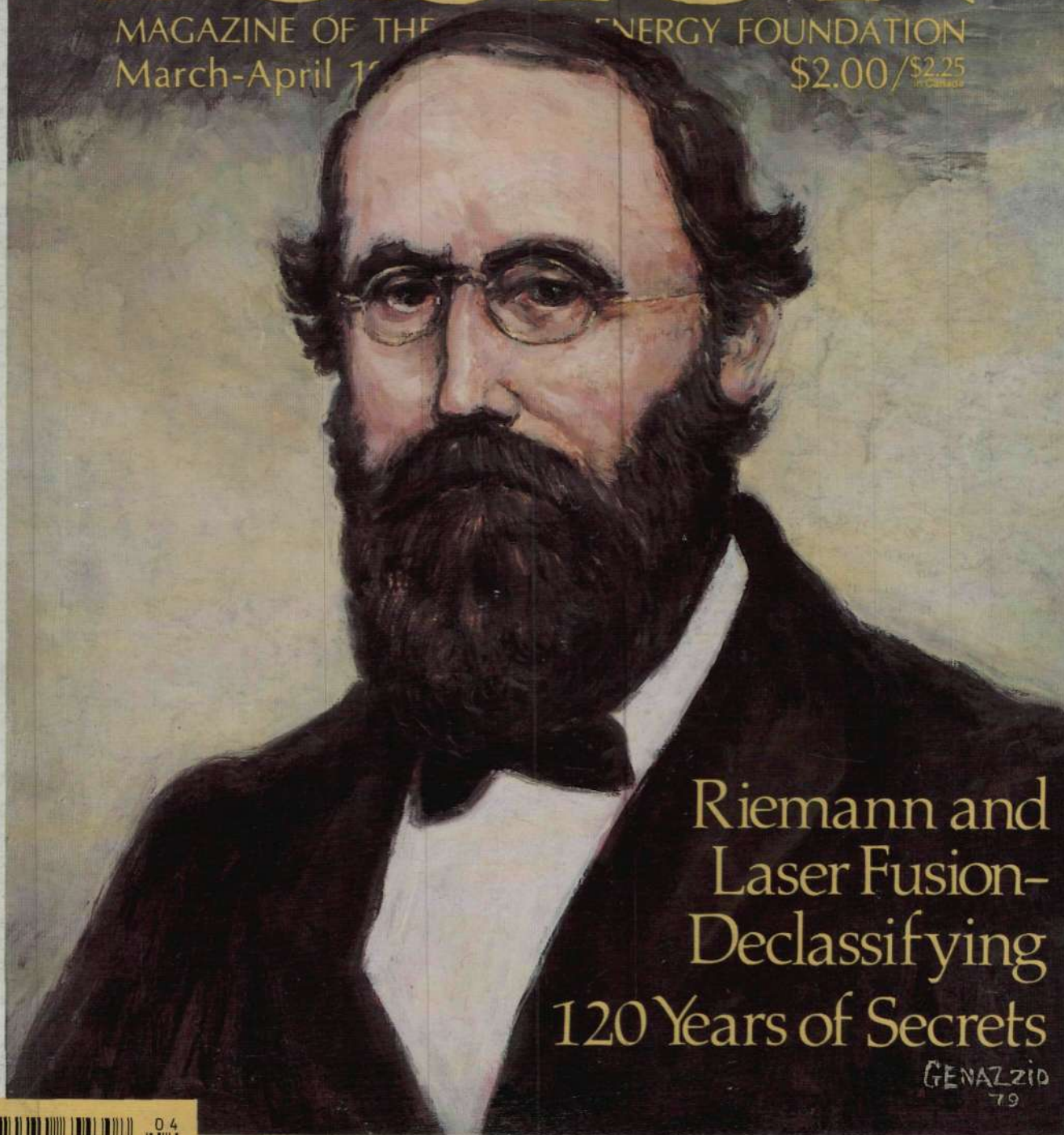


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# FUSION

MAGAZINE OF THE ENERGY FOUNDATION  
March-April 1979 \$2.00/\$2.25  
in Canada



Riemann and  
Laser Fusion-  
Declassifying  
120 Years of Secrets

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# FUSION

MAGAZINE OF THE FUSION ENERGY FOUNDATION

March-April 1979

Vol. 2, No. 6

ISSN 0148-0537

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FUSION is published monthly, 10 times a year except September and April, by the Fusion Energy Foundation, 304 West 58 Street, New York, New York 10019, telephone (212) 265-3749.

Subscriptions by mail are \$18 for 10 issues or \$34 for 20 issues in the USA and Canada. Airmail subscriptions to other countries are \$36 for 10 issues.

Address all correspondence to Fusion Energy Foundation, P.O. Box 1943, New York, New York 10001.

Second class postage paid at New York, New York.

The FEF publishes a wide variety of material for the benefit of decision makers and the interested public. The views of the FEF are stated in the editorials. Opinions expressed in signed articles are not necessarily those of the FEF directors or the scientific advisory board.

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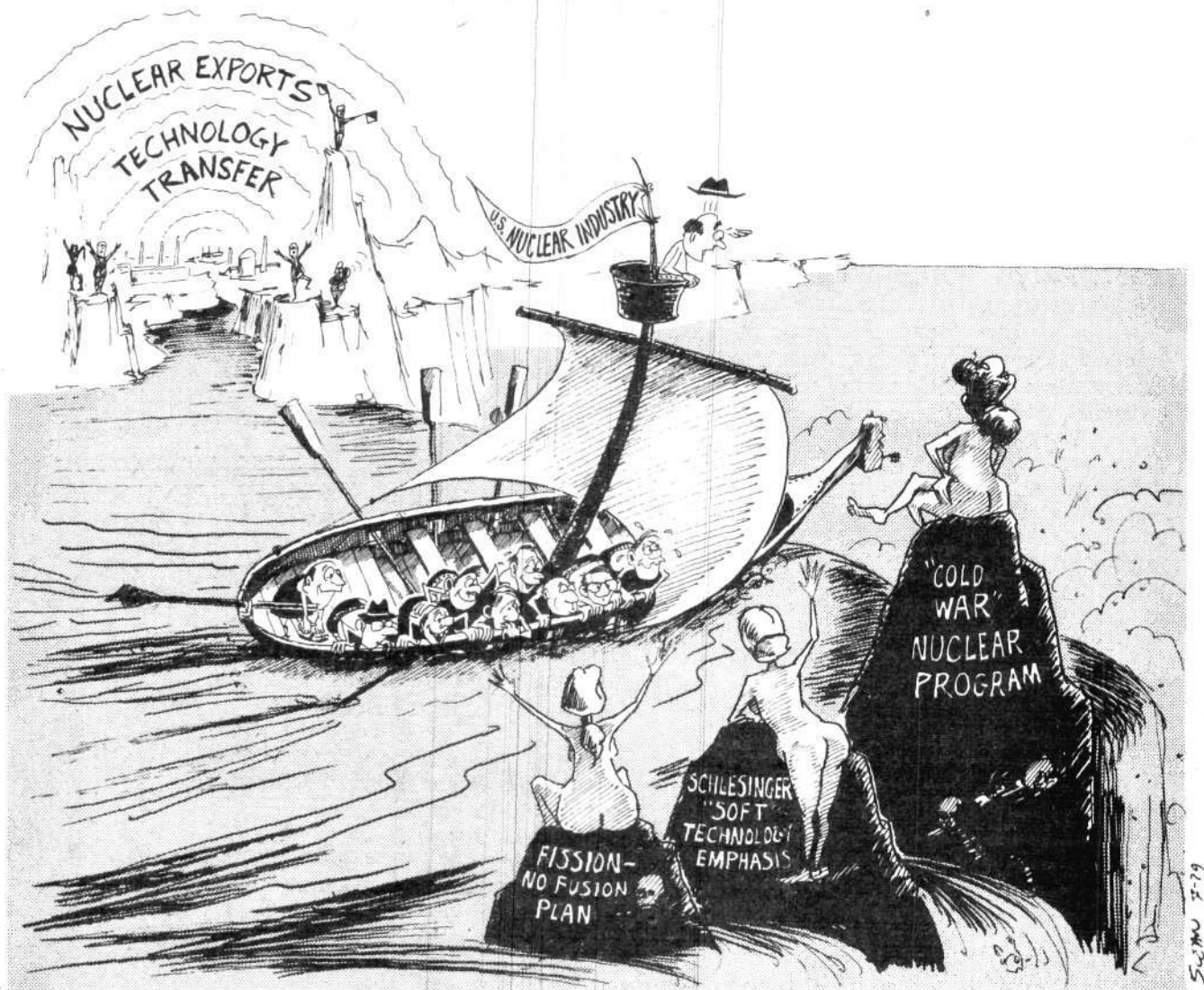
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## Editorial

# U.S. Energy Policy: Out of The Dark Ages

It's about time the United States started conducting its science and energy policies like a sovereign nation. This means facing a basic fact. The relatively small number of individuals and institutions that are blocking U.S. development and export of nuclear power, blocking the conduct of broad-based basic scientific research, and blocking the upgrading of U.S. industrial technology are un-American. They are un-American on two counts. First, they don't share the *Founding Fathers'* commitment to the fullest possible realization of the unlimited potentialities of the American people and the world population; and second, they place a foreign ideology above the national interest.

Take the case of classification. As the feature articles in this issue demonstrate, the system of classification of basic research in inertial confinement has not kept any deep, dark secrets from the Soviets. Rather, it has served to keep most of the U.S. scientific community in the dark about the most fruitful methodological approaches in nonlinear hydrodynamics. This is not just an unfortunate by-product of the security policy; it is the intended purpose of classification.

### The Known Enemy

There is no secret, however, about the identities of the individuals and institutions complicit or witting in the assault against science and industry in the United States. First, there are the so-called humanitarian environmentalists, like Amory Lovins and Ralph Nader, who have decided that the Third World is better dead than nuclear. Their statements on the costs, safety, and environmental impact of nuclear power, without exception, are lies.

Then there are the environmentalists' friends in the government, like the antiproliferation kooks in the White House staff, the State Department, and

the National Security Council. Deserving of special mention in this category are the appropriate technology cultists in the office of President Carter's science advisor, the National Science Foundation, the National Academy of Sciences, and the foreign affairs sections of the Departments of State and Energy.

And lastly, there is the bipartisan lunatic fringe in the Congress, exemplified by Senators Percy and Kennedy, that is going gung ho to stop nuclear exports and dismantle the energy industry.

Granted, these ladies and gentlemen don't come up with their medieval philosophy on their own. They are carefully tutored in their antiprogress litany by a number of think-tanks and foundations: the Aspen Institute, the Hudson Institute, the Rand Corporation, the Brookings Institution, the Institute for Policy Studies, the Heritage Foundation, the Ford Foundation, and the Rockefeller Foundation, to name just a few.

However, whether the slogans emanating from these outfits are "environmental protection" and "appropriate technology" on the one hand, or "fiscal conservatism" and "free enterprise" on the other, the prescriptions and policies are equally disastrous for the world economy.

The worst of this bunch is Energy Secretary James Schlesinger. For those of us who try to make our contribution to human progress in the fields of science and energy, it is hard to imagine a more demented crew than Schlesinger and his top lieutenants at the Department of Energy. Even those individuals in the science community who were initially most credulous about Schlesinger's role by now have come to see that his record is an unbroken string of acts of sabotage against present and future energy supplies.

### Treason

The time has come to stop asking why Schlesinger and the other un-Americans continually sabotage U.S. growth and development and to start asking why the nation tolerates such treason. In every case it can be shown that underlying their patently irrational actions and policies is a deep-seated antagonism to the American System of scientific and technological progress conceived by Benjamin Franklin, George Washington, and Alexander Hamilton. Schlesinger, for example, professes to be a Malthusian, a philosophy anathema to the Founding Fathers.

If one surveys the attempts to destabilize the most growth-oriented nations of the Third World as well as the industrialized sector, it becomes clear that the objective of these un-Americans is not merely to put the brakes on growth and development, but to reverse the global progress achieved since the American Revolution. Among certain queer circles schooled at Oxford, Cambridge, or Sussex universities and their cothinkers outside Britain, this reversal of progress, code-named the new Dark Ages, is alleged to be both necessary and inevitable.

The world has every opportunity to avoid this medieval fate. We are at the threshold of the greatest scientific and technological revolution in history with the onset of controlled fusion. A new international monetary system, the European Monetary System, promises a new era in North-South and East-West economic and political collaboration in a giant process of global reconstruction. And, most important, men of vision and responsibility in all corners of the globe are seeking the conditions, like fusion development and the EMS, that will make it possible for the world to achieve prosperity and peace.

### The Choice

If the United States is to play the role it can—and must—of leading these developments, it must put its own house in order. It's past time in our national affairs when any industrialist, scientist, or other citizen passively can choose one road to national disaster over another, instead of a real solution. The issue no longer can be avoided. Either we will have science and development—which means that the United States must join the EMS and end the British veto power over U.S. science and technology—or we will suffer the new Dark Ages.

Which side are you on?

## Calendar

### March

18-21

Reactor Construction and Operation  
Atomic Industrial Forum  
Dallas, Texas

26-29

APS General Meeting  
APS  
Chicago

27-28

1st Annual National Energy  
Conference  
American Society for Quality  
Control, Nuclear Division  
Princeton, N.J.

28-29

Semiconductor Injection Lasers  
and Their Applications  
Institute of Physics, London  
Cardiff, Wales

28

FEF Seminar: "The Problem of  
Electron Transport and the  
Anomalies of Plasma Physics"  
Dr. Steven Bardwell, FEF  
New York City

*Continued on page 71*

### Note to the Reader

We fully expect that with the appearance of this issue of *Fusion* magazine, Energy Secretary James Schlesinger and his staff will begin circulating the story—if not attempting legal prosecution—that the information in "The Secret of Laser Fusion" is classified. Therefore, we want to make it clear that this article is based upon information made public by the Soviet Union and readily available in Soviet and other international scientific circles, as well as upon information contained in a scientific paper published by Bernhard Riemann in 1859.

As far as we know, it is only British government policy, not U.S. policy, to attempt to classify scientific knowledge already released in the public domain. We hope that James Schlesinger does not lead the U.S. government down the same path.



## Letters

### RIGHT-TO-DIE DEFENDED

To The Editor:

I must protest comments in the January 1979 issue, in the national section, particularly your comments pertaining to Kubler-Ross, the "right to die" movement, and your adverse reflection, by inference, on hospices for the dying.

Have you ever watched a loved one struggle gallantly in the throes of an incurable cancer? I watched my husband wage such a battle and I know that the time comes when the suffering one cries out, either silently or verbally, "I don't want to fight any longer." Your statement, "Its [Brompton Mix] advocates explicitly promote it as a substitute for expensive medical technology development that could prolong life," is misleading. The Brompton Mix is used to bring comfort and freedom from pain to the terminally ill when there is no longer hope for recovery. Prolongation of life is not always desirable, if the life prolonged is full of pain and misery. You may wish to keep inflicting life-preserving techniques on a loved one to gain a few more days or weeks of discomfort—such a choice is your privilege. But such a viewpoint is not for me. I would not have wished for a single additional hour for my husband. Had he not asked for treatment to cease, I would have asked for that in his behalf.

Have you ever visited a hospice for the terminally ill? There is no possible valid way that you can relate them to an "antitechnology depression society." They provide for the terminally ill a pain-free environment surrounded by those who are not afraid of relating to a dying person.

In your comments on Kubler-Ross, you have ignored the tremendous pioneering work she has done. You say that she has been "widely publicized in a cross-country tour to promote death and her book, *Death and Dying*." At no time has she promoted death. She is promoting *understand-*

*ing* of death and that promotion is long overdue. I was able to go through the long ordeal of my husband's illness in ways that were helpful to him because an inspired friend gave me Kubler-Ross's book. Your article is a great disservice to Kubler-Ross's efforts and to those of us who want to make it a little easier for our terminally ill loved ones.

Marjorie A. Reid  
Lincoln, Nebraska

### The Editor Replies

The overriding significance of the "right to die" movement and Kubler-Ross's book is not the solace they might provide terminally ill patients and their families. On the contrary, the implication of the right-to-die outlook is that human life is not sacred, that it might be preferable to let someone die rather than struggle for their survival, and that some medical care is unnecessary and cruel because it prolongs life.

The policy implications of this way of thinking are clearly expressed in a recent speech by Senator Kennedy: "American industrial, high-technology model of health care has hurt medical care in the U.S. and we cannot allow it to be established elsewhere. We produce 25,000 pharmaceuticals here in the U.S.; we cannot and should not export these. These drugs do not meet the needs of these Third World people any more than costly diagnostic equipment does...."

"[As far as the U.S. goes] we will do better to close down centers that would provide for basic needs as well as contain costs. You don't need a physician on duty; paraprofessionals can tend to most problems, particularly in our poor urban centers. They can provide palliative care and appropriate drugs at a reasonable cost."

*The ultimate of this position is the British health care system where kidney dialysis is denied to retired or unemployed people since they are judged no longer productive. Why prolong their lives, the British reason, they have a right to die. And besides, as Kubler-Ross assures us from her ongoing discussions with dead people, death isn't so bad?*

Readers are invited to comment on issues raised in *Fusion*. Send letters to *Fusion*, Box 1943, GPO, New York City 10001.

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# The Lightning Rod

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My dear friends,

As some latter-day Juntos have penetrated even the ranks of the present U.S. government, perhaps we can expect some progress out of Washington eventually. But the evidence of one of my spies, who recently contrived to get hold of a fiscal year 1981 planning document from the Energy Secretary's office suggests, as Dr. Schlesinger might put it, "little reason for unbridled optimism."

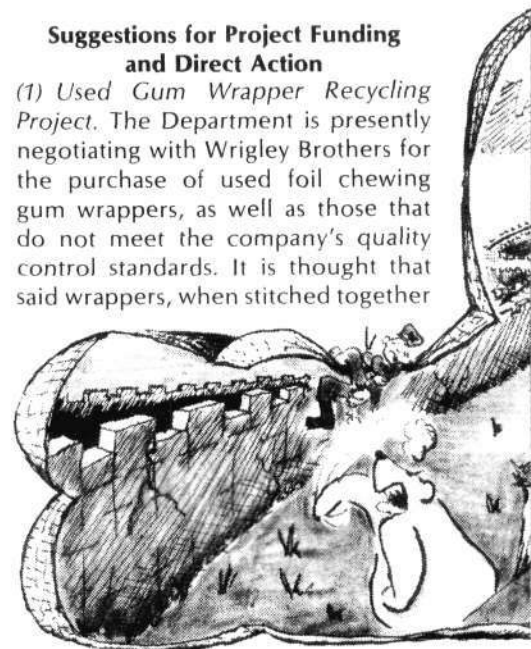
Herewith the document, which might be titled "Poor Rodney's Almanac." I remain,

Yr. obt. svt.



### Suggestions for Project Funding and Direct Action

(1) *Used Gum Wrapper Recycling Project.* The Department is presently negotiating with Wrigley Brothers for the purchase of used foil chewing gum wrappers, as well as those that do not meet the company's quality control standards. It is thought that said wrappers, when stitched together



"shiny side out," can be used to form giant solar energy collectors, reducing our oil import bill and providing work for thousands of unemployed seamstresses.

(2) *Snail Darter Retraining Project.* Funds are needed for the purchase of one dozen electric eels to aid (on a one-to-one basis) in the reeducation of snail darters to generate power from the waters around the Tellico Dam. If all the "eel-conditioned" snail darters in the world are laid end to end in continuous current, it is anticipated that enough electricity can be produced to run a moderate-sized penlight. While the gains may appear marginal, the public relations value in demonstrating the usefulness of the snail darter is hard to underestimate.

(3) *The K-9 Water Wheel.* Of the 8 million dogs in New York City, it is estimated that during any single hour, approximately 333,333 can be found in close proximity to a fire hydrant (assuming a regular performance schedule) uselessly expending energy. The department is presently recommending utility firms to make substantial investment in the K-9 Water Wheel, a portable attachment to be carried in the purse or pocket of the faithful pet owner, as a safe replacement for the hazards of nuclear power.

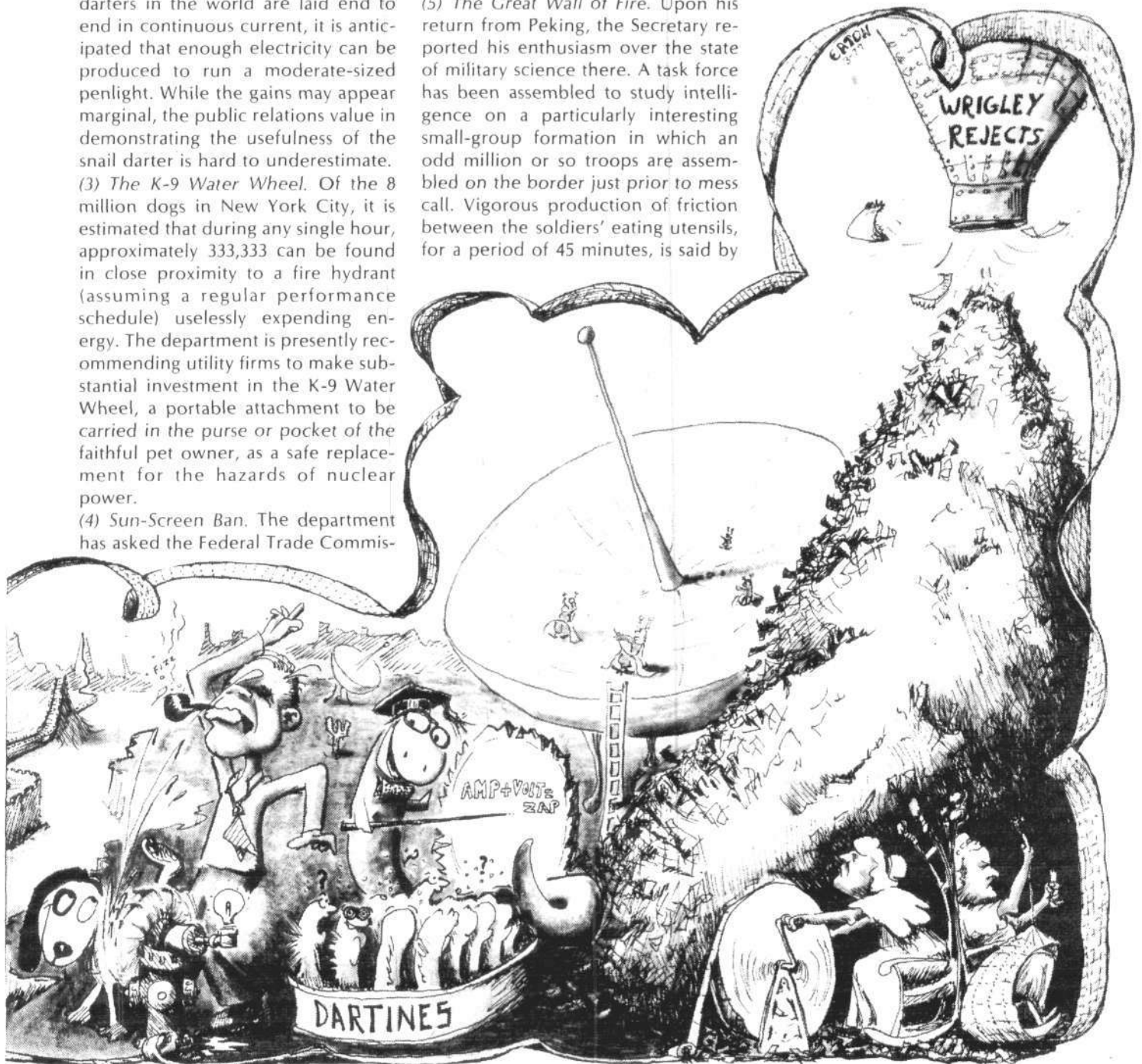
(4) *Sun-Screen Ban.* The department has asked the Federal Trade Commis-

sion and the Justice Department to consider legal action banning the sale of sun-tan lotion, on the grounds that certain solar rays (but not others) are "screened out" from reaching the human body through such preparations. This obviously represents an illegal restraint of free competition among rays. Moreover, as the sun is expected to burn itself out sometime in the foreseeable future, no ray should be wasted.

(5) *The Great Wall of Fire.* Upon his return from Peking, the Secretary reported his enthusiasm over the state of military science there. A task force has been assembled to study intelligence on a particularly interesting small-group formation in which an odd million or so troops are assembled on the border just prior to mess call. Vigorous production of friction between the soldiers' eating utensils, for a period of 45 minutes, is said by

Chinese military experts to produce amazing results, deemed very useful for scaring off the polar bear. (This technique is classified "Top Secret").

Of course these are only a few of the numerous plans and projects in the department's "alternative energy bag." In these troubled times, we are all tormented by the high cost of living, but here we are working to make human life cheaper every day.



## News Briefs



Pumping a crisis

### IEA HEAD SAYS NO CAUSE FOR OIL PANIC

"We do not think there is any cause for panic," said Dr. Ulf Lantzke, head of the 19-nation International Energy Agency, which is charged with supervising world oil supplies and stockpiles. "You cannot move from a glut to a crisis situation in such a short time."

In a Feb. 12 interview with the *London Financial Times*, Lantzke pointed out that stocks of crude and oil products of IEA members, which now stand at 390 million tons, are marginally higher than in January 1978 when there was no supposed oil crisis.

Lantzke did, however, single out British Petroleum and Royal Dutch Shell for criticism, accusing them of causing unjustified panic reactions about world oil supplies. He specifically scored a report issued by Royal Dutch Shell in early February claiming that the cut in world oil supplies as a result of the Iran situation was as bad as the impact of the 1973-1974 oil import embargo. The total drop in oil supply at present is 4 percent; in 1973 it was more than 8 percent, he said.

In a reference to recent statements from U.S. Energy Secretary Schlesinger, Lantzke further said that the current situation is not one that should drive governments into making hasty decisions without a considered analysis of facts. The IEA has virtually ruled out invoking its emergency oil sharing procedures, Lantzke said, and the IEA would not convene any emergency meeting prior to the scheduled March 1 meeting.

### BASOV PROPOSES INT'L FISSION-FUSION HYBRID PROGRAM

Nikolai Basov, head of the Soviet laser fusion program, called for an international program to develop the fission-fusion hybrid. The hybrid is an excellent transition to a fusion economy, Basov told the official Soviet daily *Pravda*. "The time will come when it is a great source of energy for peaceful purposes."

Basov cited "optimistic" U.S. estimates of industrial fusion power production by the period 1995 to 2000, and said that the development of the hybrid could advance that schedule. The Soviet physicist also called for studies to be undertaken to determine the impact of fusion power development on the economy.

The hybrid uses neutrons from the fusion reaction to breed fissile fuel. Several leading U.S. scientists, including Edward Teller and Hans Bethe, have called for a crash program to develop the hybrid reactor both as a fission fuel source and as a transitional step to developing pure fusion reactors.

### BRITISH ENERGY MINISTER CALLS FOR LIMITS ON TECHNOLOGY

Speaking to the Science, Technology, and Society Federation in Britain, Secretary of State for Energy Anthony Wedgwood Benn compared today's scientific and military elite to the "monastic orders of the medieval church." There may have to be a "price paid for technical developments" and higher living standards, Wedgwood Benn said—the creation of a climate of "insecurity and fear."

"If I am doubtful about the fast breeder reactor, as I am, and believe that any proposal to build one should be delayed, as I do, it is not because I doubt the technical competence of those in the industry to construct and operate one...."

"Technology, Buckminster Fuller said, means that we can get 'more out of less' and by doing so raise living standards.... A man who keeps warm by burning logs from his garden and then finds that the logs are not available is better placed than a whole community cut off by the failure of a 1,300 MW station...."

"There is a simple question we have to ask ourselves. Could we back into a police state because of high technology?..."

Wedgwood Benn's remarks were published in the Feb. 10 issue of the British daily *The Guardian*.



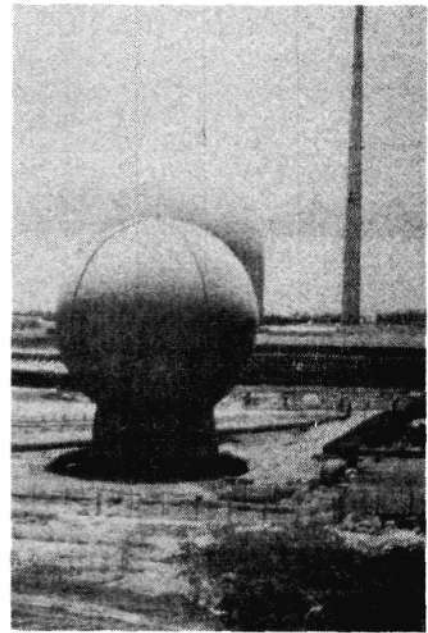
Wedgwood-Benn:  
'Insecurity and fear'

### INDIA PROTESTS U.S. 'NUCLEAR APARTHEID'

The government of India delivered a stern note of official protest to the United States Jan. 12 charging violations of agreements to supply India with nuclear fuel for its Tarapur nuclear plant, which supplies the Bombay area with power. A September 1978 Indian application for fuel deliveries to begin in March 1979 still has not been forwarded to the U.S. Nuclear Regulatory Commission for routine approval, according to Indian diplomatic sources.

A few days after the protest note, the Indian ambassador to the United States, N.A. Palkhivala, delivered a harsh speech to a closed-door session of the Asia Society in New York City. Palkhivala charged the United States with blocking India's nuclear development program and carrying out a discriminatory policy of "nuclear apartheid." "India cannot accept a world order in which such discrimination exists, especially when the arsenals of the nuclear powers are being expanded," the ambassador said.

The Carter administration has held up fuel supplies to India on the alleged grounds of antiproliferation of nuclear weapons, although India has fully complied with all international regulations regarding proliferation. At the same time, the administration has approved a French sale of nuclear reactors of Westinghouse design to China, with none of the usual assurances of nonproliferation.



India's Tarapur nuclear plant

### SEN. McCLURE WARNS THAT ENVIRONMENTALISM CAN LEAD TO WAR

U.S. Senator James McClure of Idaho told a Washington energy conference Feb. 2 that "the supporters of nuclear energy must truly believe that nuclear energy is a moral necessity for mankind and that, without it, future generations will sink even deeper into poverty and, eventually, dictatorship."

"Shortages of energy," McClure said, "will result in shortages of jobs, housing, and food ... resulting in increased government controls and increased shortages. And the tragic culmination of such a chain of events is war, as those who are without seek to take from those who have."

The "advocates of this 'new class' philosophy," McClure continued, "want to limit economic growth.... It is a pastoral vision, out of late 19th century England.... Their society would be more akin to the feudal era than to the last period of the industrial revolution."

Ironically, McClure was addressing a conference on energy alternatives sponsored by the Heritage Foundation, whose concept of "free enterprise" a la Adam Smith would have the same feudalizing effect on society as the new class McClure describes. (For an analysis of the Heritage Foundation and nuclear power, see Books, this issue.)

### LOUSEWORT LAURELS TO SENATOR TED KENNEDY

The contest this month was simple. The laurels go to Massachusetts Senator Ted Kennedy for his speech Jan. 29 in Washington at the National Academy of Science conference on pharmaceuticals for the Third World. We quote the award-winner's final solution: The "American industrial, high-technology model (of health care) has hurt medical care in the United States and we cannot allow it to be established elsewhere.... We need primary care facilities; facilities that will be run by local people to solve local problems. We need a simple basic system constructed from the ground up by people ... with a simple, basic drug list to meet local needs.

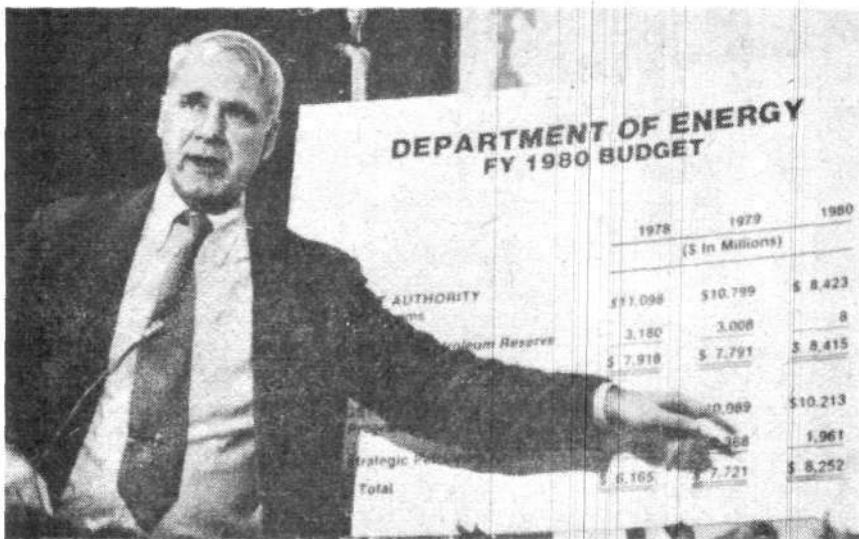
"We produce 25,000 pharmaceuticals here in the U.S.; we cannot and should not export these. These drugs do not meet the needs of these people any more than costly diagnostic equipment does. They are simple people with simple problems...."

Kennedy could not have won his prize without the able assistance of his audience, to whom lousewort credit is also due. Aside from the U.S. Labor Party's Debra Hanania-Freeman, the 300 health professionals in the audience raised no objection to this simple yet final solution to Third World health care.





## Washington



Under Schlesinger's leadership, the DOE budget has gone soft.

DOE

## Admin. Submits Dark Ages 1980 Budget to Congress

The Carter administration has submitted a fiscal year 1980 budget for the Department of Energy based on solar, solar, and more solar.

In his State of the Union address to the nation in January, President Carter said, "The transition to widespread use of solar and renewable resources can and must begin now. Solar, wind energy, and use of biomass resources can contribute significantly in both the short and long run to meeting our nation's energy needs."

In what can only be described as a total fantasy, Carter continued, "Some of these technologies, such as solar heat and hot water, use of biomass for generation of electricity, and wind energy, are available now and are competing with other conventional energy sources."

The 1980 DOE budget proposes total expenditures for solar energy to exceed \$800 million, including tax credits and programs by the DOE, the Tennessee Valley Authority, the U.S. Agency for International Development, the Agriculture Department and the Small Business Adminis-

tration. In addition, Carter plans to send a message on solar energy to the Congress in the next few weeks.

### The Solar Hoax

The administration's full-scale junking of fossil-fuel technology, nuclear development having anything to do with plutonium, and an aggressive program for commercial fusion development is based on advice from Carter's domestic policy staff, the Council on Environmental Quality, and the "China Lobby" faction in the White House.

The supposedly factual basis for the president's sudden leap to solar energy is an interagency study conducted under the Domestic Policy Review System. This internal report was put together by three staffers from the environmentalist Council on Environmental Quality who temporarily moved over to the DOE headquarters building to do the solar review. Its outrageous conclusion states with absolutely no proof that by the year 2000, 20 percent of U.S. energy supply will be from solar.

A source of great embarrassment to

the antiscience mob in the White House, however, is a recently completed study requested a year ago by the Office of Science and Technology Policy. Headed by Robert Hall of General Electric R&D, the panel report concluded that it would be at least 10 years before solar energy would be possible for any major conversion and that maybe 1 percent of the nation's electric need could be met by solar at the turn of the century.

The major invariant in the administration's nuclear R&D program is the avoidance of development of anything to do with closing the nuclear fuel cycle and going to a "plutonium economy." The nuclear R&D budget has been cut by 14 percent in absolute dollars — almost 25 percent when inflation is taken into account.

Although funds for converter reactor systems have been cut by \$18 million, the remaining funds will be focused on improving fuel utilization in light water reactors. This, along with the \$84 million proposed for a "uranium resource assessment" program, is supposed to prove that the United States does not really need a breeder program.

The 1980 budget does not include funding for the Clinch River Breeder Reactor. Instead, the proposed focus for the remaining breeder studies is "developing the technology necessary to reduce proliferation risks in research and power reactors" and "developing proliferation-resistant fuels."

The advanced fossil fuel technologies, mainly magnetohydrodynamics, fare no better. The MHD budget is set at a \$72 million authorization, down from the fiscal year 1979 budget of \$80 million. This reduction will destroy the momentum of the program and make it difficult for industry to continue a commitment to the DOE program.

Preliminary discussions with congressional staff members on Capitol Hill revealed that solar-mania is spreading. Even congressmen who were strongly pro-fusion last session are now swallowing the line from DOE's John Deutch that fusion will

not be commercial until the middle of the next century, while solar has nearer-term potential. And two weeks ago, 100 congressmen signed a statement calling for an increased effort in solar energy.

Congress's task is very clear. Unless it reformulates the 1980 DOE budget, Congress will doom U.S. energy policy to permanent oil shortages through manipulated political instability in the Middle East and no cost-effective, high-technology alternative to supersede fossil fuels.

Furthermore, a sagging fusion budget and slashes in MHD will kill the fruitful and necessary science and technology cooperation with the Soviet Union and Japan as well as U.S. private research. U.S. industry cannot possibly get involved in joint government R&D projects when it has no national commitment beyond one budget-year cycle.

In short, if the energy budget in its present form is not reversed, it will give the nation a swift kick back toward the Dark Ages.

—Marsha Freeman

## Congress to Study Fusion's 'Compatibility'

The Office of Technological Assessment, a congressional advisory group initiated by Senator Ted Kennedy, announced in its report on *Priorities 1979* that it will do a study on controlled thermonuclear fusion. Since the United States is spending \$500 million per year on fusion research there is a need "for a thorough assessment of just what the world is buying by this investment in fusion R&D," the report states.

OTA's previous work has been mainly involved with environmental affairs and so-called appropriate technologies.

According to OTA, the "problem" with fusion is that "formidable environmental and safety problems exist and will require careful, continued review.... Successful attainment of fusion could provide the world with an unlimited source of energy. That achievement would be without precedent and would present society with a set of benefits and possible problems for which we are unprepared."

