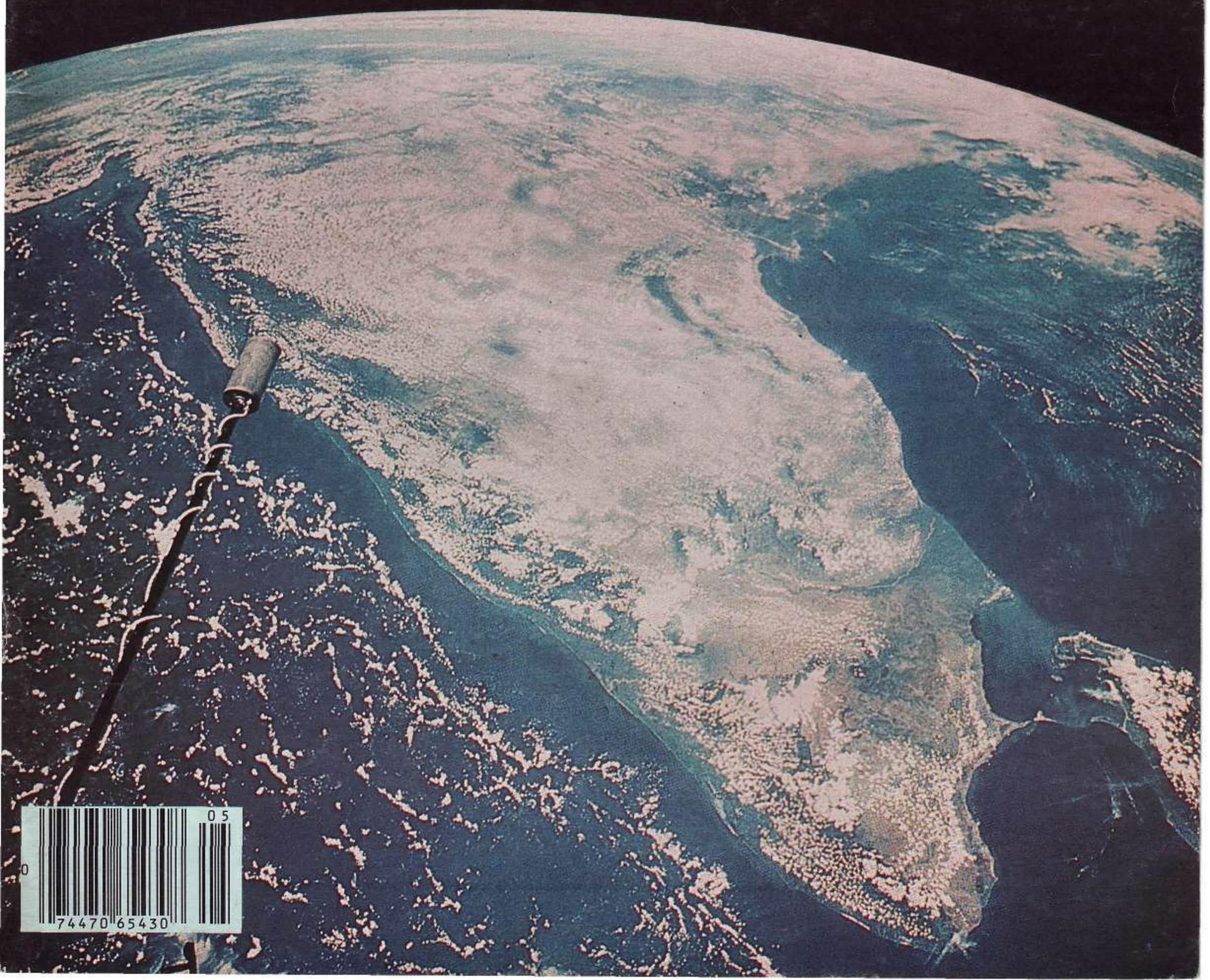
FUSION

MAGAZINE OF THE FUSION ENERGY FOUNDATION
May 1980
$2.00/$2.25 in Canada

No Limits to Growth

Making India an Industrial Superpower



FUSION

MAGAZINE OF THE FUSION ENERGY FOUNDATION

Vol. 3, No. 8 ISSN 0148-0537
May 1980 USPS 437-370

FUSION is published monthly by the Fusion Energy Foundation, Suite 2404, 888 Seventh Ave., New York, N.Y. 10019, Tel. (212) 265-3749. Dedicated to providing accurate and comprehensive information on advanced energy technologies and policies, FUSION is committed to restoring American scientific and technological leadership. FUSION coverage of the frontiers of science focuses on the self-developing qualities of the physical universe in such areas as plasma physics—the basis for fusion power—as well as biology and microphysics, and includes groundbreaking studies of the historical development of science and technology.

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.

Subscriptions by mail are $20 for 12 issues or $38 for 24 issues in the USA; $25 for 12 issues in Canada. Airmail subscriptions to other countries are $40 for 12 issues.

Address all correspondence to FUSION, Fusion Energy Foundation, Suite 2404, 888 Seventh Ave., New York, N.Y. 10019.

Second class postage is paid at New York, N.Y. and at additional mailing offices.

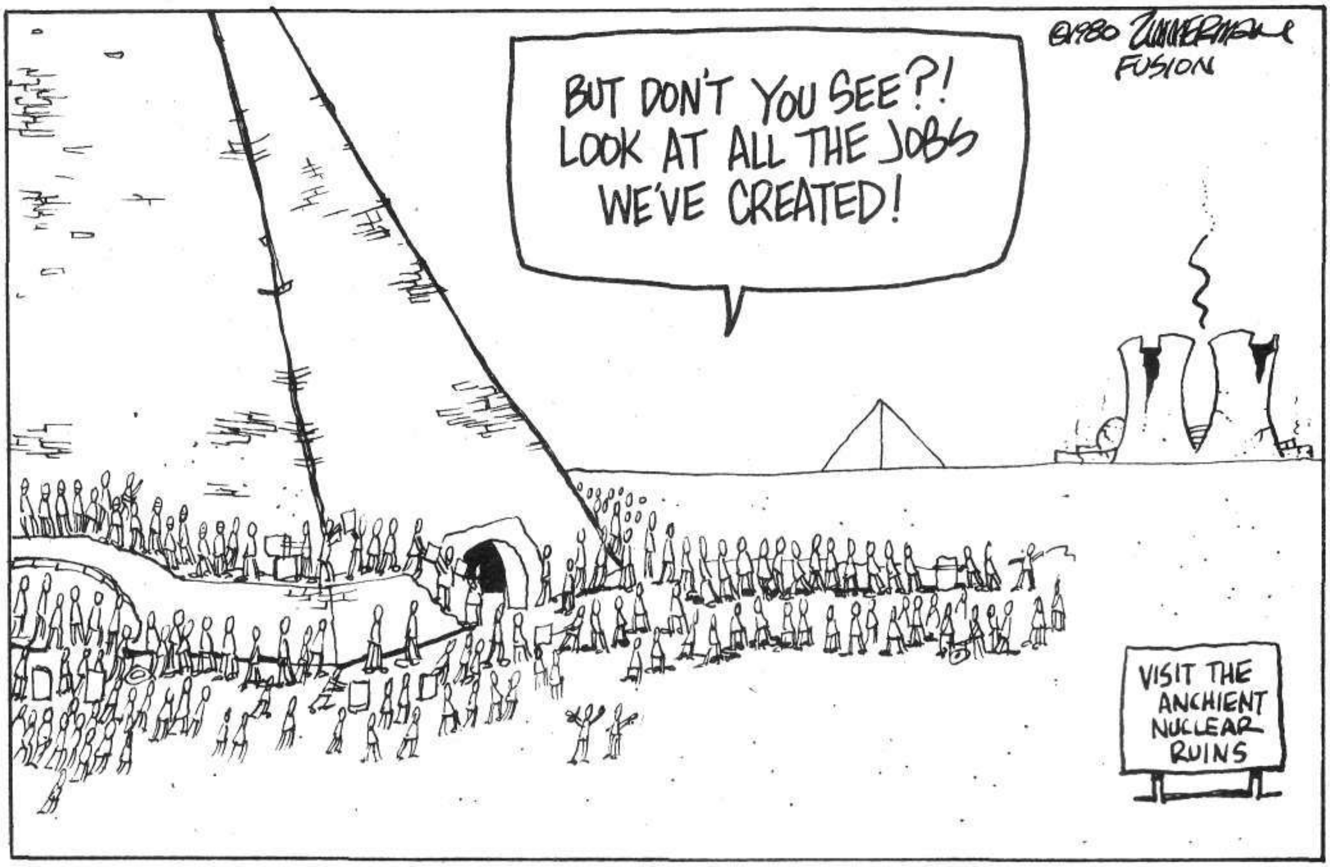
FUSION's advertising representative in Europe is Karlheinz Holz, Pf. 3329, 62 Wiesbaden, West Germany, Tel. (06121) 440277.

Features

News

Cover photograph of India taken from the U.S. NASA Gemini XI Spacecraft by the crew of Astronauts Charles Conrad and Richard Gordon, from 540 nautical miles above the earth's surface in Sept. 1966. Photo courtesy of United Nations.

Departments



Development or Dark Ages?

In an increasingly dangerous and chaotic world situation, this month's cover story on the industrial development of India demonstrates two things vital to national survival. First, that we have barely scratched the potential for world economic development, particularly in developing nations like India. Even using only existing technologies and available capital, in two generations India could produce as much industrial and agricultural output as the entire world does today!

The second crucial point demonstrated by this issue's comparison of economic models, is that *all* of the most influential economic and energy projection models in official use here and by international bodies like the United Nations are nothing but simple-minded rationalizations for harsh austerity policies. Remember that old Parson Malthus himself predicted that the work of Franklin, Washington, and Hamilton would come to naught and that the world could not possibly support any population increase or economic growth after the year 1850.

The larger issue is this: We can and must industrialize the Third World, beginning with its most advanced countries such as India and Mexico, or there is practically no chance of avoiding global economic breakdown and thermonuclear war. Despite this overriding reality, which has been expressed on numerous recent occasions by every leading world statesman, the present U.S. administration is hell bent on the opposite course.

This wrong-headed policy is not simply a question of stupidity or greed. Investment in Indian development will be enormously profitable for all parties concerned and will restore a sense of moral purpose to the United States, as well.

For these reasons, the intention to prevent such development at all costs has a primarily *political* motivation. Not to develop India is to maintain the power of supranational institutions like the International Monetary Fund and the World Bank—even though they admit that such control is over increasing economic disintegration. These institutions are the instrumentalities of an international Malthusian elite, or oligarchy, that has its headquarters in London and New York in the form of policy-making groupings like the Royal Institute of International Affairs and the New York Council on Foreign Relations.

The Question of Conspiracy

Some individuals may be silly enough to protest: "But that's a 'conspiracy theory'!" No, it's not. The so-called conspiracy is actually very public. The IMF and the World Bank make no bones about subjecting everybody—including the once-proud U.S. economy—to their Dark Ages "conditionalities." The Council on Foreign Relations has blatantly stated its intention to destroy the American System of political economy in its multivolume *1980s Project* series written during the mid-1970s. And does anyone still believe that Federal Reserve Chairman Paul Volcker is really trying to cure inflation with his interest rate hikes, when the stated intention—and obvious effect—of his policy is to cut down the industrial base of the economy?

There are no legitimate reasons for shutting down nuclear power and forcing up oil prices. There is no excuse for holding back the commercial development of fusion energy. What we are witnessing is the imposition of the Schachtian economics of looting industry and population and substituting *muscle power* for technology, just as it was imposed on Germany in the mid-1930s by Hitler's finance minister Hjalmar Schacht. Those of us committed to a sane policy of war avoidance, rebuilding the economy, and strengthening national security by accelerating technological progress recognize that we are in a state of civil war with our Malthusian adversaries, now that they have moved into an openly Schachtian phase.

Moreover, since the American republic and its Constitution are most explicitly premised on the principle of progress, these proponents of a new zero-growth Dark Ages (including the fiscal conservative sort like Milton Friedman) are not only thoroughly evil; but also treasonous in a strict juridical sense.

The Positive Solution

The reality of the present situation is that the future world will be based either on the implementation of the magnificent Indian development program outlined here, or it will likely not exist at all. The positive solution demands a new gold-backed monetary system and a massive investment fund within which the United States and its banking system is a sovereign partner. That will make cheap, long-term credit available to get industry and export markets going again. Such a system is moving ahead rapidly in the form of the European Monetary System, spearheaded by France and its initiatives in Europe and the Mideast.

We must also have a new tax system that favors R&D and productive investment. We need advanced nuclear research under NASA to create breakthroughs and bring them rapidly on line. We need a crash fusion program to provide the resources for a developing world in the 21st century.

Most of all, we need a broad leadership group in this country—persons from industry, science and technology, labor, and civic groups—that understands these necessities and places the nation's interest ahead of narrow personal, company, local, or party concerns. If *you* are such a person, now is the time to let us know.

The Lightning Rod

My dear friends,

I stepped over to visit an old acquaintance the other day, and found him in a highly agitated state. Whirling about his office waving a coffee cup and brandishing a newspaper in my face, he loudly demanded to know, "Would you like your son to grow up to be like Henry Kissinger?" So beside himself was he that he repeated the words "Henry Kissinger" three times, with the pitch of his voice rising an octave on each occasion, until it culminated in a final strangled shriek:

"Kissssingahhhh???"

I responded to his question by asking him if he thought I had taken leave of my senses, and implored him to be seated, compose his feelings, and enlighten me further on the thought that had produced this disturbance.

He collapsed into a chair, tossing his newspaper in my direction, and muttered weakly, "Here."

After a few moments perusal of one of the more rabid scandal sheets of this age, I discovered the article which I imagined had set my friend off. It was therein reported that one William Shockley, along with several additional unnamed individuals—all, by the way, winners of the Nobel Prize—had undertaken, by artificial means, the impregnation of several females selected for their high scores on what are popularly termed "IQ tests."

"I believe I understand," said I. "You are afraid this Nobel stud service will employ Dr. Kissinger?"

"Umm," he mumbled in assent. "My god, the world has barely survived to this point with one of him. What if there were more little Kissingers running around?"

I endeavored to calm his fears by pointing out that the racist theory on

Continued on page 6

Continued from page 5

which such experiments in "good breeding" were based had no foundation in science and, therefore, were unlikely to produce another individual similar to the egregious Dr. K.

"Kissingers are made, not born," I asserted. "This little fellow's prospective mother must have been awfully desperate for a child and has made a most unnatural selection, but she may be a more intelligent woman than it appears. Provided she gives him a decent upbringing far away from Georgetown and the Harvard School of International Affairs, he has a chance to do some good in this world."

"Are you sure, Ben?" he inquired hopefully.

"As sure as I am of the reverse—that good men sometimes suffer remarkable lapses in their progeny," I answered. "I can speak with some experience on this, for my own son, though ordinary red American blood ran in his veins, conceived a delusion that it was as blue as any foxhunting English aristocrat's, and took the side of Britain against the colonies and his father."

"But with all this gene-splicing and dicing . . . " he said fretfully.

"I don't think there's anything to worry about," I replied. "In any case, isn't the cat already among the pigeons? You know Dr. Kissinger is twice married, and has already produced offspring by more conventional means."

"No!" he shouted, jumping up to resume his former flailing. "He's got to be stopped."

And before I could restrain him, he was dashing out the door, leaving behind only a few barely coherent phrases, of which "involuntary sterilization" was the most audible.

On my way home that evening, I must admit that I had more than one chuckle when I reviewed the topic of the afternoon's conversation. What other Nobel individuals were involved in this affair? Would Milton Friedman raise interest at the sperm bank? Since one prize was awarded jointly to Begin and Sadat, was a double impregnation required? Would the Nobel experiment be solemnly recorded in *Foreign Affairs* as a new example of Kissinger's theory of "linkage"?

No sooner had I stepped inside my door, than I received a telephone call from my friend, who apologized for his abrupt departure.

"I've thought it over," he said. "Maybe I've let this thing get out of proportion. After all, Adolf Hitler was a great believer in this master race stuff, and look what it did for him."

"No," I said, suddenly sobering. "You are right. Look what it did to the rest of us."

Yr. obt. svt.

Benj. Franklin

Calendar

May

5-11
Global Technology 2000: Int'l Annual Meeting and Technical Display
American Inst. of Aeronautics and Astronautics
Baltimore

19-23
4th Int'l Conference on Pressure Vessel Technology
Institution of Mechanical Engineers, American Society of Mechanical Engineers
London

19-22
Int'l Conference on Plasma Physics
Nuclear and Plasma Sciences Society, IEEE
Madison, Wisconsin

June

8-13
ANS Annual Meeting
American Nuclear Society
Las Vegas, Nevada

9-12
1st Int'l Gas Research Conference
U.S. Dept. of Energy, American Gas Assoc., Int'l Gas Union, Gas Research Institute
Chicago

Letters

Newton, the Zeta, and British Plagiarism

To the Editor:

I can turn a blind eye to the attacks on the British and British science in your magazine because they do not seriously reduce the quality of the articles. However, I must object to Charles B. Stevens's choice of William Gilbert as "the leading English scientist of the 17th century" in your Jan. 1980 issue ["The Zeta Moves into First Place in Fusion"]. While Gilbert was indeed the foremost physicist of his day and the first to study terrestrial magnetism, in fact, he died just three years after the 17th century started. The obvious choice for the title is Sir Isaac Newton (1642-1727), mathematician, physicist, and astronomer, author of *Principia Mathematica* and *Opticks*, noted for his three laws of motion, the corpuscular theory of light, the law of gravitation, and the development of calculus.

Newton's description of the system of universal gravitation was (and is) a marvelous description of the world subsumed under a single set of laws; his approach represents the start of modern scientific method. I feel sure that Newton's example of scientific rigor in thinking about physics could help us today in the current emotional debate over nuclear energy.

Incidentally, his work was much derided in his time by the popular press, who hid their ignorance of science in a smokescreen of cartoons and abuse. The history of science holds lessons which still apply today.

Peter Weeks
Wimbledon, England

The Author Replies

Thank you for pointing out the technically wrong characterization of William Gilbert as "the leading English scientist of the 17th century." However, I am afraid that you have jumped from the frying pan into the fire by attempting to relocate my discussion of the propensity of present-day British science for fraud and plagiarism by bringing up the case of Sir Isaac Newton. Newton, as documented in an article on "The Royal Society" by Carol White (*Fusion*, Dec.-Jan. 1977), is the exemplar of British scientific fraud and plagiarism. It is one of the more astounding frauds of history that the Royal Society and Isaac Newton are proclaimed to be the founders of modern science while Elizabethans such as Gilbert and their continental humanist allies are brushed aside as mere magicians. In fact, the case of Isaac Newton versus William Gilbert is of particular relevance to the theoretical physics questions I raised in the article on the Zeta.

I do not have the space here to repeat the published evidence documenting Newton's plagiarism in the case of the calculus and optics, but let's look briefly at the question of "the law of gravitation" and the so-called Newtonian mechanics. Gilbert's experiments on the interaction of plasmas with magnets and magnetic field phenomena, the results of which were published in *De Magnete*, led Johannes Kepler to develop a field conception that provided the framework for his investigations of the orbits of the planets. From the empirical data of the orbits, Kepler derived his famous laws. These laws,

Continued on page 8

May
5-6
The Industrialization of India
Frankfurt on Main, West Germany
Sponsored by the Fusion Energy Foundation and the *Executive Intelligence Review*

For information and registration contact:

Ms. Dannenberg-Mletzko
India Conference
Postfach 1966
6200 Wiesbaden
West Germany
(06121) 377081 83

Letters

Continued from page 7

combined with the conceptions of force and energy developed by G.W. Leibniz (the actual creator of the modern calculus) led to so-called Newtonian mechanics, as Max Planck used to demonstrate in his graduate university classes.

The nature of Newton's theories is pointedly demonstrated in the absurd "action-at-a-distance" formulation in which Newton attempts to cloak his plagiarism. What actually marks the dawn of modern mathematical physics, however, is the contrary field-theoretic conception of Kepler.

The historical irony here is that the primacy of the Gilbert-Kepler-Leibniz concept has been experimentally demonstrated on the Zeta fusion machine by the staff of the University of Padua, the same university that Gilbert attended. And once again, the Newtonian tradition of attempted suppression of such a conception was maintained by the chief institutions of Britain. This same pattern was demonstrated in the case of the magnetic liner and magnetically insulated inertial fusion targets, both of which are closely related theoretically to the Zeta approach and both of which have been suppressed as a direct result of the efforts of the British scientific establishment.

Charles B. Stevens

'Appropriate Technology' And the Steam Engine

We are pleased to print the long-awaited reply of a spokeman for the British Newcomen Society to Philip Valenti's article "Leibniz, Papin, and the Steam Engine: A Case Study of British Sabotage" (Fusion, *Dec. 1979), along with a comment by author Valenti. Also, we thought readers would be interested to read the response to the article of one of Papin's American descendants.*

To the Editor:

I read "Leibniz, Papin, and the Steam Engine: A Case Study of British Sabotage" with interest. Of course, I agree that Huygens and Papin made significant contributions to the development of the steam engine. So, too, did a number of other Frenchmen and Germans; indeed, the line stretches back to Galileo and his disciples but not to the earlier uninformed experimenters like Worcester, Ramsay, de Caus, or even Branca. I am not so sure about the value of Leibniz's contribution. Alternatively, should you not give Francis Bacon some credit? After all, his moving appeal that science be applied for the benefit of all mankind was most influential. How he would have approved of men like Huygens and Papin!

Savery was, as you imply, a braggart —*The Miner's Friend* makes any politician you care to think of seem a model of modesty and diffidence—and, in addition, I am pretty sure that the engine could never have worked, at least in the way and on the scale he describes....

On the other hand, I think you have misjudged Newcomen who, by the way, certainly existed; there is ample documentary evidence for the fact. Our experiences in building and operating a Newcomen engine here have left us with a most healthy respect for his genius....

In fact the Newcomen engine worked reliably and economically so that it was widely used. It was safe and its construction was within the technical competence of an age without an engineering industry. It is these facts that lead me to doubt if your very favorable estimate of Papin's engine is justified. All too often ideas that look splendid on paper and that may even work when translated into prototypes fail when put to the hard test of practical use....

In the early 18th century only the mining industry offered substantial scope for the application of steam power. All other industries operated with small units that did not lend themselves to steam power, or that could be driven efficiently and far more cheaply by waterwheels or animal muscles. In other words the successful application of steam power in areas other than mining almost invariably necessitated a whole range of additional inventions to make it effective.

Nor was this all. The progressive improvement of the steam engine and its wider use depended also on the radical improvements made in the iron and steel industries in the 18th and 19th centuries and on the emergence of the machine tool industry in the early 19th century. And even so the expense, the difficulties, and the dangers of applying steam engines to seagoing ships were so great that it was not until the 1850s that a satisfactory solution was found in the expansively operated compound engine using a surface condenser. Only then did steam ships begin to drive sailing ships from the seas and oceans of the world.

Finally, on one point I am quite sure you are wrong. From my knowledge of the Newcomen Society, its members and its publications, I am entirely confident that these amiable scholars, in the U.S. as in the U.K., are now and always have been solely concerned with the history of engineering and have never sought to influence economic, political, or social policies. Nor do I believe they have allowed nationalistic considerations of any sort to cloud their judgments....

Donald Cardwell
Institute of Science and Technology
University of Manchester, England

Valenti Replies

Dr. Cardwell's letter may appear to be merely a rather polite discussion of certain academic fine points of past history. However, a close examination of the nature of Dr. Cardwell's argument will demonstrate why the accepted British-authored version of the development of technology cannot be allowed to stand.

Cardwell argues that the Newcomen mine-pump was the only "appropriate" form of steam power for 18th century Europe and that Papin's designs and models for paddle-wheel steam boats and steam-driven cars and mills were somehow too advanced.

Let us first briefly consider the merit of his historical analysis.

Dr. Cardwell concedes that Papin and Huygens (but *not* Leibniz) certainly had very advanced ideas and bold

Continued on page 69

News Briefs


Information Service of India

Indira Gandhi: Committed to the use of peaceful nuclear energy.

SWEDEN SAYS YES TO NUCLEAR POWER

The long-term environmentalist project to make Sweden a showcase of an industrial nation that turns antinuclear came to an end March 23 when Swedish voters cast a 58 percent "yes" ballot in favor of the continued operation of the nation's six nuclear power plants and the completion of an additional six plants now under construction. The vote, publicized internationally, was a rebuff to Swedish Prime Minister Thorbjörn Fälldin, who had vigorously backed the ballot line specifying a phase-out of Sweden's nuclear capacity within 10 years.

The Swedish Association for Nuclear Energy and Development, known by its acronym FKU, sees the referendum as a mandate for the expansion of Sweden's nuclear energy industry and the basis for a new trade boom involving the rest of Europe and the developing sector, according to FKU spokesman Clifford Gaddy. "The FKU was the decisive force in shaping the pronuclear vote in the referendum," Gaddy said. "There was no ballot line calling for an expanded national nuclear energy effort and we made the need for such an effort the issue of the referendum campaign."

In the past three months, Gaddy said, the FKU's roster of dues-paying members rose from 600 to more than 5,000, and its magazine *Energi* upped its circulation from 6,000 to 60,000.

INDIA VOWS NUCLEAR GROWTH—WITH OR WITHOUT U.S. HELP

Indian Prime Minister Indira Gandhi told the Indian parliament March 13 that India would act in the "national interest" and would not accept any dictates on its nuclear program. "We remain committed to the use of atomic energy for peaceful purposes," she said, including the option that the government would "not hesitate from carrying out nuclear explosions .... We must have our eyes and ears open to developments in the nuclear field and be in touch with the latest technology. We should not be caught napping," Gandhi said.

Gandhi's remarks were in answer to Carter administration threats to cut off supplies of enriched uranium to a U.S.-built nuclear power reactor unless India grants what amounts to U.S. veto rights over its nuclear program. According to Indian diplomatic sources, the State Department had asked the Gandhi government for "assurances" that spent fuel from the reactor will not be used for making nuclear devices, for an agreement not to carry out peaceful nuclear explosions, and for full-scale inspection and surveillance of the entire nuclear program. Gandhi said that India's program for peaceful nuclear explosions played an essential role in large-scale construction projects. Those who oppose this, she implied, are actually opposed to the nation's development, not to nuclear energy per se.

This point was made more explicit by the chairman of India's Atomic Energy Commission, Dr. Homi Sethna: "Public acceptance of nuclear power is not an issue in India because the no-growth philosophy and the curbing of consumption which is being advocated by industrialized Western countries has no relevance to our socio-economic conditions. Our need is not curbing consumption, but increasing production for survival." For this purpose, India must build a "string of nuclear power plants."

IRAQI NUCLEAR PROGRAM UNDER ATTACK

Italy's recently announced agreement to sell Iraq some nuclear technology, including a "hot cell," has come under U.S. criticism for allegedly giving Iraq nuclear weapons capability. A front-page article on the technology deal March 18 in the *New York Times* was headlined "Iraq Said to Get A-Bomb Ability with Italy's Aid" and reported that the Carter administration was concerned.

The hot cell is a concrete box with mechanical levers that allow manipulation from outside of objects inside the box. *New York Times* reporter Richard Burt claimed in his March 18 article that "Iraqi technicians, working with the complicated remote-control equipment in a hot cell, would also learn how to separate plutonium from spent nuclear fuel." Contrary to the Burt story, separation of plutonium from spent nuclear fission fuel is a chemical process that requires an entire fuel-separation plant.

Italian officials said that the agreement was negotiated two years ago after close consultations with the Carter administration, which raised no objections at the time.

CLUB OF ROME MEETS TO PROMOTE U.S. LIMITS TO GROWTH

The American Association for the Club of Rome, a U.S. chapter of the international zero-growth organization, met March 14-16 in Bethesda, Md. to review American acceptance of the club's limits-to-growth thesis. According to a club spokesman, the association is not so much concerned with American government officials and other influentials, but with the American population as a whole, which does not accept the Club of Rome's views. For this reason, the spokesman said, one panel of the conference was devoted to the question of "how to translate the [death with dignity] categories of Elizabeth Kubler-Ross to the plane of society as a whole." Kubler-Ross, who claims to have communicated with the dead, is a leading spokesman for the "death with dignity" and "right to die" movement.

Kubler-Ross: Translating the 'right to die' movement to the level of society as a whole.

BREEDER FACILITY ACHIEVES CRITICALITY

The Fast Flux Test Facility (FFTF) built by Westinghouse Hanford in Washington achieved criticality Feb. 9, an important step leading to start-up of the facility. (Criticality is the point at which the reaction becomes self-sustaining.)

The FFTF is a 400-megawatt-thermal reactor facility designed to test advanced nuclear reactor fuels and materials for fast breeder development. It is the first U.S. industrial-size breeder reactor and will provide important physics information.

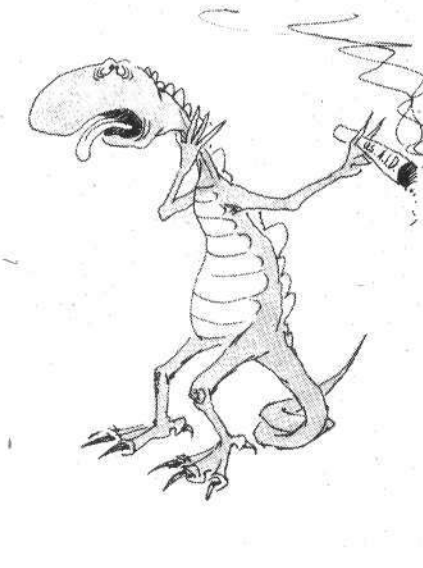
DOE ADDS ANTINUCLEAR SPOKESMEN TO ADVISORY BOARD

The Department of Energy recently announced that it has added nine new members to its Energy Research Advisory Board in the past year—and three of them are antinuclear spokesmen. The new members include environmentalist Grant Thompson from the Conservation Foundation in Washington, D.C.; Joseph Nye, now a professor at Harvard University and formerly the administration's nonproliferation advisor; and solar power advocate Amory Lovins.

U.S. AID WINS LOUSEWORT LAURELS

This month's lousewort laurels award goes to the U.S. Agency for International Development for its March 1980 publication *Agenda*. We reprint without comment the award-winning section from *Agenda*'s "Development Update":

"A two-cow plant would be large enough to make tobacco curing by cow dung gas profitable even for a poor farmer in Bangladesh. Tobacco is one of the most important cash crops in Bangladesh. Until recently the most common form of curing was by the sun and air, which produces inferior cigarettes. According to a report from the Bangladesh Agricultural Research Institute in Dacca, the scarcity and high cost of coal and firewood discouraged tobacco farmers from improving their drying methods. But producing methane gas from cow dung is simple and inexpensive, and the dung is readily available."



MAINE REFERENDUM PROPOSES TO SHUT DOWN NUCLEAR PLANT

The state of Maine could suddenly be without 35 percent of its current electrical energy if environmentalists succeed in a propaganda campaign for a referendum to shut down the Yankee Nuclear Power Station there. The referendum will probably be held in November.

The referendum was put on the ballot after 1,500 environmentalists from the East Coast gathered 55,000 signatures during several months of petitioning. A "yes" vote would mean that the problem-free plant, which has operated since 1972, would have to close. Were Maine to use oil to replace the more than one-third of its present electrical energy the Yankee now provides, the state would be virtually bankrupted.

This is the first time an environmentalist referendum has proposed the

Continued on page 12

News Briefs

Continued from page 11

shutdown of an operating plant. Previous referendums on nuclear energy in Montana and Wisconsin specified only temporary moratoria on new plant constructions.

The volunteers who gathered signatures for the referendum were predominantly from Ralph Nader's campus-based group, Citizens for a Safe Energy Alternative. They and other antinuclear groups are planning a full-scale campaign to ensure the referendum's success. Readers interested in helping the pronuclear option in Maine should contact the Fusion Energy Foundation.

TMI ANNIVERSARY: A MEDIA EVENT STAGED BY ENVIRONMENTALISTS

After two weeks of environmentalist media propaganda, the antinuclear celebration of the first anniversary of the Three Mile Island incident March 28 in Harrisburg, Pa. drew only 5,000 people, instead of the 10,000 to 20,000 that were expected.

The demonstration was preceded by an environmentalist build-up in the media staged to convey the impression that there was a local mass uprising brewing against nuclear power and that there would be riots if the utility released krypton gas in the cleanup of TMI. The media events included a crowd of environmentalists who packed a Nuclear Regulatory Commission hearing March 18 yelling "Murderer" and "No release" at NRC officials who were hearing testimony on the planned release of the inert krypton gas.

When national reporters gathered on the scene for the March 28 event, however, stories began to leak out that most of the residents in the area are still in favor of nuclear power and that, in fact, the population in the area has risen since the incident, not declined as predicted.

FEF SUBMITS CONGRESSIONAL STATEMENT ON FUSION BILL

The Fusion Energy Foundation submitted a statement for the record April 1 on the fiscal year 1981 authorization for magnetic fusion energy. The budget statement was invited by Congressman Mike McCormack (D-Wash), chairman of the subcommittee on Energy Research and Production of the House Science and Technology committee.

The FEF statement cites the analysis done by the Riemannian-LaRouche economic model demonstrating that only a full-scale nuclear program now can create the conditions for fusion in the 1990s. The statement presents figures showing that "soft path" solar and synfuels energy strategies for the 1980s will not allow the overall economy to grow and develop the advanced technology and manpower skills for fusion power.

OHIO ENGINEERS GROUP VOWS POLITICAL FIGHT ON NUCLEAR ISSUE

"It's about time that we no longer allow the environmentalists, who have infiltrated or been appointed to our regulatory agencies, to shut down our energy supplies in Ohio and the United States through their unrealistic and intolerable regulations," said Rex Sprague, assistant director of Ohio's Environmental Protection Agency. Sprague presented the keynote address (written by Ohio Governor Rhodes who could not attend) at the day-long Professional Engineers Public Affairs Forum in Columbus March 26. "We need nuclear power and we need coal power and we need expansion of both fast or we're in real trouble," he said.

Jon Gilbertson, Fusion Energy Foundation director of nuclear engineering, who addressed the group on nuclear power in the morning session and served as a panelist on the afternoon discussion of energy, told the engineers that their conference represented a "breakthrough." "I've been to a lot of engineering society events where nothing ever happened except a lot of talk, mostly technical. This is the first time that I've seen a group of more than 100 engineers ready and willing to do battle politically to reverse the ongoing economic collapse here in the United States," Gilbertson said.

Viewpoint

An Interview with Rep. Mike McCormack

Fusion: An Energy Source For All Mankind

Question: The Fusion Energy Research, Development, and Demonstration Act that you have sponsored has picked up a great deal of support in the House. What is your view of its possibility for passage?

I think we will pass the bill or that we will include it in our authorization bill [for the fiscal year 1981 budget], one or the other.

Question: Is there an optimistic sense at this point about getting a sponsor in the Senate as well?

Yes, I'm sure there is.

Question: Has the overall budget situation in Washington affected your work on the bill?

The budget squeeze is hurting the program as it seems it's hurting everything else, and we'll not be able to fund it at the level we'd like. But I think we will fund it above the administration's request, and try to keep all critical programs going at an appropriate speed given the budget restraints.

Question: How willing will industry be to get involved in something like a large-scale fusion effort when they see what has happened to their investment into advanced nuclear technology?

I believe that industry is going to need the assurance from the administration and from the Congress that the programs will be carried out and managed and continued responsibly before we'll have very much industrial money in these programs. This is going to take some time and some real, visible commitment and a degree of public support that will guarantee that that

Suzanne Klebe

Mike McCormack

commitment would continue from one administration to the next.

Question: And that was much of the purpose of your fusion bill to authorize a program over a significant length of time—to make that national commitment. . . .

Yes, that's right. Obviously any 20-year program is going to run through several administrations and we need to make it a matter of national commitment that everyone understands. We must, above everything else, abandon this idea that we can change our long-range mainline energy programs with each new administration.

Question: What would your feeling be on the economic payback to the economy for investment in both the advanced nuclear and fusion programs?

One can look at the long-range implication—having a new and extremely important, overwhelmingly important, energy production technology. That's the major payoff. The second implication is that in the intermediate term, starting almost at once, you have additional benefits in superior technology as far as nuclear fission is concerned. Third, these programs provide money pumped into the American economy and provide jobs for researchers, scientists and engineers, and vendors and fabricators. In that sense, even if one doesn't assign an intermediate or long-range value to these programs, they still are just as valuable to society in the immediate time-frame, or in the next few months, as a CETA program or any other program which results in hiring people.

