program and provide them with the funds necessary to move these daring programs forward."

Senator Harrison Schmitt, the New Mexico Republican who was the first U.S. scientist to go into space, conveyed a similar message: The real meaning of our manned space efforts is to "spread human civilization throughout the universe," Schmitt told a nationwide television audience on the ABC-TV "Issues and Answers" show the day of the launch.

Schmitt submitted a statement to the *Congressional Record* laying out the challenge to the Reagan administration:

"Although we now have this fantastic new capability in hand, it is still not certain that the United States will reach out and fully grasp the opportunities for services, products, and defense it provides. What is lacking is what has been lacking since the latter years of the Johnson administration, namely, leadership.

"The Reagan administration is now presented with the opportunity to articulate a purpose for U.S. activities in space, a purpose that establishes once and for all a permanent commitment to compete continuously and successfully in the development of space. . . .

"As important as the public, commercial, and defense applications will be, there is an even greater need to be served by the success of the Columbia. . . . All of us for a shared moment once again stood with John and Crip on the edge of the universe. Americans need to step beyond the Earth's shores of the new ocean of space and put once again to test heart and soul against the frontier of the unknown."

The President made it clear that he, too, shared the vision for America that the space program provides. In his April 28 speech to the nation on the budget Reagan said: "The Space Shuttle did more than prove our technological abilities: It raised our expectations once more. It started us dreaming again."

The Fight Ahead

Will the United States take up the challenge of the Shuttle and fulfill its dream?

The answer depends on whether Senator Schmitt and those who agree with him will fight the economic battle, challenging the budget-cutting policy of Office of Management and Budget Director David Stockman and his financial advisers. Here, even Schmitt has fallen short. "For the short term" he wrote, "the space budget like most others must bear its share of cuts necessary to commence a national economic recovery."

The vision of America in space must be translated into concrete resources to enable the space program to fulfill its mission. To make this dream come true for all mankind requires an organized political lobby of citizens that will fight to create the national resources necessary to do the job.

—*Marsha Freeman*

NASA

Young and Crippen deplane at Edwards Air Force Base in California after the first Shuttle flight.

FUSION EXCLUSIVE

An Interview with Capt. Robert Crippen

Getting the U.S. Back into Space

We all saw how exuberant Astronauts John Young and Robert Crippen were when they stepped out of the Columbia Space Shuttle after its magnificent performance. Here, in an exclusive interview, Capt. Crippen talks about the flight, where he thinks NASA is going, what the Shuttle has done for America, and what an accelerated space program would mean for the nation's youth.

Asking the questions is Fusion's *Marsha Freeman, who watched the launch in person at Cape Canaveral and who frequently writes about the space program.*

Fusion *is proud to claim Capt. Crippen as a regular reader.*

* * *

Question: While you were up in space there was a geat deal of discussion by the media, former astronauts, and people who have been following the Shuttle very closely about its potential, especially about the military versus civilian uses. From your sense of working in the program and actually flying the plane, could you give us an idea of what you think of the program and its potential?

Actually, what I would say about the Shuttle and what it has opened up for us is what I was saying prior to doing the flight. It proved that it could do everything we said it could do, at least to this point in testing. We still need to complete all the other test flights that we have outlined in the program, and these are very important to us to ensure that we understand its full operating capability. But the main thing it will do for us is get us in and out of space easily.

Some people refer to it as a space truck, both derogatorily and, in my opinion, not derogatorily. That's what it is—it's a truck.

But it's important to us from many viewpoints, starting from the scientific standpoint. It is important to us from the standpoint of science: being able to get out and study the environment of space and also to study our own environment back here on Earth. It is important from the standpoint of being able to exploit space for manufacturing, and your magazine has done a good job of exploring for us the things we can do while we're out using the vacuum and weightless environment. It's important to us from the standpoint of communications, weather satellites, and what have you, because we can build the satellites more cheaply and we can also put ourselves in a position to repair satellites.

And the military aspects of it—even being a military manned station down here we don't deal directly in the DOD [Department of Defense] things. All we're planning on doing right now is being able to carry them [DOD things]. The DOD is a heavy user of space already. It's proven very beneficial to them and that's just one of the reasons that the DOD was a big supporter of the Shuttle. They need to utilize it and they want to do it as economically as possible because they work under tight budget constraints, the same as we do.

Just the fact that we have opened up space to get into and out of easily, that's really the prime thing.

Question: We've tried in the magazine, as you mentioned, to give people a sense of what the NASA program has created on Earth economically and in terms of giving us a global view of our environment through Landsat and new communications possibilities. What do you think about when you are up there and you see the Earth from 170 miles away? What kind of perspective do you gain on everything that's going on down there?

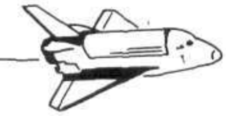

NASA

Actually, I'll probably disappoint you with that question, because we were so darn busy we really didn't have time to be philosophical at all. We had planned a very tight flight plan to get as much out of the flight as we possibly could and we were pretty successful in accomplishing most of it, but that required that we were pretty busy.

Other than enjoying being weightless and getting a chance to observe the Earth from that altitude, which is a fantastic thing—it's a beautiful place—I really did not have time to sit down and be very philosophical. I'll tell you what: It's the kind of thing that I wish more people could get to enjoy. It's really a treat.

Question: The excitement among the press and the guests who were there for the launch was tremendous. We felt that we were almost up there with you and Young—

I've talked to several people who observed both the launch and the landing, and apparently that was a fairly general feeling. I really think that the flight shows that what people quite often say, that the general pub-



I think that getting back into space and getting the economy going on a scientific note creates jobs, and people want to fill those jobs, and that is going to stimulate the educational system to make people smart enough to fill them.

NASA technicians assist astronauts John Young and Robert Crippen a few hours before the scheduled liftoff. Left: Capt. Crippen.

NASA

lic is kind of lackadaisical about going into space—I really don't think that that is the case. Any indication that I've ever had in going out and talking to people is that we still have a lot of enthusiastic supporters, and it was even more obvious during this flight.

Even in the press—there are always people who are going to be critical of us in the press and knock us for being a little bit late in our schedule and so forth—but in the end, when we were proving that we could do what we set out to do, I think we had nothing but supporters.

Question: I think the excitement you're talking about was not limited to the pride Americans felt in the Shuttle but was really something shared internationally. For example, the Shuttle launch and landing were carried live on TV in Japan and India.

Now I'd like to ask you where you think the space program should be going over the next 20 years. Just a few hours after the launch former astronaut Harrison Schmitt, the New Mexico senator, told ABC-TV's "Issues and Answers" show that the real potential of the space program was that it would help us spread human civilization throughout the universe. What do you see as the horizons for the space program over the next two decades?

One of the things that Senator Schmitt, myself, John Young, my boss Chris Kraft at the Johnson Space Center here, and a large number of other people feel very strongly about is that we need to put a United States man and woman in space permanently. Our goal that we would like to proceed on in that direction, which looks like the best, is what we're calling a Space Operations Center. That's a fancy name for a permanently orbiting manned satellite that will allow us to explore some of the manufacturing things that we talked about, some of the scientific things, and also, one that we feel is very important, seeing how we can develop using solar energy from outer space and beaming it back to Earth. We think there is a large amount of potential in that particular area.

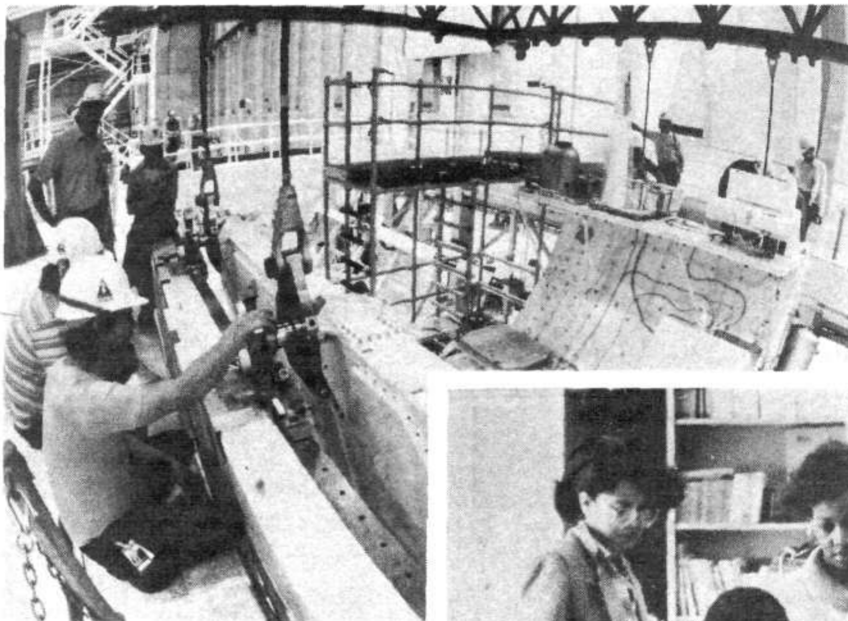
We would like to get the go-ahead from the administration and start working on such projects very soon. In fact, John and I, when we get the opportunity to go to Washington, plan on trying to make that point very heavily both to the administration and to the Congress. I guess I would like to see that done in parallel with continuing to utilize the Shuttle not only to build that space station but to see it really put to work getting satellites up.

We want to get the Shuttle operational, where it's like an airline kind of operation. In parallel with that, we would like to put up some kind of permanently orbiting space station. It would take quite a bit of time, but certainly in the next decade we could have something going of that nature—if we could get that kind of financing.

Beyond that, we hope to go back to the Moon, but before we go back to the Moon, we want to be in a position so that when we get there we could put up a colony that would allow people to stay up there for extended periods of time. I expect to see us colonize the Moon and, eventually, travel out beyond. We'll get a trip to Mars some day. Unfortunately, I don't think it will be while I'm flying.

Question: One of the areas that we have been most interested in is the contributions of NASA in education. About four months ago we began publishing a children's science magazine called The Young Scientist, geared to junior high school youth. Have you given any thought to the kind of role that a more invigorated space program might play over the next decade in upgrading all our science education programs?

We tend to cycle somewhat of a sine wave with regard to where we stress education. I still think that we have fairly important and good scientific and engineering development in our education, all the way from



NASA

Science is very fundamental to our nation, and so is technology. It is important that we continue to have people that stress those areas at all levels, from the man on the street all the way up to the people who run the country.

Carlos de Hoyos

Above: Technicians lower a payload of experiments into Cargo Integration Test Equipment at Kennedy Space Center. Right: Students at Camden High School in New Jersey with the experiment they submitted to fly on the Shuttle: an ant colony to study how social animals behave in space.

grammar school on up. It is also true, I believe, that the general trend of education has seemed like we're not producing the same caliber of students on an overall level. I'm not sure exactly what the reason for that is. I think if we knew what the reason is, we'd go solve it.

I know from the standpoint of the military, quite often when we go out and recruit people who are high school graduates, you would anticipate that they have a certain caliber and knowledge. At least they ought to be able to read training manuals, but we've had problems with that.

I think that getting back into space and getting the economy going on a scientific note creates jobs, and people want to fill those jobs, and that is going to stimulate the educational system to make people smart enough to fill them.

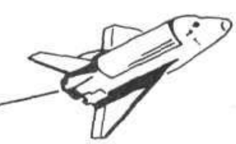
I was a sophomore in college when Sputnik was first put up, and that was certainly when we got a lot of furor about what the educational system was doing in this country—could it produce the same level of scientists and technical capabilities as the Soviets were doing? As far as I'm concerned, we can easily do that without even trying, but we can do much better. I believe that any time we've got scientific programs such as going into space that are viable, we've got to create jobs and we've got to create education. It's a natural by-product.

Question: We are taking up the fight as a scientific foundation to push for an upgraded NASA space program, and we're mobilizing for a very public fight on the issue. I know that our readers and foundation members have an overall commitment to scientific development and technological progress. Is there something you'd like to say to them?

Science is very fundamental to our nation, and so is technology. It is important that we continue to have people that stress those areas at all levels, from the man on the street all the way up to the people who run the country. As long as we have people and organizations like yours that focus on those particular areas, I think that we can keep that drive that we need. I appreciate the kinds of folks who do that.

Question: I know everyone would like to know why you joined NASA and became an astronaut, and when you first thought about getting into the space program. It's an important question, especially for children.

That's also a very difficult one to answer. Since I was a very young man, I had been interested in flying, and I was also interested in space. It was obvious to me as I was going up through high school that technology was reaching the point where very



soon people would be going into space. I was somewhat disappointed when the Soviets ended putting up Sputnik—I was only a sophomore in college—because I knew I wouldn't get the opportunity to fill all the squares that I needed to, to be able to fly very soon!

However, I also realized that in getting a chance to fly in space, there were not going to be a lot of folks doing it initially, and I would have been happy just to work at helping put people up there. I more or less stressed my education in that particular area when I joined the Navy to get an aviation background. I was really planning on just spending one tour with the Navy and coming back and getting some advanced degrees to get to work in the space program. I had the opportunity after my first tour to go to test pilot school, so I pursued it, and I was lucky enough to be standing in the right place at the right time to end up getting selected for astronaut training.

I have spent some long, dry years on the program getting reoriented [for the Shuttle], but I've had lots of fun in the work that I've been able to do.

As to why I wanted to do it, I guess I enjoy working on engineering kinds of problems. I enjoy operational kinds of problems and always have—and to me, space lets you do all those kinds of things. It's very interesting work, and I like things that keep me busy. The actual flying in space is kind of like the icing on the cake. It's the main work that's all the fun.

Question: We're especially concerned in terms of the future about the situation facing our children—peer pressure for the use of drugs, rock music, and so on. We are trying, through The Young Scientist magazine and our other work, to reeducate a generation of American youth, to stimulate an excitement about science. Is there something special you'd like to say to American young people?

I'm not sure that I share some of the pessimism that you expressed. I really think very positively about the youth in our country today. They can and do prove that they can produce as well as all the people in the past. I think perhaps that certain negative things tend to get stressed sometimes. I recall that when I was growing up they were saying some of these things about my generation as well.

The main thing that I always try to tell young people is that they really ought to try to find themselves some kind of a goal—I think goal-oriented people are what make our country great—and that goal ought to involve something that they enjoy. For some people it's science, for some people it's art, for other people it's social work, and for some people it's reporting or doing news work. But all levels of endeavor are important to us.

You should have something that you want to cling on to and work on, and if you don't have that, you're going to find yourself drifting around with very little personal satisfaction in your life.

The main thing that I've always tried to orient young people to is to latch on to something that they enjoy. It may not be necessarily what your parents want you to enjoy, but if it's something you really enjoy, and if you work hard at it, you'll be successful. I think that's the main thing that I've always tried to convey to kids.

I think that the Shuttle did give a sense of pride to the country and a feeling that we can accomplish something that we set out to do.

Houston FEF Meeting Celebrates Launch

A Rockwell International supervisor of management systems for the Space Shuttle support crew at the Johnson Space Center shared the happiest day of his life April 12 with a gathering in Houston, Texas of members of the Fusion Energy Foundation.

"You'll have to excuse me," Jim Hudson explained to the FEF meeting, "but I didn't get much sleep last night, and I haven't quite come down to earth yet. The vision of that liftoff and orbital insertion this morning is engraved in my brain, and I will never forget it."

Hudson added, "The last seven-and-a-half years of my life have been devoted to this event, and the last fifteen years of my life overall have been spent with NASA. I've seen some Apollo launches. I've seen some Skylab launches. I've seen the ASTT launch. But never have I seen anything so lovely as the Shuttle launch this morning."

Hudson, who presented an in-depth slide show on the Shuttle to the captivated audience—many of whom had been involved for years in organizing and lobbying efforts on behalf of a renewed American commitment to scientific and technological advance—was thanked by FEF regional coordinator Harley Schlanger and FEF national education director Carol White for taking time out so close to the momentous liftoff to address the meeting.

Hudson replied, "I want to express my admiration and the admiration of thousands of people like me for the kind of work you are doing in trying to overcome the neolithic, Neanderthal Naders and Fondas, and others of their ilk."

'Space Week'

The meeting endorsed the proposal by supporters of NASA to celebrate "Space Week" from July 13 to 20. Activities around the country during that week will promote an expansion of NASA and the U.S. space program. The week will culminate in a campaign to make July 20, the anniversary of the first Moon landing by astronauts Neil Armstrong and Edwin Aldrin, a national holiday. This holiday would provide the time for national gratitude to dedicated individuals such as Jim Hudson, and to encourage the youth of this country to follow in their footsteps.

—Nick Benton

Viewpoint

Continued from page 10

proval of both the executive and legislative branches of government before being implemented, but the agency must have a certain amount of independence in developing policies and programs. The review function of the organization should be limited to the implementation of the program approved by the executive and legislative branches.

I do not mean to endorse the Water Resources Council as the agency that should carry out these functions. The council has not been a success for several reasons, the most important of which is that it has been under the exclusive direction of the executive branch. In fairness to the council, however, it should be noted that Congress delegated all authority for water resources development to the executive branch when it enacted the 1965 Planning Act, leaving Congress only the authorization process. Thus, friction developed between the two branches.

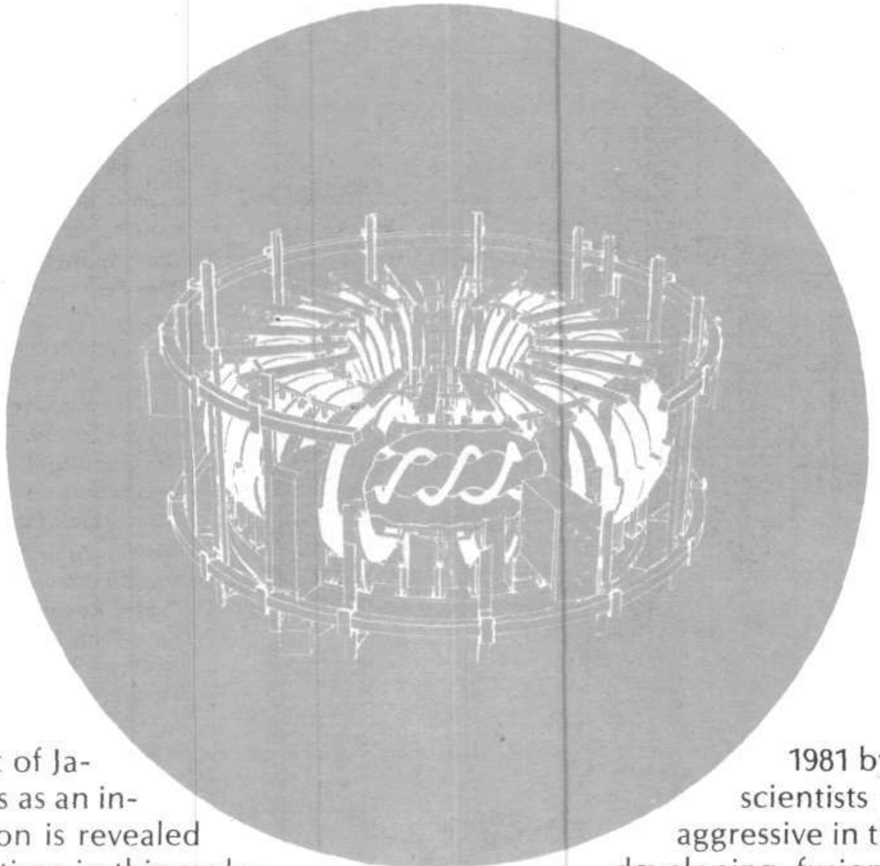
Also, the council became too involved in minor details and ignored the broad policy aspects of a water program.

For these reasons, the proposed water agency should definitely have a different name from that of the Water Resources Council if it is to enjoy any credibility. Such names as Water Resources Policy Board or Water Resources Board might be appropriate.

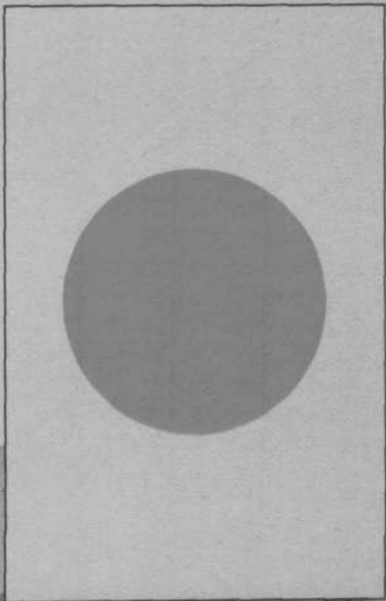
These are the steps that we should adopt if we are to rejuvenate our nation's water resource development. First, develop a program for each river basin of the country. Then provide a mechanism to implement and direct the program to meet our water requirements.

B. Joseph Tofani, president of the Water Resources Congress, is a registered professional engineer who has spent 45 years in all phases of water resources development, including in the planning, designing, constructing, and administrating of federal water programs. He served with the Army Corps of Engineers for 33 years.

Japan
Number 1 in Fusion?

