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May/June 1983

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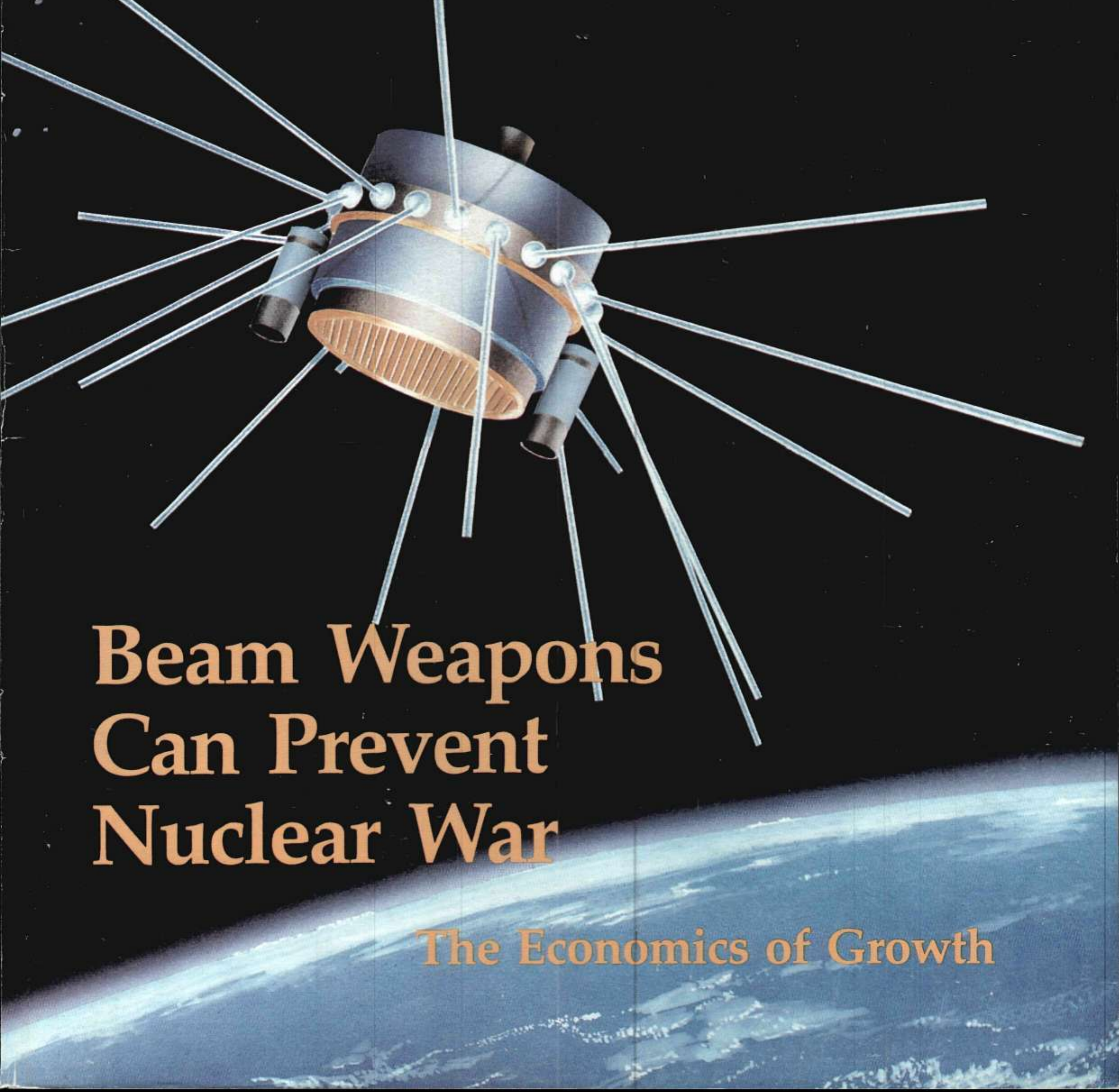

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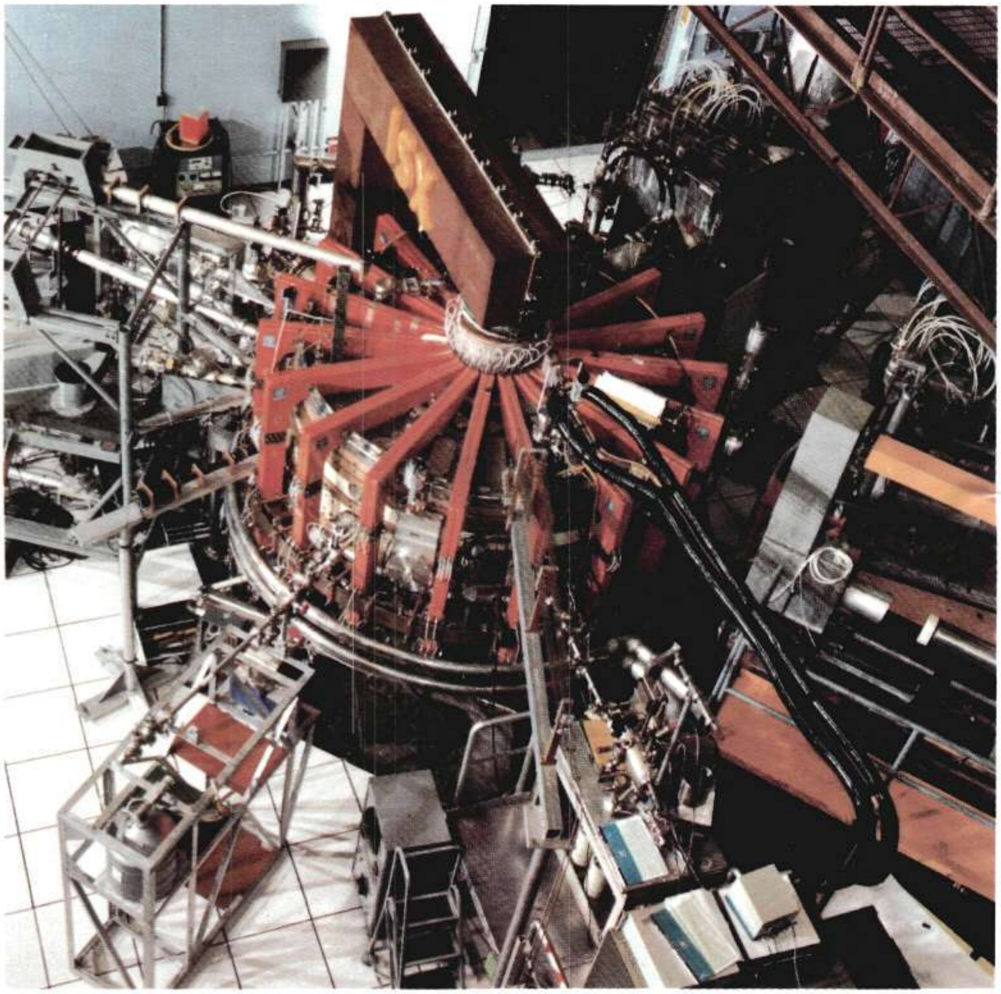

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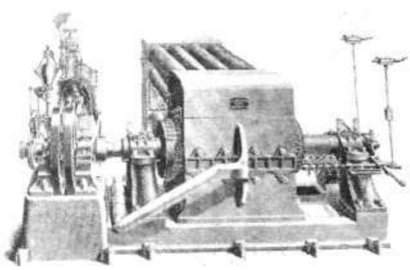
Ronald E. Stecker

Entomologist and naturalist J. Gordon Edwards: The bias of the media and Rachel Carson—not DDT—created cracked bird eggshells and a host of other misinformation on environmental issues.



The shock wave of U.S. economic growth in 1900-1913, caused by the introduction of electricity, is what we have to replicate today by developing advanced technologies. The LaRouche-Riemann model tells you why this is the only way for an economy to grow. Above, Edison's Central Station dynamo.

On the cover: Illustration by Christopher Sloan of X-ray laser defensive beam weapon satellites being deployed into orbit by the Shuttle. Cover design by Virginia Baier.

Features

News

Departments

From the Editor's Desk

Throughout history, new technology has had its gainsayers. The *New York Times,* for example, termed Edison's light bulb "an ingeniously constructed toy" and declared that the Wright brothers' plane wouldn't fly. In this issue, editor-in-chief Steven Bardwell answers today's scientific gainsayers who say that beam weapons are impossible (p. 45). Both the guest editorial by Lyndon H. LaRouche and the report on the FEF Washington conference on beam weapons (p. 50) present additional ammunition for those readers who want to fight to implement a strategic defense policy that ends the era of Mutually Assured Destruction.

What happens when the lies of the news media prevail is fully documented in the shocking story of how environmentalists and bad journalism banned DDT (p. 36). This exposé by entomologist J. Gordon Edwards was originally scheduled for publication in January 1982, but deferred because of our irregular schedule. Now, however, it is particularly important to publicize the antiscience role of newly appointed Environmental Protection Agency head William Ruckelshaus, who in 1972 substituted "popular opinion" and politics for scientific fact and arbitrarily banned DDT.

Coming up in the July-August issue is the never-before-told story of how Thomas Edison fought to establish centralized power stations, a first-hand account of the Japanese laser fusion program, and a report on the breakthroughs in magnetic fusion at the Los Alamos National Laboratory.

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The views of the FEF are stated in the editorials. Opinions expressed in articles are not necessarily those of the FEF directors or advisory board.

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President Reagan's New Strategic Doctrine

This is a guest editorial by Lyndon H. LaRouche, Jr., a founding member of the Fusion Energy Foundation and a member of its board of directors. LaRouche, who heads up the National Democratic Policy Committee, has aggressively promoted a policy of beam weapon ABM defense.

Since the first and second editions of Soviet Marshal V. D. Sokolovskiy's *Soviet Military Strategy*, during the early 1960s, Soviet long-range strategy for war-winning capabilities has been the development of weapons based on relativistic physics principles, such as lasers, adequate to destroy thermonuclear ballistic missiles. Until such strategic ABM systems were developed, Sokolovskiy's doctrine remained the policy-guidance policy shaping long-range development of Soviet capabilities, leaving Moscow otherwise locked into medium-term policies responsive to the continuing realities of "nuclear deterrence." Nonetheless, over the course of the recent decade and a half, Soviet emphasis upon development of the largest scientific cadre of the world, and Soviet applications of Riemannian physics to relativistic physics discoveries directly relevant to strategic ABM systems, have progressed far. In principle, the Soviet Union could deploy such a strategic ABM system by as early as 1988-1990.

Meanwhile, emphatically since 1966-1967 in the United States, a new trend of decisive importance for long-term Soviet strategy emerged as an increasing factor in the "strategic balance." From the beginning of U.S. Defense Secretary Robert S. McNamara's launching of the doctrine of Mutual and Assured Destruction (MAD), nuclear deterrence signified a U.S./NATO doctrine of "decoupling" technological development of the agroindustrial base from strategic planning. This exploded to the surface with President Lyndon Johnson's Great Society doctrine of the middle 1960s, a policy doctrine coupled to the taking down of the NASA and related research and development capabilities. The United States and Western Europe began an accelerating drift into becoming the rubble and increasing strategic impotence of a "postindustrial society." To optimistic strategic thinkers in Moscow, it became calculable that the postindustrial drift of the West meant automatic Soviet world-hegemony during no later than the 1990s.

In respect of visible shifts in Soviet foreign policy and strategic practice, beginning as early as 1968, the postindustrial drift of the West became a conspicuous adjustment in the mode of application of Sokolovskiy's doctrine. While discreetly pushing ahead with development of laser and related ABM technologies, Moscow engaged in the game of "arms control" negotiations. There are three chief considerations of Soviet interest involved: economic, military-strategic, and strategic-psychological.

(1) *Economic.* The post-Stalin pressures for increasing the ration of consumer-goods production conflicted with the backward social organization of Soviet agriculture and the demands for capital goods and military investments. Since the backwardness of agriculture was stubborn, it was the capital goods sector which suffered the effect of concessions to household consumption, lowering the rate of growth of productivity in the Soviet economy as a whole. If the West could be induced to lower the level of its expenditures on military capabilities, the Soviet economy would achieve strategic superiority at a lower cost to the domestic economy.

(2) *Military-strategic.* It was a matter of strategic importance for Soviet strategy to avoid provoking the West into abandoning its post-1966 postindustrial society drift. Accepting arms control, as arms control is associated with nuclear deterrence, fostered the continued postindustrial drift of the West, while relieving military-expenditures pressures upon the Soviet economy.

(3) *Strategic-psychological.* In the event the OECD nations continued to drift into the postindustrial rubble and impotence foreseeable for the 1990s, it was most probable that U.S./NATO perception of this emerging condition would prompt the U.S.A./NATO to resort to a last-gasp effort to halt the emergence of qualitative Soviet strategic superiority. This point would be reached during the middle of the 1980s or slightly later. Arms control and related institutions of "crisis management" became the obvious institutions to be promoted.

The logic of nuclear deterrence is that increasing reliance on such deterrence leaves the West with no strategic capabilities except threatened or actual use of thermonuclear weapons. As the in-depth economic and military capabilities of the Western alliance were weakened and virtually destroyed by Malthusian policy-influences, the nuclear arsenal (the heavy artillery) of the alliance tended to be deployed increasingly toward the front lines, to replace the collapsing infantry and cavalry. All capabilities excepting nuclear capabilities were permitted to decay into a mere "aura of their former power"; this meant an increasing escalation of strategic nuclear capabilities, as exemplified by the mid-1970s upsurge of "forward nuclear defense." Now, we are at the point that the West has no significant resort in crisis but to trigger a general, intercontinental thermonuclear war.

This doctrine of forward nuclear defense forced the Soviets to escalate in response. The SS-20s and new generations of submarines are exemplary. The "double track" pushed through NATO by the clamorous demands of Henry A. Kissinger forced Soviet escalation of these kinds of responses. Now, during the crisis period of October 1983 through March 1984, we face between 400 and 500 warheads of highly accurate SS-20s targeting every significant target in Britain, France, West Germany, and Italy. This is totally unacceptable. The third-generation Peenemünde V-1's (cruise missiles) and V-2's (Pershing II's) are totally unacceptable to Moscow. The Soviets will escalate, perhaps with submarines deployed in relays off the Atlantic and Pacific coasts of the United States. Very unacceptable! So, nuclear deterrence and Henry A. Kissinger brought the world to the brink of a new missiles crisis far more dangerous than that of 1962.

There was no alternative to nuclear war within the geometry of nuclear deterrence. On March 23 of this year, President Ronald Reagan acted, junking nuclear deterrence as U.S. strategic doctrine. Within hours, a corresponding set of strategic doctrinal adjustments was triggered, chain-reaction-like, in Moscow. We are left for a time with the very dangerous relics of MAD, and in a very dangerous interval of history. Now that both superpowers are locked into the March 23 strategic doctrine, there is no force on earth which could reverse the change in strategic doctrine which President Reagan has effected.

Moscow's Rage

The principal cause for the explosion of anger from Moscow was not the military implications of the new U.S. strategic doctrine. The explosion of rage and frustration was Moscow's recognition that the United States of the 1990s was not going to be a heap of postindustrial rubble, but the most powerful economy of the world, as it was more or less at the close of World War II and during the 1950s. For the same reason, the new U.S. strategic doctrine implicitly destroys all of the curious dreams of the Club of Rome and like-minded factions throughout the world. So, Moscow and the Club of Rome are unified in rage against President Reagan's actions.

As for the matter of beam weapons themselves: Those who imagine that these are "music of the future" have been totally deceived. Such weapons systems either already exist or exist in the form of proven laboratory models which must be translated by engineering and production into mass-deployed weapons of warfare. Happily, these are not only weapons of warfare; they imply the eruption of a new industrial revolution during the remainder of this century, greater leaps in the productive power of labor than was accomplished by development of the heat powered machine, by chemistry, or by the generally increasing use of electricity.

We have existing technology which can target an object the size of a missile warhead across more than 5,000 kilometers of the stratosphere. We have laser beams which can destroy missiles at that distance. We have the technology to power such weapons. Some of this is deployable presently; some will require some years of engineering work and production development.

The Autumn Crisis Negotiations

The greatest danger that the autumn 1983 missiles crisis might lead to the brink of international thermonuclear warfare is not military, but economic and monetary. If the President's efforts to implement his strategic doctrine are sabotaged in Congress, and if the present monetary policies of the Bank for International Settlements prevail during the monetary crises of the spring and summer, the West will lose the industrial technological capability to implement the new strategic doctrine. In that case, unless Moscow makes very dramatic concessions, contrary to its vital strategic interests, the U.S.-Soviet negotiations mean for the United States and NATO that no significant concessions are possible. Then a very dangerous situation exists during the coming winter months, a situation which will become increasingly dangerous over the following two years.

It is the effect of the present worldwide economic depression and threatened financial collapse which is making nations materially weak and increasingly ungovernable by democratic-republican forms of institutions. This feeds the "technological pessimism" and "cultural pessimism" out of which mass-based irrationalist movements grow. This combined material and moral decay in the West, and among developing nations ruined by International Monetary Fund "conditionalities," creates the conditions for immediate danger of thermonuclear escalation to warfare.

If we abruptly reverse this, by an economic mobilization approximating the U.S. recovery of 1939-1943, we create economic and political stability, and foster cultural optimism. Under those conditions, we postpone the danger of warfare long enough for the superpowers to complete deployment of strategic ABM systems. That becomes the basis for negotiations over the coming winter, and provides both powers the basis for de-escalating missile deployments.

This also unleashes the greatest technological revolution in history, as technologies such as high powered lasers, including X-ray and gamma-ray lasers, and laserlike particle beams enable some workmen during this century to "mass produce" transmutations of matter at the workbench, so to speak.

Naturally, there is cultural shock and lingering resistance to the new U.S. strategic doctrine. One might imagine how the monstrous ultimate weapon of the Cretaceous age, Tyrannosaurus rex, might have viewed the onset of the age of mammals, the mammals eating his eggs. People sharing a similar outlook on the new strategic doctrine would prefer to continue their present habits, of turning the world which used to be into postindustrial rubble.

Unless reckless fools sabotage the implementation of the new strategic doctrine, we are already entering a new age. We are leaving the evil age of thermonuclear blackmail and terror, and entering the age of Mutually Assured Survival. It will be a very prosperous age, an age in which reason is prized more widely and more profoundly than ever before.

News Briefs


Stuart Lewis/NSIPS
Bardwell (standing) to Garwin (seated at right): "You don't believe in progress."

FUSION EDITOR AND IBM'S GARWIN DEBATE BEAM WEAPONS

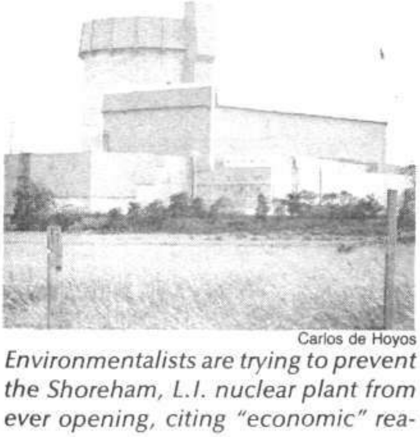
Dr. Richard Garwin, science adviser to several U.S. defense secretaries and now a fellow at IBM's Watson research center, endorsed a "launch on warning" posture in a debate with *Fusion* editor-in-chief Dr. Steven Bardwell April 28, sponsored by the Greater New York chapter of the American Institute of Aeronautics and Astronautics. Garwin attempted to show that in several critical parameters, proposed laser defenses are orders of magnitude away from current engineering achievements. "But even if we could do it," Garwin argued, "I would rather that the Soviets built such a system and we deploy against it." If the Soviets did in spite of everything achieve a reliable ABM defense, "I would launch on warning," he said.

Bardwell showed the audience that the technologies exist today to make a first generation beam weapon system feasible, and he explained how such as system would make it possible for the United States to eliminate the policy of Mutually Assured Destruction, and give us the technologies, including fusion, that would remove the causes of war.

During the question period, Garwin advocated zero population growth and insisted that "fusion is just a means to produce electric power." "We don't need fusion because we have the breeder reactor," he maintained.

TELLER: 'IF WE HAD CENSORSHIP IT COULD NOT BE WORSE'

"Our press is informing the American people about the possibilities of defense and conjoined possibilities of freeze in a manner that far surpasses the best efforts that the KGB could put forward in order to mislead the American public," Dr. Edward Teller told a conference on "Freedom and Responsibility in Communications" at New York University on April 9. Teller singled out ABC, NBC, CBS, the *New York Times*, the *Washington Post*, and the *Los Angeles Times* for spreading "disinformation" about President Reagan's March 23 proposal to shift the emphasis in U.S. nuclear strategy from retaliation to defense. The eminent fusion scientist reported "from direct knowledge" that the President's decision was "carefully discussed for many months." But all the "brilliant ideas" about defense are classified, Teller said. However "where someone has a wrong idea about defense, for instance, a proposal that has been widely circulated as High Frontier, that is published."


Carlos de Hoyos
Environmentalists are trying to prevent the Shoreham, L.I. nuclear plant from ever opening, citing "economic" reasons.

SUPREME COURT UPHOLDS ANTINUCLEAR DECISION

"The United States Supreme Court decision upholding 'states' rights' to block nuclear power plants for 'economic' reasons openly defies the 1954 Atomic Energy Act while affirming the pre-1789 anarchy of a 'confederation' of U.S. states," FEF executive director Paul Gallagher charged. The April 20 decision, written by Justice Byron White, concludes, "it is strongly contended that Section 25524.2 [the 1977 California law banning nuclear plant construction on economic grounds] frustrates the Atomic Energy Act's purpose to develop the commercial use of nuclear power. The Court of Appeals is right, however, that the promotion of nuclear power is not to be accomplished 'at all costs.' "

"The clear intent of the Atomic Energy Act was to promote the most power-dense and therefore efficient source of energy for the fastest possible rates of national and international economic development," Gallagher said. "Nuclear power remains the most insistent demand of developing nations today, *irrespective of start-up costs*, for the same reason."

DOE LAWRENCE AWARDS GO TO CHAPLINE AND LINEBERRY

Dr. George Chapline of Lawrence Livermore National Laboratory and Dr. Michael J. Lineberry of Argonne National Laboratory received the Department of Energy Lawrence Awards April 7 for work on the X-ray laser and the liquid metal fast breeder reactor (LMFBR), respectively.

Chapline noted in receiving his award that the "best minds of the country" now agree that defensive laser beam weapons are possible and desirable. Lineberry, Associate Director of Argonne's Applied Physics Division, commented: "I must admit to one regret, for I would rather have won this award for actually building a large breeder plant." He recalled that in the late 1960s nuclear power based on light water reactors was viewed as an "interim technology," a near-term expediency "until the real nuclear energy future began with LMFBRs," which he described as "the only electrical resource of inexhaustible proportion that we know can be made to work on the scale required." Lineberry said he and his colleagues at Argonne believe their experiments have resulted in a "reduction of cost, or technical risk, or risk of licensing delay for an actual plant."

NSIPS

X-ray laser inventor Dr. George Chapline.

ANDERSON AND NEDDERMEYER WIN FERMI AWARD

Two pioneers in harnessing nuclear fission—Herbert L. Anderson, senior fellow at Los Alamos National Laboratory, and Seth H. Neddermeyer, currently at the University of Washington—were named winners of the Enrico Fermi Award for exceptional contributions to the field of atomic energy on April 22. Anderson was cited for his role in constructing the first chain-reacting piles, among other achievements, and Neddermeyer, who was also at Los Alamos during the development of the first nuclear weapons, for his invention of the implosion technique and his role in the discovery of the muon, the first discovered subatomic particle.

In making the Department of Energy award, President Reagan affirmed the important role of nuclear power in meeting our nation's energy needs and told an anecdote about the smog problem in a wood-burning Colorado mountain resort as "a reminder that there is a cost to every form of energy."

JAPAN REPORTS BREAKTHROUGH IN SEMICONDUCTOR TECHNOLOGY

Researchers at the Nippon Telegraph and Telephone Public Corporation (NTT) in Tokyo reported on April 4 the world's first laboratory success in integrating about 10,000 "Josephson junction" devices on a chip 9.3 millimeters square, marking an important step forward in the development of a superhigh-performance "Josephson computer." This application of Josephson junction technology, in which electrons "tunnel" through circuit junctions at superconducting temperatures without resistance, addresses a major technological problem in the development of supercomputers—that of the heat dissipation arising from closely packing together the required number of electrical circuits on a computer chip.

At a temperature of about 270 degrees C below zero, the memory is on par with the top-rated silicon chip in access time, while its power consumption is much less than one hundredth that of a silicon semiconductor. According to an NTT spokesman, the laboratory success has made it possible to manufacture Josephson Junction large-scale circuits for "practical use."

LOUSEWORT LAURELS TO ELECTRIC LIGHT & POWER

Lousewort Laurels this issue goes to *Electric Light & Power* publication, nominated by an angry reader because it named Southern California Edison chairman William Gould as its Electric Industry Man of the Year for 1983. Under Gould's direction, the giant utility is diversifying into alternative and renewable energy sources, including wind, geothermal, biomass, and solar power, and now uses more low-density energy than any utility in the world. "In order to survive you have to accomplish mutations necessary to accommodate your environment," says Gould, in a apparent reference to California's greenies.

Viewpoint

Congress Awards NASA 1.5 Million for Phone Call to E.T.

by Jack Catran

Who has not been duped, at one time or another, by the latest rage in vogue? Take, for instance, astrology, flying saucers, est, ESP, the Flat Earth Society, or dolphin intelligence. (I have observed dolphins for months on end, and have never seen them do anything but swim and eat.) When you get right down to it, how about colonic irrigation, bee pollen, exorcism, clairvoyance, levitation, chariots of the gods, pet rocks, or encounters of the third kind—to name but a prominent few in the passing parade of fads, fashion, and trends.

The history of flimflammery, rooted as it is in continuity and sameness, drones on. Would you believe that anybody would deposit 30,000,000 nickels into a public telephone coin box to put through an interplanetary call to E.T., the agoraphobic alien who suffered a two-hour anxiety attack trying to raise a dime to call home?

Believe it. It happened. And guess who were gulled. We were, while our brain fiber was temporarily eroded by the pervasive media hyperbola of *E.T.*, the motion picture.

To be specific, this astronomic swindle occurred just before the last congressional recess, when our legislators breezily disbursed $1.5 million—that's 30,000,000 nickels—to NASA to cover the first year of a five-year program to develop complex signal-processing equipment for Project SETI, NASA's acronym for the Search for Extraterrestrial Intelligence.

With due respect for the father-knows-best expertise of the NASA people—and I come to my main point—did our Congress consult other space scientists for a technical briefing on the worthiness of the search before they shelled out the money?

Of course. Prominent astrophysicists, in an ingenious adaptation of Einstein's equation, $E = mc^2$, convinced the Senate Appropriations Committee that the probability of encountering E.T. was clearly tied to the number of dollars invested in the search. E stands for encounter; m means mucho; c represents cash. In other words, Encounter equals Mucho Cash. $Cash^2$ is math for a lot more greenies than you or I will ever see.

One of the many cosmologists supporting the search for E.T. is Robert Jastrow, who maintains that "our curiosity may soon be satisfied. At this moment a shell of TV signals carrying old *I Love Lucy* programs and *Tonight* shows is expanding through the cosmos at the speed of light—our neighbors know we are here and their reply should be on its way. Let us be neither surprised nor disappointed if its form is that of Artoo Detoo, the bright, personable canister packed with silicon chips."

A good part of our Earth's thin crust is made up of crushed beer cans, nonbiodegradable milk containers, dried artichoke leaves, and spatterings of hard chicken fat. Still, we appear to be the only planet *in our solar system* fit for human habitation excluding, of course, the polar ice-caps, the South Bronx, and the black hole of Calcutta.

Mitten Drinnen

"Mercury's too hot Venus *also* Mars is still *conjectural* Jupiter and Saturn are out Uranus and Neptune too *cold* there is no planet like Earth *in* the solar system *hoo-hah* we have to search for signals from intelligent life in *other* solar systems," announced the legendary astronomer Mitten Drinnen, an unctuous scholar who speaks in sudden starts, without periods or commas.

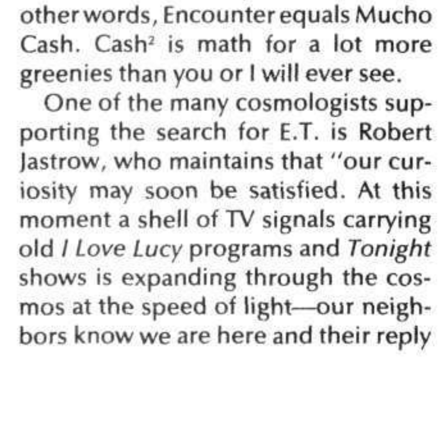
Scientists agree with Drinnen. If E.T. is to be contacted, we must place a call to those billions of stars outside of our solar system.

Sapient beings on other planets would not resemble earth people, for we share no common ancestor. Still, they could have evolved to a similar point in their technology and culture, say to polyethylene roller skates and portable stereos.

At this very moment, they could be listening to music similar to ours. The record album now riding aboard the Voyager 1 and 2 space vehicles, featuring the music of Bach, Beethoven, Louis Armstrong, and Chuck Berry, should tell us something about the personality and physical make-up of the space people NASA expects to encounter. The music was selected by Carl Sagan for the listening enjoyment of whoever might intercept the spacecraft.

But that isn't the half of it. Anthropologists are already preparing for an engagement. On that unavoidable day when our culture meets the space al-

Continued on page 13



Sagan to E.T.: "Anybody home?"

Jack Catran is a scientist who has worked on Apollo and other space programs. He is the author of Is There Intelligent Life on Earth?