"Manmade fusion would be a centralized very high-technology energy source that could raise a number of problems about control of the energy economy and compatibility with the dispersed technologies based on solar energy, the natural fusion energy."

As one Capitol Hill observer commented, "It is only natural based on this shining example that Congress investigate the manmade idiots within the Office of Technology Assessment."

## Elmo Bumpy Torus Gets DOE Go-Ahead

A proof-of-principle experiment for the Elmo Bumpy Torus magnetic fusion concept, to be built at Oak Ridge National Laboratory, has been approved by the Department of Energy. If this experimental model, the Elmo Bumpy Torus (EBT-II), proves successful, the EBT concept will join the ranks of the tokamak and mirror fusion reactors to become the third mainline magnetic fusion concept pursued in the United States.

Since the present EBT-S experiment has obtained stable plasmas with electron temperatures in excess of 5 million degrees at densities above 6 trillion nuclei per cubic centimeter with multimillisecond energy confinement times — close to the achievements of the tokamak in the 1960s that showed fusion to be feasible — it is likely that the improved EBT-II will reach breakeven.

The Elmo Bumpy Torus concept is one of the most complicated experimental systems ever attempted in fu-

sion research. If successful, it promises to lead to an economical toroidal reactor with good accessibility for construction and improvements and the advantages of modularity, direct current "steady-state" operation, and lowered requirements for auxiliary heating power. A toroidal magnetic confinement device, the EBT uses a rippled magnetic field to achieve MHD equilibrium, keeping the plasma from drifting into the walls of the torus through magnetic drift.

### The 'Rippled Donut'

The 24 connected sections of the EBT form a torus, with external magnets forming a magnetic mirror in each section. Microwave heating at each mirror section both heats the main body of plasma and generates a relativistic plasma ring in each section to stabilize the overall plasma-magnetic field configuration. The "rippling" effect of the plasma rings has given the device its name.

To achieve MHD stability, relativistic electrons are trapped, one in each magnetic mirror section, creating a stable magnetic field through resonance with the applied microwave heating frequencies. The effect of this complex system of intense microwaves, mirror geometries, relativistic electrons, and dynamic plasmas is to produce a stable, high-beta plasma in a steady-state device. (Beta is a measure of the efficiency with which a magnetic field confines a thermonuclear plasma. The high beta of the EBT means that relatively low magnetic fields can successfully be used to control the fusion plasma.)

### EBT-II

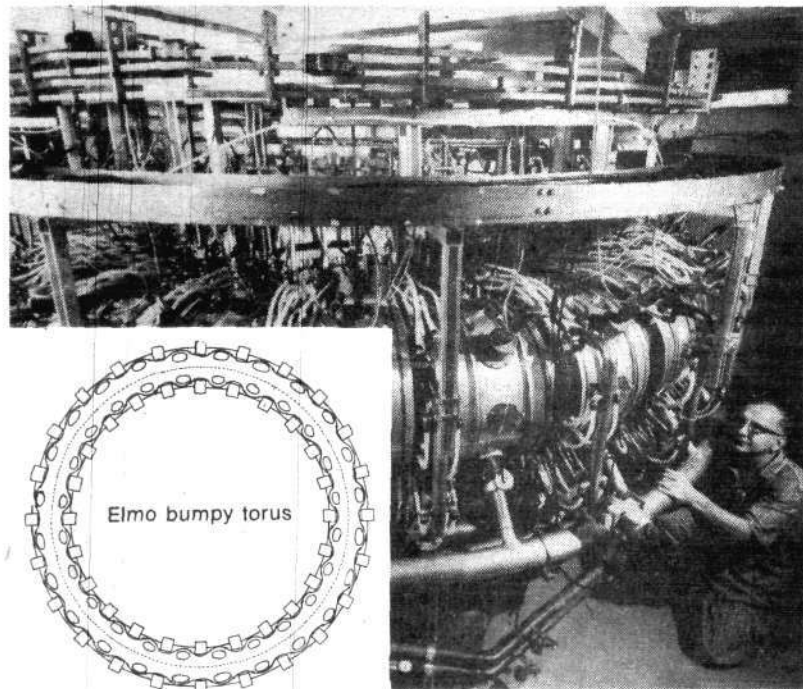
The EBT-II will have toroidal magnetic fields of 30 to 60 kilogauss and microwave heating power in excess of a million watts. This heat will be delivered by 120-gigahertz, 200-kilowatt modules scaled up from the Varian microwave heater tubes used

in the EBT-S. The total cost will be approximately \$20 million, about two-thirds that of the PLT tokamak at Princeton.

EBT-I and EBT-S, the first models, were developed by Ray Dandl and co-workers at the Oak Ridge National Laboratory beginning in 1973. Although work on the EBT had been started by Gibson, Jordan, Lauer, and Roth at the NASA Lewis Research Center in Cleveland, Ohio during the early 1960s, Dandl is generally credited with the experimental success of the bumpy torus concept to date. Using a complex magnetic geometry of several different magnetic fields interacting with each other to confine the plasma requires the type of experimental genius attributed to Dandl by his fellow scientists. Innovative ideas like his are the prerequisites for developing fusion energy by the 21st century.

The decision to proceed with the EBT came after more than a year of study of alternative magnetic fusion systems by the DOE Fusion Office. The study also determined that the LINUS (slow liner system), the Los Alamos ZT reversed-field pinch, and the stellarator merit further experimental investigation.

—Charles B. Stevens



The Oak Ridge EBT-I. Inset is a schematic of the Elmo Bumpy Torus, a cross-section view from the top. The 24 mirror sections are represented by the region between each four squares. The squares are the external conductors that generate the basic mirror magnetic field. Within each section, a ring of relativistic plasma is generated by intense microwave generators (not shown). The two ovals in each section are a cross-section of the plasma ring for that section, the plasma ring itself curving above and below the plane of the page.

## Dean Leaves DOE Fusion Program

Dr. Stephen O. Dean, director of confinement systems for the U.S. Department of Energy in the Office of Fusion will resign in mid-March to organize a fusion program for Scientific Associates, Inc. based in California. A 17-year veteran in government science programs, Dean has been in the national leadership of the U.S. fusion program in the AEC, ERDA, and the DOE.

Dean feels that the initiative for an aggressive U.S. fusion effort will come from continued pressure from advanced fusion efforts abroad and from U.S. industry and utilities. At Scientific Associates, he will be working to encourage private sector participation in fusion research.

### National Fusion Spokesman

As a national spokesman for the fusion program, Dean was instrumental in making public the important breakthrough this summer at the Princeton Large Torus tokamak. He has continued to insist that the rate of progress in fusion research is primarily a function of the amount of money and resources the government is willing to allocate for the program.

Dean commented in a recent interview that despite generous offers for international cooperation in fusion over the last year, particularly from the Japanese, the "potential for

confusion in the bilateral science negotiations between the United States and Japan is unlimited" now that the DOE budget for the required coal project is in question. As much as the DOE Fusion Office, and the Japanese, and the Soviets have wanted the cooperation—especially to push forward a sagging U.S. effort—U.S. Energy Secretary Schlesinger has stonewalled the international offers.

Dean's resignation follows that of DOE assistant secretary for energy technology Robert Thorne last month and will seriously weaken the government coordination of the fusion program. As many Washington observers have noted, Schlesinger has succeeded in convincing the DOE's most capable and talented scientists and administrators that positive motion for development of high-technology energy sources will take place only in the private sector.

# The Antiscience Policy of the President's Science Advisor

*My job is different from those of earlier science advisors. While science used to be associated with high technology, it now also concerns some other, more fundamental things like the environment, or nuclear waste management. In earlier days, science was fancy, military, space-aged stuff. Here it's much broader than that.*

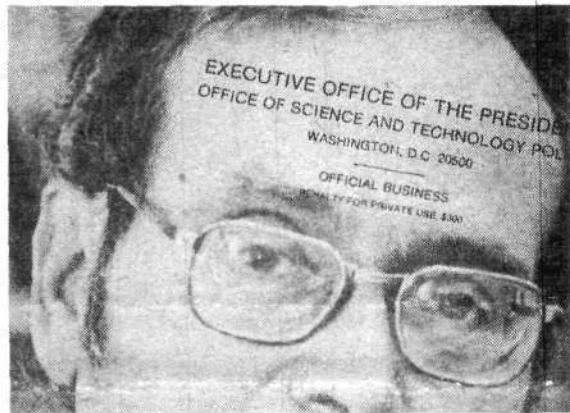
This is how Dr. Frank Press, the president's science advisor and director of the Office of Science and Technology Policy (OSTP), described his role in an interview with the *National Journal* in January.

Press, a geologist who has held various administrative posts since the Kennedy administration, was appointed by Carter in 1977. These comments are all the more ominous because they were made amid great fanfare on the part of the administration that OSTP, which had been abolished by President Nixon, was going to be reestablished to play an important role in national policymaking.

The "broader" view of science that Press has pioneered is actually a new definition of science by Frank Press. For him, science is a battle between

H.G. Wells-type science fiction "space age stuff" versus the Bertrand Russell-greenie view that "science is at best unnecessary, and at worst dangerous." In short, Frank Press has promoted an antiscience policy.

Under Press, science also has become a tool of international geopolitics, where the "China Card" policy of National Security Advisor Zbigniew Brzezinski and Energy Secretary Schlesinger has been given full play under the guise of "science and technology" agreements that do nothing but allow the Chinese to circumvent U.S. trade restrictions for the import of advanced technology. OSTP scientists have been put in the embarrassing position of trying to convince a justifiably skeptical White House press corps that the United States will benefit from "scientific"



exchange with the Chinese. For example, such scientists cited "advanced" methods of earthquake prediction that consisted of sending Chinese peasants to the countryside to put their ears to the ground, and "advanced" Chinese methods of manual "bug picking" that can replace energy-intensive pesticides.

## Holding Back U.S. Science

The president's science advisor has refused to allow even current U.S. scientific and technological advances to become the "best foot forward" for the nation in leading scientific research in the world.

In late summer, before the breakthrough achieved at the Princeton Large Torus fusion tokamak experiment was made public, the Fusion Energy Foundation advised the White House to make the announcement, as an expression of national pride and confidence in U.S. science. (See "The Princeton Story," *Fusion*, Oct. 1978). With Press's compliance the White House not only did not announce the breakthrough but tried to squelch the news.

During the same period, a proposal for a U.S. program for a fusion-fission hybrid breeder was circulated among the White House science policy staff, submitted by an internationally respected U.S. Nobel laureate in physics, Dr. Hans Bethe. To date the OSTP has taken no action to begin — or even debate — this vital program.

Frank Press has made crystal clear why the suggestions and advances made in U.S. science have been ignored by the Carter administration. According to a current consultant to

## U.S. and China: Politics, Not Science

Under the space agreement section of U.S.-Chinese cooperation in science and technology signed by President Carter and Chinese Vice-Premier Teng Hsiao-ping Jan. 31, the People's Republic of China will purchase a U.S. Landsat communications satellite system. The United States also will provide land stations to enable China to become part of the international communications system.

As Washington observers have noted, the satellite technology as well as the planned Chinese purchase of an advanced particle accelerator have definite military applications, and it is highly unusual that such agreements are arranged so quickly outside of the normal channels. The conclusion is that the U.S.-China science and technology agreements have little to do with the topic and are just a convenient cover for the "China Card" and "U.S. Card" (respectively) policies being played by each nation.



Frank Press

OSTP, quoted in the *National Journal* article, "Press" is very much trying to serve as the White House science advisor...not as an advocate of science, as was the case during some previous administrations."

Press underscored this shift in the role of the science advisor himself: "I can't become a sounding board for the scientific community. I work for the president. A lot of things I do on his behalf they may like or they may not like. You can't have among the president's advisors constituency representatives."

Press reiterated his sabotage of the American system's commitment to advancing the frontiers of science in his presentation at the American Association for the Advancement of Science Colloquium on R&D Policy in Washington, D.C. June 20, 1978. "...It may be time to recognize that it is not possible, or even necessary, to be first or number one in everything as long as our overall primacy is not threatened," Press said.

In the same remarks, Press put forward what was to become the hue and cry of the department of Energy's secretary and assistant, John Deutch, as well as the president's domestic advisors: Government support of advan-

ced R&D in industry where the private sector cannot commit large sums of capital to a future technology is simply a boondoggle to "special interest groups."

Said Press: "Often projects or programs tends to take on a life of their own. They build a constituency and a momentum that is difficult to deal with." In the DOE budget now before Congress, government-supported energy R&D has become a guessing game, as the government suddenly cancels projects to which industry had already made large financial commitments.

#### Going Solar

On Jan. 22, Frank Press presented the fiscal year 1980 budget for federal support for research and development to the press. Energy R&D strategy, as he laid it out, is to deemphasize nearer-term technologies and focus support to "longer term R&D, where there is less incentive for private investment." Did this mean an upgrading of the fusion budget? No, in keeping with this strategy, Press announced that the Department of Energy will "increase support for solar R&D by 24 percent and longer-term solar-related technology development and applied research by 40 percent."

In fact, with the administration's late 1978 scramble for solar energy, nuclear R&D will decline in absolute dollars, while magnetic fusion R&D will increase by 2 percent. At the same time, more than \$800 million will pour into the solar program in fiscal year 1980, unless Congress alters the budget now before it.

#### Grounding NASA

Throughout the 1960s the nation's space program was the leading edge of basic scientific research and advanced technological innovation. The National Aeronautics and Space Administration had a budget in basic R&D funding second only to that of the Department of Defense. Under its program for eventual deep-space exploration and near-space colonization, NASA was essential in funding developmental work in fusion, magnetohydrodynamics, thermionics, and advanced nuclear technology.

Directly through Frank Press, the Carter administration has publicly

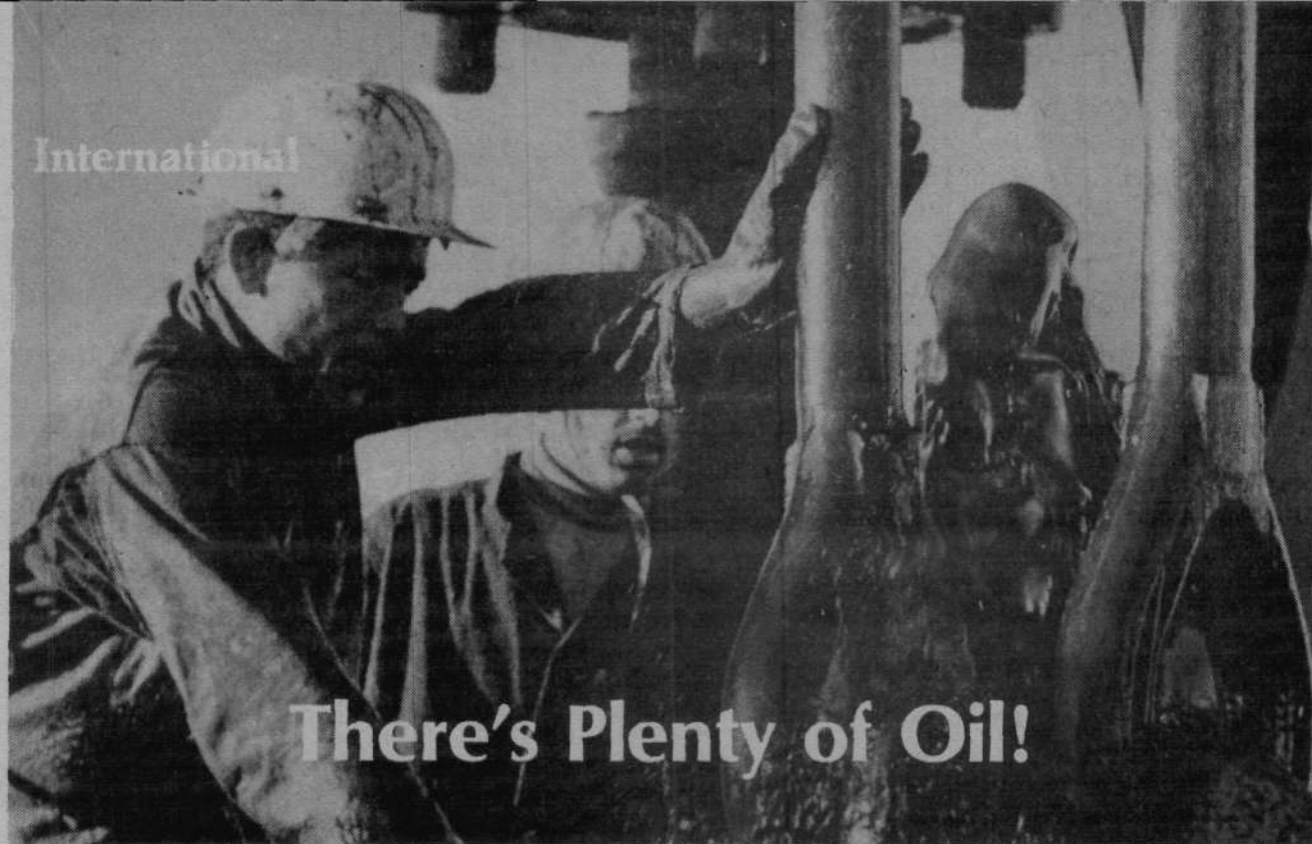
revised the mission of the U.S. space effort. As a result, no new project starts will be initiated in the next two to three years. NASA officials describe the program as in a "holding pattern," with all attention given to the space shuttle and "earthly" applications of space technology.

The principles guiding the new space policy were stated clearly in the White House fact sheet on the U.S. Civil Space Policy prepared by Frank Press and released Oct. 11, 1978 by the President. Space science and exploration will take place in a manner that "provides short-term flexibility to impose fiscal constraints when conditions warrant," the statement reads.

Furthermore, the Press statement poses the goal of "increasing the return on the \$100 billion investment in space to the benefit of the American people," and posits that "it is neither *feasible nor necessary* to commit the United States to a high-challenge space engineering initiative comparable to Apollo [emphasis added]."

These basic changes in U.S. policy have not slipped by unnoticed. In a presentation before the National Space Club Jan. 16, Senator Adlai Stevenson voiced his concern about the administration's space policy, as chairman of the Senate Commerce Committee's Subcommittee on Science, Technology, and Space. "We must not restrict our vision by relying excessively on the grim calculus of cost-benefit ratios and zero-based budgets. We need to recapture an earlier spirit — a willingness to run risks, try new ideas, compete, test the unknown, and excel."

It is clear that the goals Stevenson presented can never be national policy in an atmosphere where scientists are told they are a "special interest group" whose ideas have to compete with those of uninformed citizens, environmentalists, endangered species, and presidential advisors. The first step in returning to a national commitment to answer the fundamental questions of human knowledge and translate basic scientific breakthroughs into technological advances is to have a presidential science advisor who is committed to science.



## There's Plenty of Oil!

Talk of the new oil crisis precipitated by the halt in oil production in Iran has neglected several crucial facts. At present consumption levels, Iran supplies 15.8 percent of crude oil imports of the advanced sector nations that make up the Organization for Economic Cooperation and Development. Overall, Iran supplies 10.8 percent of these countries' oil supplies.

Should Iran not resume production in the near future, it is still highly likely that other sources could supply part of the needed oil on a short-term basis. Such possible sources include: the removal of environmental restrictions in the United States, which would result in an increase of 0.4 million barrels per day (mbd); an increase in Alaskan production of 0.8 mbd; an increase in Kuwaiti production of 0.2 mbd; an increase in North Sea production of 0.4 mbd; an increase in United Arab Emirates production of 0.6 mbd; an increase in Libyan production of 0.5 mbd; and an increase in Iraqi production of 1 mbd. Other members of the Organization of Petroleum Exporting Countries are said to be able to generate a hike in production equal to 1.5 mbd.

In other words, 7 million barrels a day of oil could be brought on line to offset any perceived emergency.

In fact, Saudi Arabian oil produc-

tion, which was down in January, has bounced back to nearly 10 million barrels per day after having fallen to 8 mbd. Sources say that the decrease was the result of a decision made in mid-January by the Saudi Arabian Supreme Council and was prompted by a proposal submitted by Saudi Oil Minister Zaki Yamani to impose a production ceiling of 9.5 mbd. More recently, Yamani's proposal has been countermanded by powerful elements in the royal family around Crown Prince Fahd who favor holding

Saudi production to at least 10.5 mbd to compensate for Iran's collapsed exports.

### Oil Spot Markets Gone Wild

Since the beginning of January, the spot markets in both crude oil and petroleum products have climbed astronomically. According to *Platt's Oilgram Price Report* Feb. 12, a number of OPEC producers were auctioning crude at \$20 a barrel. In January, *Petroleum Intelligence Weekly* reported that the producers of North Sea crude were one of the instigators of the

## DOE Predicts 'Hellish' Crisis

A U.S. Department of Energy spokesman gave the following description Feb. 7 of the world energy crisis foreseen as a result of Iranian chaos.

**Question: What is the likely impact of the continuing loss of Iranian oil exports?**

Regardless of who heads up the Iranian government, it will be physically impossible for them to resume full production for at least seven to nine months because of the sloppy way the wells were shut in.

**Question: What will this mean for the rest of the world?**

With Iran out of the picture for a sustained period, life is going to be particularly hellish for the Third World.... The dollar will be hard hit. So will Italy. Turkey will be in a disastrous situation to meet its IMF obligations and the loss of 1 million barrels of Saudi oil won't help.... For the United States, \$1 per gallon gasoline [Schlesinger's proposal] is an affordable nuisance, but for the Third World, it will bring them to the brink of disaster....

speculative bubble in the spot markets. Since then numerous press sources have named both Royal Dutch Shell and British Petroleum, which jointly control half of the North Sea crude output, as the source of the bidding-up process of prices on the spot market.

According to one New York oil analyst, unlike the U.S. multinational companies, neither BP nor Shell is subject to any restrictions on the use of its inventories of crude and petroleum products. This means that these two companies can sell petroleum purchased for inventories at any price whatsoever. In the current market situation large inventories held by these companies can be dumped into the spot market at whatever price will bring in the highest profit.

Since the 1973 oil crisis, legislation passed here has restricted U.S. companies from such price hedging with

inventories. Moreover, according to official figures, U.S. company inventories are down significantly from a year ago this time.

According to the French daily *Les Echos*, spot market prices for petroleum products such as gasoline and heating oil have taken a massive leap. Heating oil has climbed from \$120 a ton on the Rotterdam spot markets to \$250 a ton. In the last week alone, gasoline in European spot markets has jumped by 50 percent from \$200 to \$300 a ton.

Although the petroleum products spot market represents only 2 to 3 percent of the total European market, it does set trends for long-term contracts. And considering that many refineries are producing less because of cutbacks in crude deliveries resulting from the Iranian shutdown, the spot market becomes a last resort to hard-up vendors of products.

Like the spot markets in the United States, European spot markets are nearly dried up with respect to additional marketable crude and refined products.

#### **OPEC Feeds Price Hysteria**

As a result of this upward trend in prices, certain of the producing nations of OPEC have begun to auction oil at the spot market level. According to *Les Echos*, there is a growing coalition within the cartel calling for a special meeting to discuss raising OPEC's official price. The reasoning behind such a move is that the oil companies are raking off mammoth profits on oil from OPEC wellheads and, therefore, the developing nations producing the crude should enjoy the revenues.

*Les Echos* says that Kuwait, Libya, Nigeria, and Algeria are united in pushing for higher OPEC prices. According to informed sources, the United Arab Emirates, a traditional ally of the Saudis on pricing matters, is also joining this coalition. In this connection, UAE Oil Minister Oteiba attacked the multinational oil companies for profiteering.

Sources on the inside of OPEC affairs indicate that Saudi Oil Minister Yamani is pushing the high price posture behind the scenes. A statement by Yamani to the Jan. 29 *Middle East Economic Survey* tends to confirm Yamani's complicity. In the interview Yamani defended the right of OPEC

nations that are more hard pressed, such as Algeria, to raise the price of their oil to compensate for the decline of the dollar and the inflated cost of imports. Yamani's actions, sources say, are a product of a simmering factional struggle within the Saudi royal family in which Yamani has opposed Prince Fahd and Fahd's policy of keeping oil prices down and Saudi production high.

With Iran out of the picture as a key ally of Fahd in enforcing this strategy, Yamani has taken an aggressive position to see his more militant anti-U.S. policy come into being.

#### **The Outlook in Iran**

Although U.S. State Department and oil industry sources now estimate that the new Iranian Premier, Mehdi Bazargan, will make every effort to bring Iran's oil production to capacity as soon as possible, the continued violence makes that prediction uncertain. Conservative estimates are that without any foreign technical assistance, the National Iranian Oil Company could increase crude oil output from the present 0.7 mbd to about 3.5 mbd within a month. Department of Energy sources state that even if Iran were to produce sufficient crude to export 1 mbd, it would have a mollifying effect on the constricted oil markets and in turn bring down spot (open) market prices where the price of high-demand, low-sulfur crude has gone as high as \$26 a barrel, a full \$12 over the OPEC benchmark crude price.

Continued political chaos in Iran, however, does not bode well for this forecast. Within the camp of Iranian Shi'ite leader Ayatollah Khomeini, there are known divisions on future Iranian oil policy that are reflected in the new government of Premier Mehdi Bazargan. Moreover, there are still many unknown elements to the plan worked out last month by Abdullah Entem, the head of the National Iranian Oil Company, to fully take over Iran's oil industry from the consortium of multinational oil companies led by British Petroleum.

Both government and private oil industry sources agree that the National Iranian Oil Company alone could market at least 2 mbd independently on a state-to-state basis with Japan as a key purchaser.

—Judith Wyer



Yamani:  
Pushing oil  
prices up?

# Schlesinger Pumps Crisis Over Iran

"Schlesinger is a liar, and you can quote me on that," Mexican Foreign Minister Santiago Roel told a reporter, apropos of U.S. Energy Secretary James Schlesinger's role in Mexico's thus-far futile oil and natural gas negotiations with the United States. It appears, in the wake of the secretary's repeated warnings of a U.S. oil crunch as a result of the Iranian crisis, that many Americans are coming to share that view.

Following his publicized statement to the Senate Energy Committee Feb. 7 that the current Iranian situation was "prospectively more serious" than the 1973-1974 oil embargo, Schlesinger told the House Energy Committee that the Iran crisis may trigger the emergency oil-sharing agreements of the 19-nation International Energy Agency. This, despite the fact that the IEA's director, Dr. Ulf Lantzke, had stated that the impact of the Iranian shutoff was being exaggerated, and that it was now inconceivable that the emergency agreements would be invoked.

Said one Washington analyst bluntly: "Schlesinger is exaggerating the Iran situation to push through emergency legislation and price increases he would otherwise not be able to sell politically." In the view of this analyst, and many others, there is little reason that the loss of 900,000 barrels per day of Iranian crude the United States normally imports should cause a crunch. That is only 5 percent of U.S. oil imports, and the difference could easily be made up from other sources, many within the United States — such as increased flow of Alaskan oil and eased antipollution restrictions on types of oil that power companies and industry can burn.

The danger of an oil crunch arises not from any present shortage, but from the possibility that Schlesinger



*Closing down America, the Schlesinger way.*

may take advantage of an uninformed atmosphere of crisis to push through price increases and mandatory conservation measures for both industry and consumers—measures that could be avoided by a stronger emphasis on new production. Schlesinger, it should be noted, is compulsively committed to the 1977 Carter "energy program" which he authored and which was, for the most part, rejected by the Congress, industry, and the public as incompetent and unnecessary.

### Schlesinger's Plans

Schlesinger has promised to send Congress a set of legislative proposals by Feb. 26 that would be a first step in such a program of cutbacks. The proposals are likely to include plans for forced closing of gasoline stations one or more days per week, forced reduction of commercial heating levels, and cutbacks in parking spaces. The energy secretary has also publicly raised the specter of \$1 per gallon gasoline prices.

In addition, quiet congressional approval was granted last month to the Standby Allocation Authority, which, under conditions of a shortage, gives

Schlesinger sweeping powers to allocate U.S. consumption of all crude oil, both imported and domestic, to utilities, refineries, and industry. According to one industry spokesman, by April the impact of the loss of oil to small refiners who normally purchase their oil on the now scarce and prohibitively expensive spot market, could produce conditions under which these standby rules can be invoked—placing powers amounting to rationing in the hands of Schlesinger and his Economic Regulatory Administrator, David Bardin.

Predictably, other government agencies are not moving to mitigate the threat of a shortage either. The Environmental Protection Agency refused to postpone rules requiring the nation's gasoline refiners to lower the lead content of gasoline to meet EPA antipollution standards. The EPA decision portends a major shortage of gasoline next fall (the regulations go into effect in October), because refiners are refusing to add the new refinery capacity required to meet the regulations, as they cannot do so profitably.

—William Engdahl



## Brazil, West Germany Conclude Nuclear Deal

Brazil and West Germany concluded contracts this month worth \$6.5 billion in the nuclear energy technology transfer deal signed by the two countries in 1975. Bernhard Plettner, president of the board of the West German Siemens Corporation, announced Feb. 8 that the Kraftwerk Union, a Siemens subsidiary, will carry out the deal, which includes building eight nuclear power plants and a uranium enrichment and reprocessing facility by the mid-1980s.

Plettner's announcement appeared as a counterweight to increasing reports in the Brazilian press that the new government, which takes power March 15, intends to cut the multibillion dollar deal in half for "financial reasons." Incoming Mines and Energy Minister Cesar Cals told the press that implementation of the deal would not be immediate and that there were

concrete plans made only for four reactors.

The conflicting reports on the implementation of the nuclear deal reflect Brazil's continuing energy dilemma.

### Unresolved Energy Dilemma

Brazil is an anomaly among developing nations. It is simultaneously the site of Latin America's most technologically advanced and most retrograde energy-production programs.

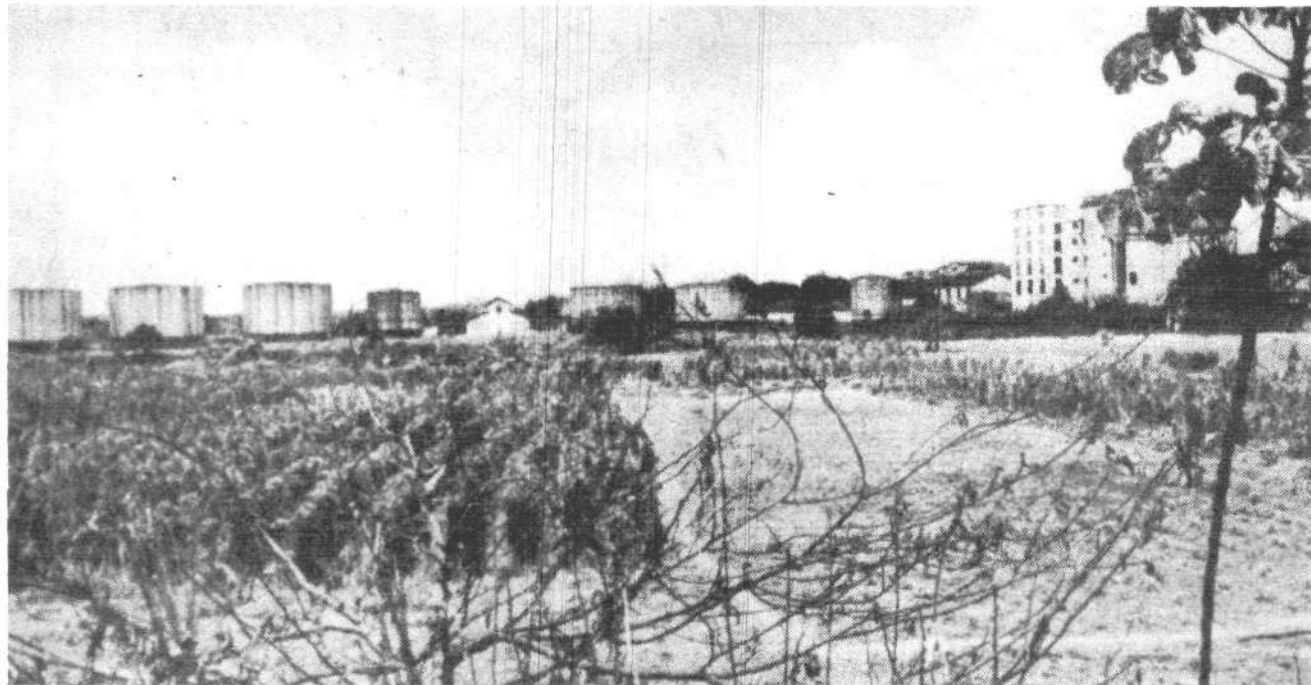
On the basis of the model transfer-of-technology agreements with the government of West Germany, Brazil is now well on its way toward the construction of its first nuclear fission reactor, and this plant will be complemented shortly by the Third World's first complete nuclear fuel reprocessing center. But the Brazilian government has at the same time embarked on a labor-destructive, economically

inefficient project to replace oil with "gasohol," alcohol produced from sugar cane.

Although many Brazilian politicians would vigorously deny it, these two energy programs are entirely contradictory and imply two distinct, irreconcilable strategies of economic development for that nation.

To give some idea of the social costs involved in these energy alternatives: It would take more than 400,000 peasants farming sugar cane on 2 million hectares of land to provide as much energy as will be provided by 100 skilled workers manning only two of Brazil's eight planned nuclear plants. And the efficiency of conversion of solar energy into gasohol, through the growing and processing of sugar cane, is a pathetic 0.23 percent.

Of course, the defenders of the gasohol program argue that its labor-intensive nature is one of its major advantages, and that unlike nuclear energy or even oil imports, it requires no foreign exchange. This is a powerful argument in Brazil, which has a total foreign debt of \$40 billion and a yearly debt service of \$9 billion. A more rational solution, favorably renegotiating Brazil's debt in order to eliminate the foreign exchange obstacle to capital intensive programs, is all too rarely discussed in public.



*It would take 400,000 peasants farming sugar cane for this Brazilian gasohol plant to equal the energy provided by 100 workers at two nuclear plants.*

## An Interview with the President of Petrobras

# Which Way for Brazil's Energy Future?

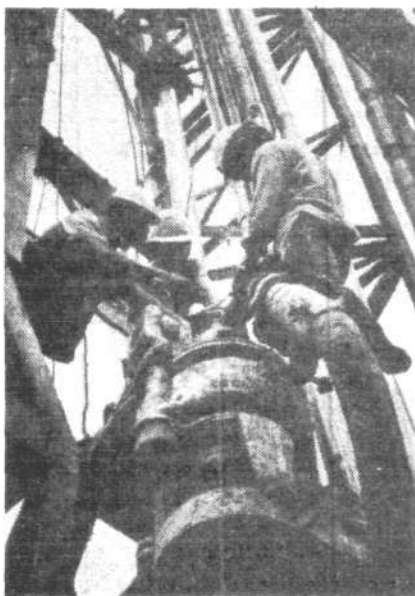
The parameters of Brazil's unresolved energy dilemma—high technology versus labor-intensive energy systems—are discussed in this exclusive interview with General Araken de Oliveira (ret.), president of Petrobras, the Brazilian national oil company. Araken de Oliveira was interviewed in New York City in December 1978 by reporters Dennis Small and Joao Carlos de Almeida.

Petrobras, the 21st largest corporation outside the United States, has assets and sales of \$9 billion annually. It was created in 1953 as a national monopoly over domestic oil production, and its history has reflected the vicissitudes of Brazilian politics. Araken de Oliveira has taken important initiatives in Petrobras, including the sponsorship of two-way deals with oil-supplying nations and the socialist countries. Petrobras is also producing petrochemicals and fertilizer to help raise Brazilian agricultural production levels.

**Question: What are Brazil's present energy problems and which energy sources is Brazil studying?**

After the 1973 Middle East crisis, Brazil faced a balance of payments problem because oil prices increased practically tenfold between 1968 and 1974. The last increases in late 1973 and early 1974 were the biggest. These had a direct effect on the country's balance of payments—25 percent of our foreign exchange was spent on oil payments. As a result, within our energy balance, a greater national effort was needed to liberate ourselves as much as possible from dependency on oil imports in particular, but more generally on the energy we must import to fill out our energy needs.

Brazil's energy balance has some unique characteristics. Around 30 percent of our energy comes from hydroelectric power, 40 percent from oil, and 22 percent from firewood,



*Capital-intensive industry ...*

charcoal, and sugar cane bagasse. Since the country is a major sugar producer, the sugar mills use the cane fibers for fuel. While other countries don't even compute wood and cane in their energy balance, Brazil has to, because they are a significant portion—22 percent. The remainder of our energy comes from coal, part of which is imported. Brazilian coal supplies 10 to 20 percent of the coking coal needed by our steel industry.

### **Decreasing Dependency**

Thus, starting in 1973, what did we seek? To decrease this external dependency which, discounting the 17 percent of oil needs produced in Brazil and the 3 percent of coal needs supplied locally, left us in 1976 with the need to import 40 percent of our energy.

On the other hand, the country does not want to stop its development. Since this development lies, above all, in industrialization, the country needs more energy. And this

development—given the needs of transport and industry—has to have petroleum.

To reduce external dependency and permit greater energy consumption to sustain development, we are making a real oil exploration effort. We set up a program to satisfy, within four years, Brazil's need to know what its petroleum potential is. This \$1.2 billion program will be implemented by Petrobras itself. Beyond this, the government authorized Petrobras to grant risk contracts to maximize investment in oil exploration.

Petrobras itself has 32 exploration rigs operating today offshore on our continental shelf. Some of these rigs are totally operated by Petrobras personnel, except for key technicians who are contracted from the company chartering the rig.

We also have 17 risk contracts with international oil companies. From the time of their signing, mostly in 1976, these companies have three years for exploration; that is to reach a conclusion whether the area they selected



*... versus labor-intensive gasohol.*

does or does not have commercial oil possibilities. Of these 17 companies, 5 have already made drillings.