Question: How do you see what you're doing intersecting the national discussion that is taking place on energy policy?

I hope it's providing some influence. I have taken it upon myself to provide some information to each of the presidential candidates, or to most of the presidential candidates, on fusion and my fusion legislation. I intend to continue to provide information on major energy-related subjects that may become political issues, so that candidates will have the facts and not get themselves in a position that they would make unfortunate statements based on lack of information.

Question: It would seem that you've put forward a policy perspective that is critical in terms of revitalizing industry. Using the phrase, "an Apollo-style program for fusion" does go back to a time when there was a tremendous amount of government-vectored investment in high technology areas. . . .

Between then and now, the difference is not so much in dollars as in commitment.

Question: There has been an extensive attempt to make the United States "self-sufficient" in liquid fuels. It is interesting to juxtapose that to the trip that France's President Giscard d'Estaing just made to a number of Mideast countries. What he is trying to do, and is doing rather successfully, is to set up a number of bilateral agreements with the oil-producing countries to ensure that France and other Western European countries have an assured, reasonably priced supply of oil. I think he has been able to do that because of the commitment to export technology to these countries.

I think this is quite valuable. I have toyed with the idea of trying to sell energy credits, to buy oil with energy coupons cashable in the future, in the 21st century. We would pay part of the price of the oil—instead of paying $30 per barrel we'd pay $15 and give the other in energy credits in terms of 21st century provision of fission or fusion production machines in those countries which over a reasonable length of time could produce the same amount of energy. I think if we had an appropriate degree of imagination in this administration we would look seriously at that. It would save us a great deal of money now and provide them with energy then.

Question: I think this is exactly what is on the agenda, certainly in terms of the French. One thing that impressed me in your bill was your reference to the export of fusion technology when it is available. I think this would provide the basis for some kind of reasonable trade agreements.

It's critically important. We should think of fusion as being for all mankind right from the start. It can be the most important deterrent to war in all of history.

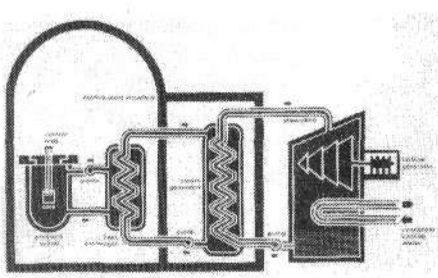
Congressman Mike McCormack is a Democrat from Washington state. Known as one of the most knowledgeable and vigorous proponents of high-technology energy production in Congress, he chairs the Energy Research and Production Subcommittee of the House Science and Technology Committee. Before his election in 1970, McCormack worked for 20 years as a research scientist in the Hanford nuclear facility in his home state. This "Viewpoint" interview was conducted by Fusion *news reporter Marsha Freeman.*

Fighting to Save U.S. Advanced Nuclear Technology

In the past decade the U.S. utility industry and electrical equipment manufacturing suppliers have invested hundreds of millions of dollars in the next-generation nuclear technologies—the production technologies that will provide the energy, engineers, scientists, and industrial infrastructure to lay the basis for the fusion era in the next century.

In one clean sweep, the fiscal year 1981 DOE budget submitted by President Carter would eliminate all of the nuclear programs this nation needs for the future, surrendering the nuclear technology lead to other nations in the advanced sector and leaving U.S. high-technology industry holding the bag. So far, Congress has responded for the most part, with the "lifeboat" mentality—selecting for survival only those of the advanced technologies the nation allegedly can least afford to lose.

Liquid Metal Breeders



In 1971, President Nixon made a speech before Congress calling for commercial demonstration of breeder technology by 1980. Without interference by the Carter administration, this would have been accomplished. In 1972, Congress authorized the Clinch River Breeder Reactor Project as a joint government-industry effort. Seven hundred and fifty electric utilities pledged $257 million for the single largest project partly funded by utilities.

This technology, which would produce a 60-fold increase in the efficiency of uranium use over the present system of once-through fueling in light water reactors, so far has received more than $105 million from these utilities. In 1977, Carter stopped licensing procedures for the Clinch River project, and has stricken it from the DOE authorization request each budget year since then.

The only thing that has kept the project alive is a Congress-industry alliance that has restored minimal funding each year. Once again during hearings of the subcommittee on Energy Research and Production of the House Science and Technology Committee March 4, industry spokesmen urged the Congress to restore funding levels for Clinch River development to previous levels.

The fiscal year 1980 authorization for all breeder programs was $614 million; the fiscal year 1981 request was $299 million. Specifically, breeder studies were cut in half; breeder technology programs were reduced from $149 to $83.1 million; and nothing was included for Clinch River, which received $172.4 million by congressional resolution in the last fiscal year.

What the elimination of this program would mean for the future of nuclear development was made clear in the March 4 testimony of Dr. Clark Gibbs, the director of nuclear activities for Middle South Utilities, Inc., who spoke as a representative of the Edison Electric Institute and the American Nuclear Energy Council.

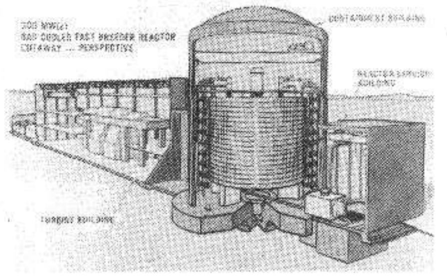
"The proposed budgetary actions appear to make a mockery of the administration's own recent position on the critical nature of nuclear power . . . The most recent proposal to emasculate the LMFBR [liquid metal fast breeder reactor] base program can only be interpreted as a phase-out of the long-term viability of nuclear power," Gibbs said.

Gibbs reminded the subcommittee that every other advanced nation has made a commitment to commercial development of the breeder and that the recent International Nuclear Fuel Cycle Evaluation conference characterized the LMFBR as the best option to alleviate doubts about resource availability and the security of domestic energy supplies.

Sol Burstein, executive vice president of Wisconsin Electric Power Company, also testified on the fiscal year 1981 nuclear budget. One reason that there is a moratorium on new nuclear plant construction and licensing in his state, Burstein said, is that the Public Service Commission is concerned about the "uncertainty of uranium supplies"—an uncertainty that a breeder program would eliminate.

The sharpest picture of what will happen if the breeder is eliminated was given by Gibbs. France's electric utility just ordered two new commercial liquid metal breeder reactors for the mid-1980s and the United States will have to import this advanced technology from France if Congress does not bring the next-step Clinch River project to completion, he said. "We will be a second rate technical power."

Gas Cooled Breeder Reactors



The gas-cooled helium breeder and the high-temperature gas-cooled reactor programs have been eliminated from the DOE budget completely, for reasons that belong in "Alice in Wonderland." The DOE argued in official testimony before the subcommittee in February that these next-generation technologies would not be needed because electricity demand and particularly nuclear plant demand, was now much less than projected a few years ago. This self-fulfilling prophecy, of course, is based not on need but on the DOE's analysis of public sentiment after the Three Mile Island incident (see Inside DOE, this issue).

During the past 15 years, a number of farsighted utilities and high-technology companies have put more than $92 million into the helium breeder program, and the government has spent about $79 million on the project. The value of the helium-cooled breeder is that it allows the operation of the reactor core in an energy range that can breed more fuel than the liquid metal cooled breeders. Furthermore, the coolant is noncorrosive, chemically inert, and does not become radioactive. As a result, the helium breeder is expected to provide easier operation and maintenance than the LMFBRs.

During the March 4 hearings, Ralph M. Davis, the chairman of the board of Helium Breeder Associates and chairman of Puget Power and Light Company in Washington, reviewed the history of the helium breeder project. A group of utilities first began to make financial contributions to GCFR (gas cooled fast reactor) R&D in 1965. In 1976, these utilities submitted a proposal in response to a request from the Energy Research and Development Administration (ERDA), the DOE's predecessor, which described a development program for the GCFR.

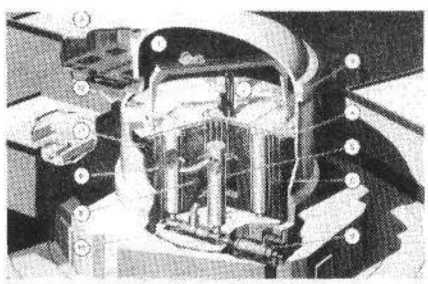
"With encouragement from ERDA, a nonprofit company, Helium Breeder Associates, was incorporated to provide program management to the joint effort. . . . In 1977, ERDA contracted with HBA to perform a commercialization study for the GCFR. . . . The research and development program . . . in support of the GCFR program was thoroughly reviewed and found to be adequate," Davis said.

After President Carter's antinuclear energy statement in April 1977, HBA sought—and received—additional assurances that ERDA would not change its policy on the GCFR. As late as 1979, Carter specifically endorsed the continuation of this breeder project with HBA as part of a "large and diversified technology program, the largest of any country in the world."

Davis concluded that he had never been told of any change in administration policy on the GCFR; the program simply did not appear in the DOE 1981 fiscal year budget.

Congressman Mike McCormack, Chairman of the House subcommittee, minced no words in his analysis of the situation: "HBA was encouraged by the DOE as a ploy to discredit this nation's commitment to the LMFBR," he stated. The administration said it was pursuing GCFR research because it was potentially superior technology. "I never accepted these arguments as sincere by the administration at that time. You have been used by the administration," McCormack told Davis.

The 'Workhorse' HTGR



High-Temperature Gas Cooled Reactor (HTGR) technology, which has already been demonstrated here and in West Germany, would open up new heat and energy relationships for industry and the utilities. For the first time, heat produced from the nuclear fission reactions would be hot enough to serve as industrial process heat as well as for electricity production.

For example, thermochemical processes for producing hydrogen, the fuel of the future, would be feasible with heat from the HTGR. Various direct reduction configurations for the iron and steel industry are also possible and nuplexes, industrial complexes based on one or more nuclear plants, could be built around pairs of HTGRs. The nuplexes would produce their own chemicals, fertilizer, metals, and food using the "waste" heat from these advanced nuclear reactors.

How this high-quality heat could be used for the steel industry was described at the hearings by Dr. Donald Blickwede, vice president and director of research for Bethlehem Steel.

Utilities have been interested in developing the HTGR for more than 20 years. Two years ago, 20 utilities formed the Gas Cooled Reactor Associates, which now includes 29 utilities that together generate about 25 percent of U.S. electric power.

All in all, government and industry

have spent $1 billion to bring this next-generation technology on line, and last year the DOE signed an implementing agreement with West Germany and Switzerland to define the intent and structure for international cooperation for the HTGR program.

The DOE proposed cutting *all* government funding for the HTGR in its fiscal year 1981 budget. The result of such a move was stated bluntly by Dr. Harold Agnew, president of the General Atomic Company in San Diego, which has invested substantial funds in HTGR development. If the government pulls out of the program, Agnew said, the HTGR will die. The utilities and industry groups alone cannot sustain the cost of either the HTGR or the helium breeder.

Congressman McCormack and ranking Republican subcommittee member John Wydler (N.Y.) quizzed the industry representatives who testified on the international reaction to the DOE's HTGR cuts. Agnew answered that no one, either here or abroad, could figure out why the administration has done this.

"I can't find a rational answer," Agnew said. "Even Gerard C. Smith [U.S. representative to the International Fuel Cycle Evaluation group] questioned the Office of Management and Budget as to why the action was taken. I can't believe that a nation built on technology would turn its back on such a promising future technology."

Perhaps the most telling exchange of the hearings came when the subcommittee commented on industry's request that $55 million be restored to the HTGR budget. The subcommittee warned the representatives that substantial funding for both the HTGR and the helium breeder may not be possible given the administration's budget-cutting austerity and asked the industry representatives to "choose" between them!

It is this approach to the problem that will ensure that the nation has no advanced nuclear technology—and therefore no advanced industry at all. The question remains: Will industry and Congress make the political fight necessary to save the nation's industrial future?

—Marsha Freeman

Special Report

Energy and Economics

1 Energy Intensity and Productivity

Monetary stability depends on continued technological innovation in manufacturing, contrary to the current mythology based on money supply manipulation and the substitution of manual labor for energy. This is the main conclusion of a recent study of U.S. inflation by the *Executive Intelligence Review*, using the Riemannian economic model developed in collaboration with the Fusion Energy Foundation.

The study spells out in quantitative terms how the efficient use of manpower depends on substituting energy for human muscle power and that new, more advanced technologies must continually supersede existing ones to prevent economic depression. When there is a shift away from energy-intensive production modes, from high rates of capital formation, and from a rising ratio of workers employed in tangible wealth-producing jobs, the result is stagnation or decline in the growth of labor productivity (output per manhour) and uncontrollable inflation.

The accompanying graph illustrates this point. The graph is a so-called phase-space diagram, measuring shifts in the energy intensiveness of labor (in millions of British thermal units of energy consumed in production per manhour of labor) against the output of goods per manhour of labor. The time evolution of the total manufacturing sector of the U.S. economy is represented by motion along the curve starting with 1954 at the left and ending in 1977, the last year for which the data are available.

During the earliest years, up to 1967, there was a rapidly rising output per manhour for relatively small increases in energy consumption per manhour. This was a period in which innovations in technology were rapidly being introduced and applied to production.

Stagnation

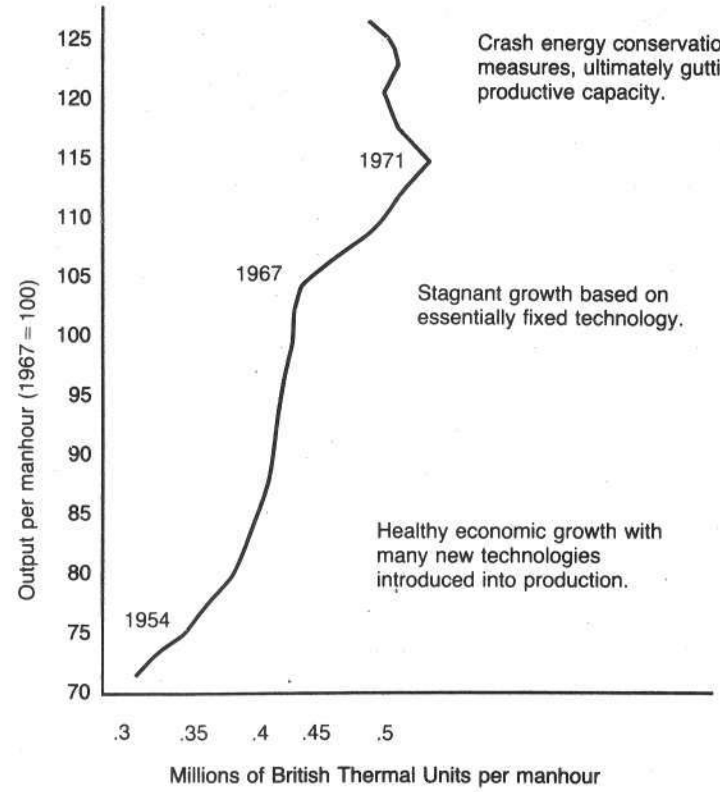
However, in about 1963, the innovative activity slowed rather abruptly, followed by a long period during which the achievements of the previous decade were disseminated throughout the manufacturing sector.

This stagnation can be seen in the sharp break from the accelerating period in about 1966, to a new regime; to use Riemannian terms, this is essentially a new manifold in the development of the economy governed by a new set of laws. Here, marginal increases in output per manhour are achieved by relatively large increases in the energy consumed. This trend is the result of failure to continue productive innovations in technology as capital equipment in the manufacturing process.

A third regime opens around the period of the 1973 oil embargo, when manufacturers implement energy conservation measures, such as turning off the lights, using less air conditioning, and marginal savings in energy use in production. It is still too early to tell how this new regime will terminate, but left to its own devices, the built-in instability of the situation indicates that a dramatic drop in output should occur.

On the other hand, if national economic policy were to focus on rebuilding the capital stock in productive manufactures and developing new capital-intensive technologies, the healthy regime depicted at the beginning of the graph could be regained, short-circuiting the current inflationary debacle.

—*Dr. John Schoonover*



FIXED TECHNOLOGY LEADS TO COLLAPSING PRODUCTION
The efficient use of manpower in production depends on the substitution of machinery and energy for human muscle power. However, new technologies must continually supersede existing ones or the economy rapidly becomes hostage to dissipative processes, as shown here.

2

Debunking the 'Decoupling' Thesis

In the last two years a new and purportedly "revolutionary" econometric theory has gained prominence, the theory of the decoupling of energy consumption and economic growth. This thesis, which first received widespread political recognition with the 1977 publication of a study by Marc Ross and R.H. Williams for Senator Edward Kennedy's Senate Subcommittee on Energy has since gotten a number of public airings, the latest in an article by Ross in the Feb. 1 issue of *Physics Today*.

The basic idea of decoupling—that economic growth is no longer dependent on increased per capita energy consumption—ranks as one of the most patently absurd conclusions ever drawn by an already incredible lot, the econometricians. The credibility

NSIPS/Detroit

The decouplers claim that the replacement of energy-intensive processes by labor-intensive ones—like the neighborhood job street cleaning program pictured here—is the basis for a new kind of economic growth.

of the decoupling thesis has grown, as Lewis Carroll noted, by its repetition; if you hear it three times, it must be true.

The crux of the decoupling argument is the fact that the U.S. economy has, for the last 7 to 10 years, been increasing its output per unit of energy consumed. The economy seems to be becoming more energy "efficient" as measured by this statistic. But as is well-documented by the decouplers themselves, this remarkable shift in the U.S. economy is *not* due to more advanced technologies used in American industry; it is not due to higher productivity of the U.S. workforce; nor is it due to new energy technologies that supply energy in more efficiently usable (more intense) forms.

Rather, it is the result of the replacement of energy-intensive economic activity by labor-intensive economic activity.

Labor-Intensive Shift

As Ross and Williams and others from the decoupling school are proud of pointing out, in practice this has meant that an increasing proportion of economic activity represents "services," entertainment, and transportation—highly labor-intensive sectors. This changing composition of the economy has been accelerated by rapidly rising oil prices that have tended to favor the replacement of energy-intensive processes by labor-intensive ones. Hudson and Jorgenson from Harvard University claim that their econonometric model shows that each doubling of oil prices results in a 5 percent increase in employment because of this substitution for energy by labor.

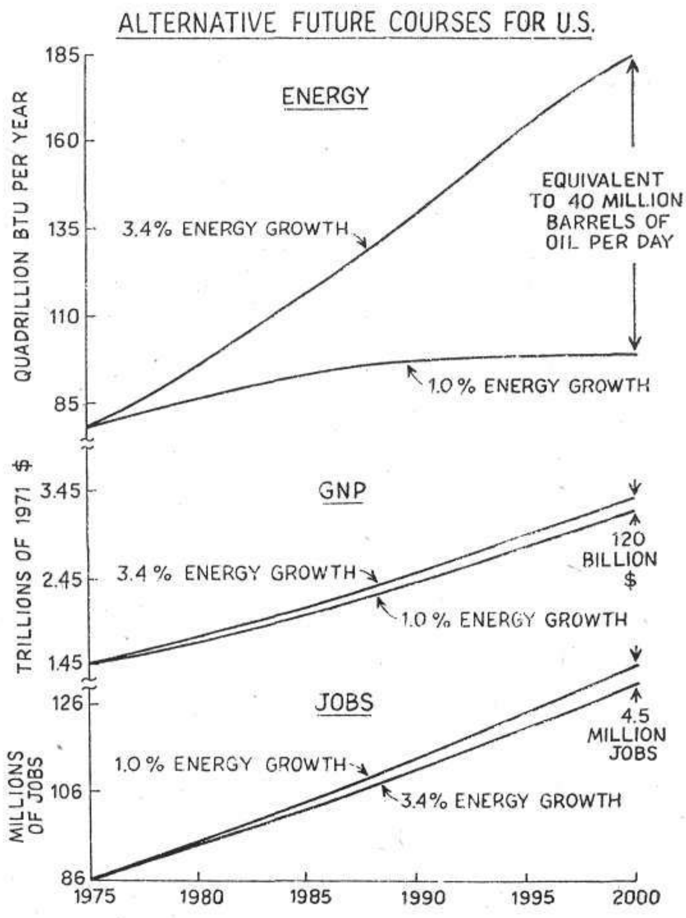
The facts of the case are uncontested. The questions that must be answered are of policy—what is causing this transition, is it desirable, and what does it portend for the future?

The econometricians and their co-thinkers in Washington are convinced that this shift in energy usage is good, that it can continue indefinitely, and that it should be the basis for a new kind of "economic growth." Like the man falling from the roof of a skyscraper who notes that he had passed 50 floors and everything is still fine, the decouplers assure us that we will prosper as we have for the last 10 years into the indefinite future.

The opposite is unfortunately the case. The real meaning of decoupling is the obsolescence of U.S. industry (older than any other industrialized country); a rate of productivity growth last but for Britain; the collapse of capital-intensive industries like steel and nuclear, and a negative rate of capital investment for more than a decade.

Can We Survive Decoupling?

Are the decouplers right? Can we *survive* decoupling? The obvious answer is no—a common-sense answer whose correctness is borne out by studies done using the Fusion Energy Foundation's Riemannian economic model. Without massive investment in new technologies, especially nuclear ones, without rapid upgrading of the labor force, the nation will *not* survive the present economic crisis. The economy experienced decoupling once before during the last depression; it is unlikely it could withstand it again.



THE DECOUPLERS' THESIS

This is a page from the "Energy and Economic Growth" report by M.H. Ross and R.H. Williams, a study done at the request of the Joint Economic Committee and other members of Congress.

The authors note their thesis under the figure: "These calculations suggest that energy growth could be sharply curtailed in response to rising energy prices without adversely affecting the economy because there are considerable opportunities for substituting other inputs for energy throughout the economy."

Industry Spokesmen Testify For Accelerated Fusion Plan

The House Subcommittee on Energy Research and Production heard testimony March 6 from nongovernment witnesses on the authorization proposed by the Department of Energy for the magnetic fusion program in fiscal year 1981.

Two scientists representing the nuclear and fusion-related high-technology industries were chosen to testify out of dozens who made requests—Dr. Stephen O. Dean and Dr. Sibley Burnett. Dean is the president of Fusion Power Associates, a group that includes 13 high-technology companies as charter members and one utility as an associate member. Burnett, the manager of fusion technology and development for the General Atomic Company, spoke representing the nuclear industry's Atomic Industrial Forum.

Dean, the first to testify, supported a $100 million add-on to the committee's fiscal year 1981 budget proposal (see table). He told the subcommittee: "Scientists at many laboratories and universities throughout the world have been working together closely for many years to discover fundamental scientific principles on which to base the design, construction, and operation of practical fusion energy systems. During the decade of the 1970s, systematic, and in some cases, dramatic, progress has occurred in fusion on a broad scientific front. . . ."

After summarizing the accomplishments in both the science and technology for fusion, Dean described the funding limitations: "The pace of fusion energy development today is clearly limited by the funds available rather than by science and technology. The skills required for engineering development exist today in a variety of institutions—national laboratories, universities, and industry. If these skills are properly mobilized and utilized, the time will soon come when society may reap the considerable benefits which fusion has to offer. These benefits include a virtually inexhaustible fuel supply, cheaply available to all nations."

Departing from his prepared remarks, Dean noted that President Carter's budget cuts might affect the fusion program. It was rumored, Dean reported, that the administration would recommend a cut in the Elmo Bumpy Torus proof-of-principle program, thus delaying design and construction of the next-step device scheduled for Oak Ridge National Laboratory.

This project was OK'd by the DOE just a week before and the department was already preparing a request for proposal to a group of industry consortia to bid on the project, Dean said. He strongly suggested that the subcommittee continue its commitment to take the most promising fusion designs, including the Mirror Fusion Test Facility at Lawrence Livermore Laboratory, through to scientific feasibility.

Dr. Burnett began his testimony by telling the subcommittee that he wanted to "commend your efforts to accelerate the fusion program by introducing the Fusion Energy Research, Development, and Demonstration Act of 1980 " into Congress. This bill, HR 6308, was introduced Jan. 23 by sub-

Rebecca Harrington

Dr. Al Mense (left), congressional staff member for the House Subcommittee on Energy Research and Production; Congressman Mike McCormack, chairman of the subcommittee; and Dr. Stephen O. Dean, chairman of Fusion Power Associates, at a reception after subcommittee hearings last December.

THE $100 MILLION ADD-ON TO THE FUSION BUDGET

Project	Amount
Mirror Fusion Test Facility	$ 15
Engineering Test Facility	
Conceptual design work	10
Facilities architect and engineering	10
Technology and development engineering	40
Supporting experiments upgrade	25
Total	$100

In this suggested breakdown of the add-on to the fiscal year 1981 magnetic fusion budget, the $15 million added to the mirror facility would make it a tandem mirror design. The increase to support existing experiments would provide additional experimental data to be used for the ETF design.

committee chairman Mike McCormack and cosponsored by 140 congressmen.

Burnett continued: "As you know, there is strong consensus in the scientific community that fusion energy is ready for far more aggressive development than currently planned by the Department of Energy. Your foresight in recognizing the need for rapid development of this promising energy source is to be congratulated."

During the question period, Congressman Nicholas Mavroules (D-Mass) asked both witnesses: "Do your industry associations support the bill that Congressman McCormack has introduced, which I and many other members of this committee have had the honor of signing as cosponsors?"

With no hesitation, Burnett stated that the Atomic Industrial Forum "appreciates the bill and, of course, supports it." Dean answered, "Absolutely. It is long overdue."

Mavroules then asked about the international tokamak reactor study, INTOR, which is a joint project of the United States, the Soviet Union, the European Community, and Japan. The cooperation "has been quite remarkable for so many countries in such a short time [one year]," he said. Dean replied that the INTOR work is complementary to the Engineering Test Facility design work being carried out here and shows that there is an international consensus to go ahead in fusion.

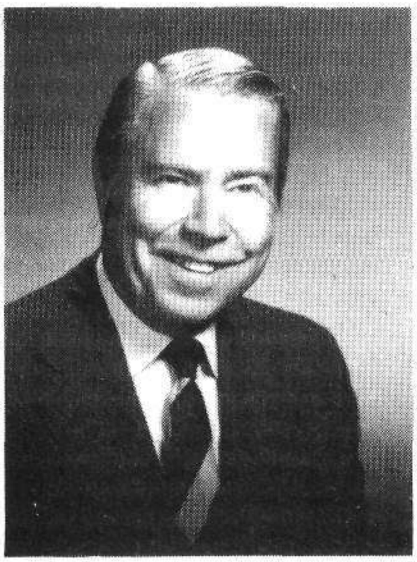
The Proposed Budget

Dr. Alan Mense, a former fusion scientist at Oak Ridge and now fusion staff advisor to the subcommittee noted that if we are not just "paying lip service" to accelerate the fusion program, we have to "determine the funding levels appropriate for fusion to go to the next-step engineering phase." What would be appropriate for the fiscal year 1981 budget the subcommittee is now considering, he asked?

Dean then submitted for the record a proposed breakdown of the $100 million add-on for the budget included in Congressman McCormack's fusion bill. This money would bring the magnetic fusion budget up to the $.5 billion level required just to get a crash program off the ground. If we wanted to push the program to go as fast as it could, Dean said, "the program could spend twice the amount of money" proposed in this add-on.

Mense asked the two industry witnesses to prepare in writing for the committee members, the minimal level of government funding required to move the program ahead in terms of private industrial involvement and an account of what would happen if that level of funding were not provided.

A report on Fusion Office Director Edwin Kintner's testimony appears in the fusion news section, this issue.



John Rhodes

The Fusion Bill **'A Distinctly Reachable Goal'**

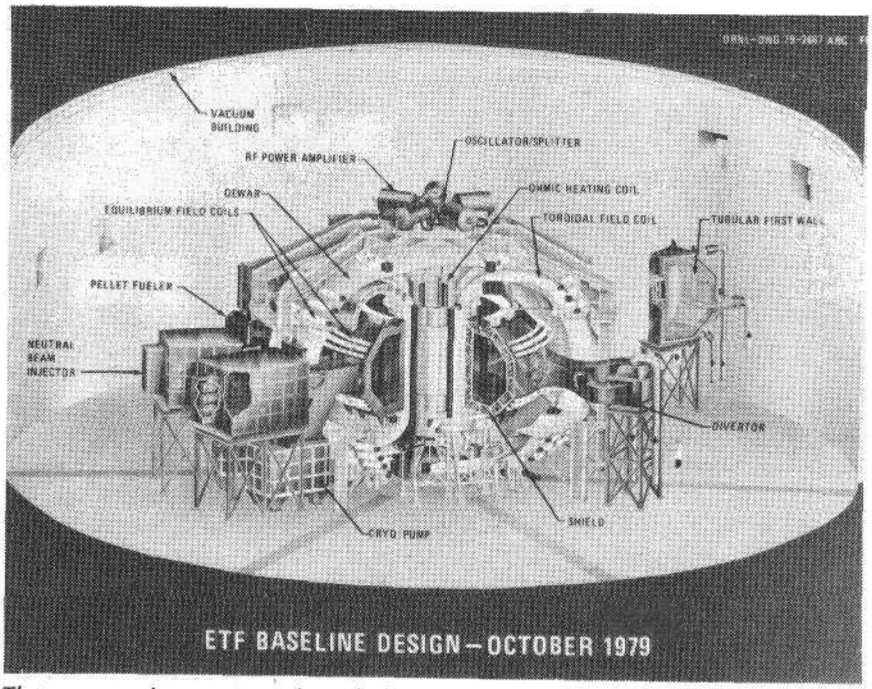
The Fusion Energy Research, Development, and Demonstration Act of 1980, introduced into Congress Jan. 23 by Congressman Mike McCormack, now has 140 congressional cosponsors. One of the most important statements of support for the legislation was submitted to the Congressional Record *Feb. 21 by Arizona Republican John Rhodes, the House minority leader.*

Rhodes's statement on the importance of accelerating the fusion budget is a refreshing contrast to the Carter administration's recent announcement that $20 billion must be cut from the federal budget for fiscal year 1981. Reprinted below are excerpts of the Rhodes statement, which commented on the results of the fusion research program as reported by the fusion advisory panel commissioned by Congressman McCormack last year.

"We are accustomed to expectations of what we call breakthroughs—momentous turning points that open vast vistas and solve heretofore insoluble problems. A recent report by the Fusion Advisory Panel .... indicates that we are ready to turn a significant corner in our quest for fusion energy. It represents a quiet breakthrough—with vast implications for our economy....

"The panel calls for a $1 billion reactor demonstration project. This is no pig in a poke. It is a distinctly reachable goal by 1995. Measured against the almost limitless potential of fusion power, a larger investment by our government in fusion seems a wise course. Put simply, practical fusion power would make our lakes and oceans vast reservoirs of energy....

"The potential is there. Now it is up to the Congress and the American people to get behind this program—to bring magnetic fusion into our future.... Fusion represents the very real possibility of energy independence ... if we are willing to make fusion a national purpose. We are at the stage that increased funding has become a key factor. An infusion of funds now can bring fusion power to fruition in this century. That is a great potential. We should not fumble it by haggling—or hesitancy."



The proposed next-step tokamak device, the Engineering Test Facility, would provide broad-based engineering studies for all types of magnetic fusion. This ETF baseline design was completed by Oak Ridge National Laboratory in 1979.

GAO: Get Industry Into MHD Program

The General Accounting Office, the research arm of Congress, released a report Feb. 11 that calls for the formation of a group of industry, government managers, and utility representatives concerned with magnetohydrodynamics, MHD. The report, titled "Magnetohydrodynamics: A Promising Technology for Efficiently Generating Electricity from Coal," was commissioned in response to the Department of Energy's announcement Dec. 11 before the Senate Committee on Energy and Natural Resources that the DOE was considering accelerating the MHD program.

MHD is a process of directly converting heat from burning a fossil fuel or from nuclear energy or fusion into electricity. A gas of charged particles is passed through a channel surrounded by a magnetic field and electric power is produced in the channel. Less efficient steam turbines are not required, and the MHD generator has no moving parts. (See *Fusion,* April 1980, pp. 25-48.) This possibility of doubling energy efficiency through MHD is a striking alternative to the Carter administration's inefficient energy alternatives.

If the technical problems in coal-based MHD can be solved, MHD "could become an important technology for utilities and some industries," the GAO report concludes.

The major criticism the GAO makes of the current DOE program is that the department "does not have procedures to systematically involve users in the program and has relied on these users to come to the department." Unlike the fusion area, there is no organized group of government program managers, representatives from experimental programs, and prospective utility and industrial users of MHD that works together and exchanges information and ideas. Such a group would immediately involve utilities and the metals and other industries that have already expressed a keen interest in developing MHD technology.

The MHD program, like the fusion program, is now at the point where "scientific feasibility" has been proven in the United States and on the agenda is a next-step Engineering Test Facility that would produce net power in a pilot plant. Unlike fusion, however, this next step has already been demonstrated in the Soviet program.

A major concern of the GAO report is whether the next-step Engineering Test Facility, ETF, will be government-owned, a government-utility plant, or a government-industry partnership. A survey by the report's authors discovered that most utilities did not know anything about MHD and, therefore, were cautious about their own financial involvement. Given the fact that MHD could cut the utilities' fuel bills in half and eliminate costly and nonproductive pollution control devices, this lack of knowledge is astounding.

Some utilities, however, have made MHD proposals to the DOE. Southern California Edison, for example, has suggested that an MHD topping cycle be placed on one of their already operating oil burning units by the mid-1980s to demonstrate the technology. A more advanced proposal has come from the Montana Power Company in Butte, which is now considering potential sites for two power plants.

Reynolds Metals has financed its own MHD program to produce electricity and process heat for its aluminum facilities. Because such an industrial MHD unit would be smaller and less complex than a utility unit, the GAO recommends that the DOE study the potential for a joint government-industry program. Even though it would not demonstrate complete utility compatibility for the technology, it would get commercial feasibility earlier than is currently planned.

What is clear from a reading of the GAO report is that the DOE has simply ignored the support offered by private companies to help develop commercial MHD technology.

Pronuclear Bills Hit Carter Policy

At the March 6 hearings on nuclear waste management before the subcommittee on Energy Research and Production of the House Science and Technology Committee, ranking minority member John W. Wydler (R-NY) released a statement charging that the administration's nuclear "program is nothing less than a national scandal . . . premised on a geological sandbox emphasis in order to rationalize political delay and indecision."

Wydler outlined four legislative initiatives to preserve the nation's nuclear energy options, which he said "lay out a strategy for getting the nuclear option back on track."

A week before the hearings Wydler introduced a bill to manage the low-level nuclear waste that comes primarily from medical users. Low-level waste is "not a significant technological program," Wydler said. His bill proposes that such waste be the responsibility of each state with federal technical assistance to help in the planned takeover of waste burial operations. This responsibility would be transferred from the Department of Energy and the DOE would be reimbursed for interim storage of waste at commercial sites.

The second piece of the pronuclear package, introduced after the March 6 budget hearings, is a radiation protection bill that will "direct the Environmental Protection Agency to assume major responsibility for radiation protection and approach its rule making on the basis of comparative risk of various sources."

This would be aimed at establishing realistic rather than arbitrary guidelines. "This is another area where we have unfortunately allowed the public to be misled by an ambivalent and negative policy. The administration has been derelict in pointing out [that is, it has exaggerated] the real risk from operation of nuclear power plants and allowed the responsibility for assessing risk and protecting the public to remain hopelessly fragmented."

The third bill, not yet introduced, will address the critical issue of high-level nuclear waste management. "I intend to address this problem from spent fuel to genuine high-level waste with a comprehensive bill," Wydler told the subcommittee. A fourth bill, he said, will "place nuclear energy in the true perspective of comparative risk."

"We must decide to solve these problems and not allow the administration an opportunity to further delay an ultimate solution and waste hundreds of millions of dollars in the offing," Wydler's statement concluded.

DOE Tries to Fulfill Its 'No Nuke' Prophecy

The DOE's Energy Information Administration recently released a study, "Commercial Nuclear and Uranium Market Forecast for the United States and the World Outside Communist Areas," that is an exercise in self-fulfilling prophecy: The report fully backs up the administration's determination to shut down U.S. nuclear capacity, no matter what the cost to the nation.

The executive summary of the report states "This forecast is a better representation [since its Dec. 1978 report] of the domestic political and economic climate following the reactor accident at the Three Mile Island generating station on March 28, 1979. . . ." Since that Dec. 1978 forecast, the report continues, "the accident at Three Mile Island has eroded the general confidence of the utility industry, the investment community, and the public. These and other trends have prompted EIA to make a major reevaluation of the nuclear forecasts published in its annual report."