UCLA Machine Scores Major Advance

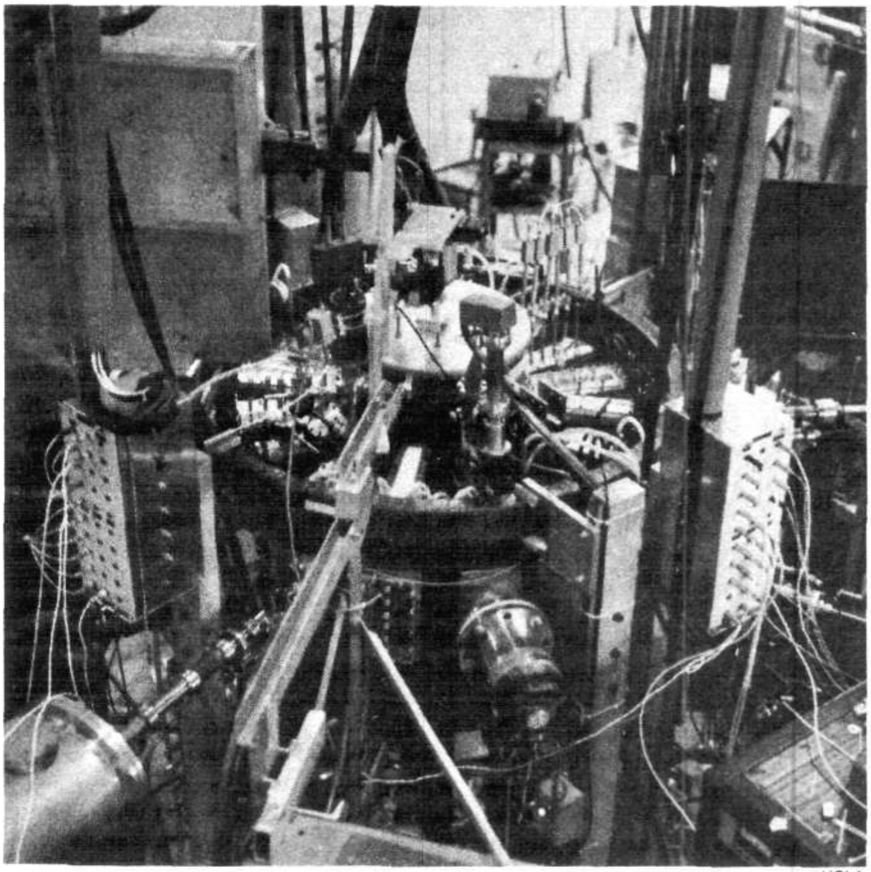
Sometimes the best scientific results come in small packages, and engineers at the University of California at Los Angeles point to their Microtor II tokamak to prove the point.

Dr. Robert J. Taylor, who in the early 1970s helped construct the history-making Alcator tokamak at the Massachusetts Institute of Technology, and his UCLA team have just completed the assembly of the $1 million Microtor and succeeded in achieving the full operational capabilities of this small tokamak within hours of its final completion.

Microtor produced pure, hot, and dense fusion plasmas within 24 hours of the turning on of the machine. Never before in the history of the development of fusion energy has a machine been put into operation according to plan in such a short time.

To put this feat into a clearer perspective, a brief comparison might help. Like a truck and a compact car, which are built on the same basic principles but for different rates of performance, the UCLA Microtor and Princeton Tokamak Fusion Test Reactor (which began operation on Dec. 25, 1982) were designed to function at different levels. However, since at this early stage of the game both machines are out to prove that the simplest of basic fusion principles can work, some comparisons are possible.

In generating a high-quality plasma, the UCLA device reached its maximum performance within 24 hours of start up. It is likely to take one year to achieve the same parameters in Princeton's $300 million TFTR.



UCLA

The small Microtor tokamak at UCLA reached its full performance just 24 hours after startup.

Microtor was designed to operate at a maximum power of 100,000 amperes and has already reached 100 percent plus of its goal. TFTR has achieved 3 percent of its design maximum of 3 million amperes and expects to reach 100 percent within three years.

Microtor initially obtained a much denser plasma and sustained it twice as long (one tenth of a second) as the first TFTR shots.

These two factors are of considerable importance, because fusion can only work with the right combination of plasma temperature, density, and confinement time within the tokamak's "magnetic bottle."

The initial plasma temperature in the Microtor test was 5 million degrees Celsius. Princeton's test was run at 100,000 degrees, but TFTR is expected to reach temperatures of 100 million eventually.

Microtor has recorded another significant result. The test obtained a remarkably low q value of 1.5, where q is the amount of plasma current the machine can withstand without experiencing disruptions. The smaller the q value, the better the performance. Typical q values in tokamaks have ranged between 2 and 3.

Last fall, Taylor's Microtor tokamak set a record high β value of 8 percent. β is a measurement of the efficiency with which a magnetic bottle confines hot plasma.

Cleanup Techniques

Taylor, who now heads the UCLA tokamak laboratory, designed many of the cleanup techniques that permitted the Princeton Large Torus to achieve record 80 million degree fusion temperatures in 1978.

The Microtor II owes much of its quick success and start up to two cleaning methods developed by Taylor. The first, achieved four years ago, is now used and known worldwide as the Taylor plasma cleaning technique. The tokamak chamber, Taylor explains, functions as a vacuum bottle surrounding the magnetic field that contains the plasma.

When hot plasma collides with the cold chamber walls, the effect is to introduce impurities into the plasma, which knock down its temperature. The Taylor technique, which was also used in the successful Princeton experiment, uses a low temperature plasma to, in effect, scrub the walls and remove the "loose debris."

In the construction of Microtor II, Taylor went one step further and for the first time used a low temperature plasma in the actual construction of the chamber walls.

"What we did was to coat the stainless steel walls with a combination of cool plasma and metal vapors," he said. "The coated walls act like a sponge, absorbing the impurities."

Taylor's next goal is to improve the technology of existing fusion devices so that their plasma temperatures can be increased to approach the 100 million degrees needed for commercial fusion power production. But Taylor's successful fusion experiments and plasma cleanup techniques already represent a general advance for plasma science and technology with potential industrial and military applications.

Soviets Publish Specifications of Livermore X-ray Laser

FEF analysts have recently determined that Soviet scientists published the specifications for the Lawrence Livermore National Laboratory X-ray laser tests only six months after the first published report appeared in *Aviation Week* (Feb. 1981). The article, "Specification for Pumping X-ray Laser with Ionizing Radiation," by F.V. Bunkin et al., appeared in the *Soviet Journal of Quantum Electronics* in July 1981.

According to the original *Aviation Week* report, to which the Soviet article refers, the first successful Livermore X-ray laser tests took place in December 1980. The Soviet article reviews in detail the specific atomic transitions that could have been utilized with X-ray pumping from a nuclear explosion. It would appear, though, that the Soviet article purposely fails to give the proper configuration for the Livermore X-ray laser.

Some scientists have speculated that metal plasma pinches are actually utilized as a lasing medium instead of mere metal rods. This would permit the lower-than-solid densities specified by the Soviets, while getting rid of the deleterious "beam divergence" effects of simple thermal expansion.

The magnetic fields generated in the metal plasma pinch would hold the metal lasing medium together at the desired temperature for a sufficiently long period (20 to 30 nanoseconds) so that a low divergence beam could be generated.

Japanese Follow Up Winterberg ICF Concepts

Japanese laser fusion scientists have begun to investigate and elaborate many inertial fusion concepts pioneered by Dr. Friedwart Winterberg of the University of Nevada. In particular, the Japanese have found Winterberg's work on blackbody radiation generation and compression quite "fascinating."

A recent Osaka University report (ILE 8303P) by Takashi Yabe and Takayasu Mochizuki gives a detailed elaboration of Winterberg concepts first published in *Nature* (Vol. 286 [1980], p. 364) and *Z. Physik A-Atoms and Nuclei* (Vol. 296 [1980], p. 3).

Yabe and Mochizuki note that "This letter proposes a new, fascinating ICF scheme. The scheme employs the soft X-ray production by hypervelocity projectiles. The soft X-ray of 10 trillion watts per sq cm and 10 nsec duration, which is focusable onto a small sized pellet, can be efficiently produced.

" . . . The next problem remaining in our scheme is the efficient method to accelerate such projectiles up to some tens of kilometers per second. Anyhow, the physical process discussed in this paper will be fairly general, thus extremely important since the process is likely used in a part of implosion stage for other driver schemes as well as the projectile scheme."

Advisory Council Assesses University Role in Fusion

The Magnetic Fusion Advisory Council (MFAC) Panel on University Fusion Programs met on March 24-25 at Columbia University in New York to assess the long-term role of universities in the fusion program. Although the official findings of the meeting have not yet been made public, the outlines of several of the important presentations at this MFAC panel meeting can be reported.

Dave Nelson of the Department of Energy Office of Fusion Energy gave the keynote presentation on the important role of universities in the U.S. fusion program. This was followed by presentations by Rolf Sinclair of the National Science Foundation and Leon Shohet representing both the University of Wisconsin and the University Fusion Association.

Dr. C. K. Chu of Columbia University gave a detailed report on Japan's fusion program, which *Fusion* will publish in the future.

Dale Meade of Princeton Plasma Physics Laboratory, Bob Borchers of Lawrence Livermore, and Bill Drummond of the University of Texas gave extensive reports on small tokamak programs, mirror programs, and the universities' perspective on the scientific and engineering requirements of fusion energy.

All of the talks made clear that the university fusion programs have suffered from the general curtailments by the Carter administration of the main fusion program. Students are becoming less interested in pursuing fusion and plasma studies because of the uncertainties involved in fusion research funding. This has significantly curtailed the vitality of the overall fusion effort, since it is the university programs that have provided many of the innovative new concepts that kept fusion progressing throughout the 1970s.

An Interview with Uwe Parpart Henke

Fusion in Japan Advances on Schedule

NSIPS

Japan's fusion program is the fastest growing in the world today. Despite the slowdown in the world economy and the stagnation of fusion funding in the United States and elsewhere, Japan has been investing in fusion development at an accelerating rate since the mid-1970s, when Japan's leading scientists and cabinet members decided that fusion was "the energy resource of the 21st century."

FEF research director Uwe Parpart Henke toured Japan's major fusion facilities in October 1982, and in this interview he reflects on the unique system of government-industry collaboration in Japan that has made possible the remarkable progress of the country's magnetic and inertial confinement fusion programs.

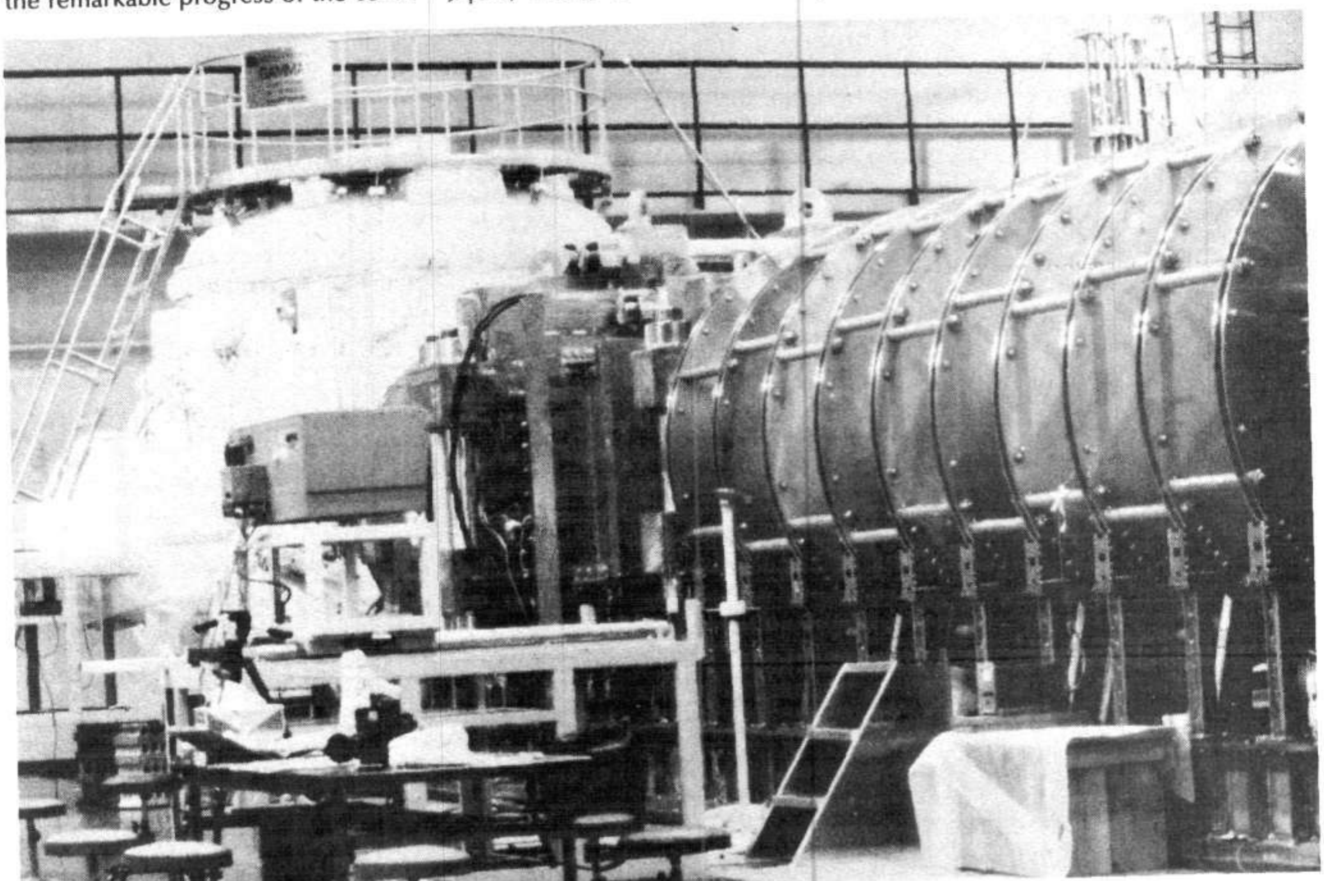
The main stops on Henke's tour were the Institute of Laser Engineering at Osaka University, the Institute for Plasma Physics at Nagoya University, Japan Atomic Energy Research Institute in Tokaimura—site of Japan's largest tokamak experiment, the JT-60—and the Plasma Research Center of the University of Tsukuba. Tsukuba is Japan's "science city," an academic city established in 1973, which will eventually accommodate 10,000 students and is currently the site of Japan's ambitious fusion mirror program.

Fusion magazine is widely read in Japan, where its theoretical insights have been incorporated into actual experiment designs.

* * *

What is different about Japan's fusion program, as compared with the U.S. program, for example?

One of the things that really sticks in my mind is the very obvious, very high



Japan's Gamma-10 mirror machine in Tsukuba, the "science city," will be about the same size as the U.S. Tandem Mirror Experiment at Lawrence Livermore National Laboratory.

level of successful collaboration between the university and government-related laboratories and industry. An outstanding example of achieving very rapid success with complex machinery along these lines is the development of the GEKKO XII laser at the Institute of Laser Engineering in Osaka, under the direction of Dr. C. Yamanaka. This is a 20-kilojoule 40-terawatt glass laser with 12 beams, which is scheduled to be fully assembled by March or April of 1983.

It was built fully by Nippon Electric Company, and almost all of its components, with the exception of some optical switches, I believe, were manufactured by Japanese industry. Some very interesting and innovative approaches have been taken in the development of this laser experiment.

The obvious problem the Japanese researchers face is that because of classification in laser fusion, they are forced in their target design and similar aspects of the work to keep reinventing the wheel. But in doing that they quite clearly seem to be coming up with better wheels.

The other thing that interested me very much about Japan's fusion program was what I learned about the background of Dr. Yamanaka and other leading scientists. Yamanaka, for example, was trained in aerodynamics and, therefore, has the same basic background as Adolf Busemann and other scientists of his school, whose ideas were important in the development of inertial fusion.

In fact, I asked Yamanaka about Busemann, and he acknowledged his indebtedness to the German aerodynamicist. Yamanaka would have been a young researcher at the end of World War II. He then apparently switched to electrical engineering.

To sum up, the laser program is very impressive and extremely well run, and I think it will show some very good results. It will also contribute to a more open discussion of the problems in laser fusion research around the world, because it will come up with new ideas that are as valuable as anything that is produced in the United States. And those ideas will then not be classified.

What were your impressions of the magnetic fusion program?

Dr. Chiyoe Yamanaka, head of the Institute for Laser Engineering at Osaka University.

That program also reflects the very close and successful collaboration between laboratories and industry. This was perhaps most evident in Tsukuba, the science city, which is the leading facility of the magnetic mirror program. Japanese scientists are now building a very large mirror machine there, the Gamma-10, which will be about the same size as the Tandem Mirror Experiment at Lawrence Livermore National Laboratory in California. This has been built in large part directly by Toshiba Electric.

Two things about the mirror program are impressive: It was built very, very rapidly with the relevant help from industry over a period of only five or six years to the level of the large U.S. program. And it was built up by only a relatively small handful of physicists—which obviously demonstrates that they are working hard and being successful at it.

But this may also be one of the Achilles' heels of the program. The amount of fully qualified manpower is perhaps still insufficient at this point to fully exploit all the opportunities that the experiments afford. In order to remedy that problem, the Japanese already at the very beginning of their program built up the theoretically oriented Institute for Plasma Physics at Nagoya, which does a good deal of postgraduate training. And in addition to that, there is now a national program to train a sufficient number of individuals in plasma physics. This program is operated by the collaboration of a number of government agencies, including the education and science and technology departments.

Singling out the Osaka laser and the Tsukuba mirror does not mean that the other programs are in any way less significant or impressive. In fact, the largest project by far is the JT-60. When I saw it last October, the entire building that will contain the tokamak had been put up. The assembly was going to begin this spring, and operation was expected to start on schedule in late 1984.

The JT-60 is an extremely well-managed program. The machine is the same size as the reactor-scale Tokamak Fusion Test Reactor now operating at Princeton. It is designed to achieve breakeven using all deuterium fuel, so it will not produce a sustained fusion reaction. Therefore, the Japanese are now also designing an ignition experiment at Nagoya University.

Do the Japanese intend to export tokamaks by the year 2000, as *Fusion* reported in August 1981?

I think that might have been possible if the kind of momentum that existed behind the U.S. program at the time had been maintained. That in turn would have given greater encouragement to a more rapid expansion of the Japanese program. I think the slowdown of the U.S. program has hurt the worldwide program, including the Japanese program. Clearly, there is a certain interdependence of the U.S. and Japanese programs. The U.S. program is still the leading program in the world, and if it slows down, it will become necessary three, four, five years from now to slow down the other programs—unless we turn around the situation in the United States.

Nevertheless Japan's fusion expenditures are continuing to go up, whereas ours are stagnating. Japan is now spending an equivalent amount on magnetic fusion as the United States, although its laser fusion program is not as big as the U.S. program yet.

Are any U.S. fusion scientists or plasma physicists going to Japan to work, given the employment problem here?

It might be a tempting thing. There are some exchanges always going on. In fact, I met some U.S. researchers in Nagoya, who are working there in the context of an exchange arrangement with General Atomic. The manpower needs in Japan will continue to go up, as the country has made a very firm decision to push fusion development through as rapidly as possible.

The Japanese have also drafted a long-term plan on how to develop fusion and related industries through the year 2010. That kind of long-term planning obviously is very useful because it provides the point of perspective for making short-term decisions.

Are the Japanese doing much to introduce laser and beam technologies into industry, as the Soviets are apparently doing?

They are not concentrating on introducing lasers into their industry on a large scale at the present time. What they are focusing on is developing mass production techniques for industrial lasers, for their own industry and for export. Specifically, this involves the application of lasers, together with robotics and computers, for flexible machining. The concept is to be able to replace an entire factory with lasers and robots, with computers directing the whole production process.

U.S. specialists in this field estimate that the Japanese will have a demonstration model in two years and that they will begin marketing the process in two to five years.

This is, of course, a very exciting prospect. The entire project is being coordinated by MITI [the Ministry for International Trade and Industry]. MITI also played a leading role in the development of Japan's steel, nuclear, and computer industries and every other field in which the Japanese have excelled. So we come back to the point about the exceptional collaboration between government and industry in Japan.

Japan's reactor-size JT-60 tokamak, scheduled for operation in late 1984, is designed to reach breakeven. Shown here is the construction site of the JT-60 in Tokaimura.

Viewpoint

Continued from page 8

ien culture, they intend to be there to make certain that neither group will offend the other by some unintended rudeness or insult. Anthropologist Barbra Moskowitz warns us that if they consider us a threat they will probably be represented by one of their military leaders; if they believe we are representatives of a God we will most likely be asked to meet with their clergy.

We should not be surprised if, in the near future, our secretary of defense and the defense minister of the Soviet Union are dispatched aboard a spacecraft to some high-orbit secret rendezvous to attend high-level SALT-type meeting with the military leaders of an alien intelligent civilization.

Huzzahs all around. All that remains now is for NASA to receive its first remittance; a new era shall then begin, as the many Star Warriors, UFOlogists, and cereal box spacemen well know. Isaac Asimov says, "We don't know what they are like, but they are intelligent." Professor George Wald of Harvard takes the matter one step further, revealing that he *knows* where the E.T.'s are: "I think there is no question that we live in an inhabited universe that has life all over it."

Astrophysicist Jacques Vallee shares a foreboding secret, "—[we] have photographs—*reliable* photographs." He adds that E.T.'s have already been sighted on the runway of Turin airport in Italy.

The quest goes on. We trust that somewhere in that vast expanse of stars the audacious midget is at home waiting for our call. As long as we continue to support the astronomers and cosmologists patiently manning their giant SETI antennas, it is an inescapable fact that we will make contact. And the E.T.'s, if their technology has surpassed ours, may answer many of our questions about the riddle of the universe, and tell us how to avoid inflation, and maybe even let us in on how they manage to live without working in a nine-to-five world.

Adjust your spectacles and look to the sky, Earthlings. We're going to have an encounter! And don't act too surprised when you see their faces. For they are us.... er, we.

The LaRouche-Riemann Economic Model Works!

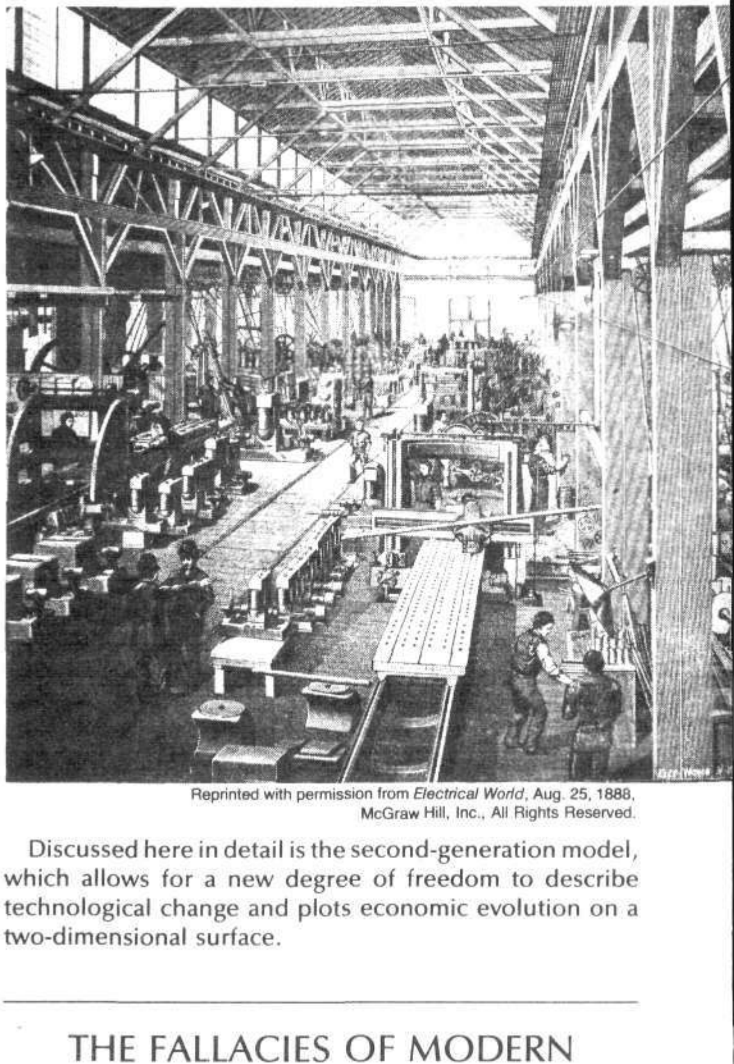
by Steven Bardwell
and Uwe Parpart Henke

Economics is the science of an inherently nonequilibrium evolutionary process, characterized by apparent discontinuities in the form of depressions and rapid growth, qualitative change with the appearance of new technologies, and catastrophic collapses brought on by the finitude of resources and raw materials. The rigorous description of economic progress has defied conventional economics—conventional economics has even denied that growth and development are long-term features of any economy.

We have developed a new model of economic development, the LaRouche-Riemann model, which identifies the underlying continuous causality of human economic history as the necessary increase in the relative potential population density. In other words, the measure of a society is the ability of a given amount of developed land to support an increasing population at an increasing material and cultural level. This requires a continuously increasing rate of introduction of new technologies into the economy.

As we demonstrate, a national or world economy functions as an integrated heat engine, a thermodynamic device that transforms energy and raw materials into useful economic output. From this perspective, economic evolution is then a sequence of discontinuities in a generalized function expressing the potentialities of this transformation process. The process itself is defined by the intersection of two tendencies: first, the depletion of finite resource supplies, which makes itself felt as an accelerating decline of returns on capital investment; and second, increases in thermodynamic efficiency or "reducing power." In an economic system this latter increase is expressed by rising productivity as a result of technological innovation and increasing skill levels in the work force. The successful resolution of this intersection results in a rising potential relative population density, an occurrence that appears in economic terms as a set of "jump conditions" to be satisfied by any new technological innovation.

This model has been very successful in predicting the real behavior of the economy, consistently providing accurate estimates of quarterly industrial and employment statistics at a time when *no* other model was even close. Based on three years of work under the sponsorship of the Fusion Energy Foundation and the weekly magazine *Executive Intelligence Review*, the model weds the physical and mathematical methods of Bernhard Riemann to the economic analysis of economist Lyndon H. LaRouche, Jr. The result is a model of remarkable empirical and theoretical power.



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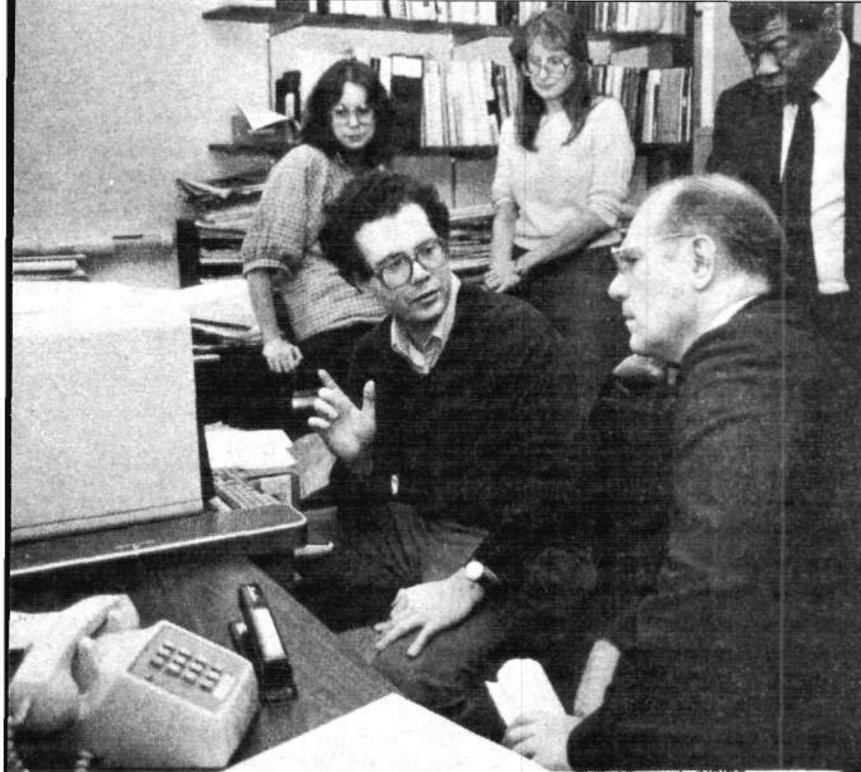
Discussed here in detail is the second-generation model, which allows for a new degree of freedom to describe technological change and plots economic evolution on a two-dimensional surface.

THE FALLACIES OF MODERN ECONOMICS

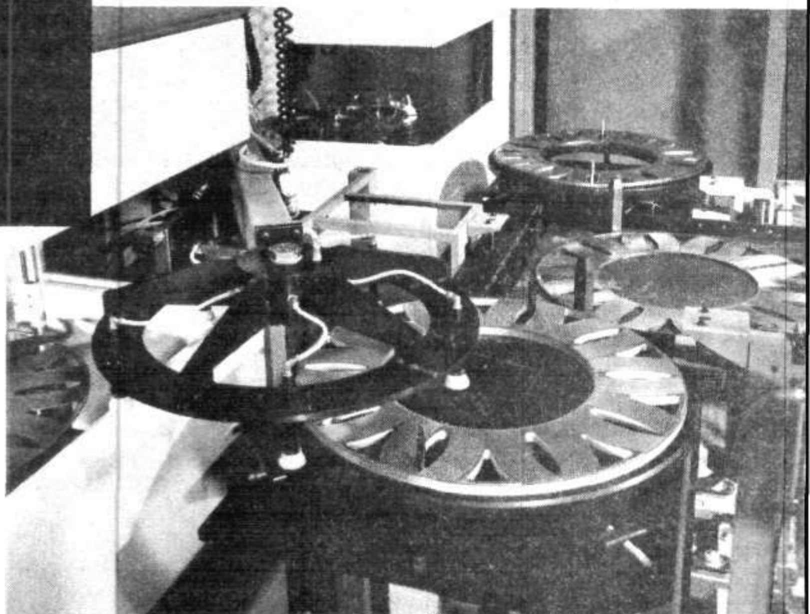
In one of the classical papers of economic theory—a paper that is one of the few examples of rigorous mathematical thinking in economics and has so formed the basis of almost all of modern econometrics—John von Neumann sets out to prove the existence of a quasi-stationary equilibrium state in economics.[1] Von Neumann's proof has gained stature since its first appearance in 1938 in his paper "A Model of General Economic Equilibrium," because it states explicitly the conditions required for such an equilibrium state to exist. In marked contrast to the academics who have since dominated economic theory, von Neumann is explicit



Philip Ulanowsky/NSIPS

The key to the success of the LaRouche-Riemann economic model is its focus on the role of technological innovation in increasing productivity.