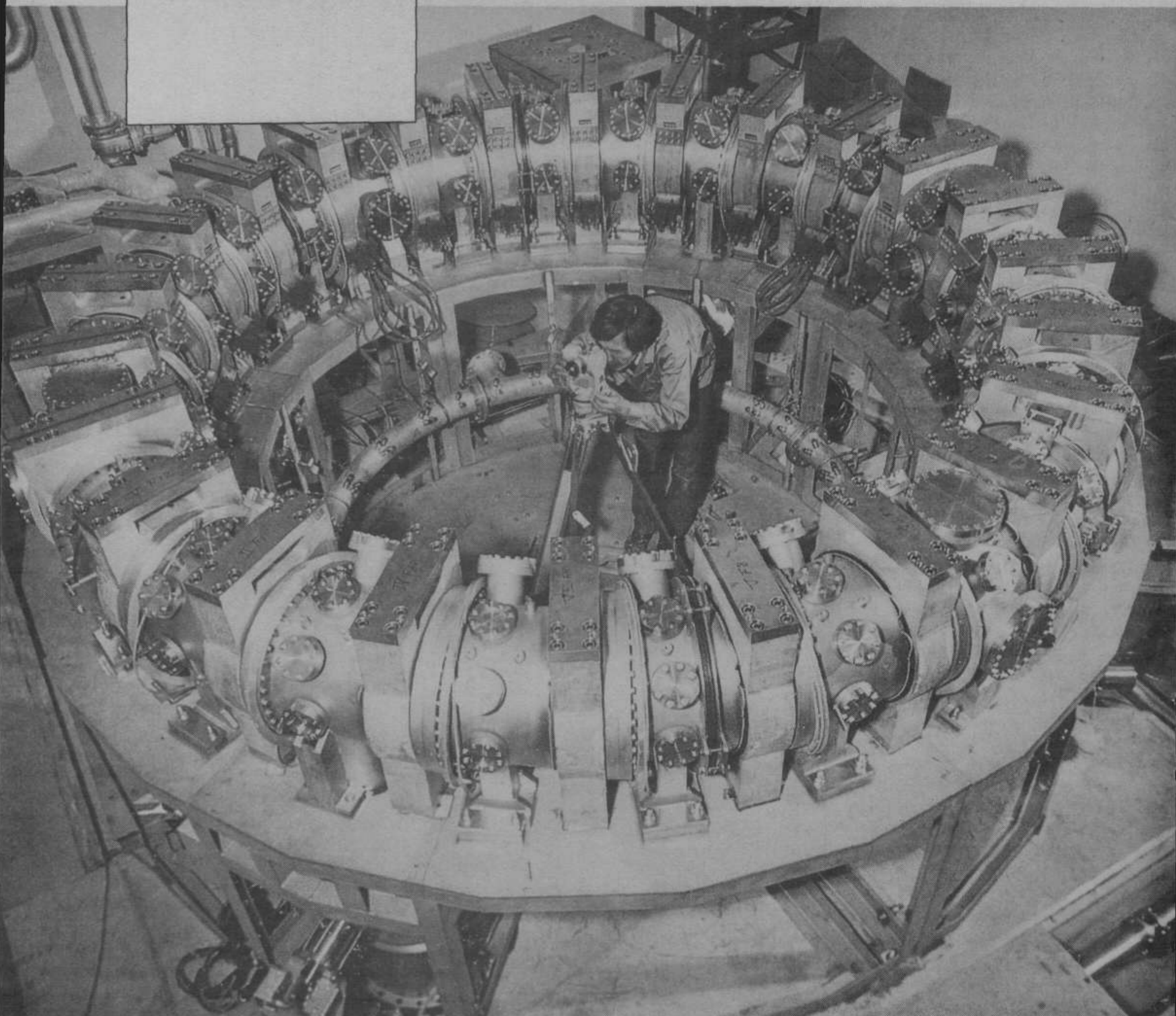


The secret of Japan's success as an industrial nation is revealed for the first time in this exclusive report. Japan is the only non-Western nation to become fully industrialized. And, as shown here, it did so using the methods of the American System—investing in the most advanced technology to power the nation's economic growth. Since 1975, the Japanese have viewed fusion as the leading edge of a strategy for development through the 21st century. The fusion program proposed in March 1981 by Japan's top scientists is the most aggressive in the world for developing fusion energy: It will put a demonstration power reactor on line by 1993. For 25 years, Japan's involvement in fusion has depended on international scientific cooperation, especially with the United States. Today, the Japanese are convinced that fusion is the key to their nation's survival—regardless of the fate of the U.S. fusion budget. As one Japanese fusion scientist put it: "If the United States won't do it, we will."



'If the U.S. Won't Do It, We Will'

Japan's Ambitious



Fusion Program

by Marsha Freeman

IN MAY 1978, JAPAN'S Prime Minister Takeo Fukuda surprised President Carter—and his nation's Finance Ministry—with the announcement at a New York City foreign policy forum that Japan was prepared to spend $1 billion in a joint program for fusion research. Three years later, in March 1981, Japan's scientific experts have recommended to the Japanese Atomic Energy Commission that Japan build and operate a 400- to 800-megawatt fusion reactor by 1993. If approved by the present Prime Minister, Zenko Suzuki (and according to Japanese sources, this is nearly certain), the Japanese fusion program would merge plans for an Engineering Test Reactor with those for a multi-billion-dollar Experimental Power Reactor in order to achieve the 1993 goal.

This accelerated program would catapult Japan ahead of other nations, including the United States, in developing controlled thermonuclear fusion, an energy source that uses seawater as fuel and is clean, safe, and virtually unlimited. Unless the 1980 U.S. fusion legislation is implemented, the United States will be left years behind the Japanese.

Fukuda made the proposal based on his personal commitment to ensure the development of fusion energy, a commitment made in 1975 when Japan's leading scientists and cabinet ministers evaluated international fusion research and decided that fusion was "the energy resource of the 21st century."

The United States, largely because of former secretary of energy James Schlesinger's maneuvering, has not yet taken full advantage of the Fukuda fusion proposal. Now, many Japanese feel that Japan is going to achieve its fusion goal with or without the collaboration of the United States government.

"We have a two-track system," explained Tokyo University Professor Taichiro Uchida, one of the five plasma physicists on Japan's long-term planning subcommittee of the Nuclear Fusion Council. "We are cooperating internationally with the [International Atomic Energy Agency's] Intor tokamak program. And we are developing fusion reactors on our own."

◄ *Japan's Nagoya Bumpy Torus, which combines features of the magnetic mirror configuration in a tokamaklike machine, is the only fusion device of its kind besides the Elmo Bumpy Torus at the Oak Ridge National Lab in Tennessee.*

Although the Japanese involvement in the fusion effort goes back to the late 1950s, the aggressive goal-orientation dates from 1975. Since that time, and especially since 1979, the fusion program has been under intense discussion. Of particular importance were the Intor meetings during 1979 and 1980 with scientists from the United States, the Soviet Union, and the European Community. It was through evaluation of the fusion research results worldwide that the long-term planning subcommittee of Japan's Nuclear Fusion Council, led by Shigeru Mori, decided that the Japanese program could successfully skip some of the steps in fusion development that were earlier thought to be necessary.

How soon do the Japanese expect to achieve commercial fusion? In an interview with *Fusion*, Uchida estimated that fusion would be commercialized by 2010, with the current international tokamak program. But he quickly added:

> You [pointing to a copy of *Fusion* magazine] have to ignite the hearts of mankind to be excited about fusion. And if you do that, then we can have fusion by the year 2000. Man can do anything if he'll put the resources to it. By resources I don't mean money. Money is just how you value labor; it's not a real resource. How many plasma physicists are there working on this [fusion]? Only about 1,000 in Japan. And how many are there in the United States? Only several thousand. So if the nations decide that this is a priority and devote the human resources to this project rather than other projects, and multiply the number of scientists in the field 10 times to work on fusion, then we could have commercial fusion by the year 2000. But if it moves forward at the current momentum, then we'll achieve that goal by 2010.

The Japanese decision to accelerate their fusion timetable is not surprising. Japan's economic philosophy has been to invest in the frontier technologies and industries in order to move the whole economy forward. In scientific terms, similar Department of Energy and congressional reviews of the U.S. fusion program over the past year have also recommended an aggressive entry into the engineering phase of fusion development. As several leading sci-

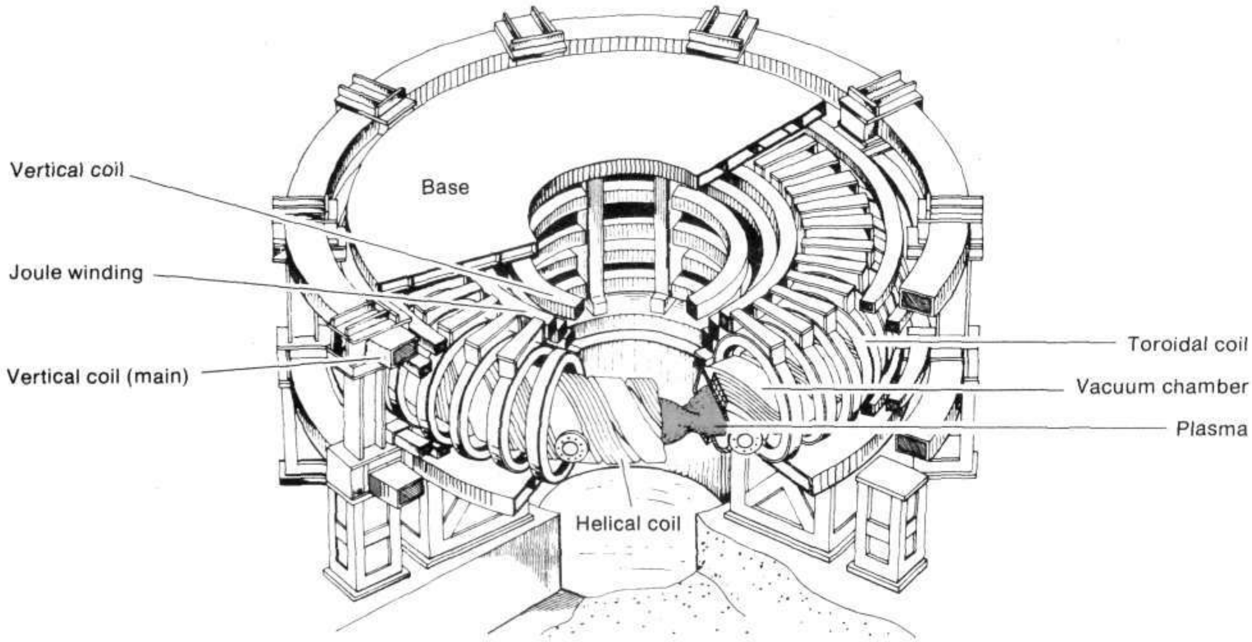


Figure 1
HELIOTRON E SCHEMATIC

The Heliotron E is a toroidal plasma experiment using a spiral-shaped conductor to create the magnetic force field that contains the fusion fuel or plasma. Although these laboratory devices use a normal hydrogen plasma, the fusion reactor itself will burn a mixture of the two heavy forms of hydrogen (deuterium and tritium), available from seawater. The fuel mixture must be heated to a temperature of millions of degrees in order to ignite the fusion reaction. At this temperature, hotter than the Sun, the fuel must be insulated and confined, a function performed by the magnetic field. The other magnetic field coils on this device provide heating and stability control for the hot, ionized fuel.

entists have put it, the remaining problems with fusion are not scientific but political.

Japanese involvement in fusion-related research began in the 1950s, growing out of discussions at international scientific conferences.

The Early Years

Uchida credits a 1956 speech by I.V. Kurchatov, the Soviet physicist, with influencing the shape of the early Japanese fusion work. Kurchatov said that if you want fusion, you have to begin with basic theoretical work in plasma physics. The American scientists, Uchida said, agreed with Kurchatov and gave the Japanese the same advice.

In 1959, Japan's Science Council debated whether to work on an energy-producing fusion device or develop a research-oriented fusion program and decided on the latter. The first Japanese toroidal research device, the Heliotron A, was under construction at Kyoto University that same year.

Two years later, the Institute for Plasma Physics was established at Nagoya University. The IPP continues to be the lead university laboratory for the exploration of alternative concepts for fusion to the tokamak, with 20 research units involving about 140 scientists and engineers. In 1966, the Laboratory for Plasma Physics was created at Kyoto University to upgrade and continue the Heliotron work.

Another major influence on the Japanese program was the 1958 Geneva conference on the Peaceful Uses of Atomic Energy, where the United States, the Soviet Union, and Great Britain declassified their early thermonuclear fusion research. Throughout the 1960s, international cooperation with the world fusion community continued to be of prime importance, as Japanese scientists visited U.S. and other fusion laboratories and participated in various international symposia.

At the third IAEA conference on fusion, held in Novosibirsk, Siberia in 1968, the Soviets announced their startling progress with a toroidal-shaped magnetic fusion container, or tokamak. This and subsequent results with the tokamak convinced the Japanese to pursue a comprehensive program geared not only to research but to energy production. Professor Uchida recalls that at the time Japanese scientists were still not absolutely sure that fusion was practical, but they thought it was worth an aggressive try to find out. In 1969, Japan's Atomic Energy Commission launched a five year plan for fusion as part of a national energy program.

Three years later the JFT-2 (Japan Fusion Tokamak) began operation to test basic plasma physics theory.

The evaluation of the research on the JFT led to a decision in 1973 to launch an even more aggressive tokamak experimental program under the direction of the Japan Atomic Energy Research Institute (JAERI) in Tokaimura. At the same time, the Laser Institute at Osaka University was established to begin large-scale laser and particle beam inertial fusion research.

One of the most exciting developments in the Japanese energy program was the organization in 1973 of Tsukuba City, a new academic city similar to the Siberian scientific city of Academgorodok. Tsukuba City now has 43 research institutes and 8,000 students, with a goal of 10,000 students in the near future. Tsukuba University is the lead facility in Japan's ambitious fusion mirror program. Magnetic mirrors—open systems compared to the closed, donut-shaped tokamaks and stellarators—are the leading competitor to the mainline tokamak in the United States.

The year 1975 marked a turning point for the Japanese fusion program. Fusion became a national project, the Atomic Energy Commission created the prestigious Nuclear Fusion Council to oversee the burgeoning fusion effort, and plans were made to build a big tokamak machine—the JT-60.

There were two deciding factors in the new push for fusion. First, there was the energy crisis precipitated by the 1973 oil embargo. Second, there was the conviction of Japan's scientists, who had previously been skeptical about the practicality of fusion, that fusion would work. As one scientist put it, "We knew then that fusion was the energy resource of the 21st century."

The oil embargo hit Japan very differently from the way it hit the United States. No Japanese government official could credibly propose that Japan's high-technology, energy-intensive industry conserve its way to "energy independence"! Because virtually all Japan's energy is imported, simply cutting back on energy use would shut down the economy.

The government proposed a twofold approach to the future of dwindling world fossil fuel resources. The first was a high-technology-vectored energy efficiency improvement program (more or less the opposite of "conservation" as defined by the Carter administration).

This involved R&D programs to commercialize advanced nuclear technologies. The high-temperature nuclear reactor, for example, is being developed for process heat and industrial applications, so as to lessen the burden on liquid fuels. The government also initiated a program to develop magnetohydrodynamics to convert thermal energy from any source into electricity at potentially double the efficiency of the conventional steam turbine cycle. Japan also began a serious program for using nuclear power to produce hydrogen as the liquid fuel that will replace petroleum in the next century.

On the fusion side, the scientists talked to the politicians and convinced several key people that fusion was the long-term solution and must be developed both for Japan's economic security and for world stability. As a result, fusion was designated as a national project, with the budget for the JT-60 being made by the prime minister's office (and therefore less subject to budget cutting). Takeo Miki, then prime minister, and Toshio Komoto, the head of the Ministry for International Trade and Industry (MITI), both fully supported the program.

The Atomic Energy Commission gave the Japanese scientific community the go-ahead to begin implementing the next step in the leading fusion concept, the tokamak. As the fusion funding profile in Table 1 suggests, after 1975, Japan's scientists were ready to take the next big step. The funding for JAERI more than doubled between 1978 and 1979, representing in concrete terms the national commitment Japan made to develop commercial fusion energy.

Equally important in establishing the fusion program, the Nuclear Fusion Council was set up, with full government backing from the top. The council is a group of 20 representatives drawn from the Education Ministry, the Science and Technology Agency, the Atomic Energy Safety Commission, the Ministry for International Trade and Industry, and the universities. It is responsible for recommending plans for Japan's fusion program and for seeing that there is no overlap of efforts or unproductive competition.

It was at this time that Takeo Fukuda, then a member of parliament and a contender for prime minister, became committed to support the fusion effort. Other political figures involved at the time were Ichiro Nakagawa, now the head of the Science and Technology Agency, and Rokusuke Tanaka, the current head of MITI.

Table 1
FUSION FUNDING IN JAPAN
(in million yen)

Year	Total	Japan Atomic Energy Research Institute	Ministry of Education
1973	929	460	305
1974	1,906	808	914
1975	4,374	2,590	1,553
1976	8,247	4,070	3,920
1977	12,173	7,715	4,265
1978	17,376	11,508	5,377
1979	31,524	24,641	6,288
1980	37,000	29,229	8,239
1981	44,000	35,787	10,126

The funding for Japan's fusion program significantly increases after 1978. The more than doubled budget for JAERI in 1979 reflects the beginning of construction on the JT-60 tokamak. Funding for the Ministry of Education fusion projects has increased steadily, although not so dramatically as for the tokamak program.

To translate the figures into dollars, the exchange rate is approximately 200 yen per dollar. However, these figures demonstrate the internal growth of the Japanese program and cannot be compared with the U.S. budget because the Japanese figures do not include salaries and administration.

Will Japan be number 1 in fusion? Part of the answer lies in the nation's experience in building fusion devices and their research record, briefly reviewed here.

Japan's Fusion Experiments

The JFT series. The Japanese tokamak program is centered at JAERI. The first JAERI tokamak, the JFT-2, began operation in 1972 as a small-scale basic plasma physics experiment. Its radius is less than 1 meter, and it was superseded by the JFT-2a in 1974.

To gain experience with a larger, 1.25 meter machine, the JFT-2M is under construction and will be operational by 1983. All these devices are small scale, multi-million-dollar machines, which are considerably smaller than the pace-setting Princeton Large Torus in the United States. The PLT made international headlines in 1978 when it reached groundbreaking plasma temperatures well beyond the 44 million degrees needed to ignite the plasma and demonstrated that a fusion plasma would follow the theoretical scaling laws for containing a fusion plasma.

Arthur Grace/Sygma

Bringing the energy of the Sun to Earth was the theme of Japanese Prime Minister Takeo Fukuda's $1 billion proposal to President Carter in May 1978 for a joint fusion development program. If the 1980 U.S. fusion legislation is not implemented the United States will be left years behind the Japanese in fusion.

As early as 1970, Japanese fusion scientists were planning to scale up their research to approach the machine size needed to reach energy breakeven—producing more energy from the fusion reaction than the energy input needed to heat the fuel. In 1978, Japanese scientists began informal collaborative work on the U.S. Doublet III experiment at General Atomic Company in San Diego to gain hands-on experience with a medium-size tokamak.

The Doublet III has a radius of nearly 1.5 meters, and the Doublet experience encouraged Japanese scientists to recommend going ahead with a large-scale Japanese device.

The JT-60. The Japanese decided in the 1970s to go directly from the small-scale JFT series tokamaks to the huge JT-60, without a PLT-size machine in between. The JT-60 is about the size of the reactor-scale Tokamak Fusion Test Reactor at Princeton to be completed next year, the largest U.S. tokamak.

Design work on the JT-60, under construction by JAERI since 1978, began in 1970 and was upgraded and accelerated as the success from the U.S. PLT in 1978, as well as from other tokamak experiments worldwide, increased the confidence of the scientist community that the tokamak would indeed produce fusion power.

Until recently, the Japanese fusion program has lagged about five years behind the U.S. program. But based on the results for the medium-size U.S. tokamaks—the PLT, Doublet, and the Alcator at the Massachusetts Institute of Technology—the JT-60 will "skip a step" and jump ahead.

The JT-60 is designed to achieve a breakeven plasma condition using hydrogen (all deuterium) fuel and not radioactive tritium. This makes it a more flexible experimental machine than the TFTR, which will use deuterium-tritium as fuel and, therefore, require remote handling equipment. In the JT-60, the technicians will be able to make adjustments with hands on the equipment. However, the JT-60 will not produce a sustained fusion reaction because with all-deuterium fuel, this would require ignition temperatures of 400 million degrees.

The mission of JT-60 is not only to extend the scientific basis for continuing the tokamak development program, but also to develop fusion engineering and technologies like plasma heating and impurity control. In this way, it will lay the physics basis for the next tokamak device in the Japanese program, as well as guide the work with continuing experiments on existing machines—the JFT-2M and a new ignition experiment to be built at Nagoya University. JT-60 is designed to extend the pulse length of the plasma current and external heating power from less than 1 second, which is now common, to up to 10 seconds.

The JT-60 will test experimental magnetic limiters as a method of controlling impurities in the fusion plasma without the need for physical diverters. Also, neutral beam injection, radio frequency, and ion cyclotron heating will all be used in the JT-60 to evaluate the most effective ways to heat the fusion fuel.

The current time schedule for JT-60 is initial operation in October 1984, with the start of supplementary heating experiments in August 1985.

If the jump from operating the JFT-2 to the design of the JT-60 was a big step, the now-proposed step from JT-60 to an Experimental Power Reactor (EPR) is a giant leap. The projected cost of the JT-60 is about one-quarter of a billion dollars; the EPR will be at least double that.

The Giant Step

The proposed EPR will combine two steps in the previous fusion program plan, which included an Engineering Test Facility before the operation of a power reactor. This giant leap was the substance of the Japanese fusion review in March that recommended that the nation accelerate its fusion timetable and put an EPR on line by 1993.

The EPR will be considerably larger and have a higher performance capability than the next step in the U.S. fusion program, the Fusion Engineering Device, or FED. The FED was mandated by the 1980 fusion legislation as an approximately $1 billion device, on line by 1990 producing between 100 and 200 megawatts of power. Japan's EPR is estimated to produce from 400 to 800 megawatts of power—indeed, an experimental reactor.

In their program review work for the EPR, which began a year ago, the Japanese are considering a unique engineering design, based on their experience with conventional nuclear power plants. Instead of surrounding the fusion reactor with solid shielding material, they have designed a Swimming Pool Tokamak Reactor, or SPTR, where water would make the repair and maintenance easier and less costly. The SPTR could potentially cut the cost of the fusion reactor by 40 percent and cut the cost of the entire power plant by 10 percent—a significant savings.

Using water as a shielding material eliminates the 6,000 to 9,000 tons of heavy shielding structure projected in other tokamak designs as protection for the superconducting magnets. Since water does not crack, fatigue, or permit leakage, maintenance would be simplified. The reduced need for maintenance and repair is a significant advantage, since the EPR will require remote handling, like the TFTR, to handle the D-T fuel.

A phased machine, the EPR will be upgraded and modified throughout its operation. It is also planned as a test bed for various blanket designs for breeding tritium needed for fusion fuel. In its first stage, it would operate without a blanket, but with many diagnostic ports for the investigation of the burning plasma.

The preliminary swimming pool design, shown in Figure 3, is a first draft conception. As work continues on the design, it will undoubtedly be modified, but the process of initiating this EPR stage for the Japanese tokamak program is expected by next winter.

According to Japanese officials, the Nuclear Fusion Council has requested that representatives of industry and other experts from the scientific community comment on the proposal by the review committee to go ahead with the EPR.

By August 1981 the AEC will decide whether to support the recommendations and then forward its report to the prime minister and the other cabinet ministers. From September to December the Ministry of Finance, the Science and Technology Agency, and other cabinet agencies will deliberate on a strategy for the fusion program.