And what are these new forecasts? For the 1990 milestone, which is when the majority of the approximately 120 reactors under construction, awaiting construction permits, or on order should come on line, the recent forecast of a range of 142 to 171 gigawatts is a 10 percent reduction from 1978, when there were expectations of 157 to 192 gigawatts by 1990. All of these figures include the approximate 50 gigawatts of nuclear power already operating.

By 1995, the latest projections are for between 186 to 225 gigawatts. At this rate, fewer than 10 reactors would be produced each year, requiring that the U.S. nuclear industry *scrap two-thirds* of its production capacity, for it is assumed that this loss of domestic orders would not be made up through exports.

For the rest of the world, the Energy Information Agency report demonstrates that its forecasts have no correspondence to reality. Its latest projections are for between 550 to 750 gigawatts nuclear by the year 2000 for all the noncommunist countries. The projections carried out by those countries themselves, however, estimate on-line nuclear capacity to be between 770 to 1,050 gigawatts by the turn of the century—potentially double the U.S. estimates for these nations.

The INFCE Backlash

As part of its antinuclear campaign, the administration has tried to pin its hopes on the argument that civilian nuclear development will increase the dangers of nuclear weapons proliferation. This has taken the form of the International Nuclear Fuel Cycle Evaluation, INFCE, a policy exercise that the administration foisted on the world community—at a cost of more than $100 million to the United States alone.

The INFCE group, which ended its deliberations in February, however, underscored the industrial and developing nations' commitment to develop all aspects of the nuclear fuel cycle and made the U.S. position on proliferation dangers look silly.

In addition to projecting worldwide use of nuclear energy at double the rate the Carter administration had projected, the conference concluded with a statement on the need to develop breeder, reprocessing, and spent fuel storage technology to meet the world's future energy needs.

Given the pronuclear sentiment at the conference, the administration's representative to INFCE, Ambassador-at-Large Gerard Smith, was forced to admit at the final plenary session Feb. 24: "We all recognize that proliferation is basically a political matter and that if a nation elects to develop nuclear explosives, it can do so without misusing civilian nuclear power facilities." Smith also told the international community that "spent fuel can be safely stored on an interim or long-term basis. . . ."

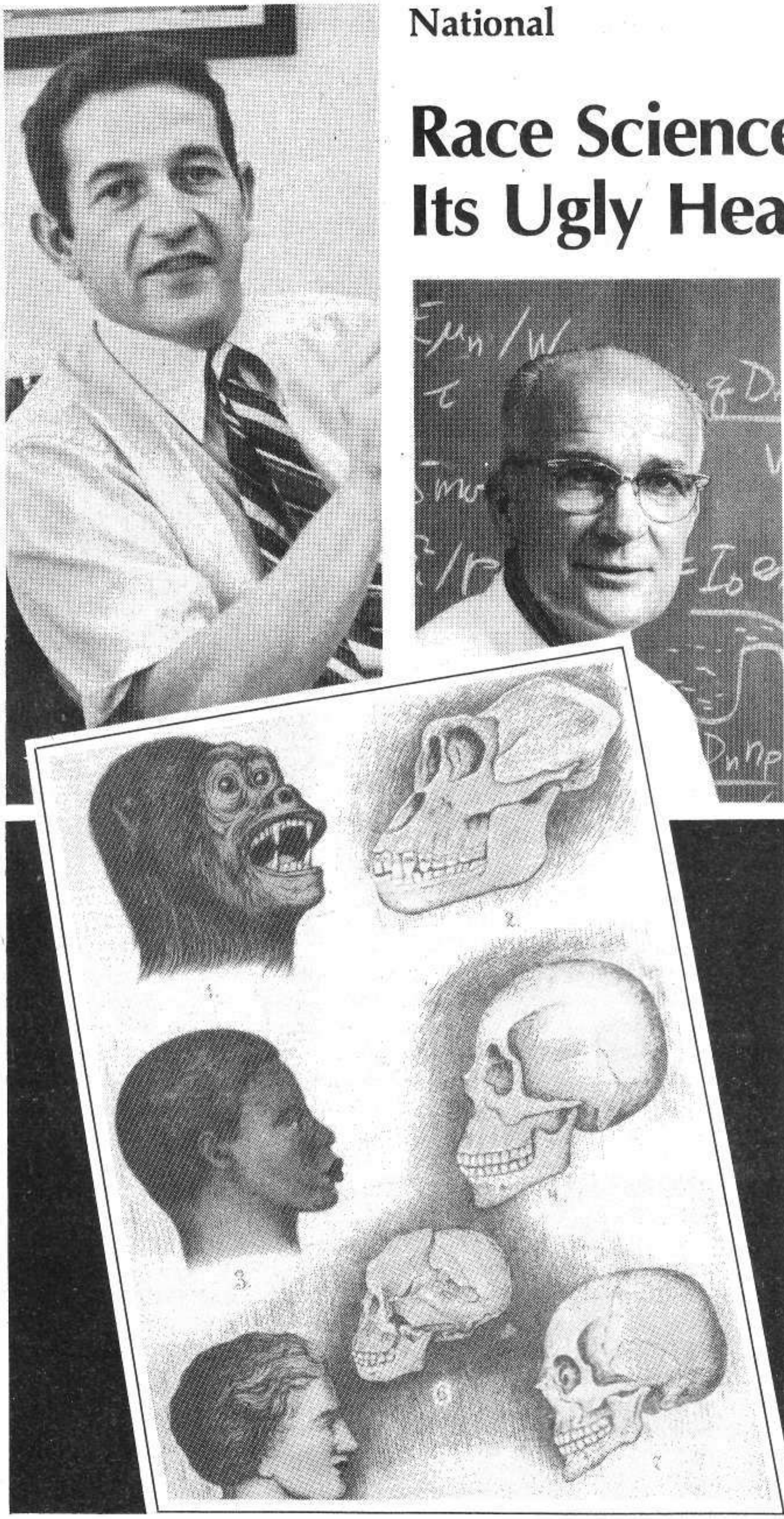
However, on the question of future demand for nuclear power, Smith backed up the DOE's self-fulfilling prophecy: "On the demand side, there will be a need for periodic revisions of the estimates developed in INFCE. For example, since these estimates were prepared over two years ago there have been large reductions in reactor orders and lengthy delays in construction schedules. This has resulted for the United States, which makes a major contribution to total demand, in a reduction in projections for 1995 nuclear capacity of about 30 percent."


United Press International
Gerard C. Smith: Proliferation is 'basically political.'

Carrying this tortured argument further, Energy Secretary Charles Duncan told the House Science and Technology Committee Jan. 31 that the funding for the Liquid Metal Fast Breeder Reactor "has been reduced in light of current projections that breeder reactors will not be needed until after the year 2020." This, of course, is only because the DOE has cut back on its projections of nuclear plants.

National

Race Science Rears Its Ugly Head



Today's race scientists Richard Herrnstein (above left) and William Shockley; their theories parallel Nazi eugenics that pegged intelligence to characteristics such as skull size.

William Shockley, a physicist who won the Nobel Prize in 1956 for his work on transistors, reappeared in the news the first week of March, when he announced that he was one of several Nobel winners who had contributed their sperm to a sperm bank in California with the idea of "increasing the people at the top of the population."

The sperm bank is operated by Robert Graham, a California businessman who was an associate of the deceased Nobel-prize winning geneticist Hermann J. Muller. Graham solicited the "Nobel sperm" for freezing and later use to inseminate "especially intelligent women" whose relationships have been childless.

Shockley achieved notoriety in the early 1970s for his collaboration with the University of California's Arthur Jensen and Harvard University's Richard Herrnstein, both geneticists. During that period, major scientific and educational journals gave much publicity to their theories that intelligence is "80 percent determined" by genetic factors and only 20 percent by environment, education, and other factors.

Shockley was the most outspoken in concluding that those sections of the population not now manifesting high intelligence through standard IQ-test scores were therefore genetically inferior beings. He developed the theory that blacks were in fact genetically inferior to white races and that what he called their "breeding" had to be reduced. Shockley referred to the theory as "antidysgenics—my past and present emphasis on reducing the tragedy of the genetically disadvantaged at the bottom of society."

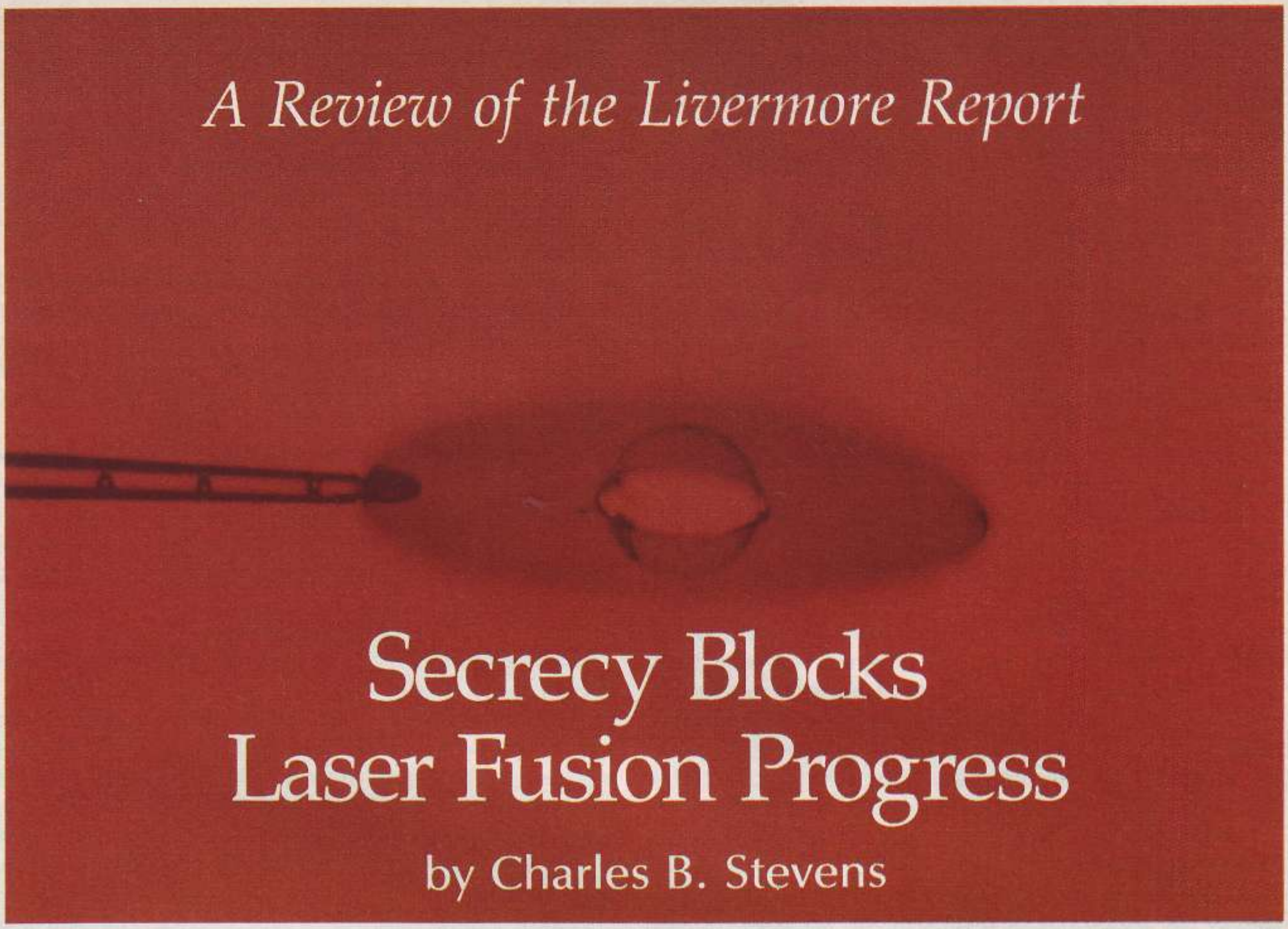
Herrnstein, Jensen, and Shockley based their notorious 1970s studies strictly on IQ scores, which they then categorized according to physical characteristics of the testers, notably ra-

Continued on page 59

A Review of the Livermore Report

Secrecy Blocks Laser Fusion Progress

by Charles B. Stevens



LLL

Ball-on-plate target set up for 20-beam laser shot. The disk (plate) was added to prevent laser system damage. Because the disk cooled the equatorial region of the target, it reduced target yield as much as a factor of 10.

LAWRENCE LIVERMORE LABORATORY has just published its 1978 report on the status of the U.S. inertial confinement fusion program. Specialists will find the document, "Laser Program Annual Report—1978," informative on a variety of secondary aspects of laser fusion research; overall, however, the report is a major disappointment.

There is no reason to assume that the laser program itself has been a disappointment. The severe shortcomings of the report, for the most part, are not the work of the Livermore scientists or management; nor does it reflect their research. The problems in the report appear to be the work of the Department of Energy censors.

The Lawrence Livermore Laboratory in Livermore, California is the principal nuclear weapons research facility of the U.S. Department of Energy (DOE) and has the largest laser fusion research effort in the world, with an annual budget of $44 million and 355 scientific personnel. *Fusion* reviewed the 1977 Livermore Laser Program Annual Report just six months ago.[1] The new annual report[2] has been published within less than a year.

This series, which has now grown to three volumes, is unique in the field of scientific-technological research for its size and breadth of coverage. In the 1978 report's foreword, scientific editor Dr. Michael Monsler makes an additional claim:

> Our intent in publishing this comprehensive report goes beyond a simple chronicle of accomplishments. We explain our theories, experimental results and techniques, and systems studies in sufficient depth to allow the reader to either reproduce the results or call the person directly responsible and discuss the work in detail.

Be that as it may, the 1978 report is singularly lacking in theoretical depth. As I noted in reviewing the 1977 report, the most important questions raised there could be found only "between the lines." Although the 1978 report has been published in a more timely fashion, not even "between the lines" information concerning the crucial scientific questions of laser fusion is to be found. And this unwarranted circumspection has arisen at the precise time that the entire laser fusion and related systems research effort is approaching a critical period with regard to paths to pursue to resolve crucial scientific problems.

The fault for this situation is to be traced to the Carter administration in Washington, D.C. In the past year, the administration declared that the laser program, or rather, inertial fusion research effort, would be kept under the DOE's defense programs. The House Armed Services Committee was recruited to support this policy, resolving that inertial fusion research would be directed primarily to "military applications"; work on commercial uses would be curtailed.

This action was especially remarkable because with no explanation, the administration ignored the goverment's own blue-ribbon panel on fusion, the Foster Committee (chaired by Dr. John Foster, vice president of TRW). The committee, made up of leading representatives of the scientific and aerospace-defense communities, had submitted a detailed review of the U.S. inertial fusion program in February 1979, concluding that development of inertial fusion *for commercial forms of energy utilization* must be the national priority.

The Foster Committee had also recommended that the inertial fusion research budget be doubled as a prerequisite to resolving the most crucial scientific questions involved in the research. Both military and commercial applications depend on the increased funding, reported the panel. Acknowledging that the program has important applications to design and replication of nuclear weapons' effects, the committee nevertheless emphasized that the benefits and scientific issues raised by commercial fusion are so significant that this side of the effort ought to be pursued in as open and rapid a manner as possible.

The Carter administration promptly classified the Foster Committee's report top secret. As the Livermore report itself establishes, the administration has since gone on to classify the experimental results of the program top secret. At present, the administration is moving in an even more dramatic fashion, suppressing the Livermore program itself through drastic cuts in the fiscal year 1981 funds for the 200-trillion-watt Shiva-Nova laser system now under construction there.

That system, specialists agree, could demonstrate the scientific feasibility of inertial fusion by the mid-1980s.

What Is Missing

These political circumstances create three major ambiguities in the Livermore report.

First, the program is experimentally reproducing the conditions in stars, thus making it possible to directly observe such conditions for the first time in human history. Yet, of this, the Livermore report says virtually nothing.

Second, as scientists enter this new physical regime a critical decision point is reached: Which technologies are to be developed to further the research? The Livermore report says nothing.

Third, in addition to technologies best suited for pursuit of inertial fusion research, the experimental results now being achieved are crucial as they pose the "frontier" problems whose solutions require fundamental advances in basic science generally. (This is immediately recognized by readers of *Fusion*'s series on the history and scientific nature of inertial fusion.) But the Livermore report says nothing.

This writer is not privileged to the information deleted. However, careful analysis of nuances present both in the report and in public presentations by Livermore fusion scientists makes it possible to piece together "educated guesses" on what is actually going on.

Among the aspects that receive *no mention* in the present report are these "educated guesses":

- Important progress is being made in the most crucial diagnostic technology relating to the monitoring of experimental events.
- Important progress has been made in developing techniques for measuring density in low-temperature hydrogen fusion fuel pellets.
- Important progress is being made in target-designs optimal for achieving compression of matter to high densities like those found in the center of stars.
- Important progress is being made in laser-plasma interactions.
- Important progress is being made on Rayleigh-Taylor instabilities and their impact on lower power, long pulse, high-gain targets, and ion beam and nonspherical targets.

In the Report Itself

The Livermore Laser Program Annual Report (1978) consists of three volumes containing 10 sections. Volume 1 presents an overview of the entire program, highlighting and summarizing the facilities and resources of the laser program (section 1). In section 2, the Argus (the predecessor facility to Shiva), Shiva, and Nova laser facilities are described in detail. Volume 1 ends with brief discussions of the theory of fusion target design (section 3) and the specialized techniques of target fabrication (section 4).

Volume 2 details the year's experiments, data, and analysis (section 5); experimental diagnostic instrumentation development (section 6); and development of glass laser components (section 7).

The final volume documents progress in developing advanced lasers that will have high enough energy efficiencies and fast enough repetition rates, together with other physical characteristics such as wavelength of laser light generated, to provide the basis for economical fusion power reactors (section 8). Section 9 presents application studies in electrical energy production and fissile fuel generation. Section 10 gives *selected* highlights of the Livermore advanced isotope separation research program, another important program being curtailed by the Carter administration.

As noted in section 1, "Laser Program Overview":

> In general, 1978 progress in core program research was good but noticeably slower than originally planned. We lost time that may prove critical to a national review of fusion options in the mid-1980s. Added resources could have helped prevent this loss. In the near term, the coupling between resource levels and progress will be even tighter than it was in l978.

Figure 1 shows that the 27-billion fusion neutron output achieved in September 1978 is actually somewhat below that predicted. Furthermore, attempts to achieve micro-

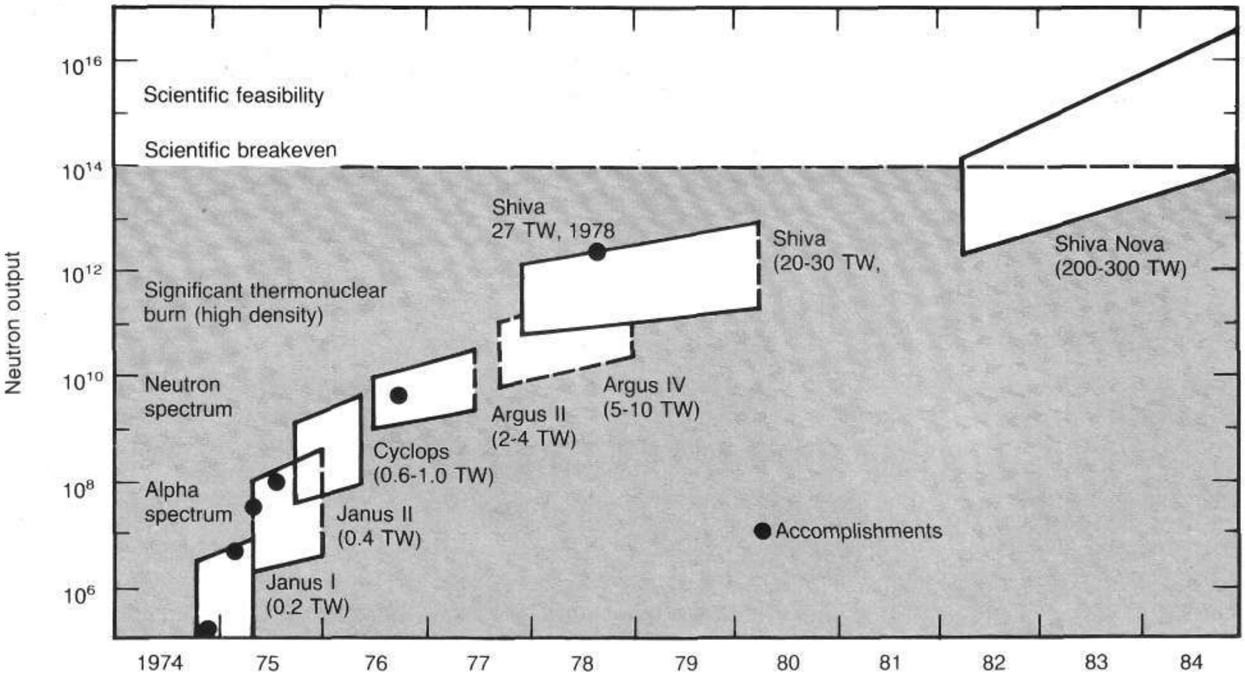


Figure 1
LASER FUSION ENERGY YIELD

The fusion neutron output of various Lawrence Livermore laser systems is shown hère by year. Neutron output is a direct measure of the number of fusion reactions actually ignited. The dots designate the achievements of the program since 1974, and the boxed areas indicate the program goals through the 1980s. The Shiva-Nova laser, now under construction, is expected to reach scientific breakeven (more energy output than energy input) and demonstrate scientific feasibility in the mid 1980s—if its funding is continued.

The laser power is given in trillion watts (TW).

sphere compressions to 100 times the liquid density of hydrogen on the Argus laser have not succeeded. However, laser shots that have achieved compressions to 50 times liquid density have been carried out with the Shiva system.

The current Livermore plans are that if the Nova is given a funding go-ahead, scientific feasibility of inertial fusion could be demonstrated in the mid-1980s with target gains of 10 to 100. (*Gain* is the amount of generated fusion energy divided by the amount of laser energy input necessary to compress and heat plasma in the target to the requisite conditions for ignition of fusion reactions.)

Advanced Drivers

Although the scientific aspects of inertial fusion may be resolved using highly inefficient glass laser systems that have low repetition rates, more advanced lasers, ion beams, or electron beams will be needed for actual fusion power plants as the efficient, high-repetition-rate target implosion drivers.

The repetition rate is a measure of how often the laser can fire at the target. In a glass laser, which consists of solid glass disk amplifiers, a large quantity of energy in the form of heat must be dissipated before another shot can be made. If not cooled, the glass disk amplifiers will be damaged. Because it is more difficult to cool solid materials, as opposed to liquids and gases, and because glass lasers are highly inefficient (more than 99 percent of the energy deposited into their amplifiers ends up as waste heat), they have very low repetition rates, which become even lower as the size and power of the laser system are increased. Shiva, for example, is capable of a maximum three to four shots a day.

In the case of a gas laser, like the Los Alamos carbon dioxide four-beam system, the repetition rate can be as high as four times an hour, and, theoretically, carbon dioxide lasers can be shot many times per second. An actual reactor would require a repetition rate of several times a second.

It is now generally recognized that the experimental capability to go from scientific feasibility gains of 10 to 100 to those needed for economical power plants, 100 to 1,000, will probably necessitate the use of advanced drivers. The Foster Committee's recommendation for doubling the inertial confinement budget was, in fact, directed at ensuring sufficient funding to develop an advanced driver within the next five years.

High gains can be achieved only with larger total energies shot onto the target. Because glass lasers are energy inefficient (as explained above), going to higher energy outputs is quite expensive and technologically difficult without a more advanced driver.

Livermore currently has a small effort to develop an

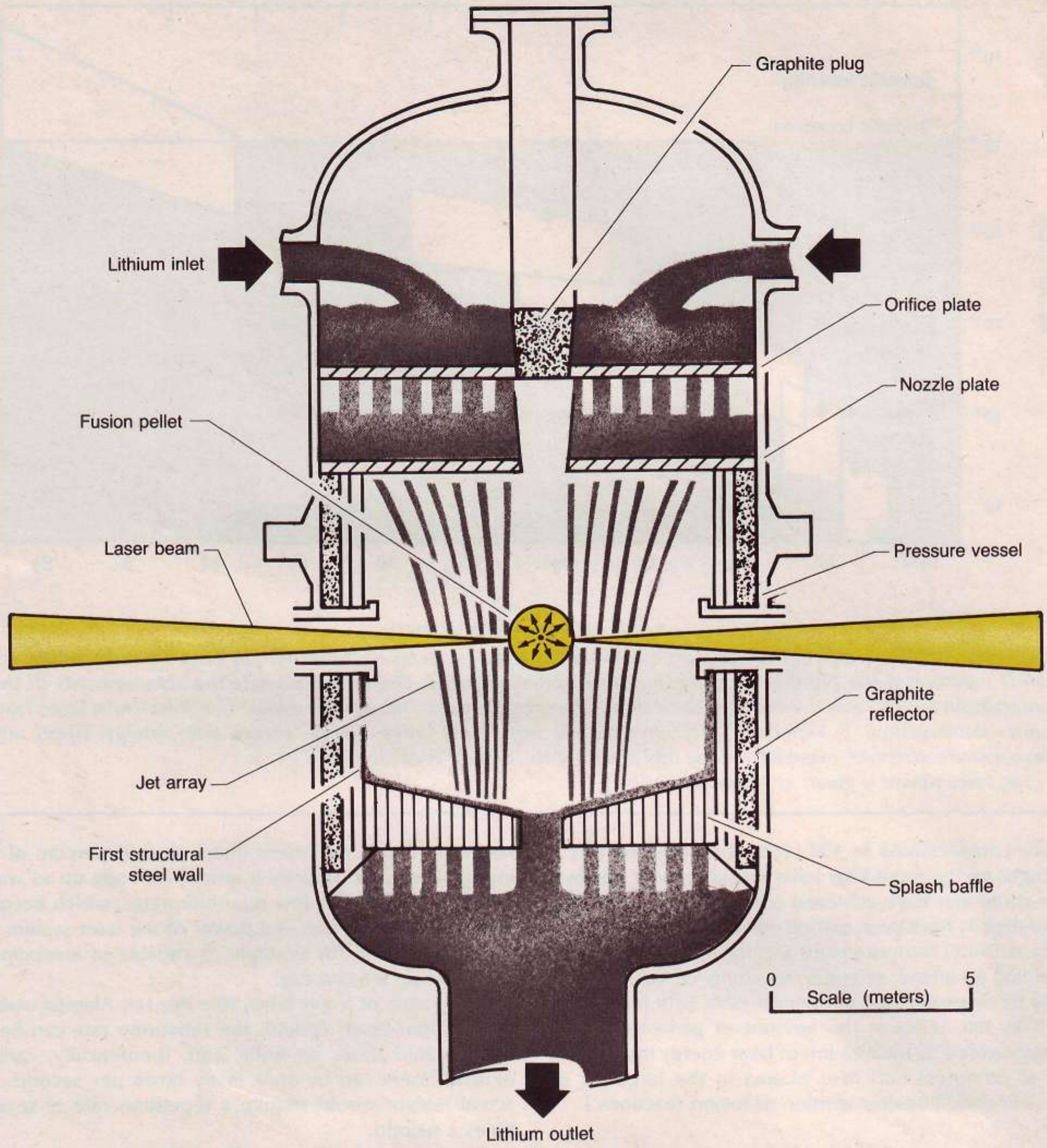


Figure 2
SCHEMATIC CROSS-SECTION OF THE HIGH-YIELD LITHIUM FUSION REACTOR CHAMBER.

This cross-section of the reactor-chamber of the Livermore design for a laser fusion electric power plant differs from designs for other types of inertial and magnetic fusion reactors in that the main heat transfer fluid is directly exposed to the reacting fusion plasma. Here the heat transfer fluid is lithium, which absorbs the fusion energy generated and conveys it out of the reactor chamber to heat exchangers that generate heated steam for driving turbines and motor-generator sets for electric power production. The lithium also protects the chamber wall from the effects of the fusion microexplosion.

To maintain a steady flow of lithium through the chamber, jet streams are formed as the lithium passes through the orifice and nozzle plates. This array of jets of liquid lithium remains stable against the blast from the pellet fusion microexplosion. The heated liquid lithium is collected in the splash baffle and goes out the outlet to a steam generator. The graphite plug and reflectors help keep the fusion neutrons within the reactor chamber.

advanced krypton fluoride gas laser that operates in conjunction with an innovative scheme for compressing the laser beam output in time and space.

Diagnostics

The chief scientific contribution that laboratory inertial confinement research makes to so-called weapons technology is based upon the simple fact that what actually goes on inside an H-bomb is now understood only in pragmatic terms. H-bombs, like stars, are so large that it is nearly impossible to obtain any reliable data on the crucial processes that unfold as the fusion fuel is imploded and ignited. In the case of microscopic laser or charged partical beam pellet fusion, however, these "interior" processes can be directly observed. This is because both intense electromagnetic energy (primarily X-rays) and high-energy subatomic particles (fusion neutrons, nuclei products, or induced reaction products) can penetrate or escape the compressed core of the igniting fusion target.

Therefore, experimental diagnostics are an essential and, at times, highly classified part of inertial fusion research. These diagnostics consist of hundreds of different types of devices for measuring the various forms of escaping energy on sufficiently minute spatial (microns) and temporal (trillionths of a second) scales to permit observation of critical processes during compression and ignition.

The hundreds of different diagnostic systems needed to cover the energy, temporal, and spatial spectrums involved in inertial fusion, and the fact that these diagnostics all have to work almost perfectly to make the once or twice-daily laser-pellet shot a success, mean that inertial fusion experiments are every bit as complicated and vast an operation as a major manned space-craft launching. Scores of scientists and engineers monitor hundreds of television screens and oscilloscopes, checking and rechecking everything before the experiments begin.

Although this year's Livermore report spells out important progress in X-ray microscope, optical imaging, X-ray probing, ultrafast streak cameras, and multichannel high bandwidth fiber optics development, the most crucial diagnostic developments described in previous annual reports go virtually unmentioned.

For example, given the unconfirmed report that Livermore scientists experimentally measured compressions of hydrogen fusion fuel pellets to more than 50 times the liquid density of hydrogen, there is little doubt that major progress in developing techniques for measuring density in these low-temperature targets has been achieved. But not a word of this appears in the annual report. Therefore, it is reasonable to conclude that advances in these diagnostic methods, the subject of much discussion in previous annual reports, has been classified top secret.

The general type of diagnostic used on these low-temperature, high-density targets is that of activation analysis, inserting isotopes in the target pellets that create secondary reactions by which one can measure the density.

In order to get high-energy-gain targets, it is essential to achieve efficient compressions of hydrogen fusion fuel to densities as high as 10,000 times liquid density (2,000 grams per cubic centimeter). The existing power level of the

SUMMARY OF HYLIFE POWER PLANT CHARACTERISTICS

System parameters	
Fusion power	2,700 megawatts-thermal
Gross thermal power	3,215 megawatts-thermal
Gross electric power	1,255 megawatts-electric
Net electric power	1,060 megawatts-electric
Net electrical efficiency	33%
Laser and pellet parameters	
Beam energy	2 megajoules
Pellet gain	900
Yield	2700 megajoules
Pulse repetition rate	1 hertz
Laser efficiency	3%
Power consumption	100 megawatts-electric
Energy conversion chamber	
Height	8 meters
Radius	5 meters
Material	2.25chrome-1.0 molybdendum
Neutron flux at midplane:	
With lithium	0.32 megawatts per square meter
Without lithium	5.76 megawatts per square meter
Number of jets	300
Jet diameter at midplane	0.2 meters
Velocity at midplane	9.9 meters per second
Lithium flow rate	93.3 meters per second
Packing fraction of jets	0.5
Effective blanket thickness	1 m
Tritium breeding ratio	1.7
Lithium temperature (average)	500° Celsius
Effective temp rise/pulse	13° Celsius

The latest parameters of the Livermore pure fusion inertial power plant design are shown here. The total fusion power output in the form of heat is given in megawatts. This energy output is further enhanced by nuclear reactions in the lithium heat transfer fluid. (These reactions also generate more tritium fusion fuel.) The recirculating electrical power of 195 megawatts is used to run the various systems of the reactor such as the laser driver and the lithium and steam pumps.

The energy of the laser beam input is in megajoules and this quantity divided by the actual fusion yield gives the pellet gain at a rate of one laser shot per second. The laser system itself consumes about one-half of the recirculating power.

The energy conversion chamber operates at a power density comparable to the high power densities achieved in existing nuclear fission reactors. The projected rate at which tritium fusion fuel is bred, through nuclear reactions in the lithium coolant jet streams, is quite high: 1.7 tritium atoms produced for each tritium atom burned up in fusion reactions. This excess tritium output could be used in other fusion power plants as fuel input. As the last entry in the table shows, the temperature excursion in the lithium coolant is quite small during each fusion microexplosion (pulse).

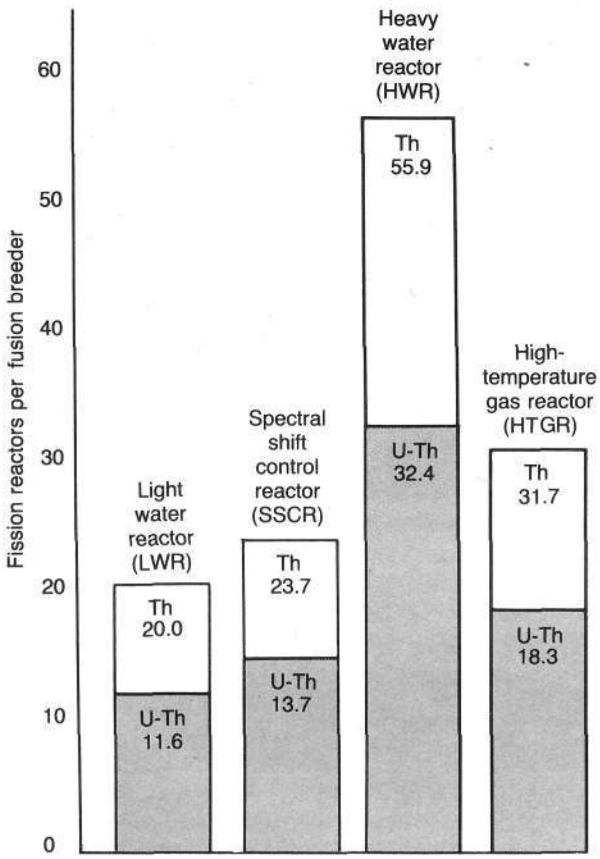


Figure 3
NUMBER OF FISSION REACTORS FUELED BY A FUSION BREEDER

In the past few years Lawrence Livermore has engaged in in-depth studies of alternative applications of inertial fusion energy. These studies could be crucial to how rapidly inertial fusion is commercialized because these alternative uses could prove more immediately practical economically and technologically than pure electric power generation. This is particularly the case with regard to hybrid fusion-fission fuel breeders, because these systems would primarily produce fissile fuel for conventional reactors.

Shown here are the number of various equivalent-thermal-power fission reactors that could be fueled by one fusion breeder reactor based on an all-thorium (Th) cycle or a thorium-uranium (U-Th) cycle. According to the Livermore study, one thorium-uranium fusion hybrid could fuel 55.9 heavy water reactors—an encouraging result.

Light water reactors (LWR) are conventional pressurized water or boiling water reactors; spectral shift control reactors (SSCR) are a modified version of these conventional light water reactors using heavy water; heavy water reactors (HWR) use heavy water as the primary coolant; and high temperature gas-cooled reactors (HTGR) are the most advanced fission reactors in terms of safety and efficiency.

Shiva laser, 30-trillion watts, is not sufficient to achieve high-density compressions and high temperatures simultaneously. This will be achieved on the Nova laser system, 200 trillion watts.

However, the Shiva is able to produce significant compressions with temperatures of 10 to 20 million degrees. Under these conditions a relatively small number of fusion reactions are induced—100,000 to 1,000,000. At fusion ignition temperatures above 50 million degrees, about 10 to 1,000 trillion fusion reactions would be generated.

At below the million reaction level, it becomes quite difficult to directly detect the fusion neutron output. In the deuterium-tritium reaction the chief product is a high-energy neutron that readily escapes the compressed core of the burning fusion fuel because it is both electrically neutral and traveling at a high velocity, near that of the speed of light.