Far left: Edison's Machine Works in Schenectady, N.Y., in the 1880s mass produced the equipment for building centralized power stations. Left: Economist Lyndon H. LaRouche, Jr. (seated, right) discusses the model work with the economic staff of the Executive Intelligence Review. *Below: An automated laser welding system, one of the most technologically advanced ever built, used by AVCO in making turbine engines.*



Courtesy of Coherent Industrial Systems

about the assumptions that must be made if economic equilibrium is to exist. Von Neumann makes three assumptions:

[1] That there are constant returns (to scale);

[2] That the natural factors of production, including labour, can be expanded in unlimited quantities. . . .

[3] consumption of goods takes place only through the processes of production which include necessities of life consumed by workers and employees.

In other words, we assume that all income in excess of necessities of life will be reinvested.

Von Neumann shows that under these assumptions it is possible to prove in a rigorous mathematical fashion the existence of a quasi-stationary economic state, in which the economy grows at a uniform rate without change in internal composition.

Of course, the basic fact is that not only does economic equilibrium not exist, it is in principle impossible, and any chance of forcing it upon the economy necessarily leads to increasing entropy in the economic process. The characteristic problem is that under circumstances of no fundamental technological innovation, the relative finitude of the resource base will always begin to assert itself, even before the critical phase of resource depletion, in the form of lower returns on investment; it will lead to the appearance of overcapitalization, of too-rapid growth in the ratio of capital to labor, and so on. Such is the analysis these economists provide for the American economy today—industry with too much capacity, unemployed workers, and rising raw materials costs.

We define the principal problem of economic theory in exactly the opposite fashion from von Neumann; namely, what are the principal requirements for successful economic evolution from the standpoint of the negation of von Neumann's equilibrium premises. This is what the LaRouche-Riemann method is essentially designed to deal with.

We are interested in investigating what requirements an economic process must satisfy in order to offset the problem of the relative finitude of resources and relative growth in overhead consumption (for example, education) under conditions of successful economic development. Our principal proposal is that in spite of the seemingly discontinuous nature of economic development, there exists a continuous mathematical background function that determines the possibility of successfully offsetting the finitude of resources, a function defining increasing values of energy flux density used in economic production (energy flux density is the ability of a technology to transform energy into its embodied economic output) and the skill levels implied by rising productivity. This function itself characterizes a given level of technological achievement and labor power and thus a given level of the transformation efficiency of the total economic machine.

Investment Decisions Vs. Theories of Inevitable Entropy

Some economists who politically favor population reduction and a "small is beautiful" world, have taken the relative finitude of resources and relative growth in overhead consumption and turned it into an irreversible law. In the recent period, the most explicit statement of this comes, not surprisingly, from the original authors of the Club of Rome document, *The Limits to Growth*.[2] Dennis Meadows and Jay Forrester perhaps realized that their original arguments for the necessity of population curbs in a resource-shrinking world were so full of holes that it was necessary to dress up the same shoddy thesis in a new fashion. This is done in their newly developed model, described in a paper "Economic Behavior: Implications for the Next 20 Years," written by Forrester in June 1980. The most important conclusions of this new so-called national model are stated on pages 9 to 11 of the document:

> We believe that the national model now provides a theory for how the economic long-wave is generated. The process involves an overbuilding of the capital sector during which they [sic] grow beyond the capital rate necessary for *long-term equilibrium*. In the process capital plants throughout the economy exceed the levels justified by marginal productivity of capital [that is, the declining rate of return on investment changes the efficiency of capital]. Finally, the overexpansion is ended by the onset of a great depression during which excess capital plant is physically worn out and exponentially depreciated on the account books until the economic stage has been cleared for a new era of rebuilding [emphasis added].

Forrester would apply this Yin-Yang theory of human development to the situation in the United States today:

> The process of decline and revival produced by the long-wave can be traced by thinking back to the 1920s. Prices had been rising. Interest rates were high. Investment opportunities in the technologies of that time had diminished. Cities were afflicted by excess office space. Land prices had been rising sharply. Heavy debts had been incurred, and the financial system was overextended.
>
> Assume for the sake of illustration that the appropriate level of capital plant was reached in 1965 as is indicated since that time by declining return on investment in new capital plant, and by progressively deeper business cycle recessions. Nevertheless, the capital accumulation process did not stop in 1965 because tremendous momentum had been established in the previous years. . . .

It is certainly true that the recent period in U.S. economic history has been characterized by declining returns on investment and stagnant productivity. Especially important has been the decline in infrastructure investment since the mid 1960s.[3] But to conclude from this, as Forrester does, that there is an inherent limit to capital investment seems as eccentric as liberal economist Lester Thurow's proposal, approvingly quoted by Forrester, that it is easier to make productivity gains by destroying old (and outmoded) productive capacity than by making new investment.

Why, one naturally asks, must one wait for the depression? Is it not possible to start with the innovation earlier? Forrester's answer is interesting:

> Some of the corporate overhead charge goes to people making capital equipment, but much of the overhead is for expediting, coping with the past stresses of growth, responding to government questionnaires and doing research less and less efficiently because major innovative advances are incompatible with the entrenched maturing technologies at the top of an economic long-wave.

This bizarre metaphysics is not much more than a modern derivative of Malthus's original thesis of the inevitable impossibility of generalized growth and progress. As Malthus outlines at length in his *Principles of Political Economy*, agricultural land is not the only object of economic activity afflicted by "depletion."[4] All technological processes, individually and as a progression, require more and more human effort and investment to generate the output that they, in their natural and virgin state, provided so generously.

Arnold Toynbee was one of the earlier modernizers of this economic doctrine, and both he and Forrester deduce from it the only conclusion possible: The world, or at least substantial parts of it, are overpopulated. The potential population density of the Earth is not only finite, they argue, but it has already been exceeded for large parts of the developing sector. Toynbee's formulation in 1953 is ironically outdated.[5] Listing India, China, Japan, Indo-China, Indonesia, and Egypt, he says:

> In all these non-Western countries the impact of the West has brought with it a progressive increase in the food supply through irrigation, through the introduction of new crops, and through the improvement in methods of agriculture under Western inspiration; in all of them, at every stage so far, this increase in the food supply has been spent, not on raising the standard of living of a stationary or gradually growing population, but on maintaining the largest possible population on the old level, which was and is only just above starvation point. Since progressive improvements in productivity must sooner or later bring diminishing returns, the standard of this swollen population seems bound to decline and there is no margin between the present standard and sheer disaster on the grand scale.

As is the case with all Malthusians, Forrester assures us that while Malthus's thesis of the eventual absolute finitude of economic growth might have been violated in the past, the *eventual* limit to growth must be reached. He predicts again in his 1980 paper that India has reached this limit:

> For many years, economic development planners have tried to establish a Western pattern of economic growth in countries like India, but without notable success in raising the average standard of living. I believe the

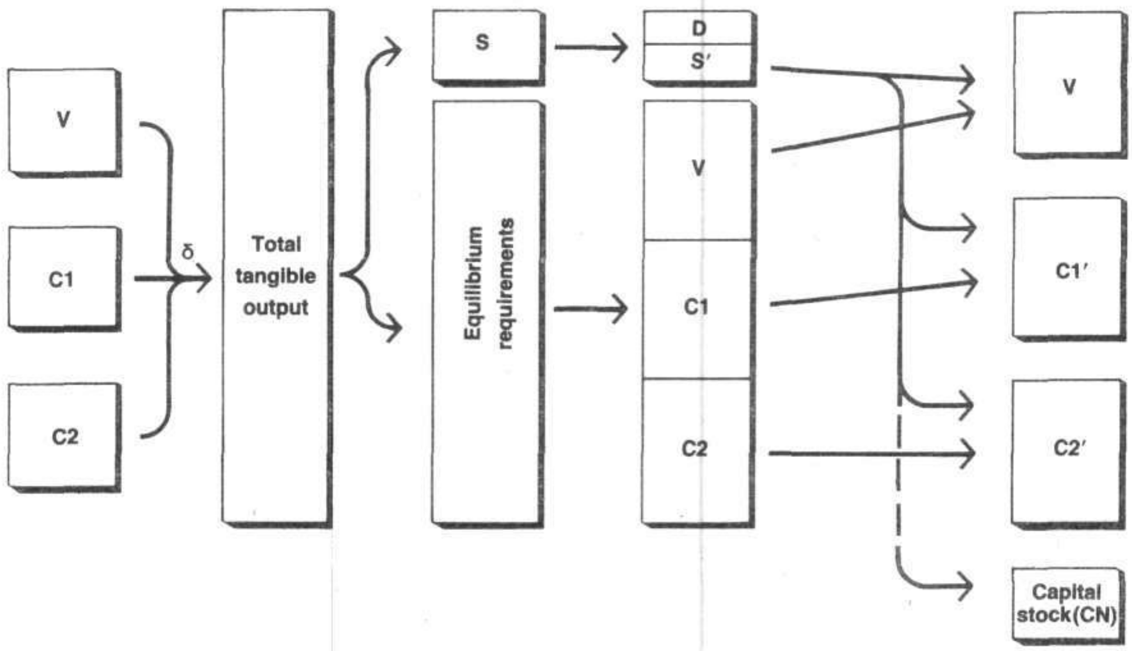


Figure 1
FLOW CHART OF THE FIRST GENERATION LAROUCHE-RIEMANN MODEL
The flow of tangible investment is shown here schematically in a flow chart of the model. The chart starts with the inputs at the beginning of a reproductive cycle, measured in terms of the tangible consumption by the goods-producing work force, V, the tangible raw materials and energy requirements, C1, and the tangible expenditures on depreciation, C2. The productive process then transforms these input values into an aggregated total tangible output. This output is divided into two principal parts: the output required to replace the input goods (the equilibrium requirements) and the total tangible profit, or S, which is what remains after the equilibrium requirements have been met. This total tangible profit, in turn, is divided into nonproductive consumption, D, and reinvested capital, S′, which may go to increasing V, increasing C1, or to new capital investment, CN. Note that the system is not "conservative" since, to the extent that undepreciated capital exists, part of CN does not pass its value onto the total output (in the next cycle).

explanation is in failing to realize where India lies on the life cycle of economic growth. India is already at one of the possible end points of the life cycle of growth, not at the beginning. India already has too great a population for its geographical capacity.

Manpower and the Creation of New Resources

Contrary to what these Malthusians would have us believe, the cases of both Japan and India demonstrate that growth and development exist as secular trends in modern times as well as in the longer course of human history. Development occurs through a process traditionally called progress whose most essential feature is the *creation* of new resources through the perfection of new technologies. But the process of capital investment in new technologies is intimately intertwined with the evolution of the manpower that runs that machinery.

India since its independence provides a dramatic case study in how these processes of manpower development and technological change are interlinked. The earliest economic development plans by the Nehru government stressed the education of a cadre of scientists, engineers, and technicians. Nehru's conception was that from this core of highly skilled labor power the literacy, discipline, and culture of a modern industrial society would radiate out to increasingly large circles of the population. However, Nehru was uncompromising in his demand that India supply itself with the highest skill levels of human labor.

The setting up of a chain of national laboratories doing research at the frontiers of theoretical physics and mathematics, of ground-breaking agricultural research centers, and of an indigenous nuclear power industry were the most dramatic projects in this manpower development strategy. In spite of intense criticism of the Nehru plan during the 1950s and 1960s—under the pretext that it was a waste of money for a poor country like India to attempt basic scientific research or a moral outrage that in the face of widespread poverty and hunger India would spend money on space and nuclear research—the succeeding Indian governments have, with the exception only of the ruralist Janata regime, continued with the Nehru strategy. The results have been spectacular: India has the capability to construct and launch its own communication and reconnaissance satellites, which it has used in a series of educational and agricultural projects with tremendous impact on the rural population of India. The Indian nuclear industry now has the capability to construct an essentially complete nuclear reactor from components manufactured in India; and the development of an Indian fuel cycle based on India's large reserves of thorium is under way at Indian laboratories. India's agriculture has progressed at an astonishing rate so that today, based on high-technology agriculture in regions like the Punjab, India is self-sufficient in grains and nearly self-sufficient in all food products. The second largest country in the world, which prominent spokesman for the Malthusian point of view are still ready to triage, is now not only on the verge of permanently solving its minimal physical requirements, but has trained the fourth largest group of scientists and engineers in the world—a resource that the nation correctly identifies as India's most important.

The interrelation between this type of manpower development and the existence of economic equilibrium is shown in an ironic way in von Neumann's paper. Von Neumann makes a three assumptions in his proof of the existence of an equilibrium economy:

(1) that natural resources of a given cost are available in infinite supplies;

(2) that manpower of a given level of skill is available in infinite supply; and,

(3) that the only costs of an economy are those of raw materials, subsistence consumption of the productive work force, and new investment in the simple quantitative expansion of the economy (that is, that there are no overhead expenditures).

The first of these assumptions can, as we argue, be satisfied, *if* new technologies are continually introduced that create resources. Contrary to the usual assumption, these additional resource supplies are *not* harder to get as time goes on, but (as the example below of steel shows), are *produced* at an accelerating rate by a healthy economy. However, and here is the main point, the satisfaction of the first assumption makes the second and third untrue. It is precisely the increase in new technologies that requires increasingly skilled manpower at all levels of an economy. Furthermore, the preparation of this increasingly skilled pool of manpower requires increases in the overhead expenses that the economy must provide for education, training, and cultural activities. Thus, the new technologies that provide unlimited resources also require increasing skills and increasing overhead expenses to pay for the development of those skills.

In summary, Von Neumann proved a theorem on the existence of an economic equilibrium that requires for its truth premises that cannot all be simultaneously satisfied, a theorem that is thus empty because both it and its converse are "provable." But von Neumann was precisely correct in identifying the interaction between these assumptions as the most critical for economic studies. As we shall see, it is the interaction between the processes of investment in new technologies and the development of the increasingly skilled and educated human "resources" that determines the texture, rate, and, indeed, success of economic progress.

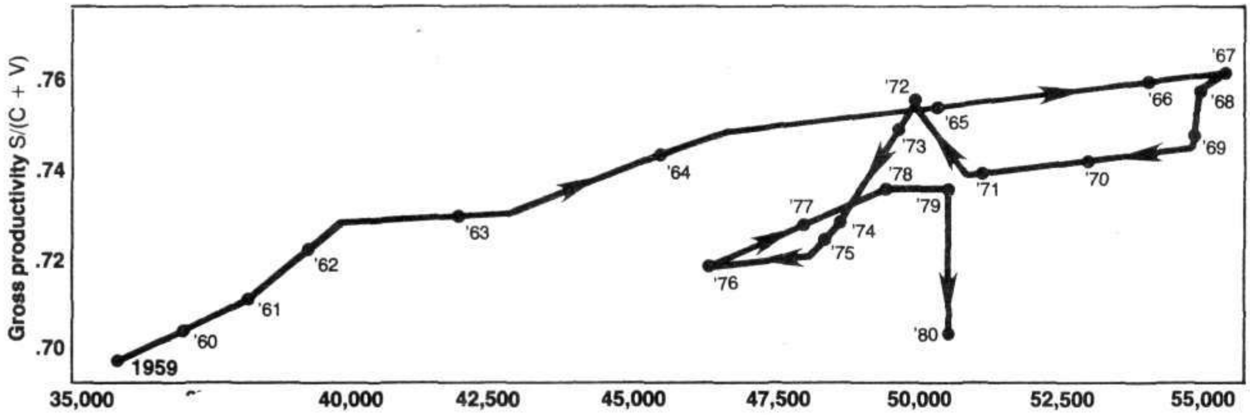


Figure 2

GROSS PRODUCTIVITY AND INFRASTRUCTURE SPENDING IN THE UNITED STATES, 1959-1980

The gross productivity of an industrialized economy (the ratio of total tangible profit, S, to tangible expenditures on plant and equipment and tangible consumption of the goods-producing work force, C + V) is very sensitive to the component of new capital investment devoted to new infrastructure investment. This relation, shown here for the United States between 1959 and 1980, involves a causal link that depends on the impact future infrastructure spending has on investment decisions today. The points plotted are infrastructure spending in the previous year. Thus, the lag between the spending and the increase in S/(C + V) is only one year, even though the completion time of almost all of the infrastructure investment considered here is much longer than one year.

A MODEL OF ECONOMIC REPRODUCTION

The existing LaRouche-Riemann model uses a set of coupled differential equations to analyze the impact of investment decisions on the objective state of an economy. It depends on two sets of inputs: the first, a set of ratios that quantify the investment decisions made at every level of an economy; and the second, tangible measures of output and consumption or the objective state of the economy that results from the investment decisions made. The first have been given Greek symbols, the second capital Roman letters, as summarized here:

α = composition of reinvested capital = $\Delta V/S'$
δ = productivity = S/V
γ = overhead expenditure ratio = D/V
η = ratio of circulating to fixed capital = $\Delta C1/(1-\alpha)S'$
ε = depreciation rate
$\dot{\delta}$ = time rate of change of δ
$\dot{\gamma}$ = time rate of change of γ
V = tangible output required for maintenance of productively employed work force (wages in tangible terms)
$C1$ = tangible output required for replacement of productively consumed raw materials, energy, etc.
$C2$ = tangible output required for replacement of productively employed plant and equipment
S = total tangible output less $(V+C1+C2)$, or the gross tangible profit or surplus
S' = portion of S invested in new productive capacity (that is, next year's V, C1, or C2), or, the net or productively reinvested portion of total profit
D = $S-S'$, the total tangible consumption in activities that are not goods producing; the total tangible overhead consumption.

The equations, in their differential form, are as follows:

$$dS'/dt = \alpha(\delta-\gamma)S' + (\dot{\delta}-\dot{\gamma})V, \quad (1)$$

$$dV/dt = \alpha S' \quad (2)$$

$$dC1/dt = (1-\alpha)\eta S' \quad (3)$$

$$dC2/dt = (1-\alpha)(1-\eta)\varepsilon S' \quad (4)$$

The flow chart shown in Figure 1 summarizes these equations. Qualitatively, the equations express the impact of the flow of the reinvested tangible profit S' through an economy. Equation 1, the driving equation of the system, expresses the simple fact that S' is drawn out of the general fund of tangible profit, S, and that it can change over time for three distinct reasons:

(1) *Changes in the work force at constant productivity and constant overhead expenditure.* An increase in the work force results in increasing S' in proportion to the fraction of investment made in increasing the work force. Note that the portion of S' invested in capital cannot directly increase the rate of S' production.

(2) *Changes in productivity with constant work force.* An increase in productivity obviously increases the rate of S' production, in direct relation to the size of the work force. This term is the only means by which investment in capital goods, raw materials, or new technologies can influence the growth of an economy.

(3) *Changes in overhead expenditures with constant work force.* An increase in the overhead expenditures of an economy will depress the rate of tangible reinvestment if all other factors remain unchanged.

As long as the productivity of an economy (or the productivity implied by a given investment strategy) is con-

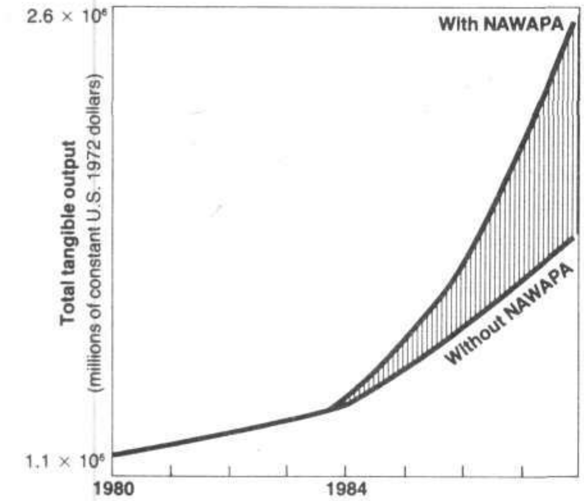


Figure 3
TOTAL TANGIBLE OUTPUT FOR THE U.S. ECONOMY WITH AND WITHOUT NAWAPA, 1980-1990
A massive increase in productivity, such as that shown in the shaded area here between the two curves, is the effect of new investment in infrastructure on a large scale. The North American Water and Power Alliance (NAWAPA), a huge project first proposed in the 1960s, would make full use of the water and snow melt in Canada and the northern United States to provide drinking water, flood control projects, water for irrigation, and a vastly enlarged water transportation system for the entire continent. As shown here, if the United States were to embark on a project such as NAWAPA, the technological innovation in the form of infrastructure would **produce productivity.** *Modeled in the present LaRouche-Riemann model, this productivity increase appears as a "hidden growth" term. The geometric significance of this productivity growth is not accessible to this form of the model.*

stant, this generation of the LaRouche-Riemann model is a powerful tool for economic impact analysis. Its ability to predict the short-term movements of the U.S. economy over the past three years, for example, has been remarkable. In a period characterized by stagnant productivity, the quarterly forecasts done with this model have consistently provided accurate estimates of industrial output, unemployment, and tangible reinvestment. As a barometer for the real (not monetary) performance of the U.S. economy, the model has been able to follow the collapse of basic industry, the destruction of agriculture, and the decline of the American skilled work force. On this basis, the long-term growth potential as well as the short-term movements of investment have been forecast. At a time during which every other econometric model has been consistently wrong, the record of the LaRouche-Riemann model is even more astounding.

Accounting for Productivity Changes and Growth

The more interesting case is that in which the productivity of an economy is changing. In this case, the present generation of the model has no *intrinsic* way of accounting for productivity change and the growth it produces. Productivity, δ, varies with changes in the tangible output required for the replacement of productively consumed raw materials and plant and equipment, C1 and C2, and overhead, D; but this relationship does not convey causality. That is, there is an exogenous parametric relation:

$$\delta = \delta(C1, C2, D) \qquad (5)$$

that provides the only means by which this model can simulate productivity change. The result is that the model produces an account of economic change that contains a "hidden" source of growth only explicable through an appeal to an exogenous relation like Equation 5.

A striking example of this effect is provided by an historical analysis of the impact of infrastructure spending in the U.S. economy during the period 1960-1980. A study of the level of infrastructure expenditure during these years shows that there is a very close correlation between the gross productivity, $[S/(C+V)]$, of the U.S. economy and the infrastructure spending from the year before. Figure 2 shows this data graphically.

The version of the LaRouche-Riemann model shown in Figure 1 has no systematic way of dealing with this effect. Of course, a hybrid model is possible in which the simple effects of a set of investment decisions are calculated using Equations 1 through 4, followed by a second calculation on this output, and then adding on an additional increment of surplus, proportional to that implied by the coefficient of regression of infrastructure spending on gross productivity. Figure 3 shows the results of such a calculation modeling the impact of a large infrastructure project, the North American Water and Power Alliance (NAWAPA), on the U.S. economy.

This treatment of technological change (here in the form of infrastructure) is inadequate, however, because it treats productivity change like any other parameter in the economy. Technological innovation, whether in the form of infrastructure, new capital investment, or education, does not exert its primary impact in terms of increased output; rather, it *produces productivity*. But this parametric formulation is incapable of describing anything other than the purely quantitative (and so continuous) changes in output. Since productivity enters the actual economic process not as another parameter but as a *geometric determinant* of the the state of an economy, the present model is incapable of describing the actual impact of technological change.

To remedy this limitation, a new generation of the LaRouche-Riemann model has been constructed that adds a new geometric degree of freedom to describe technological change, and plots the trajectory of economic evolution on a two-dimensional surface. *This second dimension is a measure of the level of implemented scientific or technological knowledge in an economy*. That is, the first generation model envisions an economy moving only in the time direction as it evolves. Real economic evolution, however, occurs in two directions at once, in a calendar time direction as well as in a direction defining its level of scientific development. These two directions are both "timelike" in the sense that if we are given an observed growth of an economy, say a 50 percent increase in per capita income, this growth can be accounted for by different distances traveled in each of these two directions by the economy in question. It may take 100 years with a relatively stagnant technology (and hence resource) base to achieve the 50 percent increase in per capita income, while the same transformation might be accomplished in 10 years with a rapid rate of technological innovation. The propagation of an economy in this space is a geometric problem, definable in two degrees of freedom: t, which equals calendar time in a purely chronological sense, and x, which equals the state of scientific development of an economy.

This dimension, x, is a measure of the actually embodied scientific knowledge used in the production process at a given time. This is measurable, as we shall see, with a "normative" energy or work flux density, a semiquantitative measure of energy transport in a given technology, which measures the ability of that technology to transform energy into embodied economic output.

The present version of the model is a projection from this two-dimensional space—chronological time and scientific development—into a one-dimensional space. The results of this projection from a higher-order to a lower-order space are typical of a projection from a "physical" space into a "visual" space[6]:

(1) The loss of a degree of freedom results in the loss of causality (or apparent causality) in the lower-order space. Thus, the problem of "hidden" sources of growth arises.

(2) Parametric exogenous factors are necessary to deal with what is clearly a geometric problem.

(3) Singularities are generated in a noncausal way.

The Two-Dimensional Propagator

To "unproject" the present model to a higher-order space can be accomplished by using a mathematical technique well developed in continuum mechanics. In formal terms it involves replacing the simple time-derivatives in the present model with a two-dimensional "propagator" (so-called because it moves the variable it operates on through the two-dimensional space):

$$d/dt \text{ becomes } \partial/\partial t + u\ \partial/\partial x.$$

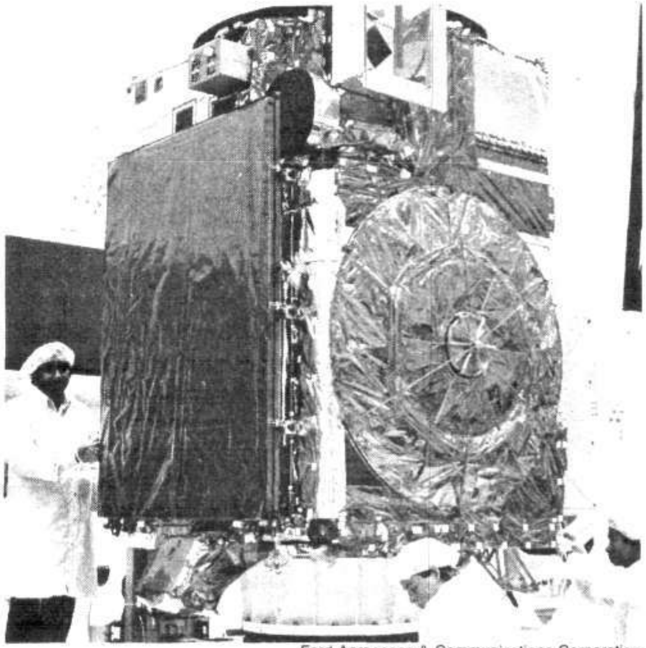
The significance of this propagator can be understood by examining three different aspects of it:

First, all causal motion in two continuous dimensions must be governed by an equation using this propagator (or its formal equivalent). Thus, the properties of the propagator are those necessary for understanding causal motion in any two-dimensional space. In the simplest terms, this propagator expresses the fact that the motion of a system in this two-dimensional space occurs because the system has a "velocity," u, which "moves" it through the x-direction, from a starting position of x_0, as time passes (that is, for increasing values of t, or motion in the positive t-direction). Formally, this fact is expressed by solving the propagator equation for the "position" of the system:

$$(\partial/\partial t + u\partial/\partial x)X = 0.$$

This equation has the obvious solution (since $\partial X/\partial x = -1$) of $x = x_0 + ut$, the equation governing motion with a constant velocity. This formula is familiar from high school physics showing that a particle (or any other system) moves a certain distance in a given time t, dependent only on its velocity.

Second, in physical terms, the propagator describes the rate of change of any quantity as measured at a point moving with an element of the continuum system that is evolving. If we apply this analysis to a fluid, for example, this propagator could be used to determine the temperature of the water as measured on a ship floating in the water: The changes in the measured temperature come from two sources: (1) the intrinsic change of the temperature ($\partial T/\partial t$) and (2), the change in the temperature caused by the motion of the ship itself (given by $u\partial T/\partial x$). As noted above, the causality of this motion is geometrically incorporated in the measurement of the real or total rate of change by virtue of the trajectory for the system implied by the propagator, given locally by the equation $x = x_0 + ut$. In economic terms, this is precisely the rate of change that we would like to measure, since it gives the total rate of change as *determined in the economy itself.*



Ford Aerospace & Communications Corporation

The injection of new technologies into an economy defines and creates the resources used by that economy. Here, technicians at work on India's INSAT satellite.

Third, in mathematical or numerical terms, the propagator can be understood as representing the infinitesimal or local direction of change of a system. Again, the propagator breaks this motion into two pieces, the first measuring the local rate at which motion in the time direction occurs along a trajectory and the second, the local direction or slope of the trajectory. The result is two equations (which will appear again in their fuller geometric significance below):

$dS'/dt = G$, and $dx/dt = u$, where G is the right-hand side of the equation for the full propagator, or the source term.