### NUCLEAR POWER

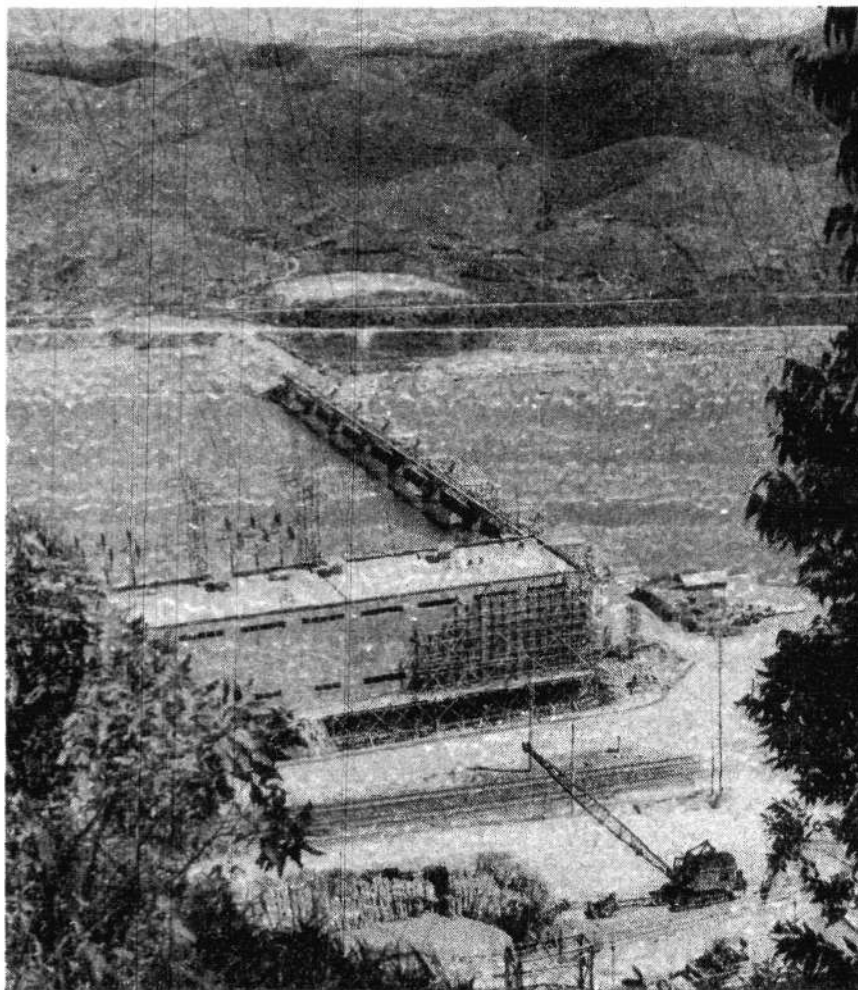
**Question: One of the most disputed and most internationally debated aspects of Brazil's energy policy is the nuclear agreement between Brazil and the German Federal Republic. Some political observers have seen an attempt by the United States and other countries to stop this agreement in an effort to keep Brazil from developing without increases in energy production. Would you comment on the Brazilian nuclear agreement and how it fits within your nation's overall energy program?**

How do we plan to increase energy production? On the one hand there is the oil exploration program, to be achieved with massive investments over a four-year term. On the other hand, we are going to develop other sources of energy, one of which has to be nuclear energy, because we have sufficient uranium reserves and because energy based on our hydroelectric potential is located very far from our consumption centers.

We have two ways of developing electric energy; either through coal-burning thermoelectric plants, or through our hydroelectric potential. Our coal is found in Rio Grande do Sul, Santa Catarina, and Parana, and our energy consumption is in the Rio de Janeiro-Sao Paulo axis. We would thus have to transport inert material for great distances, which makes this alternative nonviable.

We now use 20 percent of our total hydroelectric potential. But most of our hydroelectric potential, 80 percent of it, is located in the Amazon. Transmitting electricity from the Amazon to consumption centers is uneconomical because it is a distance of almost 3,000 kilometers, and the cost of transmission lines and energy loss makes it too expensive.

The third alternative is using uranium—using uranium for developing our energy supplies. We have no other purpose than this. Since we have adequate quantities of uranium and we lack technology, we searched for someone who wanted to give us technology, and we searched in several countries. The best offer came from West Germany, so we made a



UN  
*Most of Brazil's potential hydroelectric power is located too far from the population centers to be economical. Here, a power station under construction at Santa Cecilia.*

deal with them. There is only one objective: to develop our energy sources. We do not have other objectives.

**Question: One of the greatest problems for Brazilian development is obtaining sufficient credit to be able to develop high-technology processes in hydroelectricity, nuclear, and petroleum energy. How do you see the broader question of diversification of markets, not only for exports and imports, but also the market of finance capital?**

Our country lacks capital. An enterprise like Petrobras has had, up to now, the capacity to raise the capital needed for its programs, for its own exploration program and the exploration by the companies. And beyond this, we have programs set up by the government. We have a development

program to make us self-sufficient in nitrogenous fertilizers, and for this Petrobras opened up credit lines with the World Bank, the Interamerican Development Bank, French cooperative banks, and so on. You can see that the government has the right image to obtain credit, since Petrobras—an element of the government—has credit-worthiness.

Naturally we need such capital because we are interested in developing technology inside the country, in being able to create our own technology. We are interested in road, railroad, and urban mass transit plans because we lost a lot of time when oil was cheap and abundant. And when this was the case no projects were presented at any level that didn't use a petroleum product as their energy source. Petrochemical industries, of

course, had to use petroleum, but other industries, such as capital goods, were designed to burn fuel oil and diesel oil.

Nuclear energy is not the only energy source we are developing. We are working on using Rio Grande do Sul coal at the mine head, so we don't have to transport the 35 percent cinder content. We are constructing coal gasification plants on site and using the gas for petrochemical products like ammonia and urea. In Santa Catalina, depending on capitalization decisions, we will probably have an iron ore reduction plant using coal gas to produce pellets or sponge iron for us to export instead of just plain ore. Further north, in Parana, we have a large shale oil belt, which runs all the way south from Sao Paulo to Rio Grande do Sul.

Petrobras is developing technology to extract oil from shale. Even though the cost (\$17 per barrel) is slightly higher than that of imported oil, it wouldn't waste foreign exchange; and I think that by the time this unit is on stream at the end of 1982 or the beginning of 1983, oil will already be at that price.

In addition, another energy source being put into production is alcohol, from sugar cane and from manioc.

All this has one purpose—to rectify our energy balance and decide what we will use of hydroelectric, coal, oil, et cetera, so that our energy balance becomes less dependent on imports. The goal of doing all this is so that four years from now, we can move to a model of energy balance which is more desirable for the economy of our country.

#### ON MEXICO'S OIL DISCOVERIES

**Question: I understand that you passed through Caracas, Mexico City, and Houston on your way to New York, and I believe that you spoke with your colleagues, General Alfonso Ravard in Venezuela and Jorge Diaz Serrano in Mexico. I would like you to comment on the Mexican discoveries, on what they imply for Latin American energy policy, and if there are plans for Brazilian purchases or cooperation with Mexico.**

The data shown us really give Mexico a very great potential to develop its reserves. They export about 470,000 barrels per day today, and as a result

of those exports are very rapidly building nitrogenous fertilizer plants; they also have a great plan to use the fertilizer to develop agriculture. They have two plants going and three 1,500-ton ammonia plants being built simultaneously. They are building ammonia pipelines to distribute this fertilizer. This is a very far-reaching program for the development of the country. They are also building natural-gas-fed petrochemical complexes, which is really the best raw material, the cheapest one for petrochemical production.

As far as Brazilian-Mexican commercial unity is concerned, we have bought some ammonia from them; we have a petrochemical agreement to exchange surpluses of specific chemicals, since we already have two petrochemical plants in Brazil and are building a third. And we have already signed a contract to buy Mexican oil starting in 1980.

Right now, the problem is with one of the products we could place in Mexico and which would be very useful for us—iron ore pellets. They need it for their steel program, since they still import iron ore. However, the [Mexican] ports are still too small. There is no way at the moment to send ships of iron ore there and have them return filled with oil. We can bring oil from Mexico on ships of 150,000 tons since they have set up floating oil buoys just outside the port where you can operate efficiently. But what we want, to minimize shipping costs, is to fill the ships both ways, and they are constructing a new terminal which will make this possible, at a location called Dos Bocas.

With Venezuela, we have signed a contract to buy around 30,000 barrels (of crude oil per day), which will be increased to 50,000 barrels when the increment becomes available in March 1979. All of our efforts are within the goal of interchange, of helping each other and minimizing the effects of buying because we are also selling.

#### Question: And your Houston stop?

During my recent stay in Houston, Texas, I had the opportunity to talk with a number of American businessmen. All of them were very interested in the development of Brazil, and were willing to do whatever is necessary for that to happen.



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## American Technology Goes Down The Biopot

An Interview with  
Dr. Ralph Smuckler  
of the FITC



*The Foundation for International Technological Cooperation, created by President Carter's executive order in March 1978, centers around appropriate technology, a euphemism for low-energy-use labor-intensive production. Although most Americans probably don't know much about it, this appropriate technology concept is now the law of the land—both for export and domestic use. (See "Appropriate Technology: The U.S. Goes Back to the Stone Age" in this issue.)*

*This interview with FITC director Dr. Ralph Smuckler, conducted by FEF director of industrial research Marsha Freeman, shows how the United States is pursuing a technology policy completely the opposite to those of Japan, the Soviet Union, and the countries allied with the European Monetary System.*

*The FITC, which may change its name to the Institute for International Technological Cooperation, comes up before Congress this month for approval.*

*As long as it is based on appropriate technology, the FITC or institute should be killed as inappropriate policy for an advanced technology nation.*

**Question: Dr. Smuckler, what is the goal of the new institute?**

The goal is to close the gap between the advanced sector and the developing countries. This may require a balancing of the standards of living between the United States and the developing countries. The institute will help the developing countries choose technology more effectively rather than simply taking it from the West.

**Question: What was the motivating force behind the setting up of the institute? Was the impetus the Humphrey bill?**

The National Academy of Sciences did a study in the early 1970s first recommending that technology for development be separated out from AID. The U.S. Agency for International Development and other government agencies. The real impetus, though, came from a report by the Brookings Institution in the fall of 1977.

**Question: How does Senator Adlai Stevenson's proposal for an independent science and technology agency fit in with the institute?**

Senator Stevenson's legislation has the same objectives but is less tied to development assistance and more to science and technology.

**Question: What kind of joint R&D**

**projects will the United States formulate for energy development in the Third World?**

Not enough work has been done in the area of disaggregated energy systems. Although they have seemed less cost-effective [than large, central power station technology] their economics have not really been looked into. We will also be trying to encourage the development of local resources.

### REVERSE FLOW

**Question: In the part of the draft report dealing with agriculture it is suggested that low-energy farming and agricultural methods that the institute wants to help develop for the Third World would be applicable to advanced farming in the United States. It is certainly a novel idea to transfer "appropriate technology" back from the Third World to the advanced sector. Could you comment?**

We were not the first ones to propose this in agriculture. A few years ago, Bill Stout from Michigan State University did a report for the United Nations making the same point. More recently, *Science* magazine has also said that the future of agriculture is in energy-saving activity. I think that also in areas of urban problems and the

environment, this reverse flow of technique and information is possible.

**Question: What role will the institute play in bilateral negotiations with other countries with which the United States is just beginning exchanges in science and technology?**

The institute will play a role in the upcoming bilateral agreements that the president will discuss in his trip to Mexico. We were not set up in time to help get anything going with the Chinese, but they have made interesting advances in contraception. They have developed a male pill for population control, which may be useful in the United States.

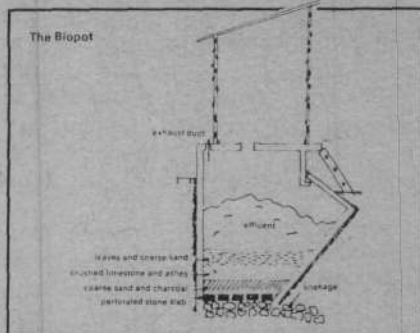
**Question: What about political opposition from Third World countries that have made clear they are not interested in appropriate technology but want to build nuclear plants, advanced agriculture and industry? Mexico has certainly made that clear in its statements on development.**

Lopez Portillo's program sounds to me a lot like the Shah of Iran's.

#### THE 'IRAN' TREATMENT

**Question: Do you agree with Henry Kissinger, then, that other countries going ahead with large-scale development plans are in for the "Iran treatment"?**

Yes, I think the Shah was trying to move too fast. Our goal is that by the year 2000, we will overcome the physical manifestations of poverty. We are interested in global maintenance. Energy technology has been driven by the West in the last few decades. Developing countries should have new alternatives.



The biopot, an outhouse outfitted to turn human and kitchen wastes into fertilizer, is one of the hottest items in the appropriate technology catalogue.

## Knocking Out Nuclear Power

# NRC Nixes Rasmussen Report

The Nuclear Regulatory Commission released a report in January that calls into question some of the findings of the 1975 Rasmussen Safety Report, the standard U.S. study of nuclear plant safety. The Rasmussen study, which is often used in support of licensing nuclear plants, concluded that the probability of a serious nuclear plant accident was approximately once in a million years.

The Risk Assessment Review Group that performed the review for the NRC had three major criticisms of the original study: First, the summary report was misleading in that it implied that the safety of nuclear reactors was beyond doubt; second, the error bounds given to the probability of a catastrophic accident were too low; and third, the report had not received a sufficient peer-group review prior to its release in 1975.

Based on these criticisms, the NRC decided that the Rasmussen study could no longer be used to support the licensing of nuclear plants.

The significance of the release of this review and its timing must be looked at from two levels. First, what are the actual technical questions raised, and second, what were the political decisions motivating the report's release.

#### The Technical Questions

From a technical standpoint, the original Rasmussen study was never anything more than a probabilistic assessment of the risk of having a "Class 9" accident; that is, an accident with an extremely low probability of occurrence but with catastrophic consequences such as a core meltdown coupled with breach of containment in the reactor. The Rasmussen conclusions, like the conclusions of any probabilistic investigation, cannot and did not prove that such a reactor accident is absolutely impossible, but only that it has some very low probability of occurrence. By definition, a zero probability in such assessments is impossible.

In assessing reactor safety, the basic

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*There is no way to see the NRC review group's conclusions that the Rasmussen report summary was misleading and did not have proper peer-group review except as political statements that represent the position of the environmentalists on the NRC and on the review group itself. Such statements were meant to discredit nuclear power and to reactivate the waning issue of nuclear safety.*

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assumption that must be made is in estimating the failure rates of the thousands of different multiredundant components in the safety system; that is, switches, circuits, pumps, latches, pipes, gauges, thermocouples, magnets, blowers, vessels, and so forth. Some of these failure rates are known fairly accurately but others are not, since much of the equipment used in nuclear reactors has only 10 to 20 years operating history at this point in time. (The first U.S. commercial reactor, the Shippingport Plant in Pennsylvania, started up in 1957.)

The probability analysis, therefore, uses these assumed or known failure rates and applies them in series and in parallel from some initiating event—let's say, a severe earthquake—through a very long chain of equipment throughout the safety systems. The analysis then ends up with some overall probability attached to the failure of all equipment in the chain. This then becomes the probability of occurrence of a severe accident.

The original Rasmussen report concluded that the probability of occurrence of a "Class 9" accident was once in a million years, plus or minus

a half-order of magnitude. This turns out to be the same probability as that of a large meteor hitting New York City.

In their only technical disagreement, the NRC review group said that based on their assumptions of failure rates, the error bounds should be larger; that is, plus or minus one order of magnitude (instead of a half-order). This is the difference between once in every million years or once in every 10,000 years. However, whether one looks at it based on the original study or the NRC review, the probability of such an accident is extremely low, and the original conclusion remains the same—the risks are acceptable.

From a technical standpoint, the review group agreed with and supports the Rasmussen study and said that it produced valuable methods for evaluating risks. Harold Lewis of the University of California at Santa Barbara, chairman of the NRC review group said,

*The thing we did, which people have overlooked, is to advocate a much more widespread use of probabilistic methodology.... I have been asked ... 'Is this a death blow to nuclear power?' I'm pronuclear and even though the impact of this can be narrowly construed as antinuclear, I think NRC has enhanced its credibility in such a way that it can be good for nuclear power. It has taken a defensible position on this whole question.*

#### **Antinuclear Politics**

What Lewis either doesn't know or doesn't understand are the politics behind the review group's decisions. Congressman Morris K. Udall, chairman of the House Interior and Insular Affairs Committee that oversees the NRC and has authority over reactor licensing legislation, initiated the review group's activities in 1976. Although some consider Udall a moderate on nuclear power, he actually is no friend of the nuclear industry and has spent much of his time, along with liberals like Ted Kennedy, supporting the greens in their battle against nuclear power.

"The use of the Rasmussen report in reactor licensing can now be stopped once and for all," Udall says. Udall has proposed that no

new nuclear plants be licensed after 1981 until the NRC approves a waste-storage facility design. (See "The Fraudulent Nuclear Waste Controversy," *Fusion* Jan. 1979.)

There is no way to see the NRC review group's conclusions that the Rasmussen report summary was misleading and did not have proper peer-group review except as political statements that represent the position of the environmentalists on the NRC and on the review group itself. Such statements were meant to discredit nuclear power and to reactivate the waning issue of nuclear safety. As a representative of the environmentalist Union of Concerned Scientists and the National Resources Defense Council stated, "The repudiation of the Rasmussen report returns the reactor safety debate to those terms on which we will win."

Professor Rasmussen of the Massachusetts Institute of Technology, the chairman of the original study, has rebutted the major conclusions of the NRC review. The draft report was circulated in 1974 and 800 pages of comments were received, he said. "I can't accept that it wasn't an adequate review." Furthermore, Rasmussen said, "I don't believe the error bounds are as large as they suggest." Even if the error bounds were large, he said, "It could be used with care in the licensing process."

Rasmussen agreed that the summary report's conclusions had been misused by nuclear opponents and proponents alike and that this would happen no matter how the report was rewritten.

Overlooked in the Rasmussen report controversy is that in actual practice, several hundred nuclear power plants throughout the world have continued (as expected) to far outperform any other comparable energy system in the area of safety as well as in most other areas of operation. Since actual failure rates can be generated only from on-line operating experience, and since such failures are proving to be extremely small in number, the actual probability of a "Class 9" accident is likely to be smaller even than the lower error bound suggested by the NRC review group—that is, less than one in 10 million years!

—Jon Gilbertson

## **Conferences**

### **U.S.-Soviet Symposium Scientists Call**

The fusion-fission hybrid can have a dramatic, immediate effect on world energy needs. This was the conclusion of the scientists gathered at the second U.S.-USSR Symposium on Fusion-Fission Reactors at Princeton University in New Jersey Jan. 22-26.

The fusion-fission hybrid, which could be built in the immediate future, uses the high-energy neutrons generated by the fusion reaction to breed nuclear fuel for an attached fission reactor. It is seen as an intermediate step in an all-out program to develop pure fusion reactors.

American physicists such as Edward Teller, Hans Bethe, and Eugene Wigner have gone on record calling for development of the hybrid because it can supply energy as well as fuel for now-operating fission reactors that depend on a quickly diminishing supply of natural uranium. (For a detailed account of the hybrid, see "The Fusion-Fission Hybrid Reactor: Fuel Factory for Nuclear Power" in *Fusion*, Jan. 1979.) The scientists at the Princeton Symposium called for the Tokamak Fusion Test Reactor scheduled to come on-line at Princeton Plasma Physics Lab in 1983 to be integrated into an initial fusion-fission hybrid test demonstration.

As demonstrated by Dr. James A. Maniscalco of Exxon Corporation for the case of laser-fusion-driven hybrids, one modest-sized fusion hybrid could supply the nuclear fission fuel for up to 15 to 20 conventional nuclear fission reactors of the type now in operation—and do it economically despite the initial capital cost of the laser fusion hybrid itself.

#### **Soviets Project 'Nuplex' Society**

Dr. G. Shatalov of the Kurchatov Institute in Moscow gave a presentation showing how a fully developed world in the year 2000 would be based on nuclear energy and fueled by the fusion-fission hybrid. He gave a projection showing an energy consump-

at Princeton

## for Fusion-Fission Hybrids

tion rate of about 100 trillion watts in the year 2020, about 12 times the present rate. From 30 to 40 percent of this total energy consumption would be met by a system of nuplexes—groups of conventional light water reactors, high-temperature, gas-cooled reactors, and breeder reactors together with fusion-fission hybrids. The overall mix would be 50 percent conventional nuclear fission, 30 percent fission fast breeders, and 20 percent fusion hybrids.

Dr. Igor Ganey of the Soviet Energy Technology Institute, the chief center for design of nuclear reactors in the Soviet Union, followed up this presentation with a detailed description of fission-fusion nuplexes. Ganey outlined how these energy centers would produce much more than just electricity: high-temperature steam for industrial processing, hydrogen from water for synthetic fuel production, and other forms of energy needed for advanced industries.

Dr. W. Wolkenhauer of the Washington Public Power Supply System emphasized that the utilities couldn't wait a hundred years for fusion to have an impact. What was needed, Wolkenhauer pointed out, was a massive, international effort. In a paper coauthored with Ms. Jensen and Mr. Huse of New Jersey Public Service Electric and Gas Co., Wolkenhauer called for an immediate two-pronged program. First, an overall development plan for fusion hybrids should be worked out in detail. Second, experiments should be initiated as soon as possible. In particular, he called for a hybrid module test on the Princeton Tokamak Fusion Test Reactor.

### Many Possibilities

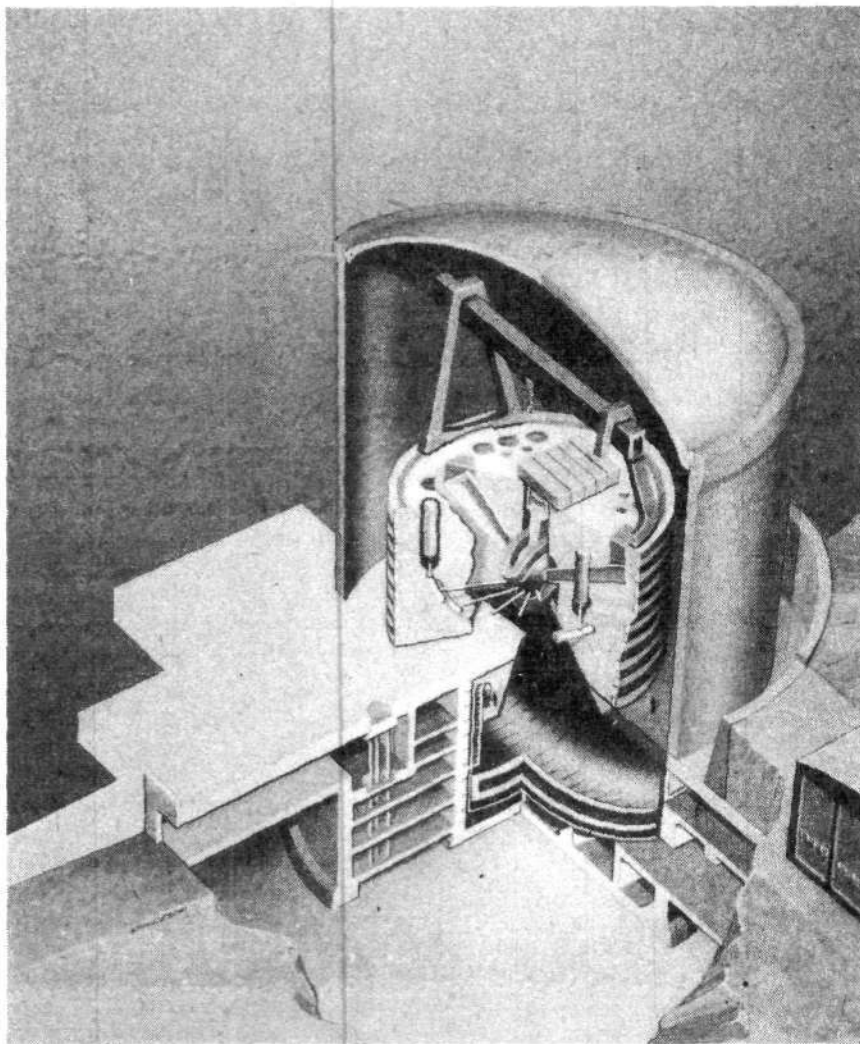
Because of the high quality of the energy generated in the fusion reaction, a large number of promising hybrid designs exist: Dr. James Maniscalco of Exxon presented a design based on laser fusion with liquid-

metal cooling of the hybrid blanket, which emphasized the breeding of fissile fuel from both thorium and uranium. His coworker Dr. Dave Berwald showed how the fusion-generated neutrons could be used to burn up the radioactive wastes that are produced in fission reactors. R. Rose of Westinghouse presented a steam-cooled tokamak design for the hybrid. And Dr. C. Nedoseev, of the Rudakov

electron beam group in Moscow, presented a design for electron beam pellet fusion that was quite similar to the liquid lithium waterfall design of Livermore Lab for laser fusion.

The most innovative new design, presented by Dr. Shatalov of Kurchatov, was a cold water-cooled tokamak hybrid that generated only fuel and no electricity.

—Charles B. Stevens



*Fusion-fission hybrid: the fuel factory of the 1990s.*



# Riemann Declassified

## *His Method and Program for the Natural Sciences*

by Uwe Parpart

[Concerning the existence and uniqueness or multiplicity of solutions of the aerodynamical equations] to this day, the only thing of any degree of generality that we possess is the classical discussion by Riemann, and this very strictly in the isentropic case. In this case at least, Riemann proved that there are no discontinuities. He also gave the exact conditions under which there can be a solution at all and he proved that in those cases there is only one. So he proved that the number of solutions is either zero or one. He also showed that it is zero in general, i.e., unless certain (infinitely many) very stringent conditions are satisfied. Thus, unless the initial state of the gas fulfills some very particular conditions, the (continuous) solution will cease to exist after some definite finite time. Riemann also inferred, essentially by physical insight, what happens when the continuous solution ceases to exist. He made it very plausible that a discontinuity of a certain type, a "shock wave," develops (von Neumann 1963 [1951]).

THESE REMARKS by mathematical physicist John von Neumann introduced a far-ranging discussion of the solutions of the aerodynamical equations during a symposium on "Problems of Cosmical Aerodynamics" in August 1949—three years before the United States exploded its first thermonuclear fusion device, or hydrogen bomb. The symposium had considered the more large-scale explosions of stars that form so-called novae and supernovae, such as the explosion that occurred less than 1,000 years ago and gave rise to the Crab nebula.

However, the fundamental physics problems in both cases are quite similar and are replicated in a third problem area, the

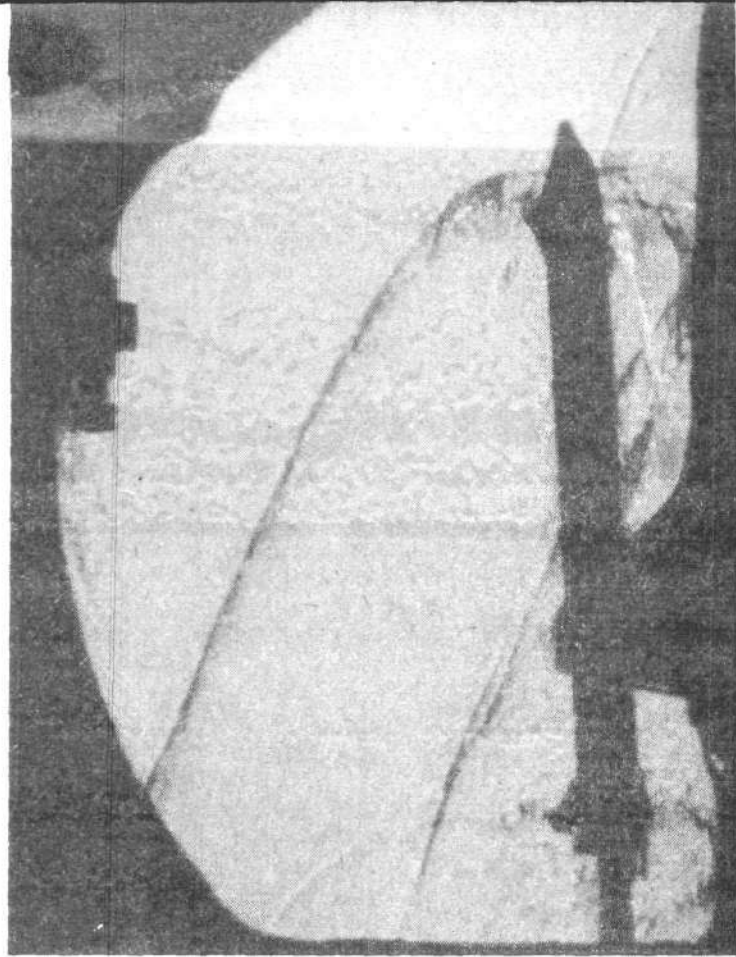
production of controlled thermonuclear reactions in inertially confined plasmas, as with laser fusion and electron beam fusion.

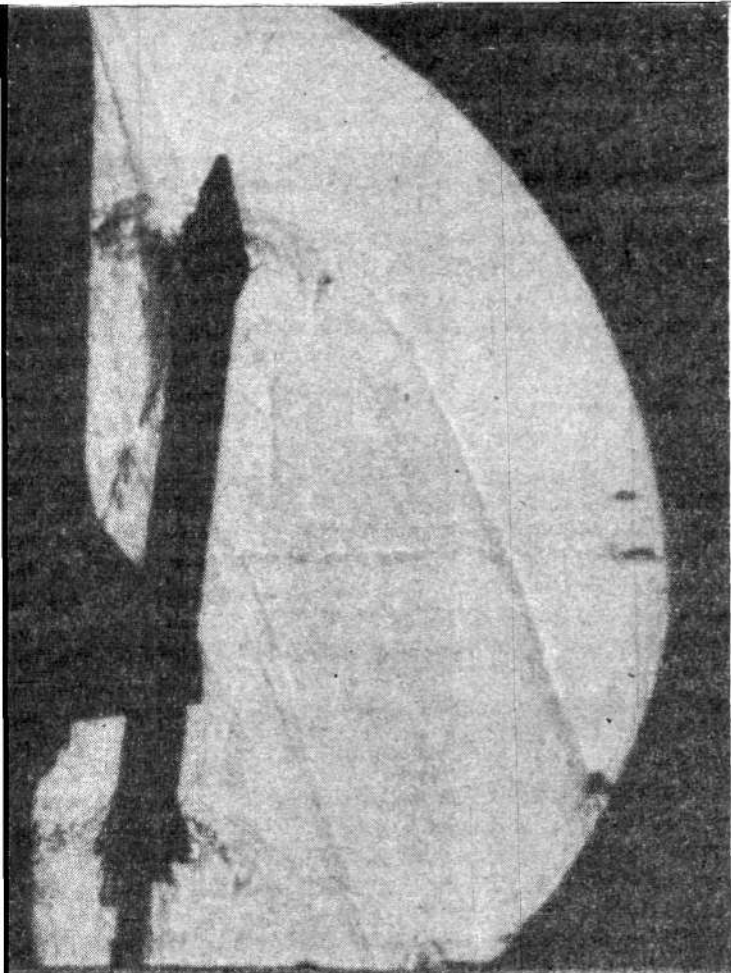
Riemann's ideas on shock waves, referred to by von Neumann, are crucial to the understanding of the kind of implosion process defining all three classes of phenomena, and were developed in an 1859 paper "On the Propagation of Plane Air Waves of Finite Amplitude."

It is an extraordinary fact that before 1972, when Edward Teller brought about the declassification of certain key concepts in laser fusion, Riemann's 1859 thoughts on shock waves and isentropic compression, if presented in conjunction with certain problems in inertial confinement fusion, would have been classified as military secrets of the United States by the security division of the U.S. Atomic Energy Commission.

Nor is there any doubt in this author's mind that the continued military classification of central theoretical aspects of laser fusion is largely responsible for the fact that today, 30 years after von Neumann's writing, his statement that "the only thing of any degree of generality that we possess [concerning solutions of the aerodynamical equations] is the classical discussion by Riemann" remains as true as in 1949. Military classification has made it extremely difficult for any researcher to launch a coherent and coordinated attack on outstanding problems in astrophysics and plasma physics, with laser fusion presenting the ideal mode of experimental access to the extreme conditions prevailing, for example, at critical junctures in stellar evolution.

Even more serious is the fact that implosion problems, problems of highly compressed matter and so forth, do not merely





NASA

*Riemann's 1859 paper on shock waves was fundamental to the weapons research in the 1940s and 1950s leading to the development of the atom and hydrogen bombs. The methodology of the paper plays an equally important role in attempts at understanding the dynamics of the implosion processes in laser fusion and in large-scale astrophysical phenomena, such as the creation of a nova or supernova.*

*Airflow interaction: This Schlieren photograph of the NASA space shuttle and solid rocket boosters shows the interaction between the separation motor exhaust and the airflow around the shuttle. The test is in the Air Force Arnold Engineering Development Center at a simulated altitude of 140,000 ft. and a speed of Mach 4.5 (4.5 times the speed of sound).*

define a specialized area of physics research. They cut across most principal domains of research, and the hydrodynamic continuum physics approach, characteristic of the treatment of implosion problems, has proved extremely successful in all problem areas to which it has been applied.

This "hydrodynamic" methodology was first coherently developed by Leibniz and then fully brought to bear on the entire spectrum of physics problems in the 18th century by the Bernoullis, Euler, Lagrange, and the great scientists of the Ecole Polytechnique, and it remained central to the Continental science tradition in Europe through the 1930s. It found a final, most developed expression in the decade before and the decade after World War I in the collaboration between the mathematicians and theoretical physicists and the researchers at the Institute for Applied Mechanics at the University of Göttingen. Under the leadership of Felix Klein, David Hilbert, Hermann Minkowski, Carl Runge, and, later on, Richard Courant in mathematics, and Ludwig Prandtl and his assistants and students—notably Theodore von Kármán and later Adolf Busemann—in hydrodynamics and aerodynamics, accomplished an extraordinary synthesis in mathematical physics in the Riemannian tradition.

Today only faint echos and isolated outposts of this tradition, such as the Courant Institute of Mathematical Sciences at New York University, remain.

Researchers in the Leibniz–Riemann–Göttingen tradition played leading roles both in the United States and in the Soviet Union in these countries' respective efforts during and after World War II to develop nuclear fission and fusion weapons and to put these energy forms to peaceful uses. The names John

von Neumann, Edward Teller, and Hans Bethe on the U.S. side should suffice to make the point.

However, the utterly unjustifiable continued military classification of the theoretical scientific results obtained by these researchers in the course of their weapons research and the extension of such classification to the civilian applications of such theoretical results have all but succeeded in wiping out what should rightfully be regarded as and be functioning as the mainstream of theoretical work in physics today.

The "hydrodynamics" tradition in physics was driven underground and has not reemerged; instead Newtonian reductionism at its worst reigns supreme in the physics departments and laboratories in the United States and Western Europe. In the Soviet Union the situation is less extreme.

Still, where in the second half of this century we should have gone beyond Riemann, on the basis of fully absorbing his Platonic method of hypothesis—the "poetry of hypothesis" as he called it on one occasion (1876 [posthumous], p. 319)—physicists both in the United States and the Soviet Union today have regressed to a point where fewer and fewer are capable of even a purely pragmatic adaptation of Riemann's results (rather than his method) to their work.

A dramatic turnaround in this situation is the necessary condition for making significant progress with the outstanding physics problems at this juncture.

### Shock Waves

*The Difficulties of Messrs. Challis and Stokes*

In 1848, the Reverend J. Challis, MA, FRS, Plumian Professor of Astronomy and Experimental Philosophy at the University of



*The Leibnizian tradition: Leibniz and the succession of mathematical physicists who created the hydrodynamic methodology. From top, Leibniz, Euler, J. Bernoulli, and Riemann.*

Most of the portraits in this article are taken from Hilbert by Constance Reid (Berlin: Springer-Verlag, 1970). The photographs of Runge and Courant are courtesy of Mrs. Richard Courant.

Cambridge, communicated to the *Philosophical Magazine* the results of his mathematical investigation of the theory of sound. According to his second communication May 19, 1848, "Clearly the analysis [of the exact equation applicable to plane waves] rejects the supposition of plane waves, by giving an integral which admits of no physical interpretation. Plane waves are thus shown to be physically impossible."

G.G. Stokes, in his 1848 reply titled "On a Difficulty in the Theory of Sound," is clearly not prepared to endorse his colleague's radical conclusion; however, he thinks it necessary to draw attention to a more limited but "very remarkable difficulty which Professor Challis has noticed in connexion with a known first integral of the accurate equations of motion for the case of plane waves."

The difficulty as described by Stokes is this. Starting with the Poisson integral

$$u = f\{x - (c + u)t\}$$

(where  $u$  is the flow velocity,  $f$  an arbitrary function, increasing values of  $x$  indicate the direction of wave propagation, and  $c$  is the propagation velocity of the wave moving within the medium moving with velocity  $u$ ) of the gasdynamic equations, it is easily demonstrated that there will always exist a finite value of  $t$  for which this solution ceases to be single-valued; that is, for sufficiently large  $t$  more than one value of  $u$  will correspond to a given value of  $x$ .