At the million-reaction (or less) level, it is possible to indirectly measure the fusion neutron flux by adding specific isotopes of certain elements to the target pellet. These isotopes, usually placed in the outer layers of the pellet, readily undergo nuclear reactions with the fusion neutrons. The products of these secondary reactions can be detected either instantaneously or at some later time. Through this fusion neutron "activation" of inserted isotopes, it is possible to indirectly detect the fusion neutron flux. In this way, given the measure of the fusion reaction rate determined by the neutron flux, the temperature of the fuel and even its temperature distribution can be worked out together with density.

Overall this activation diagnostic represents the most advanced and complex scientific experimental state of the art. Not only must precise means be used to detect the activation products, but the isotope deposition in the test pellet must be even more precise, since both the amount and exact location of the added material must be known.

Applications

Although the commercial applications division of the Livermore laser fusion effort has continued to receive cutbacks in funding and manpower allocations by congressional and administrative mandate, important work was realized in 1978. Livermore completed an inertial fusion power plant design called HYLIFE (High Yield Lithium Injection Fusion Energy), in collaboration with Rockwell International, Bechtel National, Inc., Colorado School of Mines, and the University of California at Davis. Studies on using fusion-generated neutrons to produce fissile fuel for existing nuclear fission reactors were also completed.

A schematic cross-section of the HYLIFE reactor chamber is shown in Figure 2. This reactor concept uses a curtain of liquid lithium made up of jets of lithium to protect the reactor chamber wall from fusion-generated neutrons and radiation. The liquid lithium curtain also carries out two other functions: It is the primary coolant and heat transfer fluid that eventually heats steam for driving electrical generators, and tritium fusion fuel is bred in the lithium by a nuclear reaction with the fusion neutrons.

The table summarizes the HYLIFE power plant characteristics. Although many of the technical features of the HYLIFE design have been further perfected since the last Livermore annual report, the most striking developments are the results of a detailed calculation of induced radioactivity and damage to the reactor chamber wall as a result of fusion-generated neutrons. This study concludes that: (1) The reactor materials could operate for the full life of the power plant (20 years or more); (2) induced activation in the structure and in pellet materials is relatively low and is manageable with existing techniques: (3) long-term radioactive waste is practically nonexistent; (4) areas requiring remote maintenance and inspection can be serviced with present-day systems.

These important characteristics are the result of the protection the lithium curtain provides. It is further suggested that if the ordinary metal used for the reactor chambers—a ferritic alloy consisting of 2.25 percent chrome,1.0 percent molybdenum, and the rest iron—is made with molybdenum that has been put through isotope separation, induced activation could be reduced to the point where hands-on maintenance and recycling of reactor materials becomes possible. Livermore is also working on the laser isotope separation technology to do this.

Figures 3 and 4 give the final results of the Livermore analysis of using laser-fusion-generated neutrons to produce fissile fuel for fission reactors. Figure 3 shows that one fusion breeder with an output of 1,000-megawatts-electric could supply 55.9 1,000 megawatt-electric fission power plants on an annual basis.

In other words, a handful of laser fusion breeder reactors could fuel all the world's fission reactors in the year 2000, or shortly thereafter. A cost analysis of the laser fusion breeder (Figure 4) shows that its capital cost would be from two to three times that of a conventional fission light water reactor. This would put the cost of electricity from both the fusion breeders and fission-supplied reactors in the range of 38 to 50 mills per kilowatt hour, very close to current electrical power costs.

Target Design

The target design section of the report discusses some important basic scientific work on laser-plasma interactions, such as nonlinear filamentation of the laser beam in the plasma generated around the microsphere target during irradiation and backscattering of the laser light (another nonlinear laser-plasma interaction leading to nonabsorption of the laser light.) However, the most important areas are *not even mentioned*.

It is noted that in December 1978 Shiva achieved an implosion of a fusion target to a density greater than 50 times hydrogen liquid density, generating a temperature of 5.5 million degrees Celsius. This meant that Shiva reached the necessary *confinement* of fusion fuel for breakeven energy production without attaining the 55 million degree reaction *ignition* temperature. This is an important result, because the most crucial question in inertial confinement is that of efficient compression of matter to high densities like those found in the centers of stars. However, the report discusses neither the target design that was used nor the wanted comparison to similar results achieved with a *much inferior* laser reported two years ago by Soviet scientist N.G. Basov.

In fact, there is almost no mention of inertial fusion research in other countries or even other U.S. laboratories.

Figure 5 gives the optimistic and conservative projections of fusion target energy gains (fusion energy *out* divided by laser energy *in*) for various total energy inputs in joules. For practical electrical power plants these projections have been further elaborated for various drivers—laser, light ion beams (protons), and heavy ion beams (uranium).

The optimistic projection for lasers is based on a laser system with a total energy of 1 million joules at a maximum power of 100 trillion watts. The laser light would have a wavelength of .2 microns, which is about one-fifth that of the 1.06 micron wavelength of neodymium glass lasers. The energy efficiency of the laser system would have to be

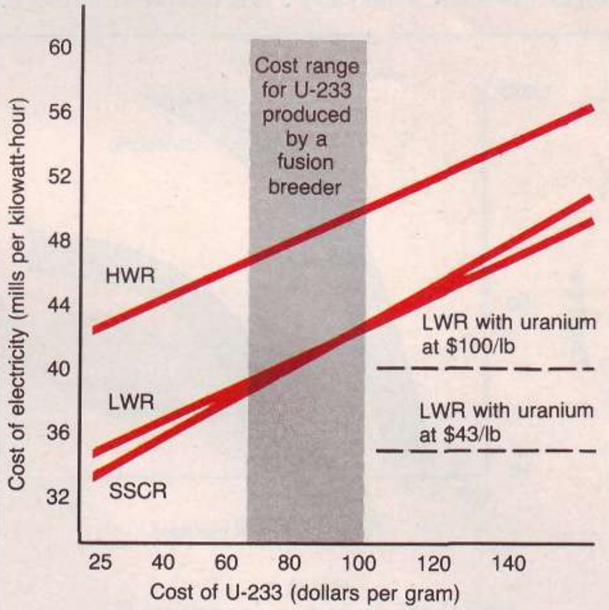


Figure 4
ELECTRICITY COST FROM A FISSION REACTOR FUELED BY A FUSION BREEDER
The cost of electricity produced from fission reactors that are fueled with uranium-233 from a laser fusion breeder based on an all-thorium cycle indicates that this system could supply the world with reasonably priced electricity for hundreds of years, the Livermore report concludes. The shaded region in the figure is the cost range found in the studies of laser fusion hybrids—from $65 to $100 per gram of uranium-233 bred from thorium. The cost variation is primarily a result of differing projected capital costs of the laser fusion breeder, which range from 2.5 to 3.0 times those of a conventional light water fission reactor.

HWR is a heavy water fission reactor; LWR is a light water reactor; and SSCR is a spectral shift control reactor.

greater than 1 percent, and the laser would have a repetition rate of four times per second.

The conservative laser projections are: 3 to 5 million joules total beam energy at .3 microns with a 6 percent laser efficiency and a maximum power level of 200 trillion watts.

For light ion and heavy ion beams, the optimistic and conservative projections are the same as those for laser beams in terms of beam energy and maximum power levels. In the measure corresponding to wavelength for laser beams, the energy per ion, the optimistic projection for light ions is 20 million electron volts; for heavy ions it is 20 billion electron volts. The respective conservative projected ion energies are 10 million electron volts for light ions and 5 billion electron volts for heavy ions.

In current experiments, Shiva produces laser pulses of 10,000 joules, with peak powers of up to 30 trillion watts at a wavelength of 1.06 microns and an efficiency of a fraction of 1 percent. When and if it is completed, Nova will generate short pulses at the same wavelength and efficiency, at 300 trillion watts; for longer, lower power pulses Nova has a total beam energy of up to 300,000 joules. Both of these glass lasers can be fired only several times a day, however.

As noted previously, Livermore is working on development of a krypton fluoride laser system that could meet the prerequisites for the conservative projections. But funding for this work at Livermore and elsewhere is at too low a level to attain any definitive results in the near future.

One alternative possibility noted in the Livermore report for meeting the conservative requirements with an existing laser technology is that of the carbon dioxide gas laser being developed at Los Alamos. It appears that the carbon dioxide laser is the exception to the theoretical analysis that predicts that the efficiency with which laser light is absorbed by a fusion target goes down with increasing laser light wavelength. This is quite important, because the carbon dioxide gas laser has a wavelength of about 10 microns.

The usual alternative mentioned for a reactor driver is that of heavy ion beam accelerators. This technology could readily achieve driver efficiencies of 20 to 30 percent. Although it is apparently the most straightforward in terms of technology needed,its development would be quite costly.

Light ion beam accelerators, such as the electron beam diode proton beam accelerating machines under development at Sandia Laboratories in New Mexico, are candidates for meeting the conservative projections at relatively low cost. Major progress in this type of accelerator has recently been demonstrated at Sandia, but there still are major questions in the development of a technology for propogating and focusing the beam onto the fusion target.

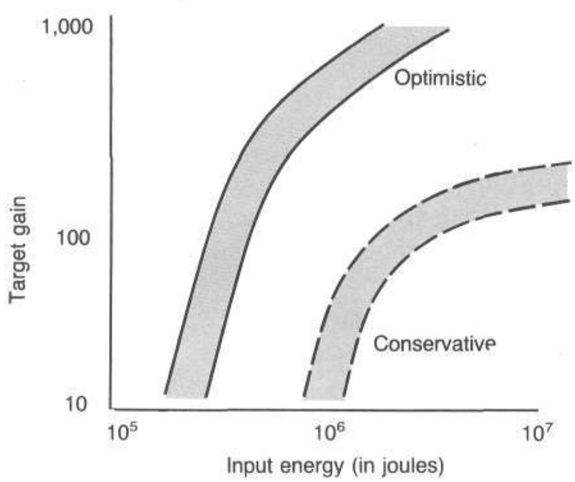


Figure 5
ESTIMATES OF FUSION TARGET GAIN VS. DRIVER ENERGY INPUT

To many observers it would appear that the prognosis for obtaining the sort of gains (fusion energy output divided by driver energy input) needed for practical inertial fusion power reactors has become more pessimistic over the years. Actually, looking back at previous Lawrence Livermore Annual reports, it is clear that the range of estimates has increased at both the conservative and optimistic ends of the total spectrum. The figure gives the most recent Livermore conservative and optimistic estimates of fusion target gain versus driver energy input (assuming appropriate peak power, wavelength, and voltage). Note that the conservative projection gives gains of only about 10 for 1-million joule driver input. To achieve gains of 100 or more, which are needed for an economical reactor, it may be necessary to go to driver energy inputs of several megajoules.

Subjects Not Covered

Among the crucial questions not covered in the latest Livermore annual report are high gain targets, impact fusion, magnetically insulated targets, and Rayleigh-Taylor instabilities, together with their impact on lower power, long pulse, high-gain targets, ion beam targets, and nonspherical targets.

These omissions are probably traceable to the Carter administration policy of increased secrecy. But there is strong evidence that another element is affecting the current situation—obstacles that demand actual scientific discovery. Researchers are encountering entirely new physical regimes like those only previously found in the core of stars, and these raise new scientific questions in mathematical physics. This does not mean that the inertial fusion program is failing. But in the context of insufficient funds for basic research and stricter classification policies that make the sort of general scientific dialogue needed to work through basic issues impossible, the appearance of failure and potential for misdirection of the program abound.

The Crisis in Inertial Fusion Research

In programmatic planning terms, the current crisis in inertial fusion research can be described as follows. Light ion and carbon dioxide laser drivers could prove inade-

How the Shiva-Nova Laser Works

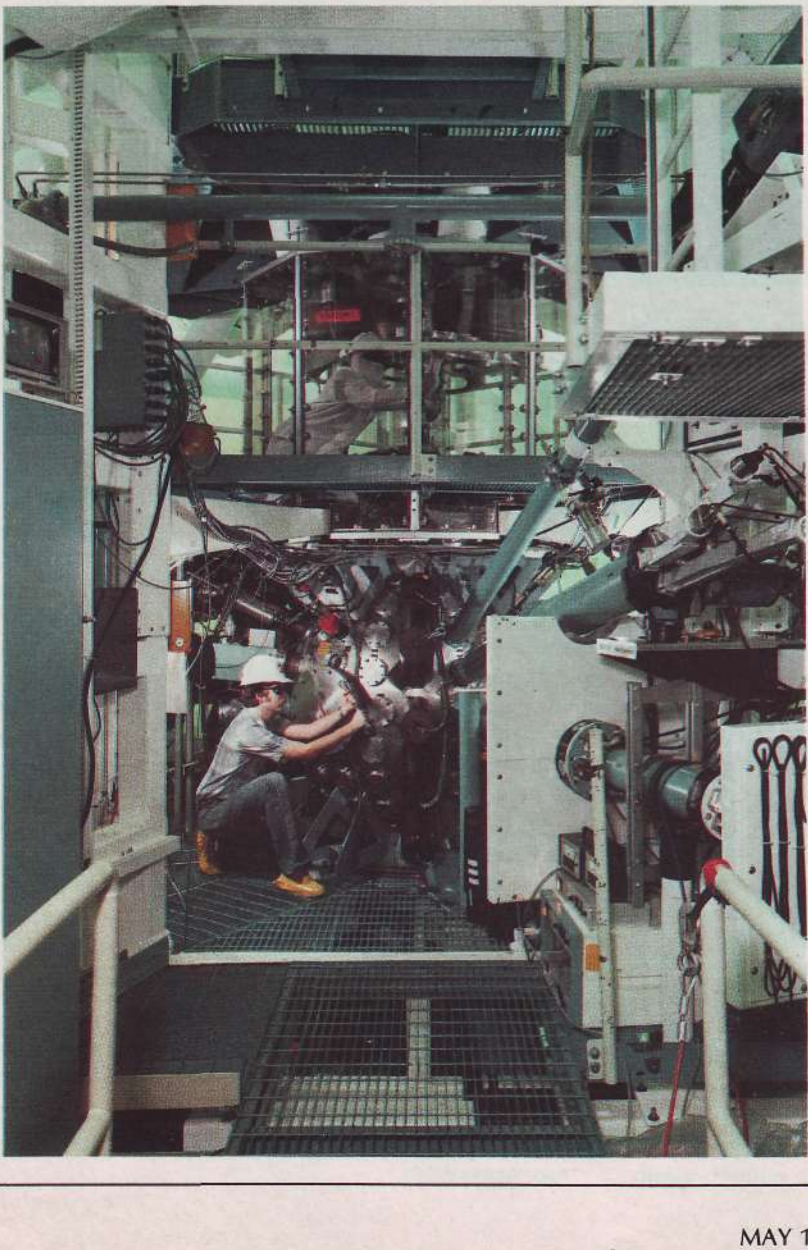
The 40-beam Shiva-Nova laser system at Lawrence Livermore Laboratory is a gigantic energy amplifier that transforms an input of several hundred megawatts of electrical current into a pulse of light with a power level of several hundred trillion watts. Hundreds of laser amplifiers make up the generating chain of the 40-laser beams. Two processes are involved: (1) the absorption of the energy input; and (2) the stimulated release of that energy in the form of laser light.

Within a few millionths of a second, the laser system's large capacitor bank releases enough current to power a huge metropolis. This rapid pulse of electrical energy lights the hundreds of flashlamps that surround the cylindrical cases of glass laser amplifier disks. The energy of this intense burst of light, as bright as the sun, is absorbed by the amplifier disks.

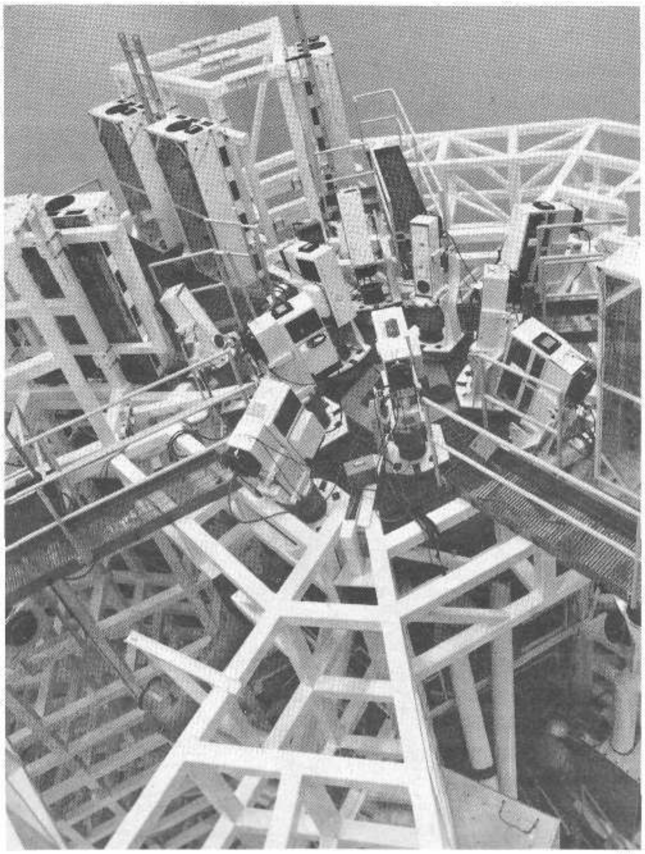
At this point, a minute pulse of laser light is directed into the long series of aligned amplifiers and travels through all of them in a few millionths of a second. In the process, this pulse stimulates the release of the flashlamp energy just absorbed by the amplifiers. The form of this stimulated release of energy is a beam of light at the same wavelength as the pulse. This new light is added to that of the pulse and transforms the initially tiny pulse into an intense beam of more than 1 trillion watts power.

Twenty such laser beam pulses are simultaneously formed and focused, using arrays of finely polished mirrors and other optical apparatus, onto a glass sphere less than a few hundredths of an inch in diameter. The glass microsphere is hollow, filled with hydrogen gas that consists of the two heavy isotopes of hydrogen, deuterium and tritium.

Within a billionth of a second the intense laser beams crush the microsphere and its contents to a density comparable with that of lead, heating the hydrogen interior to tens of millions of degrees. Under the huge pressures—several billion times atmospheric pressure—and temperatures—50 million degrees and more—the nuclei of the hydrogen atoms fuse to form the next heavier element, helium. In the process, mass is converted into energy.



Shiva target chamber, showing 10 upper and 10 lower beams entering in nested pentagonal clusters.
LLL



LLL

Shiva target area showing upper cluster of 10 pointing, focusing, centering return-beam diagnostics as well as 10 incident-beam diagnostics.

quate because of poor beam transport and energy coupling to the fusion target. As can be seen in Figure 5, the conservative projection—that a total beam energy to demonstrate high gain targets is above that of 1 million joules— is the best that can be achieved. It is therefore essential to begin development of an alternative, short wavelength, efficient gas laser or heavy ion beam driver now. The current workhorse of inertial confinement, high power glass lasers, cannot be economically scaled beyond 1 million joules total beam energy output. And the cost for building a 1 million-joule glass laser (several hundred million to a billion dollars) would be as great, if not greater, than the cost of developing the alternative driver technology.

Currently there is great pressure upon the inertial fusion program to get significant scientific results (target gains of 10 or more), especially from the perspective of military applications. Therefore, in order to attain the most rapid experimental schedule, the program is being forced to stay with glass lasers. As a result, scientific-technological catastrophe threatens. The program could find itself married to a "white elephant" billion-dollar glass laser, and falling far short of the sort of scientific progress needed for either commercial or military applications.

The scientific side of the current crisis in inertial fusion research is even more pernicious. From a military applications standpoint, the *raison d'etre* of the program is the massive reduction in scale of the implosion and fusion ignition processes otherwise found in the large, unobservable action of the H-bomb. Hydrogen bombs currently operate as high-gain fusion targets for soft X-ray radiation emitted by a relatively large fission atom bomb, providing a driver input at above the 1 billion joule level. The scale of such devices obviously prevents direct observation of the implosion and ignition processes; yet, despite the lack of verified theoretical knowledge, the H-bomb, from the pragmatic standpoint, works quite well.

Therefore, as the laser fusion effort runs into difficulties and new, unexpected results, the programs's managers tend toward a path that duplicates the approach used in H-bombs, opting for higher driver energies and shorter wavelengths approaching those of the A-bomb trigger's soft X-rays. Overly strict security classification further reinforces this tendency, as do Carter administration threats of funding cuts unless quick results are achieved. The H-bomb approach, at least, works.

But does it? H-bombs do work, of course, but the evidence is overwhelming that they do not work in the way scientists currently think they do. Computerized models simulating the supposed implosion and ignition processes do not, in fact, achieve the results recorded for actual H-Bombs. The reason is that the computer-simulated, prevailing interpretations are *linear* in method, whereas the key to fusion power processes is demonstrated to be the *nonlinear* behavior of all the important phenomena.

What, then, must be the result of an "H-bomb" theoretical and technological approach to controlled implosion and ignition on the microscopic level? Political and financial pressures could catch the U.S. program into a one-track dead-end path.

What should be happening? We know that inertial fusion works in the "uncontrolled" manner of those weapons systems that are the current basis of U.S. national security forces. We also know that the fundamantal processes involved are of crucial significance for science in general. Therefore, while the mainline track of using glass lasers up to the Nova scale must be maintained, the inertial program must be broadened to develop an alternative driver capable of economically going beyond the megajoule level. With that technological factor being taken care of, the so-called classification policies of the government must be rolled back, to permit the sort of open dialogue needed to explore the basic scientific issues thoroughly.

Because of government classification—for instance, the censorship of the Livermore Laser Program Annual Report—we and scientists elsewhere do not know what results and what progress is actually being made. But also because of that classification, we know that no progress is being made on the two essential matters just identified.

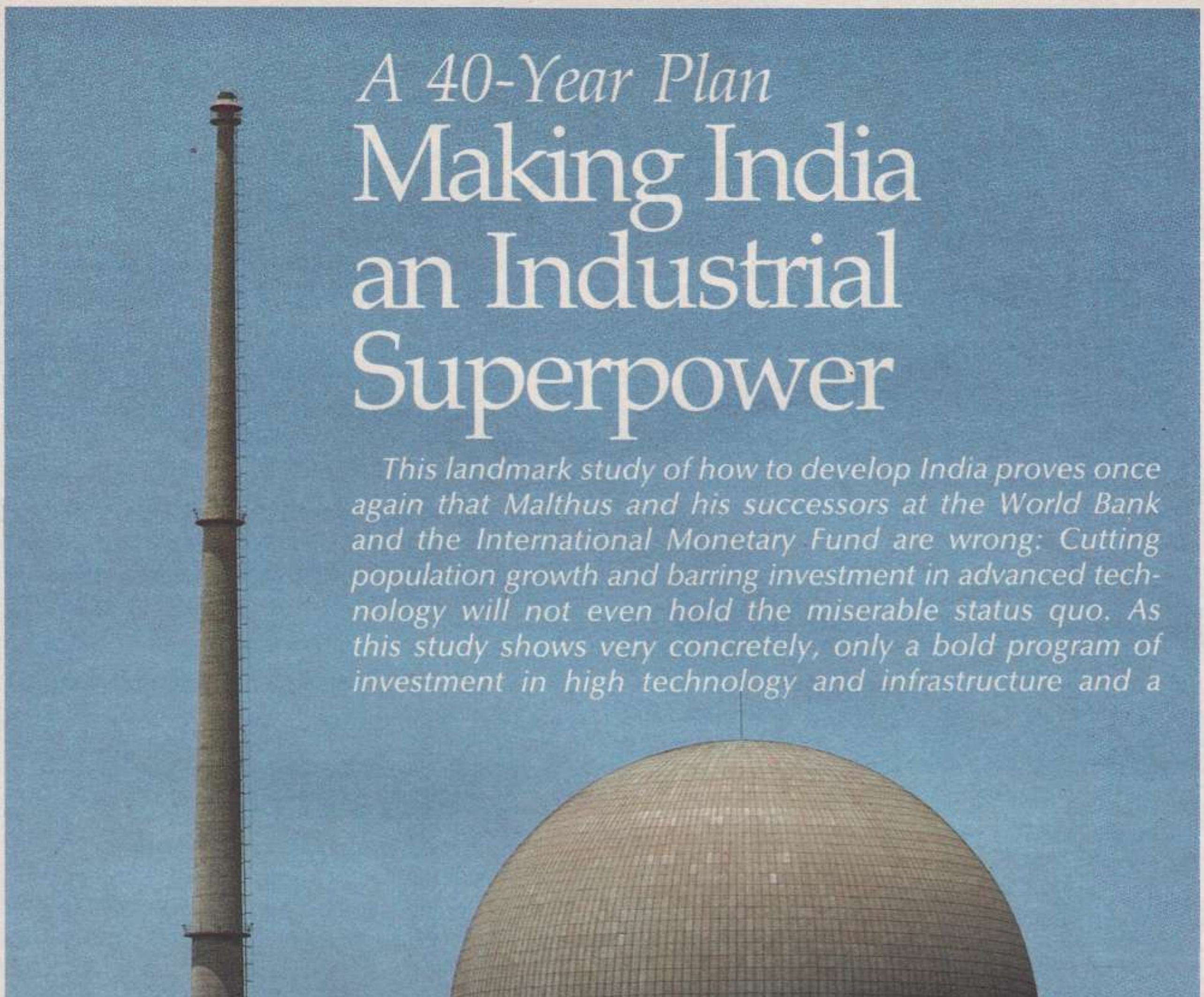
Notes

1. Charles B. Stevens, "Laser Fusion: A Review of the Lawrence Livermore Report," *Fusion*, October 1979.
2. UCRL-50021-78. Available from: National Technical Information Service, United States Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

A 40-Year Plan

Making India an Industrial Superpower

This landmark study of how to develop India proves once again that Malthus and his successors at the World Bank and the International Monetary Fund are wrong: Cutting population growth and barring investment in advanced technology will not even hold the miserable status quo. As this study shows very concretely, only a bold program of investment in high technology and infrastructure and a



India's Tarapur nuclear plant
Jehangir Gazdar Woodfin Camp and Associates

vast upgrading of the population's material and cultural level can transform India into an industrial power in 40 years.

The capital investment required for this program is entirely feasible—if the developed nations carry out the intentions of the European Monetary Fund, as it was conceived by the governments of France and West Germany. Investment on the scale required, for example, characterizes the oil-for-technology deals recently worked out between French President Giscard and several Arab nations. (See international section, this issue.) And as can be seen from the projected Indian outputs in the 40-year plan, the rate of return on such investments would be enormous, unlike the now largely uncollectable billions of dollars in Third World debt to institutions like the International Monetary Fund.

The specifics of the India program were calculated using the Riemannian economic analysis that was developed in spring 1979 in collaboration with the Fusion Energy Foundation. (See Fusion, *July 1979 for details.) A team of specialists from the FEF, the weekly* Executive Intelligence Review, *and Indian scientific and political circles used the Riemannian economic analysis to quantify in detail how much investment is necessary, what technologies are necessary, and what the results of any lesser-scale program will be.*

The India program was commissioned in July 1979 by Lyndon H. LaRouche, Jr., a Democratic presidential contender, after discussions with Indian scientists, engineers, and political leaders. The full 40-page study, which includes all the computer-generated data, is available at $50 per copy from the Executive Intelligence Review, *304 West 58th Street, New York, N.Y. 10019.*

Presented here are excerpts from the study, including an introduction by Uwe Parpart, director of research for the FEF; a discussion of the Riemannian economic analysis by Dr. Steven Bardwell, director of plasma physics for the FEF, and Peter Rush of the Executive Intelligence Review; *a section of the nuclear program by Jon Gilbertson, director of nuclear engineering for the FEF, and nuclear engineer Ramtanu Maitra; the history of the Indian nuclear program by* Fusion *energy news editor William Engdahl; a manpower summary by Paul Zykofsky, New Delhi correspondent for the* Executive Intelligence Review; *and a summary of the water management program by the FEF's Calvin Larson, an agricultural engineer specializing in water resources.*

Introduction

IN A SPEECH DELIVERED in the Lok Sabha (House of Parliament) on May 23, 1956 to initiate the debate on India's Second Five Year Plan, Prime Minister Jawaharlal Nehru spoke on the principles adopted by the Planning Commission in the preparation of its report:

> When we talk of planning we have to think in technological terms, because it is this growth of science and technology that has enabled man to produce wealth which nobody could ever have dreamed of. It is that which has made other countries wealthy and

The India Program: **Where Is It Going?**

Fusion magazine asked Daniel Sneider, editor-and-chief of the weekly political and economic intelligence journal Executive Intelligence Review, *to comment on the prospects he sees in India for implementing the 40-year plan. A long-time journalist and specialist on Asian affairs and on issues of Third World development, Sneider's writings have been widely published throughout Asia, in newspapers and magazines from Sri Lanka to Pakistan to India. He is also the recipient of the Silver Medal Award from the Bhutto Shahed Memorial Trust for his efforts to save the life of former Pakistani prime minister Zulfikar Ali Bhutto.*

As the editor of the *Executive Intelligence Review*, I am pleased to have *Fusion* magazine feature the 40-year program for the industrialization of India in this issue.

This program is not an academic effort; it is intended to shape the policy of prominent scientists, planners and governments. The India 40-year plan has already been published in India by the Committee for Democratic Action, a multipartisan group of Indian civic leaders, scientists, and economists. With the assistance of the widely read Indian weekly newspaper *New Wave*, the program has already received wide circulation and created great interest, especially among those leaders who will be shaping the economic policies of Prime Minister Indira Gandhi's government. Similarly, the program has reached the desks of government and private business leaders in Western Europe, particularly in France and West Germany.

The realization of this program will be the subject of a series of special seminars and conferences in Western Europe, cosponsored by the Fusion Energy Foundation and the *Executive Intelligence Review*, with the assistance of *New Wave*. One-day seminars will be held April 25 in Rome and April 28 in Paris, to be followed by a major conference in Frankfurt, West Germany. A number of prominent Indians are expected to participate, including representatives of the Indian government, as well as scientists, economists, and businessmen from the United States and Europe. Similar efforts are also planned to take place in India under Indian sponsorship.

In summary, we see this program and its spinoffs as only one part of a broad campaign to educate and motivate governments and policy makers on the kind of economic development and planning necessary to guarantee a future for us and for the rest of the world.

prosperous, and it is only through the growth of their technological process that we shall grow and become a prosperous and wealthy nation; there is no other way....Therefore, if India is to advance, she must advance in science and technology, and India must use the latest techniques, always keeping in view, no doubt, the fact that in doing so, the intervening period, which is inevitable, must not cause unhappiness or misery....But the fact is that our poverty is due to our backwardness in science and technology, and by the measure that we remedy that backwardness, we create not only wealth but also employment.

This report on the future industrial development of India was prepared in the spirit that guided Nehru's 1956 remarks, although—as he would be happy to note—its proposed goals and objectives well exceed those he envisaged 25 years ago. The report's principal conclusion is that in the 40-year period between 1980 and 2020, India, while almost doubling the size of its population from 660 million to slightly less than 1.2 billion, is entirely capable of advancing from abject backwardness to the status of a modern industrialized nation with an educated population and an industrial infrastructure comparable to those of the Soviet Union today.

This of course presupposes precisely what Nehru demanded: utilization in the development process of the latest, most advanced production technologies rather than reliance on the World Bank or Club of Rome "appropriate technologies" concept that stresses labor-intensive production methods and technologies appropriate only to the present backwardness of the overwhelming majority of the population. Nor can a gradual "organic growth" approach to economic development be expected to alleviate India's misery. This is the type of growth currently advocated by the Club of Rome in contraposition to the allegedly cancerous exponential growth experienced by the advanced sector nations during the past century and one-half.

A Well-Defined Shock

Nothing but a sharp, well-defined shock delivered to the entire economy, especially to the dominant but at best marginally productive rural and so-called unorganized sectors, will break the cycle of underdevelopment. This will be accomplished by marshaling the 10 million most highly skilled Indian workers along with India's extraordinary and well-qualified corps of scientists and engineers. A necessary initial infusion of imported capital will bring this concentrated force to bear on two principal objectives:

First, a nuclear-based energy development program to power the industrialization process. By 1990, 10 years into the program, more than 50 1,000 megawatt-electric nuclear power plants should either be operating or in various phases of construction. Simultaneously, the first nuclear-centered agroindustrial complexes; so-called nuplexes, will come on line and become the highly productive cores of several major new cities. This will spearhead a rapid urbanization process, which, by the turn of the century, will have increased the share of the urban population from today's 22 percent to almost 33 percent. Detailed plans for

United Nations/J.P. Lafonte

'India has enormous agricultural potential—if advanced-sector levels of energy throughput are realized': Here tractors are being assembled at a New Delhi factory.

nuplexes at two separate locations were initially drawn up in the mid-1960s by the Atomic Energy Commission of India and Oak Ridge National Laboratory in the United States.

The extent to which worldwide energy development, industrial development, and standard of living go hand-in-hand is evident, and there should be no illusions about the fate of tens of millions of Indians between now and the year 2000 if the "hard technology" energy program detailed below is not enacted.

This fact is well known in India. As the great Indian scientist Homi Jehangir Bhabha remarked in 1955 before the Geneva Conference on the Peaceful Uses of Atomic Energy, "For the full industrialization of the underdeveloped areas, for the continuation of our civilization and its further development, atomic energy is not merely an aid; it is an absolute necessity."

The second principal target area for Indian economic development is water management—the huge but entirely unavoidable task of harnessing the subcontinent's immense water resources in order to break the deadly, centuries-old cycle of droughts and flood and to replace one of the world's least productive rural economies with a modern agricultural industry. Although now only the Ganges carries sufficient water during the dry season, India's other rivers, if properly dammed up and channeled, could put the whole country under two feet of water year round and, in addition, produce at least 40,000 megawatts of hydroelectric power—four times the present amount.

The irrigation and power reserves stored up in India's river and hydroelectric balance thus are enormous and require a commensurate effort for their development and activation. It is proposed here that a National Water Management System of the kind first put forward by former irrigation minister K. L. Rao, representing an approximate total investment of $180 to $200 billion over a 30-year period, become the single largest industrial construction project for the subcontinent. This plan, through the required manpower and capital resources mobilization and its massive impact upon the productivity of agriculture, singularly exhibits the shock properties for the economy mentioned above.

Concomitant with the high-impact nuclear energy and water development project, an in-depth mass literacy and education policy must be adopted to eradicate illiteracy, which still afflicts close to 70 percent of the population. The problem was defined in the 19th century by Jamsetji Tata, the founder of one of India's largest industrial concerns. Speaking of the preconditions of industrialization in 1876, he listed these priorities: "Knowledge and know-how. And once again, knowledge, know-how, and experience. In addition our own iron and steel. Plus our own cheap electricity."

Through the expansion of primary education, the broadening of secondary education to enlarge the base of an already (in many areas) qualitatively excellent higher education program educating the teachers of the next generation, and the targeted development of adult manpower training programs geared toward specific industrial projects, illiteracy can be substantially eliminated by the turn of the century. At that point, what now appears as India's greatest liability and is defined by the World Bank as the principal barrier to its development, its population, will turn out to be its greatest asset. In 2020, the final years in the projections for this program, the productive industrial (nonagricultural) labor force will reach between 230 million and 240 million—greater than the world's entire manufacturing work force today.

The Agricultural Potential

Agricultural labor will decline to around 130 million. But India's agricultural potential is so large, the gap between the present production per hectare and the productivity levels reached in advanced-sector countries so wide, that the water and energy inputs provided for by the water and nuclear projects will transform the country into a major exporter of agricultural goods.

Here are some of the relevant figures: India now has about 190 million hectares under cultivation, which could easily be increased by 20 to 30 percent; but even of the existing cultivated land on average only two-thirds was sown in recent years. Even more telling, U.S. farmers use 90 times the amount of fertilizer per hectare as their Indian counterparts.

These figures demonstrate the enormous development potential of Indian agriculture—if advanced-sector levels of energy throughput, representing higher degrees of mechanization, irrigation, and fertilization, are realized. But these same figures, left unchanged and juxtaposed to present consumption levels of the population, show an equally enormous potential for ecological catastrophe. Out of 660 million Indians, 360 million, well over half of the population today, receive less than the government-designated daily minimum requirement of 1,900 calories, and this minimum is already 500 calories fewer than what is specified by advanced sector countries for their populations. At least a half-million people die of malnutrition every year, and the mortality rate of children under five years of age has risen from 32.2 percent in 1951 to 36.1 percent in 1976.

These last figures are the most telling, but the trend they indicate can be reversed. The physical parameters generated by the program presented here allow us to chart a navigable course for India that will find the country well on its way toward advanced-sector status by the turn of the century.