With this change the equations of the model become:

$$\partial S'/\partial t + u_1\partial S'/\partial t = \alpha(\delta - \gamma)S' + (\dot{\delta} - \dot{\gamma})V \qquad (1')$$

$$\partial V/\partial t + u_2\partial V/\partial t = \alpha S' \qquad (2')$$

$$\partial C1/\partial t + u_1\partial C1/\partial t = (1-\alpha)\eta S', \text{ and} \qquad (3')$$

$$\partial C2/\partial t + u_1\partial C2/\partial t = (1-\alpha)(1-\eta)\varepsilon S' \qquad (4')$$

where u_1 is the rate at which new technologies are incorporated into the production process, and u_2 the rate at which new skills are added to the labor force.

It is essential to realize that these equations are not definitions but statements of causality. That is, on the left hand side of the equation we have a mathematical formula for the "effect"—the total rate of change of S', V, and so on. On the right hand side, we have the "cause" for the observed rate of change. The equality of these two formulas is a statement that the only reason S' changes is because of changes in the work force, productivity, and so on.

From a mathematical standpoint only Equations 1' and 2' need concern us, since the solution to this coupled set of equations will determine the solution to the others, but it is important to note that each of these two equations has a different u "driving" it through our two-dimensional space. For Equation 1', $u_1(S')$ expresses the rate at which new technology is implemented, and $u_2(\gamma, V)$ expresses the rate at which the spectral distribution of the labor force evolves.

The critical new economic phenomena that these equations capture are twofold. First, an economy grows and progresses because it moves in the time direction. Economic production takes time, in many cases, a time unit determined by technology—a growing season in agriculture, radioactive decay times in energy production, and so on. In addition, it grows because it changes technological level and speeds up the processes that go on in the economy. Both time and technological innovation are *geometric* determinants of economic evolution. Second, the economic significance of the x-axis is that it determines productivity—that is, productivity is a function of the x-coordinate of the economy at a given time. This point is critical; technological innovation, just like infrastructure, does not produce output, *it produces productivity,* and this is an essentially geometric feature of economic evolution.

APPLYING THE RIEMANNIAN METHOD: A THERMODYNAMIC APPROACH

Riemann's method makes a unique contribution to the effective modeling of economic evolution because it approaches physical systems geometrically and it provides for a lawful physical description of nonlinear or discontinuous evolution in such systems. The example of resources and equilibrium is one such nonlinearity that conventional economic theories cannot explain.

Resources and their exhaustion can be defined only relative to a given technology. Oil, the most famous of the so-called finite resources, was not finite in any interesting economic sense before 1900, when it existed mostly as an annoying pollutant of water. Nor will it be finite in any important economic sense when nuclear power sources, both fission and fusion, assume the task of energy production. "Natural resources" are created by man; the injection of new technologies into an economy defines and *creates* the resources used by that economy (see Figure 4).

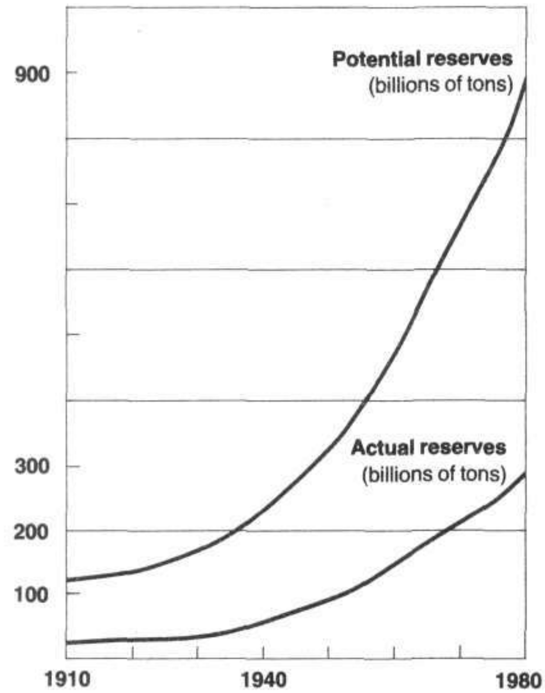


Figure 4
ESTIMATED AND POTENTIAL WORLD RESERVES OF IRON ORE

The "natural resources" available at any point in time are created by man and the technologies in use. These technologies determine what raw materials are available for use, based on the energy density of the processing techniques made available by those technologies. In the historical data shown here for iron ore, the introduction of new technologies during World War II dramatically increased both the apparent actual reserves and the potential reserves.

The most important consequence of this realization is that an economic system cannot approach equilibrium through zero technological growth without destroying itself. Since this economic engine is inherently nonequilibrium, its free-energy and entropy conditions are not amenable to conventional thermodynamic interpretation. Rather, we shall derive three connected measures of this nonentropic economic heat engine's performance:

(1) the changing spectrum of work or energy flux density,
(2) the changing spectrum of the division of labor,
(3) the changing input-output matrix.

By change, we mean not only quantitative changes, but even more important, qualitative change; for example, the addition of new "spectral lines" to the economy. The essential nonequilibrium character of this process derives from the critical qualitatively determinative role of time, well shown by the way that qualitatively new technologies allow a given worker to produce more in a unit of calendar time, to be able to "speed up" the production process. Figure 5 shows this effect in a case study of the relation between productivity and work flux density in the Japanese steel industry. The effect of increased work flux density appears here precisely in the ability of a worker to work up the same amount of material in a shorter time. The result is that the quality of temporal change is technologically determined and changes as the economy advances.

The mathematical treatment of a system characterized by qualitative change of this sort demands superseding the linear, equilibrium assumptions of conventional econometrics. The Riemannian method is uniquely capable of providing this mathematical treatment. The most characteristic aspect of Bernhard Riemann's method—not just in function theory, but more broadly and most directly exemplified in his function theory—is to bring out in the clearest possible terms the discontinuities of the development process. Looking at a nonlinear development process characterized by a many-valued complex function, it is clear that this many-valued complex function is one that reaches branch points and is analytically continued in different possible ways so that in the future, more than one functional equivalent corresponds to a given value. To make such a

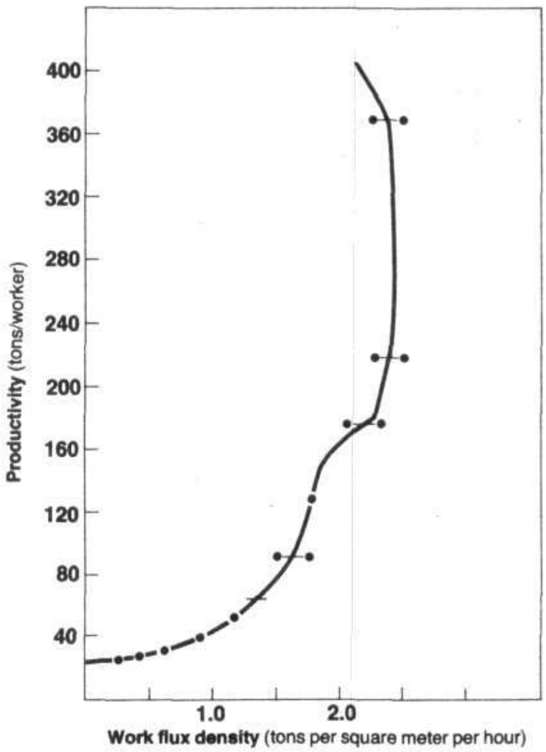


Figure 5
PRODUCTIVITY AND WORK FLUX DENSITY IN THE JAPANESE STEEL INDUSTRY
One important measure of the technological level of an economy is the work flux density (output per unit area per unit time). The historical course of the development of this measure of productivity and efficiency is shown here for the modern Japanese steel industry, a dramatic example of an industry that has continuously introduced new technologies into the production process.

process causal in the usual sense, Riemann introduces the notion of a Riemannian surface that takes this discontinuous process and forces it into a continuous succession of simply connected surfaces. This allows the definition of a unique path of integration to be pieced together out of integrals that on any given simply connected surface are independent of the path.

Riemann here forces the understanding of a discontinuous process by its topology to determine its underlying continuity. He uses this topological method to look at the "visible" boundary conditions and discontinuities and analyze them for the purpose of inferring the underlying continuity.

In the case of a function of one complex function, Riemann's method works as follows: Look at the complex function $f(z)$ of a complex argument $z = x+iy$. In this case, $f(z) = u+iv$ must satisfy the Cauchy-Riemann equations, and under these circumstances, we can look at u as the velocity potential of an incompressible fluid in the x,y plane interpreting du/dx and du/dy as the components of the velocity. Simultaneously, we can interpret v as the stream function that is associated with the given velocity potential.

Riemann stresses on various occasions that the way in which he looks at potential theory in terms of complex variables and vice versa was exemplary for him of the way in which the various physical problems that lead to partial differential equations should be looked at and treated. One must always ask what kind of singularities are compatible with the partial differential equations under consideration. This is what Felix Klein stresses in his various comments on Riemann's function theory, integration theory, and work on differential equations.[7] The 1859 paper on shock waves by Riemann, "On the Propagation of Air Waves of Finite Amplitude," must be seen in this same context.[8] In this paper, Riemann starts by looking at the potential functions and then asks himself how the boundary value problem of potential theory must be varied in order for it to become applicable to the solution of the hyperbolic partial differential equations describing hydrodynamics. With this approach, he is able to reduce the nonlinear hyperbolic equations to a set of linear differential equations, and then treat them using his method of characteristics (described below in detail), not in an analytical way but rather geometrically. The geometric method is very reminiscent of the geometrical treatment of problems in potential theory solvable using the conformal mapping properties of complex (harmonic) functions.

Riemann's method involves first, the interpretation of the two parts of the complex function from the standpoint of potential theory, and second, the determination of the existence of such a function under certain concrete boundary conditions with concretely specified singularities. The problem here, what Poincaré called *Le Problème de Dirichlet*, is that of uniquely determining a potential function, u, that satisfies given boundary and singularity conditions. Riemann solved this problem by means of the minimum principle, the so-called Dirichlet Principle.

The existence of a potential function (that is, a function that satisfies the Laplace equation and that is continuous on the specified surface) can be proved by showing that there exists an integral of this potential function (the so-called Dirichlet integral extended over the specified surface with given boundary) that achieves a minimum for the correct potential function. The extremal property of the integral then proves the existence of the potential function.

The economic problem is very similar to the hydrodynamics problem: to specify the behavior of a kind of generalized potential function that has to be extended across a shock wave front, the conditions of its continuation beyond the shock front being specified by a "conservation law" or a generalized Dirichlet Principle. Analytically speaking, the shock wave equation, described below, if specified in function theory, would lead to a function of several complex variables, much as a potential function leads to a function of one complex variable. The harmonicity of the potential function is, of course, what allows a closed theory of potential functions, and the lack of such harmonicity means such a theory is not possible in the case of a shock wave. But these shock wave functions represent a class of functions that are "structure makers" more generally and are found in every case in which qualitative evolution is to be described.

Riemann's Theory of Shock Waves in Economics

The physics of many continuum systems can be described by Equations 1′ and 2′. These equations, first systematically treated by Bernhard Riemann, contain the essential geometric features of economic evolution—both the process of technological development and the process of economic collapse.

Riemann began his analysis of these equations by noting (as Fourier had before him) that any function that depends on time and x through the combination $x - ut$, will be a solution to the simple propagator equation

$$(\partial/\partial t + u\partial/\partial x)\, S' = 0. \tag{1''}$$

That is, S′ depends on time, t, and scientific development, x, through the combination $x - ut$. This is a result of the fact that economic systems are *causal*, and so move as do all causal continuum systems. Each "point" in the economy gets pushed through this two-dimensional economic space by an amount, ut, in a time t, so that its trajectory is given by the equation that governs causal position change in any continuum system:

$$x = x_0 + ut. \tag{6}$$

This is just the equation for the trajectory or instantaneous position of a particle moving with velocity u.

From this it follows directly that the quantity $x - ut$ for any point in the system (that is, any point propagated by the continuum motion) is a *constant*:

$$x - ut = x_0.$$

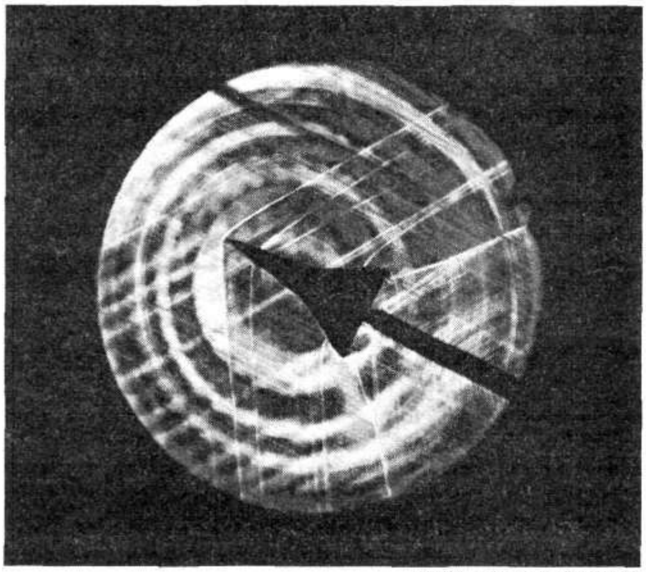
This then implies that any quantity depending on the geometric position through the *combination* $x - ut$ and *not* through x or t independently, will be a solution to the original equation, which requires that the propagator equal zero.

Riemann's essential contribution to the understanding of causal propagation in continuum systems was his geometric method of analyzing these trajectories defined by the condition

$$x = x_0 + ut.$$

Riemann noted that each point (for example, on an economic profile of S′ shown in Figure 6) will move on a line defined by Equation 6, where x_0 is the starting x-position of that point on the profile (its position when $t = 0$). He called these straight lines *characteristics*. The collection of these trajectories for the distribution of S′ shown in Figure 6 generates the complete solution to the problem at hand!

Having a complete solution means that given any x and t, we must be able to find the value of S′ at that point. The pattern of characteristics allows the solution to Equation 1″ to be calculated for any t and x given the initial values of S′ as a function of x, $S'(x, t = 0)$ by merely finding the



NASA, Ames Research Center

The hydrodynamic problems studied and solved by Bernhard Riemann provide solutions for accurately modeling the economy. Riemann's geometric solution—the shock wave singularity—lawfully explains nonlinear economic evolution, or growth. Here, air flow shock waves around a shuttle model in a wind tunnel, captured in a Schlieren photograph.

characteristic that goes through the point (x,t) and following that characteristic back to the starting point at $t = 0$. At $t = 0$ we know the value of S′ for every x, so that we will have found the value of S′ at (x,t). In economics, such a solution tells the consequences for future times of investment decisions made in the past.

This solution is simple in the case where u is a constant independent of S′, but the typical continuum system is more complicated in that the value of the velocity of propagation depends on what is being propagated. It is "nonlinear"; that is, u, the velocity, is a function of S′. As in the case of sound waves in a compressible gas (the problem that Riemann used to solve these equations), the louder the sound wave (and hence the higher the pressure and so the greater the density), the faster the velocity of propagation of a point on the wave, (although the wave as a whole moves only as fast as the smallest value of the density at the front of the wave). Riemann showed that even *if* the equation is nonlinear in this way, the characteristics will still be straight lines, and the nonlinear partial differential equations can be solved by the relatively simple geometrical exercise of plotting the characteristics generated by a given initial distribution of S′.

This remarkable fact follows from the general solution to Equation 6, which, as noted above, follows from a geometric analysis of causal propagation in two dimensions. First, causal propagation implies that the trajectory of the system (called in the general case, the characteristics) will be governed by the general version of the simple case of $x = x_0 + ut$; namely, $dx/dt = u$. In the case that u is constant along a characteristic, the trajectory is given by the simple velocity formula; in the more complicated case, the differential form must be used. Second, the value of S' (or whatever continuum property is propagated) *along the trajectory* is given by the equation $dS'/dt = G$ (where G is the source term), and since in $G = 0$ for Equation 6, $dS'/dt = 0$. Thus, in the case that S' is constant along the characteristics, the trajectory of the characteristic *even in the nonlinear case* is a straight line:

$$x = x_0 + ut.$$

Riemann's method of characteristics reduces the solution of the original nonlinear partial differential equation to that of plotting the straight line trajectories of the characteristics!

The Shock Wave Singularity

Using this technique of geometrical analysis, Riemann was able to prove an astounding fact: If the velocity increases with increasing amplitude, the propagation of energy through such a nonlinear medium cannot continue undisturbed forever. In spite of the seemingly simple continuity of the system, there is a geometrical barrier to infinitely extended simple continuity. Specifically, the nonlinearity of the system will result in a singularity being formed in a finite amount of time. The *physical* reason is quite straightforward: If the larger amplitude parts of the curve in Figure 7 travel faster than the lower amplitude parts, the peak of the wave will eventually catch up to the trough. At that point, the wave will try to "break" like an ocean wave entering shallow water; but it cannot—that would mean that there would be two values of S' at a given x, a meaningless breakdown of the mathematical formalism. Instead, the wave "piles up" at the front and forms a shock wave.

Figure 7 shows the characteristics for such a nonlinear medium. The construction of these characteristics proceeds as follows. Since the slope of the characteristic is $1/u$, the larger the velocity is at a given point (determined by S_0 and $S'(x_0, t = 0)$, the more inclined to the horizontal the corresponding characteristic will be. If these more horizontal characteristics occur at smaller values of x, at some point in time the characteristics of the peak of the wave will intersect those from the front of the wave—this intersection defines the point of formation of a shock wave. But an intersection of two characteristics is an impossibility if the original equations are to be satisfied, because these equations specified that S' had to be constant on every characteristic, and from our starting condition, we know that neighboring characteristics have different values of S'. How can the same point—the point at which the characteristics intersect—have the value of S' specified by both characteristics?

Riemann was not the first to recognize this difficulty, but he was the first to insist that the shock wave was not a mathematical fiction, but represented a new physical state that must be analyzed using new equations and a different causality. Contrary to physicists before Riemann, who believed that the equations of gas dynamics were deficient when they were shown to predict the existence of singularities, Riemann argued that such singular structures were the necessary outcome of the nonlinear equations of gas dynamics. Further, he argued that, indeed, *any* acoustic disturbance would eventually form a shock wave—if there were no dissipative (friction-like) effects that spread the wave out.

A Phase Change and Global Lawfulness

Riemann provided the critical next step in the argument in his 1859 paper on shock waves, in which he derived the lawfulness that must supersede the original propagation equation, Equation 6, after it breaks down with the formation of a shock wave. Riemann argued that once the shock wave forms, the basic properties of the system change. A phase change occurs in which the laws governing the motion of the system change, subsuming the previous lawfulness, but representing a qualitative shift from the original system. Riemann used his general theory of singularities to derive the new laws governing the system with a shock wave by replacing the local causality of Equation 6 with a global condition. When applied locally, this global condition results in Equation 6, but it can include the formation and propagation of a singularity. This new, global condition states that in addition to every nonsingular point on the curve being propagated with Equation 6, the motion of the singularity will be governed by the condition that the area under the shock curve remain constant. Whereas the propagator describes the motion of each point in the system (and hence is called local), this so-called conservation condition is a statement about the system as a whole. Riemann's theory of singularities has as its fundamental tenet that the formation of a singularity in a continuum system is an indication that the old, local lawfulness has been replaced by a new, global lawfulness which, while coherently connected with the old lawfulness, is fundamentally different. The formation and propagation of a shock wave is a classical example of this theory.

Now, in the case where there is no singularity, this global condition is automatically satisfied, as shown in Figure 8, and demonstrates the obvious implication of the propagation law in Equation 6: Each point on the pulse at the same value of S' moves at the same velocity, thus implying that the pulse deforms like a deck of cards sliding over one another. The outline of the deck may change, but the volume of the whole pulse cannot. Once the shock wave forms, the propagation of the shock front cannot be described by the old propagator, but the area under the curve must still be conserved. This can be achieved only if the height of the shock wave decreases in the same proportion that the base of the wave increases. A simple geometrical construction using similar triangles (Figure 9) shows that the conservation condition allows us to calculate the speed of the shock wave, its rate of decrease in height, and the length of the pulse as it propagates.

An examination of the laws governing the new system containing the shock wave show that there are several important differences between the system before and after the formation of the shock wave. The most striking change that wave propagation undergoes with the formation of a

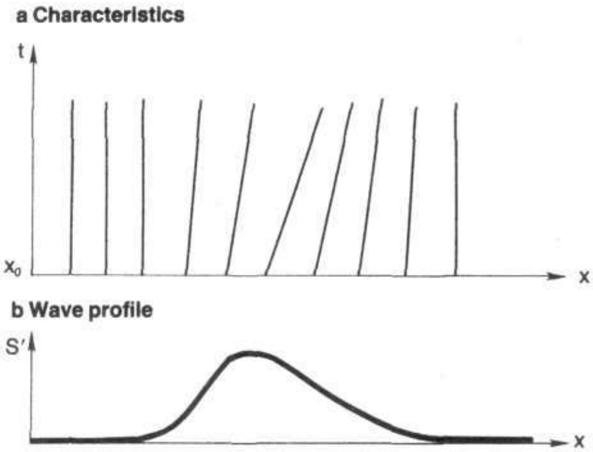


Figure 6
CHARACTERISTICS FOR A SIMPLE, WEAKLY NONLINEAR WAVE

*Riemann's construction of the trajectories, or characteristics (**a**), for the propagation of a wave (**b**) requires the plotting of the family of straight lines: $x = x_0 + ut$, where the velocity, u, is a function of the initial values of the amplitude of the wave, and x_0 is the starting x-position of S' at t = 0. Shown here is a case of weak dependence of u on the amplitude.*

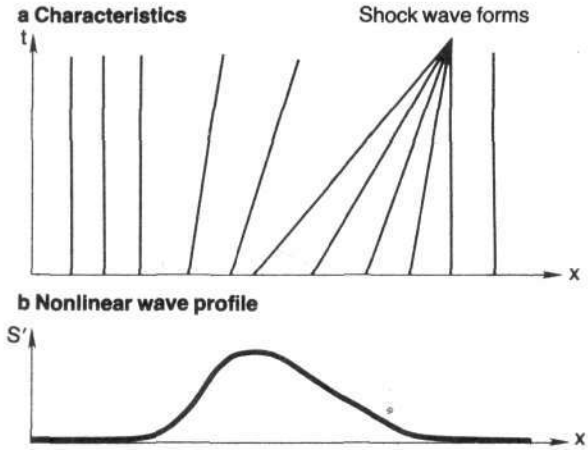


Figure 7
CHARACTERISTICS FOR A NONLINEAR WAVE UNDERGOING A SINGLE SHOCK WAVE

The characteristics can be looked at either as the trajectories along which each part of the initial disturbance propagates, or, equivalently, as the lines of constant amplitude. A shock wave occurs when characteristics representing different values of the amplitude intersect. This is an an indication of a singularity at which the amplitude attempts to become multiply valued.

Shown here is the simplest kind of shock wave, produced by a wave profile shaped so that all the characteristics from the front of the wave intersect at the same point. More common is the case in which the wave front produces a cascade of shocks.

shock wave is in the relation between growth of the wave and its velocity in the direction of increasing scientific progress, x. Before the shock wave forms, the increasing growth of the economy (that is, growing S') results in an increasing velocity in x (of scientific progress) for the peak of the wave. This is a simple result of the basic nonlinearity condition, Equation 5, which guarantees that u increases with S'. In the preshock condition, however, the velocity of the pulse as a whole was zero (since the front edge of the pulse had S' = 0 and so could not move), even though the peak of the wave was moving at velocity u. This difference in velocity is the cause noted above for the formation of the singular shock wave. In an economic sense, this means that progress is impossible for the continuous pulse.

New Mathematical Laws

After the shock wave forms, the relation governing the velocity of the maximum of the wave changes, because a new set of mathematical laws comes into force. There are four differences in the new laws for propagation of the shock front:

(1) *The pulse as a whole moves.* This is a result of the simple geometrical argument shown in Figure 9 and demonstrates how strikingly different shock wave propagation is from normal wave propagation. In economic terms, progress in terms of scientific development can occur only after the formation of a simple shock front; all economic evolution occurs only after an economy enters this singular state.

(2) *The velocity of the shock front is smaller than the maximum velocity of the peak of the pulse before the shock wave formed.*

(3) *The new relation between increasing S' and the velocity of propagation governing the shock front means that the whole pulse, which before the shock formed was stationary, can now propagate with a finite velocity.*

The velocity of the shock front now depends not only on the size of S' at the front, but also on the growth rate of the economy. Depending on this growth rate and how it is realized, the economy can remain stagnant in x (the scientific level), progress at less than u, or travel at a speed greater than u.

The critical distinction here has been emphasized in a number of the recent works of Lyndon LaRouche, the initiator of the LaRouche-Riemann model.[9] On the one hand, there is reinvested surplus that is used to rebuild existing factories, to expand production at present levels of technology, or to repair existing machinery. This investment, a form of "virtual investment," to use LaRouche's term, expands an economy in purely quantitative terms, but does not result in a shift of the scientific level of the economy. It moves the economy forward in time, but has a velocity of zero associated with its consumption.

On the other hand, what LaRouche has called "net investment," S' invested in *new technologies*, has a totally different impact on the evolution of an economy. Net investment of S' results in the movement of an economy

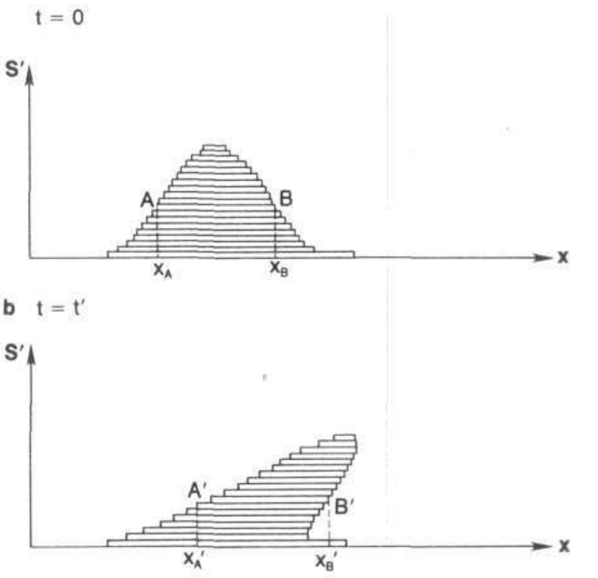


Figure 8
CONSERVATION OF AREA UNDER A SHOCK WAVE PULSE
In the special case that the S' is constant (a zero source term), the area under the curve is the geometrical measure of the total S'. It is the sum of the S' invested at each value of x (at each factory with a differing technological level). That the propagation law $x = x_0 + ut$ conserves area is clear if one notes that the velocity, u, of a point on the curve is determined by its value of S'. Thus A and B move at the same rate and so $x_A - x_B$ must be constant. The motion of the whole pulse is made up of the sliding of these "plates" of constant width. The whole pulse moves like a deck of cards, changing its profile, but conserving the area, or volume, of the cards.

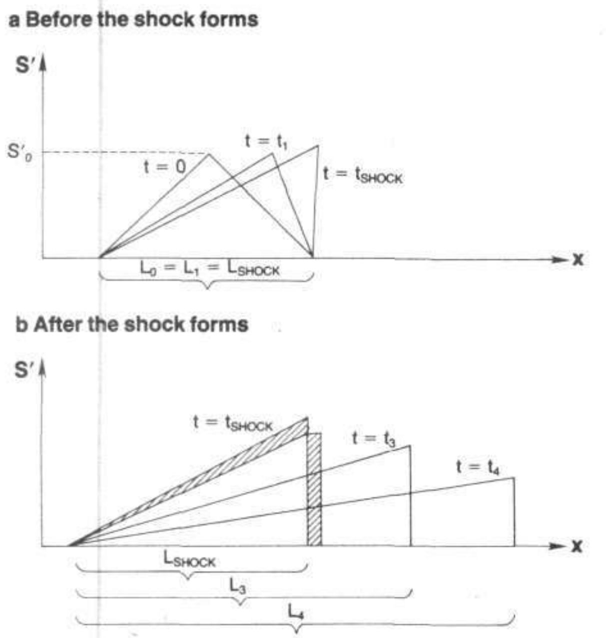


Figure 9
PROPAGATION OF A SIMPLE SHOCK WAVE
The implication of the "conservation law" for the propagation of a shock wave is shown by simple geometry (similar triangles where the base, or length L, remains the same) in the case where the velocity, u, depends linearly on amplitude. Before the shock forms (t_0, t_1) the pulse deforms as in Figure 8 and the conservation of area is obvious from the fact that the front and back of the pulse do not move, leaving the base of the pulse constant. Since S_0', the maximum S', is fixed, the area is constant.

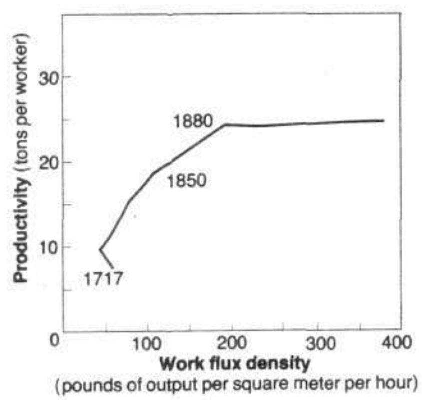
After the shock wave forms, a new set of mathematical laws comes into effect. At $t = t_{SHOCK}$, the front of the wave **must** *move if the area is to remain constant. But, as it moves, the maximum S' must decrease if the area is to remain the same. The velocity of the front can be calculated by equating the change in area 2, given by u(S'), since it is behind the shock, and the change in area 1, given by the shock velocity. Now the whole pulse can propagate with a finite velocity, which depends on the size of S' at the front of the pulse and the growth rate of the entire economy. The critical determining factor in this growth is investment in new technologies that change the geometry of the economy by changing its scientific level.*

forward in x as well as in time. This propagation in x is the mark of a successfully evolving economy, but the above geometric analysis shows that this propagation cannot be indefinitely continued.