By next February the government's budgetary and program policies will be sent to the Diet (parliament) and will go into effect at the beginning of the next fiscal year, April 1. By this time next year, therefore, the Japanese fusion program will be officially on its way to designing and building an Experimental Power Reactor by 1993—a timetable considerably ahead of the United States.

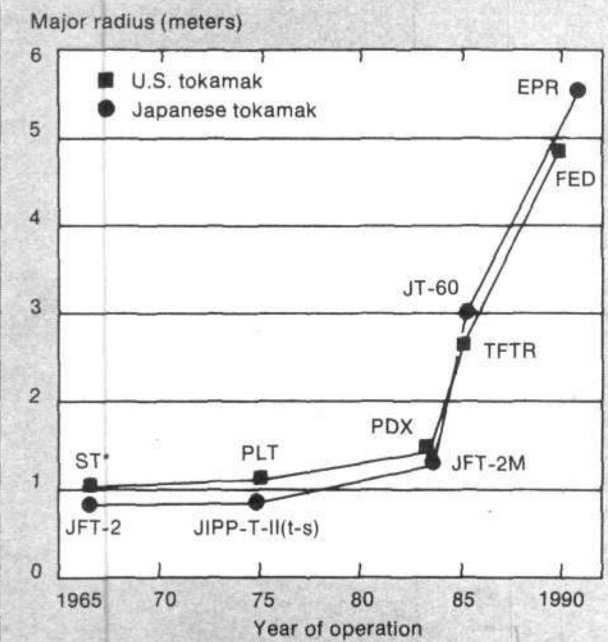


Figure 2
COMPARISON OF U.S. AND JAPANESE TOKAMAK DEVICES
When Japan's Engineering Power Reactor comes on line in 1993, Japan will surpass the United States in the tokamak fusion program, reversing the 20-year U.S. lead. For sake of comparison, the parameter used here to measure tokamak progress is the major radius of the donut-shaped device

*Symmetric Tokamak

A Broad-Based Program

Like the United States, Japan has chosen the tokamak fusion program for its first power-producing reactor at the same time that it is pursuing a broad-based program in alternative fusion concepts and supporting engineering and technology development. And like Japan's tokamak research, all of this is being done in close collaboration with the United States.

The alternative concepts for fusion that Japan is pursuing are a generation behind the U.S. devices, but they are achieving experimental results in step with the U.S. fusion program.

The Heliotron series. One fusion design unique to the Japanese program is the Heliotron series of experiments. The Heliotron is a variation of the U.S.-developed stellarator, the first U.S. experimental fusion device. A stellarator is a nonpulsed, steady state machine in the toroidal category that has all of its confining magnetic fields generated by external magnets. By comparison, in a tokamak the poloidal fields are produced internally by an electrical current induced in the fusion plasma itself. In the stellarator, the plasma is not a smooth shape, as it is in the donut-shaped tokamak, but it can be a variety of rippled shapes that reflect the helical windings of its magnets.

The Heliotron E, which began operation at Kyoto University last year, is a $34 million machine built by Hitachi. It is a PLT-size machine that is a proof-of-principle device. If it performs according to expectations, the Japanese hope to take the Heliotron configuration to the next-step energy breakeven Heliotron-F experiment, which would be a D-T ignition experiment.

Mirrors. Tsukuba University is the leading facility for the Japanese magnetic mirror program. The Gamma-6, operational since 1978, has a tandem mirror plasma profile similar to U.S. mirror experiments and is supported by theoretical work at Nagoya, Kyoto, and Tsukuba universities.

Fusion scientists are now building the Gamma-10, about the same size as the Tandem Mirror Experiment at Lawrence Livermore National Laboratory in California, which will be ready in 1983.

Bumpy torus. Among the diversity of experimental devices in its 20-year fusion history, Nagoya University has provided the only other bumpy torus machine in the world besides the Elmo Bumpy Torus at the Oak Ridge National Laboratory in Tennessee—the Nagoya Bumpy Torus. The bumpy torus design, which combines features of the magnetic mirror configuration within a toroidal system, is providing some important experimental insight into both the tokamak and mirror programs.

Also at Nagoya is the JIPP-T-2 stellarator/tokamak hybrid device, a unique facility because it can be used either in a tokamak or a stellarator mode. Therefore, it is a versatile test bed for plasma heating and other experiments, which, if successful, can be used on other machines. If the current JIPP-T-2 program is extended, a JIPP-T-3 device that burned D-T could be built by the late 1980s.

Inertial confinement. Like the magnetic fusion effort, Japan's inertial fusion program is a few years behind the United States. Osaka's Laser Institute, established in 1972, is involved in the operation and construction of a full series of inertial fusion experiments, which include glass and carbon dioxide lasers, relativistic electron beams, and light ion beams. Osaka's Dr. Yamanaka announced in 1980 that the Institute has plans to build a 40-terawatt glass laser—GEKKO XII—later in the 1980s. GEKKO XII would be larger than the 30-terawatt laser at Lawrence Livermore, now the world's largest laser system.

For the decade of the 1980s, the Japanese inertial fusion effort will carry out what is known as the KONGO program, which includes next-step devices in all the inertial fusion driver systems—gas lasers, ion beams, and electron beams. This decade-long effort will cost approximately 63 billion yen ($315 million) for equipment alone.

Supportive technology. The Japanese are also pursuing the full array of required supportive technology developments for fusion. In some areas, like superconducting magnet development, Japanese industry is already building similar components for other energy (or related) technologies.

Table 2
MAJOR PARAMETERS FOR THE SPTR

Plasma burn mode	Ignition
Burn time (sec)	≥100
Fusion power (MW)	420
Neutron wall loading (MW/m²)	1.0
Major radius (m)	5.3
Plasma radius (m)	1.1
Elongation	1.5
Toroidal field at centerline (T)	5.2
Plasma current (MA)	3.9
Safety factor (edge)	2.5
Average β_t (%) (without impurities)	4
Average ion density (m^{-3})	1.1×10^{20}
Average ion temperature (keV)	10—12
Impurity control and ash exhaust	Poloidal divertor
Heating, NBI/RF (MW)	30/30
Tritium breeding ratio	1.0 (target)

The Swimming Pool Tokamak Reactor (SPTR), shown at right, is a unique Japanese design for an engineering fusion reactor of commercial size that would produce 420 megawatts of thermal energy. According to the Japanese plans, the device will be the first machine to produce large quantities of electrical energy from fusion. The SPTR would produce about 150 megawatts of electrical energy, the equivalent of a small to medium-size fossil fuel plant. The significant advantage of the swimming pool water shield is its flexibility in maintenance.

In other areas, like fusion materials development, the Japanese effort requires collaborative research and development with the United States. These areas are on the top of the list of both nations for extending the cooperation that is already underway.

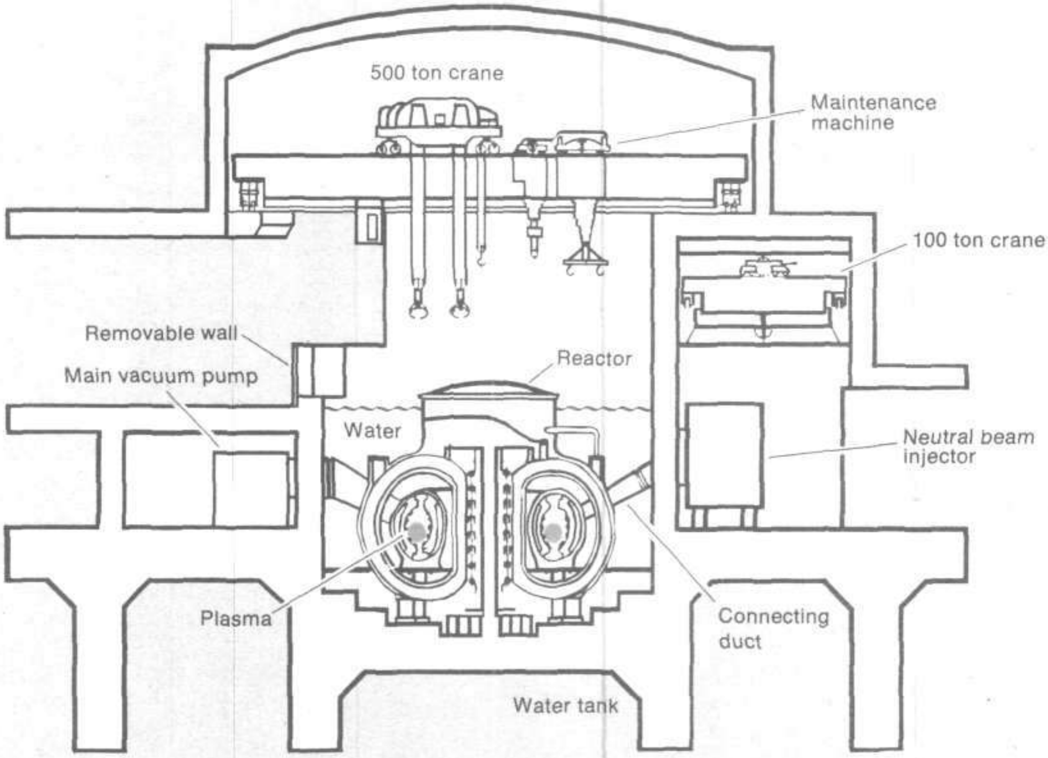
Industry involvement. The involvement of Japanese industry in frontier technology development is direct: The government agency responsible for construction and operation does not have to go through a competitive bidding procedure to grant a contract, as is the practice in the United States.

Because the largest electrical and heavy machinery supply companies in Japan are involved in building fusion devices, it's likely that the transfer of this technology, once commercial fusion power plants are ready for the marketplace, will be a painless procedure from the R&D departments to the commercial operations within the same companies.

International Cooperation

Overall, the Japanese fusion effort has benefited greatly from international collaboration, especially from the U.S. fusion programs. If the Japanese fusion effort jumps ahead of the United States, this will be because Japan has made a national commitment to push forward and reach its

Figure 3
SWIMMING POOL TOKAMAK REACTOR SCHEMATIC



goals. The fusion cooperation program between the United States and Japan, it is hoped, will encompass new areas of joint work, including Japanese participation in U.S. materials facilities such as the Fusion Materials Irradiation Test facility at Hanford, Wash. and the Rotating Target Neutron Source facility at Lawrence Livermore.

The collaborative fusion agreement, proposed by Fukuda in 1978 and signed by DOE fusion director Edwin Kintner and Japanese AEC director Hiroshi Fukunaga in August 1979, has fulfilled three of the four initial areas of collaboration outlined: the exchange of personnel for work visits to U.S. and Japanese fusion facilities, a $60 million upgrade program and joint work on the Doublet III experiment, and the setting up of joint fusion theory centers in the two countries.

The fourth area, joint planning, is now under discussion and could become the most interesting aspect of the agreement. If the Japanese decide, as is likely, to take that giant step for an Experimental Power Reactor by 1993, the United States will have much to contribute to making this goal a reality. And if the U.S. fusion program is not fully supported by the Reagan administration, Americans may have their first opportunity to participate in a fusion project that is more ambitious than our own.

In 1978, Takeo Fukuda proposed that the United States and Japan cooperate in a fusion development program "to bring the energy of the Sun to Earth." This would take "colossal investments in human and material resources," he said, but the resulting energy security and economic benefits would be worth it.

Fukuda made that proposal because he knew that with Japan's determination and American know-how, the job could get done.

Today, the task remains essentially the same, but the U.S. fusion program is in jeopardy.

As one Japanese scientist commented on the U.S. plan to cut the Fusion Materials Irradiation Test facility out of the 1982 budget: "The FMIT is necessary for fusion, not immediately in the research experiments but in the actual reactor-building phase. We need it, and if the United States is not going to build it, we will. There are certain things that have to be done, and if you're not going to do them, we will."

Will the United States be importing Japanese tokamaks in the 21st century? The answer is up to the United States and how much budgetary support it gives the U.S. fusion program.

Marsha Freeman is the industrial research director for the Fusion Energy Foundation.

An Unbeatable Plan for Economic Growth:
Japan's 'Frontier Industry' Strategy

It is April 1993. Joseph P. Kennedy III, the young senator who made his name in the 1980s as an antinuclear crusader, has just introduced a bill to restrict shipments to the United States of Japanese tokamak fusion reactors. "It will bankrupt the U.S. windmill industry," he complains.

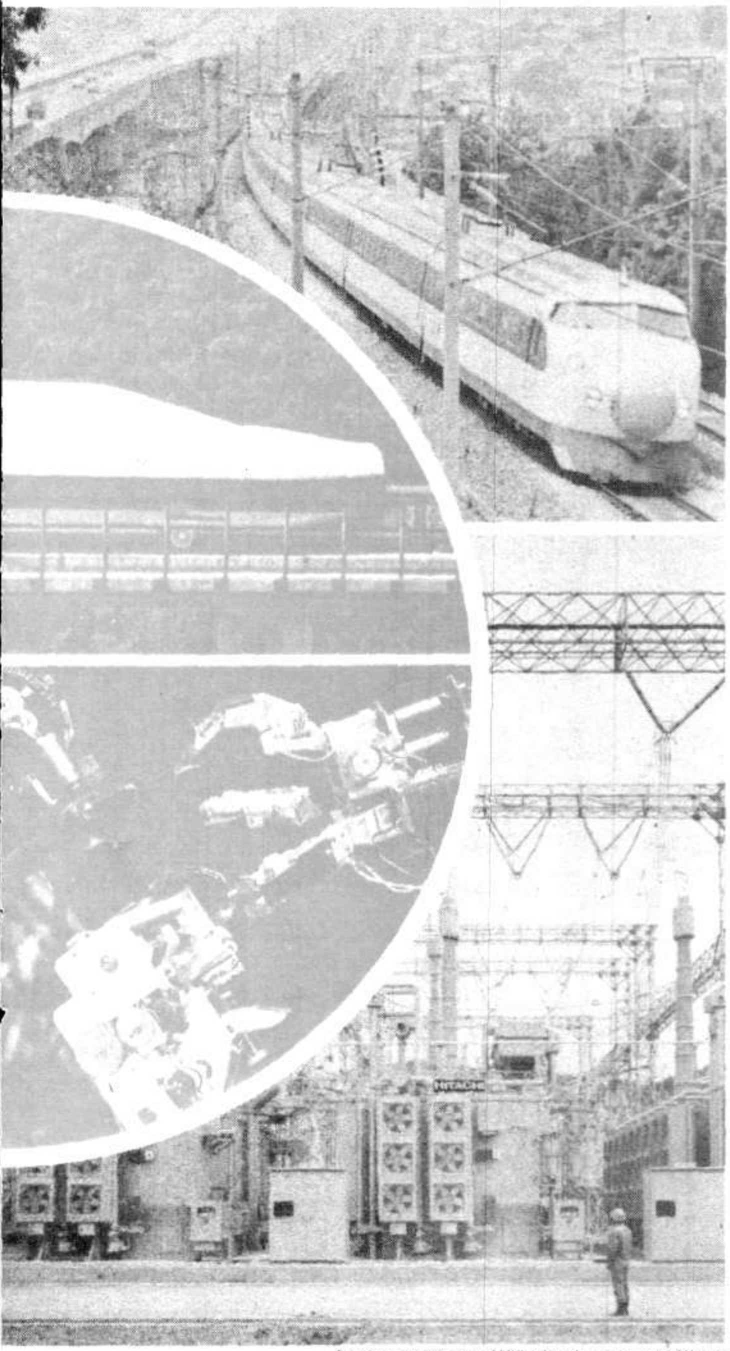
* * *

WHAT ACCOUNTS FOR the apparent invincibility of the Japanese economic machine? Only 10 years ago, textiles were Japan's main economic challenge to the United States. Five years ago, it was steel. But today the Japanese are threatening to overtake the United States in areas once considered its special preserve. In 1980, Japan surpassed the United States as the world's leading automobile manufacturer. And industry sources are now beginning to sound dire warnings about a Japanese invasion in the fields of integrated circuits and computers.

In fact, one of the fastest growing industries in America is the publishing of articles on Japan's successes, typified by *Iron Age* magazine's "What Can American Manufacturers Learn from the Japanese?" last year. Another big growth area is consulting companies that specialize in teaching American businessmen the managerial gimmicks that are supposed to account for the Japanese miracle. The American Management Association offers a seminar series on "Using Japanese Quality Control and Productivity Techniques in U.S. Industry"; AMA advertises: "Learn the Japanese methods that are producing amazing results in U.S. firms."

Like the proverbial blind men and the elephant, different groups have focused on various, isolated aspects of the picture hoping to discover the secret of the Japanese economic miracle. Some Japan imitators rather mystically attribute Japan's economic successes to unique features of Japanese culture. One southwestern electronics firm went so far as to dress its employees in kimonos, put Japanese slogans on the wall, and teach Japanese-style company songs. Other U.S. companies have seized on Japanese model labor-management relations and attempted to reproduce Japanese industry's quality circles.

Still others are mesmerized by the external structure of by Richard Katz



Container ship courtesy of MHI; other photos courtesy of Hitachi

Japanese business. Thus, Senator Adlai Stevenson, Jr. of Illinois introduced a bill in Congress in 1980 that would permit the creation of an American imitation of Japanese-type trading companies, the multi-billion-dollar commercial conglomerates that do the buying and selling of most products within Japan's domestic economy and in its foreign trade.

The secret behind Japan's achievement is neither intangibly cultural, nor is it a collection of managerial and structural gimmicks, which can be easily copied. The secret is, in fact, as American as Abraham Lincoln, for it was from President Lincoln's economic advisers that the founders of modern Japan learned the ideas that turned the country into an industrial giant overnight.

However, in Japan the American System ideas still guide day-to-day governmental and business practices, while in the United States these ideas have been largely abandoned. Faced with a depressed market and serious competition, the U.S. Steel Corporation, for example, has scrapped its steel investment and diversified into real estate and other quick profit areas.

By contrast, Japanese steel firms, which were operating at 67 percent capacity because of the orders collapse, launched a multi-billion-dollar modernization drive that emphasized investment in high-technology forms of energy saving such as continuous casting, and they are making profits again. Japan's top five steel firms plan to invest $3 billion more in 1981, a 27 percent increase over

◄ *A succession of planned frontier industries has been the key to Japan's economic miracle. Yesterday's frontier industries are arrayed counterclockwise on the field of the Japanese flag: a giant ladle crane manufactured by Hitachi for Nippon Steel; Mitsubishi Heavy Industry's new high speed container ship; electric power plant equipment produced by Hitachi for Kansai Electric; and the electric bullet train operated by Japanese National Railways, which travels up to 210 kilometers per hour. The next phase of frontier industries is shown in the emblem: an experimental, magnetically levitated train designed to travel 500 kilometers per hour; precise welding technology used in the manufacture of fusion vacuum vessels; and an integrated, "intelligent robot" with grasping, pushing, and pinching functions.*

LIVING STANDARDS, INVESTMENT, AND PRODUCTIVITY: U.S. AND JAPAN COMPARED

Growth in Hourly Compensation per Worker
(adjusted for inflation)

	1960=100		Average annual growth	
	1967	1976	1960-67	1967-76
Japan	140	300	4.9%	8.8%
U.S.	113	122	1.7	0.8

Gross Private Fixed Investment As a Percentage of GNP: 1955-1980

	1955	1960	1965	1970	1973	1975	1980
Japan	11	18	19	27	27	24	25
U.S.	14	14	14	14	15	12	14

Growth in Labor Productivity

	1960=100		Average annual growth
	1960	1978	1960-78
Japan	100	450	8.7%
U.S.	100	164	2.7

Growth in Industrial Production

	1960=100		Average annual growth
	1960	1974	1960-74
Japan	100	426	10.9%
U.S.	100	197	5.0

Sources: United Nations, U.S. Department of Commerce, Japan Ministry of International Trade and Industry

One often neglected spinoff of Japan's frontier industry investment strategy has been rising living standards. In the United States from 1960 on, the real growth of hourly compensation of manufacturing workers was negligible because of the stagnation of surplus-generating capital investment and productivity. Japan, on the other hand, enjoyed a positive cycle of mutually reinforcing investment rates and productivity and wage increases. Hourly compensation tripled between 1960 and 1976, at the same time that productivity soared. The key was the rising portion of GNP invested in frontier industries.

1980, to install energy-saving continuous casting and to upgrade their operations from basic steel production to specialty steel.

Permeating the daily decision-making process at Japan's corporations and government ministries is an unshakable commitment to technological advance and a "can do" spirit, a spirit rekindled in the American population by the successful flight of the Space Shuttle.

Japan's Frontier Industries

For Japan's economic planners, technology does not simply mean better, and growth is not merely more. Rather, business and government cooperate in setting national goals of economic growth through planning a succession of frontier industries.

"We think about our economy in the following way," explained a Japanese banker. "Imagine an individual standing with an iron ball in his hand with a long rope attached. If he could throw the iron ball hard and far enough ahead of himself while holding on to the rope, the ball he throws would carry him forward a certain distance.

"So, every five or seven years, we Japanese throw out some industries more advanced than the general economy. In the post-World War II recovery it was textiles. They were followed by steel, then autos, and now computers. The next industry is fusion power. The rest of the economy, by participating in the success of that frontier industry, grabs on to the rope of that industry and is carried forward."

Each technological advance makes possible the next. Therefore, Japanese businessmen and government planners consider where they want Japan to be 10, 20, and even 30 years into the future and then what technological phases Japan must pass through to achieve that 30-year goal. Thus, as early as 1953, the government and business leaders jointly initiated Japan's shift from coal to oil and launched a research and public education program to promote atomic energy. As early as 1970, an official of the Ministry of International Trade and Industry declared, "By the year 2000 Japan will supply up to half the world's energy through mass production of fusion power machines."

The current, massive fusion research budget, therefore, is no exceptional effort but an outgrowth of the normal functioning of the Japanese economy.

This approach of deliberately planning new frontier industries made it possible for Japan to achieve 12 to 15 percent increases in productivity growth year after year, while the United States plodded along with 3 to 6 percent per annum productivity growth rates; in the last couple of years, U.S. productivity has actually fallen.

Japan's acclaimed high growth—regular 10 to 15 percent annual rises in production up until the 1973 oil price shock—was not planned as an end in itself but as a means of achieving the upward spiral of technological advance. After all, with those growth rates, within only 4 to 7 years, the vast majority of the national product consists of entirely new products produced with new capital. Thus, rapid restructuring of the economy is the normal tendency.