Politically, and as a matter of historical record, it is not unimportant to point out at this juncture that India today is not so much an underdeveloped country as it is a country that was ruined by centuries of British colonial rule and imposed backwardness. As late as the 17th century, India was a developed country by the standards of that time and throughout its long history had, over several protracted periods, achieved cultural heights and initiated developments exemplary for the rest of the world. "Arabic" numerals should rightfully be called "Indian," advanced techniques of iron and textile production have their origin in India, and, at the time of Emperor Ashoka in the third century BC, India had the world's most highly developed

Table 1
SELECTED PHYSICAL PARAMETERS OF THE ECONOMY

	Electricity						Steel	Cement
Year	Annual required amount (billion kilowatt-hours)	From hydro	From coal	Deficit	From nuclear program	Net surplus	(Million tons)	(Million tons)
1980	120	36	83	1	1	0	12	22
1985	213	56	128	29	40	11	24	33
1990	380	96	156	128	180	52	44	50
1995	675	128	156	391	430	39	78	76
2000	1,202	160	156	886	906	20	125	115
2005	2,138	—	—	—	—	—	200	174
2010	3,803	—	—	—	—	—	300	263
2015	6,765	—	—	—	—	—	450	397
2020	12,635	—	—	—	—	—	700	600
Growth rate 1980-2020	12.2%	—	—	—	—	—	11.2%	8.6%

educational system. Through what nowadays would be called an agricultural extension service, new cultivation and irrigation techniques were spread throughout the land, and in 1950 Pandit Nehru consciously adopted several of Ashoka's ideas and guidelines to demonstrate the continuity of his service as prime minister with that of his great ancestor.

Recovering Historical Greatness

India must now reconnect its destiny to this tradition, and in attempting to do so, it will find itself confronted every step of the way by today's disciples of the British East India Company's most evil product, Thomas R. Malthus.

An ugly mixture of updated Malthusianism and cultural relativism is presented in the chapter "India and the West" of Arnold Toynbee's *The World and the West*. Explaining that Western culture on the planes of technology and science, language and literature, administration, and law, is "extremely alien" to Indians, he voices his hypocritical concern, "the tension in Hindu souls must be extreme, and sooner or later it must find some means of discharging itself."

Aside from the social catastrophe implied by such an "emotional discharge," there looms, according to Toynbee, the truly unsolvable problem of overpopulation: "Since progressive movements in productivity must sooner or later bring in diminishing returns, the standard of this swollen population seems bound to decline, and there is no margin between the present standards and sheer disaster on the grand scale."

To the extent that India's present political leadership understands the very palpable threat behind Toynbee's theorizing will it be able to recover India's historical greatness following the course outlined two decades ago by Nehru and the scientific elite exemplified and organized by Bhabha.

The Riemannian Model

To arrive at reliable quantitative estimates for the general parameters characterizing India's economic development, the three major projects for nuclear energy, water resources, and manpower development mentioned in the introduction were embedded in a more comprehensive model describing the economy as a whole in terms of five major sectors: agriculture, steel, construction, nuclear, and a residual sector that covers all remaining areas.

A detailed computerized analysis of the model was then carried out using the method of the Riemannian economic analysis, which was developed specifically to solve analytical problems of this sort that involve evaluation of the impact on productivity and economic growth of large-scale, high-intensity technology development projects. In contrast to conventional econometric models, the Riemannian economic analysis is based on a fundamental distinction between the productive components of an economy—those which contribute to further expansion of economic activity and output—and nonproductive components—those aspects of consumption that are a net tax on the capabilities of an economy for further growth.

This distinction is used to generate a dynamic set of equations that describe the interrelations between capital investment, productivity, living standards, and technological development. These four factors are regarded as the principal determinants of economic development and form the core of the Riemannian economic analysis quantification of economic activity.

However, rather than observing trend lines for these factors and projecting them into the future, as competing econometric models do, the Riemannian analysis is designed to investigate causal relations and generate growth rate values based on calculation of the actual investment

Table 2
NET FOREIGN CAPITAL

Year	Surplus generated (billion rupees)	Required capital import	Percentage of national income
1980	72.1	2.05	2.45
1985	112.9	3.25	2.37
1990	156.9	3.66	1.48
1995	272.0	4.85	1.21
2000	435.0	5.95	0.91
2005	734.0	8.16	0.79
2010	1,258.4	8.66	0.52
2015	2,202.4	7.38	0.28
2020	4,331.8	–2.13	–0.049

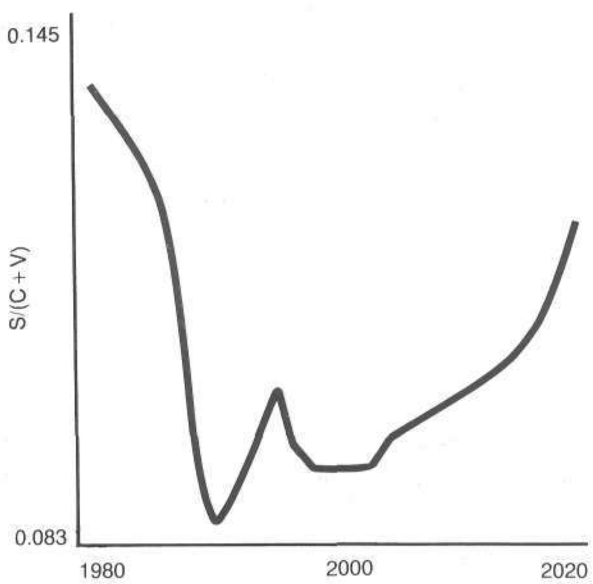


Figure 1
REPRODUCTIVE RATIO OF THE INDIAN ECONOMY

This graph from the 40-year development plan projects Indian economic growth through the year 2020 on the basis of the Riemannian economic analysis computerized model. The reproductive ratio is defined as $S/(C+V)$, where C is the relative reproductive cost of plant and raw materials, V is the relative cost of maintaining the productive labor force, and S is relative surplus as tangible output available to expand the total economy by combined increases in C and V. By using existing resources and realizing the applications of new technology, the reproductive ratio will rise dramatically after the first 10 years of the plan. The sharp decrease of the first 10 years is the result of mandatory initial investment costs (C and V) prior to the turn-of-the-century take-off.

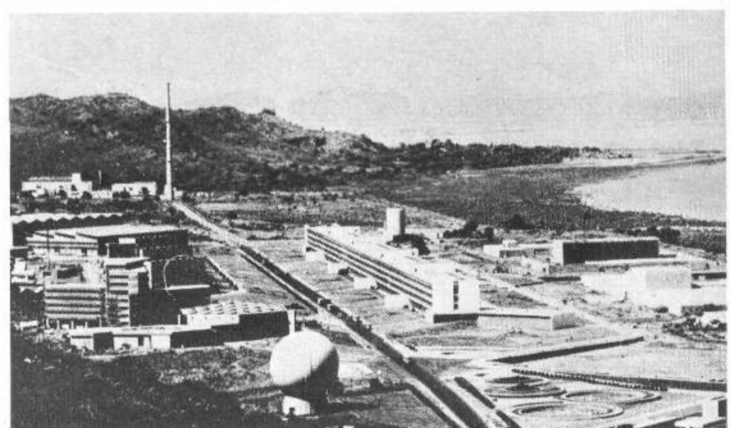
decisions that are the cause of economic growth. As a result, the model is capable of providing accurate information on the constraints to achieving certain levels of growth and permits reliable evaluation of whether or not specified goals are attainable and realistic.

For the detailed Riemannian study of the problems of India's industrial development, a data base was prepared that consists of two "economic states." The first is an estimate of the growth potential of the Indian economy as it stands today. Given the stagnation of the Indian economy over the past several years, 1976 figures—the last set of data complete enough for the model—were chosen as indicative of the highest productivities and capacities of the economy. Thus, all "initial state figures" represent 1976 prices and all values in the tables and graphs are in constant 1976 rupees.

Second, a "final state," to be achieved in 40 years, was chosen. This state is required to correspond to the economic profile of a large-scale present-day industrial economy which, however, retains a relatively large agricultural sector. Such a final state is best approximated by the economy of the Soviet Union, not in terms of absolute levels of output and employment, but in terms of the internal ratio of agriculture to manufacture, rates of productivity, and per capita material consumption.

The principal questions the computer analysis then allows us to answer are the following:

(1) Is it possible to start with the Indian economy in its present state and reach the hypothetical industrialized state 40 years from now? That is, is there a trajectory



'The heart of the Indian nuclear program': The Bhabha Atomic Research Center near Bombay.

Table 1
SELECTED PHYSICAL PARAMETERS OF THE ECONOMY

	Electricity						Steel	Cement
Year	Annual required amount (billion kilowatt-hours)	From hydro	From coal	Deficit	From nuclear program	Net surplus	(Million tons)	(Million tons)
1980	120	36	83	1	1	0	12	22
1985	213	56	128	29	40	11	24	33
1990	380	96	156	128	180	52	44	50
1995	675	128	156	391	430	39	78	76
2000	1,202	160	156	886	906	20	125	115
2005	2,138	—	—	—	—	—	200	174
2010	3,803	—	—	—	—	—	300	263
2015	6,765	—	—	—	—	—	450	397
2020	12,635	—	—	—	—	—	700	600
Growth rate 1980-2020	12.2%	—	—	—	—	—	11.2%	8.6%

educational system. Through what nowadays would be called an agricultural extension service, new cultivation and irrigation techniques were spread throughout the land, and in 1950 Pandit Nehru consciously adopted several of Ashoka's ideas and guidelines to demonstrate the continuity of his service as prime minister with that of his great ancestor.

Recovering Historical Greatness

India must now reconnect its destiny to this tradition, and in attempting to do so, it will find itself confronted every step of the way by today's disciples of the British East India Company's most evil product, Thomas R. Malthus.

An ugly mixture of updated Malthusianism and cultural relativism is presented in the chapter "India and the West" of Arnold Toynbee's *The World and the West*. Explaining that Western culture on the planes of technology and science, language and literature, administration, and law, is "extremely alien" to Indians, he voices his hypocritical concern, "the tension in Hindu souls must be extreme, and sooner or later it must find some means of discharging itself."

Aside from the social catastrophe implied by such an "emotional discharge," there looms, according to Toynbee, the truly unsolvable problem of overpopulation: "Since progressive movements in productivity must sooner or later bring in diminishing returns, the standard of this swollen population seems bound to decline, and there is no margin between the present standards and sheer disaster on the grand scale."

To the extent that India's present political leadership understands the very palpable threat behind Toynbee's theorizing will it be able to recover India's historical greatness following the course outlined two decades ago by Nehru and the scientific elite exemplified and organized by Bhabha.

The Riemannian Model

To arrive at reliable quantitative estimates for the general parameters characterizing India's economic development, the three major projects for nuclear energy, water resources, and manpower development mentioned in the introduction were embedded in a more comprehensive model describing the economy as a whole in terms of five major sectors: agriculture, steel, construction, nuclear, and a residual sector that covers all remaining areas.

A detailed computerized analysis of the model was then carried out using the method of the Riemannian economic analysis, which was developed specifically to solve analytical problems of this sort that involve evaluation of the impact on productivity and economic growth of large-scale, high-intensity technology development projects. In contrast to conventional econometric models, the Riemannian economic analysis is based on a fundamental distinction between the productive components of an economy—those which contribute to further expansion of economic activity and output—and nonproductive components—those aspects of consumption that are a net tax on the capabilities of an economy for further growth.

This distinction is used to generate a dynamic set of equations that describe the interrelations between capital investment, productivity, living standards, and technological development. These four factors are regarded as the principal determinants of economic development and form the core of the Riemannian economic analysis quantification of economic activity.

However, rather than observing trend lines for these factors and projecting them into the future, as competing econometric models do, the Riemannian analysis is designed to investigate causal relations and generate growth rate values based on calculation of the actual investment through the economic phase space spanned by the parameters of our model that has today's Indian economy as its starting point and that after at most 40 years passes through the state of development of an economy like the Soviet one in 1980? The answer is by no means obvious, as becomes clear if we compare present per capita energy consumption—the best indicator of overall economic development—in India and in the Soviet Union. The figure for India is 221 kilograms of coal equivalent per capita per year; for the Soviet Union it is 5,546 kilograms. The figures differ by a factor of 25; and given that India's population will almost double between 1980 and 2020, total energy for domestic consumption must increase 40 to 50 times in this time period.

(2) If such development is possible, what rates of capital investment, what productivity increases, and what rates of manpower development are required to realize it?

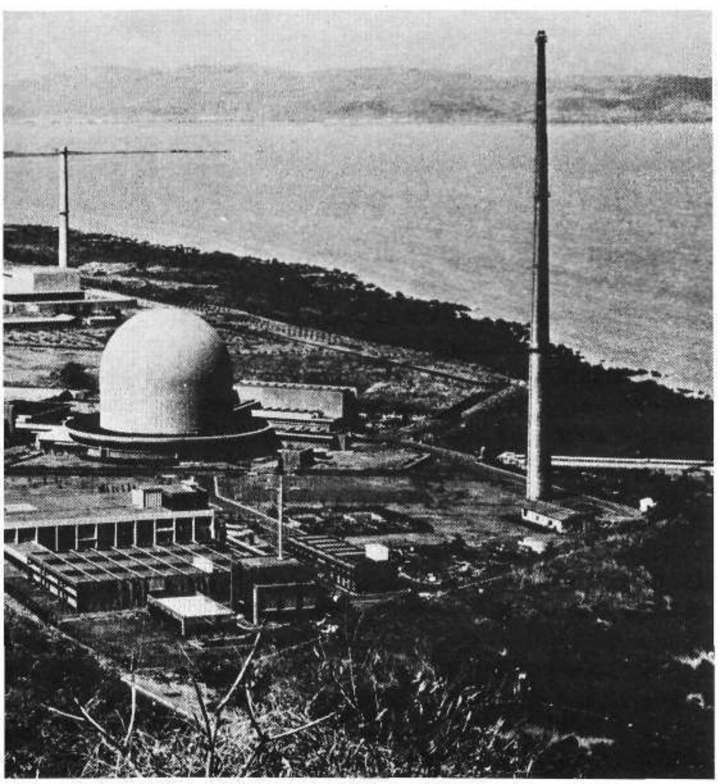
(3) Given political and economic constraints, what is the investment strategy that will minimize the investment required to achieve the set of development goals?

The details of the investment plan developed in answer to these questions are contained in the full report and summarized in the charts and graphs of the report's appendix, which give a sector-by-sector breakdown of the productivities projected, the capital investments required, the investment strategies for each sector, and the total impact of the development plan on the economy and population.

The conclusions of the analysis are unequivocal: The projected development of India is not only possible, but is achievable within the bounds of relatively modest (though sustained) increases in productivity and capital investment.

In searching for possible development trajectories we studied several proposals by a variety of institutions and think tanks. In particular, a simulation of the World Bank trajectory was prepared that showed some striking aspects of economic development. If we assume that population growth is not halted, yet economic stagnation continues as the World Bank projects, we found that such stagnation could continue for roughly seven to eight years, at which point a rapid and irreversible economic collapse took place. This catastrophic megadepression is a *singularity* in the Riemannian sense of the term and is not a mathematical fiction. However, the solution the World Bank proposes is not economic development, but decreasing population.

In this study, several simulations were prepared to study this alternative, which found that if one is willing to accept a *decline* in population of 30 percent, then a quasi-steady state can be reached in the India economy. However, this steady state has the interesting property of being an unstable steady state. Any small perturbation will precipitate a similar megadepression catastrophe. We found that a decrease in the investment of the order of $10 *million* in the economy in this "steady state"'—the order of magnitude of loss that a severe storm would cause—would result in the renewed descent of the economy into the above described singularity of collapse. The fact is that the much-touted steady state of the World Bank does not exist; an economy either grows and progresses or it collapses. There is no third alternative.



Information Service of India

Nuclear Energy: The Foundation of Growth

Today India produces fewer than 50 gigawatts of energy. To meet its development goals, India must produce 365 gigawatts energy of which 286 gigawatts will come from nuclear power. By the second decade of the development program, India will be an exporter of nuclear power plants to its neighbors.

Meeting that requirement means bringing on line 316 nuclear plants in India, 190 of them imported, and exporting another 58.

India will also become the first nation in the world with operating nuplexes. Beginning in 1980, India will begin the designing and building of nuplexes, or agroindustrial complexes, in which the nuclear power plant is the hub for a network of industrial and irrigated agricultural production.

Why Nuclear Power?

Hydroelectricity and coal and oil-powered fuel capacity will provide 79 gigawatts of India's total energy by the year 2005, a little more than one-fifth of the total.

Although hydroelectricity is cheaper than nuclear power, its future capacity in India is relatively limited and it is usually located far from the areas where it is needed. When fully developed it can provide only about 40 gigawatts of India's power.

India does have large deposits of coal and although it is of a low grade (high-sulphur-content lignite, and so on), it can be burned in fossil fuels-based plants. However, the coal is also located far from the areas that need it, making transport costs high. Thus, compared to nuclear power, coal electricity is more costly.

Over the next 10-year period, India's coal-based electricity will be increased, requiring at least a doubling of India's current coal production capability. As nuclear power plants are brought on line, coal and other fossil fuel resources will be diverted to more productive uses—petrochemicals, steel, and fertilizer industries.

India's cheapest energy source is the thorium-based nuclear plant. India has the largest reserves in the world of thorium, a potential nuclear reactor fuel—more than 500,000 tons presently are now known, with undoubtedly more to be discovered. If this resource can be efficiently tapped, it can become the cheapest way for India to produce electricity. Thorium can also become a resource for export, creating a major income generator for India.

India must immediately launch a program for its own CANDU design and construction for plants of the 1,000 megawatt-electric size, quickly ending its reliance on Canadian CANDU technology. Uranium fuel for these reactors will come in small part from India's tiny uranium ore supply; but the bulk of it must be imported until the breeder reactors come on line. This ore could come from several locations—most likely Australia, Canada, or the Soviet Union.

At the same time, India must begin importing liquid metal fast breeder reactors (LMFBR). The current plan is to build up an inventory of plutonium, a reactor fuel produced in the CANDU reactor, and use it to fuel the LMFBRs. The fast breeder moves India to the thorium fuel cycle because it is able to convert thorium into U-233 fuel, which can be used effectively in any reactor.

Thus, India's CANDU reactors and imported light water reactors will produce plutonium, which will fuel the fast breeders, which, in turn, will produce U-233 in their thorium blankets and plutonium in their fuel regions. Both fuels can be used to fuel more fast breeders, LWRs, CANDUs, high temperature gas reactors, or a combination of all of these.

The goal of the nuclear energy program is to install in

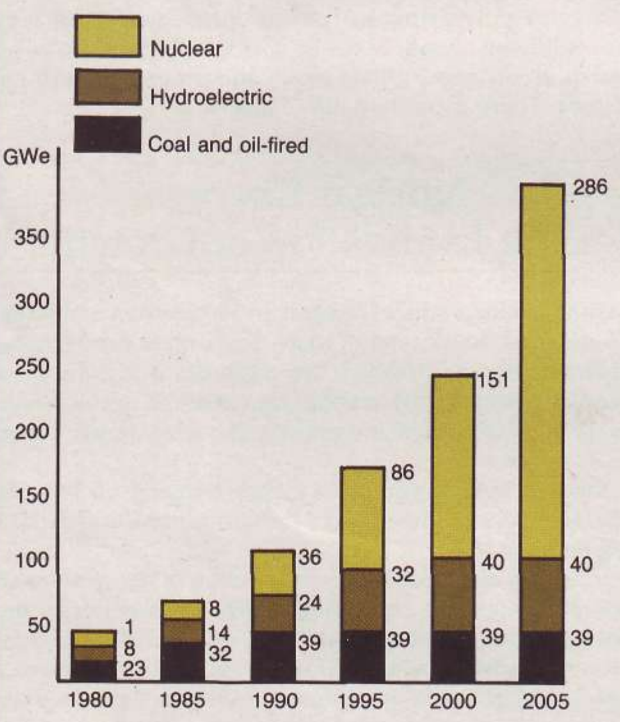


Figure 2
TOTAL POWER-GENERATING CAPACITY
Shown here in gigawatts-electric is the increase in total power-generating capacity projected over the first 25 years of the program. Nuclear energy, which now supplies 1 percent of India's capacity, will supply 78 percent by the year 2005.

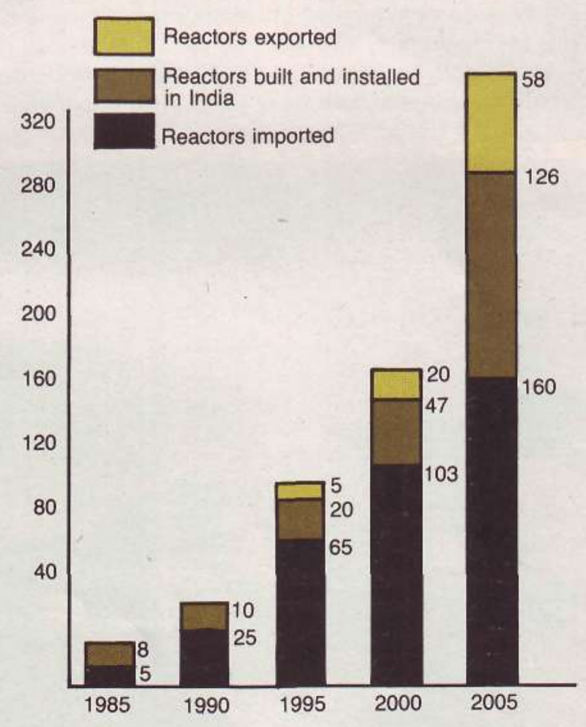


Figure 3
NUMBER OF REACTORS IMPORTED, BUILT AND EXPORTED
During the first 25 years of the program, 316 nuclear plants are slated to come on line in India, 58 of them built for export.

India about *150 nuclear reactors, averaging 1,000 megawatt-electric capacity each, by the year 2000.*

In the same time frame, India will develop the capacity to export 20 reactors, produced by Indian skilled labor in Indian-owned and operated production facilities. India's electrical generation by the year 2000 will be 185 to 190 gigawatts, up from the present figure of 26 to 28 gigawatts. Of this total capacity, 80 percent will be nuclear.

In its first phase especially, India will have to rely upon imports. It will import 16 light water reactors, five of which will be floating nuclear plants; six high temperature gas reactors; and three fast breeders.

The country most advanced in the development of the fast breeder is France, and it is the most likely source for India's imports. France has the 1,200 megawatt-electric Super-Phenix power plant under construction, scheduled for completion in 1983. India is already working with France in constructing a 15 megawatt-electric experimental fast breeder slated for operation in the early 1980s. This effort should be expanded and advanced so that India will have several commercial-size LMFBRs coming on line by 1990. The Soviet Union, the United States, West Germany, and Britain also have the capability to supply India with the 37 fast breeders it will need to import by the year 2005.

Before the year 2000, when India can begin building its own, it will import 12 high temperature gas cooled reactors (HTGR). The HTGR is especially required for nuplexes because it supplies high temperature process heat for industry. This reactor is already a developed system in both the United States and West Germany and should be ordered almost immediately from these sources.

During the second decade of the development program, India will import 26 LWRs, 19 of them floating nuclear plants; six high temperature gas reactors; and eight fast breeders. After the turn of the century, the balance will shift to importing only floating nuclear plants, HTGRs, and fast breeders.

India's goals for domestic production are 45 CANDUs, seven HTGRs, and five fast breeders by the year 2000. By 1990, India will build 10 CANDU reactors. By the middle to the end of the second decade, India will begin construction of its own version of the fast breeder and HTGR. These designs will be based on the experience gained from those imported plants.

Table 3
NUCLEAR DEVELOPMENT PROGRAM MILESTONES

1980	Begin accelerated expansion of Indian CANDUs construction program.
1985	Construction of Indian CANDUs and import of LWRs, HTGRs and LMFBRs begin on large scale.
1988	First nuplex comes on line.
1990	Delivery of first floating nuclear plant (LWRs). Operation of world's first nuplexes begin. Starting of India's first LMFBR initiates India's transition into the thorium fuel cycle.
1995	India completes construction of first CANDUs for export to developing nations. India begins fuel reprocessing and fuel fabrication on large scale.
2000	India produces first floating CANDU. Construction of Indian-designed and Indian-built LMFBRs and HTGRs begins on a large scale. Use of converted thorium-to-uranium fuel begins in significant quantity.
2005	Imports of LWRs peak out and begin to decline as the construction of Indian CANDUS and advanced reactors (LMFBRs and HTGRs) rapidly expands.
2008	India completes construction of first LMFBRs for export to developing nations.
2010	Fusion-fission hybrid reactor "fuel factories" begin coming on line to accelerate India's conversion of thorium to uranium fuel.

India's Nuclear History

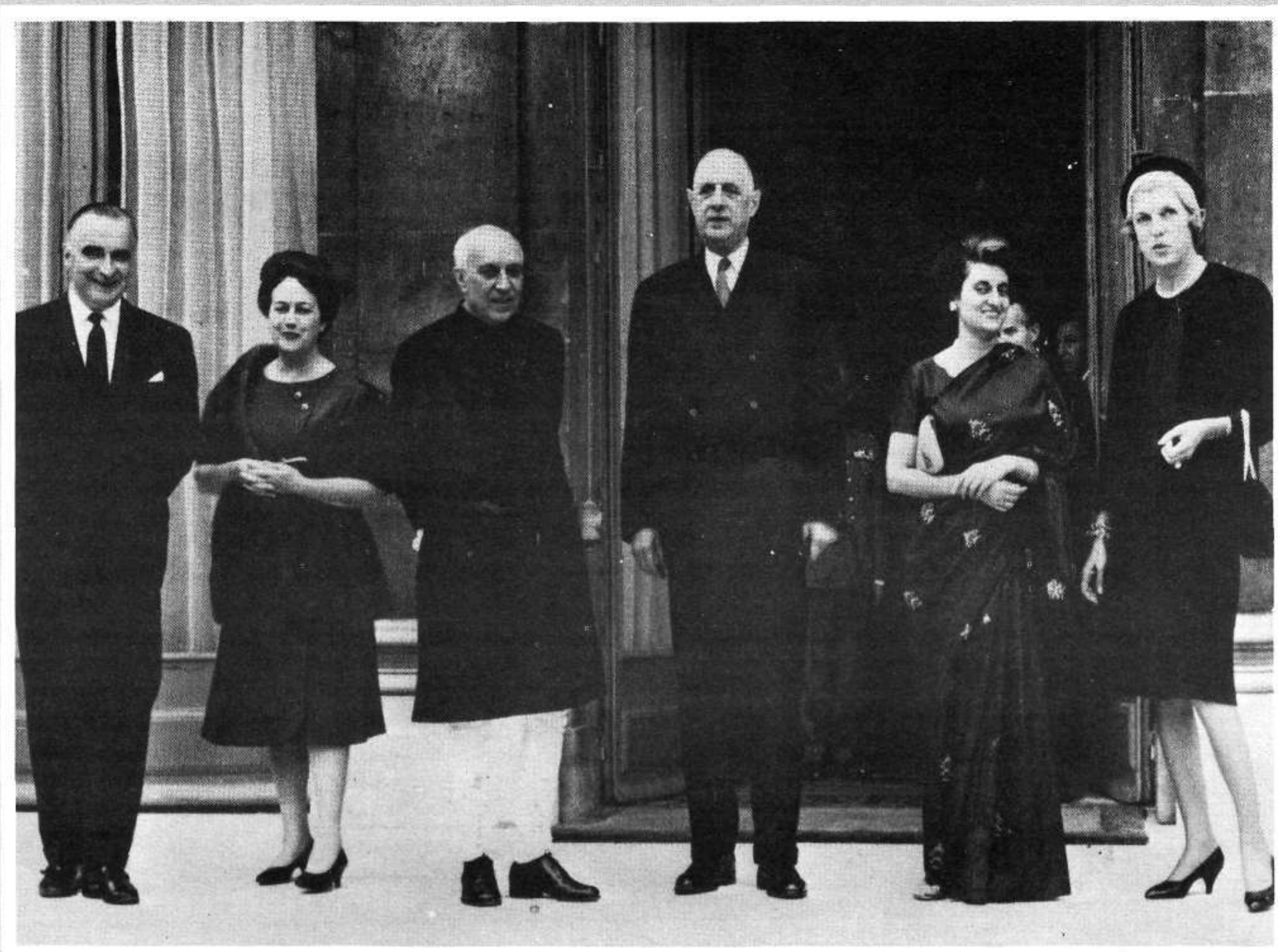
This ambitious nuclear program is well in the tradition of India's nuclear energy history.

In 1955, Dr. Homi Bhabha, father of the Indian nuclear program, told the first United Nations Conference on Peaceful Uses of the Atom:

> It is well known that atomic energy can be obtained from a fusion process as in the H-bomb, and there is no basic scientific knowledge in our possession today to show that it is impossible for us to obtain this energy from the fusion process in a controlled manner. The technical problems are formidable, but one should remember that it is not yet 15 years since energy was first released in an atomic pile by Fermi. *I venture to predict that a method will be found for liberating fusion energy within the next two decades.* When this happens, the energy problems of the world will truly be solved forever for the fuel will be as plentiful as heavy hydrogen in the oceans. The so-called barriers of science have again and again in the past proven surmountable by man [emphasis added].

This is the vision and optimism that shaped the development of India's nuclear research program dating back to as early as 1944, before Indian independence from British colonial rule. At that time, speaking as India's foremost scientist, Bhabha persuaded the nation's leading industrialist family to fund India's first basic research center, the Tata Institute for Fundamental Research. As Bhabha argued one year prior to Hiroshima:

> An institute is needed as an embryo from which I hope to build in the course of time a school of physics



Wide World Photos

'The Nehru-de Gaulle years': France and India began their partnership for the development of nuclear technology in the early 1960s. Here, Prime Minister Nehru on a visit to the Elysée Palace in 1962. From left to right, are French Premier George Pompidou, Madame de Gaulle, Nehru, General de Gaulle, Nehru's daughter Indira Gandhi, and Madame Pompidou.

comparable to the best in the world. When nuclear energy has been successfully applied to power production, in say a couple of decades from now, India will not have to look abroad for its experts, but will find them ready at hand.

Our Debt to Bhabha

The world today owes an enormous debt to Bhabha, who died in a mysterious plane crash in 1966. He and his students have laid the basis for solving the food and industrial problems of the major portion of the world's population. In addition to creating the world's third largest force of trained scientific and technical cadre (surpassed only by the Soviet Union and the United States), Bhabha's group has developed sophisticated capacities such as techniques for mining uranium, fabricating fuel elements of the best quality in the world, extracting highly sensitive plutonium, and carrying out complete design and construction of atomic power plants. These industrial and scientific capabilities exist in no more than eight or nine countries in the world. Why India?

Bhabha set about to industrialize a nation of 450 million and bring it up to the energy throughput levels of the United States. India had no fossil or hydroelectric capacities anywhere adequate to this task and Bhabha correctly saw the development of nuclear technology as the only avenue for accomplishing the forced pace of rapid and long-overdue industrialization for India.

"Let us leave out the cowdung economy for the moment," Bhabha argued in 1955 in making the case for nuclear energy. He calculated the energy deficit equivalent to 360 million tons of coal annually to bring India to U.S. levels:

> The utilization of a potential of 35 million kilowatts of hydroelectric power would make little difference to this arithmetic....We therefore come to the inescapable conclusion that the resources of hydroelectric power and conventional fuels in India are insufficient to enable it to reach a standard of living equivalent to the present U.S. level. That is what we must strive for.

Bhabha and the scientific and industrial cadre he as-

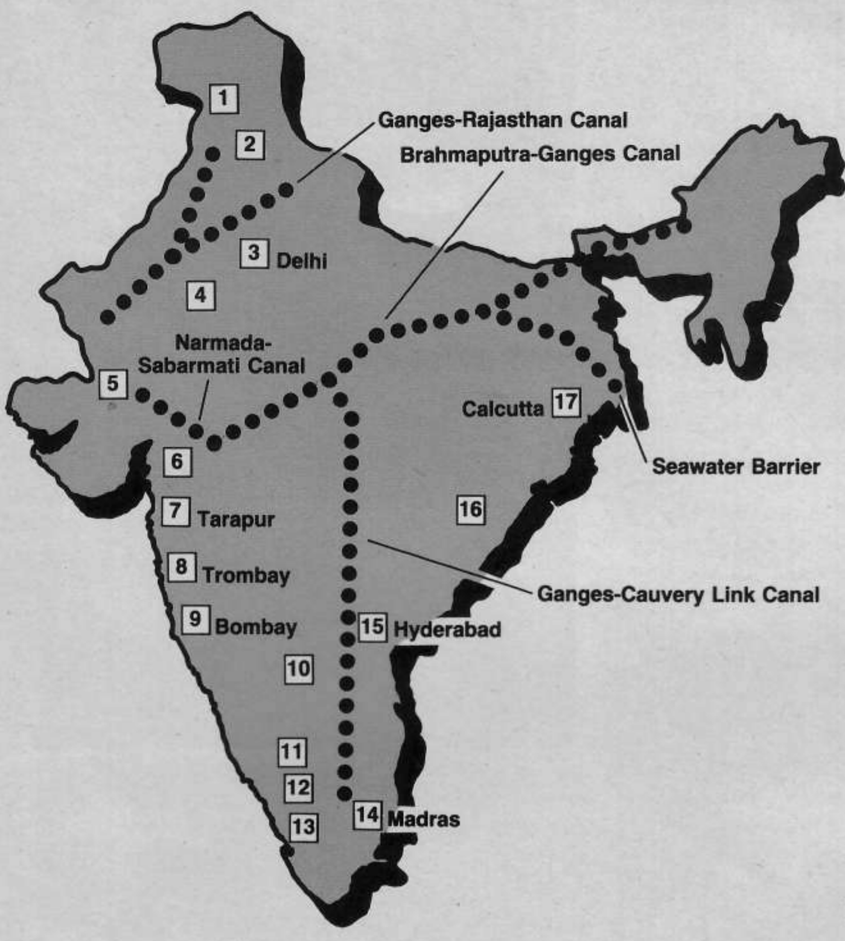


Figure 4
INDIA'S NUCLEAR INDUSTRY
This map showing India's present nuclear industry is testimony to the extraordinary vision of Dr. Homi Bhabha. The dashed lines show the 40-year plan's proposed water projects.

1. High altitude research center
2. Heavy water plant
3. Atomic Minerals Division
4. Nuclear power station
   Heavy water plant
5. Physical research laboratory
6. Heavy water plant
7. Power reactor fuel reprocessing unit
8. Nuclear power station
   Bhabha Atomic Research Center
9. Tata Institute of Fundamental Research,
   Tata Memorial Center
10. Seismic station
11. Rare earth plant
12. Mineral sands
13. Heavy water plant
14. Reactor research center
    Nuclear power station
15. Electronics Corporation
    Nuclear power station
16. Uranium Corporation
17. Saha Institute of Nuclear Physics
    Variable energy cyclotron

sembled at the Tata Institute proceeded with urgency. By 1946, he headed up a provisional Atomic Energy Commission. In 1953, the commission became a fully empowered member of the government Planning Commission, mapping out the course of the nation's future industrialization. Two years later, Asia had the first experimental nuclear reactor outside the Soviet Union.

The heart of this Indian nuclear development operates out of the Bhabha Atomic Research Center (BARC), just outside the western metropolis, Bombay. BARC has more than 10,000 personnel, four research reactors, a uranium plant, a fuel fabrication plant, and a plutonium plant. BARC has indeed fulfilled Bhabha's conception of training an advanced scientific cadre equal to the world's best.

During the Nehru-de Gaulle years, France became a vital partner with Bhabha and the development of Indian nuclear technology. Beginning in the early mid-1960s, France and India collaborated and in 1971, they signed an agreement for fast-breeder technology transfer. Development of fast-breeders is essential for the development of India's nuclear industrial base, for India's vast reserves of thorium can be efficiently used only with fast breeders that convert the thorium into fissile U-233.

India also has technical agreements with other nations, including a host of developing nations whose scientists are sent to BARC to be trained.

The Bomb Hoax

The Ford Foundation and Rockefeller Foundation architects of the nonproliferation policy that the Carter administration used to deny India fuel for its Tarapur nuclear plant based their emotional appeal to Congress and the public on India's 1974 detonation of a low-yield nuclear device. The 15-kiloton plutonium-based device in question was actually detonated as part of a massive development project that envisions turning the Indian desert into the breadbasket for all of Asia with the coordinated application of the "Nuclear-Powered Agroindustrial Complex—Nuplex," a project that BARC initiated just before Bhabha's untimely death in 1966. The detonation, in fact, took place in the Rajasthan desert as an applied, noncontaminating test of the applicablity of what the U.S. Atomic Energy

Commission in the 1960s had dubbed "Operation Plowshare." Put simply, Plowshare was the controlled application of low-yield underground nuclear detonations to achieve otherwise impossibly costly irrigation and river diversion projects throughout the subcontinent.