Here lies one of the essential insights of the LaRouche-Riemann method in economics: Continuous economic evolution is impossible. Expansion of investment of S'—the condition for a healthy economy shown in Equation 5—results in a barrier to continued evolution in that mode. In fact, the more successful an economy is in making net investment, the more rapidly it will feel this singularity; a shock wave will form and perforce change the laws of that system.

(4) *Without a minimum level of positive growth, the shock wave will dissipate even in the case of supposed equilibrium or steady (but insufficient) growth.* In mathematical terms, the formation of the shock wave means that the system becomes subject to what mathematicians call an "entropy condition." This entropy condition means that the wave in a system with a shock singularity will asymptotically decrease to zero unless the growth rate of the economy is above a certain threshold. If the growth rate is zero, the final state of such a system can be rigorously shown to be one in which S' is zero for all x.

This result is quite remarkable from a mathematical standpoint, since the system, which was initially "conservative" (S' was neither created or lost in Equation 1" when the right-hand side was zero) becomes "dissipation dominated" and decreases to zero everywhere after a shock



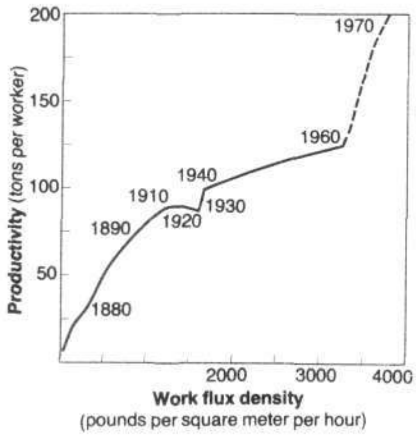
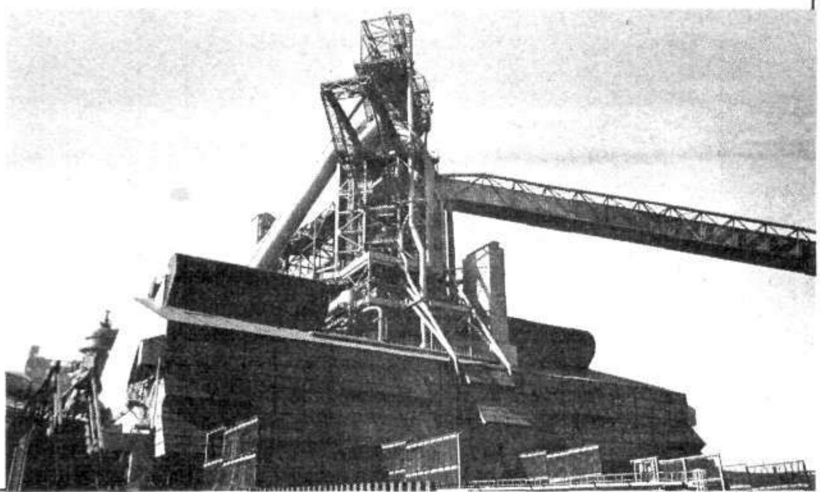


Figure 11
WORK FLUX DENSITY AND PRODUCTIVITY FOR BLAST FURNACES IN THE U.S. IRON INDUSTRY, 1717-1978

The significance of Figure 10 becomes clear only when the 150-year trend is put in a larger historical context, as shown in this graph. With the development of several new technologies (hot blast techniques and automation) the productivity of workers in blast furnaces has quadrupled since 1850, and, over the entire 250 year period, there have actually been accelerating returns to investment.

Figure 10
WORK FLUX DENSITY AND PRODUCTIVITY FOR BLAST FURNACES IN THE U.S. IRON INDUSTRY, 1717-1880

The early history of the iron industry provides a classic example of declining returns on investment and the appearance of limits to growth. Graphed here are returns on investment measured in terms of productivity (tons per worker) plotted against the work flux density (pounds of output per square meter per hour). As shown, after approximately 1850, there were no further increases in the scientific level of development in this industry, decoupling it from its most critical economic impact, productivity.



Inland Steel Company

Historically, the iron-making industry overcame apparent "limits" to growth and made great strides in productivity through the introduction of new technologies such as the hot blast technique. Here, the Madeline No. 7 furnace at Inland Steel's Indiana Harbor Works, currently the largest blast furnace in the Western hemisphere.

wave forms. In other words, a finite growth rate is required just to stay even. Economically, this is not so remarkable, since it is a simple statement of the long-term limits to growth that exist in the situation where there is no qualitative change in technology. This fact is the most essential counterproof to von Neumann's work on economic equilibrium, since it shows that in principle, economic evolution has no accessible steady-state or equilibrium. *An economy either grows or it dies.*

The most difficult question, however, concerns the evolution of an economy after the shock wave. It can be shown that the requirement that solutions to Equation 1" be causal implies that a shock wave, once formed, must remain in a singular state for the rest of the life of the system. More specifically, this condition says that the characteristic along which a shock wave propagates cannot be the starting point for any new characteristic. This means that a shock wave, in the simple case examined here, can never be removed if the constituent equations describing the system remain the same.

Riemann's Theory of Singularities

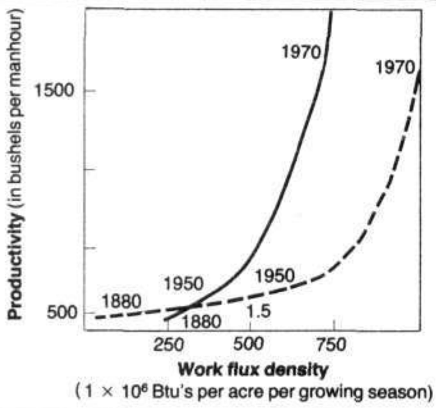
The idea that a perfect continuum system, such as an economy governed by the condition for progress shown in Equation 5, can result in the formation of an essential singularity in a finite time is one of the most disturbing results of Riemann's method applied to economics. This conclusion contradicts the basic epistemological foundations of conventional economics that hold qualitative change to be impossible. Riemann, on the other hand, insisted that singularities like a shock wave are characteristic of evolving systems and can be used to determine the global properties of these systems. Indeed, the Riemann-Dirichlet method described above is a technique for deriving, in one complex variable, the global functional relations that are uniquely implied by the boundary conditions and singularities that constitute the initial conditions for the problem.

Equations 1' and 2' are much more complicated than those to which Riemann applied his theory of harmonic functions and so have a richer set of singularities. The nature of these singularities can be delineated by an examination of the precise nonlinearity contained in the simple

Figure 12
WORK FLUX DENSITY AND PRODUCTIVITY FOR U.S. CORN PRODUCTION, 1880-1970

The impact of qualitative innovation on the work flux density of agriculture is an old subject, because the work flux density (measured in bushels per acre per growing season) is the traditional measure of yield. The graph here shows the 80-year stagnation in yields of U.S. crops like corn that was dramatically and irrevocably reversed with the widespread use of chemical fertilizers, pesticides, and electrically driven irrigation.

Plotted on the graph is productivity in U.S. corn production (in bushels per manhour) and work flux density, shown by the dotted line in bushels per acre per growing season, and shown by the solid line in Btu's of energy applied per corn acre per growing season.



form of our equations, given in Equation 1″. As the shock wave begins to form, and the natural energy-concentrating mechanisms in the system create a condensation of energy in a self-feeding way, the second term in Equation 1″ becomes larger and larger. Now, this term, depending on its precise geometrical characteristics, can be expanded in several ways:

$$(\partial/\partial t + u\,\partial/\partial x)S' = 0 \qquad (7)$$

$$(\partial/\partial t + i\,\partial^2/\partial x^2)S' = |S'|^2 S' \qquad (8)$$

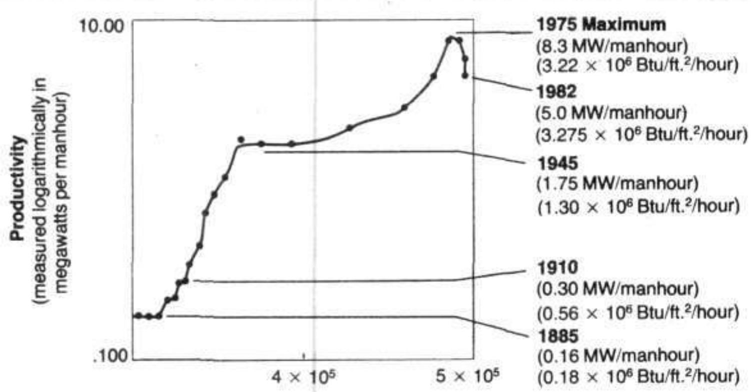
$$(\partial/\partial t + S'\partial/\partial x)S' = -\partial^3/\partial x^3 S'. \qquad (9)$$

The first of these is Equation 1″, whose characteristic singularities are shock waves. However, this is not the only kind of singular behavior that might result. Equation 8, also called the nonlinear Schrödinger equation, describes a singularity in which the energy of the system is concentrated into collapsing blobs called *cavitons*. These singularities are the one-dimensional analogue of diffraction in the propagation of a high-intensity optical disturbance. Equation 9, the Kordewieg-deVries equation, supports a self-sustaining concentration of energy, called a *soliton*, which can propagate indefinitely with undistorted shape. Depending on the changes induced in the functional dependence of u on S′ as the system concentrates its energy (or in physical terms, changes in the equation of state), any of these different outcomes is possible.

In each of these cases, the presence of essential singularities along almost all trajectories is evidence of the structure-making qualities of singularities. That is, the presence of a singularity indicates a qualitative change in the laws governing the system; the quality of this change in general increases the structure of the system. In the case of shock waves, this structure is *dissipation dominated*; for the nonlinear Schrödinger equation, the structure is *diffraction dominated*; and in the case of the Kordewieg-deVries equation, it is *dispersion dominated*.

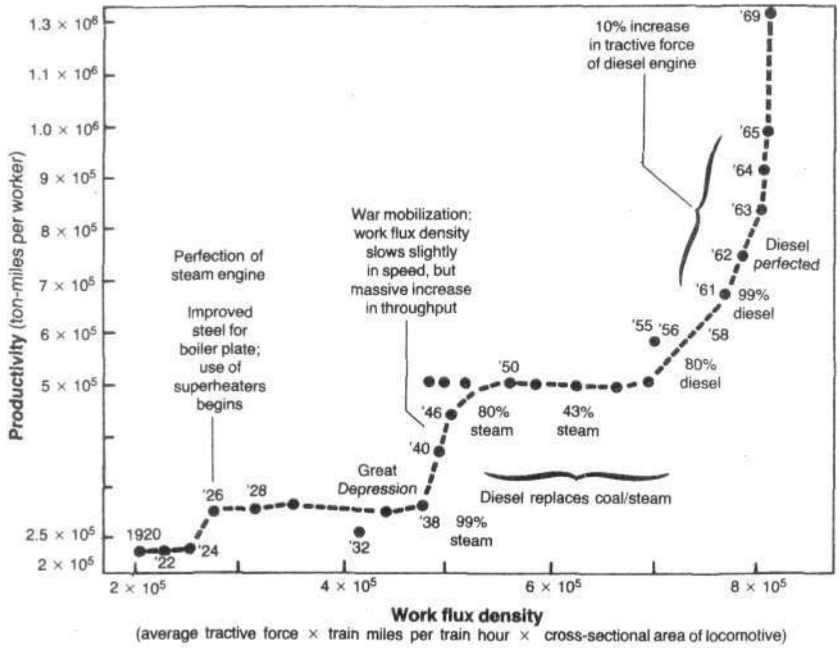
The impact of any of these singularities is felt by a economic system even if that system does not directly encounter the singularity. As Riemann demonstrated, the global long-time evolution of any system is determined by the singularities that exist in that manifold; the overall structure of economic space is determined by the various singularities that are inherent in the dynamical equations describing

Figure 13
WORK FLUX DENSITY AND PRODUCTIVITY FOR U.S. ELECTRICITY PRODUCTION, 1885-1982



The electrical production industry has undergone a series of qualitative steps that are quite dramatically shown in the figure, increasing overall productivity by a factor of 10. The same pattern of accelerating returns on investment appears until the effects of the oil price rise are felt. At this point, an actually destructive investment policy is established based on government subsidies to net-energy-consuming energy technologies (like solar electric production) and to suboptimal large-scale investment (coal rather than nuclear). The consequent loss of overall efficiency in the economy appears in the utility industry itself as a falling productivity, even in the face of marginal increases in the scientific level of the technologies being implemented. As we show, there is a certain minimum rate at which scientific progress must occur for a economy (or sector) to survive.

Figure 14
WORK FLUX DENSITY AND PRODUCTIVITY FOR U.S. RAIL TRANSPORTATION, 1920-1962
The productivity (in ton-miles per worker) plotted against the work flux density for rail transport (average tractive force times train miles per train hour times cross-sectional area of locomotive) shows the gradual impact of the development and implementation of diesel-electric engines. The perfection of the steam locomotive is superimposed on this development up until 1940, after which the accelerating percentage of diesel engines dominates the industry.



economics. Even if a given economy does not enter into a shock state, its evolution has been shaped by the singularities. In economics, the implications of this more general methodological result derive from the conditions in Equations 1′ and 2′ that result in a shock wave. These conditions for the formation of a shock wave are threefold:

(1) Economic progress in terms of advancing values of x is achieved (see Equation 5) within the existing group of technologies. That is, there is *continuous* progress within the existing technologies.

(2) Productivity is increasing relatively slowly and continuously. No qualitatively new technologies are introduced.

(3) There is no coupling between Equation 1′ and 2′. This results mathematically from the relatively slow growth of productivity that is caused by the perfection (as opposed to the introduction) of a given technology. In economic terms, the cumulative result of these conditions is expressed by the appearance of declining returns on investment, a necessary result of any fixed technology. Figure 10 shows the typical relation between productivity and scientific progress within a given technology, x. This graph, based on historical data for the iron-making industry in the United States from 1880 to 1920, demonstrates that the introduction of a new technology affects economic productivity in two distinct ways: The initial period of use of the new technology shows a dramatic increase in productivity with relatively small increases in scientific level (see Figure 11 for a discussion of the measurement of scientific level by a measure of work flux density). This almost explosive initial growth is followed by a leveling off of the productivity increases associated with the technology, in a period of declining returns on investment. It is this period that Forrester and the Malthusians describe as the dominant feature of capital investment.

The historical significance of these declining returns on investment is not, however, correctly imputed by the Malthusians. Figure 11 shows the historical context for the technological evolution shown in Figure 10; actual economic history is a sequence of such technological changes, each of which is characterized by rapid productivity increases followed by declining returns on investment. The conditions on Equations 1′ and 2′ that lead to the formation of a shock wave occur only in the second phase of this evolution, during which declining returns on investment dominate the productivity-scientific level relation.

HOW TO ACHIEVE SUCCESSFUL ECONOMIC GROWTH

From the standpoint of economic science, two questions must be answered. First, what causes declining returns on investment, and second, can an economy overcome these "limits" to growth implied by stagnation in technological development: Is the Malthusian predicament a permanent one?

A detailed examination of the historical determinants of the technological evolution shown in Figure 9 for the iron-making industry, in Figure 12 for corn growing, Figure 13 for electricity production, and Figure 14 for rail transport, demonstrates quite convincingly that this sequence of concave curves is of systematic significance in economics. In each of these cases, the cause of the onset of declining returns on investment is the impending exhaustion of the resource base on which the technology depends.

In the case of the iron-making industry, for example, the first discontinuity is caused by the rapid depletion of wood as source of carbon for reduction of iron ore. It is *not* the case that the forests of the United States were completely chopped down (although this was certainly a local problem) but rather, that a further increase in productivity required higher temperatures in higher velocity and volume furnaces. These changes were technologically excluded for wood as long as wood was the primary energy source for iron making. There was not enough energy density potential in wood to increase productivity. Similar historically conditioned considerations define jumps in all of the curves in Figures 10 through 14. It is critical to note that the depletion of resources required for each level of technological development does not appear directly as declining resources, but rather as *declines in the ability of that technology to supply ongoing productivity increases for that industry*.

In the case of the electrical production industry (Figure 13), the relation between these technological innovations and resource depletion is particularly clear. Especially important are the last two jumps in productivity resulting from the introduction of superefficient coal combustion and nuclear power cycles. Figures 15 through 17 show the machinery responsible for the increases summarized in Figure 13. These machines generated the curve in Figure 13 by increasing efficiencies, higher temperatures, and higher flow rates, creating new resources sufficiently quickly to "jump over" the limits to growth implied by the declining returns on investment in then existing technologies.

New technologies have a dual significance in economic evolution: On the one hand, they increase productivity and in so doing directly influence economic growth. Without this, new technologies would not be "economical." On the other hand, they create new resources by defining new processes with new raw materials and higher energy flux densities, which then turn previously unusable inputs into "ore." Aluminum is an outstanding example of a "natural resource" that was very rare until the development of electricity provided a technology and a dense enough source of energy to make this natural resource available.

Overcoming 'Limits' to Growth

The second question—Can an economy overcome the "limits" to growth implied by stagnation in technological development?—is more difficult. Since humanity does exist today, with a world population and consumption level many times that of any previous period, Forrester and his "limits to growth" cothinkers are certainly wrong. But economic science must explain the unique capabilities of the human species for successful economic evolution and the ability to overcome the supposed limits of a finite resource base.

Economic progress is certainly not preordained or necessary, since it is true that any society is, in the end, free to destroy itself. There are rigorously determinable conditions that an economy must meet if it is to survive, and as we have indicated, these conditions require growth in both a qualitative and quantitative aspect.

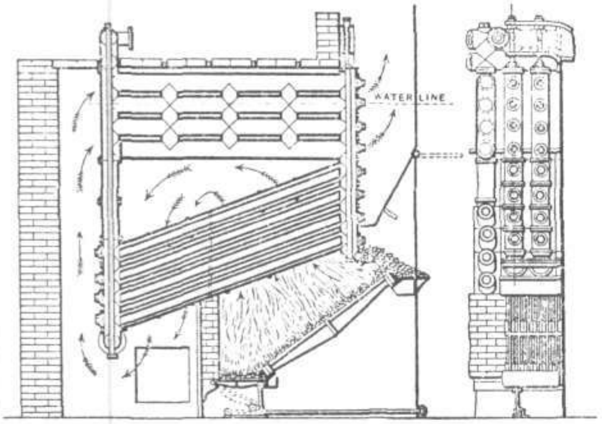
First, a certain rate of quantitative expansion is necessary. Economic progress is nonlinear in that there is a close relationship between the size of an economy and its level of development. A modern industrial society cannot be maintained by an overall population size (and corresponding division of labor) less than several billions of people. And, on the other side, this size of population could not itself be sustained by any lower level of economic efficiency. There is an exponential relation (within these upper and lower constraints) between population potential and population size.

Second, a certain rate of qualitative change or propagation in x, scientific level, must be maintained if the degenerative effects of the *"entropy condition" are to be outrun*. Whether these appear directly in the form of falling or stagnating productivity, or indirectly in the form of declining returns on investment or increasingly scarce resources, only qualitative change in the mode of economic reproduction can succeed in ensuring continued growth.

These two criteria are closely intertwined.

Figure 18 shows the characteristics for an economy not meeting these criteria and tracing out a course of economic devolution. The first phase shown is a classic shock wave. In the case of insufficient growth, a precisely quantifiable condition, the trajectory of the shock front progressively decelerates, the total size of the economy decreases, and the economy quickly disappears. The significance of the singularity in this case is totally negative.

The alternative economic course is illustrated in Figure 19. Here there are four distinct regions of behavior. After



Courtesy of Babcock & Wilcox

Figure 15
ORIGINAL BABCOCK & WILCOX BOILER (U.S.), 1867
The boiler is the most critical component of a heat-powered engine in terms of energy. The boiler does not, as Lazare Carnot pointed out, **produce** *energy; it provides for the motion of heat energy (Carnot called it the caloric energy) from a heat source to a cold sink. Carnot emphasized that the* **movement** *of heat energy was key, and that this depended on the difference between the temperatures of the heat source and the cold sink. The first industrial boilers, as shown here, used a nest to horizontal cast-iron tubes at the top in place of the earlier steam-and-water drum.*

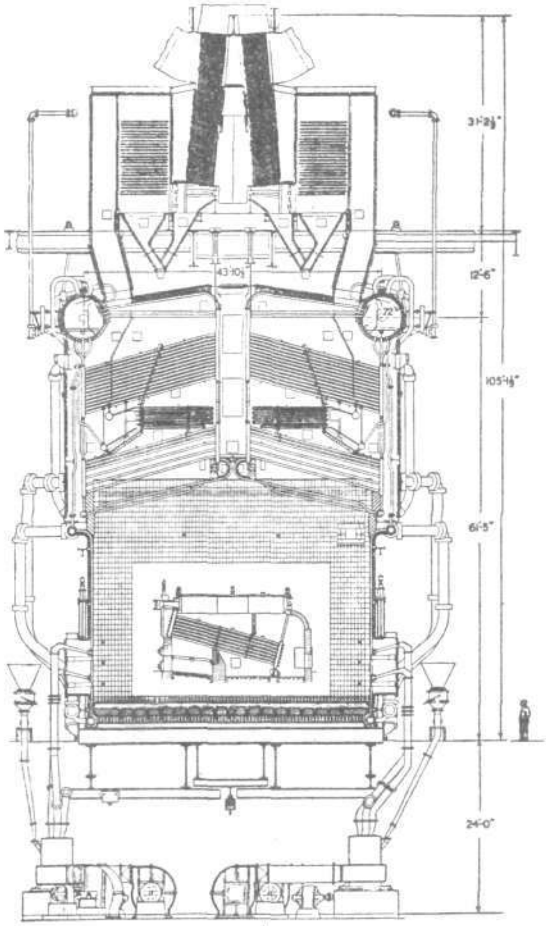


Figure 16
BABCOCK & WILCOX BOILER (U.S.), 1930
The next generation of boilers removed the internal tubes and changed the materials from cast iron to wrought-iron. However, the greatest improvements occurred in scale. The boiler from Figure 15 is superposed at the center of the picture, where it is seen to easily fit in the fire box of the more modern boiler. The boiler shown here is from the Hell Gate Station (New York) of United Electric Light and Power.

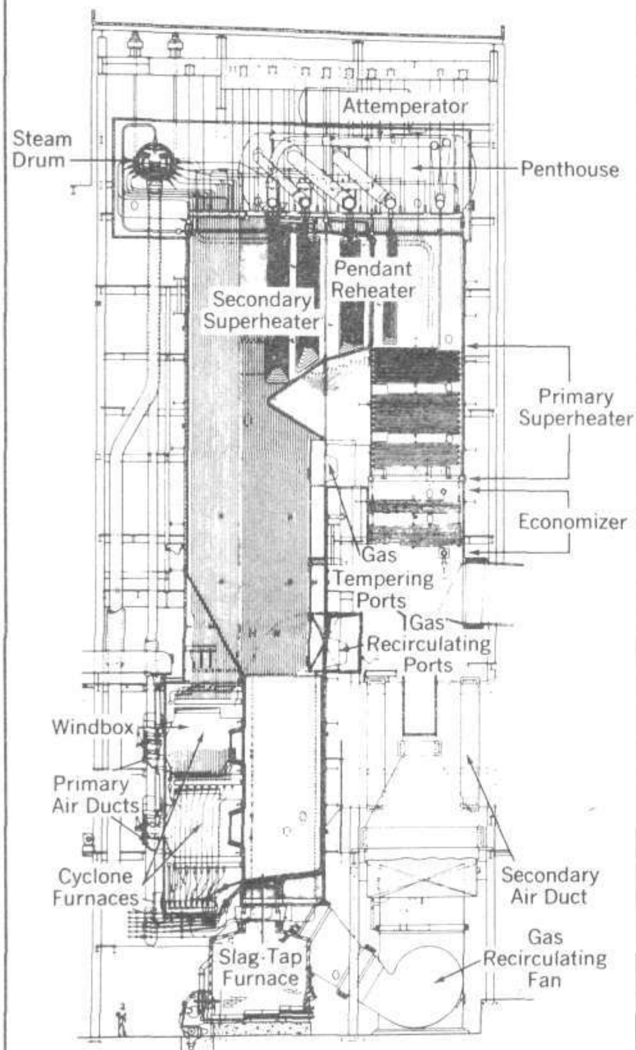


Figure 17
MODERN REHEAT BOILER (U.S.), 1960
This 1,300-megawatt-electric boiler shows the typical geometry of pipes and valves in a modern boiler, designed to use as much of the heat as possible from the coal. This is a radiant boiler for pulverized coal firing. Multiple recycle of steam, preheat of water, and the like have raised the efficiency of a modern steam boiler in converting heat into electricity to almost 40 percent.

the formation of a shock in the region marked 1, the growth rate exceeds the minimum required and a slowly accelerating shock front appears. This acceleration takes the economy through a region dominated by virtual investment (in region 2) into region 3 in which there is a sudden acceleration resulting from the introduction of a new technology (see the graph of δ versus x in Figure 19b).

As this hypothetical example shows, there are three distinct components of successful evolution:

(1) $u_1(S'[x,t])$: Here, u_1 as a function of S′ (and hence, of x and t), is the velocity with which the economy moves at (x, t). Its functional dependence on S′ is determined by the investment decisions made at that time, specifically by the proportion of S′ that is "net investment." In our examples, we assumed a given functional relation between S′ and u, as that which characterizes an economy like Japan's in which there is a very tight, constant investment strategy for technology innovation.

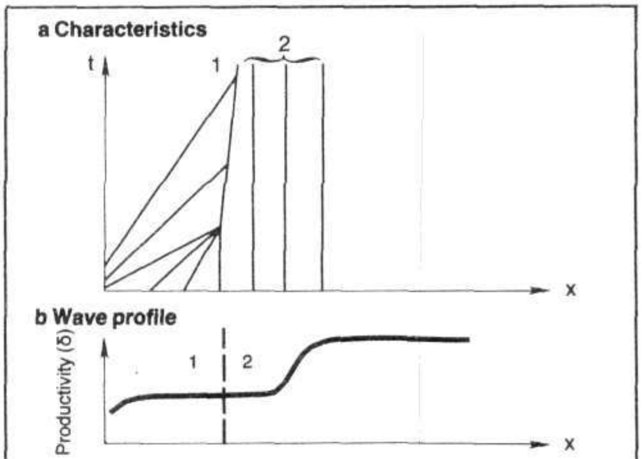


Figure 18
CHARACTERISTICS FOR AN ECONOMY FAILING TO SURVIVE SHOCK FORMATION

The two regions typical of an economy that is not progressing "fast enough" are shown in this figure. In region 1, the economy experiences a "limits to growth" shock wave and, because of insufficient rates of growth, stagnates after the shock formation. The solution (and the economy) now become subject to the entropy condition, and the economy collapses.

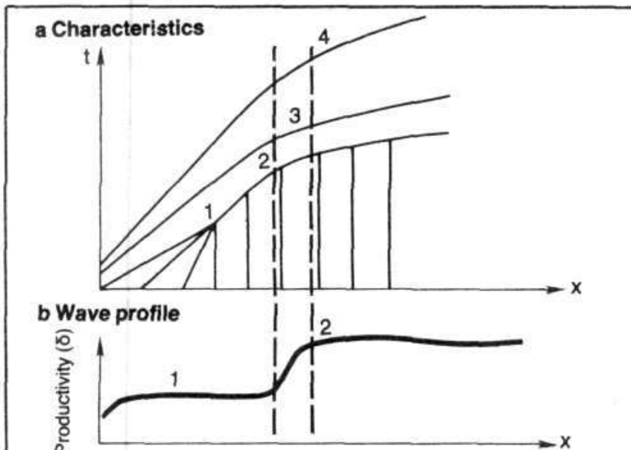


Figure 19
CHARACTERISTICS FOR AN ECONOMY MAKING A SUCCESSFUL TRANSITION PAST A SHOCK SINGULARITY

If sufficient rates of growth can be maintained, then an evolution is possible that contrasts totally with Figure 18. In region 1, a shock wave forms, but the growth rate of the economy is large enough that the shock wave results in an acceleration of the economy (shown in region 2). The forward motion of the economy pushes the economy into the implementation of a qualitative new technology (region 3) and the acceleration from its use (region 4). The forward propagating economy then sweeps up formerly quiescent characteristics at the shock front in a cascade of absorbed shock waves.

Such a relationship need not be constant. Indeed, the most direct way of changing a trajectory like that of Figure 18 into that of Figure 19 is to change investment strategies!

(2) $\alpha(\delta-\gamma)S'$: The qualitative expansion of the economy, reflected in positive values for this product, increases S' and so increases u (as long as the condition holds that u increases with increasing S'). This term is responsible for the gentle bending of the characteristic in Figure 19.

(3) $(\dot{\delta}-\dot{\gamma})V$: The qualitative change of an economy is captured in this term as the product of the rate of change of productivity. This is a function of x since

$$\dot{\delta} = d\delta/dt = \partial\delta/\partial t + u_1\partial\delta/\partial x$$

and the size of the work force is also a function of x through Equation 2". This term includes the following effects:

Increasing productivity. Progress requires technological innovation, which is reflected in increasing productivity. The relation between δ and x shown in Figures 11 through 14 means that the economic impact of increases in x depends very sensitively on the degree of maturation of a given technology. It is, of course, possible to smooth out the actual impact of an investment policy so that the jumps in this technologically determined relation are avoided. (See Figure 5 and Figure 10 for a comparison of the Japanese and U.S. data for the iron industry.)

A work force capable of utilizing technology. V, a measure of tangible consumption of the work force, is a function of x because there exists a range of skill levels in the work force each of which can be assigned the value of x for the machinery (or capital investment) that it sets in motion, or is capable of setting in motion. That is, V is a function of x as determined by its consumption, not its production or distribution. Hence, this third component of the source term in Equation 1" is only significant if at the scientific level, x, at which it is being evaluated, the level of implemented technology corresponds to a new technology with large rises in productivity, δ, *and*, there is a work force of adequate size and quality to utilize this technology.