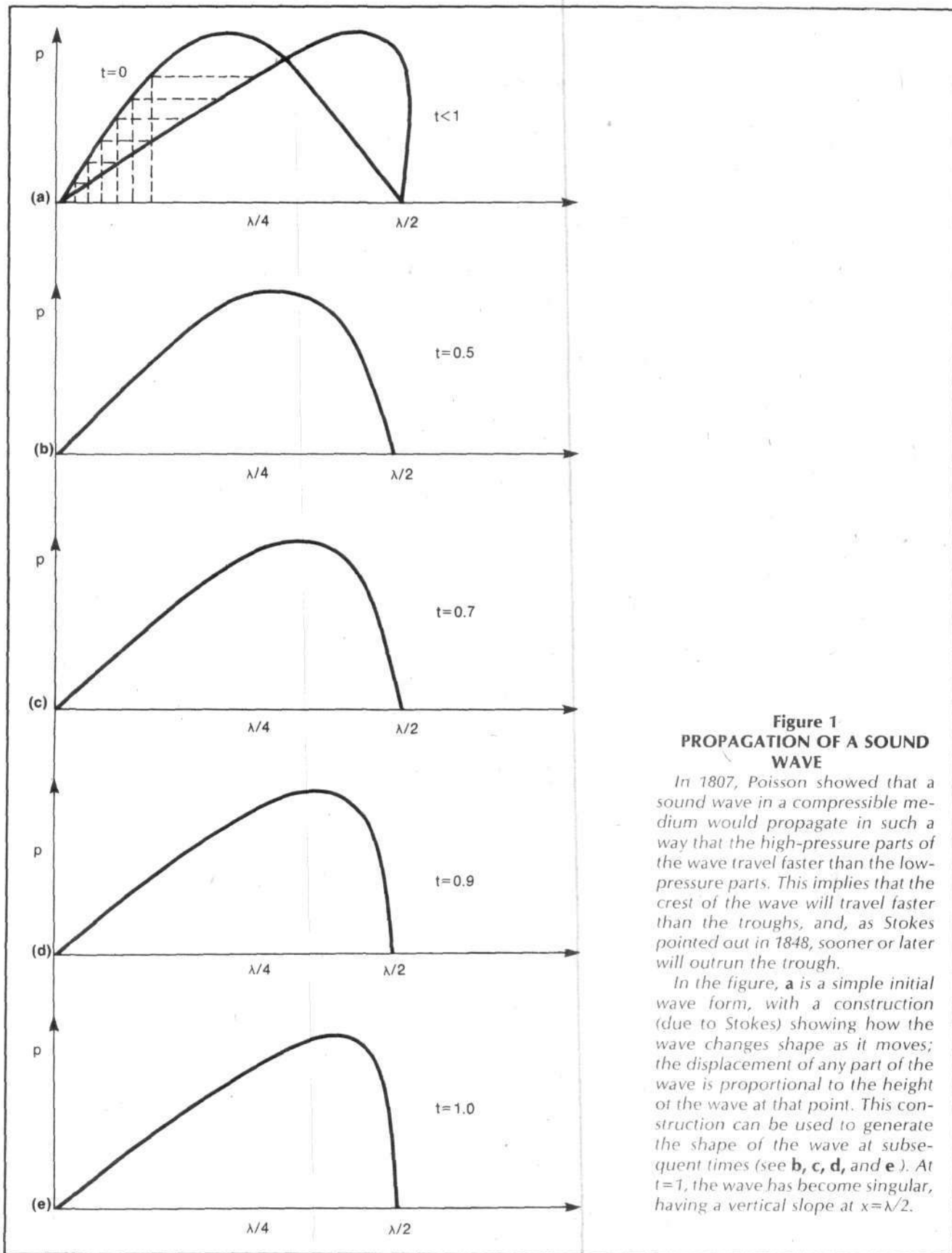
Figure 1 shows why. The Poisson equation asserts that whatever value the velocity  $u$  may have at any particular point when  $t = 0$ , it will have the same value at some later time  $t$  at a point in advance of the former by the distance  $(c + u)t$ . Thus the crests of the velocity curve gain continually on the troughs and must finally overtake them.

Stokes's calculation shows that this point—the point at which the velocity curve has a tangent vertical to the  $x$  axis and the continuous Poisson solution breaks down—is reached after a time equal to the reciprocal taken positively, of the greatest negative value of  $du/dx$ .

Simultaneously, we have reached an epistemologically critical juncture of the investigation. The significance and nature of the derived discontinuity must be determined and the subsequent progress of the fluid motion, no longer given by the usual differential equations, must be established.

Stokes writes:

Perhaps the most natural supposition to make for trial is, that a surface of discontinuity is formed, in passing across which there is an abrupt change of density and velocity. The existence of such a surface will presently be shown to be possible, on the two suppositions that the pressure is equal in all directions about the same point, and that it varies as the density. I have however convinced myself, by a train of reasoning which I do not think it worthwhile to give, inasmuch as the result is merely negative, that even on the supposition of the existence of a surface of discontinuity, it is not possible to satisfy all the conditions of the problem by means of a single function of the form  $f\{x - (c + u)t\}$ . Apparently, something like reflexion must take place (Stokes 1848, p. 352).



**Figure 1**  
**PROPAGATION OF A SOUND**  
**WAVE**

In 1807, Poisson showed that a sound wave in a compressible medium would propagate in such a way that the high-pressure parts of the wave travel faster than the low-pressure parts. This implies that the crest of the wave will travel faster than the troughs, and, as Stokes pointed out in 1848, sooner or later will outrun the trough.

In the figure, **a** is a simple initial wave form, with a construction (due to Stokes) showing how the wave changes shape as it moves; the displacement of any part of the wave is proportional to the height of the wave at that point. This construction can be used to generate the shape of the wave at subsequent times (see **b**, **c**, **d**, and **e**). At  $t=1$ , the wave has become singular, having a vertical slope at  $x=\lambda/2$ .



Richard Courant, who inherited Felix Klein's chair of mathematics at Göttingen, realized Klein's dream of the creation of a mathematical institute there (shown above). He came to the United States in 1935 and set out to recreate the kind of center for mathematical sciences at New York University that he was forced to leave behind in Germany after the Nazi takeover.

There follow three pages of half-hearted and confused discussion on the possibility of the existence of a surface of discontinuity.

The contrast with Riemann's presentation of essentially the same subject matter in his 1859 paper could not be more striking conceptually. Virtually from the outset of the Riemann discussion, the occurrence of discontinuity is treated not as a "remarkable difficulty" and mathematical curiosity whose actual physical significance is doubtful at best, but as the crucial phenomenon illuminating the highly nonlinear character of wave propagation in compressible fluids and occasioning a much extended comprehension of the nature of such processes. That the relevant discontinuities are physically real is never in doubt. Riemann dubs them "compression shocks" and presents a detailed analysis of their behavior, thus discovering and describing shock waves well in advance of their experimental demonstration.

#### Riemann's Theory

Felix Klein points out in his 1894 Vienna lecture on "Riemann and His Significance for the Development of Modern Mathematics" that, for Riemann, his paper on the propagation of air waves played the role primarily of exemplifying the method to be employed in an encompassing program that amounted to "nothing less than a systematic reconstruction on new foundations of the integration methods of mechanics and mathematical physics."

According to Klein, this method consists of constantly inquiring what are the discontinuities compatible with the differential equations and to what extent the solutions might be determined by the discontinuities they reveal and by certain added boundary conditions. Klein's point, which coheres well with Riemann's more general approach of deducing the principal features of functions from their behavior in the neighborhood of (or "when encircling") singular points, provides an appropriate lead for a competent analysis of the Riemann paper.

As opposed to Challis and Stokes, Riemann proceeds decidedly not from a given limited solution of the gasdynamic equations, which would tend to lock the analysis into the domain of continuity for that solution with the Challis-Stokes discontinuity an absolute boundary to the investigation. Rather, Riemann subjects the partial differential equations for compressible fluids themselves to close scrutiny so as to identify their most general properties.

In the Eulerian form, which describes the properties of the fluid passing by a fixed point (in contrast to the Lagrange formulation, which traces the motion of the individual particles), these partial differential equations in question are the following:

The equation of continuity

$$\partial\rho/\partial t = -(\partial\rho u/\partial x), \quad (1)$$

where  $\rho$  is the density of the fluid (gas) and  $u$  its velocity at point  $x$  and time  $t$ . This equation expresses the condition that the density in a given volume element can change only as the result of flow of the fluid into or out of this element; that is, it expresses the conservation of fluid mass.

The equation of motion

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x}\right) = -\phi'(\rho)\frac{\partial\rho}{\partial x}, \quad (2)$$

where  $\phi'(\rho)$  is the derivative of  $\phi(\rho)$ , a function expressing the fluid pressure  $p$  in terms of the density. This is simply Newton's equation with the mass  $m = \rho dx$  and the force propelling the fluid mass in the direction of the positive  $x$  axis

$$\dot{f} = -(\partial p/\partial x) dx = -\phi'(\rho) (\partial\rho/\partial x) dx.$$

A number of simple algebraic operations and substitutions—multiplying the equation of continuity by the square root of  $\phi'(\rho)$ , adding it to the equation of motion, and introducing the square of the speed of sound,  $c^2 = dp/d\rho = \phi'(\rho)$ —transform Equations (1) and (2) into

$$\left\{\frac{\partial u}{\partial t} + (u \pm c)\frac{\partial u}{\partial x}\right\} \pm \frac{1}{\rho c}\left\{\frac{\partial p}{\partial t} + (u \pm c)\frac{\partial p}{\partial x}\right\} = 0, \quad (3)$$

and, by letting

$$\omega = \int \frac{dp}{\rho c} = \int c \frac{d\rho}{\rho}, \quad (4)$$

further into

$$\{(\partial/\partial t) + (u \pm c)(\partial/\partial x)\} (u \pm \omega) = 0. \quad (5)$$

The quantities  $(u \pm \omega)$  of Equation (5) are called the *Riemann invariants*. The so-called *characteristics* of our differential equations,

$$dx/dt = u \pm c, \quad (6)$$

have the significance of defining the paths in the  $x, t$  plane along which fluid disturbances are propagated.

Parenthetically, I would like to point out that the Riemann invariants defined here bear a strong resemblance to the invariants of certain differential forms defining measure relations in Riemannian geometry. This is certainly not an accidental feature of this exemplary treatment of the fluid-dynamical equations.

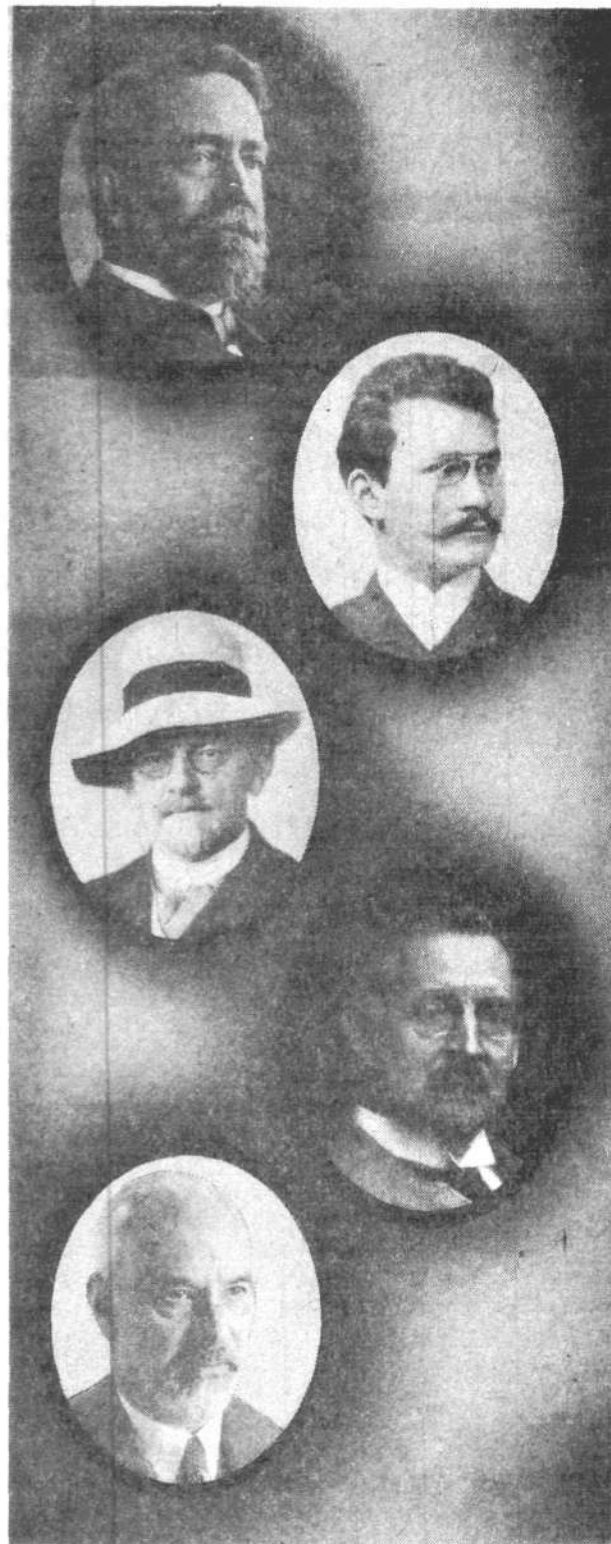
Riemannian space, or the Riemannian manifold as developed in the foundational treatise, "On the Hypotheses Upon Which Geometry Is Based," is the relative space of the multiply connected unified physical field. The topological and measure relations of this manifold are imposed upon it by the singularities and invariants of the actual physical field as exhibited by the equations of mathematical physics. Riemann's graphical (that is, geometric) approach to the integration of these equations (to be elaborated below), therefore, is a coherent expression of his overall method.

The search for invariants of the equations rather than for specific limited solutions demonstrates one further point. Riemann thought of differential equations principally as one crucial of several possible relations between functions and as a way of classifying these functions *modulo* (or, with respect to) this relation (that is, thinking of differential equations as a kind of equivalence relation between functions). Thus, what is essential about a function is again here determined from its behavior in the small. Put differently, what is important about functions is revealed by the differential equations they satisfy. In turn, what is important about differential equations is revealed by the invariants that connect them with other equations and reveal global connections and harmonies not determinable from particular solutions (if such could be found in the first place).

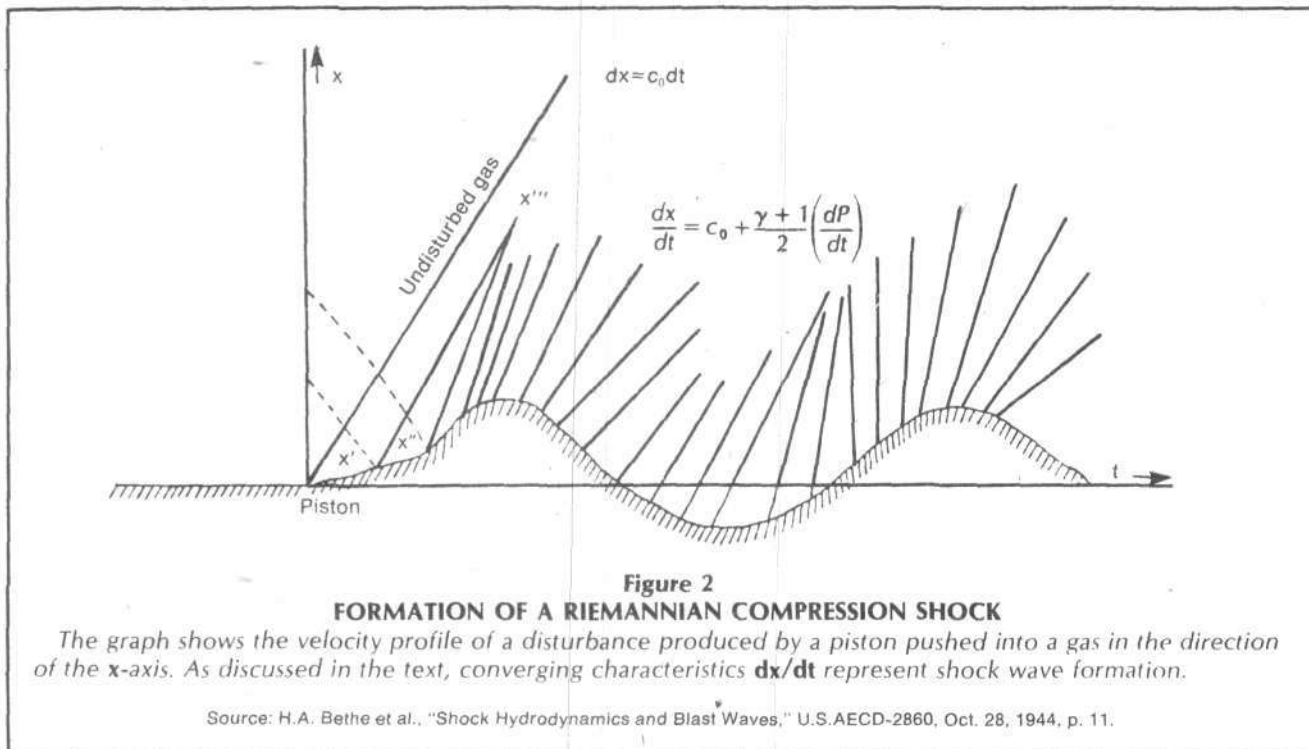
A more fundamental point, which I owe to a discussion of the matter with Lyndon H. LaRouche, is this. The invariants and characteristics of differential equations should be viewed not only as primary in their formal significance, but also as *ontologically* primary; or, put differently, their formal preeminence reflects the fact of the ontologically prior status of the "integral" reality they reflect.

In first approximation, this can be seen by looking at the relationship of points, lines, and surfaces. A point is best thought of as the intersection of lines, a line as the intersection of surfaces, with the higher-order object in each case the primary datum. Or, to take a different example, a growth rate actually reflects something more basic about an organic entity than, say, its size at a given time.

Lastly, the most precise example is from economics. It is not the total product produced, nor even the growth rate of total



The Göttingen School: Leading members of the Göttingen school at its high point before World War I. From top, Klein, Minkowski, Hilbert, Runge, and Prandtl. The first four were professors of mathematics at Göttinger; Prandtl was the director of the Institute for Applied Mechanics.



output that reveals and determines the basic health of the economy, but an invariant, dubbed *negentropy* by LaRouche, that reflects the impact of technological innovation on the evolution of the productivity of labor.

This *transinvariant* for successive production periods is the fundamental measure quantifying the principal ontological datum of the human economy: human ingenuity.

Returning to the specific equations at hand, combined utilization of the Riemann invariants and the characteristics  $dx/dt = u \pm c$  allows us to arrive at a complete understanding of the fluid motion in any given case. Depending on the choice of sign, Equation (5) states that if we start at any given point in the fluid and move with the velocity  $(u + c)$  (that is, our frame of reference is no longer a fixed point but moves with the local speed of sound with respect to the moving fluid) in the positive  $x$  direction (or with velocity  $u - c$  in the negative  $x$  direction), then the quantities  $u + \omega$  (or  $u - \omega$ , respectively) will remain constant. For a given time  $t$ , therefore, if we know the velocity  $u$  and the density  $\rho$  for every point of the fluid, then Equation (5) gives the values of  $u + \omega$  and  $u - \omega$  at any subsequent time. But knowing the values of  $u + \omega$  and  $u - \omega$ , we know the values of  $u$  and  $\omega$  and hence (from  $\omega$ ), via the equation of state of the fluid, can determine the density and the pressure.

It must be emphasized, however, that in order for the Riemann invariants to have a precise physical meaning the differential expressions  $(du + dp/\rho c)$  and  $(du - dp/\rho c)$  must be total differentials of these invariants. In nonisentropic flow, when density becomes a function of temperature, this is no longer the case. (I shall return to this point below in the section on isentropic compression.)

The way in which discontinuities in the fluid flow (that is, shock waves) arise can also be deduced readily by making use of the invariants and characteristics: To simplify matters, sup-

pose the fluid satisfies the ideal gas adiabatic relation between pressure and density such that

$$p = k\rho^\gamma,$$

where  $k$  is a constant and  $\gamma$  is the ratio of the specific heats. Then a simple computation shows that

$$\begin{aligned} \omega &= \int_{\rho_0}^{\rho} \left( \frac{dp}{d\rho} \right)^{1/2} \frac{d\rho}{\rho} = \int (\gamma k \rho^{\gamma-1})^{1/2} \frac{d\rho}{\rho} \\ &= \sqrt{k\gamma} \left( \frac{2}{\gamma-1} \right) \rho^{(\gamma-1)/2} = c \left( \frac{2}{\gamma-1} \right). \end{aligned}$$

Now consider a piston that is set in motion, let us say to the right, at  $t = 0$  and creates a disturbance in the gas in front of it. The position of the piston ( $P$ ) at any given time is

$$\begin{aligned} x &= 0 & \text{for } t < 0 \\ &= P(t) & \text{for } t \geq 0. \end{aligned}$$

Initially the gas is at rest and we have  $u = 0$ ,  $c = c_0$  (that is, a constant speed of sound).

As the piston is set in motion, on the surface of the piston

$$u = dP/dt.$$

To determine what happens in the gas as the result of the disturbance caused by the piston, we investigate the behavior of the characteristics  $dx/dt = u + c$ ; that is, the path of the propagation of the disturbance in the phase space spanned by  $x$  and  $t$ .

First, for  $u = 0$ ,

$$u + c = dx/dt = c_0.$$

This defines the line to the left of which the gas remains undisturbed. The general expression for  $u + c$  is derived as follows: Since the lines of constant  $u - \omega$  all arise in the undisturbed part of the gas,  $u - \omega = \text{constant}$  throughout; that is,

$$u - \omega = \frac{dP}{dt} - \frac{2c}{\gamma - 1} = \text{const.}$$

But also

$$u - \omega = u - \frac{2c_0}{\gamma - 1} = -\left(\frac{2c_0}{\gamma - 1}\right) = \text{const}$$

for the special case of the gas at rest. Thus

$$\frac{dP}{dt} - \frac{2c}{\gamma - 1} = -\left(\frac{2c_0}{\gamma - 1}\right),$$

which yields

$$c = c_0 + \frac{\gamma - 1}{2} \left(\frac{dP}{dt}\right)$$

and

$$u + c = c_0 + \frac{\gamma + 1}{2} \left(\frac{dP}{dt}\right).$$

It is easy to show that the lines

$$\frac{dx}{dt} = c_0 + \frac{\gamma + 1}{2} \left(\frac{dP}{dt}\right)$$

are straight lines. Therefore, for two points  $(x', t')$  with  $(dP/dt)' > 0$  and  $(x'', t'')$  with  $(dP/dt)'' > 0$ , such that

$$(dP/dt)' < (dP/dt)'',$$

the lines emanating from these points must intersect at some point  $(x''', t''')$ . Point  $(x''', t''')$  marks the place and time at which a Riemannian compression shock or shock wave is formed (see Figure 2).

The physical reality corresponding to the preceding mathematical derivation is this. Converging characteristics represent different speeds of sound and hence different densities. As the characteristics come closer to the point of intersection, a progressively sharper density gradient develops, and finally—in Riemann's words—"a discontinuity arises, so that a larger value of  $\rho$  follows immediately upon a smaller one. . . . The compression waves, as they progress, become ever narrower and finally are transformed into compression shocks" (Riemann 1876 [1860], p. 153).

This phenomenon, the occurrence of discontinuous states in compression waves, as they progress, become ever narrower and conductivity can be disregarded) resulting from compressive influences, is quite general, as Riemann had predicted on

purely theoretical grounds. That shock waves will always be formed—given sufficient time to develop—when a gas (or arbitrary compressible substance) is compressed, today is not only theoretically verified in full, but well confirmed by experiment.

Following Riemann's exposition, we must next "since sudden condensations almost always occur, even if density and velocity initially change everywhere continuously, seek to determine the laws for the propagation of compression shocks (Riemann 1876 [1860])."

### Isentropic Compression

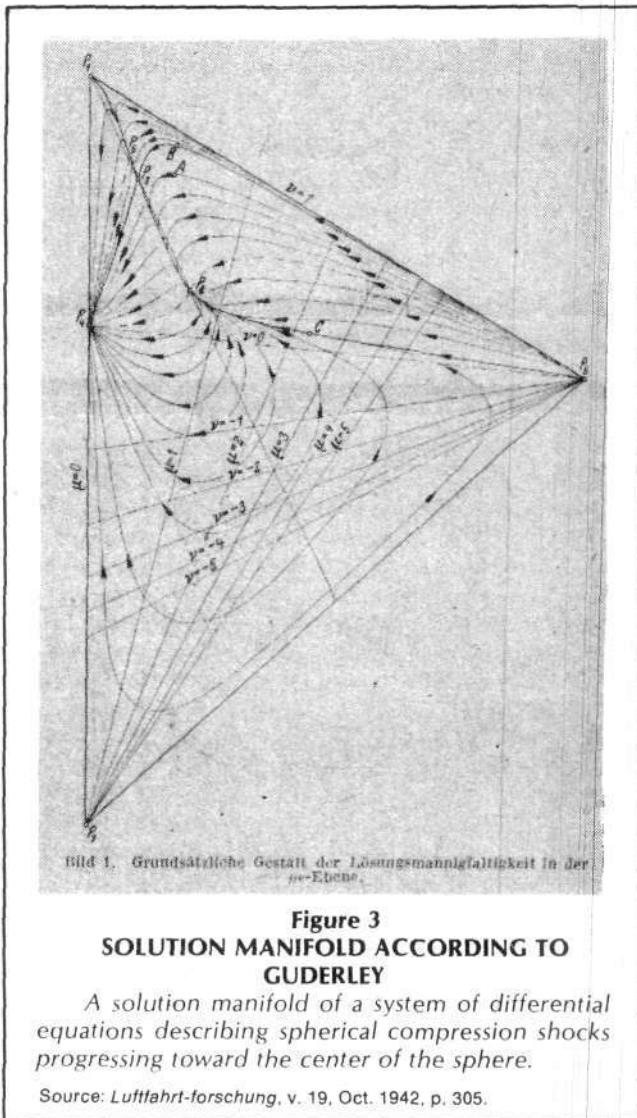
Ever since Lord Rayleigh's alleged discovery of "an error on the subject of discontinuous motion into which Riemann and other writers have fallen" (Rayleigh 1945 [1896], p. 40), it has been commonplace for writers on the subject to credit Riemann with the discovery of shock waves, but to note that he unfortunately did not succeed in specifying the correct "jump conditions"; that is, the conditions for the maintenance and propagation of the surface of discontinuity once formed. I do not intend to get involved here in a lengthy argument over this matter or attempt to defend Riemann on every point of his presentation. Admittedly, his discussion is incomplete. Apart from certain indifferent details, however, there is a serious point of method at stake, which makes it necessary to take up Rayleigh's "discovery."

First, like Challis and Stokes, and later Sir Horace Lamb, Rayleigh does not realize that Riemann has not simply presented a more general discussion of the mathematical discontinuity described by Stokes at an earlier point: Riemann has actually introduced a new kind of discrete entity evolved continuously out of continuous flow. Hence, it is not surprising that Rayleigh and those who follow in his footsteps miss Riemann's two additional points, which are methodological consequences of the first: First, with the formation of discrete compression shocks a new kind of lawfulness has arisen that now must be elaborated; and second, at the same time the coherence between the manifold characterized by the differential equations for continuous wave propagation and the "new world" of shocks waves (their interactions, and so forth) must be examined.

The Riemann invariants are precisely the right kind of tool to conduct such an investigation, and they turn out to be valid in "both worlds," if entropy is conserved across the discontinuities; that is, precisely under the circumstances presented in Riemann's paper. The question then arises whether or not there are substances, defined by an appropriate equation of state or appropriate changes in the equation of state of a given substance (for example, phase changes), that could support isentropic shock wave propagation.

I am not maintaining here that Riemann actually had in mind such an ambitious research program, which necessarily would have involved detailed experimental investigations. On the other hand, I find it hard to believe that a mathematician of Riemann's stature (although he, unlike Rayleigh, never came out "Senior Wrangler" in the Cambridge Mathematical Tripos)<sup>1</sup> would have "overlooked" the fact that the significant application of the invariants, the status of  $du \pm dp/\rho c$  as total differentials of the invariants, and the decoupling of density and temp-





**Figure 3**  
**SOLUTION MANIFOLD ACCORDING TO**  
**GUDERLEY**

A solution manifold of a system of differential equations describing spherical compression shocks progressing toward the center of the sphere.

Source: *Luftfahrt-forschung*, v. 19, Oct. 1942, p. 305.

erature are all of one piece. It is interesting, in fact, that Rayleigh's argument against Riemann ultimately turns precisely on the assertion that a certain kind of equation of state is impossible (Rayleigh 1945 [1896], p. 41).

Without further belaboring the historical point of what exactly Riemann had in mind when he gave the rather specialized isentropic jump conditions in his 1859 paper, the examination of the Riemann-Rayleigh controversy nonetheless has brought us right up to the point where the central problem of large-scale astrophysical as well as experimentally realizable laser fusion implosion processes can now be defined—the problem of isentropic compression.

That isentropic or "cold" compression plays a major role in laser fusion (as well as in efficient H-bombs and probably a variety of the most interesting astrophysical processes) until 1972 was one of the deepest U.S. military secrets.

At issue is this. Soon after physicists in the 1960s began to seriously consider the use of powerful lasers for the intense compression and the ignition of nuclear fusion reactions in small pellets of fusionable material, relatively simple calcula-

tions showed them that if this was to be achieved using spherical compression effected by a one-time, simultaneous firing of a battery of laser guns that were arranged in spherical symmetry, laser fusion probably never would be achieved under controlled laboratory circumstances, because the energy requirements for the laser were too high. Precompression of the pellet, however, could very significantly reduce these requirements and put them within range of what was then and is now regarded as an economically solvable engineering problem.

However, a major physics difficulty stands in the way of the realization of this precompression idea. Precompression to relevant densities of  $10^3$  to  $10^4$  times liquid density, it appears, must inevitably generate enormously high temperatures inside the pellet and force it apart before the major laser pulse has a chance to bring about fusion ignition.

At first glance, the problem seems insurmountable. The fusionable material is a compressible substance and hence the Riemannian theory developed in the previous section demands that formation of shock waves must result from the action of strong external forces on the pellet. Further, it can be demonstrated that, in general, in order for energy to be conserved across the shock front, an increase in entropy (or, equivalently, temperature) is a necessary jump condition.

The relevant calculations leading to this conclusion were first carried out by H. Hugoniot in 1895 and amount to the following: To explore the behavior of energy and entropy in a gas compressed by shock waves, we expand the gasdynamic equations [Equations (1) and (2)] to include an expression for the conservation of energy

$$\left[ \frac{\partial}{\partial t} + u \frac{\partial}{\partial x} \right] \left( \frac{1}{2} u^2 + \epsilon \right) = -v \frac{\partial}{\partial x} (up), \quad (7)$$

where  $\epsilon$  is the internal energy of a unit mass of material and  $v = 1/\rho$  is the specific volume. The equation asserts the equality of the work done on a unit mass of material in unit time to the rate of change of kinetic plus internal energy of a unit mass of material.

From this enlarged set of gasdynamic equations [Equations (1), (2), (7)], expressions describing the conservation of mass, momentum, and energy through a discontinuity surface can be obtained, and these expressions in turn allow for the derivation of the so-called *Hugoniot relation* between the pressure and the specific volume on each side of the discontinuity:

$$\epsilon_2 - \epsilon_1 = \frac{1}{2}(p_1 + p_2)(v_1 - v_2),$$

where  $\epsilon_1$ ,  $p_1$ ,  $v_1$  and  $\epsilon_2$ ,  $p_2$ ,  $v_2$  are the internal energy, the pressure, and the specific volume before and after passage through the shock wave, respectively.

For the special case of an ideal gas with

$$\epsilon = pv / (\gamma - 1),$$

the Hugoniot relation yields particularly simple expressions for the changes in the flow variables across a shock wave. Since we are interested in the entropy change in particular, and

since—up to an arbitrary constant—the entropy of an ideal gas is given by

$$S = c_v \log(pv^\gamma)$$

( $c_v$  equals specific heat at constant volume) we substitute the expression for the internal energy of the ideal gas for the energy term in the Hugoniot relation and get for the relation of the specific volumes

$$\frac{v_1}{v_2} = \frac{(\gamma - 1)p_1 + (\gamma + 1)p_2}{(\gamma + 1)p_1 + (\gamma - 1)p_2}$$

With this the entropy difference between the two sides of the shock front becomes

$$S_2 - S_1 = c_v \log \frac{P_2 v_2^\gamma}{p_1 v_1^\gamma} \\ = c_v \log \left\{ \frac{p_2}{p_1} \left[ \frac{(\gamma - 1)(p_2/p_1) + (\gamma + 1)}{(\gamma + 1)(p_2/p_1) + (\gamma - 1)} \right]^\gamma \right\} \quad (8)$$

Thus, in the case of a weak shock wave (that is, when the pressure difference between the two sides of the wave is small), then  $p_2/p_1 \approx 1$ , and hence,  $S_2 - S_1$  is approximately zero. As the strength of the wave increases (that is, as  $p_2/p_1$  increases beyond 1), the last term (expression inside the braces) in Equation (8) monotonically increases along with it, and so the entropy difference between the two sides of a shock wave increases with the strength of the wave.

The above-mentioned jump condition of a necessary increase in entropy across the compression shock, therefore, is verified and so, unfortunately it seems, the virtual impossibility of laser fusion—and, more generally, inertial confinement fusion—along with it.

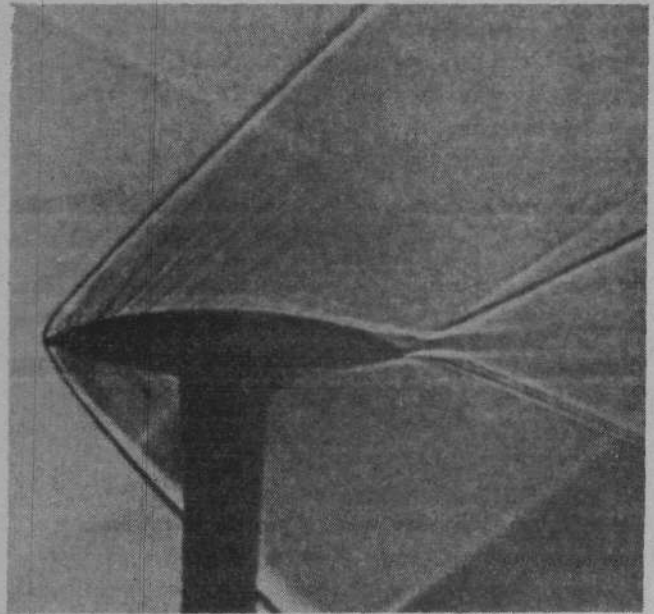
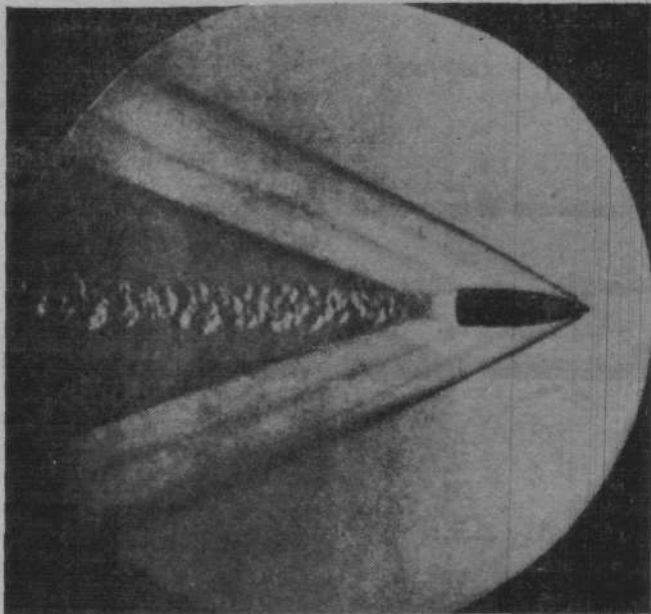
Somewhat closer inspection of Equation (8), however, as well as of the assumptions on which it was derived, shows that no such pessimistic conclusion is justified. In fact, the just-obtained result that entropy increases across weak shock waves are small immediately suggests a method of pre-compression first proposed in the open literature by John Nuckolls et al. in 1972.

Essentially, this method consists of trying to mimic isentropic compression by delivering a whole series of a half-dozen to a dozen relatively weak shocks of increasing strength into the fusion pellet by a carefully tailored, computer-precision-guided sequence of laser pulses. As can be demonstrated on the basis of known laws of shock propagation the later shocks, since they are of greater strength than the earlier shocks, eventually will catch up with the earlier ones, and, it is hoped, the entire sequence will converge at the center of the pellet and cause ignition.

The important insight here is not only that a sequence of weak shocks might simulate isentropic compression, but also that the shock sequence can be made to converge to form one strong shock in the end. This is by no means obvious *a priori*, but represents the result of years of systematic inquiry into the propagation, reflection, and focusing of shock waves called for



The World War II generation of mathematical physicists trained in the Göttingen tradition: From top, Busemann, von Neumann, Teller, and Bethe. Riemann's work on shock waves was the basis for their investigations in aerodynamics and the research that led to the atomic and hydrogen bomb.



Schriften of the German Academy of Aeronautic Research, 1937-38, p.8 and p.13.

Schlieren photographs of a flying bullet and associated shock front (l.) and of the flow around a mounted foil (r.).

in Riemann's 1859 paper and carried out in the main under the leadership of Riemann's immediate intellectual heirs at Göttingen University, Felix Klein, and, more specifically, Ludwig Prandtl.

From the early 1900s through the 1940s Prandtl and his collaborators and students carried out some of the most remarkable and ingenious experimental and theoretical investigations of fluid flow involving shock formation and interaction; for example, Prandtl's (and Meyer's) famous supersonic flow around a concave corner, von Karman's "vortex streets," and Busemann and Guderley's later aerodynamical researches. Significantly, Guderley's 1942 paper on "Strong Spherical and Cylindrical Compression Shocks in the Vicinity of the Center of the Sphere or the Cylinder Axis" remains one of the most frequently quoted papers among workers in inertial confinement fusion today (see Figure 3).