Operation Plowshare

BARC has calculated the following possibilities under the application of internationally recognized (except by the United States under its 1978 Nuclear Nonproliferation Act) detonation of peaceful nuclear explosions:

- Application of peaceful nuclear explosions along India's long coastline could enable creation of several new deep-water harbors along the western coast at one-tenth the cost of conventional methods in one-tenth the time.

- The major roadblock to industrialization in the subcontinent, provision of a cheap and abundant food supply, could be overcome by applying a network of underground nuclear explosions that would create rubble-filled "chimneys" to catch the flood waters of the Ganges River during monsoon season. This proposal, developed by U.S. AEC head Dr. Glenn Seaborg and applied to the Ganges plain by Dr. Rama of the Tata Institute in extensive feasibility studies, would allow efficient irrigation and development in such artificially created reservoirs. BARC has estimated that 200 such underground chimneys would develop and control ground water for the entire Indian southern peninsula.

- Incorporated into this development plan would be the BARC concept of nuplexes, known as the "strategy for survival" for agriculture development in the subcontinent. Bhabha first developed the concept in discussions with U.S. atomic researchers at Oak Ridge, Tennessee.

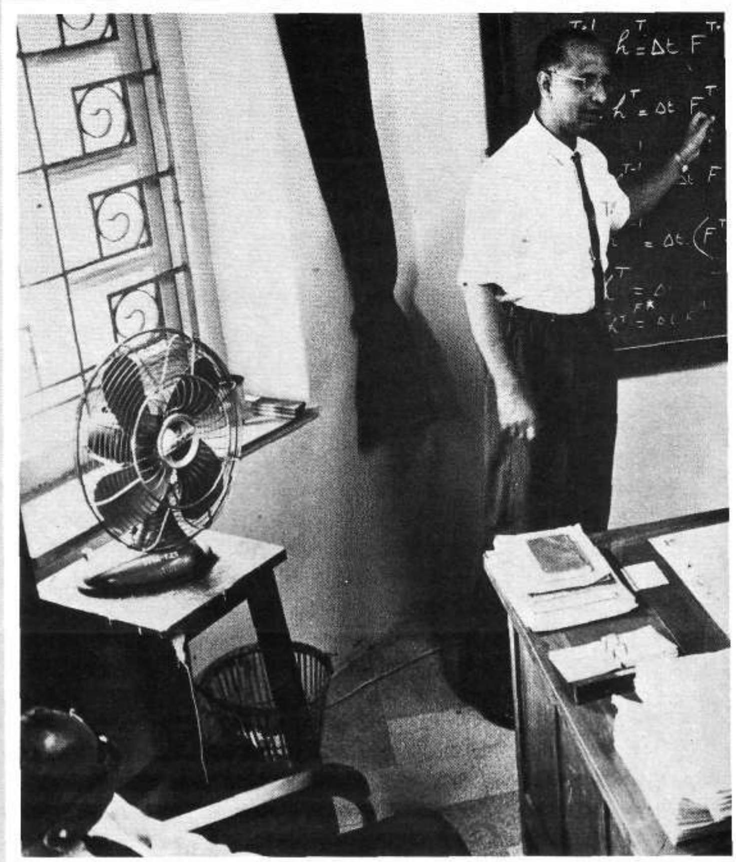
The Nuplex Plan

The BARC-Nuplex was proposed for two regions—the Ganges plain and the vast Saurastra desert region. The Ganges plan would build a nuclear power complex based on CANDU-type heavy water design of 3,000 megawatts-electric around which the agriculture and industry of a rapidly developing region would be centered.

The nuplex would be organized around two mega-modules or blocks. The first would consist of a nuclear power center surrounded by aluminum and fertilizer plants. The second would be a similarly organized agricultural complex. The two blocks would be linked by a power transmission and distribution system and rail and transportation networks. Through double and triple-cropping combined with the peaceful nuclear explosion irrigation projects, BARC estimated that this complex would provide food for 30 million.

At present, this vital development perspective is seriously stalled because of several years of Anglo-American political and economic pressure against the faction grouped around the late Bhabha.

Turning this situation around and instituting the vast development program described here is the task of the new government of Indira Gandhi.



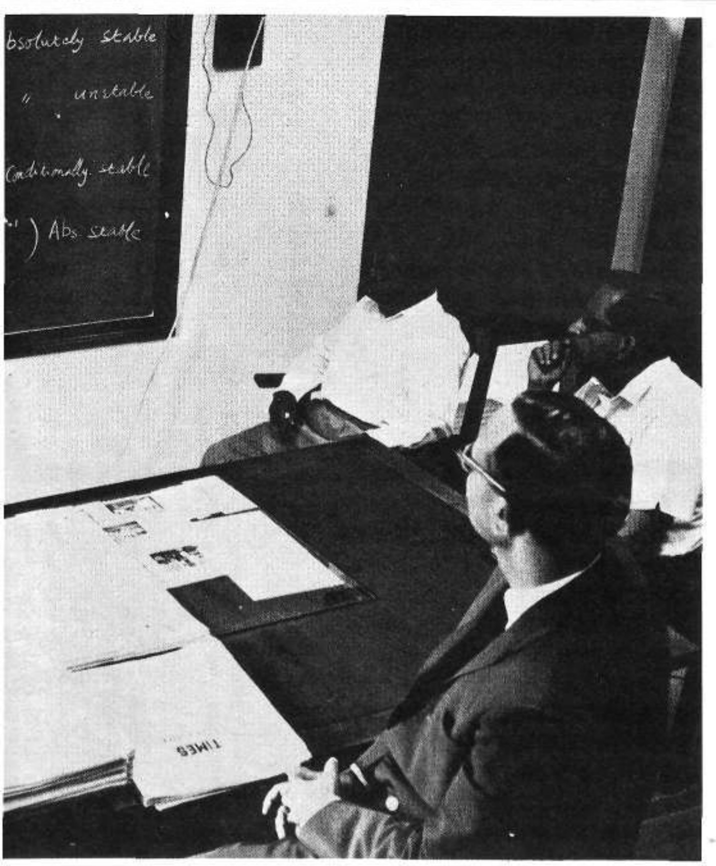
'An extraordinarily high number of scientists and engineers': Here, a group of specialists discuss a numerical computation

Manpower: Using Science to End Illiteracy

To become an industrial power by 2020, India must utilize its extraordinarily high number of scientists and engineers (the largest concentration of any place in the world after the United States and the Soviet Union) to drastically transform the overall character of the workforce.

At present, out of a population of 64 million, 70 percent are illiterate and 78 percent live in rural areas; out of an official workforce of about 230 million, 74 percent are engaged in subsistence agriculture, and two-thirds of the rest work in what is called the "unorganized" industrial sector, which consists of factories with more than 10 and less than 50 employees and no electricity, and of factories with less than 10 employees and electricity.

On top of this miserable state of affairs are two other alarming reflections of the threat to India's most vital resource: First, 60 percent of the population consumes less than the government standard of 1,900 calories a day, which is itself 500 calories below industrial nation standards; second, infant mortality has in fact been rising over the



United Nations

scheme for weather prediction at the India Institute of Tropical Meteorology.

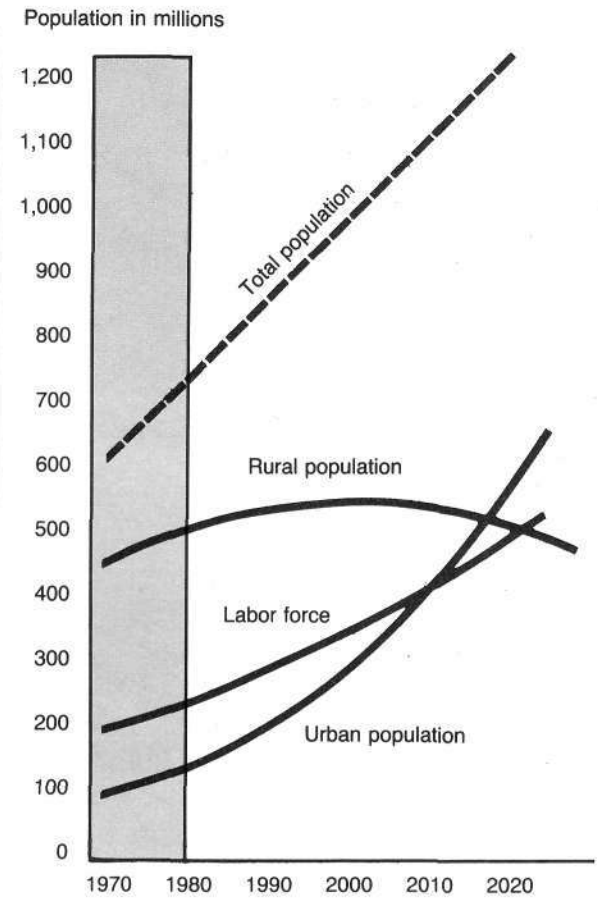


Figure 5
LABOR FORCE PROJECTIONS

By the end point of the 40-year development program, India will have a productive manufacturing workforce of 239 million, most of it urban.

recent period of World Bank strangulation of credit and technology.

India needs its population—projected to nearly double over 40 years—to carry out its transition to an industrial power; but its living standards, skills, and literacy must be upgraded immediately, long before the entire job-age workforce can be integrated into industrial production.

To create a skilled labor force of 239 million by the year 2020 requires three concurrent approaches. First, a program to put millions of people through secondary and higher education training; second, the calling back of thousands of Indian scientists, engineers, and skilled workers who are currently abroad; and finally, in this context, a campaign for basic literacy for the entire population.

To accomplish the necessary literacy and skill level, the 40-year plan proposes the creation of at least 25 new cities over the period of the program.

The literacy goal is defined as that similar to the Soviet Union today. If this virtual total literacy is to be reached by 2020 and production goals met, at least 60 percent of its goals must be reached by 2000, the midpoint of the plan.

This is a conservative estimate of labor force requirements for the economy at that time. This projection is feasible, with the most crucial period being the first 10 years of the program when the enrollment level must be more than doubled. The university levels of the program are also on a scale not at all beyond the resources of the Indian economy. Qualitatively, higher education will shift toward an emphasis on scientific training and engineering. In those areas, the needs defined by the water control and nuclear projects alone are well beyond the present level of training available.

The program for creating mass literacy depends on simultaneously putting millions of undereducated and miseducated people into secondary and higher education training and calling back thousands of Indian scientists, engineers, and skilled workers now living abroad. It is out of the universities and already skilled workforce that brigades for educating the broader population must be formed. The proper approach is the creation of a universal service corps based on universal conscription from secondary school and university students, plus on-site job training.

Such an approach contrasts sharply with the "basic needs" literacy programs now going on under World Bank sponsorship. Successful literacy will be achieved by concentrating on fostering the highest scientific development throughout the universities and workforce, not leveling off to a lowest common denominator.

Water Management: Making India a World Breadbasket

India has some of the greatest water resources of any country in the world and harnessed under a water management system, this water can provide hydroelectric power and irrigation. India's water is its oil.

The problem to solve with a water management system is the poor distribution of the country's water, by season and by geography. The water comes from the north in the Himalayas, distant from the central agricultural plateau, and from the Ganges and Brahmaputra rivers, which flood seasonally with the monsoon rains of August through October and then reside, leaving India's fertile central plateau dry much of the year.

The water management system proposed in the 40-year plan aims to:

(1) Bring the water from the snow-melting process in the Himalayas south, to where it is needed, by capturing the water in reservoirs and taking it through a series of lifts over the mountains.

(2) Link the Ganges and Brahmaputra rivers with a canal, from which irrigation canals can radiate;

(3) Build a sea barrier for the water at the mouth of the Brahmaputra at Bombay.

(4) Trap the monsoon rain in the lower plains with multiple reservoirs and radial wells, so that it can be pumped back up when needed for irrigation.

This water management system will enable India to generate *40,000 megawatts of electricity* by hydroelectric dams. At present, approximately 18 percent of India's total installed generating capacity of 28,000 megawatts—5,000 megawatts—comes from hydroelectric power.

The irrigation afforded by the program will enable India to produce more than *1 billion tons of grain per year.* No other region in the world is better-suited for large-scale cultivation than the Ganges-Brahmaputra river basin. Today India produces 120 million tons of grain per year, with 43 million hectares of land under irrigation. With a water management system, India could irrigate three times that area. If provided with the necessary inputs of fertilizer, mechanization, and most important, water, India can become the breadbasket of the world within 15 to 25 years.

The engineering details for a water management system can be worked out, with a two-stage approach and timetable (see Table 4).

Costs and Power Requirements

The estimated cost of construction is about $80 billion for stage 1 facilities and $100 billion for stage 2, including pumping power plants. Since facilities will be constructed over a continuous period of 30 years, the average capital requirement per year is about $7 billion for the first 10 years and about $5 billion in the last 20 years. The installed power requirement is about 13 gigawatts by 1990, mostly for groundwater pumping, increasing rapidly to 85 gigawatts by 2010 as the pump lifts for the Ganges-Cauvery link canal become operative. However, an estimated 25 gigawatts will be generated by the flow of the link canal through new and upgraded hydroelectric turbine installations on both the canal and the existing river systems of the peninsula.

The engineering and skilled labor estimates are based on implementing new and state-of-the-art heavy construction methods—including nuclear explosive techniques—using both national and foreign engineering and construction operatives as the nucleus for training skilled construction workers within the indigenous population. Estimates of basic materials include 40 million tons of predominantly construction grade carbon steel and 190 million tons of concrete—requiring 23 million tons of Portland cement.

Table 4
PROPOSED IRRIGATION DEVELOPMENT OF INDIA

			Land under Irrigation			
	Surface runoff (billions of cubic meters/year)	**Arable land** (millions of hectares)	**Potential** (millions of hectares)	**Existing** (millions of hectares)	**Proposed** (millions of hectares) 1980-1995	**Proposed** (millions of hectares) 1995-2010
India	1,680	160.0	168.0	43.0	81.1	122.8
Bangladesh	100	8.8	10.0	—	5.0	6.5

Stage 1:
Construct Bangladesh seawater barrier and flood embankments; divert Brahmaputra to Ganges and Yamuna to Rajasthan canal; initiate intensive groundwater recharge and extraction systems and local dams and canals.

Stage 2:
Divert Brahmaputra-Ganges southerly by link canal and regulating reservoirs; complete groundwater, dam, and canal developments.

Thomas Malthus

Model for Today's Zero Growthers

by Nancy Spannaus

PERHAPS THE MOST NOTABLE feature of today's followers of Parson Thomas Malthus is that his zero-growth ideology cuts across the usual political divisions. On the so-called right wing are the conservatives—economists like Milton Friedman who advocate austerity to keep the economy going with apparently no limits to how taut the belt must be pulled around the citizen's neck. On the opposite side of the political spectrum are the full range of environmentalists and, at a more respectable level, social planners like World Bank president Robert S. McNamara who couch the same austerity in terms of a shrinking pie that must be divided more equally.

The underlying theme for both factions, however, is that resources are limited and man has no way of solving the resource problem except by limiting the consumption of the population and limiting the population that has to share these resources. That these limits mean death to large numbers of the current population for the Malthusians is simply a necessity.

For those of us schooled in the American tradition—the Hamiltonian point of view that values the human mind and its creative powers as the nation's greatest resource and the nation's only real source of wealth—Malthusianism in any form is unthinkable. This article will review how Thomas Malthus's dire predictions have been proved utterly false, and thus provide the epistemological ammunition to ensure that today's Malthusians become a rightfully endangered species.

The World Bank's Final Solution

On Oct. 2, 1979 in Belgrade, Yugoslavia, Robert S. McNamara gave this report to an assemblage of international bankers:

Detail from Bruegel's "The Triumph of Death" (1563) at the Prado, Madrid.

We can begin with the most critical problem of all: population growth.

As I have pointed out elsewhere, short of nuclear war itself, it is the gravest issue that the world faces over the decades immediately ahead.

The population growth of the planet is ultimately in the hands not of governments, or institutions, or organizations. It is in the hands of literally hundreds of millions of individual parents who will determine its outcome. That is what makes the population problem so diffuse and intractable. And that is why it must be faced for what it inevitably is: a central determinant of humanity's future and one requiring far more effective attention than it is currently receiving. . . .

If current trends continue, the world as a whole will not reach replacement-level fertility—in effect, an average of two children per family—until about the year 2020. That means that some 70 years later the world's population would finally stabilize at about 10 billion individuals compared to today's 4.3 billion. . . .

We call it stabilized, but what kind of stability would be possible?

Can we assume that the levels of poverty, hunger, stress, crowding, and frustration that such a situation could cause in the developing nations—which by then would contain 9 out of every 10 human beings on earth—would be likely to assure social stability? Or political stability? Or, for that matter, military stability?

It is not a world that any of us would want to live in.

Is such a world inevitable?

It is not, but there are only two possible ways in which a world of 10 billion people can be averted. Either the current birth rates must come down more quickly. Or the current death rates must go up.

There is no other way.

There are, of course, many ways in which the death rates can go up. In a thermonuclear age, war can accomplish it very quickly and decisively. *Famine and disease are nature's ancient checks on population growth, and neither one has disappeared from the scene. . . .*

To put it simply: Excessive population growth is the greatest single obstacle to the economic and social advancement of most of the societies in the developing world [emphasis added].

The body count that would result from McNamara's population reduction policy would not solve overcrowding; it would wipe out any potential for the technological progress and education that would allow the world to enter an age of prosperity with the coming of the 21st century.

Case by case, McNamara's World Bank policies demonstrate the real significance of reducing population— genocide. Bangladesh, Sudan, Chile—these are the models. They are clear examples of what happens when the policies of Parson Thomas Malthus are enforced—decimation by famine, disease, and war.

That McNamara's policies are Malthusian is straightforward. There is no mistake. Just as the environmentalist movement today is calling for the murder of billions by sabotaging nuclear power, so Thomas Robert Malthus came up with the population reduction principle in the first place. And all in the name of a supposed better life for the few that remain.

Hear McNamara echoed in Malthus's first *Essay on the Principle of Population*, published in 1798.

> Famine seems to be the last, the most dreadful resource of nature. The power of population is so superior to the power in the earth to produce subsistence for man, that premature death must in some shape or other visit the human race. The vices of mankind are active and able ministers of depopulation. They are the precursors in the great army of destruction, and often finish the dreadful work themselves. But should they fail in this war of extermination, sickly seasons, epidemics, pestilence, and plague, advance in terrific array, and sweep off their thousands and ten thousands. Should success be still incomplete, gigantic inevitable famine stalks in the rear, and with one mighty blow, levels the population with the food of the world.
>
> Must it not then be acknowledged. . . that the superior power of population is repressed, and the actual population kept equal to the means of subsistence by misery and vice [first edition, Chapter 1].

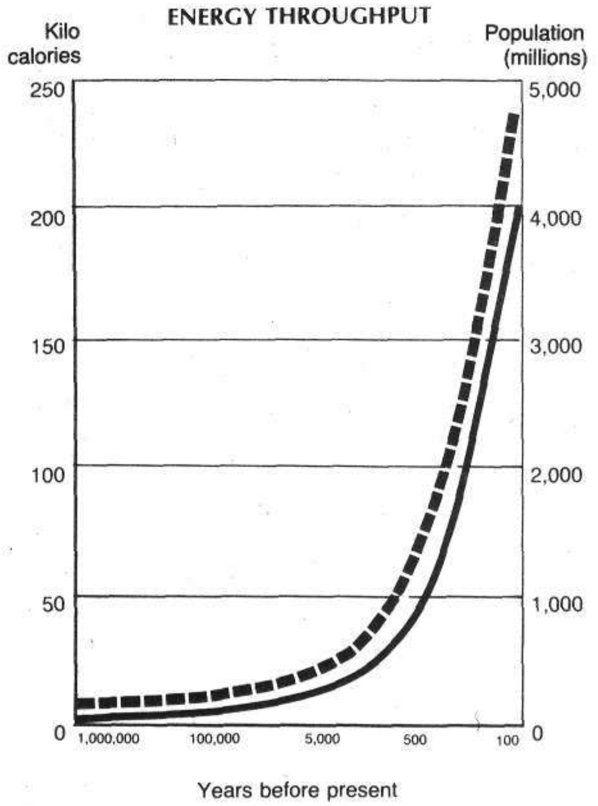
To the degree that Malthus's gloomy predictions about the inevitability of population outstripping food resources have credibility today, to that degree the British System has once again taken worldwide hegemony over the American System of industrial progress. Parson Malthus's entire career was devoted to destroying the idea and actuality of progress on behalf of the British "master race," especially as progress was embodied in the economic system established under the George Washington administration in the United States. As a professor in the College of the East India Company (to be remembered from the tea party incident of 1776) from 1805 to 1834, Malthus played more than an academic role in ensuring that British colonies like India did not violate the Empire's law of perpetual want.

Malthus's theories provided the rationale for raising food prices, cutting welfare payments, and defining a whole class of "useless eaters" according to the criterion of what contribution the individual makes to the food supply. Malthus's theories eventually achieved their most lasting form in the work of Charles Darwin and Herbert Spencer, who emblazoned the law of the survival of the fittest and natural limits to growth within the body of so-called international science.

The current threat of extinction to 2 billion persons in the underdeveloped sector by starvation, wars, and disease is real enough. But it is far from "natural." That impending holocaust is the direct result of the sabotage of the technological advances and industrial expansion that could alone reverse the slide to catastrophe.

Political Economy of Feudalism

Faced with the exemplary accomplishment of the American Constitutional republic and the republican movement around Leibniz heir Lazare Carnot in France, the British



Malthus was wrong: As this graph shows, per capita consumption has increased exponentially along with world population. The dotted line represents population, the solid line kilocalories.

oligarchy of the 1790s was anxiously looking around for new tools of international battle. Despite the success of their agents Marat, Danton, and the Duke of Orleans in pulling off the bloody Jacobin convulsions known as the French Revolution, republican forces had come back into positions of power. Britain itself was on the verge of bankruptcy. And all the proselytizing of Adam Smith had failed to convince the leading circles in the United States, France, Russia, and even Germany that they should let the forces of the free market—that is, the British Empire—consign them to raw materials production, while Britain stuffed their loot in its coffers.

Moreover, neither the working class nor capitalists of Britain could necessarily be counted on to support the bumbling monarchy. The Americans and their allies in Europe continued to pour effective mass propaganda into the British Isles. And the capitalists, despite the antigovernment intervention dicta of Smith, continued to be hamstrung in their efforts by the myriad regulations and privileges favoring the landed oligarchy. Prime minister William Pitt was swerving dangerously close to negating some of the feudal privileges in favor of developing a working class, some thought. He had extended the Speenhamland subsidy, which brought English workers' incomes up to a minimum wage, to the entire country in 1795, and then threatened to prorate it so that families with more children would receive a higher income.

With a bow to Smith and Hume, in particular, Malthus stepped into the fray, landing squarely on the side of the landed oligarchy. His first point of contention, which he won, was that the poor should not receive a larger income subsidy if they had larger families—for that would simply encourage them to have even more children to devour the limited food supply. He went on to develop a political economy that, if implemented, would dismantle the cities, keep the landlord interests on pension, and send the bulk of the population out to the countryside to dig their minimal sustenance out of the soil. As today, it was the program of a new Dark Ages.

Human existence is governed by two fundamental principles, Malthus argued: (1) that food is necessary to the existence of man; and (2) that the passion between the sexes is necessary and will remain nearly in its present state.

"Assuming then, my postulate as granted" Malthus went on, "I say, that the power of population is indefintely greater than the power in the earth to produce subsistence of man" [first edition, Chapter 1]. In specific, "population, when unchecked, increases in a geometrical ratio, and subsistence for man in arithmetical ratio" [first edition, Chapter 2].

Malthus's reasoning hinges on the basic assumption that mankind's nature, from reproduction to motivation, is that of a beast:

> Through the animal and vegetable kingdoms, nature has scattered the seeds of life abroad with the most profuse and liberal hand. She has been comparatively sparing in the room and the nourishment necessary to rear them. The germs of existence contained in this spot of earth, with ample food, and ample room to expand in, would fill millions of worlds in the course of a few thousand years. Necessity, that imperious all-pervading law of nature, restrains them within the prescribed bounds. The race of plants, and the race of animals shrink under this great restrictive law. *And the race of man cannot, by any efforts of reason, escape from it.* Among plants and animals its effects are waste of seed, sickness, and premature death. Among mankind, misery and vice [first edition Chapter 1, emphasis added].

Under the American System, founding father Benjamin Franklin and the first treasury secretary Alexander Hamilton had hammered home the Neoplatonic concept that man's place was as master of the universe, a relationship that man would continually advance through the perfection of his own creative mental powers and their application in science and technology. Man's distinguishing characteristic from animals was not his ability to talk, or, as Aristotle put it, to be "logical," but to rule himself and the world through the power of Reason.

Man As Beast

Malthus was blunt in the opposite conception. "The real perfectibility of man may be illustrated, as I have mentioned before, by the perfectibility of a plant." When one strives to improve one quality of the flower—such as its size—then one is likely to impair the beauty of another quality. It is a fruitless task, according to Malthus.

Man does not strive for perfection; in Malthus's view he tries to position himself so he and his family will not go hungry. The only reason he believes he can produce more from the soil than what's necessary for his family and himself, Malthus explains, is because of the ignorance and bad government of his ancestors. If the ancestors had succeeded, the resources would be used up. But in order to survive and have his society survive, he must control his fundamental nature—his drive to have more children than he can afford to feed. It is the exceptional person who does this of his own free will, however, Malthus explains; it is best if society discourages him from doing so by maintaining the price of food in particular at a high enough level.

The determinant of wealth and the quality of human existence, then is the quantity of food, which is in turn dependent on the amount and usability of land, in Malthus's argument. Here Malthus unambiguously identifies himself as a lying feudalist. He attacks cities and manufactories as unproductive because they do not immediately add to the store of food. He allows for a certain increase in the productivity of land, but one that is ultimately limited by a law of diminishing returns on increasingly infertile land.

The model of land productivity Malthus praises, not surprisingly, is that of feudal China, where rice can be grown abundantly in two crops a year, on the basis of the very high labor-intensive process. Not even Malthus could have been stupid enough to think that China's agriculture was the most nourishing and productive for its population. The beauty of that system in his eyes, as in those of enlightenment philosophers Montesquieu and Rousseau and the Council on Foreign Relations today, was the total control it gave to the landed oligarchs, who lived off increasingly higher rents as a result of their monopoly on land. Nothing was more threatening to them, then, than an improvement in agricultural technology that would reduce the need for and cost of extensive land, such as fish farming or greenhouse farming would do today.

Thus Malthus differentiated himself from Adam Smith, who had identified human labor, measured by units of time as the source of productive wealth and argued that an increase in that application of labor would increase the revenue of the society, and therefore the fund for labor. Like the environmentalists today, he argued that more production would simply compound the problem. "A diminished power of supporting children is an absolutely unavoidable consequence of the progress of a country toward the utmost limits of its population" [1817 edition, Volume 3].

Epistemology of Zero Growth

Despite the often open conflict between Malthus and the so-called prolabor heirs of Adam Smith (like David Ricardo) on such issues as the domestic monopoly on corn and tariffs, Malthus in fact, set the terms of the debate between British liberals and conservatives for more than a century to come.

In the context of the faculty at the East India College, Malthus was merely the conservative pole of a radical empiricist movement committed to keeping man in a state of bestial submission to the oligarchs. Malthus's closest collaborators were the notorious hedonists Jeremy Bentham and John Stuart Mill. The first social experimenter to put his concepts into effect was Robert Owen of the New Harmony communal experiment, whose isolated community was committed to zero growth.

A 19th century cartoon of Malthus. The original caption reads:
Wife: "Sir, here is your coffee."
Husband: "Let me finish, Babet. I'm proving that those who are poor have no right to be hungry."
Wife: "You will prove this between your first and second breakfasts."

The Bettmann Archive

Malthus had only a practical disagreement with his liberal colleagues who wanted to continue to supply social welfare payments. The basic question for them both was how to maintain the stranglehold the oligarchy had over power and the development of wealth through the spread of science and ideas. Neither the radical redistributionist theories of the "left" nor the "free enterprise" cutthroat approach of Malthus himself challenged the conception that man was a talking beast.

The view that both shared was that each individual was defined not by what *quality* of labor or effort he put into his contribution to society as a whole, but by the *quantity* which he and his household consumed. Within this perspective on human existence each individual can be represented adequately by a cipher on an actuarial table. Actuarial calculations—birth rates, death rates, and various averages—were some of the major raw material Malthus used for his population theories. The actual productive potential of a population is deliberately ignored by the actuary, who is more often than not interested in arranging the most profitable rates possible for life insurance company employers.

Malthus's actuarial talents—with which he informed the six subsequent editions of the *Essay on the Principle of Population*—proved particularly enticing to economist John Maynard Keynes, who cited Malthus as one of the most influential theorists in his own work.

The Malthusian approach to the individual human being, of course was not new. In philosophical approach it began with Aristotle, but was the direct progeny of the work of both Jean-Jacques Rousseau and David Hume. Malthus's father was an avid Rousseauvian, and undoubtedly regaled his son with the French degenerate's lectures about the nobility of the uncivilized individual, or noble savage. Thomas had more insight than his father. Such a Rousseauvian individual would have to be a selfish bundle of passions, forced only by the fear of the privations or pain that might face him to do his work to the best of his ability, Malthus knew. If such a beast were indulged by a lenient social policy he would soon lose all motivation to work, Malthus concluded. Therefore his policy was geared to keeping individuals in precisely such a state of bestial fear and selfishness, that they might not challenge those who were determining the direction of the society.

As for Malthus's liberal opponents, they saw the individual and his value no differently. But while Malthus's approach was geared to maintaining ironclad social control over the nonpropertied, the approach of Bentham and his ilk was geared to totally overturning social orders that threatened the oligarchy's control. In Naderite fashion, these hordes were simply to be used as battering rams against the forces of social progress.

An appropriate approach to population has nothing to do with merely assembling aggregates of individuals, along with the figures of what they consume or produce. Population is not a sum of individuals, but a degree of organization of certain qualities of individuals. A society that approaches each individual from the standpoint of what he or she can creatively contribute to the knowledge or mastery of the universe has an appropriate criterion with which to decide how rapidly to increase its population and what to do with it.

When a society's leading institutions reflect this humanist appreciation of the individual, the society is primarily concerned with the shortage of qualified individuals to lead and implement scientific advances. While putting a premium on expanding population, such a society insists that each newborn child receive the kind of resources and attention that will ensure that it becomes fully human. The result has nothing to do with a change in the "natural" rate of reproduction, as one might calculate in the case of changing the environment of rabbits. It is the progressive trend of a decrease in the number of children per family, simultaneously with a high value being put on the opportunities for each child to develop his abilities for the future generation and on the scientific advances necessary to ensure that development.

Defeat Today's Malthusians

Malthus has not been defeated today because the epistemological battle against him has not been won. Even the proponents of the American system in the years England tried to export Malthusianism to the burgeoning United States grudgingly gave Malthus credit for having identified "natural law," while roundly denouncing the devastation this law threatened to wreak on human society. Even from the best, like Mathew Carey and Daniel Raymond, the attacks were weak. Raymond, for example, wrote the following in his *Thoughts on Political Economy* in 1823:

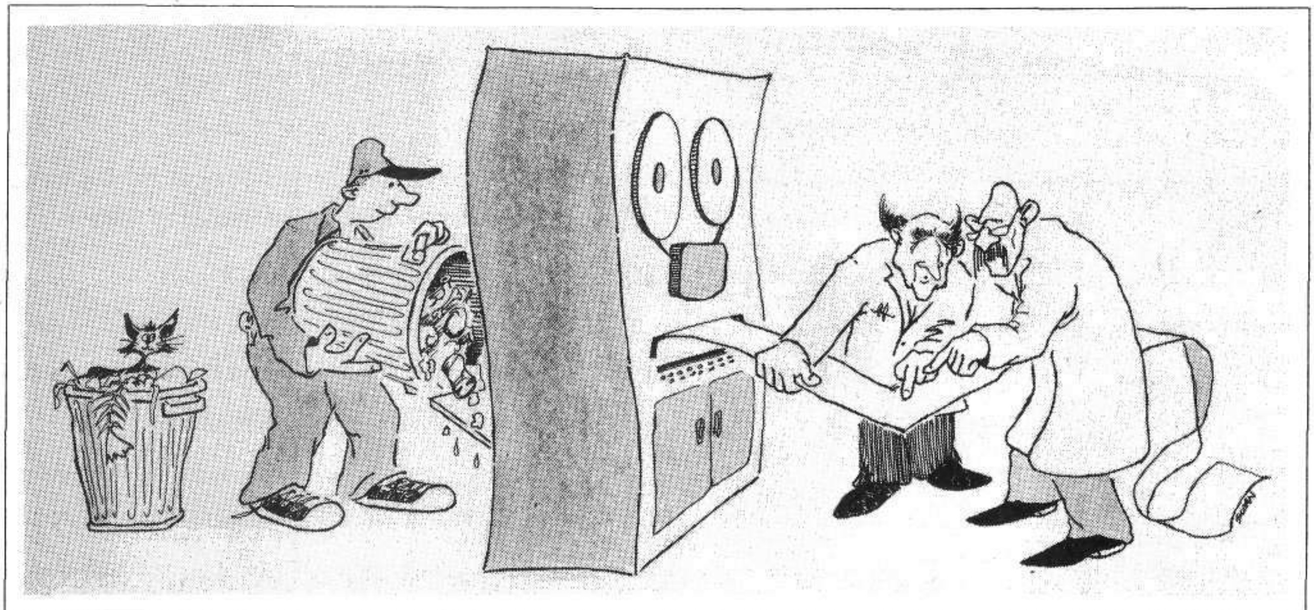
> Although his theory is founded on principles of nature, and although it is impossible to discover any flaw in his reasoning, yet the mind instinctively revolts at the conclusions to which he conducts it, and we are disposed to reject the theory, even through we could give no good reason.

The very history of the human race, of course, has proven Malthus wrong. If man were bounded within the "natural laws" of inorganic and animal nature, the human species would not still exist. Long ago it would have used up the food and other resources provided on the earth. But mankind cannot be defined as "thinking beasts" who rationally determine how to apportion the dwindling resources around them. The nature of human reason is its ability to create new resources that augment man's power over himself and the nonthinking world.

The only standpoint from which the horrors of a Malthusian universe can be avoided is that of a republican, who is committed to developing the new laws of nature necessary to increase the population potential and level of organization necessary for human posterity. And mankind has exercised that quality now for more than 10,000 years.

Nancy Spannaus writes frequently on American history and is the coeditor of The Political Economy of the American Revolution. *A national executive committee member of the National Caucus of Labor Committees, she is the editor-in-chief of* New Solidarity, *a leading independent U.S. newspaper in the Whig tradition.*

Garbage In, Garbage Out



A Critical Review Of Economic Modeling

by Vin Berg

"All economists have been wrong. I think that we have to recognize that there isn't an econometric model of any type that has been able to predict what has happened."

—G. William Miller, Secretary of the Treasury
March 16, 1980, on CBS "Face the Nation"

THE ACCOMPANYING GRID presents a cross-section of the economic models currently enjoying most widespread use at the policy-making level. The models are critically evaluated from a progrowth, protechnology standpoint. The aim here—unlike the aim of many model users—is how to put the nation back on the path of progress and industrial development.