J.P. Laffont/Sygma

What makes Japan, Inc. run? It isn't the management gimmicks and other secondary features of the economic system, as some Americans think. Here, workers take a five-minute calisthenics break at a Nikon factory in Tokyo.

The locus of economic planning in Japan is the Ministry of International Trade and Industry (MITI) and the major business federation, Keidanren. MITI is the current name of the industry ministry set up in the late 1860s by the founders of modern Japan to implement their American industrialization strategy. Keidanren, known as the headquarters of business (with its chairman as the prime minister of business), was set up in 1946 during the postwar U.S. occupation to foster economic recovery. In addition to the physical damage to Japanese industry from the ravages of World War II, Japan's economy had been set back by the initial occupation policy aimed at deindustrializing Japan, the counterpart for Japan of the proposed Morgenthau plan for Germany. Japan's large, concentrated industries were dissolved and broken down into smaller enterprises. More than 200,000 businessmen, politicians, and bureaucrats were purged from all active political, civil, or business activities. Middle and junior executives, mostly under 45 years of age, suddenly found themselves in charge of virtually every corporation in Japan—with the responsibility of resurrecting their nation and economy from the ashes. These men ran Japan and its industrial corporations for the next 30 years.

As part of this endeavor, Japan's new leaders set up the Keidanren federation, whose role is far more powerful than anything the U.S. National Association of Manufacturers ever imagined. Keidanren's membership includes the heads of the 750 largest corporations in Japan and more than 100 associations representing the major industries. Today, the Industrial Structure Council of MITI, which consists of both MITI officials and Keidanren leaders, makes policy and guides Japan's economic miracle.

The MITI-Keidanren team initially helped to promote the recovery of the textile industry as a quick way to earn foreign exchange for the resource-poor Japanese islands. But at the same time, to establish the foundation for long-term industrial growth, MITI and Keidanren stressed the development of the steel, oil, petrochemical, and shipbuilding industries.

In line with making steel a national priority, MITI encouraged banks to lend to steelmakers; granted special tax incentives and other concessions for investment in steel capacity; subsidized research; provided protection from imports; worked with the Bank of Japan, the country's central bank, to allocate then scarce foreign exchange for the import of coking coal and iron ore; directed the export-import bank to promote exports; and, for a while, provided low-interest government loans through the Japan Development Bank, although these were not as significant as the directed private credit.

Similar mechanisms were used to build up the petrochemical industry and to enable Japanese industry as a whole to switch from coal to oil.

MITI, the Finance Ministry, and other arms of the government used their control over national tax and credit policies to ensure adequate incentives for the development of heavy industry, growing capital investment ratios, and continuous investment in new technology. Interest rates for industry were kept low even in times of scarce credit, and today Japan still enjoys the industrial world's lowest interest rate of 8 percent. At its highest, the Japanese prime rate did not reach 10 percent—U.S. Federal Reserve Chairman Paul Volcker would not be able to get a job in Japan.

By the early 1960s, initial economic recovery had been achieved. Under the famous Income Doubling Plan, industrial growth was topping 10 percent per annum. MITI and Keidanren took action at that point to ensure that even in times of economic recession or slowdown, induced by periodic shortages of foreign exchange, Japan's capital investment would not suffer. The Bank of Japan would ensure that sufficient, low-interest credit would be available to keep investment going, even in periods of low corporate revenues.

In addition, MITI promoted several corporate mergers and rationalizations, which were designed to strengthen the economy. In 1964, for example, under the newly enacted Temporary Law for the Reorganization of the Shipping Industry, MITI aided the merger of many lines into six major shipping lines and arranged for government financial assistance to the merged lines.

A similar operation was carried out in the steel industry, culminating in the merger of the Yawata and Fuji Steel Companies to form Nippon Steel, the world's largest steel company. As a result of the mergers and rationalizations, the majority of the firms were able to increase their overall rate of capital investment, application of new technologies, and hiring of advanced technicians.

The special government support was terminated once its job was done; by the mid-1970s Japan was the world's leading shipbuilder and by 1979, the largest steelmaker in the noncommunist world.

After steel, oil refining, shipbuilding, and other basic industries were on their feet, MITI and Keidanren directed their attention to the next set of frontier industries—nuclear energy, materials development, and electronics. Here, research and development and their financing were guided by cross-company and joint government-private sector development corporations such as the Nuclear Fuel Development Corporation, the Fine Ceramics Council, and the Industrial Robot Association.

Japan's success in the computer field illustrates the Japanese method in action. MITI first targeted the computer industry as a key frontier industry in the mid-1960s. Besides the usual support mechanisms, MITI and the computer firms jointly established the Japan Electronic Computer Company to enable medium-size as well as large firms throughout the economy to lease computers. As a result, companies that would not have otherwise been able to afford computers were able to use them, at the same time that the guaranteed expanding market enabled the computer industry to invest increasing revenues in further development.

Japan is now the only foreign country in the noncommunist world in which domestic rather than U.S.-made computers have the majority market share. What's more, Japanese computer firms such as Fujitsu and Hitachi are now preparing to compete with IBM for markets in the developing sector, Europe, and eventually in the United States itself. The Japanese firms are beginning to develop mainframe computer technology in the same class as IBM's.

In the same period as the computer development, MITI and Keidanren also made the manufacture and export of machinery and machine tools a top priority. From producing a negligible amount of machine tools in 1970, Japan achieved a $3 billion production level in 1980, compared to about $5 billion in the United States. Japan has placed particular stress on advanced numerically controlled (computerized) machine tools and is now a world competitor in that field.

In each case, as the rest of industry geared up to provide the inputs to the frontier sectors and then upgraded themselves to utilize the fruits of those new sectors, the frontier industries propelled the entire structure of the economy forward technologically—as in the iron ball and rope principle described by the Japanese banker. This process worked even though the frontier industries themselves usually represented only a small proportion of total output.

The Captains of Industry

The Japanese system works because of the character of the men who run Japan's industrial combines. Just as many of America's corporations used to be dominated by men like Henry Ford or George Westinghouse—production men, not accountants or lawyers—so Japan's giants are still dominated by engineers. Let's look at the three largest producers of nuclear reactors, Hitachi, Mitsubishi Heavy Industries (MHI), and Toshiba Electric, which have gross sales of $10 to $12 billion a year and a wide range of products from televisions and refrigerators to heavy equipment for industry and scientific instruments:

MHI's current president, who has the authority of the chairman in American corporations, is Masao Kanamori. Kanamori is a metallurgical engineer who spent years as a researcher in Mitsubishi's technical labs before becoming an executive. He is now moving on to become chairman and will be replaced by Soichiro Suenaga, another engineer. The outgoing chairman of the company is also an engineer, in keeping with a long tradition at the company. MHI is part of the giant Mitsubishi business group that was created de novo in the 1870s by the founders of modern Japan as a chief vehicle for their policy of rapid industrialization.

Hitachi was founded in 1910 by an engineer to produce motors and other products that would use Japanese rather than imported technology. Like its founder, outgoing president Hirokichi Yoshiyama is an engineering graduate of Tokyo University, and his replacement, Katsushige Mita, is an electronics engineer. Hitachi has 500 PhDs in its R&D department, more than in any other Japanese firm. The company's executive and R&D engineering talent helps explain Hitachi's current leadership in computers, consumer electronics, and scientific work, and its role as the prime contractor for Japan's tokamak program.

Former Toshiba chief Toshio Doko has a particularly striking record. Doko is a shipbuilding engineer who graduated from the Massachussetts Institute of Technology and later become head of the Keidanren federation. Doko is renowned as the man who repeatedly built larger and larger supertankers at a time when most U.S. industrialists insisted they could not be built.

More than that, these are engineers who came to adulthood during the 1930s and 1940s and were faced with the responsibility of rescuing Japan from the consequences of that period. Former prime minister Takeo Fukuda speaks for most of them when he constantly points out, as he did to President Reagan last March, that the economics of the 1930s led to the wars of the 1940s and that today's depressed world economy could easily lead to another debacle unless government leaders take preventative action. Fukuda gave this reasoning as the motivation for his repeated, emphatic calls for U.S.-Japanese joint research in fusion energy.

Having taken a feudalist, backward nation with no natural resources and turned it in a single century into an industrial powerhouse through technology and sheer initiative, Japanese corporate executives have a respect for science and information no longer seen so frequently in American corporate boardrooms. The idea of buying up a patent on a new technology in order to prevent its being manufactured by others, an increasingly common practice among U.S. corporate giants, strikes Japanese executives as a violation of the laws of the universe.

In Japan, a scientific or technological advance achieved by one firm is not regarded as that firm's property. The advance belongs to society, to be used to advance the

J.P. Laffont/Sygma

MHI

Hitachi

Toshiba

Toshiba

Japan's largest producers of nuclear reactors are run by engineers. Top to bottom: Masao Kanamori, president of Mitsubishi Heavy Industries; Katsushige Mita, new president of Hitachi; Shoichi Saba, current president of Toshiba Electric; and former Toshiba chief Toshio Doko, a shipbuilding engineer by profession and former head of Keidanren. Above, engineering students at Waseda University in Tokyo.

ded by this attitude, special *corporations*
have been set up by competing firms in
and the prolific licensing of patents to
by the inventor is common. Both prac-
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pacity advised by their American coun-
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The 10-year plan of the Industrial Structure Council of MITI in 1970 outlined the next step in Japan's development: knowledge-intensification. For the first time, the export of capital-intensive industries to the developing countries was regarded as integral to Japan's own development. Japan would no longer simply be a supplier of commodities like steel, ships, and autos to the advanced and developing countries. Instead, Japan would move from these capital-intensive industries to the higher value-added, more knowledge-intensive industries such as machine tools, nuclear reactors, and computers.

Knowledge-intensity took on a new meaning as fusion power came to be viewed by the Japanese as increasingly realistic; and by 1975, fusion became officially known as "the energy of the 21st century." The transfer of technology was then seen by many MITI officials as necessary to Japan and the world's transition to the fusion age. A fusion economy, they understood, requires a world division of labor so extensive as to necessitate the industrialization of the developing countries.

Japan's role during the early 1970s in aiding South Korea's development of domestic steel, machinery, and auto industries is the most successful example of this strategy of creating "new Japans," in preparation for entering the fusion age.

Since the 1973 oil crisis, the U.S. government's adherence to the "limits of growth" perspective has involved pressuring Japan to abandon the strategy of creating new Japans with the threat of trade protectionism, a threat made explicit in the 1979 Trade Report of the U.S. House of Representatives Trade Subcommittee.

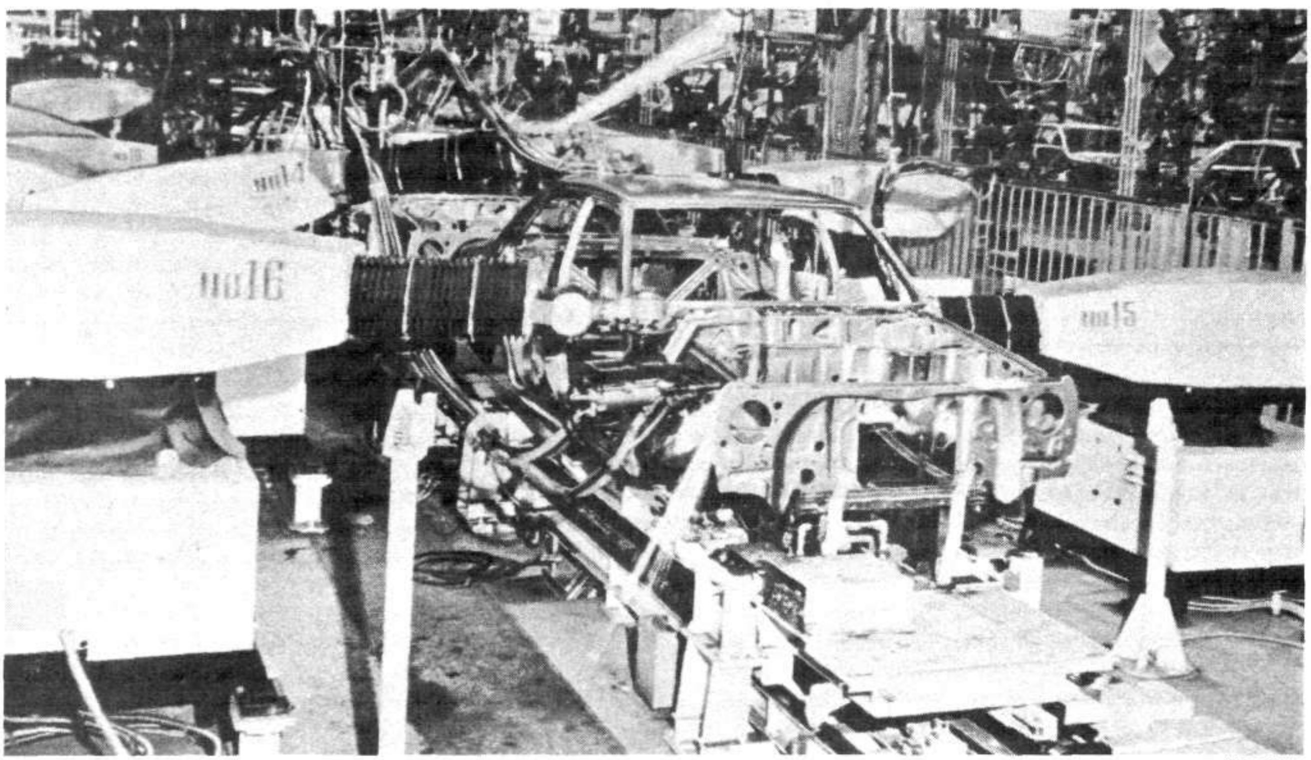
A political battle has since erupted inside Japan on whether to try to continue the internal aspects of the knowledge-instensification strategy without the international transfer of technology, or whether the latter is essential to internal development. The debate is continuing, but there is no debate over whether to continue Japan's domestic advancement.

1980s: The Decade of Technology

The 1980s has been declared "the decade of technology" by Japan's economic planners. "The Japanese economy has attained the national goal of the past hundred years, reaching the level of Western industrial nations," declared the Industrial Structure Council's "Long-term Vision of MITI Policies in the 1980s." "It is time for Japan to establish new national long-term goals and to envisage the course to reach them."

Partly because the United States can no longer be relied on as a source of new technologies, the heart of that national goal is to turn Japan into an international leader in initiating new science and technology in the 1980s. Rejecting "the now prevalent apprehension that technological progress is about to stagnate," the Industrial Structure Council's report insisted, "Great expectations are therefore placed on technological innovation providing the key to the solution of various problems in the 1980s. . . . In the past, Japanese industry achieved brilliant results in improving and applying imported technologies. In the 1980s, however, it will be essential for Japan to develop technologies of its own."

A key task of the 1980s, the report continued, is the "preparation for the next generation's epoch-making technological innovations expected in the years after 1990



Nissan Motor

Industrial robots perform repetitive assembly-line work at Nissan Motor plant, freeing human labor for more knowledge-intensive work.

. . . in the field of life sciences: treatment of cancer, genetic manipulation, investigation into photosynthesis and its application for food production; in the field of energy: nuclear fusion and MHD power generation."

Gone are the days when Japan's patents were limited to improvements or adaptations of other nations' inventions. In 1970, Hitachi paid out 12 times as much in royalties on use of other companies' patents, often imported, than it earned on licensing its own; by 1980, the multiple had been reduced to 2.

Japan will soon be a world technological leader in two areas that will revolutionize basic industry: computers and industrial robots. Japan is already dominant in robot technology and is increasingly challenging the United States in the computer field.

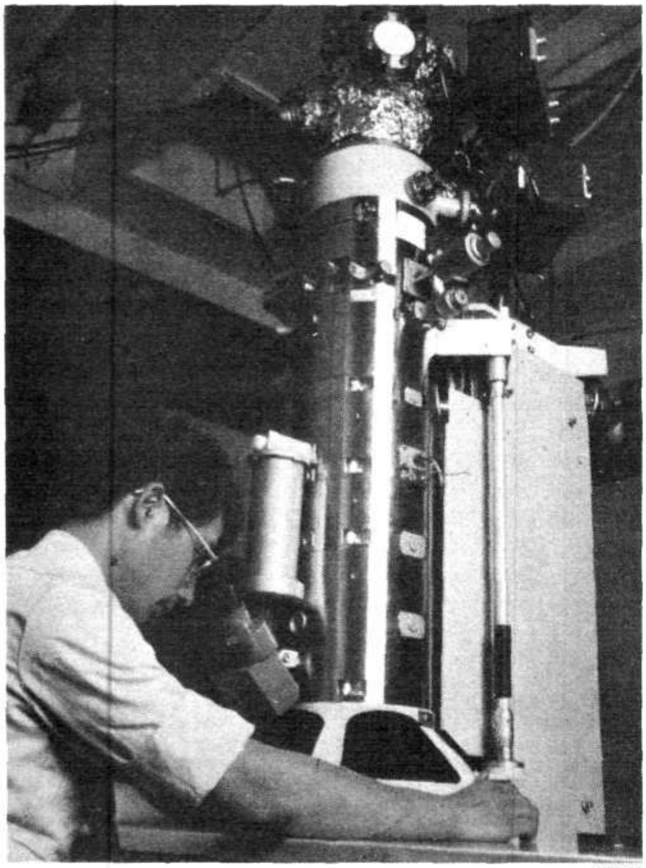
Japan's ability to leapfrog America technologically in electronics points up a crucial aspect of the relationship between old and new industries and between science and industrial progress. In stark contrast to the "sunrise-sunset" perspective that sees electronic gimmickry *replacing* heavy industry, Japanese industrialists regard advanced electronics as a means of advancing heavy industry. While in the United States computer applications have been mainly limited to administrative functions and information processing, in Japan the chief applications are computerized machine tools, computer-assisted design and production, and robotization. In the course of applying electronics to such industrial tasks, problems are posed requiring fundamental breakthroughs in science and technology. This is why, for example, Hitachi stressed in its latest annual report, "Nearly 30 percent of Hitachi's R&D is concerned with basic research, and with this being considered as having a bearing on future profits, our policy is to build up the fundamentals, especially with regard to materials."

If electronics is not applied in such a task-oriented manner, then no fundamental problems are posed, and technological progress tends to take on a plodding, step-by-step character as opposed to the leapfrogging progress enjoyed by Japan.

Such breakthroughs are putting Japan's semiconductor industry ahead of that of the United States, with Japan having just matched the United States in producing a 64,000-byte chip and expected to be first in producing a chip with 256,000 bytes.

Even more interesting, Matsushita Electronics (Panasonic in the United States) reported earlier this year that it will produce the first gallium-arsenide integrated circuit for general product use rather than special instruments. Gallium-arsenide has electron motion six times faster than the silicon-based chips currently in use. And Fujitsu and Hitachi are beginning to challenge IBM's technical supremacy in the manufacture of mainframe computers.

Seeking high-technology ways of saving energy, MITI recently made a priority the development of ceramics as a basic all-purpose industrial material. Nine companies formed last November a Fine Ceramics Council, which will work with the government to finance the research. Toshiba already reports progress toward developing within five to ten years the ability to use fine heat and shock-resistant ceramics for making automobile engines.



Hitachi

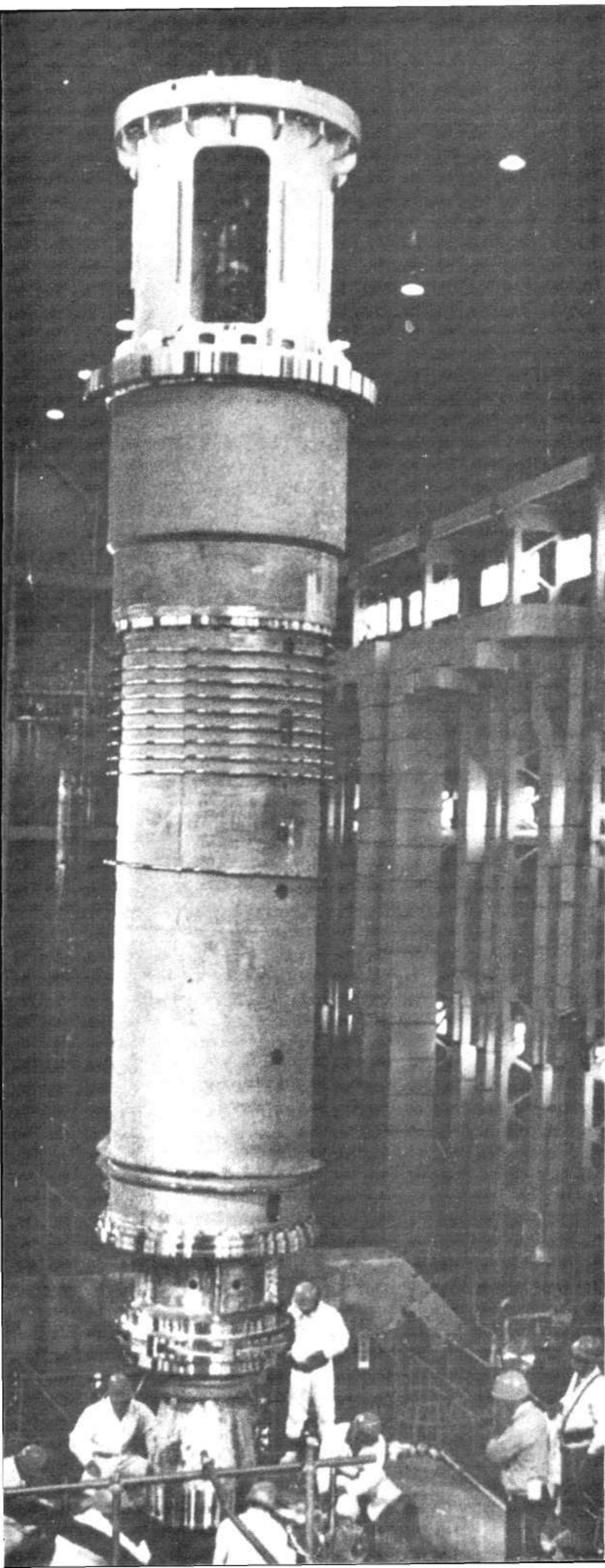
The 1980s has been declared the "decade of technology" in Japan. Shown here, the transmission electron microscope with the world's highest resolution. Among its applications is advanced biological research.