During and after World War II, the work of the Göttingen School found its most immediate application in problems of airplane design (wing profiles, and so forth) and rocket design (stability problems, for example). But, as hinted at by the continuing interest of laser fusion researchers in the Guderley paper, work on shock focusing, oblique reflection, and amplification of shock waves, and so forth, also played a crucial role in the design of the atomic and hydrogen bombs. And, pursuing the idea of optimization of shock amplification by oblique reflection at the most favorable angles, realizing that it is not spherical, but cylindrical or conical geometries that represent the optimal configurations, one is once again led not only into a once-classified but into the still-highly-classified area of laser fusion target design.

Epistemologically, however, it is not the weak shock simulation of isentropic compression suggested by Equation (8) that is most interesting, but the conclusion implicit in the entropy-difference equation and coherent with Riemann's adiabatic approach: that there might be certain equations of state as well

as specifiable changes in the equations of state caused by shock formation that could support or might add up to isentropic compression as a net result.

This conclusion is implicit in Equation (8) in the sense that in its derivation at a certain point, we expressly introduced the equation of state for an ideal gas and thus extremely narrowed down the scope of its applicability. In general, only a decrease in entropy is not a permissible jump condition (compare this with von Neumann 1963, pp. 188-189). Although conservation of entropy is certainly *not* implied by the gasdynamic equations when the fluid motion becomes discontinuous, neither is *non*conservation of entropy if that is taken to mean a necessary entropy increase. It all depends on the equation of state, as I already pointed out in my previous critique of Rayleigh's criticism of Riemann.

The equation of state of a compressible substance expresses the properties of the substance giving its specific inner energy  $\epsilon$  as a function of its density  $\rho$  (or its specific volume  $v = 1/\rho$ ) and pressure  $p$  (or the specific entropy  $S$ ):

$$\epsilon = \epsilon(p, \rho) \quad \text{or} \quad \epsilon = \epsilon(S, v).$$

Pressure and temperature are then defined by

$$p = -(\partial\epsilon/\partial v) \quad [ = p(S, v) ]$$

and

$$T = (\partial\epsilon/\partial S) \quad [ = T(S, v) ].$$

However, it is certainly possible that  $p(S, v)$  does not depend on  $S$ . Then

$$\epsilon = \epsilon(S, v) = f(S) + g(v) \quad (9)$$

and

$$\rho = -\frac{\partial \epsilon}{\partial v} = -\frac{\partial}{\partial v} g(v),$$

$$T = \frac{\partial \epsilon}{\partial S} = \frac{\partial}{\partial S} f(S).$$

What this means is that pressure is now simply a function of specific volume or density, and temperature a function of specific entropy; but there is no functional relationship between the pairs  $(p, v)$  and  $(T, S)$ , and the energy is the "disjoint union" of the energy contributions of the two pairs.

John von Neumann, in his discussion of this matter, makes reference to a paper by Kirkwood and Bethe where it is shown that such a decoupling is reasonably verified under the conditions of underwater blasts and, therefore, that the validity or invalidity of Equation (9) corresponds to a certain extent to the *division between liquids and gases* (von Neumann 1963, p. 182).

From the standpoint of the discussion here, first of all note that Equation (9) represents a type of equation of state for which isentropic compression is realizable. Second, von Neumann's remark shows that there are interesting "real life" conditions to which such equations apply. Still, the existence of specifiable empirical conditions under which isentropic compression is possible does not necessarily help us under the empirically different initial conditions of laser fusion, nor does it convey the full epistemological consequences of Riemann's method.

Riemann speaks of a new kind of lawfulness that comes into existence as a result of the formation of shock waves. Rather than applying this notion only to questions of the propagation and interaction of shock waves, it should be applied also to the interaction of shock waves with the equation of state, the interaction of interactions of shock waves with the equation of state, and so forth. Regarding laser fusion, we could then ask, for example, whether isentropic compression or equivalently favorable conditions for fusion ignition might not be achieved as the result of shock-caused changes in the equation of state, changes of changes in the equation of state, and so on.

This would be a rather different approach from the precision-guided weak shock sequence, which looks at changes in the equation of state principally from the standpoint of a hindrance to the efficient calculation of the path of propagation of the laser-pulse-caused compression wave. In the approach advocated here, on the other hand, shock-induced phase changes in the compressed substance are regarded as primary, and the qualitatively new features of the substance having undergone phase change are to be investigated—most immediately, of course, for changed shock propagation characteristics.

For example, as shock compression transforms the initially neutral fusionable material into the ionized plasma state, an equation of state resembling Equation (9) will be appropriate to the description of the substance (which, dominated by the ions, will tend to behave more like a liquid), rather than an equation involving strong coupling of density and temperature.<sup>2</sup>

Properties of the self-organization of energy (for example, the formation of solitons discussed by Steven Bardwell in his article "Elementary Plasma Physics from an Advanced Standpoint") come into play in the plasma state, creating structural features in the substance (including topologically nontrivial features) that are of primary causal significance for fusion ignition, but highly localized and, therefore, not readily comprehended by the global and necessarily "averaging" thermodynamic description of the compression process. In short, there is a certain sense in which, when we aim to fully understand laser fusion—or, more generally, implosion processes involving shock formation—the isentropy condition, although an important thermodynamic net characteristic of the process, nonetheless is secondary in its causal determination.

What is primary in the causal evolution is the interaction of the local and global hydrodynamic structures. Specifically, the fact that accounts for the essentially nonlinear nature of the process is the interaction of continuously evolved, new discrete entities with the "environment" that created them, leading to phase changes in this environment that, in turn, reflect back onto and further transform the discrete structures.

I want to remark at this juncture—and the reader may have noticed—that in the immediately preceding discussion the methodological points—and only these—were asserted categorically rather than hypothetically. The reason for this is simple. There is scant current empirical evidence concerning the details of the evolution of the equation of state of a given substance under ultrahigh compression—scant at least in the sense that there is not a good match between theory and actually recorded measurements. And, not surprisingly, military classification again has intervened to prevent a more broad-based attack on the problem.

Reportedly, in the 1960s, one of the U.S. national laboratories carried out a classified "Project Albino" to check theoretical predictions for the behavior of the equation of state of different substances under isentropic compression against empirical measurements and failed to get significant agreement. If so, the results and, more important, the method that failed should be made public, so that progress in this area no longer remains obstructed. For such progress must necessarily turn on fundamental points of method and, hence, will have significance well beyond the special purpose for which "Albino" was set up.

### Conclusions

In conclusion, I will now restate the issue of isentropic compression in the form of a generalized experimental hypothesis and draw some consequences, as Riemann's program demands, for the theory of partial differential equations.

As I pointed out above, the most interesting thing about isentropic compression methodologically is its dependence on the equation of state. In the preceding section, two equations of state were used explicitly: the equation for an ideal gas and Equation (9), characterized by decoupling of the pairs  $(p, v)$  and  $(T, S)$ . These two equations are opposite extremes; or, we can think of them as being at opposite ends of a continuous spectrum that could be parametrized, for example, by  $\gamma$ . Another way of stratifying the continuum would be by subjecting all sorts of substances satisfying all sorts of different equa-

tions of state to strong shocks and recording in some fashion degrees of approximation to isentropic compression.

"Project Albino" probably involved doing something like this, complicating the issue by introducing terms for various kinds of dissipation, and so forth. Such a procedure corresponds roughly to Linnaeus's classification of plant life or the arrangement of stars in the Hertzsprung-Russell diagram, and one should not actually expect any great insights into the causal characteristics of the evolution of the individuals and species so classified. (If this is an unfair characterization of "Albino," the matter can be quickly rectified by publication of the results of the project. In any case, I am interested here only in a point of method, not of historical accuracy.)

To understand isentropic compression, one has to identify a closer connection with the equation of state than something essentially of the nature of statistical correlation with respect to a given parameter or set of parameters. A good clue is provided by looking more closely than we have so far at the reason that Lord Rayleigh was scandalized by Riemann's paper. Rayleigh thought he could prove that Riemann's adiabatic jump condition would lead to a violation of conservation of energy; and, in fact, for the "wrong" kind of equation of state, this is a provable consequence.

However, this is precisely what makes matters interesting. Let us indeed start with a specific substance whose normal equation of state makes it a noncandidate for isentropic compression. Then, treat isentropy as a constraint upon the evolution of the equation of state during compression to identify the sequence of phase changes the substance has to undergo in order for energy to be conserved.

Qualitatively, such a sequence cannot be thought of as involving only the variation of one continuous parameter such as  $y$ , but must be pictured as a discontinuous succession of phase spaces, progressing continually to "higher states of internal organization." Either such a sequence is empirically realizable, or else isentropy will break down. For the interesting case of empirical realizability we are faced with the task of making precise this notion of "higher states of internal organization."

Physics today does not have a quantifiable concept or collection of concepts that can accomplish this. What is needed is a more refined concept of energy that is capable of discriminating between geometrically and topologically different distributions of energy taken in the ordinary sense and can impose an ordering on such distributions. In a recent article (*Fusion*, Oct. 1978), Lyndon H. LaRouche has used the term *negentropy* in approximately this sense, as I have discussed above. Although this nomenclature is clearly inspired by thermodynamic considerations, LaRouche gave the term a precise meaning in the context of a "thermodynamic model" for economics, where *negentropy* denotes an invariant representing the action of technological improvements upon the productivity of labor.

Within the framework of Riemannian geometry as elaborated in Riemann's "The Hypotheses Upon Which Geometry Is Based," the ordered succession of phase spaces traversed by a substance under isentropic compression would have to be represented on a multiply connected manifold of nonconstant curvature; that is, varying metrics for a chosen path. Riemann's geometric inventions—both in his geometry proper and in his representation of multiply valued complex functions on what

we now call Riemann surfaces—provide us with an ample arsenal of tools for the qualitative analysis of the indicated phase spatial relations.

Not currently available is a sufficiently rich number-theoretical continuum to launch an analytical attack on the most-difficult-to-handle nonlinear partial differential equations used in the characterization of fluid turbulence and so forth (for example, the Navier-Stokes equation) to which the hydrodynamic treatment of shock wave interaction with equations of state ultimately must be subsumed.

Riemann himself had begun to develop an attack on the number-and-function-theoretical issues involved in an article titled "On the Representability of a Function by a Trigonometric Series." This treatise must be read as a companion piece to the "Hypotheses"; it was instrumental in motivating Georg Cantor to undertake his groundbreaking investigations of the linear continuum and prompted his development of transfinite numbers.

A similarly bold step is necessary at this juncture if there is to be significant progress with the now-unsolved equations of mathematical physics. It would be most immediately in the spirit of Riemann's program to proceed in this not from generalities but from a definitely circumscribed experimental physics context; and laser fusion raises all the right kind of problems. To quote Riemann one last time (from his announcement of the paper on air wave propagation in the *Göttinger Nachrichten*, Nov. 19, 1859):

Much as in the case of the integration of the linear partial differential equations the most fruitful methods were not found by means of the development of the general concept of this task, but arose, on the contrary, from the treatment of special physical problems; so also, the theory of the nonlinear partial differential equations seems to be most furthered by a detailed treatment of special physical problems, taking into account all relevant boundary conditions. And, indeed, the solution of this very special problem [of wave propagation], which constitutes the object of this treatise, has required the invention of new methods and conceptions, and led to results that probably will also play a role in the solution of more general problems.

Jointly with Steven Bardwell—to whom I am grateful for a great many clarifying discussions of the specialized physics issues in this paper—I am now undertaking a survey study of the special relationships that obtain between shock waves, solitons, and vortex structures for the greater than one-dimensional realm.

The remarkable mathematical similarity between the Burgers equation,

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} - \frac{\partial^2 u}{\partial x^2} = 0$$

—developed for the purpose of mathematically modeling aspects of the Navier-Stokes equations, but actually representing weak shock waves—and the Korteweg-de Vries equation,

$$\frac{\partial u}{\partial t} + \alpha u \frac{\partial u}{\partial x} + \frac{\partial^3 u}{\partial x^3} = 0 \quad \alpha = \text{const.}$$

which exhibits soliton solutions, confirms one's physical intuition of close structural resemblances.

The survey should do much to sort out further our ideas of a comprehensive Riemannian attack on the recalcitrant fortresses among the hydrodynamic equations. Along with a simultaneous attack on the problem of the enlargement of the continuum, this maps the necessary course of the offensive.

## Postscript

In the introduction to my 1976 translation of Georg Cantor's "Foundations of a General Theory of Manifolds," (in *The Campaigner*, Jan.-Feb. 1976) I developed an argument leading to, among other things, the following comment on the notion of a "big bang" beginning (and possibly "big crunch" ending) of the physical universe:

The notion is absurd. All that Einstein's equations imply is that the "laws of nature" or that fraction of the laws of nature which they express, cannot be extended beyond a finite period of time (in either direction). . . . There is no one set of invariants which governs the process of the evolution of universal substance once and for all. . . . The structure of the physical universe extended in time is necessarily that of a nonlinear Cantorian continuum (of a succession of transfinite cardinals), characterized by variability of invariants, discontinuity of the process of nature from the standpoint of any given set of laws (emphasis added).

It is only the primitive epistemology underlying the assumption that linear continuity and fixed laws govern universal evolution that leads to the seeming unavoidability of the "big bang" nonsense. Consideration of the dynamics of implosion processes as discussed above can, I think, lead to further clarification (not just theoretically, but experimentally) of what is involved in the "variation of invariants" in the realm of inorganic matter. In addition to shock wave/equation of the state interactions, we may have to take into account changes in the metric of time in this interaction. Certainly the *a priori* assumption that the time metric is independent of the characteristics of the evolution of the physical process (especially under extreme conditions) is unjustifiable. The definition of a relativistic time frame beyond the limited scope of relativization with respect to a finite velocity of the propagation of electromagnetic effects, as in Einstein's special relativity, is called for.

Applied to cosmological problems, such a radically relativistic time concept would yield the following. Changes in the time metric as we are tracing the evolution of the physical universe back into the distant past and into radically different physical conditions will make nonsense of such talk as "90 seconds after the big bang," and so forth. The externally imposed absolute time frame tells us nothing about the actual relativistic time internal to the evolution of the physical process.

The most coherent picture, epistemologically, is that of a process of cosmical evolution defined by an ordered succession of types of lawfulness (Cantorian cardinalities) and associated time metrics, making the universe infinite in time but (for separate reasons) bounded in space-time, continually evolving its own metric for its progressive stages.

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### Notes

1. The Tripos exam at Cambridge requires the student of mathematics to memorize a vast number of techniques. Presumably the highest ranking student is called "Senior Wrangler" because he best wrestles with the volume of material.
2. As noted above, the equation or state of a medium determines whether, how, and under what conditions isentropic compression of matter will occur. One line of possible investigation for how new equations of state, or rather phases, arise in magnetized plasmas is presented by the Grad-Hogan theory (see *Fusion*, Oct. 1978, pp. 45-49).

Although conventional wisdom in inertial confinement studies of isentropic compression holds that the matter being compressed is not a magnetized plasma, multi-megagauss magnetic fields have been observed in laser pellet fusion experiments, in at least the crucial initial

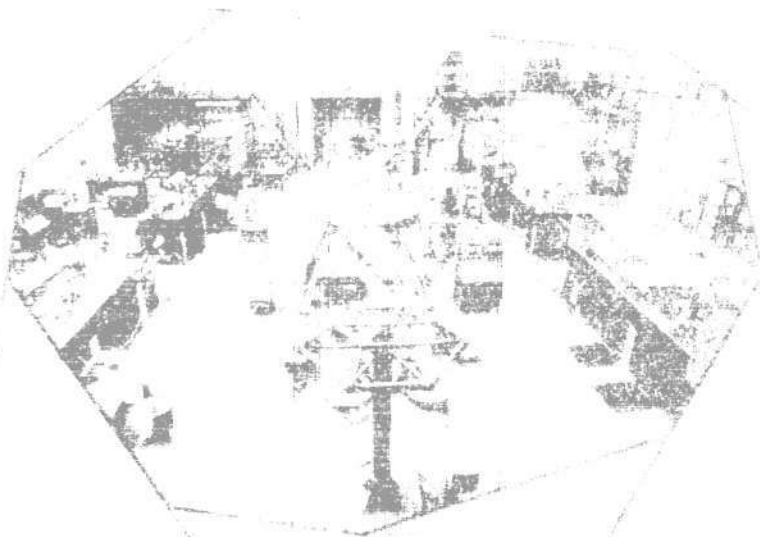
stages. Therefore, at least for these initial stages of the development of the shocks generating isentropic compression, magnetized plasma has been shown to be important experimentally.

Ironically, the Grad-Hogan theory, which was developed originally for magnetic confinement fusion, could have major application to inertial confinement fusion. The Grad-Hogan theory has important implications for continuum hydrodynamics regarding the demonstration that the Helmholtz Theorem for conservation of vorticity does not hold; minimally, it could manifest essential flaws in the "conventional approach" embedded in the various computer codes used for attempting to determine the equations of state during isentropic compression.

In particular, as noted above with respect to the von Neumann investigations of what kind of state of matter would be susceptible to isentropic compression, the decoupling of either pressure or density from temperature is necessary for isentropic compression. In magnetized plasmas, such a decoupling is determined by the magnetic and/or electric field structure, or rather topology. How such field topologies are initiated and evolve, therefore, would be essential to determining the "phase" of "equation of state" in magnetized plasmas.

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# The Secret of Laser Fusion

By the Editors of Fusion Magazine

ALL OF HISTORY tells us that humanity must have new knowledge or it will die. Today, precisely those areas of new knowledge that are most critical to the future of mankind are what are *classified* in the U.S. inertial confinement fusion program.

As will be made clear, this classification policy has proved to be a strategic and political disaster. The Soviet Union, the purported enemy, already is fully aware of the scientific knowledge involved and its civilian and military applications. By not cooperating in the joint development of inertial confinement for producing energy, the United States not only falls behind in the quest for a cheap and plentiful energy supply, but also opens itself up to be drawn into military confrontation with a very well prepared adversary.

The truth is that there really are no secrets to laser fusion. A careful reading of the available literature provides one with knowledge of all the basic issues involved.

We hope here to inform a more general audience of what these issues are and why they have been blacked out. Only by opening up discussion in these vital areas of science will we be able to rejuvenate the normal processes of scientific exchange that throughout history have led to the advancement of humanity.

## Some Classification History

To most scientists, the chronology of events in the last two years concerning the U.S. classification of inertial confinement fusion research has been bizarre. Three incidents are of special note.

First, L.I. Rudakov, the head of the Soviet electron beam program, visited the United States in July 1976 and declassified a significant amount of Soviet research on electron beam fusion. The energy bureaucracy in Washington responded by classifying Rudakov's work in the United States (including—so one story goes—one of the blackboards Rudakov used to explain some of the Soviet concepts).<sup>1</sup>

The following summer, E.P. Velikhov, the head of the Soviet fusion effort, proposed that the United States and the Soviets begin a joint research project on a branch of inertial confinement called the fast liner, an area in which the Soviet Union was the acknowledged leader. The response of the Department of Energy, prompted by National Security Advisor Zbigniew Brzezinski, was, in effect, to classify the fast liner research the United States was

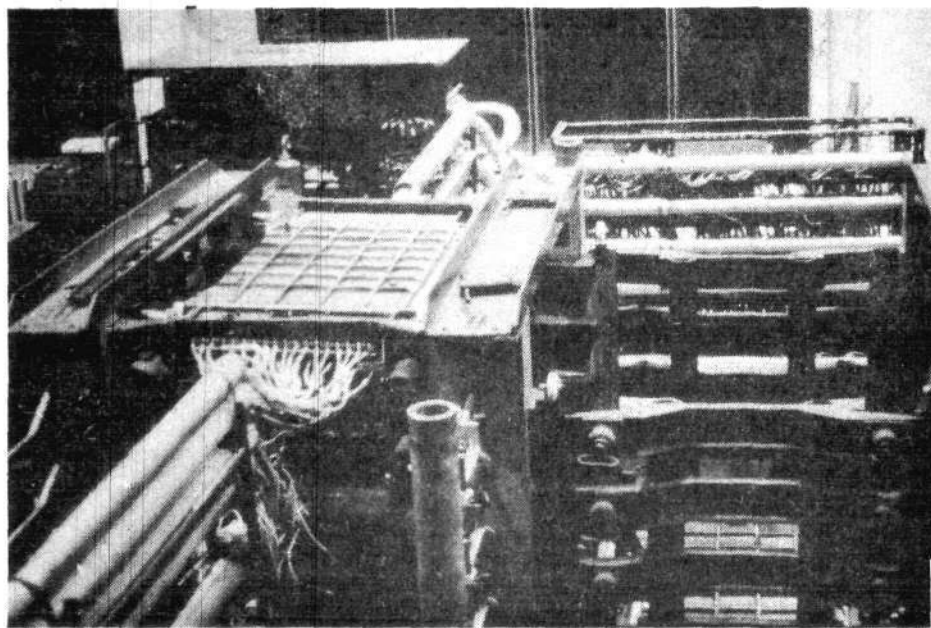
*In looking for a solution it is well to exclude one pseudosolution at the start. The crisis will not be resolved by inhibiting this or that particularly obnoxious form of technology. For one thing, the parts of technology, as well as of the underlying sciences, are so intertwined that in the long run nothing less than a total elimination of all technological progress would suffice for inhibition....*

*Prohibition of technology (invention and development, which are hardly separable from underlying scientific inquiry) is contrary to the whole ethos of the industrial age. It is irreconcilable with a major mode of intellectuality as our age understands it. It is hard to imagine such a restraint successfully imposed on our civilization. Only if those disasters that we fear had already occurred, only if humanity were already completely disillusioned about technological civilization, could such a step be taken. But not even the disasters of recent wars have produced that degree of disillusionment, as is proved by the phenomenal resiliency with which the industrial way of life recovered even—or particularly—in the worst hit areas. The technological system retains enormous vitality, probably more than ever before, and the counsel of restraint is unlikely to be heeded.*

—John von Neumann, *Fortune*, 1955



A large laser under construction at the Lebedev Physical Institute, the UMI, uses slab neodymium-glass amplifiers and the target chamber shown here. The arrangement of the ports for the laser light (the two square windows in the front of the cylinder) is interesting. There is no possibility in this geometry for spherically symmetric illumination of the target. Design of cylindrical and conical targets for the experiment is now underway.



Photos by Bardwell

doing. (For details, see "The Case of the Fast Liner" in this issue.)

In winter 1977, N. Basov, the Nobel laureate who heads the Soviet laser fusion program, proposed expanded U.S.-Soviet collaboration on laser fusion. One month later, U.S. Energy Secretary James Schlesinger personally answered Basov's proposal by stating at a press conference: "No, flatly no. We can't collaborate because it is classified."

The Soviets propose collaboration; the U.S. refuses because U.S. research is classified. The Soviets propose research in an unclassified area; the U.S. classifies its own research in that area. The Soviets declassify some of their research; the United States classifies this Soviet research in the United States. Quite a record for a nation with a tradition of scientific progress!

#### Who's Classifying What from Whom?

Observers who have tried to look at any particular piece of the classification issue invariably have come away confused by the inconsistencies between the results of the classification and its justification. How can classification of Soviet results in the United States be justified? How can the outlawing of discussion of certain theoretical concepts in physics—when they apply to laser fusion—be justified?

A clue to the answer comes from a statement by Professor John Holdren at the University of California at Berkeley, one of those reputed friends of fusion who obviates the need for enemies. In a March 1978 article on the dangers of fusion in the *Bulletin of Atomic Scientists* (page 4), Holdren said:

Technologically, "the genie is out of the bottle [in the case of fission], and it is widely held that greatly strengthened political controls are not feasible...."

In the case of fusion, choice is still possible—and likely to be relatively cheap. It is possible because research in inertial-confinement fusion is going on in

only a few places and under cover of classification; it is likely to be cheap in the sense that inertial-confinement fusion probably could be abandoned without surrendering the prospective benefits of fusion power.

Without wasting time with the usual arguments about national security and nuclear proliferation, Holdren gets right to the point: The danger of inertial confinement is proliferation of knowledge; the issue is control over the spread of knowledge.

This fear of the development of scientific knowledge and its industrial and social implications, which is the real motivation behind U.S. classification policy, has recently come to the political surface. Former secretary of state Henry Kissinger and Energy Secretary James Schlesinger have both warned that rapid modernization and industrialization are the cause of unrest and potential civil war in Iran and Mexico. On that basis, they both have argued for the decrease in capital investment and development in these countries and a return to more traditional feudal technologies.

This fear of progress is shared by the environmentalist movement and its sponsors in the highest sections of the Carter administration. In fact, this feudalist faction determines policy in the Division of Security and Safeguards as well as in the powerful Joint U.S. and U.K. Atomic Information Exchange Group in the Department of Defense.<sup>2</sup> This latter office exerted the main impetus for the U.S. classification in 1976 of Rudakov's declassified material.

Perhaps the most critical connection in the determination of U.S. classification policy is the British government and the U.K. Atomic Energy Research Establishment and military laboratory at Aldermaston. In instance after instance, input and pressure from Britain have shaped U.S. classification policy and possibilities for international collaboration on nuclear power, and more recently, laser

fusion. As Secretary of Defense Harold Brown told a European NATO official who questioned him about why the United States had not taken advantage of the Soviet declassification in the 1976 Rudakov case, "Because our British allies won't let us."

Apparently the British intelligence establishment still dreams of becoming rural gentry, ruling a small, uncomplicated world of ignorant peasants—exactly what Benjamin Franklin accurately identified as the British problem 200 years ago and over which Americans fought the War of Independence.

### Demystifying Inertial Confinement Research

From available U.S. documents and from what is available in the open Soviet literature about scientific processes now classified in the United States, we have compiled the following report on classified matter in U.S. inertial confinement research. Again, we emphasize that all the sources for this information are publicly available.

All types of inertial confinement fusion research have suffered from extensive classification because they all rely on the same general physical conditions for their success: the rapid (supersonic) compression and explosive heating of a small amount of fuel. (These conditions are the opposite of the almost steady-state operation at low density of magnetic confinement fusion.)

The primary distinction among the different approaches to inertial confinement fusion is the source of the intense energy needed for ignition, the so-called driver. The main drivers now under study are lasers (several types), particle beams (both electrons and ions), and metal shells (liners). These drivers give rise to the various kinds of inertial fusion research bearing their names.

Because of this overall similarity, the three steps in a fusion process initiated by inertial confinement—heating,

compression, and ignition—are comparable. All require knowledge of the physics of the hot, dense matter undergoing fusion. To give you an idea of what this involves: The conditions for producing inertial confinement would be the equivalent of dealing with a teaspoon of fusion fuel at a temperature of 100 million degrees (hotter than the center of the sun), a weight of 120 pounds, and an energy output of the equivalent of 250 million gallons of gasoline.

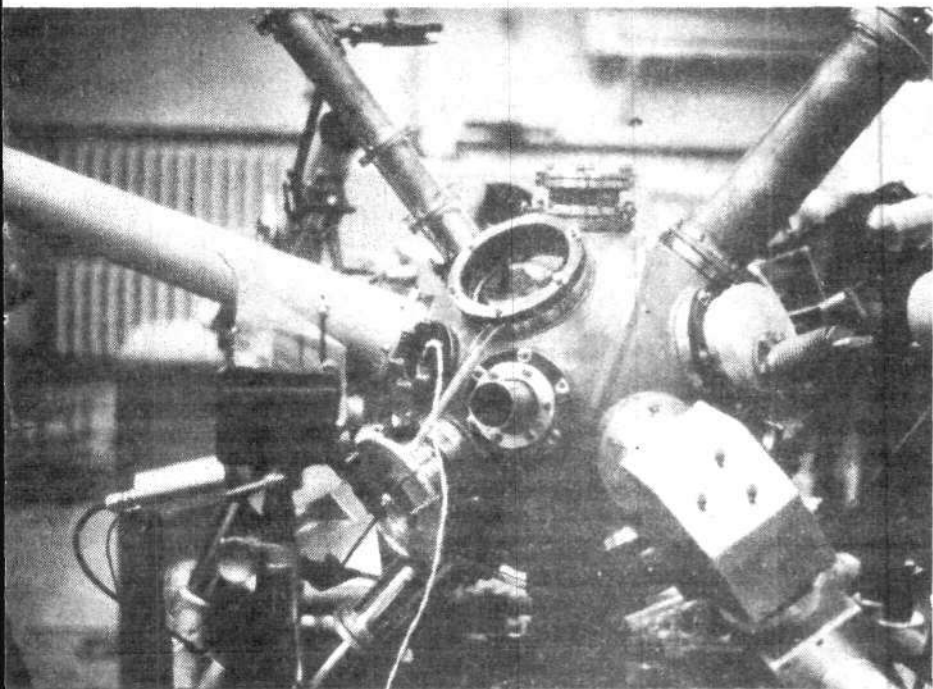
### Energy Absorption

The first problem in the initiation of the inertial fusion process is the delivery of energy to the surface of the target of fusion fuel. In the case of laser fusion, for example, an intense beam of laser light is focused on the pellet for about one-billionth of a second. During this billionth of a second, more energy is concentrated on the target than the total energy consumed by the world during that billionth of a second.

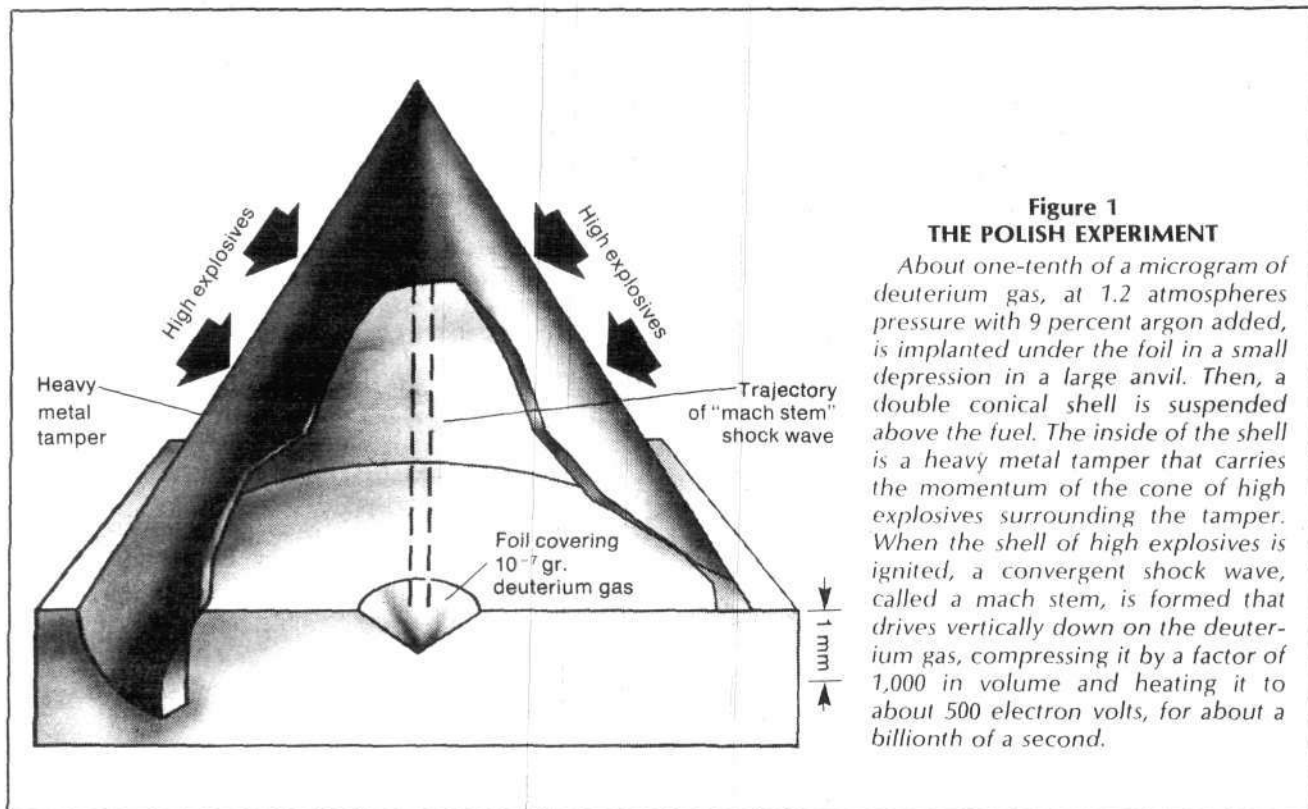
The problem both scientifically and practically is to ensure that the light energy is absorbed by the tiny pellet and not reflected or transmitted. All our intuition about the behavior of light with matter is almost useless at the tremendous energy densities involved in these experiments.

The transfer of energy to the fusion fuel must be done in a carefully controlled way for maximum efficiency. Since the pellet must be simultaneously compressed and heated, it is clear that it would be advantageous first to compress it and second to heat it, because it is easier to compress the fuel when it is cold rather than hot.

This scheme of compression and heating is called *isentropic compression*, compression of the pellet without increase in temperature (entropy). The declassification of this idea in the early 1970s by Edward Teller was the first significant indication that laser fusion was possible. With-



The Delphin laboratory contains a second, smaller target chamber, shown here, for calibration of the diagnostic equipment to be installed in the full-scale target chamber.



**Figure 1**  
**THE POLISH EXPERIMENT**

About one-tenth of a microgram of deuterium gas, at 1.2 atmospheres pressure with 9 percent argon added, is implanted under the foil in a small depression in a large anvil. Then, a double conical shell is suspended above the fuel. The inside of the shell is a heavy metal tamper that carries the momentum of the cone of high explosives surrounding the tamper. When the shell of high explosives is ignited, a convergent shock wave, called a mach stem, is formed that drives vertically down on the deuterium gas, compressing it by a factor of 1,000 in volume and heating it to about 500 electron volts, for about a billionth of a second.

out isentropic compression, the energy requirements for ignition are astronomical.

The scientific understanding of how light is absorbed on the surface of fusion targets has been the subject of a large amount of open research and does not in itself seem to have been significantly hindered by classification. The details of the absorption of energy from an electron beam, however, are significantly different from those appropriate to a laser (although the questions of compression and ignition seem nearly identical in the two cases), and results on the interaction of the electron beam and a fuel pellet have been extensively classified.

These results have important implications for pellet design and the feasibility of electron beam fusion. This information must be made public in the United States.

From literature published in the Soviet Union by L.I. Rudakov and others, it is known that the absorption of energy from an electron beam by a fuel pellet proceeds in three steps: First, the electron beam is trapped at the surface of the pellet by the conductivity of the outer surface of the pellet and by intense local, magnetic fields that capture the electrons at the surface of the pellet. The electrons execute a violent, spiral set of orbits when they first hit the surface of the pellet—as might be expected, since they are decelerated from velocities near the speed of light when they strike the pellet.

This first part of the electron beam-pellet interaction is widely studied and published. However, the second step, involving soft X rays, is heavily classified in the United States, although not in the Soviet Union.

It is well known to every physics undergraduate that when a charged particle, like an electron, is accelerated

or decelerated, it loses significant quantities of energy in the form of X rays.

This is how X rays are generated by a color television, for example. When the high-energy electrons used to excite the picture tube hit the glass of the screen, they emit some of their energy in these so-called bremsstrahlung X rays.

If the energy of the electron beam and the outer material of the pellet are matched, it is possible to obtain most of this energy in the form of X rays that are of high enough energy to ionize the outer layer of the pellet, but of low enough energy so that they cannot penetrate inside the pellet and heat the interior. Such X rays are called soft X rays, and this process of surface heating using soft X rays is an essential condition for isentropic compression.

Soft X rays provide the ideal form of energy for the final step of the energy deposition in the fuel pellet. Recall that these soft X rays are in the energy range in which they interact strongly with the matter in the pellet; their energy is sufficient to ionize the fuel but cannot penetrate deeper because it is immediately absorbed at the surface. Thus, the heating goes on in a layer always at the surface of the pellet with negligible heating of the interior of the pellet. This ensures that the compression of the pellet by the shock waves set up with this surface heating will be compressing cold fuel.

This picture of the energy deposition process on pellet design has two immediate implications—neither of which can be discussed publicly in the United States. First, the composition of the outer layer of the pellet must be of some material that combines the conductivity, density, and atomic charge that optimize the production of soft X

rays. Second, the geometry of the pellet must enhance the absorption of the soft X rays by ensuring that they are propagated in the direction of the fuel or other pellet layers. As the Electric Power Research Institute maintains, the classification of such basic considerations not only impedes scientific discussion and progress, but also prevents the engineering and industrial development of fusion.<sup>3</sup>

#### *The Soft X-Ray Case*

The story of the study of soft X rays in inertial confinement fusion in the United States fits the illogical pattern described at the beginning of this article. The first public speculation on their crucial role in electron beam fusion came at a series of talks by L.I. Rudakov given at U.S. scientific meetings here during late June and early July in 1976. These talks totally unnerved the energy bureaucracy in the U.S. and British governments. There was a flurry of telegrams, letters, and telex messages back and forth between the Energy Research and Development Administration office in Washington, the national laboratories where Rudakov had spoken, and the British Foreign Office. The net result of this hysteria was the classification of Rudakov's results in the United States.<sup>4</sup>

This classification has had some very interesting clinical effects on scientific research in the area of electron beam fusion. For example, it has created a situation in which U.S. researchers are forbidden by statute to discuss the basic physical phenomena involved in transfer of energy between the electron beam and the pellet. A survey of *Physical Review Letters*, the most important American journal for communication of new experimental results in physics (including inertial confinement fusion research), for the two years after Rudakov's visit to the United States shows no mention by U.S. authors of the role of soft X rays in the electron beam fusion process. The first paper in a Western journal to note the critical part played by these X rays was authored by a group of Japanese scientists.<sup>5</sup>

Why are soft X rays classified? The usual answer given to this question is that they play a similarly important role in the compression and heating used in the ignition of a hydrogen bomb (which is a large, uncontrolled inertial confinement fusion experiment). This might be a credible excuse, if not for the fact that the information is being provided by one's nominal enemy.