Both $\dot{\delta}(x)$ and V(x) must be simultaneously not zero. When their product is large, an economy can undergo the sort of hypershock shown in region 3 of Figure 19. The achievement of such a state requires not only u_1 for its realization but also suitable overhead, γ, and V for that value of x.

The basic texture of economic progress is determined by the intersection of these investment processes and must satisfy precise conditions on the quantitative growth and qualitative change in the economy if the population potential of the economy is to rise.

Shock Formation in the U.S. Economy, 1870-1970

A study of the past 100 years of the U.S. economy provides a test data base for the application of the new generation of the LaRouche-Riemann model. Figures 20 through 22 show graphically the results of this study. Figure 20 shows the time history of the U.S. economy in the usual terms of economic reference: The curve of total investment, S', is

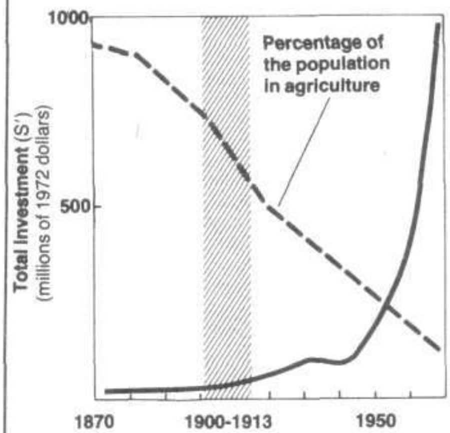


Figure 20
GROWTH OF U.S. ECONOMY,
1870-1970

The tangible profit (S') produced in the United States during this period seems to have grown uniformly, with the exception of the 1930 depression. The internal structure of this growth indicates, however, the fundamentally different significance of the 1900-1913 period. The percentage of the population engaged in agriculture drops uniformly (dashed line).

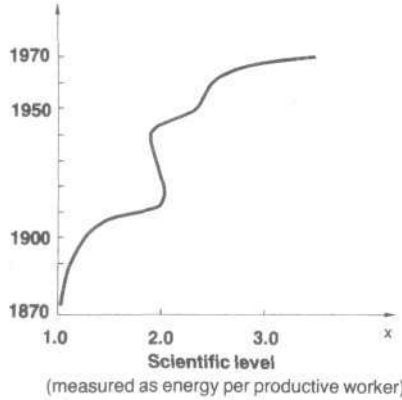
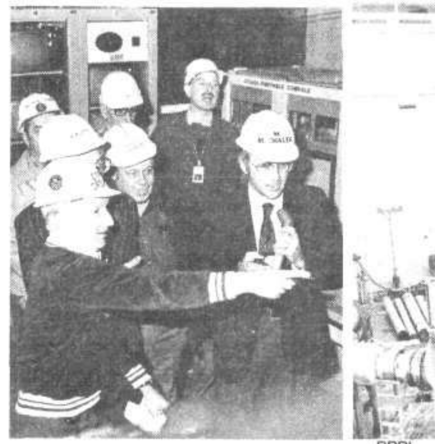


Figure 21
TRAJECTORY OF THE U.S. ECONOMY,
1870-1970

The trajectory of the average enterprise in the United States shows its rate of progress in the direction of scientific level, x—measured here as energy per productive worker—as a function of time. The periods of rapid growth and progress are almost horizontal, and the depression of 1930 appears as a regression in x. Note that the plateau of 1900-1913 is shown to be a shock formation period.



PPPL

Economic health depends on a rapid rate of scientific development, assimilated by a work force that is growing in size and skill levels. Over the last 30 years, this process has stagnated in the United States. The fusion program, for example, which could provide unlimited energy and open the door to advanced plasma technologies, has been put on a go-slow track. Here, the team of fusion scientists and engineers at the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory.

shown and appears to increase exponentially with a small perturbation during the 1930s. The percentage of population in agriculture drops almost uniformly; but the energy consumption per capita rises in a less uniform way.

In a crude approximation to an adequate data base, we will use energy consumption per capita to measure the scientific level of the economy, x, and use the data in Figure 20 to plot the trajectory of the "average" level of the economy—ignoring the distribution of scientific level of the economy that a pulse would show. In Figure 21 the "characteristic" for a rough average of the economy is shown. There are several striking aspects to this graph:

First, the period from 1860 to 1880 is almost stagnant, indicating that the first, simple shock wave has not formed. That is, the economy is propagating, but a shock front has not formed and so the "front" of the pulse does not move.

Second, a shock wave forms sometime during the 1880s, but there is insufficient growth for propagation at a constant or accelerating rate; instead, the trap of von Neumann's kind of growth appears.

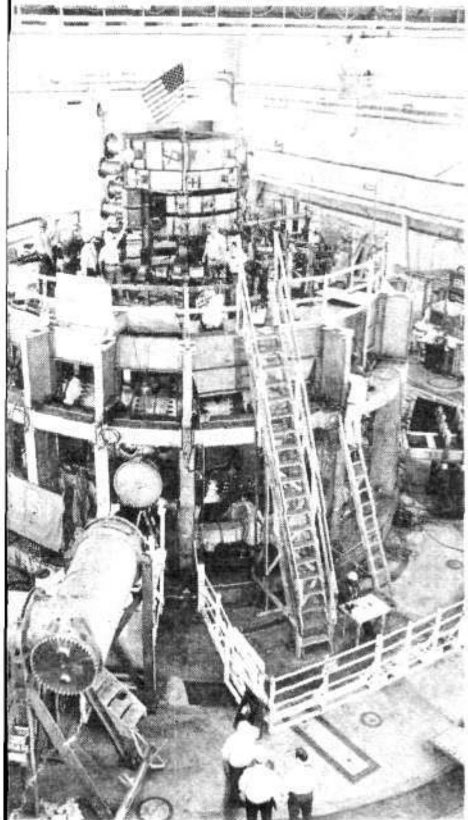
Third, between 1900 and 1915, a dramatic increase in the velocity of propagation occurs, during which the economy progresses at an accelerating rate. The growth conditions noted above for successful propagation in a shock state have been met (for reasons we shall see below).

Fourth, the impact of World War I in depressing the economy continues almost without interruption to the end of World War II, as the recovery of the 1920s is shown to be superficial in energy and scientific development terms.

Fifth, two abortive shock waves of the 1900-type appear, the first in the early 1950s, and the second during the NASA period of the early 1960s; but neither induces the sort of changes seen in the 1900-1915 period.

Figure 22 shows the underlying geometry of this process by graphing productivity against scientific level, x. Here we see that the only period with the rapid change in this relation indicative of a shock wave of the second kind occurred in the 1900-1915 period, coincident with the introduction of electricity on a wide scale. The massive qualitative change in the economy induced by electricity is exemplary of the sort of technological change measured by the model, and it has occurred only once in the past century with the introduction of electricity. The successful assimilation of this technology required two conditions to be met: First, the technology of centralized electricity production and distribution had to have been developed. This was accomplished by 1883 with Edison's Pearl Street Station and his conception of high impedance loading, and was implemented on a wide scale starting in the late 1890s. Second, a work force had to be created capable of using the new technological revolution. An examination of the rural-to-urban shift shows that the time of largest migration occurred exactly during the first 10 years of the 20th century. It was the combination of these events that created the situation of the shock wave of the early 1900s.

This analysis is corroborated by an examination of the relation between S' and u, shown in Figure 23. Here is a measure of the "nonlinearity" of economic evolution, and



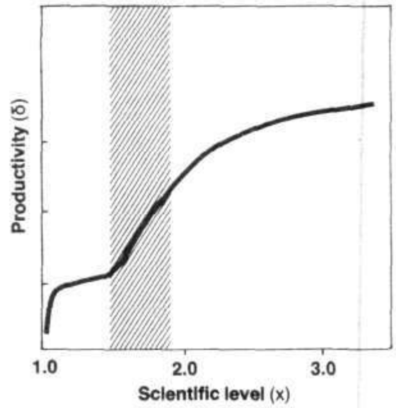


Figure 22
PRODUCTIVITY AND DEVELOPMENT IN THE UNITED STATES, 1870-1970
The significance of the 1900-1913 period appears here where the onset of shock conditions is evident from the very rapid rise of productivity with energy use. This rise results from the qualitative change brought by the introduction of electricity—a change that corresponds mathematically to a shock wave.

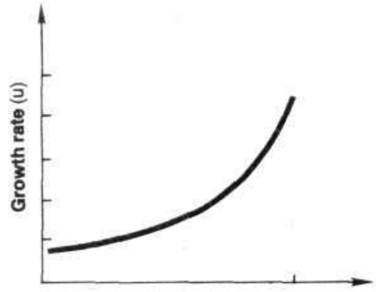


Figure 23
NONLINEARITY OF THE U.S. ECONOMY, 1870-1970
The empirical dependence of u on S' during periods of growth shows a highly nonlinear relation, with u going as S'^2. This relation indicates a series of investment decisions that were strongly driven by advancing technology and the productivity increases brought by these advances. This relation is characteristic of a rapidly growing economy with high depreciation rates.

an estimate of the interrelation between investment strategy and the real economy. The points given, taken from the points at which the economy was growing, show a very sensitive dependence of velocity on S', a measure of the tendency for investment to be concentrated in the sectors of highest productivity and scientific advancement.

The implications of this history for the current economic depression in the United States are clear:

(1) Economic health depends on a rapid rate of scientific development.

(2) The direction and pace of scientific development and its transmission to industry are dependent not on the market but on the development of specific inventions and the introduction of those most advanced inventions into the economy—a process that can be fostered as the Japanese have done, or hindered as has been the case in the United States for the past 30 years.

(3) Increasing amounts and skill levels of manpower are ultimately the rate-determining step of economic growth. More people, and more people of higher skill levels will be urgently required to provide for long-term growth in the United States.

Steven Bardwell is editor-in-chief of Fusion *magazine, and Uwe Parpart Henke is research director of the Fusion Energy Foundation. Since 1979, they have directed the overall economic research on the LaRouche-Riemann model, and they have both written and lectured widely on the economics of growth.*

Notes

1. Originally published as "Uber ein Okonomisches Gleichungssystem und eine Verallgemeinerung des Brouwerschen Fixpunktsatzes" in *Ergebnisse eines Mathematischen Seminars*, edited by K. Menger (Vienna: 1938). An English translation appeared *The Cambridge Review of Economic Studies*, No. 1, 1946.
2. *The original "limits to growth" study was conducted for the Club of Rome* under the direction of Dennis Meadows at the Massachusetts Institute of Technology, using the global model of MIT's Jay Forrester, based on his "systems dynamics." A popular version of this study was published by the Potomac Associates in 1972, *Limits to Growth*, by Donella H. Meadows, Dennis L. Meadows, et al.
3. See "Infrastructure: The Key to U.S. Productivity" by Steven Bardwell, "The LaRouche-Riemann Model Charts a Path for Industrial Growth" and "NAWAPA Could Revive the Economy" by Sylvia Barkley, in *Executive Intelligence Review*, April 6, 1982, p. 48.
4. Thomas Malthus, *Principles of Political Economy* (1836), reprinted by Augustus M. Kelley (New York, 1964).
5. Arnold Toynbee, *The World and the West* (New York: Oxford University Press, 1953), pp. 48-49.
6. A detailed discussion of the higher-order of physical space that shapes the characteristic form of transformations seen in visible space can be found in part two of Lyndon LaRouche's "Systems Analysis: White Collar Genocide," *Fusion*, Nov. 1982, p. 9. LaRouche discusses how Kepler started from the fact that visible space is characterized by the case of only five uniquely regular polyhedral solids. Once he showed that only five Platonic solids can be constructed in Euclidean space, the space of vision, he then proved that visible space is not an adequate representation of physical space.
7. *A good example of Klein's approach can be found in Felix Klein, On Riemann's Theory of Algebraic Functions and Their Integrals* (1881), reprinted by Dover (New York, 1963).
8. Bernhard Riemann, "On the Propagation of Plane Air Waves of Finite Amplitude," translated by Uwe Parpart and Steven Bardwell in the *International Journal of Fusion Energy*, Vol. 2, No. 3 (1980).
9. The question of net versus virtual investment is discussed in LaRouche's "What Are Economic Shock Waves?" which appeared in two parts in the *Executive Intelligence Review*, Dec. 7 and Dec. 14, 1982.

Pesticides and People

How Environmentalist Politics and Bad Journalism

The antipesticide lobby today commands the headlines but not the scientific facts. This case study of how DDT was banned for political reasons shows how the lies start and how the media perpetuate them.

FORTUNATELY, THE PUBLIC is developing an awareness of just how ridiculous much of the antichemical propaganda has become. Thus, people are continuing to drink beer, wine, coffee, tea, and hot chocolate, which the scaremongers claim are loaded with carcinogens. They don't worry much about eating yogurt, even though 100 percent of the rats on pure yogurt diets developed cataracts. They ignore the potent cancer-causing aflatoxins known to occur in peanuts, cottonseed oil, and some cornbread; the mercury in seafood; and the abundant nitrosamines they will accumulate from eating leafy green vegetables. They still eat barbecued steaks and fried hamburgers without much fear of the active carcinogenic benzopyrenes present in such meals. They enjoy foods and beverages containing saccharin, amused by the warning labels on the containers and in the store windows.

Why?—because most people now realize the great disparity between the dosage rates that are forced on exper-

Banned DDT by Dr. J. Gordon Edwards

imental rats and the infinitesimal traces of such substances that might be encountered in the environment or in their daily diet. Obviously what happens to those overdosed rodents should not cause any great concern about traces of the same chemicals in human diets. The same is true of traces of food additives, preservatives, and pesticides. Every chemical becomes toxic at high enough doses, and even the most hazardous substances are harmless if present at sufficiently low concentrations.

Because some government agencies, many pseudo-environmentalists, and even a few scientists have been guilty of making up or perpetuating scare stories about chemicals, many people have reached the point of not knowing whom or what to believe. Organizations of concerned scientists and nutritionists have been formed to publicize the truth about these controversies. These scientists are especially perturbed because so many unreasonable restrictions on pesticides and additives have been based on political rather than scientific considerations.

The major obstacle to the dissemination of truthful, factual information about nutritional and environmental matters has been the apparent bias of much of the news media. The press is eager to publicize "kooky" views, while refusing to report well-documented data provided by qualified authorities. Why have they given such great credence to amateurs, charlatans, and antiestablishment radicals, while routinely ignoring the protestations of leading scientists? Is it perhaps because they have an instinctive dislike for "big business," industry, agriculture, and most academic scientists, or were they simply "taken in" so completely by the propaganda that they neglected to investigate the wild claims made by the radicals? Whatever the reasons, unless the media begin to seek out and publicize the truth about environmental matters, there will be much less pleasure and plenty in our future here in America, and many of the most vital humanitarian programs in Third World nations will be prematurely halted.

How the Lies Were Started

Rachel Carson got things stirred up with her 1962 book, *Silent Spring,* which is replete with false and misleading statements. Carson's deception began on her very first page when she wrote: "Dedicated to Dr. Albert Schweitzer, who said 'Man has lost the capacity to foresee and to forestall. He will end by destroying the earth.' "Carson *knew* Schweitzer was referring to atomic warfare when she quoted this, yet she implied that he meant that DDT or other insecticides were endangering the earth. How did Schweitzer really feel about such chemicals? In his autobiography he wrote, "How much labor and waste of time these wicked insects do cause us . . . but a ray of hope, in the use of DDT, is now held out to us" (page 262).

To take another example, Carson wrote that ". . . Like the robin, another American bird seems to be on the verge of extinction." Yet, the robin was never endangered. Roger Tory Peterson, America's leading ornithologist, also writing in 1962, in the *Life Nature Library,* cited the robin as the most abundant bird in North America. Surely there is no doubt as to who was correct. In addition, the Audubon Society's annual bird counts revealed that robins became much more abundant throughout the years of heaviest DDT use.

Then there is the case of the false allegation that DDT inhibits bird reproduction. Carson wrote: "Dr. DeWitt's now classic experiments [on quail and pheasants] have established the fact that exposure to DDT, or related chemicals, even when doing no observable harm to the parent birds, may seriously affect reproduction. . . . Quail into whose diet DDT was introduced throughout the breeding season survived and even produced normal numbers of fertile eggs. But few of the eggs hatched."

J.B. DeWitt's article (*Journal of Agriculture and Food Chemistry,* Vol. 4, No. 10, 1956), however, actually had yielded a very different conclusion. The quail to which Carson referred were fed 200 parts per million (ppm) of DDT in all their food throughout the breeding season. DeWitt's table shows that these birds hatched 80 percent of their eggs, compared with his "control" birds, which hatched 83.9 percent of their eggs. Certainly this was not a significant difference, and *who* would consider an 80 percent hatch as being "few" of the eggs? Human beings at that time, it should be noted, were ingesting 0.03 ppm of DDT in their food, so DeWitt's quail food contained 6,000 times as much DDT as ours. In fact, since quail eat much more food in comparison to their body weight than people do, DeWitt's quail were actually producing good eggshells while ingesting 20,000 times more DDT per kilogram of body weight than people.

Incidentally, DeWitt's pheasants were not even men-

DDT—The Facts

USDA

DDT, dichloro-diphenyl-trichloroethane, belongs to the family of pesticides known as chlorinated hydrocarbons. Its technical name is 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl) ethane ($C_{14}H_9Cl_5$).

Although its half-life (decay time) in soil is seven years, on fruits and vegetables it is only days. For example, for lettuce, 2 days; peaches, 10; clover, 13; alfalfa, 6; citrus fruit, 35.

DDT is a contact insecticide that, by penetrating the external body surface (the cuticle) of the insect, acts as a nerve poison and kills rapidly. Its leading effectiveness in malarial eradication programs is the result of its residual activity vis-à-vis its continuous activity on the body of the insect.

In addition to its antimalarial effectiveness, DDT is also effective in controlling louse-borne typhus, plague, and urban yellow fever—diseases that have been the most important epidemic diseases throughout history. DDT also controls more than 20 other significant diseases, especially in underdeveloped countries.

DDT has a major effect on controlling crop losses caused by insects. The importance of this loss can be seen in the following figures. For Central America, South America, Africa, Asia, and Europe, crop losses because of insects are: cotton, 18 percent; rice, 39 percent; grain, 5 percent; corn, 17 percent; vegetables, 10 percent; and sugar cane, 40 percent. In addition, it is estimated that agricultural production increases as much as 40 percent where malaria is controlled.

The crop gain from DDT is phenomenal. Quoting from Wayland J. Hayes, Jr. in *Toxicology of Pesticides* (Baltimore, Md.: Williams & Wilkins Co., 1975):

"When DDT was introduced, there was an unprecedented increase in the production of those crops on which it was used, and the increase corresponded to the degree of its use. Crops such as cotton, peanuts, and potatoes, on which pesticides are used most extensively, showed gains ranging from 68 to 119 percent. The production of alfalfa seed increased from 300 to 600 percent in states where the crop was treated intensively with insecticides, but remained essentially stable in states where the crop is raised for hay and, therefore, receives little treatment with insecticides."

tioned by Rachel Carson, but his table showed that the "control" pheasants hatched only 57 percent of their eggs while those that ate 50 ppm of DDT in their daily diet for an entire year hatched more than 80 percent of their eggs. Chick survival was also much better in the DDT-fed birds (100 percent) than in the "controls" (94.8 percent). No wonder Carson avoided mention of these data, which were on the same page as the quail data she emphasized! She wanted her readers to think that there would be no more quail or pheasants around if traces of DDT got into their food, even though all scientific data disproved this thesis.

Pseudoenvironmentalists made great use of Carson's wild claims and collected millions of dollars in donations from people they frightened with her stories. They predicted mass die-offs of the bird population; they said that DDT would never be eliminated from the environment; and they charged that DDT causes cancer. Their activities in promoting these lies have already cost mankind billions of dollars in increased expenditures for food and fiber; have resulted in millions of acres of devastated forests that could otherwise still be healthy; and have adversely affected birds, fish, wildlife, beneficial insects, and many other forms of life. And in the Third World, there have been incalculable losses in human potential caused by the debilitating diseases that DDT is capable of bringing under control.

Fortunately, a great many people in responsible positions were not taken in by Carson's allegations. As a leading British scientist commented recently in a speech to the British Agro-Chemical Association, "If there *had* been a world ban on DDT, then Rachel Carson and her book, *Silent Spring,* would now be killing more people in a single year than Hitler killed in his whole holocaust." (Of course, since the National Audubon Society, the Sierra Club, and other pseudoenvironmental organizations are still actively striving to ban DDT overseas via court actions and congressional bills, we may see an anti-DDT holocaust yet.)

Other persons followed Carson's lead, and were accorded adulation by the ecoradicals and the gullible news media. To take one example: In a letter to the Richmond, California *Independent* March 29, 1969), one Marc Lappe wrote, "DDT cannot be destroyed by living things . . . and can be recycled indefinitely throughout the planet." Scientists laughed at his statements, but the media believed them and have repeated them for years. I immediately typed up a list of more than 150 scientific articles that documented the breakdown of DDT by living things, which did not even include the obvious examples of DDT-resistant insect pests. I then sent copies to dozens of radio stations, newspapers, and TV stations. Not a single media source ever made reference to these articles or modified their earlier false statements about DDT's persistence.

The Myth of the Extinct Birds

For 18 years since Rachel Carson's *Silent Spring,* we have been reading in the newspapers that DDT was killing off our birds, even though every comparative count of

United Nations

"It is estimated that in a little more than two decades, DDT has prevented 500 million deaths that would otherwise have been inevitable"—The National Academy of Sciences. Here DDT spraying in the Philippines.

overall bird abundance revealed more *increases* than decreases during all the years of greatest DDT usage. But the media were not impressed by these increases unless the birds blackened the sky, devastated crops, and broke down the trees in which they roosted. The myth of bird declines was repeated endlessly in the ecoindustry trade journals, the newspapers, and electronic media, even though not supported by any data. The false claims have become so deeply entrenched that now they are even appearing in textbooks at every educational level. The propaganda has been especially outrageous with respect to bald eagles, peregrine falcons, ospreys, and brown pelicans. An extensive discussion of each of these species of birds completely dispels the pseudoenvironmentalists' claims. Scientists have prepared those discussions, and they are available to the media.

To take just one example and discuss it briefly, let's look at the facts concerning the brown pelican. In the early 1970s, the U.S. Fish and Wildlife Service issued bulletins and gave speeches in which they stated that "50,000 brown pelicans disappeared from the Texas and Louisiana coast since 1961." In 1971 congressional testimony, I pointed out that in 1918 the numbers of brown pelicans along the entire Gulf Coast was "about 65,000 birds," and "not to exceed 5,000" on the Texas Coast. This had been well documented in T. Gilbert Pearson's article in *National Geographic* (March 1934). Dr. Robert Allen, the Audubon Society president, who had collaborated with Pearson in 1918, repeated the survey in 1934, and he found only 900 pelicans in Texas—more than 82 percent of the population had disappeared prior to any use of DDT! Pelicans declined even more, until fewer than 300 existed along the entire Texas coast by 1942, according to the bird journals such as *Auk, Condor,* and *Bird Lore*.

Since it is axiomatic that "causes" must precede their "effects," it is of course unlikely that the pelicans declined *in anticipation of* DDT usage. Yet, the antipesticide groups allege that DDT exterminated thousands of pelicans along the Texas coast, even though their own literature of 1940 to 1980 refutes that wild claim.

After reading my testimony, U.S. Fish and Wildlife pelcan specialist Robert Finley wrote to Congressman W.R. Poage, chairman of the Agricultural Committee, to revise his earlier statement that 50,000 brown pelicans had disappeared along the Texas and Louisiana coast since 1961. Finley admitted, "The year 1961 was merely a hasty approximation of an unknown time. . . . After reviewing the evidence, I think now that I should have said 'by 1961' " [rather than "since 1961"]. The significance of Finley's admission was great, because it removed the possibility of pesticide pollution during the 1960s being responsible for any pelican difficulties. Nevertheless, the claim that the Texas pelican population was suddenly wiped out after 1961 was a major factor in the banning of DDT in 1972.

The U.S. Fish and Wildlife Service then expanded the DDT hoax by paying for so-called experiments in which their birds were exposed to treatments that every poultryman knew would cause severe eggshell thinning, at the same time that they fed daily massive overdoses of DDT or the related pesticide DDE to the birds. Any thinned shells were attributed entirely to the pesticide and not to the other extreme treatment. Some of the known causes of shell-thinning that the experimenters used were reducing calcium in the diets, starving the birds, and cutting the illumination from 16 hours daily to just 8 hours daily. Other causes are noise; environmental heat; and putting lead, mercury, PCBs, or oil in food. Pseudoenvironmentalists still repeat the "thinned-shell" allegations, while continuing to conceal the real causes of the shell-thinning in experimental birds. They never mention the numerous legitimate experiments where the only variable involved was the presence or absence of DDT or DDE in the diet, for these experiments showed *no* shell-thinning attributable to DDT or DDE, even at doses hundreds to thousands of times higher than any bird might ingest in the environment. A good example of such a legitimate study was that by Scott, *et al.*, at Cornell University School of Agriculture (see *Poultry Science*, Vol. 54, 1975).

In 1964, the Audubon Society financed the establishment of the Environmental Defense Fund (EDF), which then legally lobbied for Audubon propaganda issues without endangering the Audubon Society's tax-exempt status.

EDF's Scientists

In this effort, EDF founder Victor Yannacone, an attorney, was paid $60,000 a year, plus extra benefits. He urged Charles Wurster, EDF's chief scientist, to perform some kind of biological research to make the case against DDT. (Wurster, by the way, had listed his specialty as "jet fuels and fuel luminosity" in *American Men of Science*, 1960.) Wurster then put some marine algae into flasks of seawater with large amounts of DDT, adding enough alcohol to cause the DDT to go into solution at 500 parts per billion (ppb). He then claimed that the DDT inhibited photosynthesis and implied that it might endanger the world by a reduction of oxygen in the air.

Normally DDT is soluble in water only at 1.2 ppb, and in previous tests 600 ppb of DDT, without the solvent, did not affect the marine algae. Nevertheless, the hoax continued. Dr. Paul Ehrlich, an environmental futurologist, expanded on Wurster's fraud and wrote a scenario he titled "Ecocatastrophe." He published this story in *Ramparts* magazine in September 1969 and thousands of schoolchildren were required to read it as an example of alleged environmental harm caused by DDT. Ehrlich also published the same article in Britain in a 1970 booklet titled *The Year's Best Science Fiction*, a much more appropriate outlet.

Continuing this fraud in recent years, environmental organizations have filed legal actions to halt all shipments of DDT and other life-saving insecticides that can control malaria, plague, yellow fever, and many other diseases and help raise crop yields to limit starvation and malnutrition. In 1974-1976, U.S. Export-Import Bank assistance financed more than $3 billion worth of pesticides, which saved millions of human lives in tropical countries. In 1976, the Audubon Society and the Natural Resources Defense Council filed suit in federal court to compel the Ex-Im Bank to file environmental impact data on all exports financed by such banks. The National Legal Center for the Public Interest opposed that suit, however, and in 1980 a federal court ruled against the environmentalists.

These pseudoenvironmentalists also began seeking congressional action to accomplish what they had failed to achieve by their suits. In 1977, the environmentalists sued to force the Agency for International Development to prepare environmental impact studies for all pesticides that are shipped from the United States to Third World nations. In June 1980, a subcommittee of the U.S. Foreign Affairs Committee opened hearings that could stop American corporations from making overseas shipments of pesticides that have been banned or restricted by the Environmental Protection Agency.

During the battle to ban DDT, the Audubon Society distributed hundreds of thousands of propaganda leaflets stating, "DDT should be banned throughout the land, and banned from export." In a news release dated Feb. 25, 1971, the president of the Sierra Club reiterated this demand, "The Sierra Club wants a ban, not a curb on persistent pesticides, even in the tropical countries where DDT has kept malaria under control." These actions were taken despite their full knowledge that a ban on DDT would result in the death of more than 30 million Third World inhabitants annually, and certainly would not be supported by the majority of members of such national organizations. The problem is that the leaders, rather than the members, make and execute policy in these powerful environmental groups.

The EPA Hearings

In 1971, the Environmental Defense Fund finally forced the EPA to hold hearings on the DDT issue. These proceedings lasted for seven months and the testimony filled more than 9,000 pages of transcript. Almost everyone in the antipesticide camp testified, except Dr. Charles Wurster, the chief scientist for the EDF. (He would have had a very difficult time during cross-examination.) The antipesticide witnesses were sponsored jointly by the EPA and the EDF, although the EPA was supposed to be neutral and to only seek the truth.

The EPA hearing examiner Edmond Sweeney heard all the testimony and studied the transcript carefully. His final official decision April 26, 1972 stated that

> DDT is not a carcinogenic hazard to man. DDT is not a mutagenic or teratogenic hazard to man. The uses of DDT under the regulations involved here do not have a deleterious effect on freshwater fish, estuarine organisms, wild birds, or other wildlife. . . . The evidence in this proceeding supports the conclusion that there is a present need for the essential uses of DDT.

Incredibly, this decision was overruled singlehandedly by EPA administrator William Ruckelshaus, who never attended a single day of those expensive hearings and who admitted that he did not even read the transcript.

The transcript of the DDT hearings should be widely publicized so that scientists and others can become aware of its nature. The list of anti-DDT witnesses included Philip Butler, George Woodwell, Samuel Epstein, Robert Heath, Robert Risebrough, and dozens of others; and their testimony makes it clear why they lost the "trial" on DDT. University courses should include this transcript as required reading in environmental, biological, and chemical courses, so that students will become aware of the duplicity, the omitted data, the distortions and exaggerations, the tendentious nature of the anti-DDT experiments, and the deliberately flawed analyses, as revealed by these witnesses while they were under oath.

I'll review a few typical examples here, taken word for word from the official transcript of the hearings.