Industrial robotization is perhaps the most dramatic of the technological leaps made by Japan. Of the 10,000 industrial robots now in use in the world, about 4,000 are in Japanese factories, far more than in any other country. In Nissan Motor's famous Zama plant, robots assemble and weld together sheet metal parts comprising the body sides, floor pans, front and rear fenders, and roofs into the basic body of its Datsun cars. A central control room can instruct the robots to shift programs to accommodate different models.

The Japan Industrial Robot Association and its 14 member companies are now gearing up to develop so-called intelligent robots with sight and touch; and it is estimated that by 1985, 15 percent of the robots in use will be such intelligent robots. One third of the research money for this work comes from the government.

The basic approach that Japan is using is one learned from the United States at the dawn of Japan's entrance into modernity during the 1860s and 1870s. Along with steel, autos, and tokamaks, the United States should prepare to begin reimporting the American System from Japan as well.

Richard Katz is on the Asia desk of the Executive Intelligence Review.



Japan's Fight for

OCTOBER 26 is Atomic Energy Day in Japan. Each year on that day the Science and Technology Agency (STA) and the Ministry of International Trade and Industry (MITI) award prizes to high school students for the best essays on the peaceful uses of nuclear energy. Throughout the year, high school teachers, labor union leaders, businessmen, and others are invited to courses on nuclear energy given by the Japan Atomic Energy Relations Organization, an organization set up in 1969 by MITI and STA to educate the population about nuclear power.

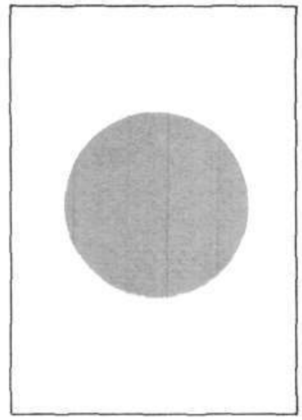
The development of atomic energy is a national project in Japan, the nation's own long-standing "Project Independence." With no oil or other natural resources to speak of, Japan's business and government leaders began as early as 1953 to chart the development of nuclear energy—even as the country was only beginning the transition from coal to oil.

As a result of this campaign, by the beginning of 1980 Japan had become the world's second largest user of nuclear power after the United States, a country with twice its population. Japan obtained its first commercial nuclear plant in only 1966, but by 1980 its nuclear capacity had grown to more than 15 gigawatts, accounting for 10 percent of electricity consumption. MITI projects that nuclear output will double by 1985 and quintuple by 1995 (see table page 42).

As in many areas of the Japanese economy, the development of nuclear power took off at an accelerating pace after a long-term planning phase. Yet, compared to what Japan could be doing or what a country like France is doing, this rate of progress is by no means adequate. In fact, by the end of the 1970s, Japan's initial momentum had turned sluggish. And by the end of 1980, France, whose big nuclear push began in 1974, surpassed Japan as the second largest producer of nuclear energy. The Soviet Union will put Japan into the number four spot by the end of 1981.

◄ *The development of atomic energy is Japan's long-standing "Project Independence." Here, the mock-up of the primary cooling pump for the prototype fast breeder reactor, Manju, being placed on a test loop at Japan's Power Reactor and Nuclear Fuel Development Corporation.* Nuclear Engineering International

Nuclear Power



In an article in the December 1979 issue of *Nuclear Engineering International*, MITI official Katsuomi Kodama reported that Japanese industry was capable of adding 6 to 10 gigawatts of nuclear power annually. MITI, however, is currently projecting no more than an additional 4 gigawatts a year for the next 15 years.

What has kept Japan from living up to its nuclear potential? The reasons are political. The Carter administration threatened Japan with an embargo on uranium shipments if the country went ahead with the development of its own uranium reprocessing facilities—a move, in the view of many Japanese government and business leaders, to keep Japan eternally dependent on the Seven Sisters oil majors. Inside Japan, the opposition Japanese Socialist Party was at the same time organizing popular resistance to the siting of nuclear plants, further undercutting the country's ability to attain energy independence through nuclear power.

In Japan, as elsewhere, the fight for nuclear power has always been a political one. The current fight is a continuation of one begun in the 1950s, the big difference between then and now being that in the 1950s and 1960s, the United States was a staunch ally in Japan's fight for nuclear energy.

Japan's Atoms for Peace Program

After a visit to the U.S. Atomic Energy Commission's research facility in California in January 1954, the president of Keidanren, Japan's powerful business federation, was convinced that Japan had no choice but to launch an "Atoms for Peace" program on the U.S. model. Two months later, the Japanese Diet, or parliament, approved the first appropriations request for building an experimental nuclear reactor in Japan. Within a year, Japan had established its own Atomic Energy Commission, headed by Matsutaro Shoriki, the publisher of *Yomiuri*, one of Japan's largest newspapers.

Shoriki was aware of the special need for a public education campaign on nuclear energy in Japan because of still-intense memories of Hiroshima, and he organized a joint government-business group called the Council for the Peaceful Uses of Atomic Energy. In the council's inaugural statement, Shoriki stated:

> It has now become clear that nuclear energy, which was once used against us as a terrible weapon of destruction, can be used as a mighty power to banish wars from the earth and liberate humanity from poverty and disease . . . to eliminate the causes of cold wars and achieve constructive peace. . . .
>
> Our country lacks coal and petroleum resources among other things. . . . Atomic energy is therefore necessary. . . .
>
> The time has come for the whole nation to forge ahead without any hesitation whatever.

Joining newspaper publisher Shoriki on the council were the heads of Keidanren and other business federations, seven "elder statesmen" of the business world, the president of the state-owned Japan Development Bank, the presidents of the two other largest newspapers, and the top leaders from the utility, steel, shipbuilding, machinery, paper, metal, and mining industries. In all, there were nearly 100 businessmen, scientists, and political leaders on the council.

One of the council's first activities was to invite General Dynamics chairman John J. Hopkins and Dr. Lawrence Holstadt of Chase National Bank's atomic energy department to give public lectures in Japan on atomic power. The Eisenhower administration actively aided the research efforts in Japan, including supplying uranium for Japan's test reactors.

At the end of 1955, Shoriki's *Yomiuri* and the U.S. Information Service jointly sponsored a six-week Atoms for Peace Exhibition in a park in the center of Tokyo. Close to 400,000 students, businessmen, workers, farmers, housewives, and cabinet ministers attended, and the polls showed that 92 percent of them walked away convinced of the need for nuclear power.

Then in March 1956, the United States and Japan signed a technology agreement to facilitate cooperation in Japan's industrial development. The agreement covered the licensing of patents, which was critical for advancing Japan's atomic research. A few days later Japan set up a special Science and Technology Agency to promote atomic power and general industrial progress.

In 1963 Japan became the fifth nation in the world to generate electricity using nuclear power, at an experimental reactor run by the Science and Technology Agency. Commercial production of nuclear power began in 1966.

For MITI and Keidanren, nuclear energy was never

NUCLEAR PROJECTIONS: JAPAN, FRANCE, AND THE U.S.
Gigawatts of Nuclear Power and Percentage of Electricity Generated by Nuclear

	1975		1980		1985		1995		2000	
	GW	%	GW	%	GW	%	GW	%	GW	%
Japan	6.6	NA	15.2	12	30	15	53	22	78	NA
France	NA	7.0	15.3	22	38	43	66	56	NA	80
U.S.	39.8	7.8	53.7	9.0	98	12	128	16	151	16

simply a cheap energy source but a classic frontier industry, whose development would propel the entire economy forward. As MITI official Kodama wrote in *Nuclear Engineering International* in 1979:

> Because the nuclear manufacturing industry is a typical advanced technology-intensive system engineering industry, great expectations are placed on its development as a stimulus to further the sophistication of the whole Japanese industrial infrastructure.

Japan Atomic Energy Research Institute president Hiroshi Murata stressed in an accompanying article that the high temperatures and energy density of atomic power opened the way for revolutionary new processes not possible with conventional energy sources. Only 30 to 40 percent of energy used in industrial societies is in the form of electricity, he pointed out; the rest is consumed as fuel or else as heat energy in industrial processes. The advent of Very High Temperature Reactors (VHTRs), he predicted, would revolutionize the latter.

"Hydrogen, reducing gas, and synthetic gas, as fuel and feedstocks for the chemical industries, can be produced utilizing nuclear heat from high temperature reactors," Murata wrote. Thus, "the steelmaking and chemical industries, which are energy intensive industries, can avoid dependence on coal and oil as energy sources."

The Japan Atomic Energy Research Institute, or JAERI, which is a unit of the Science and Technology Agency, expects to produce a 50-megawatt VHTR by 1987. In parallel with JAERI's work, since 1973 MITI has been researching direct-reduction steelmaking technology, using a VHTR to produce the high-temperature reducing gas. Commercial application of this process is expected by the 1990s.

For Japan, in short, nuclear energy has been a means of revolutionizing all of basic industry within a matter of years.

Nuclear Energy: Political Independence

Nuclear energy also means political independence for Japan. Traditionally, Japan imported most of its oil through the multinational oil companies, since it lacked a state oil importing company like those in some European countries. This dependence made it difficult for Japan to pursue an independent foreign policy especially vis-à-vis the developing sector, and it made Japan vulnerable to the sharp, politically engineered fluctuations in the world oil market in recent years—a vulnerability that the Carter administration did not hesitate to use. During the Iranian revolution in early 1979, the majors declared force majeure and disproportionately cut oil shipments to Japan.

MITI and Keidanren have therefore stressed nuclear power development as a means of achieving an independent, domestic energy industry. Once Japan develops a domestic nuclear plant manufacturing capacity and a complete fuel cycle, it will have achieved energy independence, advancing its political independence.

At present Japan's nuclear manufacturing firms, including Mitsubishi Heavy Industries, Hitachi, and Toshiba, the three largest, still operate predominantly under licenses from General Electric, Westinghouse, and other foreign firms. The United States is also Japan's major supplier of enriched uranium, giving the U.S. government veto power over the use of spent fuel. Most of the spent fuel is currently reprocessed in the United States, though some is shipped to France, which has its own independent facilities for both enrichment and reprocessing.

MITI has made it a national goal to develop independence in both reactor production and fuel by approximately 1990. Since 1976, MITI has arranged for the nine major utilities to get special low-interest loans from the Japan Development Bank to help them purchase nuclear power equipment made in Japan, utilizing an increasing proportion of Japanese R&D. The joint private-government Power Reactor and Nuclear Fuel Development Corporation (PNC) was established to provide Japan with an independent source of fuel after 1990. JAERI is conducting reprocessing work at the Tokaimura research facility, while MITI is taking the necessary steps to enable private companies to acquire the funding, technical know-how, and sites to set up commercial reprocessing. MITI and JAERI are also conducting and funding R&D work on the enrichment process and expect to complete a pilot plant in 1979. Finally, as part of the advanced work of JAERI, research is being done on fast breeder reactors, which do not need enriched fuel and which can make nuclear power economical for decades and ensure political independence.

These ambitious plans and timetable have not proceeded unopposed. In 1977, the Carter administration refused to allow Japan to operate a 0.7 ton per day pilot reprocessing plant at Tokaimura, under the threat of a shutoff of uranium shipments, unless Japan met certain conditions—conditions that in fact would make reprocessing economically unfeasible.

Japan eventually agreed to operate the research facility under a compromise arrangement, in which it virtually bound itself to the guidelines set forth by the International Nuclear Fuel Cycle Evaluation (INFCE) initiated in 1977 by former secretary of state Cyrus Vance. These guidelines required Japan to undertake costly research on coprocessing, a fuel reprocessing technique in which plutonium always occurs together with uranium. The research has since shown that this process is economically impossible for Japan.

Despite the publicity about nuclear weapons proliferation, Vance's primary motivation in calling for INFCE was to prevent the acquisition of peaceful nuclear energy by nonnuclear countries. The Carter administration's subsequent heavy pressure on West Germany to abrogate its nuclear reactor deal with Brazil had a major impact on Japan as well. Japanese firms postponed indefinitely their plans to export nuclear reactors to developing countries, even though such exports had been an integral part of the knowledge-intensification strategy developed in the 1970 long-term plan of MITI's Industrial Structure Council.

JAERI President Imai charged at the time:

> INFCE has provided two years of virtual moratorium on the rising momentum of the world's nuclear energy. It has forced people to realize that this industry is full of factors that are beyond its commercial or industrial control so that the rules of the game may be changed overnight on political, rather than economic or technical grounds; from encouragement of Light Water Reactor plutonium recycling to its prohibition, for example.

Under these circumstances, MITI complained, it had become increasingly difficult to convince the private firms to make years of investment that could go up in smoke because of a single move from Washington. JAERI president Imai added, "It is doubtful under the circumstances whether even a renewed promotional drive by powerful countries could re-create the necessary self-confidence of this industry." Thus, MITI is projecting only a 4-gigawatt increase in nuclear capacity per year until 1995, despite the potential for adding 6 to 10 gigawatts a year.

MITI Versus the Environmentalists

Internal sabotage of nuclear power development in Japan has proceeded lockstep with the external. Japan's environmentalists launched a crusade against nuclear power in the late 1960s, soon after the first commercial reactor appeared. The main political support for the antinuclear movement comes from the Japan Socialist Party (JSP), the opposition to the Liberal Democratic Party (LDP), which has ruled Japan for the last 30 years. The JSP's 1980 election platform officially called for zero economic growth, which explains why the party has never won a national election. Yet, like the environmentalists in the United States, the JSP has made it difficult for nuclear utilities to find plant sites, dragging out construction time and costs.

To counter the problem, MITI and the Science and Technology Agency have launched popular education drives about nuclear energy and created the Japan Atomic Energy Relations Organization. But the educational work and the pronuclear political leadership behind it have not always kept up with the opposition. After the Three Mile Island incident in the United States, former prime minister and Carter ally Masayoshi Ohira announced an indefinite suspension of new nuclear plant licensing until safety investigations were completed. It was not until March 1981, almost two years later, that Ohira's successor permitted the licensing of the first new nuclear plants in Japan.

AP

Antinuclear demonstrators outside Japan's Ministry of International Trade and Industry in June 1979.

However, the Japanese enviromentalists have gained ground in the interim. On March 8, for example, antinuclear crusaders persuaded the residents of the small, 18,000-person town of Kubokawa to vote out of office the local mayor who had agreed to locate a nuclear plant in the town. The chairman of the Japan Atomic Industrial Forum, Kansai Electric's Hiromi Arisawa, commented that the recall vote meant, "We have not made adequate efforts to persuade people opposed to atomic power."

The Future: A New Atoms for Peace?

President Ronald Reagan pledged to his first foreign visitor, South Korean President Chun Doo Hwan, that the United States would henceforth be a "reliable supplier" of nuclear technology and fuel. Thus, when former prime minister Takeo Fukuda met with Reagan in March, he renewed the invitation for U.S.-Japanese cooperation in fusion research, an offer snubbed by President Carter in 1978. Foreign Minister Masayoshi Ito subsequently asked Secretary of State Alexander Haig to lift the restrictions on Japan's nuclear development imposed by the previous administration. However, at a joint press conference with Ito, Haig said only that the United States would be more "flexible" on the issue—a stalling gesture.

Whether President Reagan responds to Fukuda's proposal for a new era of Atoms for Peace cooperation around fusion development, or accepts Secretary Haig's tacit continuation of the Carter adminstration's policy, may well determine, as Shoriki prophesied in 1954, if nuclear power will be used to "banish wars, liberate humanity from poverty, and end the causes of cold wars."

—Richard Katz

The American Roots of Japan, Inc.

by Daniel Sneider

NOTHING IN THE current media outpouring on Japan's economic and technological success has revealed to Americans the secret behind the so-called Japanese miracle: The simple truth is that behind that economic powerhouse there is a method labeled "Made in USA." The greatest irony of the attempt to Japanize America is that the enduring, essential features of Japan's successful economic system are largely imported from the United States.

The roots of this transfer of American know-how are not, as might be thought, in the more recent postwar period, when Japan spurred its recovery with U.S. technology. Japan's American experience begins more than 100 years ago: When the founding fathers of modern Japan threw off an oppressive feudal system in the great Meiji revolution of 1868, they looked to America as the "mother" of a new Japan.

For Japanese leaders today, the great dividing line in their history is not 1945 but 1868, when a decisive civil war overthrew the old order of the feudal Tokugawa Shogunate. A central government was established that restored the Emperor as sovereign and brought Western ideas, science, technology, and industry to Japan. Determined to avoid the fate of neighboring China, where the decaying Manchu regime had left that nation the prey of the European imperialists, a group of relatively young Japanese leaders acted to discard the backward practices of the past—and of Chinese influence—and introduce modern civilization to Japan.

Sekai Bunka

The Meiji revolution of 1868 defeated the feudal Tokugawa Shogunate and brought Western ideas, science, technology, and industry to Japan. Surrender, *a painting by a 19th century artist, depicts the defeated samurai as uncivilized beasts; the Meiji soldiers look like their contemporaries in the United States.*

It was fortunate for the founding fathers of new Japan that in the first 10 years of their new state they found an ally in America, particularly among those who carried on the tradition of Lincoln republicanism. The reestablishment under Lincoln of the American System—meaning the U.S. founding fathers' commitment to the fostering of science and industry, especially through Alexander Hamilton's national banking system—supplied the model for Japan's rapid development into an industrial nation.

In the first years after the Meiji revolution, the young leaders opened their doors to new ideas. They sent out students and emissaries around the world to study the economic, educational, social, and political systems of the most advanced nations to find models for their new system. Here in the United States they found the prototype for their banking system, one which provided credit to encourage the establishment of new industry with the most advanced technology available; for their educational system, which provided universal education and advanced training in sciences and the arts—the foundation of Japan's incredible growth; for their agricultural system, which tried to implant America's modern agricultural technology; and for their system of "protectionism," which built up and sheltered the tender beginnings of modern industrial and merchant activity.

In all these realms, still recognizable today as the foundations of "Japan, Inc.," the model was the American System forged by Hamilton and developed by the Lincoln-era economists who gave it its name. Preeminent among these was Henry C. Carey. Carey and his most important cothinker, the German economist Friedrich List, were among the first economists whose works were translated into Japanese, and to this day Japanese economists and businessmen are schooled in their writings. Unfortunately, Carey today is far better known in Japan than in his native country.

Not only the ideas, however, were imported to create the new Japan. Scores of Americans, including many prominent citizens, came to Japan to act as advisers, technicians, educators, and political allies. The modernization of Japan in the 19th century can be called America's first, and perhaps only, successful Third World development project.

The most influential of the Americans in Japan, although the least known today, was Carey's collaborator Erasmus Peshine Smith. Smith worked from 1871 to 1877 as the official adviser to the Japanese Foreign Ministry, a position held by Americans for 40 years.

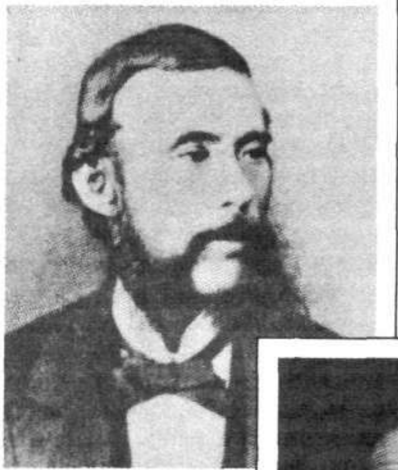
Smith was instrumental in two regards: spreading the influence of the American System economics and helping the Japanese to revise the coercive foreign treaties imposed on the previous regime, which restricted Japan's sovereignty as well as the development of its mercantile activity. In a letter from Japan Smith wrote, "The Japanese statesmen appear to have sound notions upon the policy of encouraging the protection of native industry and I think the revised treaties will be most unacceptable to the Christian powers in this particular. We mean to utterly reject commercial trammels unless we get some distinct consideration for submitting to them."

By the time Smith left Japan, one Japanese historian noted that "the American System of protectionist economic theory had become generally common thinking among [Japanese] statesmen, government officials, and philosophers."

The Americans were well aware of their influence on Japan. When the first Japanese mission abroad after the Meiji revolution arrived in San Francisco in 1872, the first stop in a world tour to open diplomatic ties with the great powers on a more equal basis, it was enthusiastically greeted. The welcoming editorial of the *Daily Evening Bulletin*, a San Francisco paper, is typical:

> Japan is today, all the circumstances of her previous condition considered, the most progressive nation on the globe. . . . Among the principal changes, there has been an entire revolution in the system of government, the Mikado (the Emperor) having become the active head of the temporal power. The entire system of feudalism has been swept away, and all the forces of the empire, both on land and sea, have been consolidated, and are fed and clothed in European style and paid by the national treasury. The Government possesses a large fleet of war and transport steamers. . . . It has also constructed a stone drydock that will admit steamers of the largest size, with ways for repairing smaller vessels, and foundries,

The roots of Japan, Inc. lie in the ideas of the "American System" economists Henry C. Carey (below), adviser to President Lincoln, and Carey's leading cothinker, the German economist Friedrich List.



Japan's founding fathers Fukuzawa Yukichi (below) and Okubo Toshimichi, leaders of the Meiji revolution.

machine shops, and forges, capable of doing the largest class of work, the machinery being the best obtainable in France. . . .

The Government schools at Yeddo [modern Tokyo] contain about 1,600 pupils studying foreign languages, three-fourths of whom are under American teachers, receiving an English education. The principal of this school and some 20 sub-teachers are American, while many subjects of other nations are employed in different capacities in other departments. An American fills the highest office that a foreign can hold under the Japanese Government—that is, Imperial Councillor, whose duty is to frame codes of general laws for the empire. Four Americans compose a scientific commission, to introduce new methods of agriculture, mechanics, mining, roads, etc. while another American has been appointed to revise and organize a system of internal revenue somewhat similar to our own. In addition, during the last four years, nearly 1,000 young men of intelligence and ability have been sent abroad to study the languages, laws, habit, manufactures, methods of government, and all other matters appertaining to western civilization, the greater part of which is to be introduced into Japan.

The leaders who created this burst of creativity in Japan were the product of 100 years of an intellectual and political movement that began in the 18th century with a small group of medical scientists known as the Rangaku, or Dutch Studies Movement. They were dedicated to the study of Western science, at the time known only through the tiny Dutch trading settlement in the port of Nagasaki in western Japan. The spread of this movement, aimed in part at what they called the "hidebound ignorance" associated with the dominant influence of Chinese classical thought, produced the 19th-century leaders of the Meiji revolution.