It should be clear to the reader that what is classified here is not a technological development, not some better gadget of military application, nor even an immediately deployable source of energy. Theoretical science is being classified!

Because it is unlawful for a scientist to talk about a central concept in the physics of inertial fusion, the discussion of a host of interesting and important problems in physics is aborted. To take one example: According to some of the best scientists in the field, the problem of transport of energy by electrons in a plasma is the most difficult, most significant, unsolved problem in plasma physics. The question of how electrons can selectively leak off energy from a magnetic fusion plasma seems to be very similar to the question of how electrons transport energy quickly into the core of a laser fusion pellet. In both situations there is an anomalous population of hot

electrons that behave in a very problematic way.

It is known that in both the magnetic and inertial cases, the plasma motion generates intense magnetic fields that violently affect the electrons, but there is a gaping hole in all discussions of the situation—mention of soft X rays is forbidden. Scientific inquiry, which requires an environment as unfettered as possible in order to flourish, is thus crippled in inertial confinement research.

#### **Compression**

It is not enough to make fusion fuel hot. In order to release net energy, the fuel must also be sufficiently dense for enough fusion collisions to take place. In the case of an inertial confinement fuel pellet, this translates into the necessity for densities up to 10,000 times normal liquid density. Since matter does not normally come like this, some mechanism must be found to use the energy of the driver to compress the fuel.

The guiding idea in this compression is that it must be isentropic, as mentioned above. The simple picture of this is that the outer layer of the pellet can be heated so rapidly that as it explodes off the surface of the pellet, the back-reaction of the rest of the pellet will drive a compression wave toward the center of the pellet, like a rocket engine pointed toward the center.

This is the usual picture of so-called *ablative compression* presented to lay fusion audiences. Unfortunately, it is also the intuitive guide to a model of compression presented in unclassified literature in the United States. The tougher, more important question is: how does this compression really work? To assume that it proceeds according to normal experience with compressions of gas or weak explosions is naive. However, to be anything but naive in answering the question is impossible, because, to quote the Department of Energy's felicitous wording, it "might lead uncleared workers into classified areas."

The central concept necessary to unravel the problem of pellet compression is the propagation and focusing of shock waves, a topic rarely talked about even abstractly in the open American literature. Interestingly, the concepts sufficient for the qualitative understanding of the problem

## **Total Classification?**

The same process of classification is under discussion for the rest of the fusion program. In December 1977, the Department of Energy circulated a memorandum for drawing up classification guidelines for the handling of tritium fusion fuel. As noted in the memo, the new guidelines are intended to affect the next generation of tritium-burning fusion experiments. The memo pointed out the supposed proliferation hazards of fusion resulting from the use of tritium and said that the new guidelines will involve the classification of some commercially available laboratory equipment, since this equipment is used to handle tritium.

The memorandum resulted in a two-volume study recommending classification, a policy which has not yet been implemented.

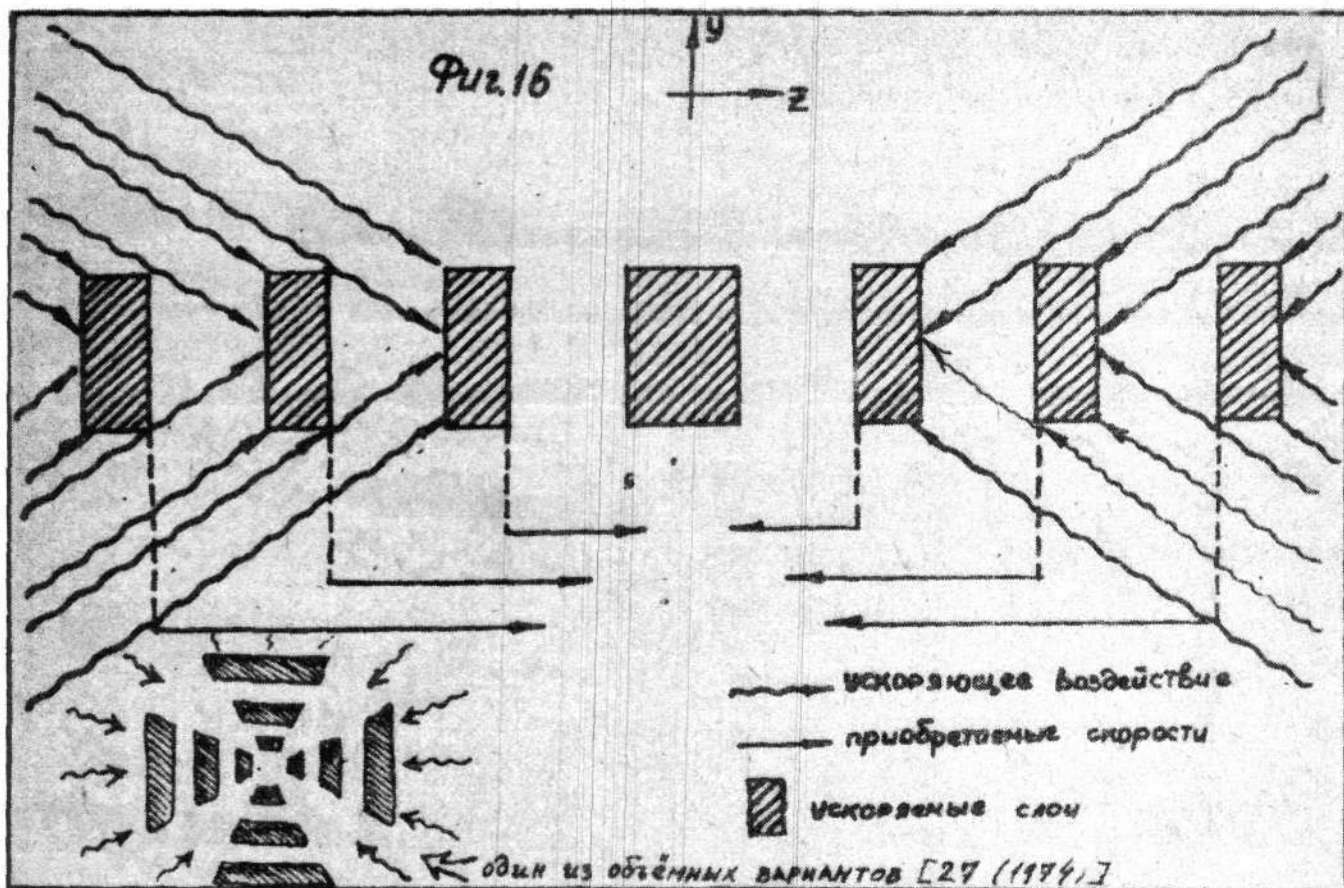


Figure 2, from the paper by Belokon', shows the conceptual design for a cylindrical, multifoil target. The illumination scheme has cylindrical symmetry, very similar to that in the Shiva-Nova laser system (see opposite). The wavy lines in the diagram represent the laser light hitting the faces of the foils making up the target and pushing the foils toward each other. Belokon' designed the targets used by Rudakov in his first series of electron beam experiments that caused a furor in the United States.

of inertial confinement fusion compression were developed in a rigorous way by Bernhard Riemann in a paper in 1859. In a very real way, Riemann's 1859 paper is now classified in the United States.

Riemann was the first to recognize that a singular wave front of compressed matter is not merely a mathematical result of the equations of wave propagation in a compressible medium, but that it exists physically and can itself propagate. The shock wave created by the sudden deposition of energy on the surface of a fuel pellet is just such a wave; its density changes from 1,000 times normal to its normal value in a distance much much smaller than any dimension in the pellet.

The shock waves generated in the highly energetic processes characteristic of inertial confinement fusion have several unique properties, all of which seem to be classified in the United States. First, classical wisdom has it that the transition across a shock wave front involves an increase in entropy and, of necessity, a nonisentropic transition as it propagates.<sup>6</sup> The conditions for the propagation of such a shock wave have been well developed by researchers over the past 50 years. However, in his original paper Riemann assumed that the transition across the shock front would be adiabatic, reversible, and isentropic.

According to Soviet researchers, it is now known that in highly energetic shock waves, like those in all kinds of inertial fusion, Riemann's assumption was the correct one.<sup>7</sup> The properties of Riemann's adiabatic shock waves turn out to be ones that actually compress the fusion fuel, both in a laser fusion pellet and in a hydrogen bomb.

The second important property of high-energy shock waves has been known since the 1930s, but its implications for laser fusion are still classified. Shock waves have the interesting property of being amplified on reflection.<sup>8</sup> When a shock wave is reflected from a boundary, the reflected shock wave is eight times as strong as the initial wave for a normal gas. In other materials, the amplification can be many times greater.

Although it is not discussed openly, it would be obviously advantageous to construct the pellet so that these shock waves could be reflected and then focused in order to generate a compressive wave many times stronger than that generated "brute force" by the driver.

The Soviets have perfected two means of doing just this using techniques that are undoubtedly being used in the United States also, as we shall show, but that cannot be discussed openly here. The first involves the use of alternating layers of matter and vacuum in the pellet. This arrangement allows for the shock wave to bounce back

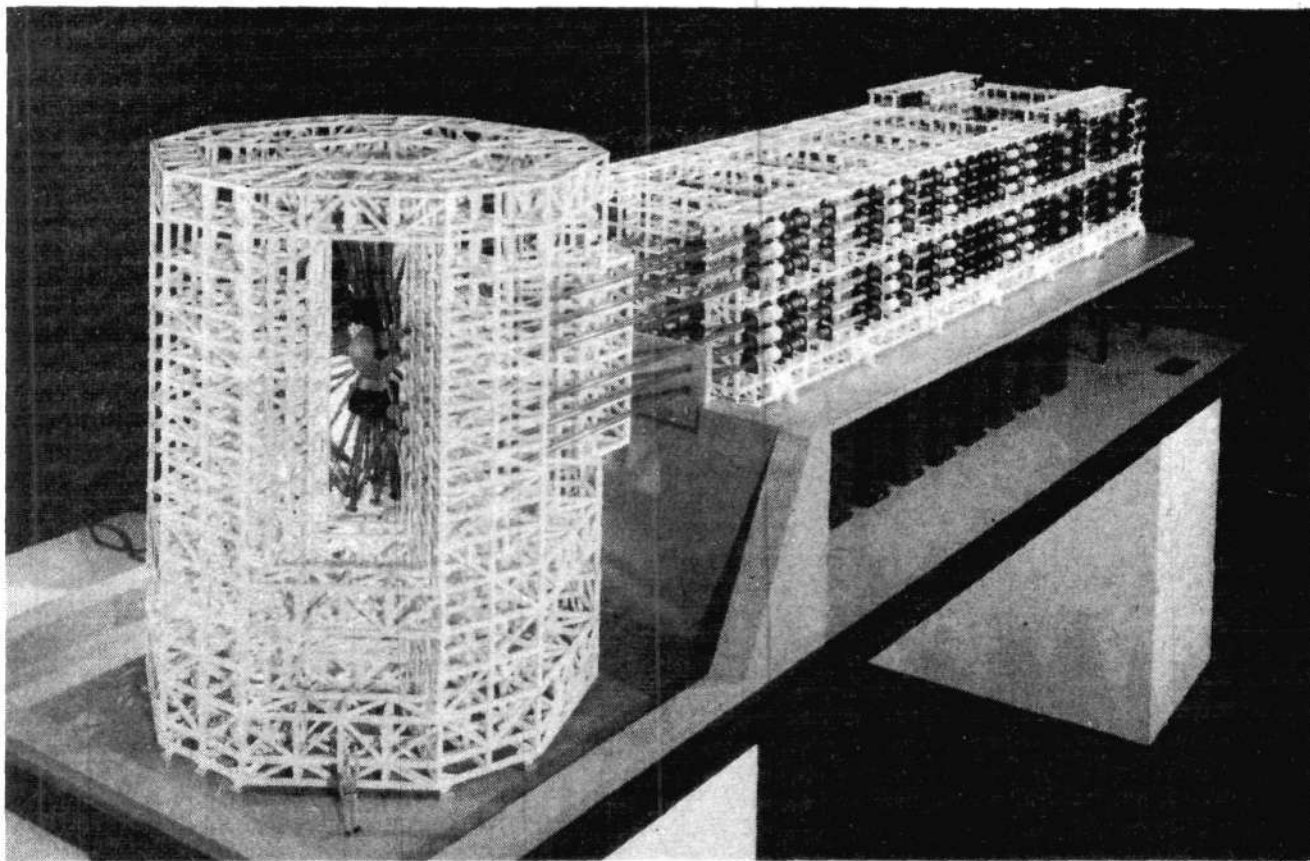


Figure 3, the Shiva-Nova at Lawrence Livermore, is the world's largest laser. The most remarkable thing about the laser is the arrangement of the ports for illumination of the target in the target chamber; the beam ports are not spherically symmetrical. In spite of much public discussion on the importance of spherical illumination of the laser fusion targets—thought to be necessary to prevent unstable implosion—the most advanced laser in the world purposely avoids spherically symmetric illumination. The classified fact that cannot be discussed openly by the Livermore scientists is that their pellets are asymmetrical also!

and forth between the layers to self-amplify; it allows the pellet to be "tuned" to the natural amplification and focusing of the shock wave; and it allows the pellet to be designed so that the acceleration of one layer can be timed to coincide with the next, inner layer. In this way, the whole energy of the shock wave is tailored to meet at the center of the pellet simultaneously.

These considerations are reviewed explicitly in a recent Soviet work and very covertly in a recent American paper.<sup>9</sup>

### Nonspherical Targets

The most striking application of these ideas, which is even more highly classified in the United States, is the use of nonspherical targets for focusing and amplifying the shock wave.

In Rudakov's 1976 work on electron beam fusion, he experimented with conical targets (Figure 1). The advantage of conical targets was shown dramatically by the Polish inertial confinement research group under Kaliski, who described in detail the focusing effect of a conical target, the formation of a Mach stem in the propagation of the shock wave in the target, and the extremely high temperatures and pressures achieved.<sup>10</sup> The Kaliski group was able to achieve fusion driven by chemical explosives, using the amplification possible with a conical target.

Another widely discussed Soviet idea, which has been kept under wraps in the United States, is the idea of cylindrical targets. As the above Soviet paper notes, the self-focusing of the shock wave and the ease of assembly of multifoil pellets for the cylindrical targets make them very attractive as the fuel geometries for laser and electron beam fusion. Figure 2 shows another target design of Soviet origin using these ideas.

There is little doubt that the United States is developing cylindrical targets as well. Striking proof is given of this by looking at the geometry of the illumination scheme of the Shiva-Nova laser at Lawrence Livermore (Figure 3). As the schema shows, the laser beams can enter the chamber only from the top and bottom; it is impossible even to approximate spherical geometry in illuminating the target.

A widely discussed problem in laser fusion is the occurrence of destructive physical instabilities in the pellet that were thought to amplify any nonsymmetry in the heating of the target and result in the bursting of the target before it could be compressed. Therefore, the sudden publication of this odd Shiva-Nova target chamber design excited quite a bit of interest.

At an international laser fusion conference in December 1978, a French scientist asked the Livermore group if it had plans later to convert the chamber to spherical illu-

mination (he apparently assumed that this asymmetrical design was a first approximation), and he asked how hard it would be to do so. The somewhat flustered Livermore scientist replied that they had not even thought of changing the target chamber, and that it would be almost impossible to make such a change.

Several other questions of similar nature—how is target design affected by this illumination scheme, and the like—were answered with the same somewhat embarrassed evasion.

The obvious point is that the targets also are asymmetrical. As Figure 2 shows, such polar illumination would be ideal for driving the two ends of a cylinder—perhaps a multifoil construction, taking advantage of the reflected shock waves in each layer, between layers, and from the sides of the cylinder, to achieve tremendous magnification of compression.

Obvious, but classified.

### The Military Question

The overall impact of the classification of shock wave phenomena in inertial confinement fusion has been much more destructive than in the case of the soft X rays. As the article in this issue on Riemann's theory of shock wave develops in more detail, the methodological and epistemological issues brought up by a serious study of shock waves are far-reaching. In the past, such study has always resulted in significant advances in mathematics and physics, as demonstrated by the experience of World War II and the Manhattan Project.

That these scientific studies have military implications is unavoidable. It is a not-so-surprising fact that the frontiers of science frequently coincide with the frontiers of military technology, as both reach for higher and higher energy densities.

To justify classification of theoretical science because it is involved with new military technology is to classify, down the line, the most important scientific work now being pursued. This classification poisons the atmosphere for creative scientific work, creating a situation in which whole areas of physics become incomprehensible to scientists who are not among the inner circle of the national laboratories privy to the classified material.

The only reason that fusion is at all technologically interesting is that it eventually involves the ignition of a fusion reaction. The payoff comes when the nuclei of hydrogen actually fuse and release energy. Unfortunately, the most exciting and challenging stage of the process is also the most highly classified. The appearance of qualitatively new species of matter from a regular plasma—a fusing plasma, a fireball of new particles, massive energy, a star in miniature—cannot be discussed. Much like the proverbial baby in Victorian novels, the conception of this fireball must remain embarrassingly vague.

The only time scientists have had access to a macroscopic amount of fusing matter on earth is the explosion of the hydrogen bomb. This immediately gives a so-called legitimate cover for classifying research into the actual fusion process.

Yet, as the Electric Power Research Institute Report notes, the most critical engineering knowledge about fusion is the mixture of energy forms (and their interdependence) in the fireball. Without a knowledge of the timing and shape of the blast wave, the mixture of neutron

energy and electromagnetic radiation coming out of the blast, and the factors affecting this mixture, it is impossible to create an engineering design for fusion reactors. Exactly this information is the most highly classified part of the fusion program.

It is not surprising that the most carefully classified area in fusion is the ignition problem, because ignition precisely raises the most fundamental problems in fusion. As Holdren said in his advocacy of more widespread classification, knowledge is dangerous. For the political faction that believes this, the fear of scientific discovery and the proliferation of scientific ideas defines a world of technology gone wild, of man helpless before the destructive powers of his own creativity.

This view of man and his role in the universe is the real determinant of the present classification policy. And for those who hold such a view, it is completely coherent simultaneously to advocate disarmament and the initiation of nuclear war—as Bertrand Russell did in 1948.

With this view, it is also coherent to sell nuclear technology to the People's Republic of China based on an informal note of agreement on nonmilitary use, while denying the sale of nuclear technology to India, a signatory of the Nonproliferation Treaty. The biggest threat to the feudalists in both situations is not war; it is the policy of science and development espoused by the Soviets or the Indians.

Whatever motivates the individual scientist or military officer to justify classification in one instance or another, and perhaps be completely proper in doing so, the question of classification in fusion goes much deeper. Classification of fusion research means the destruction of progress. It must be called by its real name, and it must be stopped.

### Notes

1. For details on these three incidents, see "Soviets Offer Joint Break-even Fusion Experiment to Los Alamos," *Fusion* Oct.-Nov. 1977, p. 6; "The Classification of Fusion: Two Case Studies—The Rudakov Case," *Fusion* Dec. 1977-Jan. 1978, p. 54; and "Who's Really Sabotaging Fusion Development?" *Fusion* March 1978, p. 8.
2. The British input is detailed in the March 1978 *Fusion* article cited above.
3. The task force commissioned by the Electric Power Research Institute in 1976 to review the status of laser fusion noted the same general problem with classification. "The greatest near-term impact of classification, however, probably lies in the time lag caused by the lack of information on the particle and energy output of classified pellets. Reactor design studies cannot be made until at least this information is available." (Reprinted in *Intl. J. of Fusion Energy*, June 1977.)
4. See *Laser Focus* magazine, August 1976, for a similar account of Rudakov's visit.
5. J. Mizui, N. Yamaguchi, T. Yamakaka, and C. Yamanaka, *Phys. Rev. Lett.* 39: 619 (1977). They discuss the problem in the context of a similar question of electron transport and energy loss in laser-created plasmas.
6. See, for example, R. Courant and K. Friedrichs *Supersonic Flow and Shock Waves*, New York: Interscience Publishers, 1948, p. 118.
7. Private conversation with Soviet physicists.
8. See, for example, Courant, *Supersonic Flow and Shock Waves*, p. 154.
9. V.A. Belokon', "Multifoil Ultrahigh Compression," to be published in *Intl. J. of Fusion Energy*, 1979. For the American version, see S. E. Bodner, et al., "Inertial Confinement Fusion at NRL," paper delivered at the IAEA International Conference on Plasma Physics and Nuclear Fusion, Innsbruck, Austria (IAEA-CN-37-B-3), 1978.
10. "Poles Create Fusion Using Explosives," *Fusion*, Dec. 1977-Jan. 1978, p. 71.

*Unemployed: DOE classification shut down the capacitor bank of the Los Alamos Scyllac, rather than permit a joint U.S.-Soviet experiment with fast liners.*

# The Case of The Fast Liner

by Charles B. Stevens

IN FALL 1978, the fast liner approach to thermonuclear fusion suddenly became classified. The mysterious decision was taken without consultation with any of the scientists in the research program, or with the fusion office and the classification division at the U.S. Department of Energy. In effect, it has killed the fast liner work as a promising line of fusion research in the United States.

Why would such an important area of fusion research be halted without the knowledge of any of the individuals immediately involved? And who in the Department of Energy had such extraordinary decision-making power?

The answers to these questions, presented below, should make those readers skeptical about the British role in sabotaging U.S. energy development think twice.

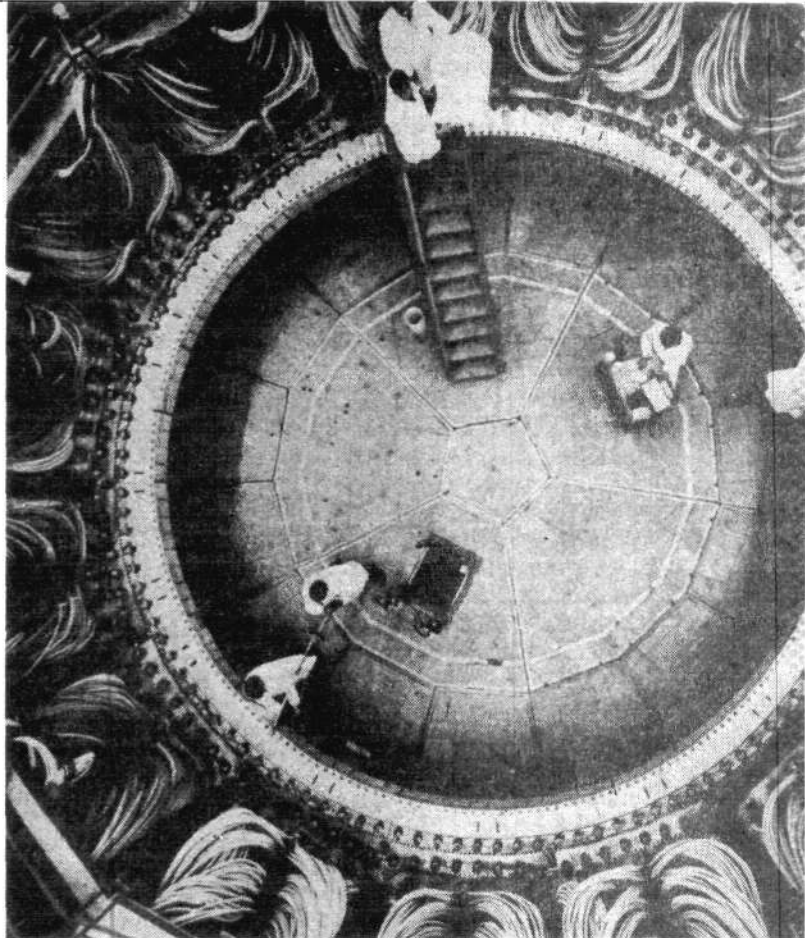
First, some facts about the fast liner.

The fast liner approach to fusion is particularly important because it efficiently and cheaply combines the two most general methods of obtaining fusion—magnetic confinement, which most prominently involves the tokamak, and inertial confinement, typified by laser pellet fusion.

The basic idea of the fast liner system is that the electrical conductor that generates the magnetic field confining the plasma is designed to collapse under the stress of its own magnetic field and, in the process, compress and heat the plasma to fusion conditions.

The electrical conductor is shaped like a hollow cylinder (Figure 1). As it collapses, or implodes, because of the pressure from the portion of the magnetic field outside, it compresses the magnetic field on the inside so that it produces fields in excess of 1 million gauss in short bursts (a gauss is a unit of magnetic field strength).

In this way, the fast liner system uses both magnetic and



LASL

inertial confinement to produce a fusion plasma a million times more dense than those found in tokamaks. In fact, magnetic systems like the tokamak ordinarily are limited to magnetic fields of less than several hundred gauss, because fields that are any larger generate stresses too great for even the strongest steels to withstand. With a fast liner power reactor, however, the liner containing the plasma would be designed to be destroyed by the burst of fusion energy, and like the pellet in laser fusion, replaced after every "shot."

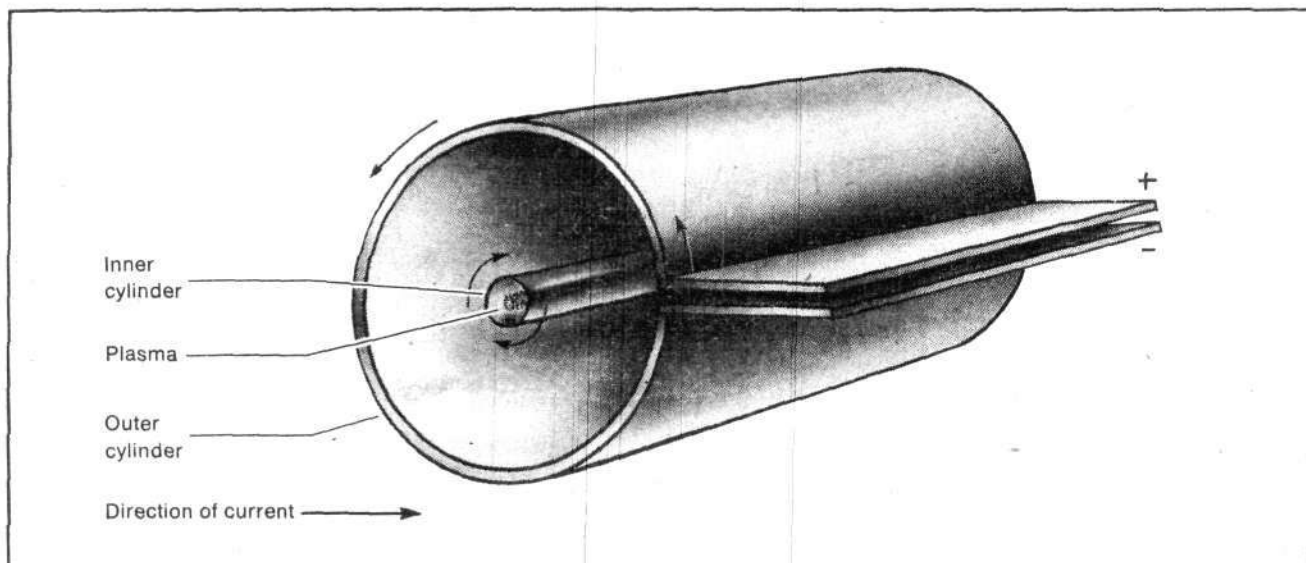
Another advantage of the fast liner is that it is driven by fairly cheap and low-grade energy—an intense pulse of electricity—and it uses this energy in an efficient manner to ignite fusion. This means that the cost for experimentally determining feasibility is minimal compared to other approaches.

## Some History

During the past 20 years, fast liner imploding systems have been investigated on a small scale by weapons laboratories around the world as a potentially cheap method of simulating the burst of fusion energy generated by a hydrogen bomb. The liner approach gained more recognition here in the 1970s as a potential commercial power source when it became known that a more serious effort was being undertaken in the Soviet Union.

In a 1975 speech at New York University, Dr. Robert Hirsch, then director of the U.S. fusion research effort, noted that on his last visit to the Soviet Union he was shown a laboratory devoted solely to fast liner research. This fast liner laboratory, larger than any lab in the U.S. program, was located at the formerly secret Soviet weap-





### COLLAPSING FAST LINER SYSTEMS

*The current flowing in the outer cylinder in one direction induces a current in the inner cylinder in the opposite direction. This produces a magnetic field that collapses the inner cylinder. The inner cylinder, called the liner, traps the magnetic field within itself as it implodes, compressing it to very high field strengths—millions of gauss. This system provides a convenient method to trap, compress, and heat a plasma to fusion conditions.*

ons outside Moscow, called Red Square. (Subsequently, "Red Square" was once again closed off to visiting foreign scientists.)

Two years later when the Los Alamos toroidal theta-pinch fusion experiment, the Scyllac, was shut down because of experimental failures, Los Alamos scientists looked for new alternative approaches to fusion. The Scyllac was one of the largest fusion experiments in the United States and was driven by a large, \$30 million electrical capacitor power supply.

Los Alamos was one of the U.S. weapons labs that had a small-scale liner research program, and it was quickly determined that the now idle Scyllac capacitor bank would be perfect for driving large liner experiments.

#### The Velikhov Proposal

During a visit here in spring 1977, E.P. Velikhov, then director of the Soviet fusion effort, informally broached the possibility of combining the large Soviet liner effort with the idle Los Alamos power supply in order to carry out a number of large-scale joint experiments. This unique proposal was formally presented to the United States the following summer at the Joint Fusion Power Coordinating Committee. Everyone concerned—the Los Alamos scientists as well as the U.S. defense and intelligence agencies—was excited by the proposal because such collaboration would mean access to the personnel and possibly even the facilities of the Soviet Red Square Laboratory.

Exchange visits between the United States and Soviet Union on the fast liner project took place in fall 1977, and preliminary plans were drawn up for joint experiments.

It was universally recognized within the U.S. scientific establishment that the United States would only stand to gain by such an exchange on the fast liner. The Soviets were far ahead on the most crucial aspect of the experi-

ments—the liner and the plasma to put in it—and the United States was contributing simply an idle (although large and costly) power supply for which the Soviets already possessed the full technological capability. In fact, this is exactly what the DOE concluded after a thorough classification review on the fast liner project, completed in February 1978.

Despite this DOE go-ahead and the enthusiasm on all sides, the joint experimental program never took place. It became an early victim of the Carter administration's human rights campaign, per order of Zbigniew Brzezinski and his National Security Council. Most ironically, when interested congressmen inquired informally of the DOE about the termination of the joint program, they were told that it was canceled to "prevent the Soviets from getting access to U.S. capacitor bank technology." As any informed U.S. specialist would have assured Congress, this was a big lie.

The ammunition for this decision—and for other attacks on international fusion programs as contributing to nuclear weapons proliferation—came from a study completed in 1978 by the antinuclear Mitre Corporation for the DOE. The Mitre study, which remains classified, broached the subject of the need to classify the full array of technologies in fusion work.

#### Who Killed the Fast Liner?

Canceling a joint U.S.-Soviet research program is one thing. How did the DOE move from this to total classification—essentially cutting out the U.S. research in fast liners altogether?

In fall 1978, the DOE Fusion Office held a special review meeting on alternative approaches to fusion other than the mainline systems. The fast liner was scheduled as one of the approaches to be presented, but it was withdrawn



*Soviet fusion policy emphasizes collaboration, not classification. Here, Velikhov (l.) and Basov, leaders of the Soviet fusion program.*

*Photo by Bardwell*

at the last minute. Rumor had it that the fast liner was being classified.

This author immediately called the appropriate officers in the DOE classification division to determine if, in fact, the liner had been classified. The classification officers were amazed at this news. They said that no one had consulted them about the fast liner since the February 1978 review. And officials at the DOE's Office of Military Applications confirmed that although they had heard rumors about classification, no one had consulted with them.

Next, calls were made to the appropriate scientists in all the major national laboratories. They reported similarly that no one had consulted with them about classifying the fast liner. And, finally, the Department of Defense assistant secretary for atomic energy, presumably a person in whose purview the classified project would fall, said that no one had consulted him about the fast liner.

Assuming then that such classification by fiat had come directly from the office of Energy Secretary James Schlesinger, I questioned DOE Assistant Undersecretary for Defense Programs Don Kerr. Kerr stated that Schlesinger's Special Assistant Jeffrey R. Cooper had sent a memo to him Sept. 1, 1978 that called for moving the fast liner program from the energy technology division of DOE to defense programs, thus classifying it. But Kerr said he had no idea who had prompted Cooper to send the memo and why.

Subsequently, the FEF confirmed that no one, including Cooper, ever consulted with any of the appropriate scientists in DOE or the Department of Defense in the formulation of the Sept. 1 memo. In fact, the only people Cooper is known to have consulted with are those at the British weapons laboratory at Aldermaston, where he was visiting at the time the memo was being discussed.

Readers may recall that certain electron beam fusion research was classified in a similar manner after Soviet fusion scientist L.I. Rudakov proposed joint research work in 1976. When questioned by a NATO colleague as to why the U.S. refused the Soviet offer and classified the research involved, U.S. Defense Secretary Harold Brown stated bluntly: "Our British allies wouldn't let us."

Is Cooper a scientist? No. He is an economist. His role as Schlesinger's special assistant has been as liaison man with U.S. security and intelligence agencies. In this capacity it is known that he was the chief DOE hatchet man in the effort that killed the U.S. nuclear fission fast breeder program.

Cooper's memo, which DOE sources said was withdrawn after its damage had been done, pushed the earlier obstructive moves by Brzezinski and Schlesinger against the fast liner program to the point where the research program is effectively dead. More serious in consequence are the facts that Cooper chose to go outside the normal channels to effect this classification and that evidence from more than one reliable source places him at the Aldermaston lab in Britain at the time of this decision.

Both facts imply a deliberate intention to impede basic scientific research in the United States and to seal the channels of U.S.Soviet scientific cooperation that had been opened up in the Nixon administration. Both consequences are primary goals of the Dark Ages faction.

U.S. intelligence agencies and congressional oversight committees concerned with strategic research and development would do well to study the fast liner case for leads on who indeed is thwarting the U.S. strategic capability.

*Charles B. Stevens, well known as a fusion reporter internationally, is director of fusion engineering studies for the Fusion Energy Foundation.*



# Appropriate Technology

## *The U.S. Goes Back*

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*The environmentalists have taken the words development and technology and twisted them into their opposites. Nowhere in the miasma of environmentalist "small is beautiful" literature can one find the concepts of growth and progress or the idea that the human minds of each generation must be nourished so that they can achieve the scientific breakthroughs necessary to take the human race to higher material and cultural levels.*

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THE UNITED STATES is the only advanced sector nation besides Great Britain to adopt appropriate technology as a national policy.

Appropriate technology is a modern-day version of Malthusianism, a policy of forcing society to use only primitive materials to meet so-called basic needs; it presumes austerity, zero-growth, low energy use, and manual labor.

How did the greatest industrial power in the world adopt a policy that is the very opposite of its Founding Fathers' commitment to industrial, scientific, and technological development, a commitment that enabled the country to become great? The extent of the appropriate technology takeover and the individuals and groups that fostered it must be understood, especially by U.S. industrialists and small businessmen who have been the main targets of the hoax in this country. And once the facts are known, the policy must be reversed.

### **Official U.S. Policy**

The U.S. government accepted appropriate technology as its policy for the Third and Fourth Worlds early in 1978, with the passage of Section 507 of the Public Law. Ostensibly Congress passed the law as preparation for the United Nations Conference on Science and Technology

# to the Stone Age

by Cynthia Parsons

for Development to be held in Vienna next August. The conference is planned solely to push appropriate technology, with a follow-up Conference on New and Renewable Energy Resources—biomass, solar, and wind energy—scheduled for 1981.

On the environmentalists' agenda for the August conference is the establishment of a "code" for technology transfer, which translates into an attack on the multinationals because "big companies push big technology."

The official U.S. position toward the conference, Section 507 of the U.S. Public Law, reads:

The president shall take appropriate steps to ensure that at all stages of the ... conference ... representatives of the United States place important emphasis in both official statements and informal discussions on the development and use of light capital technologies in agriculture, in industry, and in the production and conservation of energy.

Light capital technologies means:

those means of production which economize on capital wherever capital is scarce and expensive and labor abundant and cheap ... to ensure that the increasingly scarce capital in the world can be stretched to help all, rather than a small minority of the world's poor; that workers will not be replaced by sophisticated labor-saving devices where there is already much unemployment; and further, that poor nations can be encouraged eventually to produce their own capital from surplus labor time, thus enhancing their chances of developing independently of outside help.

The unfortunate irony in this congressional policy is, of course, that unless the United States continues to have markets for its high-technology products—particularly nuclear power—in the developing nations, U.S. industry will rapidly descend into bankruptcy, throwing the majority of this nation out of work. Furthermore, by condemning poverty-stricken nations to "independent development" through primitive technology, the United States will ensure that the necessary markets never develop, because such "independent" cultures will die out from disease and starvation.

The model for such idiocy is the opposite of the American System—British colonialism, against which our Founding Fathers fought and won a revolution.

Last March President Carter followed up the official appropriate technology policy by announcing the formation of a Foundation for International Technological Cooperation based on appropriate technology. Carter created the FITC by executive order after Congress had refused to sanction the proposal when it was part of the International Development Cooperation Act of 1978, a bill proposed by Senator Hubert Humphrey. At the time, Congress had also refused to create the Humphrey bill's proposed International Development Cooperation-Administration, an umbrella agency designed to coordinate appropriate technology activities and all science policy without being responsible to any government branch. Now, the FITC will create this umbrella agency, whether or not Congress goes along.

*The Humphrey bill made it clear that appropriate technology was not just for the poor in foreign countries, but for poor U.S. communities as well. Although the ostensible raison d'être of the bill was the reorganization of U.S. foreign assistance programs to gear them to meeting the basic needs of the poorest of the poor nations, the draft program for the FITC states that the poor of the United States are to share the benefits of this low-energy, rural approach. "Technologies relevant ... to American needs," the report reasons, are similar "to those of developing countries..."*

Indeed, federally funded environmentalist groups are already at work in ghettos like the South Bronx, building windmills, compost heaps, and solar reflectors for crumbling tenements.