Dr. George Woodwell testified that he had coauthored with the EDF's Dr. Charles Wurster a 1967 article in *Science* magazine titled "DDT Residues in an East Coast Estuary." It was discussed as follows on Jan. 13, 1972, while Woodwell was under oath (page 7,232 of the transcript):

"Decisions by the government involving the use of toxic substances are political with a small 'p.' "

William D. Ruckelshaus

UPI

Q. Doctor, in the introductory sentence in the abstract, the abstract reads, "DDT residues in the soil of an extensive salt marsh on the south shore of Long Island averages more than 13 pounds per acre, 15 kilograms per hectare." Isn't it a fact, Dr. Woodwell, that after you wrote this, or after you initially studied this salt marsh, that you continued your samplings, and that you found as a result of your continued samplings that you were getting around or less than 1—an average of 1 pound per acre of DDT?

A. No, I wouldn't agree with that.

Q. Did you continue your samplings, Dr. Woodwell?

A. We have sampled the marsh subsequently and—the conclusion we came to was that the marsh contains in the range of some pounds per acre of DDT.

Q. Tell me how how many, Doctor.

A. I can't. It would be in the range of one to probably three pounds per acre. . . .

A. It is also true that this sampling was deliberately biased in order to find the highest residues we could find, because at the time we did this study, we wondered whether we could find any residues in the marsh.

Q. Didn't you also find out later, Doctor, that one of the areas where you took your samples was an area of DDT dumping?

A. I can't say that I discovered that.

Q. Dr. Wurster, perhaps?

A. I don't believe that he knows that either. I don't believe there's any evidence to that effect.

Q. Are you aware of the statement that Dr. Wurster made at the Washington State hearings—where he said—and I'm quoting from the verbatim transcript of the proceeding, "We have since sampled that marsh much more extensively and we found that the average, the overall figures on the marsh is closer to 1 pound per acre. The discrepancy was caused by the fact that our initial sampling was in a convenient place, and this turned out to be a convenient place for the Mosquito Commission's spray truck, too." Did you learn *that* after the fact, Doctor?

A. That is a true statement in my experience. I did not know that Dr. Wurster had said that, but that is a true—

[Page 7,238, still discussing the same admission about the marsh.]

Q. Doctor, have you ever published a retraction of this 13 pounds per acre, or a further article which evidences and discloses the results of your further sampling which brings the average down to around 1 pound per acre?

A. I never felt that this was necessary.

Q. How many samples did you take in this salt marsh, Doctor?

A. —the samples are listed—

Q. Was it six samples?

A. It looks as though there are six samples plus one in the bay bottom.

The conversation then shifted to how many samples should be taken in an extensive salt marsh of that size to obtain a reasonable average. The figure, it was agreed, should be considerably higher than six.

Woodwell also addressed the question of how long DDT might persist in various environments. In a lengthy article in *Science* magazine (Dec. 10, 1971), he had pointed out that although 6 billion pounds of DDT had already been used, only 12 million pounds could be accounted for in all the earth's plants, animals, fish, and birds (the "biota"), and that this amount was "less than one-thirtieth of one year's production of DDT during the mid-1960s." Woodwell theorized, "Most of the DDT produced has either been degraded to innocuousness or sequestered in places where it is not freely available." Since this contrasted sharply with his testimony a short time later at the DDT hearings, a reporter for *Business Week* asked Woodwell why that *Science* article was entirely omitted from his EPA testimony. Woodwell replied that EPA lawyers told him not to mention it, "lest my testimony be disallowed."

Contradictions Under Oath

The testimony by Philip Butler was equally incriminating. He testified (page 3,712) that "if you expose oysters to 0.1 parts per billion of DDT you can cut their growth by about 10 percent." Under cross-examination, however, Butler stated (page 3,749) "there can be as much as 150 parts per *million* of DDT residues in the oyster and not have effect on the growth" [emphasis added]. Obviously, if there is *no effect* at 150 *ppm*, the claim of a 10 percent growth reduction at 0.1 pp*b* must be false (150 ppm is 1,500,000 times greater than 0.1 ppb). Butler also testified (page 3,766) that in thousands of oyster samples from coastal Texas, which he called "one of the most contaminated areas," the greatest DDT residues found in oysters were "from 0.2 to 0.8 ppm." Under cross-examination, however, he admitted that the absolute *highest* level ever found in Texas oysters was "about half a part per million" (page 3,757).

When asked about the persistence of DDT residues in the environment, Butler testified (page 3,726): "I am thinking of work which has shown that DDT persists for as much as 40 years in terrestrial deposits. I have no reason for thinking that it will last for any less time in silt deposits in the estuaries or in drainage basins above the estuaries. . . ." (Remember, DDT had been around only for 30 years at the time of his testimony!) Under cross-examination, Butler admitted that published reports from his own laboratory at Gulf Breeze confirmed that 92 percent of the DDT and its metabolites had disappeared from seawater in just 38 days!

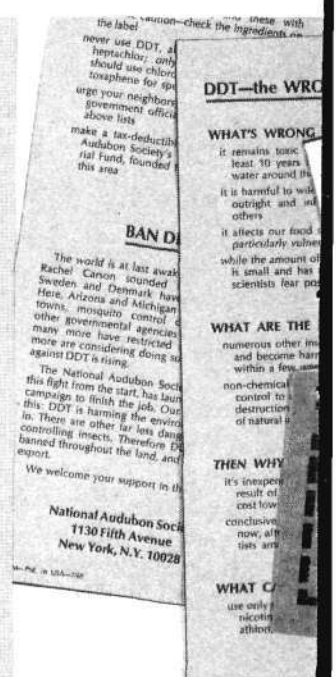
It is interesting to pursue this particular point through its media journey. A year earlier, Butler's panel report for the National Academy of Sciences had claimed that "As much as 25 percent of the DDT compounds produced to date may have been transferred to the sea." (Later, two panels of the NAS refuted such reports.) The *Washington Post* altered the Butler panel's frightening and untruthful claim to make it even worse. "Nearly 25 percent of all DDT manufactured to date is now in the world's oceans, where it is killing baby fish," the *Post* wrote on June 13, 1971. Poor Jacques Cousteau was totally confused by it all, and in his testimony before the Senate Commerce Committee Oct. 18, 1971, he stated: "For example, we now know that 25 percent of all DDT compounds so far produced are already in the sea. Finally they all will end up in the sea." Cousteau's statement was then published in *U.S. News & World Report* on Nov. 1, 1971, as their contribution to the hobgoblinization of pesticides.

And so we find that a false estimate of how much DDT *may* have been transferred to the ocean, made by the man whose own laboratory had shown that DDT and its metabolites break down very rapidly in seawater, was quickly escalated to a solid statement by the *Washington Post* and alleged to "kill baby fish." From there it was blown completely out of context by Cousteau and the anti-DDT publishers as evidence that *all* of the DDT and its metabolites ever produced will "end up in the sea." This is typical of the propaganda war against innocuous, harmless DDT a decade ago. The same sort of campaign, although much slicker, is now being waged against many other chemicals that are of great potential benefit to mankind and the environment.

Then there was the testimony on DDT and cancer. Dr. Samuel Epstein, who was being funded by the EPA at the time of his testimony, claimed that DDT causes cancer, citing as his source an unpublished 1969 study by Fitzhugh, Gross, and Davis. Dr. Adrian Gross says this study was not published because the mice were fed 300 milligrams (mg) of DDT per kilogram (kg) of their body weight by mistake, instead of the prescribed 100 mg/kg, for an unknown period of time. A total of 83 tumors developed in the "control" mice, which had no DDT, but only 68 tumors developed among the DDT-fed mice. Epstein testified that the DDT-fed mice developed cancer, but he avoided mentioning that the "controls" developed *more* cancer than the DDT-fed mice. Obviously, this was unscientific, and many might even say it was unethical. Epstein also testified under oath (pages 7,306 and 7,340) that he was a member of the Health, Education and Welfare panel on carcinogens, but under cross-examination he admitted that he was not (page 7,374).

It was after hearing this sort of testimony for seven months that EPA Judge Sweeney arrived at his conclusion that DDT should not be banned. In his estimation, the anti-DDT witnesses had not shown that the insecticide caused any significant hazard to man or the environment.

"Unless the media begin to seek out and publicize the truth about environmental matters, there will be much less pleasure and plenty in our future here in America."



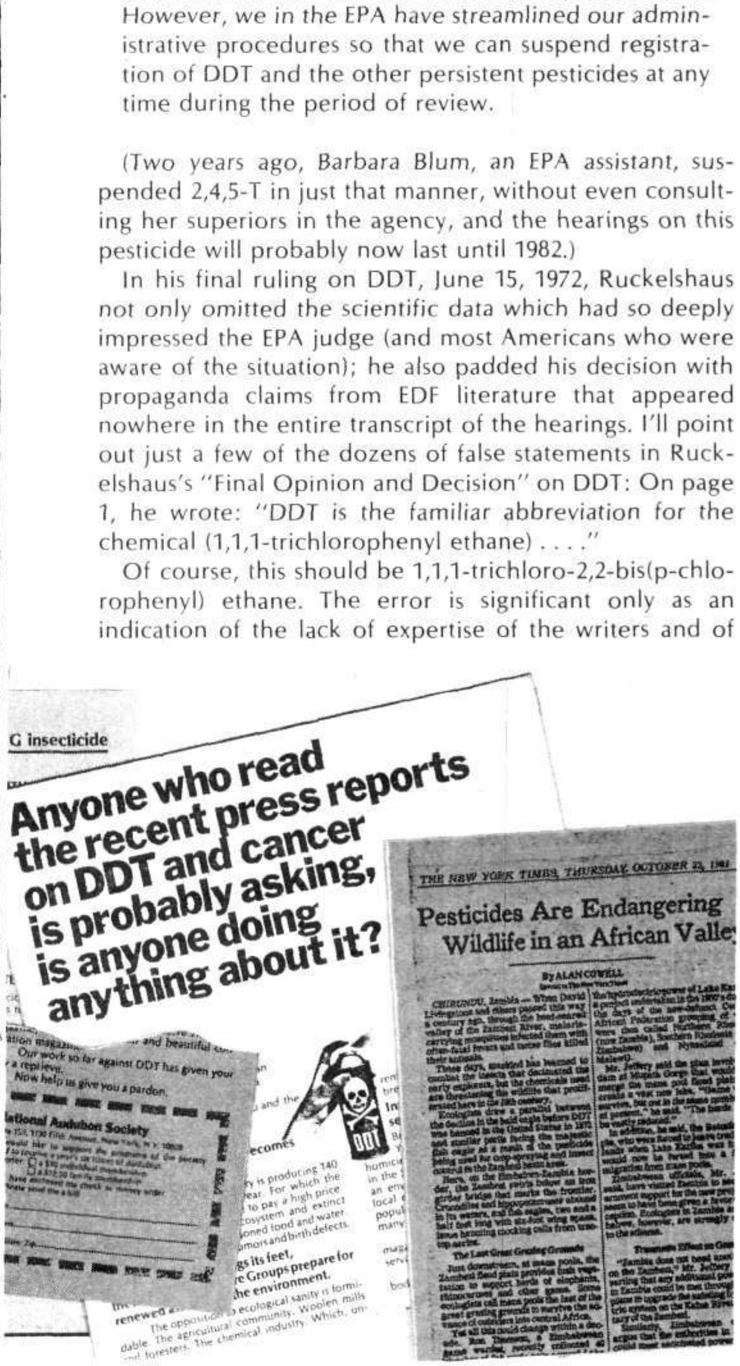
But six weeks later, this decision was overruled by EPA administrator Ruckelshaus in a scandalous acknowledgement that scientific evidence was not the basis for EPA decisions. Ruckelshaus had indicated his predilection for such capricious actions in a speech to the Audubon Society on May 2, 1971:

> As a member of the Audubon Society myself . . . I was highly suspicious of this compound, to put it mildly. But I was compelled by the facts to temper my emotions . . . because the best scientific evidence now available did not warrant such a precipitate action. However, we in the EPA have streamlined our administrative procedures so that we can suspend registration of DDT and the other persistent pesticides at any time during the period of review.

(Two years ago, Barbara Blum, an EPA assistant, suspended 2,4,5-T in just that manner, without even consulting her superiors in the agency, and the hearings on this pesticide will probably now last until 1982.)

In his final ruling on DDT, June 15, 1972, Ruckelshaus not only omitted the scientific data which had so deeply impressed the EPA judge (and most Americans who were aware of the situation); he also padded his decision with propaganda claims from EDF literature that appeared nowhere in the entire transcript of the hearings. I'll point out just a few of the dozens of false statements in Ruckelshaus's "Final Opinion and Decision" on DDT: On page 1, he wrote: "DDT is the familiar abbreviation for the chemical (1,1,1-trichlorophenyl ethane) . . . ."

Of course, this should be 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane. The error is significant only as an indication of the lack of expertise of the writers and of their slovenly attention to details.



On page 4, Ruckelshaus stated: "DDT has three major breakdown products, DDA, DDE, and DDD; separate registrations exist for TDE (DDE)." The truth is that TDE is the same as DDD, *not* DDE, and that DDE is not insecticidal at all; thus there are no registrations for it.

On page 37, Ruckelshaus wrote, "Such a program can also introduce farmers to the less acutely toxic organophosphates, like carbaryl. . . ." But even Ruckelshaus should have realized that carbaryl is a carbamate, and is not even remotely related to the organophosphates. And as an example of his disregard for the scientific literature, he wrote, "The possibility that DDT is a carcinogen is at present remote and unquantifiable." Actually, the EPA was already in possession of more than 70 articles from scientific journals specifically reporting that all of the tests performed showed no evidence that DDT was carcinogenic, and several of the studies pointed out that DDT induces the formation of liver enzymes that, in turn, *inhibit* the growth of tumors or cancers.

At the time, many people objected that the decision to ban DDT was political, rather than reflecting scientific evaluations, a charge that EPA officials vigorously denied. But in 1979, Ruckelshaus himself wrote a letter to Allan Grant, president of the American Farm Bureau Federation, in which he admitted the political nature of his decision. "Decisions by the government involving the use of toxic substances are political with a small 'p.' . . . Science, along with other disciplines such as economics, has a role to play. *The ultimate judgment remains political.* In the case of pesticides in our country, the power to make this judgment has been delegated to the administrator of EPA" [emphasis added].

After leaving the EPA, Ruckelshaus's career in the next few years is instructive in the light of his performance at EPA on behalf of the greenies. For instance, Ruckelshaus permitted the Environmental Defense Fund to advertise for funds using a letter he wrote on his Washington stationery, in which he repeated EDF propaganda and urged that donations be sent so that the EDF "can continue their good work." He then established a law firm in Washington, with nine lawyers making contacts for clients who were having difficulties with the EPA. All nine had formerly worked for the EPA, and they made 178 known contacts with EPA for their clients. Thirty-seven of these contacts were on behalf of the makers of vinyl chloride, which is a potent cause of cancer. Interestingly, the EPA did not take any action against vinyl chloride.

For a short time, Ruckelshaus was also the acting director of the FBI, where he continued to make untruthful statements. For example, at a news conference in 1974, he said that when the bureau went to presidential aide Ehrlichman's office to get some records, "we almost had to arm wrestle with the Secret Service." The Secret Service heard about that statement and objected, saying "We gave them the files they requested, without incident." Ruckelshaus then wrote an apology: "My allusion to arm wrestling was an effort at hyperbole at a time when reality cannot absorb exaggeration. . . . The gloves were never donned, and the bell never sounded. . . . In short, the bout never occurred." This was a very cute admission that he lied about the Secret Service; unfortunately, he has never been forced to retract his lies about DDT, which have caused so much misery and resulted in so many millions of human deaths. Ruckelshaus is now a vice president at Weyerhaeuser Lumber Company.

The Unscientific EPA

The next EPA head, tax lawyer Russell Train, was also lacking in scientific awareness as well as ethics. He arrived fresh from his position as head of President Nixon's Council on Environmental Quality (CEQ), a group that was previously headed by Shirley Temple Black. After pledging not to take any precipitous action against pesticides without giving Congress advance notification, Train surprised his own staff, as well as Congress, by calling a Christmas Eve press conference to announce his intention to ban chlordane. Later, the EPA claimed that "hundreds of thousands of American farm workers are injured every year by pesticides [and that] hundreds of them die annually." This fabrication came from 1970 congressional testimony by a spokesman for Cesar Chavez. After strong objections from many authorities, EPA meekly apologized, saying: "We used those statements in good faith, thinking they were accurate, and they turned out not to be accurate. . . . They cannot possibly be substantiated."

Despite the retraction, Train's EPA used that very misstatement on chlordane as the excuse to inaugurate the famous EPA "Hot Line," which anyone could call, toll-free, and anonymously accuse their neighbors of misusing pesticides. It was later discovered by the *New York Times,* via the Freedom of Information Act, that the toll-free number was *not* in the EPA offices, but was in Chavez's National Farmworkers' Information Clearing House in Dallas. Furthermore, the project was financed by the U.S. Labor Department, via Antioch College in Ohio. Only after vehement congressional criticism of this gestapolike operation, was the Hot Line discontinued.

Meanwhile, Russell Train redefined "cancer" at the EPA. For EPA's purposes, he said, tumorigenic substances and carcinogenic substances are "synonymous." "Tumors" or "cancers" (or even transient fat nodules in rat livers) would henceforth be considered as "cancer" by the EPA, he said, and the EPA could therefore invoke the "anticancer" Delaney Clause of the Food and Drug Act to justify efforts to ban various chemicals that had never been known to cause any malignancies. (This clause was supposed to deal only with "cancer," rather than with nonmalignant growths.) Train, now president of the World Wildlife Fund, eventually left the EPA and became a member of the board of directors of the Union Carbide Corporation.

Train was replaced in the EPA by Douglas Costle, formerly a lawyer at the Department of Justice and the Department of Commerce. At his first interview with agricultural leaders, Costle said: "I'm going to endeavor to bring common sense to the administration of the law and the writing of regulations. It may take three or four years, but we're starting right now." Costle obviously failed in that endeavor, as evidenced by dozens of subsequent EPA actions that lacked "common sense." His EPA had more than 10,000 employees and was budgeted in 1980 for another $5 billion; yet the agency showed no comprehension of the importance of scientific data, of dose-related responses to chemicals, of biological thresholds, or even of ethics and moral responsibility. It appeared unlikely that industry and agriculture could survive under such a monolithic agency whose capricious zeal so greatly surpassed its expertise.

When Costle was finally driven from the EPA, he and several EPA colleagues founded the Environmental Testing and Certification Corporation in Edison, New Jersey. His lack of continuing influence with the EPA, however, may doom that venture.

In May 1981, Anne M. Gorsuch became the administrator of the EPA, and things immediately began to look more hopeful for Americans with rational environmental concerns. The new EPA management has said that it intends to assure the scientific objectivity of statements made in print or in speeches by employees, thus reversing the absence of credibility that has been notorious in the past. Deputy administrator John Hernandez says the basic EPA strategy is to "get away from the adversarial role and the litigious attitude this agency has had in the past." And Dr. Andrew Jovanovich, EPA's new research director, has designed procedures to assure that research results "are of high quality and based on creditable scientific and technical knowledge." It should be noted that the adoption of these procedures was urged in 1977 by the National Research Council, but this was not permitted by the lawyers, politicians, environmental extremists, and other nonscientists who controlled the EPA at that time.

As for the EPA rank and file, Frank Greve wrote in the *Washington Post* Sept. 6 that the "activists" are quitting. A top EPA bureaucrat, who is also active in the Sierra Club, said "I don't know anyone, including myself, who isn't leaving," and the nearby bulletin board carried almost as many notices of goodbye parties as of new carpools.

If enough of these misfits leave and are replaced by sincere conscientious scientists and legitimate "environmentalists," perhaps the Environmental Protection Agency can gain some measure of respect in this country and abroad, after all, and fulfill the functions for which it was originally established.

J. Gordon Edwards is professor of entomology at San Jose State University in California, where he has taught biology and entomology for 31 years, since earning his PhD at Ohio State University. He is a long-time member of the Sierra Club, the Audubon Society, and the Explorers Club. His book Climbers Guide to Glacier National Park *was published by the Sierra Club, and his articles on birds have been published by other environmental groups including the Audubon Society. He is married, and his wife and daughter share his enthusiasm for nature study and outdoor activities.*

Calvin Campbell/MIT

Kosta Tsipis and the Scientific Opponents To Beam Weapons: A Technical Assessment

by Dr. Steven Bardwell

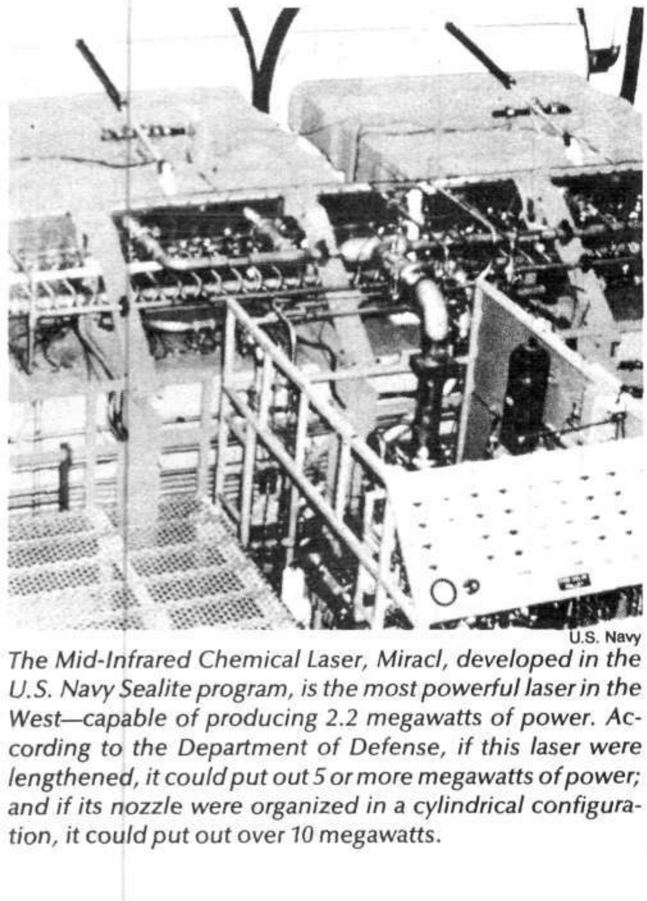
"[It's] the biggest fool thing we've ever done. The atomic bomb will never go off and I speak as an expert on explosions."

—*Admiral William Leahy*
Naval aide to President Roosevelt

President Reagan's March 23 speech on defense against ballistic missiles carried a message of hope and optimism reminiscent of President John Kennedy's speeches on the Apollo project. Reagan told the American people: "I call upon the scientific community in our country, those who gave us nuclear weapons, to turn their great talents now to the cause of peace: to give us the means of rendering these nuclear weapons impotent and obsolete." Yet, the immediate reports of the major press in both the United States and Western Europe gave the impression that the President's program was scientifically absurd, probably impossible, and certainly impractical. As the *New York Times* put it in a lead editorial March 27, President Reagan's speech "remains a pipe dream, a projection of fantasy into policy."

Unfortunately, the *New York Times*, the *Washington Post*, the *Los Angeles Times*, and all three electronic media networks did not lack members of the scientific community to provide authoritative statements on the impossibility of defense against ballistic missiles. The cynicism and pessimism of this media onslaught was echoed point-by-point by the majority of so-called expert opinion. On the basis of a careful reading of these media of record, any informed citizen would have been convinced either that the President himself was a fool or that his advisors were incompetent.

The major technical source for this assessment of the Reagan proposal for ballistic missile defense is a series of papers authored by Dr. Kosta Tsipis and his collaborators at the Massachusetts Institute of Technology. These researchers, long-time advocates of disarmament and arms control as the only solution to the threat of war, have specialized in "proofs" of the impossibility of ballistic missile defense since the first proposals for ABM missile systems in the 1960s. Recently, they have taken aim at the use of high energy lasers as a beam weapon for ballistic missile defense. Their assessment is summarized in a paper by Tsipis:



U.S. Navy

The Mid-Infrared Chemical Laser, Miracl, developed in the U.S. Navy Sealite program, is the most powerful laser in the West—capable of producing 2.2 megawatts of power. According to the Department of Defense, if this laser were lengthened, it could put out 5 or more megawatts of power; and if its nozzle were organized in a cylindrical configuration, it could put out over 10 megawatts.

Practical space-based ballistic missile defense systems using laser light as the kill mechanism are not within the visible technological horizon. Even if eventually they could be developed, the cost of emplacing and supplying and maintaining them would be prohibitive, they would be fatally vulnerable during their embryonic stage, and even if emplaced and made operational, most probably they could be defeated by the active and passive countermeasures and tactics of a determined opponent.[1]

Table 1 summarizes the objections of the Tsipis group, and some facts that answer these objections.

The actual scientific situation facing researchers in ballistic missile defense, however, could hardly be further from the gloomy picture painted by Tsipis et al. Dr. George Chapline, the inventor of the X-ray laser, which is without doubt the most important development in ballistic missile defense in the past several decades, responded to the President's critics by noting that while the press had given the impression that "no competent scientist" thought the President's program was realistic, he was not interested in debating who was a competent scientist. He and his colleagues at the national laboratories, he said, have a job to do: to create the defensive weapons that will make ballistic missiles obsolete. The problem, he emphasized, is not

Table 1
BEAM WEAPONS: FACT VERSUS FICTION

Summarized here are the most frequently mentioned objections to the development of beam weapons, and their scientific refutation. It is useful to note that scientists who claim that beam weapons are impossible are at least five years behind in terms of the scientific literature and current experimentation.

	Objection	Reply: First-generation system	Reply: Second-generation system
1	**The power levels required for a laser cannot be produced** today either economically or efficiently. The fuel is too expensive or too heavy.	A 2.2 megawatt chemical laser already exists. To scale it up to 10 megawatts is a straightforward engineering task, and there is no laser scientist who believes that this cannot be done. Ten megawatts is the power level recognized in general, and by Tsipis, as the minimum required for a laser beam weapon. For a ground-based system, the amount and mass of the fuel required are irrelevant, since the laser does not have to be put in orbit.	Short wavelength lasers, specifically the free-electron laser and the X-ray laser, have inherently high power densities, their brightness being about 2 or 3 orders of magnitude greater than the minimal chemical laser. The fuel is neither expensive nor heavy since nuclear power sources are used to pump both these lasers.
2	**A laser beam of the type required cannot be propagated,** because the beam would be so greatly attenuated by either moisture in the atmosphere or dust clouds generated in the course of a military engagement that the energy from the laser would never reach the target.	If the laser is based on a mountaintop above 12,000 feet, less than 10 percent of the beam will be lost. The critical point to be made is that there are numerous laser frequencies that will propagate through the atmosphere and other media. To flatly assert that lasers cannot propagate through the atmosphere ignores the results of experiments with plasmas during the past five years.	This objection is irrelevant here.
3	**It is impossible to produce a mirror good enough and accurate enough** to be capable of focusing a beam that is powerful enough to destroy a missile. And even if such a mirror could be produced, it would be so delicate and so vulnerable that it would be unusable in a military system.	The generally agreed specification for a first-generation mirror is between 5 and 10 meters in diameter. This is within our technological capabilities today, and United Technologies offered to build such a mirror at a fixed price. As to the fragility of such a mirror, the basic point is that a first-generation system would not be subject to countermeasures by a technologically capable opponent. The system is no threat to the Soviets and it would be pointless for them to try to destroy it, since the only function of such a system is to prevent an accidental or third power launch.	These systems have no optics.

whether the laws of physics allow ballistic missiles to be rendered impotent, but rather how to use the laws of physics to accomplish this end.

Fact Vs. Fantasy: Progress in Beam Research

The optimism of the scientists working on ballistic missile defense stems from two sets of technological advances in the past two years that have totally revolutionized the possibilities for complete protection against ballistic missiles. First, the requirements of pointing, tracking, and target acquisition, which are common to all ballistic missile defense systems, have now been met in laboratory experiments. Using new optical, computer, gyroscopic, and sensing technologies, the specifications for a defense system capable of destroying ballistic missiles in the boost phase at a distance of several thousand miles can be achieved.