Japan's Founding Fathers

The brightest stars among them, Japan's George Washingtons, Ben Franklins, and Tom Paines, are names well known today in Japan. The intellectual giant of Meiji, Fukuzawa Yukichi, through his teaching and writing popularized Western science and philosophy among an entire generation of Japanese at the time of the revolution. Fukuzawa, who had visited America twice before the revolution, founded Keio University, Japan's first, as well as Japan's first newspaper. He also wrote several books on science, education, economics, and politics which, in some cases, were sold in millions of copies. Keio, which is still one of the finest universities in Japan today, trained the cadre who led government and private industry during the post-Meiji revolution period.

Fukuzawa's ally Okubo Toshimichi was the man most responsible for organizing the revolution itself, and for creating the institutions of Japan's government and economic system. Assassinated by profeudal terrorists in 1878, Okubo had already laid the foundations of Meiji government during the first 10 years of the revolution. He was the first minister of finance, creating the national banking system based on the U.S. model. He then created the Home Ministry, which combined a bureau for civil control with the Bureau for Industrial Promotion, a government agency that set up and fostered new industries during the first Meiji years. Today that bureau's activities are carried out by its successor, the Ministry of International Trade and Industry, which is the guiding governmental center of Japan, Inc.

The Fukuzawa-Okubo alliance had a third prominent partner, Iwasaki Yataro, founder of what is today Japan's largest and most powerful industrial combine, Mitsubishi. Mitsubishi's existence and growth demonstrate the Meiji use of the American System. Fostered by the government directly under Okubo, Mitsubishi became Japan's first modern shipping company and allowed Japan to take control over its own internal shipping trade from British companies. Staffed largely by graduates of Fukuzawa's Keio University, Mitsubishi is the classic example of government-business partnership that is the trademark of Japan's economic system.

In the 1880s, Iwasaki published pamphlets arguing that the only way Japan could industrialize was by setting up a banking system modeled on that of Alexander Hamilton. Japan succeeded in using this Hamiltonian system to industrialize 100 years ago. Now perhaps the best lesson the United States can learn from Japan is an appreciation of American System economics and how to apply them.

Daniel Sneider is the Asian editor of the Executive Intelligence Review.

Misestimating Fossil-Fuel Resources

by William Engdahl

"The oil reserves of the country, as the public has been frequently warned, appear adequate to supply the demand for only a limited number of years. . . . For some years we have had to import oil, and with the growth in demand, our dependence on foreign oil has become steadily greater. . . . It is therefore evident that the people of the United States should be informed as fully as possible as to the reserves now left in this country. . . ."

This 1922 report by the American Association of Petroleum Geologists, recommending elimination of waste, development of a synthetic shale-oil industry, and increased use of coal, estimated crude oil resources in the United States at 9 billion barrels.

John D. Moody, a highly respected petroleum geologist, in 1977 compared this embarrassingly low 9-billion figure to his estimate of 50 billion barrels of discovered reserves and some 150 billion barrels in as yet undiscovered reserves in the United States, providing a potential just short of a 70-year supply.

Since that 1922 misestimate, there have been a number of attempts to estimate world oil reserves, with equally unreliable results. Why is it so difficult to determine accurately how large our fossil-fuel reserves are worldwide?

As Dr. Hollis D. Hedberg, professor of geology emeritus at Princeton University, has noted, one answer lies in the fact that "In spite of the tremendous progress that has been made in petroleum geology, geophysics, and geochemistry, it is still not possible to determine with assurance the amount of petroleum in an untested region in advance of substantial drilling." To emphasize his point, Hedberg cites the unanticipated magnitude of the recent discovery of some 10 billion barrels of oil on the North Slope of Alaska.

In other words, the resource isn't really there until exploration companies are encouraged to invest the time and money to search out new fields.

A deeper problem lies in the methodology of reserve projection techniques. A recently published study by the Rand Corporation, which was commissioned by the Carter administration in 1978 ("The Discovery of Significant Oil and Gas Fields in the United States"), states bluntly, "We estimate that 80 to 90 percent of all crude oil, natural gas, and natural gas liquids that will ultimately be produced in this country below $40 a barrel is in fields that already have been discovered." The report's author, Richard Nehring, further states that "the petroleum industry is gradually running out of ideas as to where oil and gas may still be found in the United States, not because of a lack of creativity and imagination, but because of the increasing exhaustion of geological possibilities."

Using Nehring's analytical methodology, the report then issues a pessimistic evaluation that U.S. supplies of petroleum liquids can continue at 1979 levels of production for only 20 to 40 years more, with natural gas lasting for 17 to 26 years, all at a cost of exploration and production of $40 per barrel.

"We've found a lot of oil and gas in this country," Nehring states, "but we've already produced most of it, and nearly all of it at costs of less than $10 a barrel."

An October 1980 report issued by the Congressional Office of Technology Assessment (OTA) with the title "World Petroleum Availability: 1980-2000," similarly concludes that it is "highly likely that there will be little or no increase in world production of oil from conventional sources. . . . Oil production in the industrialized noncommunist world could begin to decline by the early 1980s."

Perhaps even more discouraging is an analysis by the recently retired head of the U.S. Geological Survey, H. William Menard, which was popularized in a January 1981 *Scientific American* article, "Toward a Rational Strategy for Oil Exploration." Menard argues that, based on historical analysis of exploration effort in the lower 48 states (deliberately excluding the Rocky Mountain Overthrust Belt, Alaska, and the Outer Continental Shelf), the number of oil fields discovered has been declining exponentially from a discovery peak of 1.8 billion barrels per year in the 1930s.

Gambling

Menard's method is similar to that of a gambler who has rolled too many dice in Las Vegas. Termed a computerized "random-drilling model of oil exploration," the Menard method says that the probability of finding an oil field by purely random drilling is about equal to the actual results using billions of dollars for subsurface geology.

Significantly, Menard uses King-Hubbert units (1 King-Hubbert unit equals 100 million feet of exploration drilling) rather than the more indicative number of wells drilled—wells are now being drilled deeper to recover larger pay zones. In other words, according to Menard, drilling five 2,000-foot-deep wells at random locations is equivalent to drilling one 10,000-foot-deep well at a geologically determined site. Two half-wells equal a whole!

Not only does Menard arbitrarily ignore the areas of most vigorous new exploration and production,

Continued on page 48

Inside Energy

Continued from page 47

but he also ignores such relevant historical factors as the move of major oil companies into the Mideast over the past 25 years.

In short, statistics can be a dangerous weapon in the wrong hands.

The Rand, OTA, and Menard Assessments all share a common methodological blunder that makes them next to worthless as policy guides. Nehring, who wrote the Rand report, also collaborated with the CIA economist Walt Macdonald on the infamous 1977 CIA report, "The International Energy Situation: Outlook to 1985," which predicted peaking world oil output by the early 1980s followed by international competition over dwindling resources.

Macdonald admitted that in projecting future Soviet hydrocarbon reserves, for example, he merely made a simple linear extrapolation of past data to predict that the Soviet Union would be forced to compete for Persian Gulf oil by the mid-1980s. When asked why he did not take into account the nonlinear effects of enhanced-recovery and other improved technologies, Macdonald replied, "Because this is the way I was told to do it."

His method points up the flaw in all these reports. The science of geology should not be confused with statistical regression analysis, random-drilling models, and the like, none of which takes into account the reasons why there has been a relative stagnation of discoveries of new giant fields.

For example, using a statistical analysis of the number of giants and large (between 50 and 500 million barrels) U.S. fields, Nehring concludes that "the amount of crude oil discovered peaked in the decade from 1926-1935, coinciding with the peak in the number of giant oil field discoveries."

Yet, as we have seen, the 1922 estimate of 9 billion barrels has been "revised" to 50 billion barrels actual and 150 billion barrels in undiscovered reserves.

World reserves have been similarly underestimated. Thirty years ago, the estimated size for world reserves more than doubled to 1.6 trillion barrels when a Stanford professor named Levorsen included the highly rich offshore basins in the calculations for the first time. By the late 1960s, a consensus of 1.8 to 2 trillion barrels was reached.

Michel T. Halbouty, renowned petroleum geologist and past chairman of President Reagan's Energy Policy Task Force, agrees with John Moody's estimate that with 514 billion barrels of oil equivalent (including natural gas) produced to date, there are 1.1 trillion barrels of oil equivalent worldwide in reserves and a further undiscovered potential of 1.7 trillion barrels.

Assessing the data of Nehring, Menard, and others, Halbouty notes that one reason for a global decline in the rate of new discoveries for the years 1965-1976 is simply that exploratory drilling levels have remained more or less constant outside North America, and that although there have been increasing levels of exploration in the United States and Canada, much of it has been in marginal fields with limited potential.

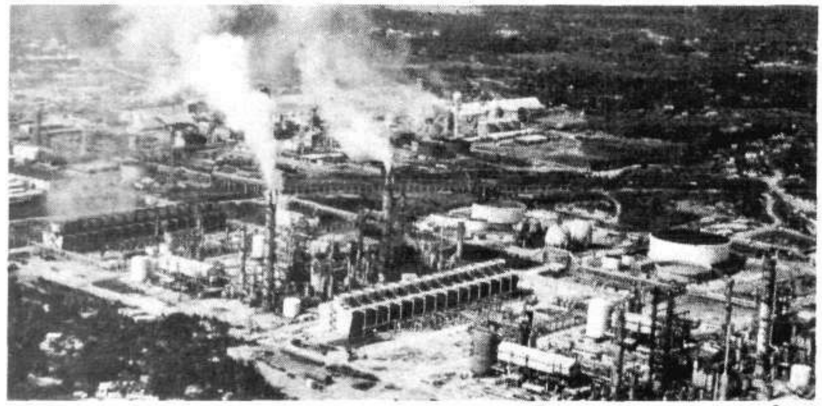
Halbouty, a scientist rather than a pure statistician like the Rand analysts, concludes: "About as much oil and slightly more gas remain to be found as have been discovered so far. . . . The undiscovered potential throughout the world is sizable."

Recent decisions by the Reagan administration, combined with record-breaking levels of exploration in new areas of the Rocky Mountain Overthrust Belt, the Williston Basin, the Tuscaloosa Trend, the Black Warrior Basin, and the Appalachian Overthrust, show that with adequate incentives for new exploratory activity, reserve additions will begin to appear—just as they did after 1922.

As Interior Secretary James Watt, Energy Secretary James Edwards, and geologists like Hedberg understand, we need exploration in the most promising new regions combined with deeper development of existing fields. Hedberg is convinced that the principal site of development of new U.S. oil lies in the largely unexplored offshore areas. He notes that of the almost 1,700,000 square miles of U.S. offshore Continental Shelf area that has great geological promise, we have leased only a little more than 2 percent for exploratory drilling.

"The amount of producible petroleum in this U.S. offshore is an unknown," Hedberg says, emphasizing that "almost all of it has sufficient prospects to be worthy of drilling exploration."

Aggressive exploration with government encouragement, development of new technologies to enhance retrieval, basic research in the science of hydrocarbon geology, and research into how fossil reserves are formed in the first place will enable us to make scientific projections about our hydrocarbon reserves for the future.



Uwe Parpart

A Mexican petrochemical complex: kept busy by Mexico's new oil finds.

Little Progress On Fusion Budget

Little progress was made in Congress during April toward an agreement on the fiscal year 1982 budget for the magnetic fusion program. Although the House authorizing committee has marked up the budget, adding $14.7 million to the Department of Energy request of $460 million, the Senate has yet to take specific action on the proposal.

The budget required to carry out the engineering phase of the Magnetic Fusion Energy Engineering Act of 1980 is $525 million.

On April 29, Senator Pete Domenici (R-N.M.), chairman of the R&D subcommittee of the Senate Committee on Energy and Natural Resources, held hearings on the programs of the DOE Office of Energy Research, which includes the fusion program.

The senator asked the DOE witness, Dr. Doug Pewitt, questions on many other programs, but nothing about the fusion budget. Pewitt, acting director of the Office of Energy Research, in previous testimony had called the 1980 fusion act "a permissive piece of legislation."

The committee staff has given no hint about Senator Domenici's thinking on fusion, although he has been a supporter of fusion development in the past.

As of this writing, the worrisome House Appropriations Committee has taken no mark-up action on the fusion budget, but staff members expect the DOE bill to be considered before the summer. The Senate appropriations process is considerably behind that of the House and may not take place until September.


U.S. Air Force


General Dynamics

James A. Beggs (right) and Dr. Hans Mark, nominees for NASA administrator and deputy administrator.

Reagan Nominates Strong Team to NASA

President Reagan named James M. Beggs as NASA administrator and Dr. Hans Mark as deputy administrator in April—a combination of an industry leader and a scientist that should considerably strengthen NASA's visibility on Capitol Hill.

Beggs, a director of the General Dynamics Corporation, has been responsible for the Convair, Electronics, Fort Worth, and Pomona divisions of the company. The Convair Division is developing superconducting magnets for the magnetic fusion program.

NASA Experience

Beggs also served in NASA's Office of Advanced Research and Technology in 1968-69 and as undersecretary of transportation. Before joining NASA, Beggs was with the Westinghouse Corporation.

Mark was the secretary of the Air Force under President Carter and was formerly head of NASA's Ames Research Center. A physicist and nuclear engineer, Mark has worked with the academic community and scientists in the national laboratories.

NASA supporters on Capitol Hill, who have tried to keep the space agency's funding at a level high enough to keep current projects on schedule as well as initiate new programs, are hopeful that this industrial-scientific combination will give them some strong backup in the fight against the Office of Management and Budget's budget cutting.

MHD Facility Dedicated

A dedication ceremony in Butte, Mont. to mark the completion of the Department of Energy's magnetohydrodynamics (MHD) test facility took place April 24 in the middle of a Washington budget fight that may end in the elimination of the MHD program.

The new MHD Component Development and Integration Facility (CDIF) is a 50-megawatt thermal MHD generator built to do engineering-scale testing of components for a coal-burning generator. MHD is a process to generate electricity directly by passing high-temperature gases from coal combustion through a magnetic field. The CDIF was designed to be the first U.S. machine in which all MHD components are simultaneously fully operational.

Although the dedication, which marks the readiness of the CDIF to begin operation, is a milestone for the MHD program, it may be the last one—unless the Reagan budget for MHD, now zero, is amended. Capitol Hill sources indicate that Congress will probably restore between $20 and $30 million to the program. The funding level was more than $60 million last year.

An Interview with the OTA

'Hamiltonianism Is Like Nazism'

Fusion reporter Mary Gilbertson asked a spokesman for the Congressional Office of Technology Assessment (OTA) to comment on the fact that the Soviet Union has moved ahead of the United States in key areas that bear on national security—space exploration, scientific and engineering manpower, and basic industrial infrastructure.

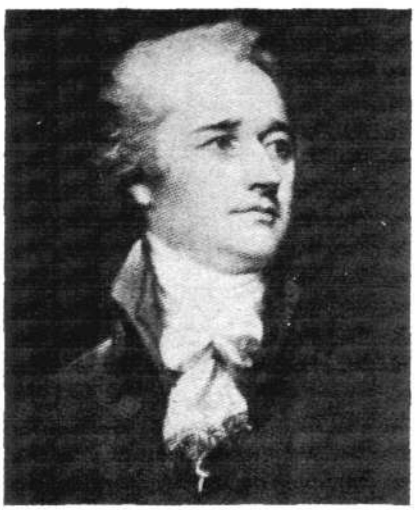
"That's the price we pay for a free market economy," she was told.

Excerpts from the OTA spokesman's remarks appear below. For a factual assessment of "How the U.S. and the Soviets Measure Up," see the special report on "Science and National Security" in the July Fusion*, p. 13.*

* * *

Question: Could you comment on the growing U.S.-Soviet gap?

It's kind of shocking that they are so far ahead, but that's okay. Our being behind the Soviets is proof of the fact that we have a free market economy; that's the price we pay for a free market economy. The Soviets and the Japanese have planned economies, but we don't want that because it would be like Nazi Germany.



A planned economy would be worse than being behind the Soviets.

Question: Article IV of the U.S. Constitution states that it is the duty of the government to foster science and technology, and when we had a national science commitment—for example, the Kennedy administration's promotion of NASA—the results were noticeable. Could you comment?

I know what you're getting at. That's Hamiltonianism. I used to think that approach was good, but I've been convinced lately that Hamiltonianism is like Nazism—I especially mean the relationship between government and industry that Hamilton pushed. I read his material on manufacturing. . . . It's a good thing Jefferson was around or we would never have had a free country. Hamilton was the man behind the Constitution, and Jefferson was behind the Declaration of Independence. Jefferson stood for the free traders.

Question: Didn't we fight a revolution against the free traders so the country could commit itself to a policy of fostering science and technology? The free traders are the ones who say sell anything—even dope.

That's the price we pay for freedom. Look at the engineering faculty in he United States today. We'll never catch up, because no one wants to teach when the salaries are so much higher in electronic engineering. . . . Having government push science and technology is like what the Nazis did, and we wouldn't want that. The Soviets and the Japanese are just like that—short hair and all.

Alexander Hamilton, the first treasury secretary of the United States. His 1792 Report on Manufactures is now considered "Nazi" by some officials at the OTA.

The OTA

For or Against Technology?

The Congressional Office of Technology Assessment (OTA) was founded in 1972 to evaluate the feasibility of new technologies—an important and influential responsibility.

The problem has been that since its inception, the OTA has been dominated by policy makers who are against technology and for zero growth.

Founded at the initiative of Senator Edward Kennedy and his adviser, Club of Rome member Michael Michaelis, OTA's first director was Russell Peterson, who is now in the forefront of the environmentalist attacks on Interior Secretary James Watt. Peterson is a member of the boards of the U.S. Association of the Club of Rome and the World Wildlife Fund, president of the National Audubon Society, and a leading supporter of the *Global 2000 Report*.

The OTA's current director, John H. Gibbons, is a specialist in university and government energy conservation and environmental quality programs. Working under Gibbons is Michael Walsh, another Club of Rome member.

The OTA has produced reports critical of the supersonic transport passenger aircraft; pesticides; fertilizer use; advanced medical technology; international nuclear plant sales; and the U.S. fusion research program. Currently the OTA rates synfuels as feasible, nuclear energy as not. According to the OTA, fusion should be rejected in favor of biomass and other low-technology energy sources, because fusion requires a more centralized economy.

The OTA is financed with U.S. taxpayers' money at a current level of $13 million a year. You can reach the OTA at (202) 226-2090.

'Gray Matter'
France's Most Valuable Resource

France has "the world's most ambitious program for research," Pierre Aigrain, France's state secretary in charge of research, told members of the French community in New York April 16. In a presentation sponsored by the Clubs Perspectives et Réalités, Aigrain reported that the French government's newly issued Eighth Plan calls for a 7 to 8 percent per annum increase in research spending for the next seven years—the highest growth rate anywhere in the world, including Japan. Moreover, the adopted research budget for 1981 is 8 percent higher than last year's.

In his speech and in wide-ranging interviews, Aigrain emphasized that France has no national resources except its R&D and scientific capabilities. However, these, he said, are an unlimited resource.

"Gray matter has an enormous advantage," Aigrain commented. "It is the only raw material that doesn't get used up when you use it. In fact, the more you use it, the more you have of it."

Another major theme of Aigrain's New York presentation was that the majority of the French population shares its government's concern with advancing France's scientific and technological capabilities. "It would be inconceivable," he said, "it would not permit our population to satisfy *its* aspirations, if we were not engaged in a fundamental research effort placing us among the first in the world."

"We have great ambitions," he continued, "but they can only be realized if the population as a whole considers scientific and technological research to be the future of the nation."

This educational goal was in part accomplished by a white paper on research, which was widely distributed last September, especially to the press, Aigrain said. "It had the impact we wanted. For the first time, research became the main preoccupation of the nation."

Nuclear energy, which is scheduled to produce 80 percent of France's electricity by 1990, is now so widely accepted in France that vacationing families frequently include tours of nuclear plants and other high-technology facilities in their travel plans.

We have a tendency to forget, Aigrain said, that France is not just a land famous for its haute couture, wine, and cheese. "France is the world's third largest exporter in volume terms, on equal footing with Japan, which has about double the population. In terms of the rate of export growth, France is first in the world, in a tie with West Germany and far ahead of the United States and Japan. The share of exports in French economic activity is 2.2 times greater than in Japan," he said.

The Space Program

Aigrain also ventured into more sensitive ground, warning that the cancellation of the U.S. side of the joint NASA-European Space Agency Solar Polar Mission puts "ESA's Survival at stake." The cancellation was precipitated by the U.S. budget cuts, and it provoked loud protests from ESA, which has already spent large amounts of funds on the now defunct project.

The International Solar Polar Mission was a cooperative venture in which two spacecraft, one built by ESA and the other by NASA, were to be launched by the U.S. Space Shuttle with trajectories taking them on paths flying over the opposite poles of the Sun. This mission was designed to give man the first three-dimensional view of the Sun through pictures taken simultaneously from the two vantage points.

Aigrain said that he hoped Congress would increase NASA's funding to enable it to revive the program or start a similar one. Despite some recent warnings that Spacelab, which ESA is building to fly on the Space Shuttle, is in jeopardy, Aigrain appeared confident that whatever funding problems may have existed have been resolved.

The French minister issued an appeal for international cooperation, particularly between the United States and Western Europe, in basic science projects. He cited the case of the Large Electron Positron particle accelerator currently being built by the Center for Nuclear Studies and Research (CERN) based in Geneva. The LEP will have a 10-kilometer diameter. "If we want to make a larger machine some day," Aigrain said, "we will need the surface of an American state to do it. I'm not even sure Rhode Island would be big enough!"

—Dana Sloan

An Interview With Pierre Aigrain

Science for Industrial Growth

In an interview with Fusion *contributor Dana Sloan, French Secretary for Research Pierre Aigrain expanded on France's fusion program, the need for U.S.-European cooperation in basic science research, and his definition of postindustrial society. The interview took place April 17, in New York, after Aigrain's public presentations. Here are excerpts.*

Question: Has the French government accelerated its fusion program with additional funding?

There has been a slight acceleration this year because we started putting money in the TOR-Supra. It's a new level of spending, but our plans are to keep that level of spending relatively constant. We are not expanding fusion expenditures any faster than other research expenditures. And of course, the biggest amount of money actually goes to the Joint European Torus [JET].

Question: Does this mean that you are banking on the JET for the industrial realization of fusion, or are you counting on the French fusion program to achieve this?