The first official U.S. recommendations for the August United Nations conference, known as the Stever report (after H. Guyford Stever of the National Research Council), is based on research by, among others, the National Academy of Sciences and the National Research Council, both of which were factionally divided on the issue of appropriate technology. The Stever report recommended a halt in all areas of growth, a cut in energy usage, a stop in the transfer of capital-intensive technology, and the establishment of a sophisticated monitoring and communication system to be used to record the rate of degeneration and famine worldwide.

Similar reports were presented by nearly all the partic-



icipating nations, although some of the preconference documents are representative of their governments' growth policies.

Leading the U.S. delegation to the conference will be Jean Wilkowski, former U.S. ambassador to Zambia, who is planning the details, and Father Theodore Hesburgh, former president of the University of Notre Dame. Hesburgh has a long history of work with appropriate technology with the Overseas Development Council, the Rockefeller Foundation, and as an advisor to the U.S. foreign assistance programs in the early 1970s.

### Kissinger's Handiwork

The man who most contributed to the U.S. shift from industrialization to applied technology, however, is Henry Kissinger. Kissinger has been associated closely with every international plan to keep the Third World agrarian and without high technology. He launched the UN World Food Conference in 1974, which set up a program of U.S. assistance for small subsistence farming throughout the United States as well as the less-developed nations. He was similarly instrumental in getting the 1976 UN Habitat conference off the ground, which brought together environmentalist groups from around the world to discuss policies for tribalizing societies so as not to disturb nature (see box on Gaviotas).

More recently, Kissinger, along with National Security Advisor Zbigniew Brzezinski, was behind the scenes at the June 1977 meeting of the Less Developed Nations strong-arming nations for acceptance of solar, biomass, and windmills and a U.S. policy of conservation, coal, and coal tar.

Kissinger is also intimately associated with the proposal for an International Resources Bank and a Common Fund for commodities, both plans to mortgage the raw materials economies of the Third World as a way of ensuring debt repayment. The Group of 77, the nonaligned nations, firmly rejected the Kissinger International Resources Bank plan at an historic 1976 meeting in Colombo, Sri Lanka. The Colombo resolution calling for debt moratoria and high-technology development enraged Kissinger, and he vented his displeasure by maneuvering to destabilize the most vocal Third World prodevelopment leaders, including former foreign minister Fred Wills of Guyana and former prime minister Indira Gandhi of India.

Just months after the Colombo conference, Kissinger called a State Department meeting for 800 U.S. businessmen and public figures. His explicit intention was to prepare for the acceptance of appropriate technology not only in the Third World but here. In particular, he wanted to create the climate to convince U.S. corporations that appropriate technology would provide a huge market for their outmoded technology and machinery, much the way colonial Britain sold broken-down machinery shipped from idle British factories to the Third World at a whopping profit.

At the State Department meeting were a number of Kissinger's most loyal cothinkers: Sterling Wortman of the Rockefeller Foundation, an advocate of small-scale subsistence farming; Orville Freeman, president of Business International Corporation and, during his tenure as secretary of agriculture in the Kennedy administration, re-



*These subsistence farmers work part of the day clearing a*

sponsible for shutting down U.S. food exports to the underdeveloped sector; G. William Miller, then head of Textron, the corporation known for its policy of asset-stripping industry, and now head of the Federal Reserve; James P. Grant, president of the Overseas Development Council, which sets development policy for the World Bank and among business circles; and Frank Pace, Jr., president of International Executive Service Corporation.

Pace set the tone for the meeting by focusing on the small-scale free-enterprise aspect of appropriate technology. "It is important to establish goals, not for the purpose of intermediate or appropriate technology in the developing countries, nor for the purpose of developing new high-level technology, but to arrange for present technology to be adapted to the needs and requirements of the small business and small farmer."

Miller went right to the Kissinger point, stating that it was impossible to raise the Third World to

the same standard of living that exists in the United States.... I don't believe that we have the resources in the world in terms of human managerial resources or



U.S. AID

canal by hand in an AID food-for-work project in Java.

labor resources, nor do we have the material resources to accomplish this in a short time. Nor would it necessarily be desirable to establish the American standard of living as it now exists, in many ways wasteful, in many ways perhaps less rewarding than alternate cultural opportunities as the norm for the world. I don't suppose that any of us would propose, in thinking of the use of technology to create development in the world, that we try to close that gap instantly.

Once it was established that a high standard of living by the rest of the world was neither necessary nor desirable, H. Guyford Stever of the National Research Council told the business leaders that the Third World didn't want it anyway. "Technology transfer, unless carefully grafted to local values and conditions, may be rejected," he said. "Agricultural self-sufficiency" using appropriate technologies is the best the Third World can hope for, Stever said, and he called on the private sector and international aid agencies to persuade the Third World to accept this.

After the 1976 Kissinger meeting, various task forces

were set up to plan for appropriate technology involving nearly all the bureaus of the State Department and working in collaboration with the U.S. Agency for International Development, AID, which is at the center of the campaign for appropriate technology. An AID official estimated that 70 to 80 percent of AID's billion-dollar budget goes for appropriate technology work.

### Small Business Focus

A special focus of AID's Office of Technology Assessment has been the small U.S. businessman and the kind of small manufacturing type schemes—cottage industries—that typify the piecemeal, localized approach of appropriate technology. For example, one such task force is working on an old World Bank plan using computerized U.S. patent data. Although it gives the appearance of being a genuine streamlining of technology transfer, it is merely a glorified cookbook geared to ensnare U.S. industries to switch over to producing solar plates or wind-mill parts.

It works like this: A Third Worlder who wants to open a small business applies to the U.S. liaison in his country and provides the input for the computer—how much manpower is available, resources, and so on. Then the computer retrieval system supplies the applicant with the "appropriate needs" and the U.S. producers who can fill his request.

As one member of this task force made clear, the program is premised on three points that obviously determine the reply: an energy shortage, environmental impact, and a world economic crisis.

AID began to be remodeled for its present role during the Kennedy administration. Part of this reshaping involved culling the old-time foreign service diplomats who still felt that the United States should be responsible for some real growth and development in the rest of the world. To complete this culling process, the Brookings Institution recommended the dissolution of AID (see next section), but Carter has not gone quite that far.

Last year the president continued this process of AID reorganization by upgrading the position of AID head John Gilligan, making him chief coordinator and fund dispenser for all U.S. foreign assistance programs. Gilligan recently announced his resignation, but it is rumored that he will head up a new U.S. coordinating agency for appropriate technology, the proposed International Development Cooperation Administration.

Carter also recently formed the Appropriate Technology International within the State Department, based on an AID proposal and funded largely by AID. The mandate for this came out of the International Food and Assistance Act of 1975, a precursor of the Humphrey bill, which specified a "private effort ... to promote the development and dissemination of technologies appropriate for developing countries (section 107)." Now the Appropriate Technology International claims to be "the first organization to be conceived by a national legislature and given birthright by a national government."

Some of the most important contributions to the drive for deindustrialization came from the Brookings Institution. For example, a November 1977 Brookings report, "Interim Report on U.S. Development Assistance Strate-





U.S. AID

One truck would free these children for full-time education. This rock-hauling in Haiti is part of an AID project to build a water pipeline.

gies" by Lester Gordon of the Harvard Institute for International Development, spelled out two primary goals. First, all development policy should be removed from the hands of the State Department, Congress, and other public entities that would fail to be tough enough on the Third World. Instead Brookings recommends the establishment of a Development Cooperation Agency responsible only to the president. Gordon makes it clear that such an agency would emphasize "quality of life" rather than economic growth.

Second, the Brookings report insisted that development aid should go only to the poorest countries—the relatively less developed countries known as the Fourth World, while the Third World should be the responsibility of the World Bank and the IMF. Such aid to the Fourth World should be "rationed," because "if it becomes substantial, it is likely to discourage the kind of economic policies which would enable it to survive on its own."

In keeping with the Kissinger view, the Brookings report states that even machinery and equipment cast-offs from the United States are too technical for the Fourth World. In a labor-abundant society, the report said, the introduction of machinery will only add to the unemployment problems.

The Brookings report had recommended that AID be incorporated into its proposed new Development Cooperation Agency, a step that would require congressional approval. Congress refused to act on this last year, and it is possible that Carter sees AID director Gilligan coming in to head the FITC or a similar agency as a way of implementing the Brookings plan without congressional approval.

### Genocide

Does the Third World want appropriate technology and zero-growth? As Andrew Young, U.S. Ambassador to the United Nations, recently put it, appropriate technology is an "insult to the Third World's intelligence."

Third World leaders like Mexican President Lopez Portillo have made it clear that they see the future of their nation allied with advanced technology and the growth and development programs put forward by the European Monetary System, the major political opponent of the appropriate technology schemes. For Lopez Portillo, industrialization goes hand in hand with human development, and the human mind is his nation's most precious resource to be developed.

Other Third World leaders never had the opportunity to "choose" between feudalism and advanced technology; the World Bank and the International Monetary System made acceptance of feudalist aid programs a condition for receiving any foreign aid. For the poorest of the poor nations, this meant choosing between short-term and long-term starvation.

Zero-growth-based economies date back to the ice ages. Over the centuries of recorded history, certain societies or cultures ceased to exist, if not because of war, then because of their inability to adapt, change, and improve nature, developing new technologies to surmount new problems of energy deficiencies, food production, and natural disasters. By definition, appropriate technologies cannot solve such problems.

Worse, appropriate technology removes from a society its ability to develop the minds that will produce the new technologies to solve new problems; it is a policy whose end product is genocide.

There are all sorts of environmentalist sweeteners designed to disguise this basic fact: "Technology causes unemployment"; "there is a small, finite world supply of capital that must be redistributed so that poor nations get an appropriate share"; "all technologies are equal"; and the more radical version, "appropriate technology will finally liberate the Third World from dependence on oppressive Western culture"—these are some of the environmentalist arguments. The tell-tale odor of appropriate technology, however, is manual labor, appropriately painful, as the United Nations picture on the back cover of this issue points out.

### Appropriate Technology's Colonial Roots

There has always been a feudalist, Malthusian faction in history, frightened by industrialization and scientific advances and the new powers these make possible for the general population. Rural, backward populations are much easier to control.

The modern-day appropriate technology faction surfaced after World War II, out of the remains of the British



UN

*Ethiopia could become the granary of the Middle East and Africa—with some tractors and threshing equipment.*

colonialists. These mainly British backers of the Baruch Plan, the Morgenthau Plan, and the Marshall Plan fought to institute a zero-growth, agrarian policy for Europe and a small-scale development and agriculture program centered around the extraction of raw materials for the rest of the world. Specifically, this faction opposed the Eisenhower Atoms for Peace idea. The European nations wouldn't buy this bucolic scheme, however; they wanted industry.

One of the major instruments to promote this feudalistic approach was the World Bank, created in 1946 under the Bretton Woods agreement. For the first two decades, the bank lent money only to create the necessary infrastructure for raw materials extraction, cash-crop agriculture, and small-scale industries. Sometimes this meant building large-scale hydroelectrical construction such as the Kariba Dam, but this was only to aid in raw material extraction.

Today, those World Bank recipient nations that are no longer capable of debt repayment or raw material looting—Tanzania, Bangladesh, Southeast Asia, for example—are slated for appropriate technology; that is, slow starvation under the name of self-reliance.

The hard core of the appropriate technology pushers came from the Fabian group in the British Labour Party

around Sir Thomas Balogh, Paul P. Streeten, and Dudley Seers. Seers designed the original "basic needs" concept and helped form the British Overseas Development Ministry to replace the tarnished image of the British Colonial Office.

Underlying the basic policies of these social planners was an avid hatred of capitalism; in particular, they were against profit and any form of society that would produce profits that could be invested in new machinery for economic expansion.

These Fabians, along with others—notably Swedish Social Democrat Gunnar Myrdal and Latin American expert Paul Prebisch, the father of UNCTAD—helped launch the United Nations First Development Decade in the 1960s, which trained and coordinated the international experts who subsequently ran the UN and private institutions that promoted zero-growth and ruralization.

In 1964, one year after the first UN Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas presented a deindustrialization policy to these nations, Balogh, Seers, and Fabian Barbara Castle created an umbrella organization known as the Institute of Development Studies or IDS at Sussex University. (Sussex University is a center of British Intelligence





work and the psychological warfare projects of the Tavistock Institute.) The main function of the IDS was as a training ground for overseas administrators. Using India as a model for small-scale development, in 1969, the IDS produced a work titled *The Crisis in Planning*, which attempted to discredit Nehru's large-scale industrial development plans.

Seers and Streeten were also involved in the Society for International Development, founded in 1957. At a 1969 conference in India sponsored by the society, Seers called for breaking the dependence of the Third World on foreign technologies, arguing that foreign technology was "inappropriate for local problems." Seers also told conference attendees that the Third World must not ignore the priority of "halting rapid deterioration in the environment." Of course, he blamed industry as the polluter.

Under Seers's tutelage, the head of the International Labour Organization, Hans Singer, reformulated the basic needs concept for fostering labor-intensive rural development projects in its World Environment Program.

In the same year, 1969, Robert McNamara took over the running of the World Bank and began immediate collaboration with Seers to reevaluate bank policies. Four years later, McNamara wrote *One Hundred Countries, Two Billion People*, establishing new, more rural-oriented guidelines for the next generation. "Our five-year prospect calls for considerable change in the allocation of our resources, both to geographical areas and to economic sectors." The new areas (replacing South Asia) were Latin America and Africa. The new economic sector: "... the sector of greatest expansion in our Five Year Program is agriculture...."

From 1969 to 1973, these organizations and the others listed below laid much of the groundwork for the current shift into an open campaign for appropriate technology. The polemic of this period was that industrialization had failed to solve the problems of the poor. To remedy this, development was to focus on rural economies.

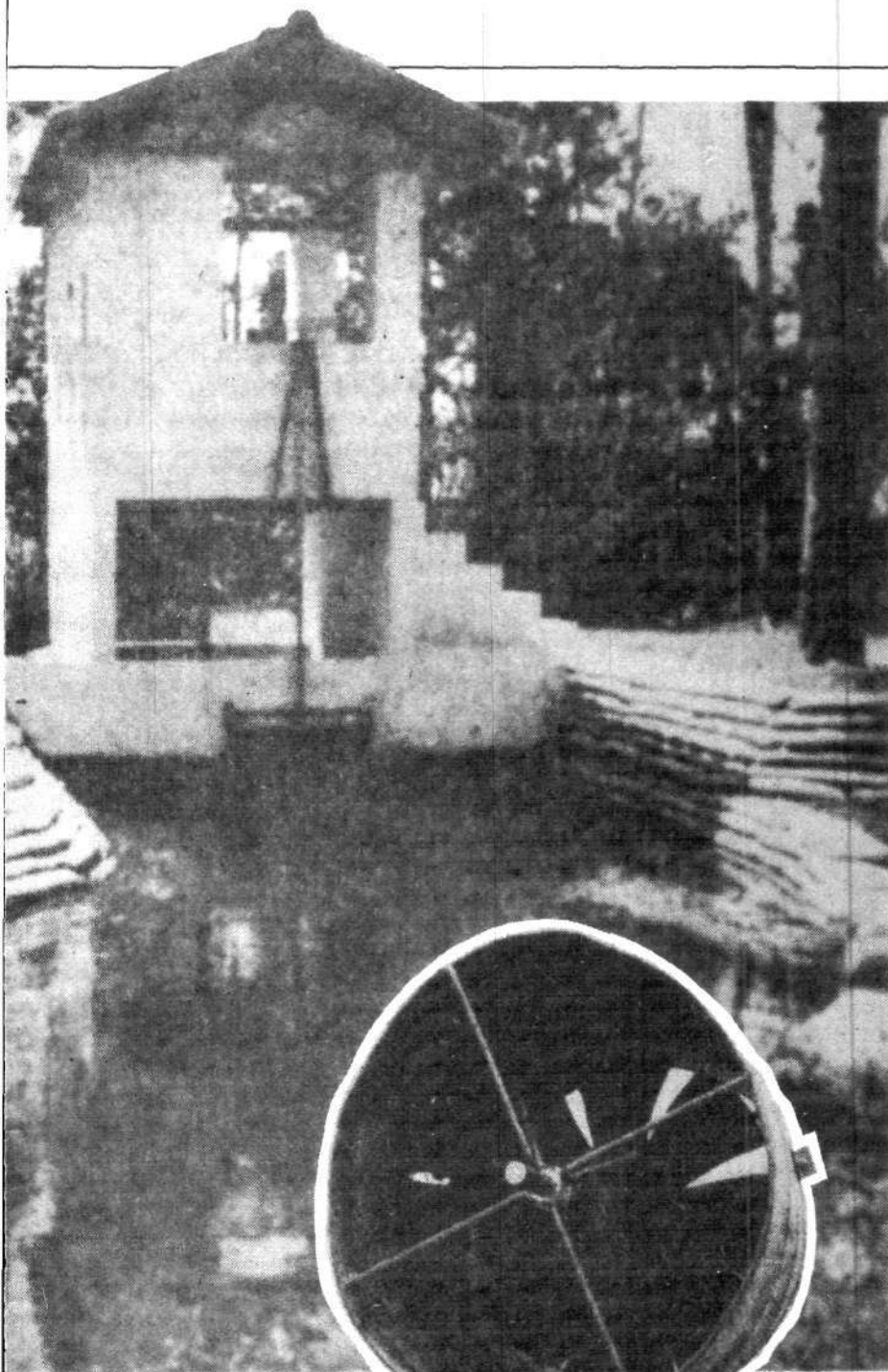
During this period, the United Nations drafted its World Action Plan, based on "basic needs" and appropriate technology, and this became the guiding principle for the Second Development Decade. As one UN document noted: "Care needs to be exercised also to prevent inappropriate technologies from being inadvertently or otherwise forced on developing countries...."

One of the activists in this period and later years was Jan Tinbergen, who developed the language of appropriate technology—the "haves" versus the "have-nots." In 1976, Tinbergen was commissioned by the zero-growth Club of Rome to write their plan for reducing the world population, "Reshaping the International Order," or RIO. To quote RIO on technology:

Research should focus less on the improvement and adaptation of technologies developed in the industrialized world and more on the development of completely new technologies specifically geared to the requirements of each country...and, where appropriate, related to the traditional technologies used by the local population.

Certainly the most revered name in the history of appropriate technology is Ernst Friedrich "Fritz" Schu-





## The Gaviotas Model

The Gaviotas project in the Amazon region of Colombia is the model selected by the UN Environmental Program and the World Bank of appropriate technology for the more advanced Third World nations.

Gaviotas, which means seagull, is designed to establish work for 100,000 persons without "disturbing the sensitive ecological balance of the region," according to one of its directors. It is also serving as a training base for teachers and leaders who will start other such colonies internationally. The eight-year project has received extensive funding from the Ford and Rockefeller Foundations, and has contracts to provide technical assistance to Ethiopia and Ecuador.

### 1. Submerged Turbine Pump

Made out of wash buckets, spokes, and old tires, the pump has the capacity to pump 8 cubic meters of water a day for 40 meters. The pump is placed in a river in front of a small mound of reinforced dirt. The mound forces water up it and through holes made in the wash bucket, which is then spun by the motion of the water.

### 2. The Bagged Dam

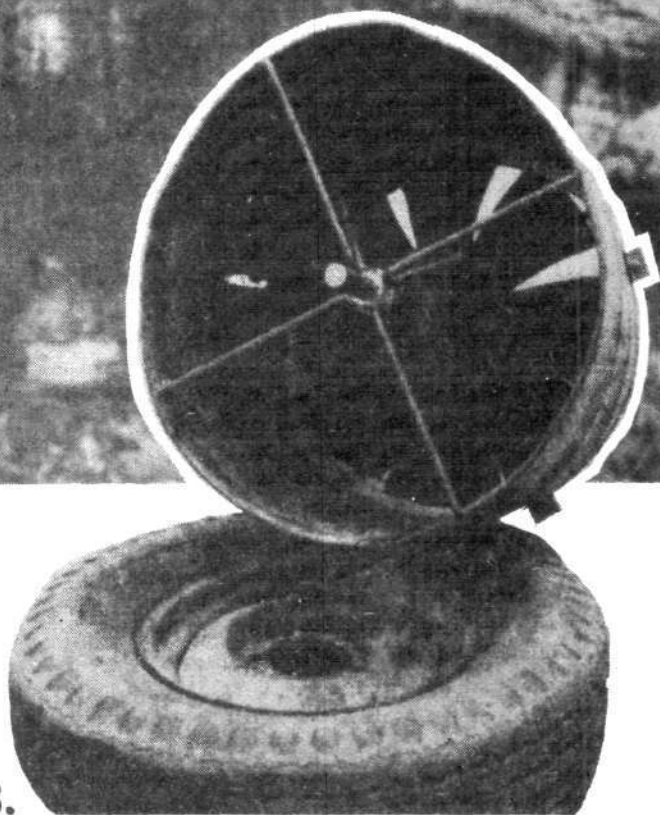
This dam is the showpiece of Gaviotas because it is both durable and flexible. Polyethylene bags are filled with a mixture of 90 percent sand or dirt and 10 percent cement. If modern imported generators are added to the dam, it could be used to supply local electricity.

### 3. Wooden Barrel Barge

This electricity-producing barge is made up of 27 barrels, held together by steel ribs, that have been treated with an anticorrosive material and filled with polyurethane foam to ensure buoyancy. Four small motors are then used under the barge, which at their peak could move at 300 rpm. The barge, held in place by a long cable, produces a total potential of 32 kilowatts-disposable, with 5 kilowatts per day converted into electrical energy.

2.

3.



macher, now deceased, whose 1973 book *Small is Beautiful* is the bible of the environmentalists. An economist in the tradition of John Maynard Keynes, Schumacher was closely connected to the British Colonial Office and served as advisor on rural development to the Planning Commission in Delhi from 1962. In the postwar years, as a member of the British Control Commission in Germany and economic advisor to the Coal Board, Schumacher had played a significant role in shaping national and international policies, with particular emphasis on the effects of modern technological developments on the human condition.

In 1966, he established the British Intermediate Technology Development group to promote his ideas, and he was personally involved with most of the groups listed in the appendix to this article.

Perhaps the best summary of Schumacher's influence here as the ideologue of the appropriate technology concept can be seen from the following two condolence messages sent to his organization after his death in August 1977.

The work of the International Technology Development group and Dr. Schumacher, particularly *Small is Beautiful*, inspired the House Committee on International Relations to initiate a new U.S. AID program on appropriate technology. While we were drafting the proposal, his presence was most helpful in alerting members to the issue of intermediate technology and his commitments assisted us in structuring the program. He is remembered with great respect and

fondness by members of the Committee on International Relations....

—Clement Zablocki, Chairman

He was one of the truly great thinkers of the Western World and a man whose moral, political and economic ideas are an inspiration to all of us. Many of the ideas in President Carter's National Energy Plan can be directly attributed to Schumacher's notion of small technologies.... He should garner the credit for showing us the way.

—Charles H. Percy  
Committee on Governmental Affairs, U.S. Senate,  
Washington, D.C.

Other leading environmentalists collaborating with Schumacher were Barbara Ward, also known as Baroness Jackson, who currently heads up the Society for International Development, and Judith Hart, British Minister of Overseas Development. At a talk last year to Anglican Bishops, Ward said the world was divided into pessimists and optimists, the pessimists being for zero-growth and conservation and the optimists pushing for fusion. She placed herself squarely in the zero-growth camp.

Hart's notable activity this year was to commission a special study on windmills as part of a British government project to develop small-scale alternative sources of energy for Third World villages. "They need low-cost sources of energy appropriate to village economies," she said.

#### In the United States

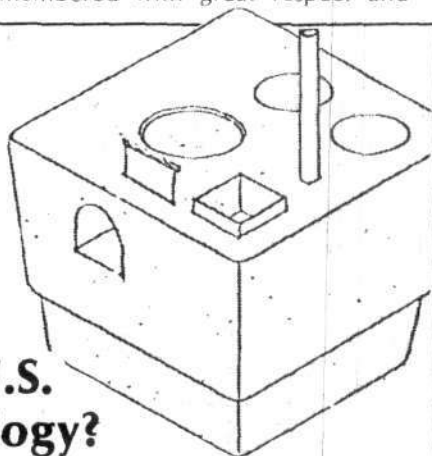
The antiindustrial movement in the United States paralleled the British colonialists on a smaller scale, beginning with the conservationist concerns of the U.S. Fish and Wildlife Service during Rachel Carson's tenure.

In the late 1950s, a group of scientists and technologists at a General Electric plant in Schenectady, New York, formed VITA, Volunteers International Technical Association. VITA modeled itself on the Sussex University collectives, which were designed as self-contained model villages for poorer countries. In 1961, AID gave VITA a \$10,000 grant, and they produced their version of the *Whole Earth Catalogue*, the *Village Technology Handbook*.

VITA became involved in the poverty programs of the 1960s with federal funding and set up offices around the country. Today its annual budget tops \$5 million, with 40 percent coming from AID, and the rest from the World Bank and the Church World Service. Since VITA's anti-industry business is windmills, biomass stoves, and biopot lavatories, it is interesting that large multinationals like Cargill, John Deere, Exxon, and Standard Oil are also among its funders.

One staunch supporter of appropriate technology is the New York Cathedral of St. John the Divine, the leading temple of the American branch of the Order of the Knights of St. John. The cathedral, which has taken an active role in preaching and supporting all kinds of "alternative lifestyles," works closely with the Lindisfarne Association, a New York project founded by Fritz Schumacher in 1972.

## The Lorena Stove: Latest U.S. Technology?



In a recent interview, a staff member of the Office of Technology Assessment, a congressional advisory group, was asked if his group was working with any of the appropriate technology organizations. His enthusiastic reply: "I have just written a recommendation of Appropriate Technology International's version of the Lorena Stove. It is a wonderful invention. It is so compact and efficient and cheap. This will give women much more free time for them to do other things, like homecraft, so they can increase their family incomes."

The accompanying picture of the Lorena Stove is from a 1978 publication of Appropriate Technology International.

Lindisfarne, which describes itself in cult terms, says it is a "contemplative community of scholars devoted to the study and realization of a new planetary culture ... one in which technological civilization becomes miniaturized and surrounded by a consciousness....The scientist works with a sense of the sacredness of all existence, he moves into a higher consciousness shared with the artist and the mystic."

Who are some of the fellows of this new planetary culture? Gregory Bateson, the husband of anthropologist Margaret Mead and an original member of the British intelligence-run 1950s program, MK-Ultra, for the mass use of LSD; Steward Brand, who along with Bateson is an advisor to Governor Jerry Brown of California; Richard Falk, director of the Institute for World Order; and Zbigniew Brzezinski.

## **PARTIAL LIST OF U.S. ORGANIZATIONS FOR APPROPRIATE TECHNOLOGY**

### **Appropriate Technology International**

Founded in 1978 by a mandate from Congress "to promote the development and dissemination of technologies appropriate for developing countries," ATI's funds are channeled through the U.S. Agency for International Development. It functions as the coordinating body for organizations involved in small-scale appropriate technologies, with its basic thrust to "build on what already exists." The board of trustees includes personnel from *Scientific American*, the Aspen Institute for Humanistic Studies, and the Rockefeller Brothers Fund. Many corporations and small business leaders are functioning with ATI.

### **Brookings Institution**

Although it does not specialize in development projects or the Third World, Brookings prepares timely policy documents on foreign aid that usually make their way into U.S. government policy. In 1965, Brookings offered the first conceptions for the reorganization of U.S. foreign aid, a program President Nixon tried to carry out but failed. Again in 1973 and 1977, Brookings put forward other papers with the same theme stressing that "basic needs" must be the main thrust of a U.S. foreign aid program and that a single foundation must control science and technology. (President Carter's 1978 executive order establishing the Foundation for International Technological Cooperation comes out of this Brookings proposal.) Brookings also was among the first to raise the issue of "new and renewable resources," a code phrase for solar, biomass and wind energy.

### **Institute for Food Development Policy**

Founded in 1975, this organization focuses on alleviating hunger by self-help and food-for-work programs. Supposedly schemes to encourage people to be self-sufficient, food-for-work usually means that recipients expend more calories in manual labor than they are provided by the food supplied. This institute works closely with AID and interfaces with the Institute for Policy Studies. It receives contributions from the United Presbyterian Church, the Episcopal Church, the Jesuit Council for Theological Reflection, and the Stern Foundation, among others. Its

personnel feature heavily in President Carter's Hunger Commission.

### **Institute for Policy Studies**

A so-called radical group founded in 1963 by a staff member of the National Security Council, this outfit is involved with environmentalist as well as with terrorist groups, especially those involved in the fight against nuclear power. (Several Weatherunderground members are fellows of the institute, for example.) Virulently antiindustrial, the IPS interfaces closely with the Overseas Development Council and Worldwatch (below).

### **National Center for Appropriate Technology**

Headquartered in Butte, Montana, the center deals primarily with appropriate technology for agriculture. It encourages small farmers to build windmills, and to use cow dung and whatever other local resources they can find in order to become energy self-sufficient.

### **New Alchemy Institute**

This center for "alternative technologies" is located at Woods Hole, Massachusetts and the San Francisco Zen Center in California. The basic New Alchemy principle is to oppose energy-intensive methods in industry and agriculture. Its directors, Nancy and John Todd, who are both Lindisfarne fellows (see text), were encouraged in this philosophy by Margaret Mead, who told them that they would be successful if they could create entire villages using feudal techniques. Their "bioshelter" and "self-enclosed ecosystem" rely on wind and solar power and the recycling of human, kitchen, and garden wastes. To quote from John Todd in the *Journal of the New Alchemy*: "If people lived in smaller systems, their experience would be more direct and political judgment on the part of the majority would become more sensitive."

### **The Overseas Development Council**

Founded in 1969 as a development front group for the World Bank by James Grant and Lester Brown, the CDC has made itself the single most influential U.S. development agency outside of the World Bank. It picked up the appropriate technology line in early 1970 and has been pushing it ever since. Rev. Theodore Hesburgh is chairman of its board of directors. Other directors include Robert Anderson of Atlantic Richfield, Eugene Black of American Express, David Rockefeller of Chase Manhattan Bank, and Charles Thornton of Litton Industries.

### **Worldwatch Institute**

Founded by Lester Brown of the Overseas Development Council, Worldwatch has adopted a more radical zero-growth, environmentalist line than the council, which retains a more professional image. Brown is also an administrator of the International Agricultural Development Service of the U.S. Department of Agriculture. Along with Bruce Stokes and Denis Hayes (the organizer of "Sun Day" in the United States last year) Brown publishes the "Worldwatch Paper." Their basic idea is that the world is running out of resources and the only solution is to cut back on consumption.

*A specialist in Third World development, FEF staff member Cynthia Parsons is studying the problems of technology transfer and education involved in bringing the developing sector into the fusion age.*



# Science and Spooks

## *The Spirit of Isaac Newton*

by Dr. John Schoonover

BY THE LAST QUARTER of the 19th century, most prominent scientists in Britain were practicing spiritualists. They believed in ghosts and conducted what they called scientific investigations of the spirit world. Sir William Crookes, Lord Rayleigh, J.J. Thomson, Sir Oliver Lodge, and Alfred Russel Wallace are a few of the famous men of science who dabbled in sorcery and gave credence to the claims of the worst spiritualist hoaxsters of the period.

How could such spiritualism coexist with real science? The fact is that although British science produced a few good applied physicists, like Stokes and Maxwell, it never contributed any fundamental theoretical advances of the caliber of those contributed by Kepler, Leibniz, Gauss, Riemann, Cantor, and Schrödinger.

There has not been any real science in Britain since the demise of the Cromwellian republic and Elizabethan science. From then until the present, so-called British science has been a tool of British foreign policy, acting only to contain and destroy real scientific advances. As forthcoming articles in this series will document in detail, the aim of the British up to the present has been to bring any real science under the control of an elite—as advocated by H.G. Wells—or to destroy it altogether, by submerging society in a miasma of primitive cult activity—the plan of Bertrand Russell.

To understand the spiritualist side of science history presented here, bear in mind that in the 1800s, the leading circles in Britain from prime ministers on down not only believed in spirits but belonged to secret societies—cults—that carried out primitive, mystical rituals. At the same time these circles were engaged in a bitter warfare to prevent an alliance for progress among the Continent, Russia, the United States, and other nations that did not share the British medieval dream.

The recruitment of scientists to spiritualism—like the recruitment of scientists to environmentalist cultism today—was part of that philosophical and political warfare.

As has been the case for millennia, these feudalists targeted scientists, because the potential for progress that science represented was critical for the battle waged by the city-building factions.

### **The Case of Sir William Crookes**

Let's start with the case of Sir William Crookes, an eminent Victorian scientist who invented the Crookes tube, an early version of the cathode ray tube, and who discovered the element thalium. I quote from Crookes's 1874 work on spiritualist research:

After closing the curtain she conversed with me for some time, and then walked across the room to where Miss Cook was lying senseless on the floor. Stooping over her, Katie touched her, and said, "Wake up, Florrie, wake up! I must leave you now." Miss Cook then woke and tearfully entreated Katie to stay a little time longer. "My dear, I can't; my work is done. God bless you," Katie replied, and then continued speaking to Miss Cook. For several minutes the two were conversing with each other, till at last Miss Cook's tears prevented her speaking. Following Katie's instructions I came forward to support Miss Cook, who was falling on to the floor, sobbing hysterically. I looked round, but the white-robed Katie had gone.

This bit of melodrama is Crookes's attested report of his final seance with the medium Florence Cook. He and the medium claimed that "white-robed Katie," whom the medium invoked, was the daughter of the famous pirate, Henry Owen de Morgan, and Crookes published photographs to prove it. However, as the antispiritualists were quick to point out at the time (and as the reader can see here), "Katie" bore an uncanny resemblance to medium Florence Cook.

Why would a notable scientist become involved in such



The British scientist and his spooks. William Crookes (top); his medium Florence Cook; and their alleged spirit "Katie" (below).



a shoddy pursuit? The answer lies nearly two centuries earlier in the case of Sir Isaac Newton and his battle against Leibniz and the Leibnizian tradition in Continental science.

### The Newton Spirit

Newton was a fraud. In the first place, and this is a tradition that Crookes and other British scientists probably continued, his scientific work was mainly stolen from other scientists. (For details on Newton, see Carol White's articles "The Royal Society," *Fusion*, Jan. 1978; "Science Is Politics," *Fusion*, May 1978; and "I Don't Make Hypotheses—I Manufacture Data," *Fusion*, Dec. 1978.)

Furthermore, Newton's primary interest lay not in science but in the black arts and alchemy, as John Maynard Keynes admitted in his biography of Newton, which was based on access to the Newton archives.

Newton's preoccupation with sorcery, like the seeming aberrations in the 19th century scientists noted above, is a lawful expression of the epistemological warfare between the city-builders and the zero-growthers that has shaped science for the last several millennia. Spiritualism is the actual worldview of the zero-growth faction, the perennial enemies of the moral and intellectual development of humanity. Since the feudalists deny Reason, the creative capacity of men to devise new solutions to seemingly insoluble problems, the zero-growth empiricists turn to various kinds of magical thinking in an attempt to establish a quasi-coherent worldview.

The next phase of the Newton-Leibniz epistemological warfare broke out in the aftermath of the Napoleonic wars. The scientific successes of the French school, primarily grouped around the Ecole Polytechnique, and the somewhat later successes of the Göttingen school in Germany made it clear that British science, centered around the Aristotelian approach of Newton, was disastrously behind these European developments.

It was then that the British feudalists decided that the Neoplatonic epistemology that had made these Continental science advances possible must be quashed; in place of Neoplatonism, European scientists must be induced to accept one of a variety of pseudoepistemologies that would be sure to prevent conceptual breakthroughs.

By the first quarter of the 20th century, the British had clearly defined suitable alternate belief structures for scientists. Most prominent and most successful among these belief structures were the Vienna-Copenhagen positivism, which is associated with the probabilistic interpretation of quantum mechanics, and that school of philistinism best summed up by the phrase, "Don't bother me with metaphysics; I'm a scientist."

Niels Bohr and Max Born, to take an example of the positivist school, immediately combined their efforts to subvert Erwin Schrödinger's interpretation of the electron as a plasmalike structure subject to shaping through the electromagnetic interaction. In its stead they substituted the degenerate interpretation that the wave function describing the electron is simply a probabilistic statement about the average location of an electron-in-itself, a little hard ball.

Less known among scientific circles but closest to the worldview of its creators is the use of science in the



Science fiction in action at an 1871 spiritualist seance.

Radio Times Hulton Picture Library

service of the spirit world, or, to put it simply, science as magic.

How does science become magic? Read Sir David Brewster, the biographer of Newton and a leading force in the formation of the British Association for the Advancement of Science in 1831. In the 1820s, Brewster provided Sir Walter Scott with a textbook called *Letters on Natural Magic*. (Journalist and intelligence agent Scott, it should be noted, was the archenemy of the American System and of Edgar Allan Poe.) In these letters, Brewster explains how the Babylonians and Egyptians were able to use their secret scientific knowledge to bamboozle the masses and thus control them through what appeared to be magic.

The point should not be lost on us moderns, Brewster said: secret knowledge is power. "When knowledge was the property of only one caste, it was by no means difficult to employ it in subjugation of the great mass of society."