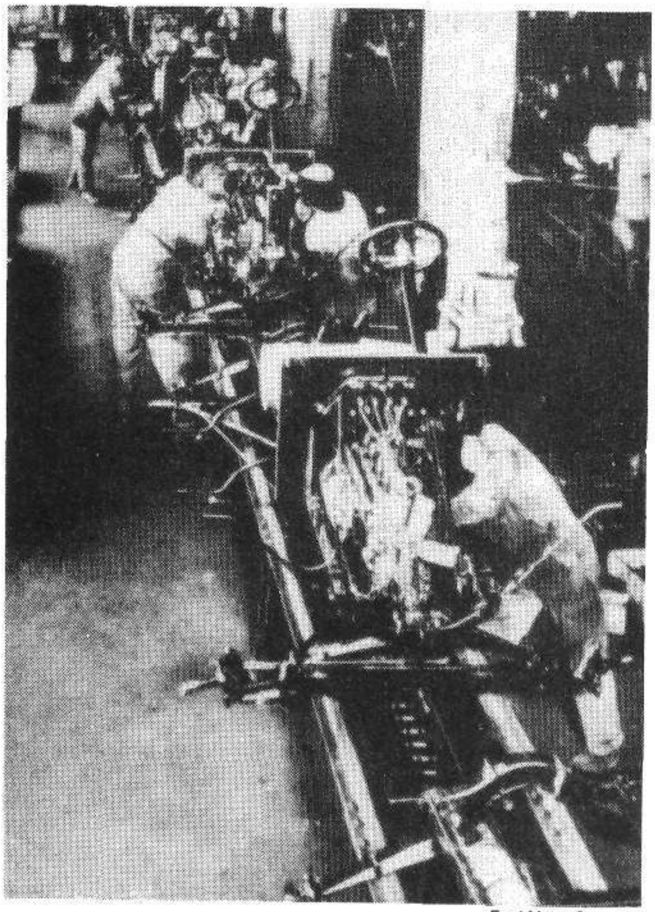
The myriad conventional modelings range from Gross National Product (GNP) "aggregate demand" representations applicable to the overall performance of the economy—led by the interfaced Wharton School and Brookings Institution approaches—to models oriented to more specific problems or relationships. The Jorgenson-Hudson and Wanniski-Laffer models are typical of the latter category, examining tax-investment correlations or attempting redefinition of the inflation-employment correlation whose recent misbehavior has so often "shifted" the conventional supply-demand wisdom of the Phillips Curve.

Within these two broad categories, there are a multiplicity of models differentiated by shadings of emphasis or purpose. However, when one examines the more fundamental issue of analytic method, it is clear that there are only two types of models—the Riemannian and the non-Riemannian.

The most serious insufficiency in conventional models is their assumption of a *fixedness* in the economic rela-

NAME	Data Resources Forecasting Model	Jorgenson-Hudson	Oak Ridge Energy-Economic Model
SPONSOR	Data Resources, Inc.	Dale Jorgenson Assoc./Ford Foundation	Union Carbide, Department of Energy
TYPE	GNP demand-side	Trade-off	Supply-side
USERS	Industry/government	Ford Foundation, Department of Energy, Department of Labor	Government, industry
NOTEWORTHY USE	Most widely used model among corporate policymakers in the United States.	Cited as basis of Department of Labor policy by Secretary of Labor Ray Marshall Feb. 15, 1980.	Basis for Oak Ridge National Laboratory, DOE, and Union Carbide studies of energy-related problems.
BASIC ASSUMPTIONS	"Aggregate demand" is principal determinant of overall economic activity, to which corporate policy-decisions adapt.	Employment levels vary directly with energy costs; in other words, as energy costs rise, employment rises by substitution of labor for energy.	Energy supplies vary directly with energy prices; as prices increase, energy supplies will increase by making production more profitable.
CONCLUSIONS	Example: U.S. economy will experience a "mild downturn" in 1980. Example: The U.S. economy's performance is minimally sensitive to oil price increases.	Example: U.S. economic growth rates and productivity will continue to fall progressively throughout the 1980s. Example: For each doubling of energy prices, employment will rise 5 percent.	Example: The U.S. economy can afford a moratorium on nuclear plant construction by turning to more expensive coal, if population growth slows dramatically.
COMMENTS	This model is singularly inefficient for determining the effect of major disruptions of economic activity, such as imperiled or overpriced energy-supply problems. Like Wharton, it cannot distinguish simple monetary flows from productive industrial-economic activity. Hence, this widely used model is often the basis for investment diversification decisions that have far-reaching, destructive consequences for the economy's overall performance and are ultimately harmful to the liquidity position of the corporations employing the model.	The notion that human labor can be substituted for energy to "increase employment" is a prescription for deindustrialization. As rising energy costs decrease capital-intensive industrial activity, productivity will collapse and employment will shift from skilled-semiskilled to labor-intensive categories. Then employment levels will collapse along with the economy itself—the latter not encompassed in the modelers' forecast. This model was devised to determine the rate at which current Department of Energy and Department of Labor policies are phasing out American industrial power and dooming large portions of the Third World population to starvation and death.	The essence of this modeling effort is that zero growth is an acceptable alternative. A U.S. nuclear moratorium, followed by a slowed-down program to bring new nuclear installations on line, would force a turn to much more expensive coal, sharply decreasing tangible industrial output. The modelers offset this with the assumption of a dramatic slowing in population growth. No mention is made of the starvation, disease and chaos that will accompany a dramatic decrease in global population and economic breakdown in underdeveloped nations.
REFERENCE	"The Data Resources Review of the U.S. Economy," (Lexington, Mass.: Data Resources, Inc., December 1979).	Edward A. Hudson and Dale W. Jorgenson, "The Economic Impact of Policies to Reduce U.S. Energy Growth," (Cambridge, Mass.: Harvard Institute of Economic Research, 1978).	"The Impact of a Nuclear Moratorium on the Economy," Oak Ridge Energy, Cambridge, Mass.: Massachusetts Institute of Technology Press, 1978).

Riemannian-LaRouche Economic Model	Stanford Pilot Energy-Economic Model	Wanniski-Laffer	Wharton School Economic Forecasting Model
Fusion Energy Foundation, *Executive Intelligence Review*	Electric Power Research Institute, Department of Energy, Stanford Institute for Energy Studies	H.C. Wainwright Co.	Wharton School of Business, University of Pennsylvania
Nonlinear, causal	Input-output	GNP supply-side	GNP demand-side
Fusion Energy Foundation, *Executive Intelligence Review*	Government, utilities	Government, industry	Government, industry
Numerous studies of the U.S. economy by the sponsors; collaboration with Indian scientists and political leaders on the industrial development of India through the year 2020; the basis for the economic platform of the Lyndon LaRouche presidential campaign.	Frequently employed in studies and reports by the sponsors.	Basis for recent tax-cut recommendations of the Joint Economic Committee of the U.S. Congress; basis for economic platform of the Ronald Reagan presidential campaign.	Used by the annual reports of most federal agencies, many large corporations and foundations, and for a July 1979 study of the Mexican economy, this is the most widely used model among government policymakers in several nations.
Long-term, noninflationary growth is a function of increased rates of tangible surplus resulting from scientific-technological progress; "equilibrium" economies are impossible beyond the near term.	Energy consumption rates have only a conditional relation to economic growth rates. By the year 2020, nuclear energy will provide no more than 50 percent of U.S. energy, with none from fusion.	Investment levels vary inversely with tax levels and inflation; in other words, as taxes fall, capital investment rises.	"Aggregate demand" is the principal determinant of economic activity, to be maintained in equilibrium by government fiscal and monetary interventions.
Example: *Third World development depends on high-technology, energy-intensive projects.* Example: Policies that cause economic "overhead" costs to rise will lead via inflation to economic breakdown in the near term.	Example: *Energy conservation can dramatically improve the economy's overall performance, under the condition of some increase in overall energy supplies.*	Example: *A $25 billion tax cut in 1980 will reduce the inflation rate by 4 percent.*	Example: *Inflation will moderate in the course of a "mild downturn" in the U.S. economy during 1980.*
This model does not assume "equilibrium"—zero growth as the long term secular trend. Instead, an increasing technological component in industrial capital formation is seen as the basis for healthy growth. Therefore, this model is uniquely efficient for programmatic application to the problems of developing nations, where the fundamental concern must be the overall effects of "crash" high-technology projects. The Riemannian model has an excellent predictive record on overall economic performance under the effects of "energy conservation," "nuclear moratorium," the Federal Reserve Board's succession of interest rate increases, and other proposed economic policies.	If, by energy conservation, these modelers had in mind shutting off electricity to houses of prostitution, gambling casinos, and the amplifiers of rock musicians, such discriminatory "conservation" would be economically prudent. However, the Stanford modelers seem to mean increasing labor-intensive forms of employment, reversing the trend toward labor-saving household improvements, reducing the cultural activities of families, and reducing the general per capita rates of energy throughput for productive persons—in which case "energy conservation" spells economic decay. At best, the Stanford model uses ambiguous assumptions to decouple consumption rates for energy from a connection to economic growth.	This ill-conceived effort to increase industrial output prescribes measures that are applicable under specific conditions of very low inflation rates. The current economic condition is an inflation/interest rate spiral now pressing 20 percent annually; this discourages long-term fixed-capital investments, but places a premium on quick-return speculation. A tax cut of the magnitude proposed would increase investible funds—but for speculative purposes, thus increasing inflation, the opposite of the modelers' intentions. The problem exemplifies the inability of non-Riemannian models to see beyond historical correlations to underlying causal relations that may rapidly change the correlation.	This prestigious, trend-setting model is incapable of defining economic growth in a meaningful way. Wharton Forecasting Associates do not even blush when reporting "healthy economic growth" under conditions in which the level of useful tangible output and capital-intensive industry and agriculture decline, but monetary flows increase through redundant services, legalized gambling, commercial entertainments, and labor-intensive make-work. The Wharton-Brookings method of assembling monetary statistics might convince the credulous government policymaker of an impending "upturn," even in the midst of megadepression.
For a treatment of the interest rate problem, see "Riemannian Analysis Predicts Industrial Shutdown," *Executive Intelligence Review*, Oct. 23,-29, 1979; for a treatment of oil price effects, see "The $53 Billion Rip-Off," June 19-25, 1979.	G.B. Danzig and S.C. Parikh, "On a Pilot Linear Programming Model for Assessing Fiscal Impact on the Economy of a Changing Energy Picture," in *Energy, Mathematics and Models*, ed. Fred Roberts, 1975.	For views of both sides of this modeling effort, see Jude Wanniski, "Inflation and the 'Arc of Crisis'," and Arthur B. Laffer, "Reinstatement of the Dollar: The Blueprint," (Rolling Hills, Calif.: A.B. Laffer Associates, Feb. 29, 1980).	"Wharton Annual Model Post-Meeting Solutions," Wharton Econometric Forecasting Associates, Inc. (Philadelphia, Pa.: University of Pennsylvania, December 1979).



Ford Motor Company

Conventional econometric models have no way of accounting for technological change or the absence of technological change—the discontinuities that transform relationships between economic sectors. Here Model T cars pour off Ford Motor Company's Highland Park (Mich.) Plant, after the introduction of the moving assembly line principle in Jan. 1914.

tionships, imposing a computer-coded axiom of simple linear continuity on the equation-variables chosen for economic focus. In other words, they allow for the mere quantitative expansion of economic sectors, with only marginal, if any, shifts in basic qualitative relationships.

The Flaws in the Models

The problem of such models is posed by the condition in which the primary characteristic is technological progress—or regression—a *discontinuity* that transforms the relationships of variables. Such a discontinuity, for example, was the invention and general application of steam power, or electrical power, or the automobile and railroad, that fundamentally transformed the relationship between economic sectors, even creating whole new sectors or sets of variables.

In one type of conventional model, selected historical trends for a given set of variables (personal income, government spending, GNP) are uncritically projected into the near or distant future. A more subtle version of the same approach establishes sometimes-complex linear relationships between variables (Wharton-Brookings) and then justifies such equations by reference to the same sort of historically observed *statistical correlations*. Either way, actual *causal relations* are not expressed.

This notion of causality is key. If a change in one variable has historically produced other changes, the question is: why?

Rather than naive extrapolation from trend lines, the Riemannian approach is designed to investigate the causal relations that account for those trend lines and produce discontinuous changes in those trend lines. Key to this difference is the inability of other models to distinguish between *productive* and *nonproductive* components of economic activity, with the result that there is no efficient definition of economic *surplus* available for expansion of the productive base. The concept of economic growth itself becomes ambiguous and is even denounced by the modelers as a cause of inflation.

The Riemannian approach makes a strict distinction of the required sort. *Productive* activity is identified as a useful alteration of nature resulting in tangible wealth. And *surplus* is conceived as akin to the "free energy" available for expansion of the productive base of the economy by investment in additional productively employed labor and "surplus" capital goods.

The effect of *technological change*, is crucial in the Riemannian Model. The disturbance of previous economic relationships that such change causes is precisely analogous to the determination of shock waves examined by 19th century mathematician Bernhard Riemann, whose procedures form the crux of the new model's mathematical approach. As a result, the model is specially designed to take account of changes in the technical composition of capitals. This not only accounts for forecasting accuracy on both right and wrong investment decisions (those that, respectively, increase or decrease net surplus), but also makes Riemannian analysis an essential tool for policy planning. This is especially true in developing nations, where the principal concern is the impact on productivity and economic growth of large-scale, high-technology development projects.[1]

When it comes to economic models, the familiar computer industry adage holds true: garbage in, garbage out. The analyses of an economic model are only as good as the model's methodology and assumptions. The effects of the Carter administration's antigrowth economic modeling are all too painfully clear. As for the prospects of the government adopting a more sane basis on which to make economics decisions, the progrowth but flawed Wanniski-Laffer model underpins the platform of the Ronald Reagan presidential campaign; and the only candidate that has used the Riemannian model as a basis for his program is Democrat Lyndon LaRouche.

Note

1. For details of such an application, see the cover story in this issue and *Executive Intelligence Review Special Report, "The Industrialization of India,"* New York: Campaigner Publications, February 1980.

Continued from page 24
cial characteristics. Their correlation proved high; blacks, Puerto Ricans, and other nonwhites occupying the bottom of the social ladder consistently scored lower than whites.

The Nazi Connection

For most scientists, such a correlation would not spur an attempted resurrection of Nazi race science, or eugenics, as it was then known in the 1930s. But the Shockley faction, (in the tradition of British eugenicist Cyril Burt who faked all his data) ignores that fact that there is not a shred of real scientific evidence for the eugenics theories. Unabashedly the Shockleyites back Nazi science—and economics. In a recent interview, for example, Shockley's collaborator Herrnstein explicitly drew the connection between Shockley's racist theory and the economic doctrines of University of Chicago economist Milton Friedman.

"A valid connection can be drawn between Shockley's ideas and Friedman's," Herrnstein said. "Shockley has on occasion suggested a more efficient use of fiscal means as incentives and disincentives to alter reproduction rates of various groups to change the current trend of welfare, which favors the perpetuation of those with lower inherited intelligence. This matches Friedman's ideas on changing the welfare system through fiscal means."

Friedman, whose doctrine asserts that simple monetary flows and their manipulation are the principal determinant of all economic activity, is a leading advocate of "fiscal austerity" policies in the domains of energy, household consumption, and industrial expenditure. Late last year in an Atlanta, Georgia radio interview, Friedman professed himself to be an admirer of the policies of Hjalmar Schacht—Adolf Hitler's finance minister. Schacht was responsible for the policies which led directly to the death-camp system for so-called inferior races in the late 1930s.

Austerity Science

Historically, race science and eugenics have cropped up during periods of fiscal austerity as a way of justifying murderous cutbacks in the standard of living and labor-intensive toil. Sperm bank operator Robert Graham's long-time associate, geneticist Herman Muller, who believed that "deleterious genes" were becoming preponderant within the "gene pool" (that is, the population), made this connection very clear. What Muller specifically blamed for the interruption of "natural selection" was "human creativity."

Human creativity, realized in scientific achievements and technological progress, increases society's capacity to progressively improve the intelligence of all its members through technology, education, and culture. Thus, in the eyes of the race scientists, improvements in culture, education, and advanced medical technology should be done away with because they interrupt Darwinian "natural selection."

New Indian Wars Against U.S. Resources

A potentially precedent-setting law suit that has disrupted the economic and political development of Maine for the past eight years is now nearing settlement. Two Indian tribes, the Penobscot and the Passamaquoddy, who filed suit in 1972 demanding 12 million acres of state land based on the provisions of a 1794 treaty, are on the verge of obtaining an out-of-court settlement granting them 300,000 acres of prime forest—what former governor James Longley calls "a nation within a nation."

The Maine case is one of 14 such litigations undertaken in Eastern states in the past 10 years; many others are underway in the West. Legal specialists have questioned how these cases, which violate the Constitution in many ways, can be seriously considered by a law firm or a court. Who's selling guns and whiskey to the tribes?

Despite talk of an upsurge in American Indian "consciousness," there is a decided parallel between this upsurge and the infusion into the Indian community of high-priced legal talent and millions of dollars from private foundations. These are the same agencies, in fact, that finance all the leading organizations in the antinuclear movement. For this reason, the new Indian movement and the environmentalist movement also share a common dedication: zero economic growth.

NARF Vs. Resources

In 1970, the Ford Foundation created what is known as the Natural Resources Defense Council to bring suits against nuclear plant construction and other industrial projects. In the same year, the Ford Foundation announced another project "to right an historic wrong," the so-called Native American Rights Fund (NARF). Several million dollars went into such programs as "Indian Leadership Training" at the University of New Mexico. Parallel efforts by the Lilly Endowment allocated $542,000 to a new Eastern Indian Legal Support Project. The result was the Maine case and other preposterous court cases to disrupt land-and-resource development.

In the mid-1970s, NARF expanded operations to territories west of the Mississippi, based on a grand strategy involving 24 western tribes, brought together to create the Council of Energy Resources Tribes (CERT), a nonprofit corporation that currently controls 60 percent of U.S. uranium resources in the West, 35 percent of Western coal, and a comparable amount of oil and gas reserves in the Rocky Mountain Overthrust Belt, the largest continental oil discovery in 20 years.

CERT has no intention of allowing these resources to be developed. It says in the organization's charter that NARF considers resource development "detrimental to traditional native activities."

The key to the entire project is the high-powered Washington law firm of Fried, Frank, Harris, Shriver and Smith. Partner Sargent Shriver, a Kennedy in-law who was then director of the Office of Economic Opportunity, assigned his federally funded VISTA volunteers to organize Indians against selling resources to pale-face "big business."

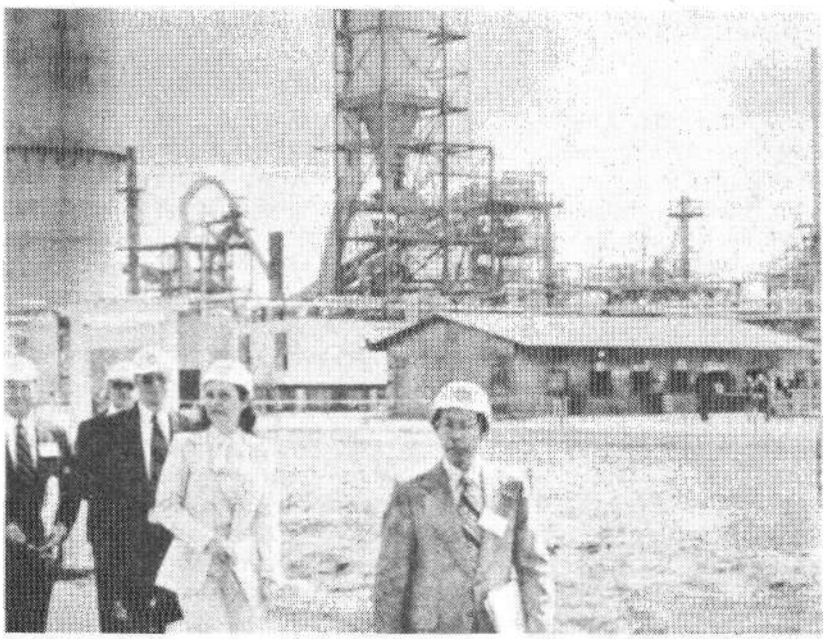
His founding partner Felix Cohen dug up 200 year-old treaties for application to 20th century Indians' "right to separate nation status." Another partner, Sam Harris, happens to be chairman of Rio Tinto Zinc, the giant British minerals concern that is the world's largest holder of uranium.

While Fried, Frank has represented NARF and CERT tribes in countless lawsuits that served to keep American uranium, for example, deep underground, Rio Tinto Zinc forced world market prices of uranium up more than 400 percent through cartel arrangements that many termed illegal. These price increases, among other functions, served as another crippling blow to the nuclear industry.

In 1977, the Supreme Court ruled that motions to increase tribal autonomy are invalid, since Indians came under the domain and protection of the United States long ago. Yet, the federal government has done nothing to stop the new "Indian wars" conspiracy. Perhaps that is because NARF members and Fried, Frank attorneys and board members also hold positions with the Bureau of Indian Affairs, the Department of Interior, the Senate Select Committee on Indian Affairs, and various energy-related agencies immediately concerned with resource development.

Lest anyone doubt just whose rights are being promoted, we note that the Indian movement sent representatives to Iran to meet in political solidarity with the Iranian hostage holders.

—William Engdahl and Vin Berg



DOE photo by Porter

COAL LIQUEFACTION PLANT EXPECTED TO PRODUCE FUEL AT DOUBLE THE PRICE OF OIL

The Department of Energy expects to begin production in April at this Exxon Coal Liquefaction Pilot Plant near Baytown, Texas. At full capacity, the plant will convert 250 tons of coal per day to 600 barrels of oil: Conservative DOE estimates are that the fuel produced will cost at least double the current price of oil, but that petroleum prices will rise to make the synfuel economically competitive.

The Exxon Donor Solvent synfuel process is one of many coal synthetics technologies developed by the Germans in World War II that the DOE is helping to finance in the pilot plant stage.

Here DOE officials tour the new plant.

International

France Gets Oil for Technology

French President Giscard d'Estaing's March tour of the oil-rich nations of the Persian Gulf and Jordan is expected to yield tens of billions of dollars in development contracts for France. The success of the tour results from the economic and political package that the French president proposed to every Arab head of state, guaranteeing the economic independence of the oil-producing nations "beyond the petroleum era."

Giscard premised this plan on two interrelated political problems facing the oil producers—the resolution of the Arab-Israeli crisis through the creation of an independent Palestinian state and the utilization of Arab surplus funds for overall Mideast and African industrial development.

At each stop in Giscard's itinerary, which included Kuwait, Bahrain, Qatar, the United Arab Emirates, Jordan, and Saudi Arabia, he proposed that France offer assistance in the development of oil refining and petrochemical capacity. In turn, France will receive increased shipments of Mideast oil on a state-to-state basis, bypassing the multinational oil companies.

Just after Kuwait announced a cutback in allocations to the multis, British Petroleum, Gulf, and Shell, it offered a drastically increased volume of crude directly to the Compagnie Française des Petroles and to the French state-owned company Elf Aquitaine.

In all, the development deals for the Gulf region over the next five years total about $500 billion. Saudi Arabia, the world's largest oil exporter, made public a mammoth five-year plan worth about $250 billion just a week after Giscard's trip began. This is nearly double the 1975-80 plan. At the same time, Iraq, Saudi Arabia's newly established partner in Mideast development announced that the two nations

Wide World Photos

The Emir of Bahrain greeting French President Giscard as he arrives for trade talks March 3.

'Nuclear Energy Is Imperative'

". . .One cannot but be struck by the near general slowdown in the development of nuclear energy at a time when its necessity is made more and more imperative by an international energy context that is deteriorating day by day. I would like to take advantage of this tribunal to launch a solemn appeal to the entirety of the world community so that all its technicians, political leaders, and citizens take the necessary step back in order to take the decisions required, and to not risk leading the world economy into a recession that could be the germ of even more serious troubles for the balance and peace of the world. . . .

"The global energy problem is posed in both technical and political terms. It can be resolved by drawing upon all the available resources of nature and the human mind and by establishing real cooperation between consumer and producer countries, which will only be fruitful if both make the necessary efforts to confront this new challenge facing humanity. . . .

"I have great confidence in the ingenuity of the human mind and do not doubt that our descendants in the 21st century will resolve in their manner the energy or other problems that will be posed during their era. However, concerning the energy problems posed to us now, I see no solution that does not involve an increased recourse to nuclear energy. . . .

"France . . . has made its choice with determination and responsibility. We have decided to increase 10-fold and beyond our nuclear production between 1975 and 1985, at which time half of our electricity will come from this source."

—Michel Pecqueur, general administrator of the French Atomic Energy Commission, speaking at the International Atomic Energy Conference in New Delhi, Dec. 5, 1979.

would work together to industrialize the region. Both nations are currently working on plans to expand their oil-producing capacity, which will enable them to produce half of the oil production of OPEC.

A former ambassador to Kuwait commented that the French "are now preparing to get a bigger than ever share of the Middle East development market .... They are armed with the policies the Arabs want to hear, unlike the Middle East policy of Washington."

France also offered technical assistance in the development of nuclear energy, an offer accepted by three of the Gulf nations during Giscard's trip. France concluded an agreement with the United Arab Emirates to jointly study the feasibility of building nuclear power generating stations in the tiny Gulf state "once the oil runs out." And the Saudis just announced that the nation would purchase nuclear facilities from France to be used for desalination and medical purposes.

As early as 1976, France began aggressively working to secure contracts with the Arab oil producers for nuclear installations. In December of that year, Saudi Oil Minister Yamani announced that his nation and France would create a nuclear research facility as well as explore for uranium in Saudi Arabia. In the last year, the Saudis have become increasingly vocal in their support for nuclear energy, urging other nations to look beyond the oil era.

—Judith Wyer

France: First in Nuclear Power by 1985

France, the only Western nation with a firm commitment to the fast breeder reactor, announced in February that it will begin building two more breeder reactors by 1985. Already under construction is the giant Super Phenix breeder reactor at Creys-Malville, which will have a 1,200 megawatt capacity when it begins operation in late 1982.

France's ambitious program will make it the Western world's foremost nuclear power by 1985. Each year from now until then, an additional 5,000 megawatts of nuclear energy capacity will be coming on line, until 50 to 55 percent of total electrical output is derived from nuclear sources.

The domestic nuclear program, under the dirigist leadership of the government and the state-controlled electricity producer, Electricité de France, is matched by an aggressive program of nuclear technology export.

Far from leaving the fate of the French nuclear program in the hands of a small group of environmentalist obstructionists, French President Valery Giscard d'Estaing has personally intervened to ensure that the program receives the support of the population as a whole. Speaking on national television Giscard declared, "We have the world's most ambitious nuclear program and the world knows that in this respect France is undertaking a unique effort for energy independence." On Jan. 18, Giscard called the nuclear program "a test of the clairvoyance and foresight of a country."

For its present nuclear capacity, France owes much to the foresight of Gaullist Prime Minister Pierre Messmer, whose name has been attached to the 1974 Messmer Plan that launched the construction of 13 units of 1,000 megawatts each, that are just now coming into use.

With existing production capacity now at more than 8,000 megawatts, France will have 38,500 megawatts on line by 1985.

On France's Nuclear 'Central Direction'

"... Right now we have 16 nuclear reactors on line and are commissioning one new reactor every two months.... The concern is generated mostly by activist groups who exploit danger.... The general feeling was that Three Mile Island was a very comforting event—everything went wrong, but it still didn't hurt anyone, except for the great financial loss to the utility.... We feel that discussion of nuclear matters must be rational and not emotional....

"You are 'over-democratized.' Democracy shouldn't mean anarchy, but that's what you have in this country—some kind of anarchy. Everybody has something to say—the county, the state, the federal, every political group and other groups, too. Nobody really knows [of what they are speaking about], and it's a great fuss. There is no central direction. In France, there is."

—Jean Stolz, head of nuclear safety department, Electricité de France, in an interview with the editor of the New Mexico Technology Review, *Jan. 1, 1980.*

Brandt Commission Reports:

No 'Sophisticated

"Appropriate technologies" under a single world government. Sound farout? That is the theme of the well-financed and recently released report of the Brandt Commission, which labored two years to produce a promotional pamphlet for the zero-growth economics of the report's unofficial sponsors, the World Bank and the International Monetary Fund.

The members of this Independent Commission on International Development Issues, chaired by former West German chancellor Willy Brandt, are bankers, politicians, economists and other leading Malthusians whom World Bank president Robert McNamara selected on the strength of their agreement that the sovereignty of nation-states ought to be surrendered as the most efficient means of preventing further scientific, technological, and cultural development.

Principal Conclusions

The principal conclusions of the report can be briefly summarized as follows:

- Development strategies in the Third World must emphasize rural, labor-intensive agriculture and small cottage-industry based on "appropriate technologies" like sticks for plows and cow dung for fertilizer. The commissioners rail against "highly sophisticated technology which threatens to ignore human values and which people may not be able to handle adequately" (p. 19).

• Overpopulation that is placing a strain on "fixed, limited resources," industrialization, and urbanization must be reversed in both the advanced and developing sectors. Economic expansion must come to an end.

• Energy policies must emphasize extreme cuts in overall consumption in the developed industrial nations and favor solar energy and other labor-intensive, "renewable sources." "We support the provision of greater funds for the research and use of solar energy in the poverty belts," report the commissioners (p. 84). They assert that nuclear energy is "problematic and cannot be expected in most countries to make more than a partial contribution to overall energy use in this century" (p. 167).

• National sovereignty over economic policy and related matters should be surrendered to a one-world government with powers of taxation over world trade, including arms, and control both of existing institutions like the World Bank and IMF, and of a new world energy institute and "World Development Fund" administering international credit flows and investment policies.

Where does the commission come from?

The Brandt Commission was created by World Bank head McNamara in 1977 when the "North-South" talks on economic cooperation between 24 advanced and developing nations were collapsing. These talks, at which developing sector nations sought a "new world economic order" based on high-technology transfers as the essential component of North-South trade, dragged on for two years while World Bank and International Monetary Fund supporters stonewalled. Finally, the talks collapsed when the Third World leaders discovered, after waiting for the new Carter administration and the ouster of Henry Kissinger, that the Carter administration had the same Kissinger-IMF policies.

At this point, McNamara unveiled his proposal for the commission under Willy Brandt, who was allegedly "pro-Third-World." For two more years, the developing-sector nations waited for Brandt, only now to discover the same "appropriate technologies" package being offered. This should have been no surprise, since Brandt has well-known, close political connections with the West German greenies who are now being used as a wedge to unseat the pronuclear and proindustrial-development government of Chancellor Helmut Schmidt.

The Selling Phase

The next phase is the selling of the policy. For this, the entire massive "One World" bureaucracy at the United Nations is being mobilized (see *Fusion*, March 1980, p. 18). The February release of the Brandt report featured a solemn ceremony at which Willy Brandt made simultaneous presentations to Jimmy Carter and UN Secretary General Kurt Waldheim. At present, the zero-growth document is scheduled to be the subject of discussion at the upcoming UN planning sessions for a New International Development Strategy.

The UN Industrial Development Organization (UNIDO), which met at the end of January in India, is spinning all sorts of proposals off the Brandt Commission document: a Global Fund for the Stimulation of Industry; an International Industrial Finance Agency; an International Industrial Technology Institute; an International Center for Joint Acquisition of Technology; and an International Patent Examination Center.

All are proposed to exert supranational control over policies and to deal exclusively with "appropriate technology."

Conserving the Poverty

A cross-section of United Nations agencies now involved in selling the Brandt Commission report to developing-sector nations announced a "World Conservation Strategy" March 5 to "unite conservation and development." A support statement by World Bank chief Robert McNamara indicates the spirit of the conservation strategy: ". . . Economic growth on the careless pattern of the past century poses an undeniable threat to the environment and ultimately to the very ecological foundations of development itself."

The groups involved undoubtedly expect to attract support by their rallying cry of supporting wildlife and keeping the Third World free from industrial pollution. However, the appropriate technologies that make up the development side of the conservation strategy [tiny farms and manual labor] will actually lead to the devolution of the ecological system as disease, starvation, and "natural disasters" such as floods and droughts take over.

Where does the U.S. government stand on this? Firmly behind the conservation strategy document, according to Erik P. Eckolm, a member of the State Department's policy planning staff and formerly with the ultra-Malthusian World Watch Institute. Interviewed by *Science* magazine March 21, Eckholm praised the strategy for leaving behind the "old-line" ideas of conservation that came out of the "elitist Western mould (sic)."

Kintner Testifies on Fusion's 1979 Progress

Edwin Kintner, the director of fusion energy of the DOE Office of Energy Research, reviewed the considerable advances in 1979 of the magnetic confinement fusion research program for budget hearings held March 3 by the Subcommittee on Energy Research and Production of the House Science and Technology Committee. Kintner's testimony parallels the thinking behind the bill introduced into Congress in January by subcommittee chairman Mike McCormack proposing a $20 billion "Apollo-style" program for fusion to build a commercial reactor by the year 2000.

The Kintner testimony, titled "A Broadly Successful Fiscal Year 1979 Magnetic Fusion Program Supports the Fiscal Year 1981 Budget Request," asks for a 34 percent increase in development and technology funding. Other areas of the fusion program were increased to a lesser extent, because now that the science is established, the priority is on developing the technology and engineering.

The total DOE budget request for magnetic fusion for fiscal year 1981 is $403.6 million, compared to the $355.6 million budget the year before. The overall increase, however, will no more than mitigate the effects of inflation. The Science and Technology Committee will be grappling with adding another $100 million on to the DOE request in order to begin an Apollo-style management program that can demonstrate commercial fusion in the 1990s.

The thrust of Kintner's testimony was twofold: First, Kintner said, improved knowledge of fusion plasma physics has led to a convergence in the understanding of plasma behavior by scientists in three different branches of the magnetic confinement program. Second, he said, this scientific convergence is leading to next-phase development of the generic technology needed to support the continued research in all three domains.

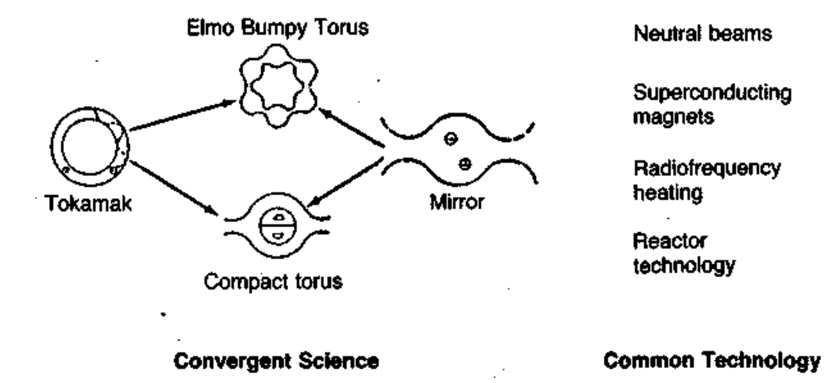
Until 1978, Kintner explained, fusion research in the magnetic confinement field was pursued along three parallel but different lines: the tokamak, a donut-shaped experimental reactor; the mirror machine, an open-ended system; and the Elmo Bumpy Torus, a series of magnetic-field "mirrors." However, advances during 1979 have enabled the program to be restructured, Kintner said, so that it is orientated to producing a common engineering technology and engineering base for all three approaches. This will then provide a technical concept for an optimum fusion reactor.

Kintner's accompanying figure illustrates the convergence of this scientific and technological understanding. The common technology now envisaged includes neutral beam heating, radio frequency heating, superconducting magnets, and basic engineering reactor technology.

A Series of Successes

Kintner referred to the series of 1979 successes realized in both technical and scientific fields:

- The successful confinement in the now-operating Elmo Bumpy Torus (EBT-S) at Oak Ridge National Laboratories led to a favorable DOE official review of the proposed Emo proof-of-principle machine, the EBT-P. (see *Fusion*, April 1980, p. 69.)
- The ISX-B tokamak, also located at Oak Ridge, demonstrated reactor-level beta results for short pulses, about 1 second, leading to a planned ISX-C to extend the results to longer pulses of 30 seconds. (Beta is a measurement of the efficiency at which the magnetic fields confine the plasma.)
- At Lawrence Livermore Laboratory, the TMX tandem mirror design's experimental success led to a positive



CONVERGENCE IN FUSION SCIENCE AND TECHNOLOGY

The science of magnetic fusion has begun to converge over the past year toward a more general understanding of plasma science. The basic science of tokamaks and mirror machines has led to the "marriage" of these two fusion geometries in hybrid concepts such as the Elmo Bumpy Torus and various compact toroid designs. This scientific convergence has generated the four major areas of technology listed here, which will probably be common to the four magnetic fusion designs shown.

Source: DOE

review of the proposal to upgrade the TMX to the Magnetic Fusion Test Facility, the MFTF, an enhanced tandem mirror design. (See *Fusion*, April 1980, p. 69.)

• The evolution of an improved tokamak design, the Starfire. (See *Fusion*, March 1980, p. 60)

Overall, said Kintner the proposed increases in development and technology authorizations from $58.6 million to $79 million in fiscal year 1981 are necessary for development of advanced materials, for Engineering Test Facility design work, and for development of the components of the technology base.

Policy Objectives

Kintner said that the policy objectives of the magnetic confinement program remain:

(1) To demonstrate scientific feasibility, with emphasis on completion of the Tokamak Fusion Test Reactor (TFR) at Princeton.