Assuming we achieve—when I say we, I mean maybe the JET program, maybe the American large tokamak, or maybe the Japanese—assuming somebody achieves scientific breakeven by the end of the decade, then I believe that before a significant amount of energy is produced from fusion, we will probably have to wait 20 to 30 years for industrial realization. There will still be all the engineering and industrial development side. And fusion, like all energy, is capital intensive.

An interesting point is that the lower the fuel costs—the recurring costs—of an energy producing system, the higher its capital costs. When a new source of energy becomes economically competitive, the sum of the amortization of the capital investment plus the recurring costs are, by definition, equal to those combined costs for all other sources of energy. So if an energy source has a lower fuel replacement cost, it obviously has a higher investment cost. And that means we are limited by the availability of capital. This is true for all new energy sources, and it will be true for fusion, too.

Between the point of scientific breakeven and a real fusion-based industry, probably 20 or 25 years will go by. The question of industrial development of fusion will arise only in 1990, and it is at that time that the problem will become urgent.

How we will do it at that time, I don't know.

Question: What can you tell us about the breakthroughs achieved in fusion by the Ecole Polytechnique team?

By the way, the Ecole is not unique in its line of research; there is a team working on the same line at the University of Rochester. The general idea they are researching is that if we work at a shorter wavelength for inertial confinement with laser light compression, the light is absorbed essentially in the area of the plasma density such that the plasma frequency is close to the wavelength. And if the wavelength is shorter, then the higher density regions and the mean free path of fast electrons are smaller; there is a smaller proportion of fast electrons moving to the center of target and preheating the target—something the scientists would like to avoid—so apparently better compression characteristics are achieved by working with shorter wavelengths.

EDF   French Embassy Press and Information Division

An aerial view of the 750,000-kilowatt nuclear power station at Chinon, France. With the change in government, a question mark now hangs over France's ambitious nuclear and R&D programs. Inset: Pierre Aigrain, state secretary for research in the Giscard government.

If confirmed by further studies, this work could change the order of magnitude of energy required for inertial confinement.

It also means that the kind of laser needed would presumably not be the same. This ultraviolet light can be produced by quadrupling the frequency of the 1.06 micron neodymium glass laser. But it's obvious that if what is wanted is the ultraviolet light, looking at ultraviolet lasers like Eximer lasers, krypton-fluoride lasers, and things like that may be a better solution. So the Ecole's work may have an influence on the kind of lasers that we have to develop.

Question: U.S.-European cooperation received a major blow with the cancellation of the joint NASA-ESA Solar Polar Mission. *Do you see any hope* for reviving this program?

I would hope that possibly other projects could be started in cooperation with the United States in this area of basic science.

Question: Perhaps with the success of the Columbia Space Shuttle there will be a new wave of support from the U.S. side?

We can hope that Congress will give more money to NASA and that

NASA will be able to start either the same project or a new project.

Question: Some institutions, for example the Club of Rome, claim that we have entered the postindustrial society. Do you think this is true?

I think that it's partially true, if what is meant is that new types of services—which by the way are strongly technology dependent—such as the storing, processing, and treatment of information are an increasing share of GNP and are going to go on increasing. And if you call a society in which the share of those services has become large and may become a majority, then it's true that we are moving toward a postindustrial society.

The point I would like to make is that this kind of postindustrial society is a big user of science and technology. Second, it is obvious that such a society exists only if the industrial hardware part of the system is there, too. The cost of that hardware, the proportion of that hardware in GNP, may be small and may even be decreasing, but it is essential. If it is not there, the rest is not there.

For the same reason, the number of people involved in primary agriculture in the developed countries has been going down. But that doesn't mean food production is going down. Fortunately, food production has been going up, and I believe that industrial production will be going up in terms of included R&D.

So it's true, we have entered the postindustrial society, but in the postindustrial society the role of industry is enormous!

Question: Does this mean that there are two definitions of the postindustrial society—the one that you have just given and the one put forward by the environmentalist movement, for example?

That's not the postindustrial society. That's the preindustrial and, to some extent, the precivilization society. I hope this is not the way we are moving. I don't believe we should have a society that is a combination of stone age economics plus philosophical discussions.

Nuclear and Thermonuclear Directed Beam Weapons

by Dr. Friedwardt Winterberg

A recent report by *Aviation Week & Space Technology* (Feb. 23) suggests that Lawrence Livermore National Laboratory "invented" the idea of pumping a short-wavelength (X- or γ-ray) laser with a nuclear explosion. Such ideas, however, most likely have occurred to many other scientists. Moreover, the feat accomplished by Livermore, a soft X-ray laser pulse of 500 kJ, does not measure up to the vastly greater pump energy available, which must have been in the neighborhood of a kiloton explosion. A 500-kJ X-ray pulse is by comparison not much larger than the explosive energy of a potato!

Furthermore, the drawing shown in the *Aviation Week* article must have been the product of a misunderstanding. The configuration shown could hardly be used to pump the laser rods with a nuclear explosion.

Nevertheless, the experimental result achieved can be viewed as the beginning of a new chapter in laser technology. The article stresses the importance that this kind of concept may have as an antiballistic-missile (ABM) weapon. What appears infinitely more important, however, is that such soft X-ray lasers should also be feasible using thermonuclear microexplosions. In this case, the application is purely peaceful.

For example, it could lead to holographic X-ray microscopy by which the cause of cancer could be investigated by the observation of living tissue on the molecular level. But even X-ray lasers driven by thermonuclear macroexplosions may have a peaceful application as a means of interstellar communication.

As I stated at the beginning, the idea of using a nuclear explosion to pump an X-ray laser must have occurred to many scientists long ago. I, for one, have considered the possibility since 1970. The idea seems obvious, but the problem is how to translate it into a practical device.

It was not until the mid-1970s that I discovered a working concept; and, on the invitation of the Air Force secretary, I presented a lecture on this idea at the Air Force Weapons Laboratory in Albuquerque, N.M. on July 15, 1977. My lecture was attended by the senior scientific staff members of the Air Force Weapons and Sandia laboratories. I subsequently submitted two papers containing detailed calculations to the Energy Research and Development Administration and the U.S. Air Force. To my knowledge, the papers also circulated at Livermore.

Neutrons Superior to X-Rays

According to the *Aviation Week* story, Livermore used pumping of the X-ray laser rod by X-rays from the nuclear explosion. If this was indeed the case, it would explain the rather poor efficiency of not more than approximately 10^{-6}. In my concept, I proposed to do the pumping by neutrons rather than X-rays.

There are two reasons for choosing neutrons. First, the X-rays do not easily penetrate into the laser rod, which consists of some high-atomic-number material. Second, the pumping efficiency, resembling optical pumping, is inherently poor. If neutrons were used for the pumping, they could easily penetrate into the rod material. Then, if the rod contained some uranium-235, for example, the neutron-induced fission reactions could locally create a population inversion.

Neutron reactions releasing γ-rays could also be used. In this kind of nuclear-pumped laser, a neutron bomb would be optimal.

One principal problem, resulting from the shortness of the X-ray laser transition, is that the pumping can be done, in any case, only by a traveling wave excitation along the rod, with the excitation wave moving with the velocity of light. I solved this problem with the concept of a neutron-induced "bleach-out" wave. This can be done by "poisoning" the laser rod with a neutron absorber whose concentration changes along the rod. Then, if the rod is exposed to the intense neutron flux of an exploding neutron bomb, a nuclear excitation wave will propagate along the rod as the neutron-absorbing nuclei are transmuted into nonabsorbing nuclei through neutron-absorbing reactions.

It turns out that by a certain exponential concentration profile, one can thereby generate an excitation wave propagating along the rod with the velocity of light, as is required for an X-ray laser.

The same principle could also be used to pump a γ-ray laser. However, because of the much larger nuclear recoil, this would require using something like the Mössbauer effect. Since at the high temperatures expected any crystal structure would be destroyed, I suggested using a strong magnetic field to take up the recoil over the excitation of Alfvén waves, rather than sound waves as used in the ordinary Mössbauer effect. A γ-ray laser would have an even greater power than an X-ray laser and would be the next most difficult goal to reach.

Various Designs

One way a nuclear X-ray laser weapon could be built is shown in Figure 1. A cylindrical neutron bomb, labeled *NB*, is positioned in the center of a cylindrical beryllium-9 neutron reflector. Surrounding this cylindrical neutron bomb are several prisms *P*, which prevent the laser rods *R* positioned behind them from being prematurely vaporized by the X-ray flash from the nuclear explosion.

Figure 2 shows a much larger device where a thermonuclear explosive *TE* pumps one large laser rod *LR*. If a 10-megaton bomb is used and if the pumping efficiency is only 1 percent, the resulting laser beam will still have an energy of 10 kilotons, that is, about 10^8 times bigger than the energy of the Dauphin X-ray laser. A laser of such an energy output could obviously be used as an ABM defense weapon.

Another alternative is to use a sequence of laser beams rapidly fired from space onto the atmosphere to drill a hole through the atmosphere to the ground. The X-rays would pass through this hole, killing all higher forms of life within a large radius while leaving all structures undamaged. The configuration shown in Figure 3 uses the principle of staged explosions to do this, where a smaller nuclear explosion compresses and ignites the nuclear explosive of a subsequent larger one.

Besides using nuclear-pumped lasers as a possible ABM defense, one may also consider alternatives such as fast plasma beams or beams of macroparticles. The first possibility could be realized by a thermonuclear shape charge like that shown in Figure 4. A spherical thermonuclear detonation wave, ignited at the ignition point *IP*, is transformed into a plane detonation wave by a thermonuclear plane wave lens. In the technology of high explosives a plane wave lens is realized by two explosives possessing different detonation velocities. Here this goal is reached by placing solid obstacles in the path of the wave, forcing the wave to go around these obstacles. The resulting thermonuclear plane wave then collapses a metallic liner *L*, as in the case of an ordinary shape charge, resulting in a fast plasma jet *J*. This jet could then be thrown against incoming missiles.

Finally, Figure 5 shows the concept of a nuclear-explosive-driven railgun. An exploding atomic bomb *F* generating an intense X-ray flash will induce a photoelectric current in one of the rails R_1. The second rail R_2 is shielded against the X-ray flux. As a result, a large electromotive force and hence a large electric current will be set up in the circuit formed by the rails, the shield, and the projectile. We thus have the conditions for a nuclear-driven railgun.

Its performance can be further im-

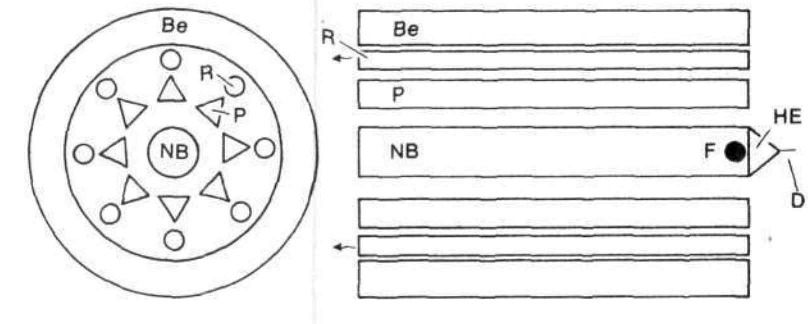


Figure 1
NUCLEAR X-RAY LASER WEAPON USING NEUTRON BOMB
The cylindrical neutron bomb NB is placed within a cylindrical neutron reflector Be made of beryllium-9. The detonator D sets off a high explosive HE, which in turn explodes the fission trigger F for the neutron bomb. The prisms P surrounding the neutron bomb prevent the laser rods R from being vaporized prematurely. The neutrons from the bomb penetrate the laser rods, which produce laser beams of intense X-rays, to be directed at ballistic missiles, for example.

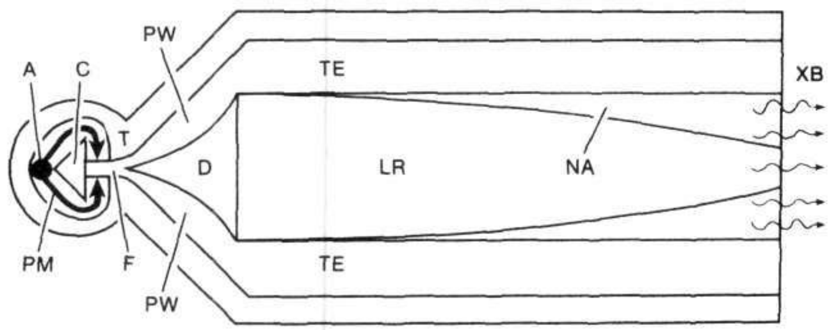


Figure 2
NUCLEAR X-RAY LASER WEAPON USING THERMONUCLEAR EXPLOSIVES
In this larger device, a thermonuclear explosive TE pumps one large laser rod LR. The fission explosive A creates a shock wave that is deflected by the deflection cone C, passing between it and the tamp T in Prandtl-Meyer flow PM. The thermonuclear shock burn wave from the thermonuclear fuse F is then shaped by the thermonuclear plane wave lens PW and the deflection wedge D. A coherent X-ray laser beam XB passes out from the laser rod LR, which has been pumped by the thermonuclear explosive TE. NA is the neutron absorber, which creates the conditions for an excitation wave propagating at the speed of light.

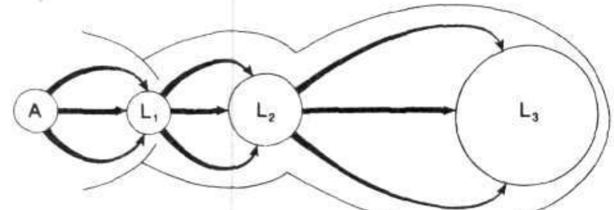


Figure 3
THE PRINCIPLE OF STAGED EXPLOSIONS
The fission explosion A creates a compression shock wave that passes through a series of staged laser rods with fissionable material L_1, L_2, L_3. Each smaller nuclear explosion compresses and ignites the next larger one.

proved, as shown, by pushing the rails against each other with the soft X-rays from the nuclear explosion, to be confined and guided along the gap formed by the outer surface of the rails and inner surface of the tamp *T*.

With such a nuclear railgun it should be possible to propel large masses, on the order of tons, to velocities of several tens of kilometers per second. A potshot of such projectiles could be used as an efficient ABM defense.

The new kind of nuclear ABM defense described differs from the old one in that it would direct the energy released, with a correspondingly larger kill radius. It depends, however, on the need for a vastly greater accuracy in aiming.

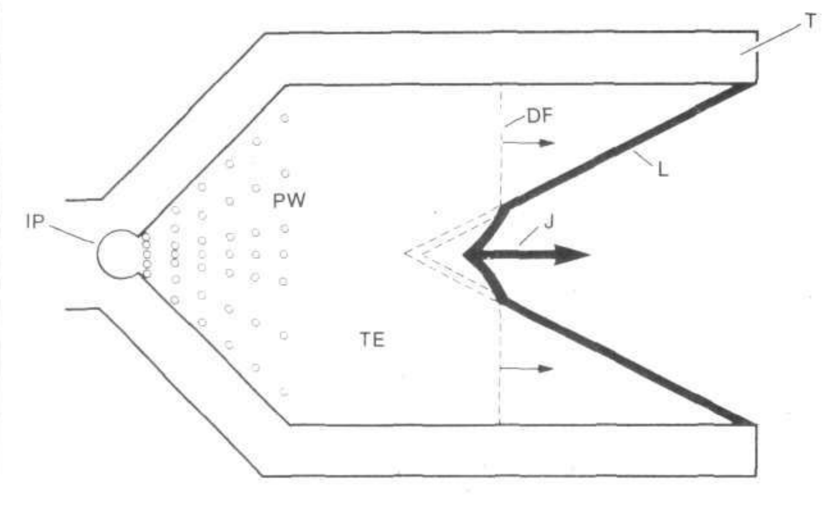


Figure 4
FAST PLASMA BEAM WEAPONS
A spherical thermonuclear detonation wave is ignited at ignition point IP and shaped into a plane wave with detonation front DF by the plane wave lens consisting of solid obstacles. TE is the thermonuclear explosive, T is the tamp, and L is the metal liner that is collapsed by the detonation front, resulting in a fast plasma jet J.

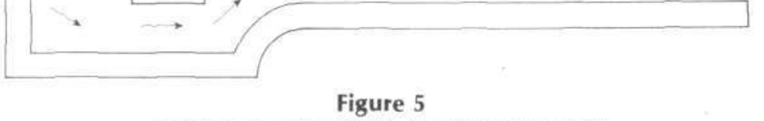


Figure 5
NUCLEAR-EXPLOSIVE-DRIVEN RAILGUN
An exploding atomic bomb F generates an intense X-ray flash, inducing a photoelectric electron current I_e in the rail R_1. R_2 is shielded from the X-ray flux by a lead shield LS, setting up a large electromotive force between the rails. The rails are pushed together by the soft X-rays along the gap between the rails and the tamp T. This nuclear railgun can propel the projectile P at great velocities.

2,4,5-T Herbicide

More Evidence To Drop Ban

The American Council on Science and Health released a comprehensive study in Washington, D.C., April 14 concluding that there is no scientific evidence to justify the permanent ban on the herbicide 2,4,5-T sought by the Environmental Protection Agency.

"No scientific evidence presented to date has shown any convincing relationship between the traditional domestic use of 2,4,5-T and any illness in humans," stated Dr. Elizabeth Whelan, executive director of the council.

The controversy over 2,4,5-T has centered not on the herbicide itself but on a contaminant, the toxic substance known as dioxin, that is formed in its manufacture. Recent research has shown that dioxin is probably less dangerous than previously presumed. Moreover, the amount of dioxin in commercial 2,4,5-T is miniscule—about 1 part in 100 million.

Nevertheless, most agricultural uses of the herbicide were banned by the EPA more than a year ago after an EPA investigation in Alsea, Ore., resulted in claims by women that a relationship exists between miscarriages and the use of the herbicide.

The herbicide scare was fueled by the subsequent flap over "Agent Orange," one of the defoliants used in Vietnam, which contains dioxin and is the subject of a lawsuit filed by Vietnam veterans. There is no evidence that the veterans' multiple symptoms are caused by Agent Orange. Moreover, the defoliant has a much higher concentration of dioxin than 2,4,5-T.

This is not the first study to attack the myths about the effective herbicide. However, in a development that may signal the Reagan administration's intention to drop the ban, administrative hearings were recessed in April so that EPA and Dow Chemical, the principal manufacturer of 2,4,5-T, could negotiate a settlement to the proceedings.

Advance in Mass Spectrometry Will Aid Fusion Development

A recent development in the technology of the mass spectrometer, an instrument that measures the atomic mass of particles, will permit far more accurate measurements of the isotopic content of fusion fuels, as well as the ingredients of fission reactor fuels throughout the nuclear fuel cycle.

A leading company in the development and manufacture of mass spectrometers has recently announced that it is producing a new spectrometer, called the Gazab, that produces a resolution of 100,000, or more than a factor of 10 higher than the next best spectrometer in its line of precision instruments for analyzing gases. The company, VG Micromass, a subsidiary of the VG Instruments Groups based in Winsford, England, is planning to market its new product to the nuclear industry in the United States and other countries.

According to its manufacturer, the Gazab spectrometer can both differentiate among isotopes of elements with only slightly differing masses and measure the amount of each isotope in a gas mixture with far greater precision than before. Thus, in a fusion fuel mixture that is made up of hydrogen (H), deuterium (D), and tritium (T)—isotopes of the same element, hydrogen, that differ only in their atomic mass—the Gazab spectrometer is capable of precisely measuring the amounts of each of the three isotopes present. The ability to identify and measure these and the other elements and isotopes present in the fuel is essential for designing, developing, and operating future fusion reactors.

The instrument, operated in combination with other specialized mass spectrometers, will also permit the isotopic and chemical analysis of every stage of the nuclear fuel cycle in fission reactors, including the ore conversion to uranium hexafluoride, enrichment, conversion to fuel pellets, reprocessing, and reactor operation.

Any mass spectrometer is based on the fact that when a charged particle—of hydrogen, deuterium, or tritium, for example—travels through a uniform magnetic field, its mass, velocity, radius of curvature, and the strength of the magnetic field are all related in a predictable way. If the strength of the magnetic field, the velocity of the particle, and its radius of curvature are known, then the mass can be determined.

How the Gazab Works

The Gazab mass spectrometer works as follows: The material to be analyzed is gasified (if it is not already a gas) and ionized and then accelerated by applying a voltage. The beam of charged particles is directed through a series of collimators and magnetic optics, which appropriately shape the beam before it enters the uniform magnetic field.

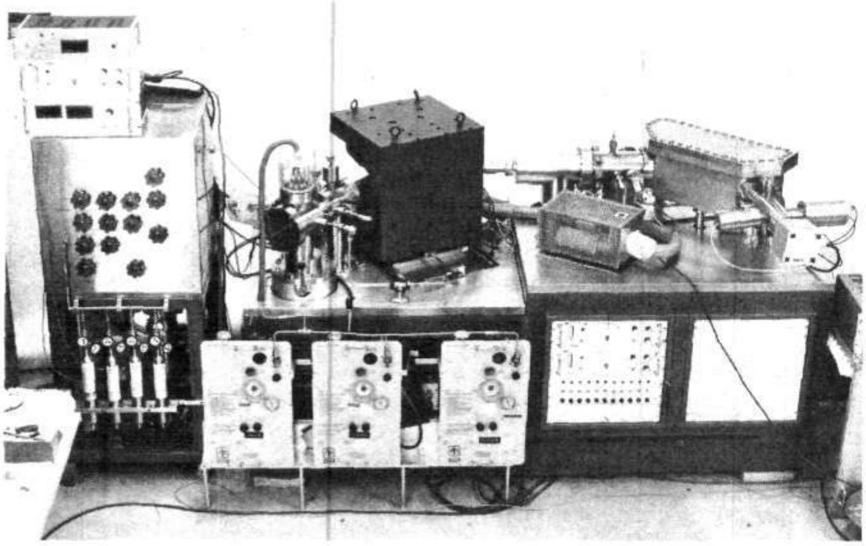
The path traveled by the particle beam is determined by the instrument. The velocity of the particles is also determined and known. Then the strength of the magnetic field is varied until particles register on the detector at the end of the path. Once the velocity, radius of curvature, and magnetic field strength are known, the mass and hence isotopic identity of the particles that reach the detector can be determined.