Brewster's work on natural magic, in fact, was the basic viewpoint of the scientific faction based at Trinity College,

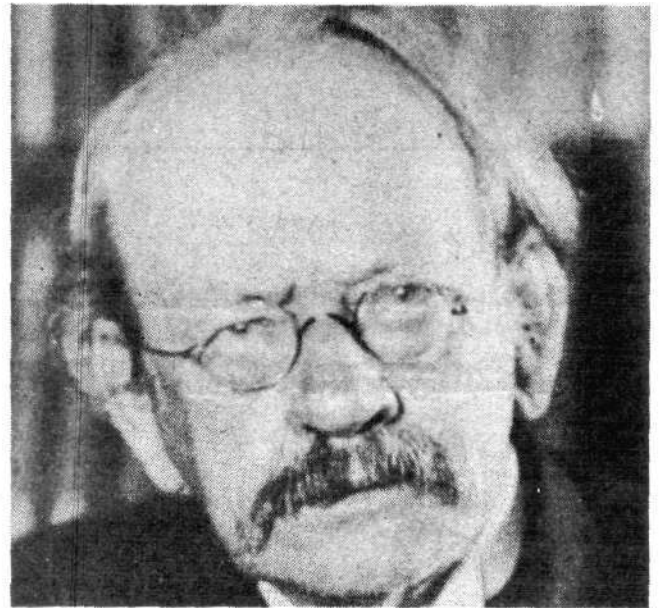
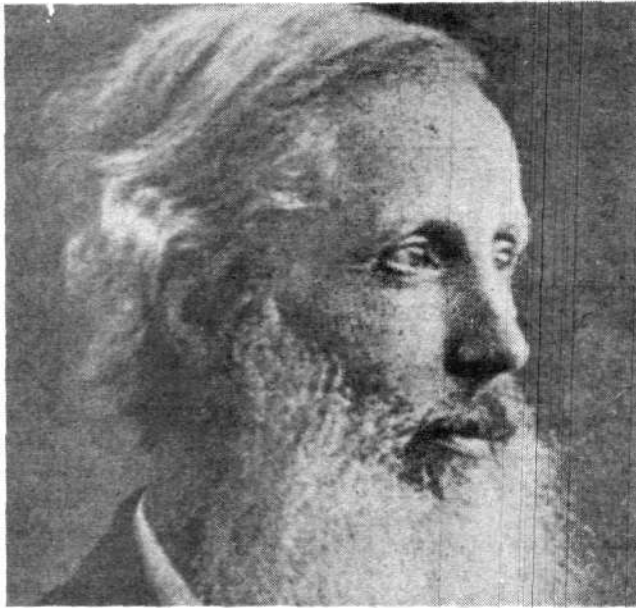
Cambridge University, and the British Association for the Advancement of Science—a viewpoint that culminated in H.G. Wells's vision of the scientific superelite. During the same period, the Oxford cousins of the Cambridge dons launched the *antiscientific tractarian* movement of religious kookery with the same purpose—population control.

#### British Scientific Spiritualism

Crookes first got involved in spiritualism in the early 1870s when Cromwell Varley, a prominent electrical engineer and a Fellow of the Royal Society, suggested that Crookes contact his recently deceased brother. He then began a well-publicized series of experiments and attestations to the validity of the claims of several mediums, including Florence Cook. Crookes's verifications became so notorious that some of his scientific colleagues with a less spiritual inclination coined the emblem *Ubi Crookes ibi spooks*, a parody of the Crookes family motto.

Despite the patent fraudulence of his spiritualist claims, Crookes was knighted in 1897 and awarded the Order of





"Very psychic and impressionable" was how Nobel laureate J.J. Thomson (right) defended shy spiritualists who did not like having their work checked by outside observers. He himself conducted seances with some of the most notorious mediums of the time. At left is Henry Sidgwick, founder of the British Society for Psychical Research.

Merit in 1910. And all during this period, he held responsible positions in the Society for Psychical Research (SPR), including its presidency from 1913 to 1915.

The SPR was founded in 1882, largely at the instigation of Henry Sidgwick, who was Arthur Balfour's brother-in-law, and Sir William Barrett, professor of physics at the Royal College of Science in Dublin, a Fellow of the Royal Society, and a pioneer in what he called the scientific study of thought transference. Many other prominent figures from the British scientific community were involved in the society, including Alfred Russel Wallace, who was Darwin's collaborator, and Augustus de Morgan, the logician. Bertrand Russell's uncle, Lord Arthur Russell, Lord Lytton, the Marquis of Salisbury, and Lord Arthur Balfour, who later became prime minister, lent the approval of the Peers of the Realm to this psychic undertaking.

### Nobel Psychics

Lord Rayleigh, another brother-in-law of Arthur Balfour, served as president of the SPR in 1919. The director of the Cavendish Laboratory, a Nobel laureate, and president of the Royal Society, Rayleigh had begun psychical research in 1874 at the suggestion of Crookes. Here is one of the more startling remarks of this renowned scientist in his presidential address to the SPR: "To my mind telepathy with the dead would present comparatively little difficulty when it is admitted as regards the living. If the apparatus of the senses is not used in one case, why should it be needed in the other?" Indeed!

Concurring with this sentiments was J.J. Thomson, who succeeded Rayleigh as director of the Cavendish Laboratory and who won the Nobel Prize allegedly for his work (using a Crookes tube) leading to the discovery of the electron. Thomson, who served as SPR vice president, described in detail a number of seances he conducted,

including some with such notorious mediums as Madame Blavatsky and Eusapia Palladino.

"There is no doubt of the reality of the dowsing effect," Thomson once stated. In his opinion, the best way to discover water was to follow a rural wizard carrying a forked stick until the powers of darkness mysteriously pull the stick toward the ground against the struggle of the overpowered medium.

For those who could not swallow such magic whole, the British developed a variety of scientific theories to explain the proliferating psychic phenomena. Two eminent physicists, P.G. Tait, who was Kelvin's lifelong collaborator and coauthor with him of the standard physics textbook of their day, and Balfour Stewart, director of the Kew Observatory, professor of natural philosophy at Owens College, fellow of the Royal Society, and president of the SPR, wrote *The Unseen Universe* in 1875. Using the latest findings of science—the concept of energy conservation, thermodynamics, and the electromagnetic ether—Tait and Stewart attempted to prove the existence of a spirit world and to explain the connection between the material (visible) and the spiritual (invisible) universes:

May we not regard ether, or the medium, as not merely a bridge between one portion of the visible universe and another, but also as a bridge between one order of things and another, forming, as it were, a species of cement, in virtue of which the various orders of the universe are welded together and made into one? May we not at once say that, when energy is carried from matter into ether, it is carried from the visible into the invisible; and that, when it is carried from ether to matter, it is carried from the invisible into the visible? Inasmuch as it [thought] affects the substance of the present visible universe, it produces a material organ of memory. But the motions which

accompany thought will also affect the invisible order of things, and thus it follows that thought conceived to affect the matter of another universe simultaneously with this may explain a future state.

### Psyching U.S. Science

The Society for Psychical Research is noteworthy not only because it drew so many prominent British scientists into its leadership and ranks, but also because its membership thoroughly overlapped with the leading epistemological bureaus of Britain's profederalist faction centered in the Metaphysical Society, its successor, the Aristotle Society, and *Mind* magazine.

These networks were quick to bring their works to the United States, and an American branch of the society was in operation soon after the British group was established.

In the early 1890s, the American Society for Psychical Research along with the SPR and William James, one of the foulest promoters of nominalism in the American academic community, participated in the International Census of Hallucinations. This was commissioned by the 1889 International Congress on Experimental Psychology in Paris, and, among other things, recorded more than 50,000 cases.

The most notable event in the American psychic movement, aside from the ongoing promotion of spiritualism, occurred in 1927 when Professor William McDougall of Harvard University moved to Duke University, an Episcopalian school with close ties to Britain, to set up the first "parapsychology" laboratory in the United States. McDougall was succeeded by J.B. Rhine.

Now, who were these birds? McDougall was a British-born, Cambridge-educated anthropologist and psychologist whose speciality during the war had been running a hospital for shell-shock victims (many of whom were probably his guinea pigs). In 1920 and 1923, he was president of both the American and British SPRs and from 1927 to 1938, he was also vice president of the Tavistock Institute, Britain's leading center for the theory and practice of brainwashing. Not exactly the clean-cut sort you would want as flag-bearer in the July 4th parade.

Rhine is the author of the article on psychical research and parapsychology in the *Encyclopedia Americana*. After outrageously claiming in his article that psychic phenomena such as telepathy have been "experimentally verified" in his laboratory at Duke, Rhine draws the following implications for science and religion:

One of the main features of ESP (extrasensory perception) to be demonstrated was its independence of all the space-time "laws" which have been tried out. ... ESP is nonphysical.

... Parapsychology is to religion what biology is to medicine, or physics to engineering... Whether man has a soul component that can exist independently of the living organism, has long been regarded as a great research project for parapsychology.

To give him his due, Rhine does contribute one scientifically competent and even self-reflexive observation. I quote: "... parapsychology has cast new light into science's darkest corner—the nature of the scientist's own mind."

In the latter part of the 19th century science had excited the minds of much of the world's population through generalized technological progress: electromagnetic experimentation had proved that there is no Newtonian mechanical ether to account for the propagation of electromagnetic energy; and Riemann and Cantor had provided the conceptual basis for true relativistic physics—the universe as a self-developing manifold of higher and higher transfinite order. Where else could the scientist who is not committed to the principle of progress turn but to magic and deception?

Unfortunately, this tale of scientific kookery does not end with the 19th century, as the above quotes from the American spiritualist-scientist show. Rayleigh's grandson carried the tradition proudly into the 1950s, serving as a high official of the SPR.

And Sir Oliver Lodge, the famous electrical theorist, who was president of the British Association for the Advancement of Science and a Fellow of the Royal Society, was a long-time active member of the SPR until his death in 1940. Just prior to his death, Lodge published his account of the importance of the ether in which he attacked the relativists who denied its existence and that it could be the mode of communication with the spirit world.

Earlier Lodge had published his spiritualist conversations with his son who had been killed in World War I.

There were, of course many scientists who opposed the wave of scientific sorcery. For example, the Curies were persuaded in 1904 to sit in on a seance with Eusapia Palladino, who had been certified by Lodge and his colleagues as a genius purveyor of psychic phenomena. Somewhat skeptical about the proceedings, the Curies turned on the lights while the psychic manifestations were in full swing. There was Eusapia wandering around the room, rapping, tilting tables, and giving participants spirit kisses.

Of course, J.J. Thomson had the answer to this and other exposés of the spiritualist hoaxsters:

The people who produce them (psychic phenomena) are very psychic and impressionable, and it may be as unreasonable to expect them to produce their effects when surrounded by men of science armed with delicate instruments, as it would be for a poet to be expected to produce a poem in the presence of a Committee of the British Academy.

Is there anyone who still claims not to know who invented the antiscience counterculture and who classified as secrets the most critical areas of science?

*John Schoonover is director of nuclear physics research for the Fusion Energy Foundation.*

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## Big Bang Theory Fizzles

New measurements on cosmic background radiation call into question the "Big Bang" theory of universal creation. This theory, which has been in vogue among astrophysicists in recent years, holds that the universe originated in a primordial fireball. As a result of this original explosion, the theory goes, vast amounts of electromagnetic radiation were generated providing an ambient universal temperature today of about 3 degrees Kelvin.

Ironically, the new data that disprove the theory are the same type of experimental evidence initially used to "prove" the simplistic Big Bang.

According to D.P. Woody and P.L. Richards, who presented their information to the Ninth Texas Symposium on Relativistic Astrophysics Dec. 14-19 in Munich, West Germany, the background radiation distributed throughout the universe deviates sig-

nificantly from the distribution of frequencies that would be expected if the universe were the product of an initial tremendous explosion.

Just a month before Woody and Richards announced their results, November 1978, Arnold Penzias was awarded the Nobel Prize for his work showing that the distribution of background radiation indicated that the Big Bang cosmology is correct.

The measurements reported by Woody and Richards indicate that the range of observed microwave frequencies is too narrow and too sharply peaked to represent a black-body radiation distribution. This deviation cannot be explained by any processes expected to produce deviations from the expected shape.

Further data supporting this thesis were presented by Penzias's co-worker Wilson at the January American Physical Society meeting in New

York. Wilson noted that the radiation spectrum cohered with the predictions of the theory, except in the long wavelength (low energy) region, where a small deviation appears.

The potential importance of these findings should not be underestimated. It was by coming directly to grips with anomalous properties in the classical interpretation of black-body radiation that Max Planck was able to formulate the quantum hypothesis. The result was an entirely new understanding of the fundamental properties of matter, whose implications have inspired physics throughout this century.

Findings like these provide astrophysicists and cosmologists with the opportunity to step back for a moment and reconceptualize current concepts of how the universe was created. For example, does it make sense that the universe could come

into existence at some time in the finite past as a result of a cataclysmic event that set the course of evolution for all time?

Within the last year or so, the Big Bang theory has come into conflict with even the special relativity theory. How can we then expect it to cohere with the extended Riemannian conception of relativity? In this latter case, the very existence of a cosmic background radiation, as an artifact of the act of creation, presumably would provide an absolute frame of reference for velocity measurements—and this is an impossibility according to the much more firmly grounded relativity theory.

At this juncture, with the results of a crucial experiment before it, the astrophysical community should consider the possibility that the Big Bang never occurred, or, if something like it actually did occur, that it was not an act of creation.

In fact, the universe is not the product of a single external act of creation; it is a continuous process of self-creation. The appropriate conception is that particular modes of interaction are not fundamental but are epiphenomena of the fundamental law of the self-development of the universe according to the principle of negentropy.

—Dr. John Schoonover

## New Research Breakthrough In Recombinant DNA Work

The exciting and promising technological promises of recombinant DNA research are realizing successes that would have been science fiction less than 10 years ago.

Two such examples have occurred recently. First, a leading laboratory in California has succeeded in producing large quantities of the rabbit protein beta-globin in tissue culture experiments. Researchers at Stanford University Medical School used monkey cells as the "factory," giving the cells genetic instructions from a specially engineered recombinant DNA molecule, which in turn was carried by a virus.

Dr. Paul Berg and his coworkers at the medical school succeeded in replacing a sequence of DNA in the SV40 virus genome that normally codes for a protein in the viral coat with a sequence usually found in the rabbit that codes for the sequence of molecules making up a particular product, usually a protein. In this case, the sequence was for the protein beta-globin, part of the hemoglobin complex in red blood cells.

This altered DNA was then packaged in a normal viral protein coat, and the engineered virus was allowed to infect monkey kidney cells growing in tissue culture. The infected cells responded by following the genetic instructions encoded for by the viral DNA. Included in the altered viral

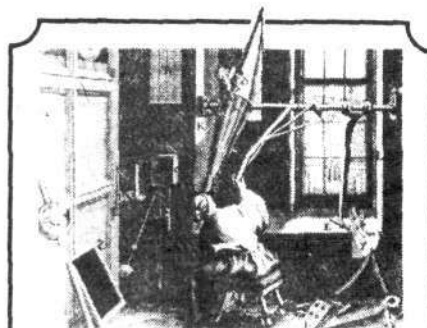
genome was the blueprint for rabbit beta-globin, which was produced by the cell's metabolic machinery.

### Pituitary Hormone Produced

Another California laboratory succeeded in having bacteria produce the physiologically essential mammalian protein known as pituitary growth hormone. These experiments by Dr. H. Goodman and coworkers at the University of California in San Francisco utilized the recently developed ability to produce large amounts of pure DNA sequences and hybridize them with other genes in order to construct a unique sequence of genetic material that would succeed in "programming" bacteria for the synthesis of a desired protein product.

In this case, rat DNA that codes for pituitary growth hormone was linked with a bacterial plasmid that codes for a variety of substances, and this hybridized DNA molecule was inserted into a bacterium. During the subsequent growth of the bacteria, the proteins coded for by the inserted DNA sequences, including the mammalian growth hormone, were produced in significant quantity.

Both experiments highlight the tremendous strides in the field of molecular biology over the last few years and hold immediately important medical and biological implications. For instance, growth defects from inadequate supplies of pituitary growth



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hormone should soon be treatable by the administration of bacterially produced growth hormone, a medical intervention now severely limited.

This hormone also might prove valuable in animal husbandry with regard to more economical food production. Additionally, as is pointed out by P.H. Seeburg et al. in *Nature* (276: 795, 1978): "The capability of expression of genes that are designed specifically or synthesized should make possible the production of new hormones analogous for examining the structural requirements of agonist or antagonist activity or for therapy."

The viral experiments also point to

very exciting possibilities; for example, that of "infecting" an individual with a virus that contains genes for which an individual might be defective or deficient. Juvenile-onset diabetes is characterized by an absolute lack of insulin production, and it is possible that this type of genetic intervention would enable this person to enjoy freedom from his or her daily injection of bovine insulin.

#### Basic Scientific Questions

Even more, the real promise of these technological breakthroughs lies in the opening up and reshaping of basic biological questions. Just to reference two such issues here: In the

beta-globin experiment, the inserted beta-globin DNA consists of a non-translated leader sequence, the globin sequence that is translated into the amino-acid chain to yield the desired globin protein, and a termination sequence. In the usual situation in the rabbit, however, the final product is the result of a DNA stretch that has inserted into the globin sequence two intervening nontranslated sequences.

The immediate questions are: What is the nature of these apparently non-essential intervening sequences? Why are they there? How does the entire genome stretch work? Can other intervening sequences be inserted in their place, or in other spots?

In other words, what is the actual genetic nature of the DNA material, beyond the usual reductionist model of beads-on-a-string sets of computer off-on instructions?

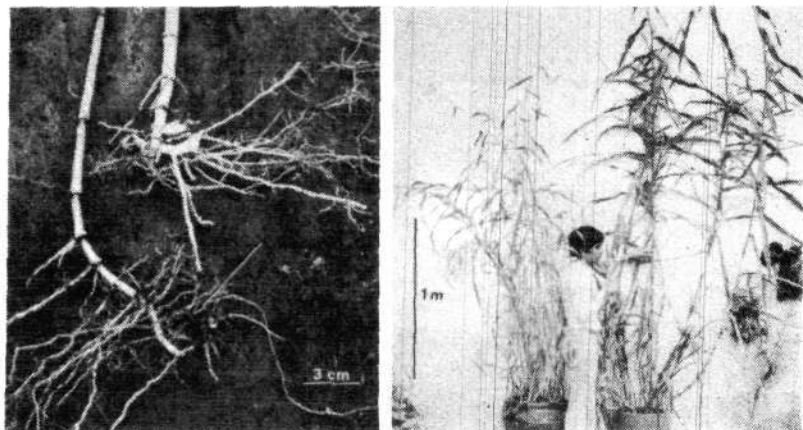
(A future article in *Fusion* will review this question in depth.)

The second experiment points up another immediate area for further investigation. Although the bacteria were engineered to manufacture the growth hormone, this protein remained in the cell, where it apparently was digested by intracellular enzymes. The mammalian pituitary normally packages and secretes this hormone; bacteria also secrete some proteins.

The tool of recombinant DNA offers a handle to solving the problem of the controlling factors that occur subsequent to the readout and translation of a particular product of the genetic code. Understanding the handling, packaging, secretion or retention, and so many other events within cellular physiology is vital for human health and material well being.

Despite the recent breakthroughs, or perhaps because of them, Health, Education and Welfare Secretary Joseph Califano and his zero-growth allies in the environmentalist movement have stepped up their attempts to halt further research in this field. Califano has restructured a Recombinant Advisory Committee, placing on it known anti-recombinant-DNA environmentalists, lawyers, and consumer watchdogs; and sources report that he intends to delay permission for new DNA research.

—Dr. Richard Pollak



The root system of *Zea diploperennis* left and two of the plants grown in a greenhouse from wild rhizomes.

## Ancient Corn Strain Rediscovered

Dr. Hugh Iltis and John F. Doebley from the University of Wisconsin at Madison announced that a research team on a field trip to Mexico last September had discovered an ancient, wild strain of corn, *zea diploperennis*, that is perennial. The discovery of the teocinte, or wild maize, was said to have "revolutionary implications for agriculture," because it would eliminate annual replanting, according to a front-page *New York Times* article Feb. 5.

Iltis said that the new corn was found at altitudes of 10,000 feet, surviving occasional snow and humidity, which means that it could be grown as far north as Virginia.

Despite the publicity surrounding the discovery, it is well known that corn is naturally perennial. When questioned about the new discovery, one official in the U.S. Department of Agriculture quipped, "so what else is new?"

The main reason that corn is sown each year is to improve the quality of the corn and to maintain the root system at optimal lengths for efficient nutrition. Roots that are too long and sprawling rot and extract too many nutrients from the soil, tending to produce foliage rather than corn.

A real revolution in agriculture would occur if the newly discovered corn could be bred with a shorter root system.

# National Review Discovers Nuclear Energy

*National Review*, Special Issue on Nuclear Power, Feb. 2, 1979.

William Buckley's *National Review* magazine has suddenly discovered nuclear energy. The Feb. 2 special issue of *National Review*—described by the editors as "unique in the history of the magazine"—ostensibly adopts a pronuclear position and attacks zero-growth forces.

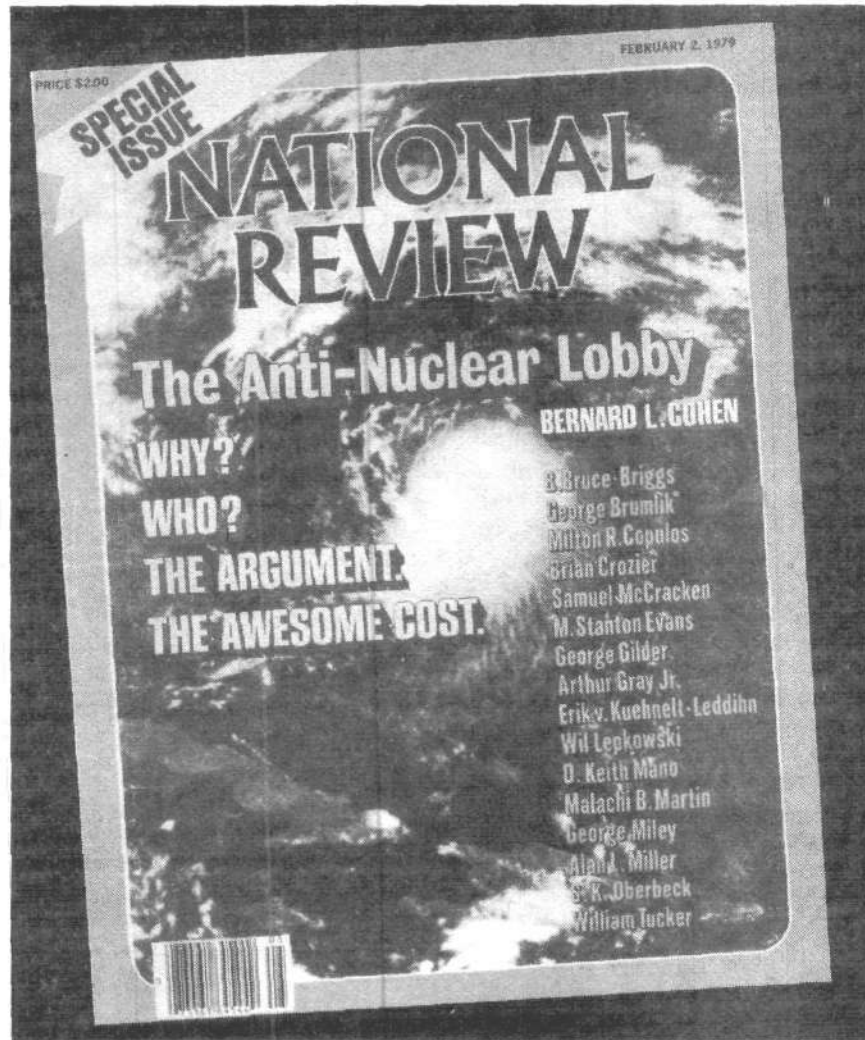
Curiously, the *National Review* revelation occurred just as the Heritage Foundation, the upholders of Adam Smith's free enterprise philosophy in the United States, held its first national conference on energy advocacy Feb. 2-4, another ostensible pronuclear event (at which the *National Review* issue was widely distributed).

Even more curious, a week later the *Wall Street Journal* ran a front-page article describing the death pangs of the dying nuclear industry and noting that the Heritage Foundation was now "working to coordinate the pro-energy groups' strategy."

What's going on here? Both the *National Review* and the Heritage Foundation have been more than tolerant of environmentalist and anti-nuclear campaigns in the past and they along with the *Wall Street Journal* openly collaborate with the Dark Ages zero-growth faction in British politics, the Tory Party of Margaret Thatcher and Winston Churchill III.

The clues can all be found by examining the political content of the *National Review*'s special issue and the *Journal* article. The *National Review*-Heritage crowd acknowledges that it has an almost-dead body—the U.S. nuclear industry—and they have come together to preside over the corpse. Their only use for those last flickers of life in the nuclear industry is to drum up support among the broad prodevelopment layers of the population for a Cold War military buildup.

It should be stressed that most of the contributors to the *National Review*'s special issue did not have this Cold War intent (just as most of the



pronuclear fish caught in the Heritage net do not have this intent). But there are key British Intelligence operatives involved in both events, and behind their pronuclear facades is not the pursuit of human development, world peace, the advancement of science or, a political program necessary to get the U.S. nuclear industry on its feet.

### British Operatives

These guys are pushing World War. They are pushing war based on a strategy that has its origins in British geopolitical theorist Sir Halford Mackinder and the Nazi geopolitician he influenced, Karl Haushofer. This demented view sees the world with

Great Britain as the center, menaced on all sides by evil communist land grabbers.

Who are some of these British operatives in the *National Review* special issue (besides its Oxonian publisher, William Buckley)?

Take Brian Crozier. Crozier, who wrote a piece in the "Big Lie" tradition ("Power and National Sovereignty") claiming that the environmentalist-zero growth movement is in large measure a KGB plot, is affiliated with the notorious British psychological warfare center, the Tavistock Institute, and directs the Institute for the Study of Conflict, one of the psychological warfare operations. Cro-

zier was directly involved in the 1968 radical destabilization of Charles de Gaulle in France, while acting as a professor at Nanterre, the base of operations of Danny "The Red" Cohn-Bendit and his anarchist student gangs.

Another contributor is Malachi B. Martin of the Jesuit tendency known as the "American Heresy," who is a collaborator of antihumanist and fascist networks around Archbishop Lefebvre. Last year Martin led the demand for the resignation of Pope Paul VI.

Then there is George Brumlik of the Slaner Foundation and the Nuclear Club of Wall Street. Brumlik has been involved in a pseudofusion operation against the Fusion Energy Foundation and he and his associates have been implicated in the illegal transfer of nuclear weapons knowledge to a foreign power.

Last but not least is Milton R. Copulos, the modern-day Delphic Oracle from the Heritage Foundation who has made a career of developing crisis scenarios cum energy breakdowns of the sort that Energy Secretary James Schlesinger has been itching to carry out. Last month when a *Fusion* reporter asked Copulos if he had "any idea which direction civilization should go—either into a new dark age or toward expanding development," Copulos screamed, "I can't comment."

### Geopolitics

Incredible as it may seem to an average American, the *National Review-Heritage* crowd still seeks the encirclement and control of the "Russian heartland." Although World Wars I and II have come and gone, this bunch is still following in the footsteps of Mackinder, Haushofer (who, by the way, authored the geopolitical sections of Hitler's *Mein Kampf*), and others of the British Dark Ages faction, like British Roundtable Lord Milner.

Why do they back nuclear power? Because it will help stop Soviet "expansionism," to use the geopolitical term. I quote from the *National Review* editorial: "America...faces three great dangers, if the antinuclear movement has its way. The first is geopolitical.... The policy of the Soviet Union, in the Middle East, in the Horn, and in the southern tip of Af-

rica, is directed to controlling the oil lifeline of Western Europe. The Soviets covet Middle Eastern oil, partly for their own uses...partly as a pressure point on their enemies. Soviets take a lively interest in the radical antinuclear campaign in the West.... America, with considerable belt-tightening, could survive the Sovietization of Arab oil. Western Europe and Japan, if they continue to rely on it, could not."

Now, the fact is that one faction in the Soviet Union is pushing this line. But the missing, critical piece of information for readers is that this faction—typified by British agents in Moscow Kim Philby or Georgii Arbatov—is connected directly to the *National Review-Heritage* clique via their common British parentage.

As would be expected, the *National Review* rails against technology cooperation with the East bloc and makes an all-out assault on U.S.-Soviet cooperation in particular. Needless to say, the recent Soviet proposals for international collaboration in laser fusion and in building a tokamak test reactor—programs in the tradition of President Eisenhower's Atoms for Peace program—go ignored.

### Dismissing Fusion

In fact, fusion is given short shrift, starting in the editorial, which introduces fusion only in so far as it is the one side of a fission-fusion debate: "The proponents of the two chief forms of nuclear power (fission and fusion) differ among themselves on questions of cost and scheduling—a difference NR has not tried to iron out in the contributions that follow. But this debate—a debate between real alternatives—should be at the heart of national energy discussions...."

But the real fusion killer, as noted in the editorial, is the idea that free enterprise must guide science and fusion policy, implying that the present funding could be more efficient if the magic of free enterprise were let loose: "Fusion advocates...slip into a paternalistic mode as a justification for the funding of their programs. The contributions to this issue, however, suggest specific ways of defraying the expense. Others might be devised, if this is the course we decide to take. Let the discussion begin."

The point is that fusion policy must

be set nationally; that's the only way we are going to get fusion power by the turn of the century. An optimum program would provide tax credits for innovative ideas from industry, and large-scale projects at national laboratories would contract out work—but the overall policy would be set nationally.

### Free Enterprise

"Free enterprise" is nothing but linguistic mumbo jumbo that would make the Founding Fathers, Abraham Lincoln, and American economist Henry Carey (who developed the term *American System* versus the British System of Adam Smith) turn over in their graves. It would mean the destruction of American industry.

And as a final slap at fusion, the *National Review* takes pains to deny the historic significance of the Princeton Large Torus breakthrough last summer and puts off the likely realization of fusion to somewhere between 2010 and 2025.

Since they know the nuclear industry is almost dead and since they say fusion won't be around for 35 or so years, one wonders what we're supposed to do for energy in the meantime? Tighten our belts and hope to win World War III?

Just in case *National Review* readers haven't gotten the message, the special issue leads off with effusive praise for none other than NATO head and potential presidential candidate General Alexander Haig ("... a rare blend: a military man with a very sure, intuitive touch for the political implications and repercussions of what happens in his area of responsibility. Eisenhower had it, Gruenther had it. Not too many others have.") and the recently deceased and Anglophile William Yandell Elliott, Henry Kissinger's mentor ("... we could have used a thousand more William Yandell Elliotts").

(William Yandell Elliott, by the way, was a longtime British Intelligence station chief in the United States.)

One useful thing the *National Review* does is end the myth that nuclear power is not political. Now we have to make sure that nuclear energy is governed by the politics of the American System and not World War III.

— Robert Cohen

# FEF News

## BOSTICK OPENS FEF SEMINAR SERIES

"If we can master inertial confinement fusion, it will probably be through ion-beams and not lasers; but the interesting thing is that the ion beam can be generated by collective plasma processes, not particle accelerators," Professor Winston Bostick told the first seminar in the FEF spring seminar series on basic processes in fusion plasma. Bostick, who is a professor of physics at Stevens Institute of Technology, presented part one of a two-part lecture on the collective acceleration of particle beams in a plasma.

Bostick's lecture reviewed the currently available experimental evidence on the mechanism responsible for the remarkable property of electron beams propagating in a plasma, by which the beam can accelerate ions to many times the energy of the electron beam. Efficiencies of up to 50 percent of electron beam energy to ion beam energy have been achieved—a striking case of self-organized plasma behavior.

The second Bostick lecture, to be given Feb. 21, will develop some theoretical insights into this mechanism, concentrating on the role of vortex filaments in the acceleration of the ions.

As Bostick pointed out, the current inability of scientists to explain the mechanism of collective acceleration is a dangerous state of affairs. Not only does collective acceleration hold great promise for fusion; it also holds the key to the perfection of a directed energy beam weapon.

Other scheduled speakers in the FEF series include Bruno Coppi of the Massachusetts Institute of Technology, Harold Grad of the Courant Institute of Mathematics at New York University, Frederick Tappert of the University of Miami, Florida, and FEF staff members Uwe Parpart and Steven Bardwell.

The proceedings of the series will be published by the *International Journal of Fusion Energy* in the coming months. An FEF seminar series on the biological sciences is also planned.

## FUSION SUBSCRIPTIONS TOP 5,000

*Fusion* subscriptions reached 5,400 for the February issue and will top 6,000 for the March issue, announced Business Manager Kenneth Mandel. A year ago in March subscriptions totaled only 1,600. At current rates of more than 200 new subscriptions per week, Mandel said, the magazine will reach a goal of 10,000 subscriptions by the end of the summer. The total circulation is 40,000 copies.

*Fusion* is applying for membership in the Audit Bureau of Circulations in order to attract major advertisers to the unique progrowth constituency *Fusion* readers represent, Mandel said. Advertising rates are available from *Fusion* by writing to P.O. Box 1943, New York, N.Y. 10001.

## CONNECTICUT FORUM DRAWS 40 PARTICIPANTS

An FEF forum in Milford, Conn. Jan. 30 drew 40 businessmen, engineers, and scientists from this high-technology area. Dr. Morris Levitt, FEF executive director, briefed the group on the prospects for fusion research, on the factors holding up nuclear power, and on FEF organizing plans.

There was an extended discussion about the FEF role in making national policy for research and science programs. "Is the FEF simply going to promote the work of the big national laboratories?," one engineer asked.

Levitt outlined the requirements for a national R&D policy as follows: "Cheap, long-term credit and large tax breaks for corporate R&D activities and new technology development; full funding for both small-scale innovative research and large-scale development in major corporate and government laboratories; and increasing by tens of billions of dollars credits and insurance for exports, especially for consortia with a city-building perspective aiming to provide in-depth basic and specialty technologies and products as well as large numbers of technologists for global development."

# Calendar

Continued from page 3

## April

1-6  
Pacific Chemical Conference 1979:  
38th National Meeting of Chemical  
Society of Japan  
and 177th National Meeting of  
American Chemical Society  
Honolulu, Hawaii

2-6  
International Symposium on  
Manpower Requirements  
and Development for Nuclear Power  
Programs  
International Atomic Energy Agency  
Saclay, France

2  
Energy Sufficiency for American  
Conference  
Am. Institute of Aeronautics and  
Astronautics, IEEE,  
New Mexico Soc. of Prof. Engineers  
El Paso, Texas

9-12  
11th National Atomic and Molecular  
Physics Conference  
Institute of Physics, London  
Liverpool

10  
FEF Seminar: "What We Have  
Learned from High-Field, High-  
Density Toroidal Plasma"  
Speaker: Dr. Bruno Coppi, MIT  
New York City

23-25  
American Power Conference  
Illinois Institute of Technology  
Chicago

23-26  
General Meeting  
American Physical Society  
Washington, D.C.

29-May 2  
Training of Nuclear Facility  
Oak Ridge National Labs  
American Nuclear Society Personnel  
Gatlinburg, Tenn.

29-May 2  
Light Water Reactor Fuel Performance  
American Nuclear Society  
Portland, Ore.





*"You are one of the few organized groups I know of that has the courage to stand up and advocate high technology as a solution for some of the problems of the world, and for that I think we owe you a debt of gratitude."*

Dr. John Clarke,  
Deputy Director, Office of Fusion, DOE,  
at the FEF annual public meeting,  
Sept. 23, 1978

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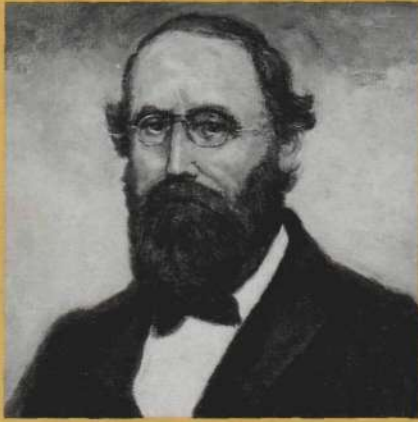
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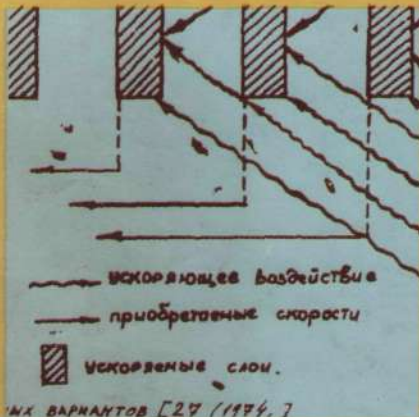
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## Ending the Dark Ages Threat to Science

### Riemann Declassified-

Ever since Bertrand Russell and Lord Rayleigh, the significance of Riemann's work has been either distorted or underplayed. However, today's leading scientific and military researchers in the compression of matter know the importance of Riemann's 1859 paper on shock waves, which was driven underground by classification policies. This article looks at Riemann's work in a fresh light, explaining its particular significance for inertial confinement and how Riemann's method and program must become the basis for today's natural sciences.



### The Secret of Laser Fusion

The truth is that there are no secrets to laser fusion. Opening up discussion in this vital area of science will rejuvenate the normal processes of scientific exchange that throughout history have led to the advancement of humanity.

### The Case of the Fast Liner

Classification has harmed U.S. national security, not helped it. Just who is classifying U.S. fusion research? This story points to the British military research laboratory at Aldermaston, showing how it killed a promising approach to fusion that combines features of magnetic and inertial confinement.



### Appropriate Technology: The U.S. Goes Back to the Stone Age

The environmentalists' concept of appropriate technology, now official U.S. policy, assumes the destruction of modern industry and offers in its place a full range of caveman technologies. The original caption on this picture from a United Nations document reads "Age-old technology—perhaps painful, certainly appropriate."



### Science and Spooks

Spirits, mediums and scientists? This article, a preview of part of a forthcoming book on the *New Dark Ages of H.G. Wells and Bertrand Russell*, describes how it was perfectly logical for most prominent 19th century British scientists to be spiritualists.