(2) To broaden the scientific base of the nontokamak alternate concepts program, through mirror, Elmo Bumpy Torus, and advanced tokamak experiments with plasma behavior, which would include compact toroid designs;

(3) To broaden the engineering base of the program, through establishment of a design center for an Engineering Test Facility, ETF, at Oak Ridge.

International Advances

Kintner also spoke of the international advances in fusion over the past year. An international fusion effort, called INTOR for international tokamak reactor, under the direction of the International Atomic Energy Agency, arrived at conclusions very similar to the Engineering Test Facility design teams. The INTOR studies characterize the proposed next-step ETF facility as including an ignited, controlled plasma.

Scientists and government representatives from around the world, Kintner said, agreed that the scientific and technical basis now exists to proceed to such an ETF, and that program emphasis should shift to solving the engineering development problems involved.

Kintner described the INTOR project as an effort that: "involved 200 man-years of work on the part of the leading fusion experts of the world [and] concluded that it was scientifically and technologically feasible to construct a power producing tokamak reactor. The agreement on technical facts and the consensus achieved in the INTOR effort were remarkable. It is a strong endorsement by the worldwide fusion community of our own confidence in our ability to produce energy from at least one type of fusion concept."

Also mentioned by Kintner was an important bilateral fusion cooperation agreement signed between the U.S. and Japan. The four-part agreement took its first step last year toward intensive cooperative work on the Doublet III facility at General Atomic Co. in San Diego. A team of Japanese physicists has been working on the facility for the past six months and a joint Institute of Fusion Study is planned. Kintner reported that other areas of possible collaboration are being explored.

Kintner noted that the only major program that fell behind schedule was the Princeton Tokamak Fusion Test Reactor, the TFTR, which is also expected to have cost overruns of about $45 million. He explained that much of that money was paid to inflation, the rest due to building construction changes to accommodate engineering design changes.

Congressman Mike McCormack, however, chided the fusion office for being so "sensitive" at this 18 percent cost overrun, pointing out that some government programs end up costing 400 percent more than they were supposed to.

—*Marsha Freeman*

Net Budget Cut for Laser Fusion

The administration's fiscal year 1981 budget for the inertial confinement fusion program results in a net cut, according to the Department of Energy presentation at the March 3 hearings of the House Subcommittee on Energy Research and Production.

The DOE testimony, presented in the name of Dr. Duane C. Sewell, assistant secretary for defense programs, by Dr. Philip Coyle, an assistant to Sewell, reported that the overall budget would suffer a cut of 10 percent, if inflation is taken into account. The budget for fiscal year 1980 was $194.9 million with $114.9 million for operating expenses, $8.5 for equipment, and $71.5 for construction. The Carter administration's fiscal year 1981 budget is $202.0 million total, with $159.5 for operating expenses, $11.0 for equipment, and $31.5 for construction.

Not mentioned in the DOE testimony was the fact that the administration's budget completely cuts funds for construction of the Lawrence Livermore Laboratory's giant Nova glass laser system. Nova, an upgrade of the Shiva laser, is the cornerstone experiment of the inertial confinement program and was expected to demonstrate the scientific feasibility of laser fusion in the mid-1980s. Although administration sources have said that the Nova cut represents only a delay in the program, the reality is that the majority of contractors responsible for building the Nova and its components are small companies whose total capital is invested in the effort, and they may not be around in a year or two if the funding is delayed.

When Congressman Barry Goldwater, Jr., a California Republican, asked Coyle why the Nova funding was being cut, Coyle replied that the Lawrence Livermore laser program was too far ahead of the other inertial confinement efforts, implying that they were being given a chance to catch up. Coyle then gave an equally implausible bit of DOE reasoning. The Nova would make the budget unbalanced, because the ratio of construction to operating funds would rise. However, a comparison of the figures for 1980 and 1981 fiscal years shows that this is not the case.

Since Coyle and Sewell are both former employees of Lawrence Livermore and personally support the Nova program, the arguments and policies they represented to the House subcommittee must actually be those of the Carter administration and Energy Secretary Charles Duncan.

This team of groundbreakers at the site of the Fusion Materials Irradiation Test facility in Hanford includes (from left) Dr. John Yasinsky, president of Hanford Engineering Development Laboratory; Dr. Knapp, Los Alamos Scientific Laboratory; George Hardigg, Westinghouse; Congressman Mike McCormack; Alex Fremling, DOE Richland; Ed Kintner, director of the DOE Office of Fusion; and Glenn Lee, publisher of the Tri-City Herald.

Construction Starts for Fusion Materials Testing Facility

Ground was broken for the Fusion Materials Irradiation Test facility, FMIT, Feb. 22 at the Hanford research center in Washington. The $105 million FMIT facility will test reactor materials in the fusion environment and is the first major engineering facility designed to move fusion out of the laboratory and into the practical production of electricity.

Westinghouse Electric Corporation, which runs the Hanford center for the Department of Energy, is constructing the FMIT under contract with the DOE Office of Fusion Energy's Development and Technology Division.

Speaking at the groundbreaking ceremony, Congressman Mike McCormack, a Washington Democrat, predicted that an electric fusion power plant will be built in the 1990s. "That moment is going to be the most important event related to energy in all human history," he said. "It will be second only to the first controlled use of fire."

The Materials Problem

At one time it was believed that developing materials to withstand the fusion environment was the most difficult, if not insoluble, problem in the realization of practical fusion power plants. In the light of actual experimental and engineering research, however, this pessimistic prospect has changed greatly. It is now generally accepted that existing stainless steel alloys will be reasonably adequate for the job.

Materials for fusion reactors are still a key question, though, because most of the cost of fusion energy will be

FMIT: 'A Vital Step'

"The FMIT is of great significance for not only our national program, but that of the entire world. Developing the materials for fusion reactors is a key pacing item in the development of this energy source, and we need fusion today. . . . So what we are initiating today is not just another solar-heated school. It is a vital step in making the ultimate energy source of the universe, the source of the energy of the sun and stars, available to man on this planet."

—Edwin Kintner, director of the DOE Office of Fusion Energy, at the groundbreaking ceremonies for the FMIT, Feb. 22.

the capital costs of the reactor. Developing long-lived materials that go beyond the minimal criteria for permitting practical power plants from an economic and technology standpoint could greatly reduce projected fusion energy costs. This could be accomplished by developing materials that last the lifetime of the plant, support more intense fusion energy outputs, and thus permit smaller, high power density reactors to be built.

The Fusion Environment

Although fusion reactor materials, especially the materials that constitute the fusion reaction chamber, will experience the full gamut of ordinary types of physical stresses—mechanical, thermal, and possibly corrosive stresses—it is the presence of the high-energy 14-million electron volt neutron generated by the fusion reaction that creates a unique problem. This subatomic, electrically neutral particle traveling near the speed of light easily escapes the reacting fusion plasma and collides with the reactor walls. The fusion neutron, which contains about 80 percent of the fusion reaction energy output, penetrates up to several feet of the wall material. In the process this neutron collides with the atoms making up the wall material, either simply knocking them about or actually inducing nuclear reactions in them. As a result, the physical properties of the wall materials can be drastically degraded, generating some radioactive waste.

Nuclear reactions with the neutrons can be avoided and modified by changing the chemical or even isotropic makeup of the alloys used in the chamber wall, but the degradation of physical properties can be fully understood only by testing all the forces—mechanical, thermal, or chemical—that act on the alloys during and after the time they are irradiated by the neutrons. In some cases, physical properties may *improve* under neutron irradiation.

The FMIT

The FMIT will be a large particle accelerator that sends an intense beam of ions to collide with a molten stream of liquid lithium metal. The nuclear reactions that result generate an intense flux of 14 MeV neutrons. This neutron flux bombards a metal target of about 2.5 by 3.5 inches.

The neutron flux is sufficient to simulate 15 years of average projected reactor operation in about 3 years, and the data collected will be applicable to magnetic and inertial fusion reactor designs.

The *Christian Science Monitor* reported March 6 that the FMIT project is attracting international interest. "Japan, which looks on fusion as being critical to its future energy needs, is considering investing $50 million to enhance the plant's capabilities, according to DOE sources," the *Monitor* reported.

LLL Proven Right On Laser Absorption

Reports from the Lawrence Livermore Laboratory laser program appear to confirm that absorption of laser light dramatically increases with the increasing frequency of the laser light.

At the February San Diego Topical Meeting on Inertial Confinement Fusion, Livermore scientists reported that experiments with the Argus laser system showed an increase in laser light absorption to 70 to 80 percent when they doubled the frequency of the laser light from their neodymium glass laser system.

Furthermore, the quality of the absorption was much improved because the presence of superheated electrons was noticeably diminished. This is quite important, because "hot" electrons tend to prevent efficient compressions of the fusion fuel, thus stopping the attainment of high gains. (Gain is a measure of fusion energy output over laser energy input.)

Whether or not this is the case has been a major controversy in the world laser fusion community for the past decade. Lawrence Livermore, in particular, has championed the theoretical perspective that this sort of scaling of laser light absorption with frequency occurred. The Livermore scientists held that both the efficiency and quality of absorption of laser light would increase with increasing frequency.

Similar results were first presented last fall by French laser fusion scientists at the American Physical Society plasma physics division in Boston.

Nat'l Labs Begin Study Of Fusion-Hydrogen

The Development and Technology division of the Department of Energy Office of Fusion Energy, under the direction of Dr. Franklin Coffman, has awarded contracts to two national laboratories for conceptual design studies on producing hydrogen from future fusion reactors. The $1 million project will be carried out primarily at Lawrence Livermore Laboratory in California and Brookhaven National Laboratory in New York, with supporting research at the University of Washington and Exxon Corporation.

The two projects will study potential designs to couple the heat produced in a fusion reactor to thermochemical hydrogen production cycles and high-temperature electrolysis. Both production methods use water as the raw material for hydrogen, rather than precious natural gas, which supplies almost all of the hydrogen produced today. Hydrogen will be an important substitute for gas and oil fuel at the turn of the century.

Water: A New Raw Material

One advantage to the application of fusion-produced heat to hydrogen production technologies is that the entire system—the production of heat and electricity as well as the production of hydrogen for fuel—uses water as its major raw material input.

A second advantage is that higher temperatures can be attained in a fusion reaction than in any advanced fission design and the higher the temperature input, the lower the cost of splitting water to liberate the hydrogen. At approximately 2,500 degrees Celsius it is possible to split water with only thermal energy (heat), but there are no existing materials that can withstand that temperature.

Therefore, temperatures up to approximately 1,800 degrees Celsius are under consideration. At that temperature the amount of electricity needed for electrolysis is considerably less than the electricity needed for today's low-temperature electrolysis processes.

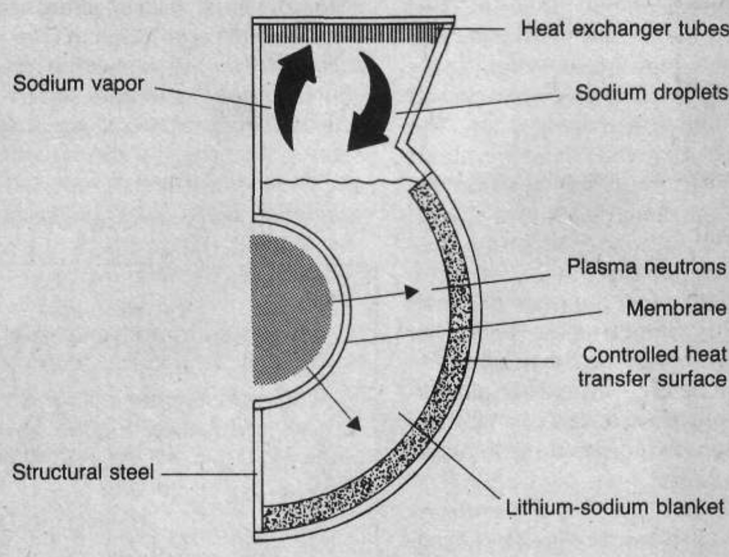
Dr. Jim Powell at Brookhaven and a team of researchers have been doing conceptual design work to couple fusion reactor heat to high-temperature electrolysis cells for the production of hydrogen. They estimate that a demonstration series of such cells could be ready for testing at the same time that the Engineering Test Facility fusion reactor is ready to demonstrate the commercial feasibility of fusion—in the 1990s.

High-temperature electrolysis consists of conducting the heat from a lithium blanket surrounding the fusion vessel through a series of ceramic ducts. The most efficient design would transfer heat at about 1,800 degrees to a set of between 9 and 12 electrolyzers where an electric current splits water with the help of the heat.

As hydrogen is liberated from the first cell, the temperature drops as the excess heat is transferred to the next cell, so a cascading series is created. The Brookhaven group estimates that 50 to 70 percent efficiencies could be reached, depending upon the temperature transferred from the fusion blanket.

Competitive with Petroleum

Very preliminary estimates at Brookhaven indicate that the cost of hydrogen



USING FUSION TO MAKE HYDROGEN

This preliminary design, considered by the Lawrence Livermore scientists for using the heat from fusion reactions to make hydrogen, involves a tandem mirror fusion reactor. Both high- and low-temperature heat is removed from the reactor for a thermochemical hydrogen process. The heat at about 900 degrees Celsius is removed from the top of the container. It is captured from the deposition of fusion neutrons in the liquid lithium-sodium blanket around the plasma vessel chamber. The sodium is heated and the liquid sodium vaporizes. The heat is transferred through heat-exchanger pipes that are also filled with liquid sodium. The vapor then condenses and falls in droplets back into the liquid bath.

Lower-temperature heat, about 400 to 500 degrees Celsius, is carried off from the vessel through a controlled heat transfer surface lining the steel container. Both qualities of heat are transferred to the thermochemical hydrogen production process. At the same time, when the lithium in the bath is bombarded with the fusion neutrons, tritium is produced as a by-product and can be used to fuel the ongoing fusion reactions.

produced by high-temperature electrolysis would be competitive with today's price of petroleum. Much less electrical energy is needed than in conventional electrolysis because of the higher temperature. Furthermore, the cost of the electric power per unit should be lower than today's cost from fossil-fired units, since fusion uses water as fuel and generates energy at a considerably higher energy density than any other process, either combustion or fission.

The only physical problem that needs to be solved in the high-temperature electrolysis process is that of materials able to withstand the 1,500 to 1,800-degree heat required by the system.

At Lawrence Livermore, under the direction of Dr. Dick Werner, the fusion program is investigating the coupling of fusion-generated heat to cycles that produce hydrogen from water through the mediation of various intermediate chemical reactions. All of the thermochemical processes under consideration use highly corrosive sulfuric acid at significantly high temperatures to help split the water.

Unlike the Brookhaven program, which is using the tokamak fusion reactor design in its high-temperature electrolysis studies, the Livermore team is looking initially at the tandem mirror magnetic fusion design for thermochemical hydrogen production.

Werner has developed the idea of surrounding the confined plasma in the cylindrical center of the tandem mirror with a liquid lithium-sodium bath (see figure). When neutrons from the fusion reaction bombard the lithium-sodium liquid blanket, the lithium is transformed into tritium, which is needed for the fusion reaction.

The liquid sodium is heated and turns into a vapor, at about 900 degrees Celsius. This vapor rises in the container and the heat is transferred into heat exchangers at the top of the vessel. As the heat is drawn off, the gaseous sodium condenses and returns to the liquid bath in droplets.

The vessel is lined with a spongy, controlled heat transfer material that will transfer the heat, at about 400 to 500 degrees Celsius, from the liquid bath to heat exchanger tubes. The lower temperature of the heated sodium can be precisely controlled by producing a large temperature gradient across the spongy liner material. This then houses the hot liquid in a relatively cool container.

Both the higher and lower temperatures would be used as the thermal input for various thermochemical cycles. Most cycles need the heat to break down sulfuric acid into oxygen and sulfur dioxide, which are used with water in chemical reactions to liberate hydrogen.

The Livermore and Brookhaven projects are both in the preliminary stage and will consider various technologies for the transfer of fusion-generated heat. Each laboratory will receive $400,000 in this 1980 fiscal year (which began in October) and both hope to have designs that can be engineered into bench-scale models, using small-scale heat sources before fusion is ready, to test the initial design concepts.

—*Marsha Freeman*

Letters

Continued from page 9

plans, but he emphasizes that only the practical Englishman Newcomen actually built an engine that "worked." The Newcomen engine "worked," he argues, precisely because it was neither advanced nor bold, but "*appropriate*" to the "objective conditions" of the period.

This argument is fraudulent and completely ignores the evidence presented in my original article. There I cited a certain proposal made by Denis Papin to the Royal Society in 1708: "Proposition by Dr. Papin, concerning a new invented boat to be rowed by oars, moved with heat." Papin had constructed and successfully tested a model paddle-wheel ship based on his study of the dynamics of rowing. He had also successfully tested his direct action steam engine, which was developed on the basis of Leibniz's suggestions for improving thermodynamic efficiency. He proposed to combine his paddle-wheeler and steam engine to construct the world's first steamboat and navigate it up the Thames, 100 years before Fulton.

However, Papin's design was never "put to the hard test of practical use"; the Royal Society rejected his proposal, appropriated his work, and forced him into obscurity and an early grave. Yet, Cardwell attempts to explain away this deliberate suppression of technological advance with a long-winded discussion of the "inevitable laws" of technological appropriateness.

Not surprisingly, Cardwell's explanation of technological appropriateness is precisely the argument put forward today by the Khomeinites, the World Bank, and the environmentalists—as can be seen from this passage from the epilogue of Cardwell's 1972 book, *Turning Points in Western Technology*:

"Attempts to raise the standards of living in 'undeveloped' countries have not, so far, been very successful. It is now realised that to institute a national airline, a university of technology, a steel works and a number of automated factories in an undeveloped society or nation does not automatically result in Western-style growth economy. Rather it further impoverishes the countryside and swells the city and town populations with unemployed craftsmen displaced by *the injection of an alien technology*....'Intermediate technology,' which takes account of these things, now seems to be the best hope for the undeveloped world [emphasis added]."

In Papin's day, this political philosophy delayed the development of steam power for almost 100 years; today, the consequences of delaying advanced technology would be far worse.

Philip Valenti

Papin: Setting The Record Straight

To the Editor:

The development of the steam engine as written by Philip Valenti in the December issue of *Fusion* was both tremendously enlightening and intriguing. It has been said among our family that we were descendants of Denis Papin, "the inventor of the steam engine." I personally paid scant heed to the claim of his inventions, however, for there was a paucity of evidence or historical documentation to support his endeavors and accomplishments. Mr. Valenti's exposé raises interesting

Continued on page 70

Letters

Continued from page 69

questions, which I sincerely hope will be addressed in due course....

I find it absolutely incredible that Denis Papin was denied support and in fact discredited by his scientific associates (among the British Royal Society) for endeavors and accomplishments which could benefit so many (and in retrospect so much earlier!). For whatever vain or other reason the society sought to supress Denis Papin's innovations in steam technology, surely they have misjudged history....

Gerard A. Papin
Boxford, Mass.

Reevaluating Marijuana

To the Editor;

...I'm an active participant in the drug abuse counseling program at the Federal Correctional Institution, Butner, N.C. Being a resident here and wanting to benefit as much as possible from my stay, I joined the drug group to explore the other side of the coin.

Up to now I have always been both a profound believer in the use of marijuana, as well as a strong lobbyist for its legalization, decreeing anything published, written, or spoken against it, as just so much more government propaganda. Now that I've had the opportunity to read the very well presented article by Dr. Nahas ("The Biological Effects of Marijuana," *Fusion*, Sept. 1979), especially with *Fusion* lending weight to it by printing it, I've had to step back from my own objectivity and reevaluate the effects of marijuana as a whole . . . .

Franklin E. Branamen,
Butner, N.C.

A reprint of the two Fusion *articles on "The Drug Plague" is available from the FEF at $1.25 postpaid.*

FEF INTERN PROGRAM

The Fusion Energy Foundation plans a summer intern program for undergraduate and graduate science and engineering students who would like to work with the foundation. Interested students should send a letter and resume to Dr. Morris Levitt, FEF, Suite 2404, 888 Seventh Avenue, New York, N.Y. 10019.

Books

How Industrial Capitalism Works

Basic Economics for Conservative Democrats, by Lyndon H. LaRouche, Jr., New York: Citizens for LaRouche, 1979, 172 pp.

Basic Economics, one of four books Lyndon LaRouche has written during his campaign as a Democratic presidential candidate, is a straightforward explanation of the scientific approach to economic problem-solving and policy, now the number one issue of the 1980 campaign.

The basic thesis of this book is of particular importance for those who support the necessity for nuclear fission and fusion development, for it provides a scientific basis for understanding and turning around current zero-growth policy. For example, the author states a thesis that has hit home with a vengeance since the March 14 economic announcements by President Carter and Federal Reserve head Paul Volcker: "The Volcker measures, driving up interest rates into the realm of usury and drying out supplies of credit for productive investment," LaRouche says, "have been more significant than the falsified [environmental impact and safety] reports in halting the process of [nuclear] construction."

The Basic Economic Thesis

LaRouche's economics thesis is this: Long-term economic growth (not simple increases in monetary flows), results solely from those increased rates of production of surplus tangible output that occur because of advances in the scientific and technological base of the economy. Growth without technological development is a short-term possibility ("simple growth"), which must quickly give way to stagnation, decline, and even collapse because of the resource limitations inherent in a fixed base of technologies.

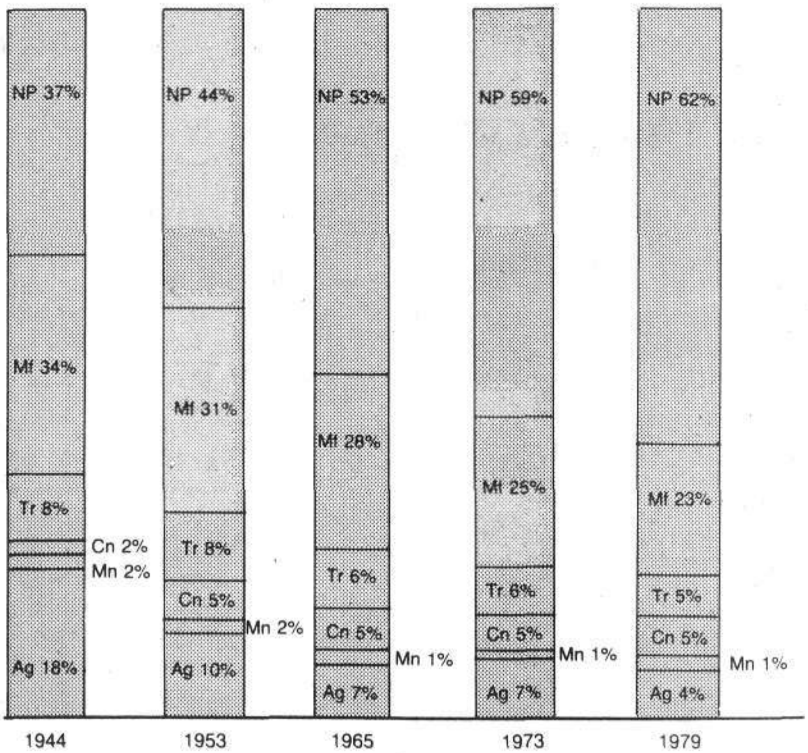
LaRouche's view is that economic policy ought to be the deliberate fostering and spreading of technological innovations, generating *simultaneous increases in wages and profits* as the solution to policy problems and crises. This was the conviction of Benjamin Franklin and Alexander Hamilton, economic architects of the American republic.

For the past two centuries, says LaRouche, that approach to economics has been termed the "American System," the term coined by the early 19th century Whigs to convey their opposition to the British System of wealth based on looting raw materials and using cheap labor. The founding fathers, however, did not originate this system; they revived and institutionalized a set of economic principles that had come into existence long before.

LaRouche attributes this unique contribution to national economic sovereignty to France's Jean-Baptist Colbert and his protégé Gottfried Wilhelm Leibniz in the 17th century. It was this Continental tradition of scientifically oriented industrial-mercantile capitalism, forced into numerous confrontations with the feudalist oligarchy that rules Britain, that defeated British "free trade" policies to found the American republic in the 18th century.

The American System

LaRouche begins by explaining his title and locating economics squarely in traditional American political wars rather than in academic abstractions. Seventy-five percent of American Republicans *and* Democrats, he maintains, want to conserve the "American System"—investment in technical progess that increases the powers of each citizen and of each generation as productive contributors to society. This conservative majority shows itself in every poll on two controversial national issues that serve as a litmus test: the need for government intervention to expand nuclear energy and to end the toleration of mind-altering drugs. Unlike the antiscience radicals and liberals, these conservatives believe in a knowable and scientific truth and morality.



THE CHANGING COMPOSITION OF THE U.S. WORKFORCE

The percentage of individuals employed in the so-called nonproductive sectors of the economy has considerably increased as a proportion of the total workforce from 1944 to 1979. Nonproductive is defined here as workers employed in the wholesale, retail, government, service, and financial sectors.

The Democrat-Republican distinction, LaRouche continues, is that the conservative Democrat bases himself in the American urban-industrial labor force. Thus, this more numerous breed of conservative looks for "a Hamiltonian policy which simultaneously increases wages and profits." In a serious economic crisis like today's, the conservative Democrat resists fiscal budget cutting and monetary austerity à la Volcker as a solution, while his entrepreneur-oriented Republican counterpart may be drawn toward wage and credit austerity against his better judgment. The conservative Democrat rejects such single-issue or mere economic protest politics.

The best of the Democrats, LaRouche believes, must take up the obligation to bring fellow conservatives on the Republican side into debate and formulation of the "harmony of interest" solution, as Lincoln's economic advisors termed it, applying principles of the Whig "American System" to the current crisis.

Larouche's approach is unique in its application of scientific principles of cause and effect to economics. He defines capital formation—not money capital but capital goods that lift the productivity of labor—as "the guts of sound economic policy making." He reports that though the book was addressed to New Hampshire conservatives met during the presidential primary, it was provoked by a complaint from a European banker: "No one pays any attention to the economics of capital formation these days."

Capital formation he defines as "improved investment in scientific and technological progress, increasing the energy-density of productive capital." LaRouche locates economic cause and effect in a single measure: the proportion of the labor force productively employed in such tangible capital formation and in contributing research and invention. One stark graphic in the book shows the catastrophic decline in the productively employed portion of the American workforce since World War II, from 63 percent to 38 percent today.

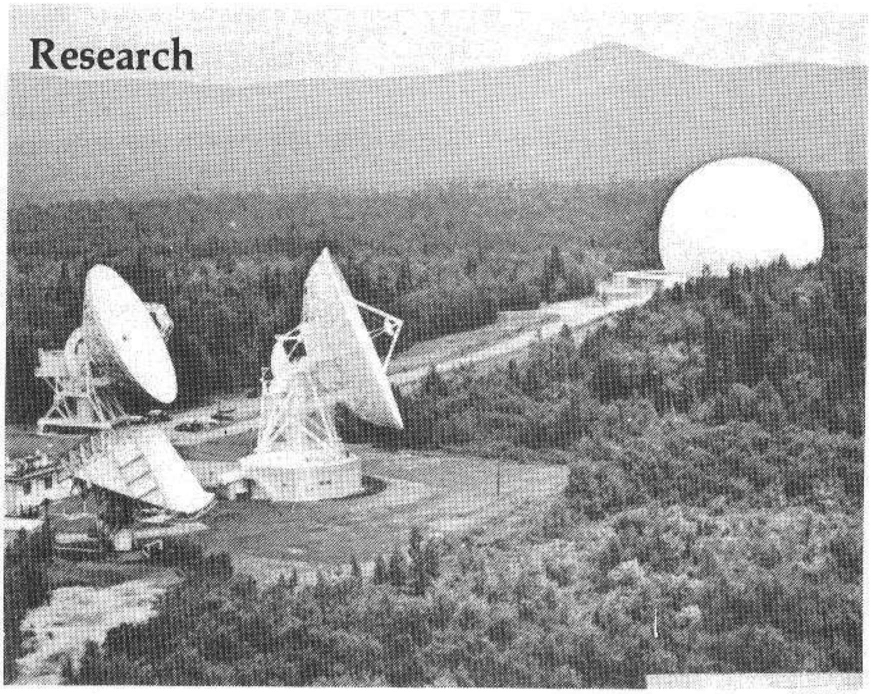
Nuclear Energy's Role

This depth of stagnation in capital formation is the only possible determining context in which nuclear energy technologies could have been held back so disastrously for so long. And rapid nuclear and high-technology energy expansion is now essential to a labor-industry "harmony of interest" policy to bring the American economy back from disaster.

To most economists advising governments and large private institutions, charges LaRouche, a new entertainment industry, a new gambling casino, even a new whorehouse, represent "GNP" equally with a new nuclear power plant. Such economists are as dangerous tinkering with America's credit system as with our nuclear industry.

To restore the rate of technological and scientific progress needed to pull the American economy out of crisis, LaRouche proposes a four-point presidential policy: a consultative body of scientists to inform the president of "the spectrum of breakthroughs in sight"; defining task-orientations and project-orientations to pull together individuals, firms, and government agencies as in the Manhattan Project and NASA; fiscal and monetary incentives for research and development and investment devised by president and Congress to "privatize" these entire national projects into the private sector; and promotion of science and technology fairs and related approaches in the universities and public school system.

—*Paul Gallagher*



Radiotelescopes at the Andover (Maine) Earth Station. COMSAT

Measuring the Universe With More Precision

Radioastronomers have recently tested a new method for measuring the distances to galaxies that promises significantly to expand our knowledge about that part of the universe near our galaxy. The new technique also has thrown into question accepted estimates for the so-called age of the universe.

The new technique was introduced last spring by Marc Aaronson of Steward Observatory and Jeremy Mould of Kitt Peak Observatory, both in Arizona, and John Huchra of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. Previous techniques have been based largely on chains of assumptions and extrapolations that might or might not be valid. By contrast, the new method is based on physical principles allied with direct measurements.

One of the first successes recorded for the new method is a new estimate for the Hubble constant. Named for Edwin Hubble, whose work pioneered the expanding universe concept, the Hubble constant measures the rate at which the universe expands. According to the new measurements, the constant must be adjusted to reflect a much more rapid expansion than had previously been thought correct. Such a correction would decrease the apparent time at which the expansion began from some 20 billion years ago to only 10 billion years ago.

This does not mean that the universe is 10 or 20 billion years old, or that it began with a "Big Bang" at that time, and has continued expanding to this day. It simply means that when the current inadequate theory is extrapolated backward in time under the assumption that the laws of the universe are fixed, a singularity arises about 10 billion years ago, beyond which it is impossible to account for anything.

Measuring the distance to a galaxy is not an easy matter. For some nearby stars, a simple parallax measurement can be made. Parallax distance measurements depend on measuring the apparent motion of an object relative to some fixed point of reference as you, the observer, move a measured distance. But when distances are as immense as those between galaxies, the apparent motion of the object is too small to measure.

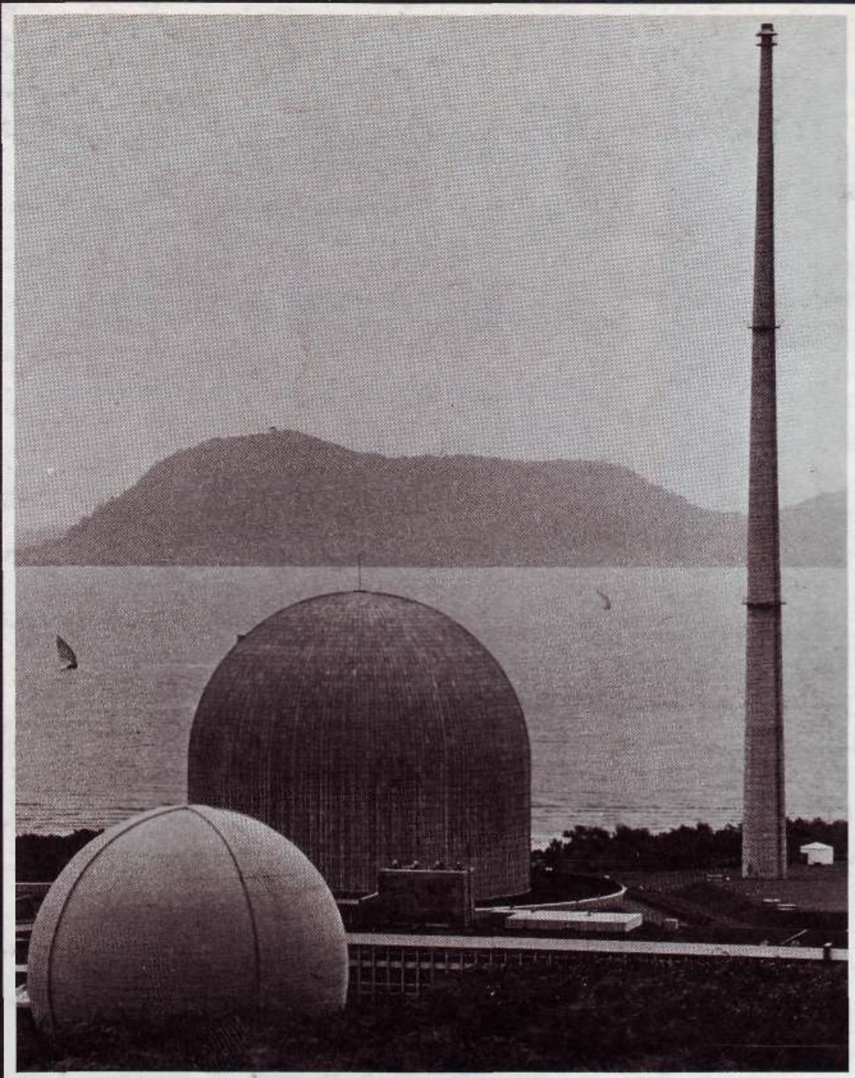
The Solution

To overcome this difficulty and to achieve nearly direct distance measurements, Aaronson and his coworkers have chosen to use some properties of the famous 21-centimeter hydrogen spectrum line, a ubiquitous radiofrequency galactic emission. Every celestial source emits this radiation, since it is produced by hydrogen, by far the most common element in the universe.

The 21-cm line emitted by a rotating galaxy will appear broadened. That is, rather than receiving a sharp signal at a single frequency, the radioastronomer will notice a smeared signal, peaked at the 21-cm frequency. The reason for this is the so-called Doppler effect, well known as the shift in pitch of a siren from a passing ambulance: The pitch is higher as the ambulance approaches, lower as it recedes. Similarly, the 21-cm emission from the arm of the galaxy rotating toward the observer will appear at a higher frequency; while from the receding arm it will appear at a lower frequency. From the center of the galaxy, the emission will appear at an intermediate frequency.

The importance of the Doppler broadening of this emission is that it can be used to measure directly the galaxy's rate of rotation. Now, since the galaxy's size is proportional to the galactic rotation rate, the size, and, consequently, the brightness of the galaxy at the infrared wavelengths can be determined. Finally, the apparent brightness of the galaxy, as measured from the earth, is compared to its absolute brightness, and the distance to the galaxy can be directly estimated since the brightness decreases in a very simple, well-known way.

—*John Schoonover*



Breaking the Limits to Growth

India can become an advanced industrial power and a breadbasket for the world within 40 years, and our cover story tells how. Using the Riemannian economic analysis, a task force that included several Fusion Energy Foundation staff members has spelled out in detail the scale and timetable of development and the material and capital inputs necessary in the critical areas of manpower, energy, water resources, and industry. With equal specificity, the Riemannian analysis shows that any lesser program—slow growth or no growth—leads to economic collapse and death by starvation for millions.

In companion feature articles, Nancy Spannaus debunks the theories of today's Malthusians who prefer to shrink the population and share an increasingly smaller societal pie, and Vin Berg shows how the various economic models used by governments and industry today are all geared to avoid the growth and development solution to get the economy out of its depression.

On the fusion frontier, Charles B. Stevens reviews the latest Lawrence Livermore Laboratory report on the U.S. laser fusion program and concludes that the classification imposed on the program not only is keeping laser fusion progress a secret, but also is preventing researchers from reaching the conditions required for economical fusion energy production.

Above left:
The Cirus experimental nuclear reactor at the Bhabha Atomic Research Center in Trombay, India. Under the 40-year development plan presented in this issue, India will be producing 344.3 gigawatts-electric of nuclear-generated power.
Credit: United Nations

Left:
A laser fusion fuel pellet, shown on the head of a pin. The tiny hollow microsphere is filled with hydrogen gas.
Credit: Lawrence Livermore Laboratory

Cover design by Christopher Sloan and Ursula Wycisk.