Particles of different atomic mass will have hit the collimators, or walls, therefore not registering on the detector. However, these particles can be identified by again varying the magnetic field strength until their radius of curvature matches the equipment, and these particles begin to impinge on the detector.

In addition to the magnetic analyzer, the Gazab makes use of an electrostatic field analyzer, which accounts for the high resolution of the device and its ability to discriminate among isotopes and compounds of nearly equal masses. When a charged particle travels through a magnetic field, its mass is proportional to 1 over its velocity; while in an electrostatic field, the mass is proportional to 1 over the velocity squared, permitting increased sensitivity in measuring the mass.

The new instrument also utilizes advanced computer and electronics techniques for recording, detection, and operation.

—*Jon Gilbertson*



VG Micromass

The VG Gazab mass spectrometer built for use by the U.S. nuclear industry. The high resolution of this new spectrometer will enable nuclear researchers to differentiate among isotopes of elements with nearly the same mass.

Anatomy of a Slander

FEF 'Bad' Because It's So Effective?

The campaign against nuclear power and industrial growth in the United States has taken some strange turns since the Nov. 4 election.

In April, Richard Bornemann, a pronuclear publisher in Oregon who is a long-time nuclear activist, brought to the attention of *Fusion* energy editor William Engdahl an attempt to derail the fight for nuclear energy by defaming the Fusion Energy Foundation.

The apparent originator of the slander was Elihu Bergman, the executive director of Americans for Energy Independence (AEI). Bergman was formerly the assistant director of the Harvard Center for Population Studies.

On Feb. 5, H. Jack Young, senior vice-president of the Edison Electric Institute, mailed out to utility executives and energy activists around the country a packet of materials slandering the FEF, which included a letter from AEI executive director Bergman to Young.

It is apparent from Bergman's Nov. 24 letter to Young that Bergman and others brought pressure on the Edison Electric Institute (EEI) for three months after the election. That pressure finally succeeded in persuading the EEI's Young to pass on to member firms slanders printed by the Anti-Defamation League of the B'nai B'rith about the FEF and Lyndon H. LaRouche, Jr., one of its founders.

One of the slanders alleges that the FEF is a "front for the U.S. Labor Party," which they allege supports terrorism. The Labor Party, founded by LaRouche in 1973, was disbanded in 1979 when LaRouche entered the Democratic Party as a conservative Democratic candidate campaigning for the presidency. Ironically, LaRouche and the U.S. Labor Party earned the enmity of radical groups such as the Socialist Workers Party and the Communist Party, because LaRouche and his party attacked terrorism and exposed its controllers in the layer of radical lawyers and university professors typified by William Kunstler, a public defender of the Baader-Meinhof terrorists in West Germany.

When Richard Bornemann asked Bergman to substantiate his allegations in a phone interview, all Berg-

RICHARD H. BORNEMANN
3700 S.E. Ellis
Portland, Oregon 97202
(503) 774-6638

7 April, 1981

Mr. William Engdahl
Fusion Energy Foundation
888 Seventh Avenue, Suite 2404
New York, New York 10019

Dear Mr. Engdahl:

I am writing you because your articles in Fusion Magazine have captured my attention and imagination over the past couple of years. Something disturbing, though, has caused me to choose this time to correspond.

Enclosed please find some materials which arrived at my home this morning from an unknown source. I thought you should be aware of some of the wild and weird conspiracy theories being thrown about against the very effective pro-energy work of the Fusion Energy Foundation.

I have met Dr. Elihu Bargman of the Americans For Energy Independence and this prompted me to call his Washington, D.C. office to inquire into the basis of his allegations and to request his sending me any evidence to support the claims of AFEI.

Dr. Bergman told me that the Fusion Energy Foundation was purely a front for the U.S. Labor Party. The literature of the U.S. Labor Party, he continued, had in the past been supportive of such international terrorist groups as the Italian Red Brigades and the German Bader-Meinhoff Gang. Ironically, he told me that he thought the material in Fusion Magazine to be quite good; but therein lies the danger of the FEF, he said. It's good enough to "deceive" middle class and conservative scientists, engineers and businessmen so that "down the road" these people will be forced to accept the "hidden agenda" of the communism which the U.S. Labor Party is waiting in the wings to enforce.

Bergman even contradicted himself in a key way. First he said that the FEF was not really pro-energy any more than the hidden agenda of the Naderites was really anti-nuclear per se. Then he said that the FEF exists only to promote pro-energy, pro-industry positions so that the U.S. industrial base remains intact so that the U.S. Labor Party could take it over.

I asked whether or not these strange allegations imposed a kind of Catch-22 on the FEF - i.e., the FEF is bad and dangerous because its postions are so positive and sensible. He replied that like the rest of the international "Left" generally, the FEF was waging a campaign of "deliberate misinformation." As for all allegations about anti-semitism, I informed Dr. Bergman that to the best of my knowledge people associated with the FEF were mostly Jewish. He contended that these were people who probably ended their ties with their faith, and then said that the "Hungarian Politburo was probably full of people with Jewish-sounding names."

Dr. Bergman told me that he was far too busy to wage a vendetta campaign against the FEF, but that he would continue to warn the energy industry against it because he's "determined to cut it (the FEF) off from the trough."

Actually, the only "evidence" he supplied to my unknown source was the enclosed report by the Anti-Defamation League of B'nai B'rith. As you can see, a representative of this organisation and one other, the Episcopal Bishop of Ohio, sits on the AFEI Board of Directors.

I asked Dr. Bergman if he was not drawing support for his allegations from too narrow a base and if it would not be wise to seek another side to the argument, perhaps by providing the FEF an opportunity to reply. He said that he would never give the FEF a forum for its views.

Dr. Bergman and I ended our conversation by his telling me to stay away from the FEF because somewhere up the road "they're gonna screw you."

If the best that Dr. Bergman can tell me is that the FEF is "bad" because it's so good, then I will stop wondering how our country became dominated by anti-energy, anti-industrial-capitalist thinking. It's high time like-minded groups with similar goal worked together. Let us negotiate an end to this ridiculously stupid and destructive gossip spreading!

Sincerely,

Richard H. Bornemann

man could do, Bornemann said, is offer "some wild and weird conspiracy theories . . . against the very effective proenergy work of the Fusion Energy Foundation."

The FEF countered the slander with its own mailing to utility executives on April 12, which included the evidence turned up by Bornemann and a call to the executives to join with the FEF in its campaign to revive nuclear power in the United States. The FEF's letter noted that the Anti-Defamation League's "fact-finding division" produced the report that Bergman and the EEI have been circulating. That division is headed by Irwin Suall, an avowed socialist, who led a national campaign against President Ronald Reagan when Reagan was a public relations executive promoting advanced energy technology for General Electric in 1962.

The Bornemann Letter

Richard Bornemann's letter to *Fusion* editor William Engdahl, dated April 7, appears at left.

Pa. Meeting Initiates Fight To Open TMI 1

An FEF members' meeting April 29 in Harrisburg, Pa. unanimously voted to work on getting a resolution introduced and passed in the state legislature demanding that the President, Congress, and the Nuclear Regulatory Commission restart TMI 1.

The customers of the utility that operates the plant, Metropolitan Edison/General Public Utilities, are now paying replacement power costs for the closed nuclear plant of $14 million per month. TMI 1 was shut down for routine refueling at the time of the incident at the TMI 2 plant in March 1979. The NRC has denied the utility approval for a startup, despite compliance with mandated modifications over the past 25 months. Seven other reactors similar to TMI 1 have been allowed to operate while making the same modifications.

The meeting was chaired by Ira Seybold, FEF coordinator in central Pennsylvania and former manager of the Dosimetry Department at Three Mile Island, who briefed the audience on the positive responses so far to the resolution in the state legislature.

The main presentation was by Jon Gilbertson, FEF director of nuclear engineering. Gilbertson summarized the cost to the nation of keeping nuclear plants shut down. "Delays in plant licensing and construction have cost U.S. electricity users a whopping $25 billion already," he said, "and if the licensing procedures are not changed, this figure will rise to $50 billion by next year." Gilbertson said that the FEF would publish a national report on the cost of not going nuclear.

The members and guests attending included a state legislator, union leaders, representatives of the Pennsylvania Chamber of Commerce, a Met Edison representative, and several community leaders.

Watt Testimony

Continued from page 15

as a spokesman for the very real public interest involved in the protection and preservation of a strong minerals sector.

Law of the Sea Treaty

The matter of deep seabed mining and the Law of the Sea Treaty negotiations provides a graphic illustration of the complex, highly interrelated nature of strategic minerals policy, of the need for a national minerals policy, and of my personal commitment to achieve such a policy.

The United States is now dependent on foreign sources for effectively 100 percent of our manganese—vital to the production of steel, and 100 percent of our cobalt—a critical hardener of steel. Many experts believe that manganese nodules, located on the ocean floor, are an important long-term source of manganese and cobalt for the United States and the western world. Yet the ability to mine these nodules is dependent upon the existence of a secure and stable financial climate. Given the size of the investment required (about a billion dollars per project), the most critical element to the undertaking of deep seabed mining is the security of that investment—a security now being determined by Law of the Sea Treaty negotiations.

The decisions made and agreements reached in these negotiations intimately concern the broadest aspects of strategic minerals supplies. For that reason, I have communicated with Secretary Haig on the Law of the Sea Treaty negotiations. . . .

The Secretary of the Interior has minerals management responsibilities for all federal lands. It is obvious, however, that federal land use decisions have not been coordinated with national strategic and economic goals. There have been no official determinations of how much public land is off limits or restricted from minerals exploration and development.

Coordination is imperative if we are to make sound land use decisions essential to the national interest. I am considering elements of a new public lands policy within the Department of the Interior, to be undertaken in conjunction with other federal land managers, that will ensure the application of the multiple-use concept that Congress established in its major public lands legislation. One of the first steps that will be taken in the implementation of that policy is the determination of the status of federal lands relative to all decisions affecting mineral access.

In addition, I am considering the advisability of legislation to statutorily "release" to multiple-use lands determined under section 603 of the Federal Land Policy and Management Act of 1976 to be unsuitable for wilderness. I am reviewing, as well, provisions permitting exploration for and development of minerals within the wilderness system. As minerals manager of the public's lands, I will oppose single-use designation of those lands if there is evidence that their withdrawal means a significant loss of fuel or nonfuel mineral resources vital to our economy and the nation's interest. . . .

AIF STUDY SHOWS NUCLEAR STILL CHEAPER

A recent study issued by the Atomic Industrial Forum of the relative costs of producing electricity using nuclear and coal-fired power plants makes a convincing case for the economic advantage of nuclear over coal, especially in a period of rapidly rising fuel costs.

Titled "An Economic Comparison of Nuclear and Coal-Fired Generation," the study was written by Gordon R. Corey, financial consultant and retired vice-chairman of Commonwealth Edison Company of Chicago. It was based on the actual operating experience of the two types of power plants owned by Commonwealth Edison, and the results were unambiguous:

Despite all the environmentalist-caused regulatory delays, nuclear power remains the cheapest way to produce electricity. The cost of nuclear power not only has risen more slowly year to year than coal-generated electricity, but it can be expected to continue to do so into the foreseeable future.

Oil-fired plants were not even considered in Corey's study, since they are not a financially viable way to provide base load electrical-generating capacity.

With regulatory changes and uncertainties "continually increasing the construction costs, delaying the service dates and jeopardizing the availability of new facilities, both nuclear and coal," the relative advantage of nuclear is attributable to its far lower fuel costs, Corey says.

Corey notes that construction costs for both nuclear and coal-fired plants have risen at an annual rate of about 15 percent in recent years. Coal-fired plants cost only one-half to two-thirds as much to construct as nuclear plants. However, in the annual operating costs of coal-fired plants, the large fuel bill outweighs amortized depreciation and other operating costs. The cost of coal has risen nearly as dramatically as oil in recent years.

Uranium, on the other hand, represents only a small portion of the cost of nuclear electricity production, with amortized capital costs representing the largest portion.

Thus, five years ago the per-kilowatt cost of electricity generated in a nuclear plant was only a couple of mills cheaper than in a coal-fired plant. Today, that difference has increased to about 16 mills per kilowatt-hour and is expected to rise to 18 mills in the near future. The main contributing factor has been the rise in the cost of low-sulfur coal.

On the other hand, with improvements in nuclear technology, it has been possible to more than double the energy content of a pound of uranium used in reactors.

* * *

MORE NEWS THAT FITS THE TIMES

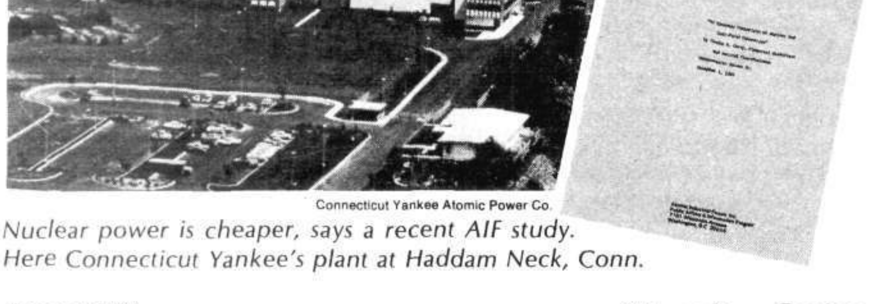
"Nuclear power is sinking in this country—not because of chaotic financial markets, public protests, or bureaucratic tangles, but under its own economic weight," claimed Anthony Parisi in an article titled "Hard Times for the Nuclear Industry" in the *New York Times Magazine* April 12. "Despite the almost universal assumption of years past that power from the atom would one day provide an endless source of cheap electricity, the nuclear genie has turned out to be a very demanding, very expensive servant. Even the help the industry expects from the Reagan administration would not alter that reality."

Parisi deliberately ignores the negative impact on the cost of nuclear power of regulatory delays and record high interest rates and the ray of hope held out by the Reagan administration's promise to cut through much of the regulatory red tape. His argument is based on a study of the relative economic merits of coal and nuclear power plants by Charles Komanoff, a long-time antinuclear activist. Komanoff concludes that coal-generated electricity is now cheaper than nuclear power because of the rapidly escalating construction costs of the latter (costs that the Corey study reviewed above shows are rising no faster than those for coal-fired plants).

Who is the reader to believe? Commonwealth Edison will probably base its investment decisions on the findings of the Corey study, so it's hardly likely that Corey made up his figures. Komanoff, as noted, is an avowed antinuclear activist. Parisi, formerly the *New York Times* energy correspondent, is now an editor of *Petroleum Intelligence Weekly*, a trade publication of the major oil companies, which are not exactly disinterested parties.

The *Times*, which ran the article, has a long history of opposing such dangerous and polluting inventions as the electric light bulb and the stringing of cables to carry electricity throughout New York City.

—*Dr. John Schoonover*



Connecticut Yankee Atomic Power Co.

Nuclear power is cheaper, says a recent AIF study. Here Connecticut Yankee's plant at Haddam Neck, Conn.

Letters

Continued from page 6

juxtaposed with your long-term goal. Please reverse your stand. I cannot support your efforts if you continue to seek big government . . . because I believe with big government the rate of development of nuclear energy will clearly be moderate at best, and probably well behind France and other countries. You cannot have your cake and eat it, too. Your purpose is nuclear energy . . . not big government. Bite the bullet. I think your fundamental purpose is perhaps the most important in the long-term economic success of America. Please get on with the big show and quit quibbling about how the shoe pinches.

Charles C. Cook
Cambridge, Mass.

To the Editor:

I support all budget cuts proposed by President Reagan. I am not convinced his advisers are "self deluded."

Nor am I convinced that we must whine for money from the government! We must look to the private sector for the financing of energy projects—*of course* it will be difficult.

Ann C. Nolen
Tulsa, Okla.

The Editor Replies

If the United States is to avert a national disaster over the immediate period ahead—an irreversible erosion of our industrial base and scientific edge—the country's proscience constituency must take responsibility for ensuring that there is a "bigger pie" and not accommodate itself to a perspective of "sharing the poverty" (a concept, incidentally, borrowed directly from British Fabian socialism).

As for the issue of government intervention, there's a big difference between government funding of low-skill, make-work employment and the proliferation of the government bureaucracy in general—which *Fusion* has criticized as nonproductive—and government funding of leading-edge scientific endeavors and technologies. The latter type of government intervention is the motor that makes the whole private economy go. Moreover, the U.S. Constitution's Article 4 states unequivocally that it is the obligation of the Congress "to promote the progress of science and useful arts."

We're not worried about irritating Office of Management and Budget director David Stockman, because we know that groups like the FEF and other citizens concerned about the effects of the budget cuts are the only thing standing in the way of his utterly wrecking the nation's economy and science capability.

Keeping Up the Good Work

To the Editor:

I just signed up to receive *Fusion*. As a construction engineer on nuclear power plants, I was very interested . . . and have been wondering if the Fusion Energy Foundation has any local chapters. . . . The time is here for grass roots organizations in support of nuclear power.

I was very impressed with *Fusion*. Don't let the negative letters about your articles on dope and the antinuclear movement stop you from printing the truth. The de-moralization, de-energization, de-industrialization, and de-education is all one program to make the United States a second-rate country. Keep up the good work.

Melvin G. Vinson
Metairie, La.

To the Editor:

Although unable to have completed high school, I am interested in science. *Fusion* is much too deep for me to understand, but *The Young Scientist* isn't.

Being "middle aged" I am so tired of hearing the pessimistic side of science. It is very uplifting to realize people are still very optimistic about energy.

Please find enclosed $8 for five issues of *The Young Scientist*, not for my youngest three teenage daughters, but for myself to give me a little more knowledge of our beautiful world and the people trying to maintain and improve it. Hopefully, in time I will change to Fusion.

Eilleen Simmons
Groton, Mass.

FEF's Seybold Requests Contributions for Restart TMI 1 Campaign

Editor's note: Ira Seybold, former manager of the Dosimetry Department at Three Mile Island and FEF coordinator in central Pennsylvania, is circulating the following letter to FEF members and nuclear power supporters. An article on the Harrisburg meeting appears on page 59.

Dear Friends:

On April 29, I chaired a meeting called by the Fusion Energy Foundation in Camp Hill, Pa., near Harrisburg. The purpose of the meeting, which had excellent representaton from the leadership of labor, business, and farm organizations in the area, was to plan a campaign to put Three Mile Island Unit 1 back on line.

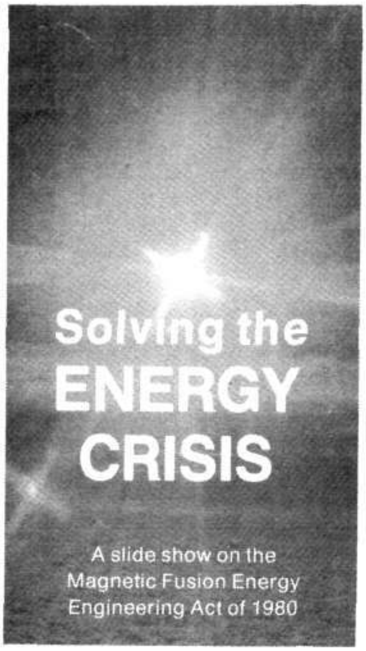
All present agreed that Unit 1 must be allowed to return to operation as soon as possible. We developed a plan that involves introducing a resolution to the Pennsylvania state legislature and distributing a pamphlet to the citizens in that area. The pamphlet, written by Jon Gilbertson of the Fusion Energy Foundation, explains that the cost of replacing power from TMI Unit 1 is $14 million per month.

I need your help in this effort. If you can make a contribution toward printing the pamphlet, make your check payable to the Fusion Energy Foundation. Please write to me [in care of the FEF] at your earliest opportunity in support of the resolution to put TMI 1 back on line. I cannot overemphasize the value of such letters when dealing with legislators. Letters especially from outside Pennsylvania will help them realize that they have a responsibility to the nation.

The resolution has already been well received by some of the state representatives, including one who attended our meeting and who pledged himself to get it introduced. I think you'll agree that starting up TMI 1 will make it much easier to resolve similar but less publicized situations around the country.

We are on the move, so please act now. Let your voice be heard.

Ira Seybold
Mechanicsburg, Pa.



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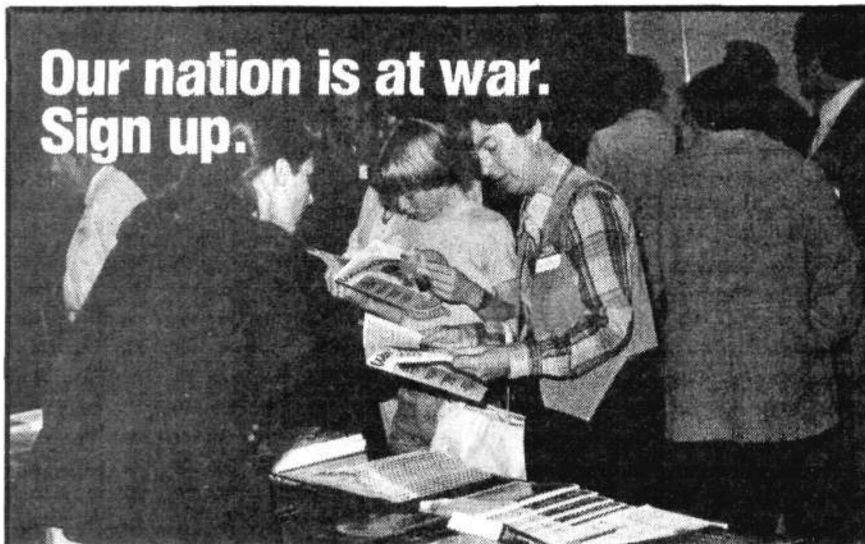

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PUTTING AMERICA BACK INTO SPACE

President John Kennedy said it, Senator Harrison Schmitt said it, and in this issue of Fusion Shuttle pilot Robert Crippen says it: the United States has to get into space.

Twenty years ago, scientists were not sure that spaceships—or man—could survive in space. Now, after years of successful unmanned and manned exploration, the magnificent flight of the Space Shuttle has made it certain that we are ready to colonize space and start using its resources.

As this issue of Fusion shows, the barriers to a reinvigorated U.S. space program are the same ones the fusion program faces—short-term budget cuts and, at best, an ignorance among policy makers of how to keep progress going.

The cover: The front cover photograph of the toroidal field coil for Japan's JT-60 tokamak is courtesy of the Japan Atomic Energy Research Institute and Hitachi; the photo of the shuttle lift-off above is courtesy of NASA. Cover design by Christopher Sloan.