Table 2 summarizes the situation in these technologies. It is now possible to point a mirror with an accuracy of .05 microradians (the displacement of a dime in New York City as seen from Washington, D.C.); and the space telescope will be deployed in 1986 with this pointing accuracy. Kosta Tsipis's research group claimed in 1980, however, that 1 microradian was the best pointing accuracy achieved to date, and that no major improvement was likely in the near future.[2]

Fourth-generation gyroscopes achieve the tracking rates

4	**There are no technologies available that can point such a mirror accurately enough** to hit a target at a range of 1,000 to 2,000 kilometers (the range required for the strategic task of destroying missiles).	The mirror has to be pointed with the accuracy of 0.1 microradian in order to hit the target. This is done routinely with space satellites, and will be done with the existing Space Telescope.	The same applies to the pointing of the X-ray lasing medium.
5	**Even if such a mirror could be aimed accurately, the technologies do not exist to track missiles long enough** for the beam to destroy them—a tracking accuracy of 0.1 microradian per radian per second.	The required tracking capability has been demonstrated by fourth generation gyroscopes in the laboratory. It is now an engineering problem to put these on a telescope and make them usable for a laser system.	The problem of tracking is irrelevant for these systems, because the lasers are so bright that they blast the target in microseconds, virtually without any dwell time.
6	**The sensing technologies do not exist to distinguish between decoys and armed missiles.** Since decoys are lightweight, cheap, and easy to build, this gives the advantage to the offense, which can saturate the defense with decoys, thus aiding the penetration of the armed missiles.	The technology exists—long wavelength infrared telescopes—to distinguish the infrared emission of missiles at several thousand kilometers. This emission is dependent on how heavy the missile is, and therefore provides the capability of distinguishing between decoys and armed ICBMs in the boost phase, which is the purpose of these first generation systems. With reentry vehicles, the task is much more difficult.	The same applies.
7	**Given the constraints of focusing and tracking, there are a series of simple and cheap ways to defeat beam weapons,** such as using missiles with a reflective coating, or an ablative coating, or rotating the missile so that the laser energy is spread out so much that it will not be able to destroy the missile.	The various countermeasures that have been proposed to defeat a first-generation beam weapon system are strategically irrelevant at this point since the Soviet Union is not going to retool its existing missiles to defend them from a weapon that does not threaten them. In the future, scaling up the power density of the laser beam by a factor of 10 would defeat all passive defense systems mentioned—such as reflective coatings, ablative surfaces, and space mines.	Passive defenses are totally helpless because of the intense brightness of the short wavelength lasers, which can burn through anything.
8	**The cost of developing a beam weapons system** for protection against all-out attack is so great as to make it impossible.	As we have proposed it, to develop a first-generation system would cost no more than $20 billion, and the deployment of such a system would be a small multiple of this.	The X-ray laser is smaller, more efficient, and much less costly to deploy for protection against an all-out nuclear attack than would be a scale-up of a chemical laser system to achieve this goal.
9	**Beam technologies would be used for offensive purposes.**	The amount of energy that the beam delivers is actually tiny; it could never be a weapon of mass destruction, but might perform a selective surgical delivery of energy.	These systems could be used offensively. Their technological superiority shifts the advantage to the defensive, however.

and accuracies required for ballistic missile defense systems. The Tsipis group claimed that this performance would not be "ready before the mid-1990s."[3]

The early warning, sensing, and target discrimination requirements for a beam weapon antiballistic missile system have been met using new computer technologies and a major advance in sensing called long wavelength infrared sensing. These sensing devices use the heat loss rate of an object to determine its mass, allowing armed missiles to be distinguished from decoys, which are lightweight diversionary vehicles. This technology completely and elegantly solves one of the primary contentions of the Tsipis group that cheap (that is, lightweight) decoys could be deployed in huge numbers to saturate the boost phase intercept system.[4]

The cumulative impact of these developments is that a first-generation boost phase ballistic missile system could be deployed using existing technologies when these are integrated into a beam weapon system. Such a system, using a ground-based laser and orbiting mirrors, would be capable of a limited defense, sufficient to accomplish the aims of the original ballistic missile defense systems: point defense of ballistic missile emplacements, prevention of accidental launchings, and defense against third-power launchings.

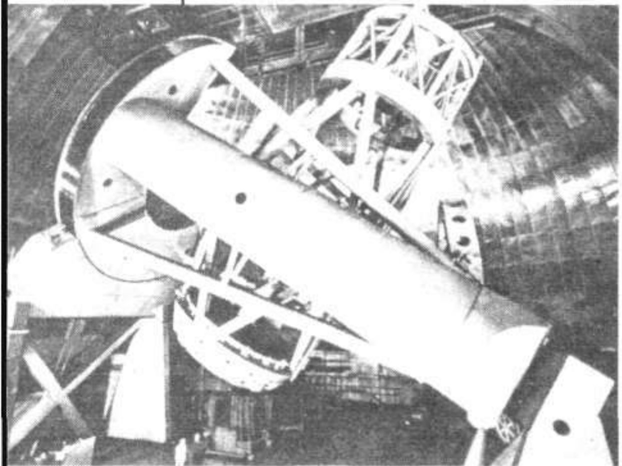
Tsipis and his group have claimed that the mirrors and lasers required for such a device do not exist and could not be constructed in the foreseeable future. Table 2 summarizes the situation with both lasers and mirror requirements, again showing just the opposite of the claims of the Tsipis group. Especially egregious is the claim of the MIT group that mirrors of the required size "are not within current U.S. technical capacity."[5] Given this fact, it is difficult to understand where the Mount Palomar 200 inch (5 meter) telescope mirror came from or where the large power lasers routinely used in the fusion programs of the world were constructed!

The New Frontier of the X-ray Laser

The second technological development that has changed estimates of the potential of beam weapons is the invention of the X-ray laser. This device, whose scientific "proof of principle" occurred more than two years ago in a secret test at the underground Nevada Test Site, uses a small nuclear explosive to pump a solid state or magnetized (zeta-pinch) plasma laser. This advanced laser emits a high-energy beam of coherent, highly collimated X-rays. Even though it is inherently a low efficiency device, its energy source is so compact, lightweight, and cheap that the X-ray laser far outdistances its rivals in ability to solve the key problems of a complete boost phase missile defense system:

(1) It can be completely space-based in large numbers. Since the X-ray laser is lightweight, highly compact, and cheap, the Space Shuttle can be used to launch multiple laser stations at the same time, as shown on this issue's front cover. Because each satellite has the ability to destroy 10 to 100 missiles (and each missile carries up to 10 warheads) the defense achieves a 100:1 leverage and so can saturate any offensive buildup that an adversary might contemplate in response to deployment of the X-ray laser system.

(2) Because the energy of the X-ray laser is so great, the



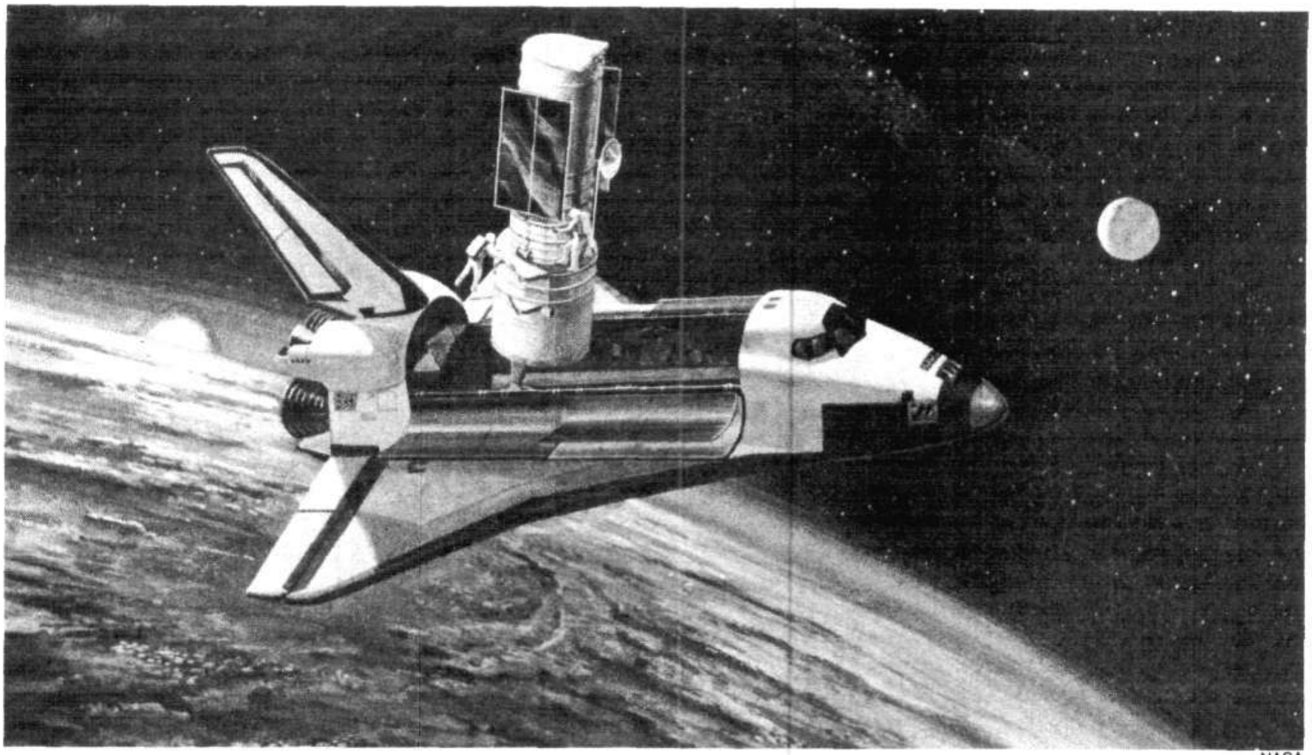
Mount Palomar

The technological requirements for a first-generation beam weapon ballistic missile defense either exist or are realistically within reach of current laboratory programs. Above, the 5-meter Mount Palomar telescope, built 35 years ago.

Table 2
COMPARISON OF REQUIRED AND ACHIEVED PARAMETERS FOR A FIRST-GENERATION BEAM WEAPON SYSTEM

Technology	Required	Achieved: Deployed	Achieved: Laboratory	Comments
Pointing (μ radians)	0.05–0.1	0.048		1 μ radian is the "best to date," according to the Tsipis group.
Tracking accuracy (μ radians/at 0.01 radians/second)	0.01	0.1	0.01	
Mirror size—diffraction limited (meters)	5–10	2.4	5–6	A 4-meter mirror is "not within current U.S. technological capacity," according to Tsipis.
Thermal stability (kw/cm²)	1	3		
Laser power (megawatts)	5–10	2.2	1,000,000	

The specifications for a laser beam defensive weapon system capable of destroying ballistic missiles in their boost phase at a distance of several thousand miles can be achieved based on the recent advances in these technologies.


NASA

The pointing accuracy required for beam weapons will be achieved by NASA's large Space Telescope, which is scheduled to be launched by the Shuttle in 1986.

pointing and tracking requirements for the laser are at least an order of magnitude less stringent than those of the first-generation beam weapon system. With energy to spare, a larger beam divergence can be used to great advantage to cover larger areas and relax the aiming requirements. Since it operates in the X-ray band, no optics are available for pointing and focusing. Instead, the requirements for focusing and collimating are met by the dynamics of the beam production itself, either through "geometrical focusing," using a long, thin solid-state laser, or through intense magnetic fields generated in the lasing plasma, which naturally focus the beam. Thus, no large, fragile optics are required; no mirrors or lenses are used.

(3) With very high power densities, no passive defense against an X-ray laser is possible. The X-rays are so highly coupled to matter that no surface finish can prevent the absorption of the laser light.

Using the X-ray laser, a second-generation beam system could be built that would provide at least 90 percent protection against booster vehicles. If this were coupled with a layered defensive system using other technologies for intermediate range interception and a terminal system for reentry vehicle destruction (perhaps using ground-based particle beams of electrons or muons), each with 90 percent efficiency, a combined system of 99.9 or 99.99 percent protection would have been constructed.

President Reagan evoked the significance of that accomplishment in his speech when he concluded:

> [Until this defense is constructed], it will still be necessary to rely on the specter of retaliation—on mutual threat, and that is a sad commentary on the human condition.
>
> Wouldn't it be better to save lives than to avenge them? Are we not capable of demonstrating our peaceful intentions by applying all our abilities and our ingenuity to achieving a truly lasting stability? I think we are—indeed, we must!
>
> What if free people could live secure in the knowledge that their security did not rest upon the threat of instant U.S. retaliation to deter a Soviet attack; that we could intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies?

Dr. Steven Bardwell, a plasma physicist, is the editor-in-chief of Fusion *magazine. His comprehensive report on beam weapon technologies has been acclaimed as the best nonclassified summary on the topic available. Bardwell has lectured widely and debated on the topic of beam weapons technologies throughout the United States and in Europe and Japan. Bardwell's special report, "Beam Weapons: The Science to End Nuclear War," is available from the Fusion Energy Foundation for $250.*

Notes

1. M. Callaham and K. Tsipis, "High Energy Laser Weapons: A Technical Assessment," Program in Science and Technology for International Security, Report Number 6 (Cambridge, Mass.: Massachusetts Institute of Technology, Department of Physics, Nov. 1980), p. 70.
2. Ibid., p. 51.
3. Ibid.
4. Ibid., p. 69.
5. Ibid., p. 51.

800 Scientists, Laymen Attend FEF Beam Technologies Conference

While the *New York Times* and other major media were panning President Reagan's program for beam weapon antiballistic missile defense as science fiction, the Fusion Energy Foundation held its largest ever educational conference to demonstrate that a first-generation laser ABM system is only five to seven years away and that its development can trigger a strategic, scientific, and industrial revolution worldwide.

The April 13 event in Washington, D.C., "Directed Energy Beam Weapons Can End the Era of Mutual Thermonuclear Terror," drew 800 participants, including representatives of 30 U.S. states and 16 foreign embassies and about a dozen government officials.

Noticeably absent were any representatives of Congress, whose members appear to be clinging to the Mutually Assured Destruction doctrine that the President's March 23 strategic address sent to its demise. The House was at the time locked in the controlled debate over the nuclear weapons freeze resolution.

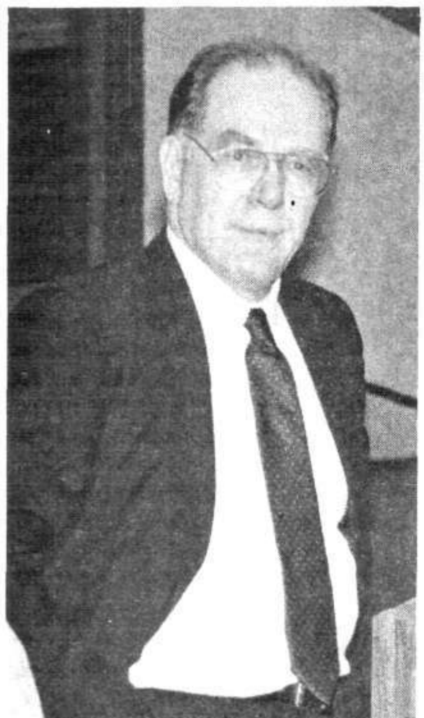
As the conference speakers pointed out, whereas the freeze resolution and related disarmament proposals will actually increase the threat of war—because they are premised on a Malthusian technology freeze—the development of defensive weapons, based on new physical principles, can create a climate in which arms negotiations can actually succeed.

This point was emphasized in the keynote evening speech by Lyndon H. LaRouche, Jr., an FEF director and the U.S. political figure who has most aggressively promoted a policy of beam weapon defense against intercontinental ballistic missiles. LaRouche's speech, focused on how a defense strategy founded on space-based laser and beam weapons could immediately contribute to a solution to the impending U.S.-Soviet Euromissile crisis. (See his elaboration of this point in the editorial, p. 4.)

LaRouche lambasted congressional foot-dragging and sabotage aimed against the President's beam weapons program, emphasizing that Reagan spoke on March 23 as the commander-in-chief of the U.S. armed forces.

A Strategic Shift

At the morning session, Dr. Keith Payne, vice president of the National Institute of Public Policy in Fairfax, Virginia, described President Reagan's initiative as beginning the transition to a defense posture that features "damage limitation" to the American homeland. By contrast, the strategy of punitive deterrence—MAD and its subsequent modifications—relies exclusively on the withheld threat of nuclear weapons to deter a nuclear attack, Payne said. "But we have no proof that deterrence really works."



Stuart K. Lewis/NSIPS

Lyndon H. LaRouche, Jr.: A strategy based on defensive weapons can solve the impending U.S.-Soviet Euromissile crisis.

Payne said the Schlesinger doctrine and the Carter administration's Presidential Directive 59 were responses to doubts raised about the credibility of the concept of extended deterrence. *Extended* deterrence, he explained, requires that the Soviet leaders believe that the United States will employ its nuclear arsenal to deter nuclear attack on NATO allies as well as to defend American interests in distant countries. However, it was never certain that an American President would risk 160 million American lives in this manner.

The motivation for the Schlesinger doctrine, Payne said, was to introduce the notion of "limited nuclear war" and "flexible nuclear response"—a handful rather than thousands of missiles would be deployed—and thereby increase the credibility of extended deterrence.

But the new doctrine did not alter the basic reliance on punitive deterrence—and all of the uncertainties that

Stuart K. Lewis/NSIPS

Dr. Frederick Wills: The President's beam weapons program, coupled with Roosevelt's dirigism, can open up a new era in North-South relations.

surround the doctrine—Payne concluded.

Uwe Parpart Henke, research director of the FEF, followed with a presentation on how the transition from MAD to Mutually Assured Survival can be made. He outlined the two-phase approach proposed by the FEF, the first phase of which could be in operation within five to seven years, providing defense against accidental and third nation nuclear launches and point defense of strategic targets. Such a system could provide one answer to the MX missile basing question, Henke said.

The second-generation system, which could be developed in 10 to 12 years, could defend the nation against a full-scale ballistic missile attack, Henke said. This system would be entirely space-based and presupposes the development of more sophisticated lasers. The leading candidate is the short wavelength X-ray laser, which deposits its energy on the target instantaneously, eliminating the problem of tracking.

Henke said that a system such as the *nuclear-pumped* X-ray laser, which would employ several independently targetted pods, might weigh only several hundred kilograms and would not have to be left in space but could be launched on expectation of attack.

The objection that beam weapon systems are destabilizing, that they will

BEAM THE BOMB

Stuart K. Lewis/NSIPS

Dr. John Cox: The nuclear powered laser is a prime candidate for space-based ABM systems.

Stuart K. Lewis/NSIPS

Dr. Nicholas Uwazie: A revival of Atoms for Peace must accompany President Reagan's beam weapon program.

Stuart K. Lewis/NSIPS

Dr. Keith Payne: We need a more balanced approach to offense and defense.

give one side an advantage for first strike, is "science fiction," Henke said. "It does not take into account the fact that by embarking on a program to develop these systems, we have actually transformed the strategic system." We have begun to move from a situation in which we relied solely on offensive systems to one in which we will develop more and more successful defensive systems.

In response to questions, he added that he could not imagine an offensive use of space-based laser systems in the next decade. The X-ray laser, for example, cannot penetrate through the atmosphere and releases only four to five times the energy of a pistol. It cannot penetrate an armored tank, he said, and is only useful against thin-skinned ICBMs and other soft targets such as bombers and cruise missiles.

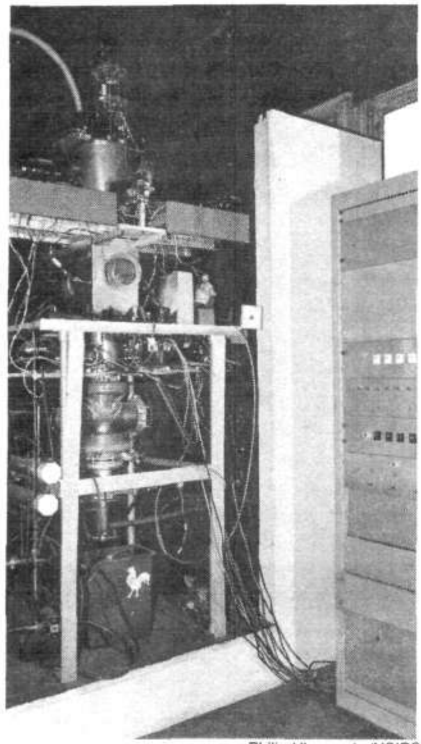
Regarding the possibility of countermeasures, Henke said reflective coating and the hardening of missiles, for example, are not only costly but they increase the bulk and reduce the effectiveness of offensive weapons.

"We're not talking about putting up foolproof systems that will solve everything all at once," he said. The important thing is that it will become "increasingly cheaper to defend ourselves than to build offensive weapons."

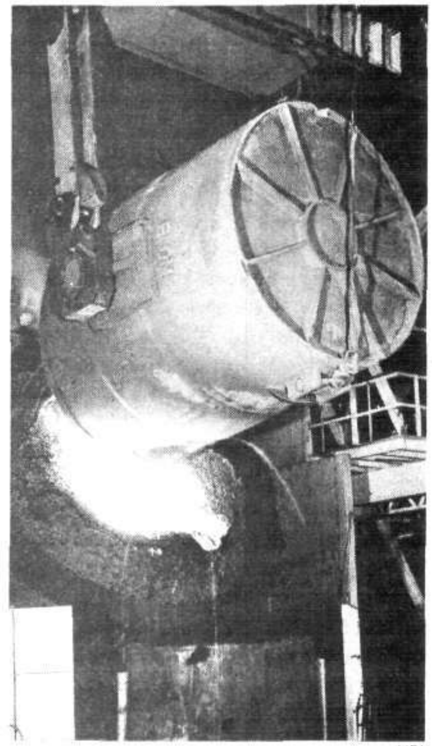
The final speaker of the first panel was Frederick Wills, former foreign minister of Guyana and a founding member of both the Non-Aligned movement and the Club of Life. Wills said he welcomed President Reagan's March 23 announcement as an affirmation of the American Revolution of 1776 and the proposition that "man is the ultimate arbiter of his own destiny."

Wills pointed out that the complement of the MAD doctrine is the Rapid Deployment Force—mobile conventional forces for intervention into the Third World.

The President's beam weapons defense program, Wills said, coupled with "Rooseveltian dirigism," can open up a new era in North-South relations. It can mean the opening up of new frontiers in science and technology and exports for the development of the Third World. This would relieve the Third World of all the "technology and credit freezes" under which it has been suffering, Wills said.



Philip Ulanowsky/NSIPS



UPI

The introduction of laser and plasma technologies could up U.S. productivity by as much as 1,000 percent. At left is a plasma steel-making furnace, which has demonstrated that a 31,000 degree ionized gas can make a better quality of alloy steel than electric arc furnaces. The ore or scrap metal is refined or reduced in less than 1 second as it travels through a cone of plasma down the length of the furnace. The plasma furnace is 10 times hotter than the most advanced oxygen process now used, such as Fuji Iron and Steel Company's oxygen-process steel converter shown at right.

The Third Industrial Revolution

Dr. Steven Bardwell, editor-in-chief of *Fusion*, led off the second session with a preview of the industrial and scientific revolution that will be unleashed by the development of beam technologies. He predicted that the civilian applications will surpass the military applications of beam weapons—even more than they did in the cases of rocket and nuclear technologies.

If we assume that current technologies, based on matter in its chemical state, have an energy density of 1, Bardwell said, then the energy densities involved in beam technologies, where we are dealing with matter in its fourth, or plasma, state, are 100 to 1,000 times greater.

A second measure of any technology is the energy per relevant particle. The active particles in a steel furnace, for example, have energies of about 10 electron volts per particle, he explained. In the case of plasma beam technologies, we will be dealing with 100,000 electron volts per particle.

The impact of being able to concentrate energy to that degree can shorten the relevant time of industrial processes by a factor of 1,000, he said. In addition, whereas currently all industrial and energy technologies are dominated by a very small part of the electromagnetic spectrum—the infrared region, or heat—with plasma and beam technologies we will access the entire spectrum from X-rays to microwaves.

"The kind of distinction between a microwave oven and a regular oven will be able to be applied to every aspect of human life," Bardwell said. We will be able to apply much more intense energy for a much shorter time, with an enormous overall savings of energy.

Bardwell then described the major applications of the new beam technologies—in fusion energy, advanced materials processing, metal cutting, welding, heating treating, and food processing.

He asserted that the most far-reaching implication of beam technologies would be the scientific revolution they trigger, toward understanding the self-organizing and self-focusing properties of beams and lasers.

Lasers, for example, exhibit a property known as self-induced transparency, Bardwell said. The front of the laser modifies the medium, allowing the pulse to travel through the atmosphere. At the end of the laser pulse, the medium goes back to its unexcited state, resupplying the energy to the beam. It works in the same way that a slinky goes down stairs.

The second speaker was Dr. John Cox of the University of Florida Nuclear Science Center at Gainesville, who discussed the nuclear-powered laser that he is helping to develop. This second-generation laser was originally intended as a self-sustaining power source for NASA's deep-space mission, which has since been abandoned.

Cox explained that in this laser concept nuclear energy is converted not to heat but to light, to optically pump the laser, making it an extremely efficient system. Besides its space application, the system is a prime candidate for a driver for inertial confinement fusion and for space-based ABM systems.

The final presentation of the afternoon panel was given by Ned Rosinsky, MD, of the FEF staff, who discussed the impact of the short wavelength laser on medical and biological research. Because the X-ray laser has dimensions the same order of magnitude as the atom, X-ray laser microscopy will enable us to observe living biological specimens. The width of the DNA molecule is about 10 angstroms, and X-ray lasers operate in the range of hundreds of angstroms down to 1 angstrom, he explained.

With current light and even electron microscopy, where it is impossible to get down to this level, it is necessary to look at stained preparations of dead cells.

Rosinsky then described one con-

Continued on page 63

Beam Weapons and the Press

Because of its long-term support for the development of beam technologies, the Fusion Energy Foundation has been looked to as a major source of information on the strategic and scientific issues surrounding the proposed laser and particle beam antiballistic missile systems.

Press coverage has grown steadily since last fall, when *Fusion* editor Dr. Steven Bardwell's Capitol Hill briefings and his West Coast tour were covered in the regional and campus press and specialist publications such as *Defense Daily*, *Aerospace Daily*, and *Stars and Stripes*, the unofficial newspaper of the U.S. Armed Forces overseas. When President Reagan's March 23 adoption of the policy lifted the taboo on discussions of beam weapon ABM defense systems, in-depth interviews with FEF spokesmen appeared internationally.

The faction opposed to the President's initiative has gone to extraordinary lengths to keep the facts on beam weapons out of print. Below we reprint in full an editorial that appeared in the Mobile, Alabama *Register* on March 31 on the efforts by the Associated Press news service to kill an interview with FEF research director Uwe Parpart Henke filed by AP's own military writer in Washington, Fred Hoffman.

The FEF was informed by AP that the wire story in question was replaced by a more "balanced" article at the request of an AP subscriber, the *New York Times*. But by the time AP acted, the original wire had already appeared in more than 100 regional papers in 35 states around the country.

Here's what the Mobile *Register* wrote:

AP Provides Example of 'Balanced' News

Should there be any doubts remaining in the minds of Americans as to the outrageous bias of our national news media, consider this typical example as perpetrated this week by The Associated Press:

Early Monday afternoon, the AP's foremost expert on military matters, Fred Hoffman, filed an article for nationwide distribution quoting a respected researcher as saying, in effect, that President Reagan's plan for a space age nuclear defense system is not only feasible but is already under study.

Hoffman wrote from Washington: "The United States could have within 10 to 12 years a space-based system of laser weapons that would afford the entire country a 'foolproof' defense against missile attack, according to the research director of a foundation which has explored the concept since 1977.

"A more limited ground-based laser system that could defend key targets such as command centers and important military bases, could be achieved in about seven years, said Dr. Uwe Parpart Henke, a physicist who heads research for the Fusion Energy Foundation in New York City."

Hoffman continued in a rather lengthy story to outline Henke's assessment of such a missile defense program and also added information

relative to the impressive credentials of the qualifications of the physicist.

But there was a fatal flaw in Hoffman's story: It went against AP policy of denigration of any and all Reagan administration arms policy pronouncements.

Even as news editors across the country were considering Hoffman's article, the AP sent out a command to "WITHHOLD" the story since "We are seeking balancing comment and additional background information."

Calls went out from AP in Washington to all the traditional anti-Reagan hotbeds and by early evening the editors were satisfied to release what they considered their "balanced" version of Hoffman's story.

Bearing no resemblance to the original, it read: "President Reagan's call for a US. defense system that would render nuclear weapons obsolete has sparked a debate among physicists, who disagree over whether such a defense system is possible.

"Most scientists interviewed by The Associated Press say research on laser and particle beam weapons—which has been going on for some time—should continue. But they disagree over how long it would take to develop an ironclad system, and whether it can be done at all."

Then came the AP's usual litany of quotations from its hand-picked list of "experts" who scoffed at Reagan's plan.

Although the original story was an interview of Henke, the "balanced" version relegated him to insignificance (two paragraphs of quotations) and went to great lengths to question the credibility of his organization.

In its search for "balance," AP came up with four "experts" (Jane Fonda was presumably unavailable) to debunk Henke's theories.

AP also managed to challenge the Fusion Energy Foundation, informing us that the "organization was founded in 1974 by several people including Lyndon Larouche, a longtime nuclear energy proponent, the founder of the U.S. Labor Party and an unsuccessful candidate for Democratic presidential nomination in 1980."

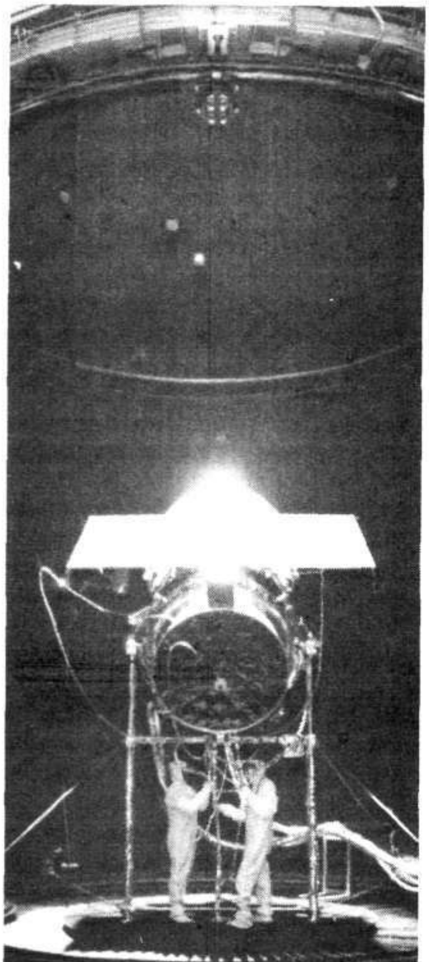
If this is the AP's idea of balanced reporting, it would be interesting to see the Washington editors trying to walk a tight rope.

The Young Scientist

IRAS Telescope Maps Birth and Death of Stars

by Marsha Freeman

The first satellite that will show us the birth and death of stars, something we cannot see from Earth, was launched on January 25 by the National Aeronautics and Space Administration, and within a month, on February 18, NASA announced that the satellite had already located some new objects in the sky. Scientists will be looking for more new stars while the satellite continues its orbit.



The IRAS satellite undergoing thermal testing in a space simulator at the Jet Propulsion Laboratory in California.

This new satellite works by looking at the infrared radiation emitted by certain objects in the sky and is therefore called the Infrared Astronomical Satellite, or IRAS for short.

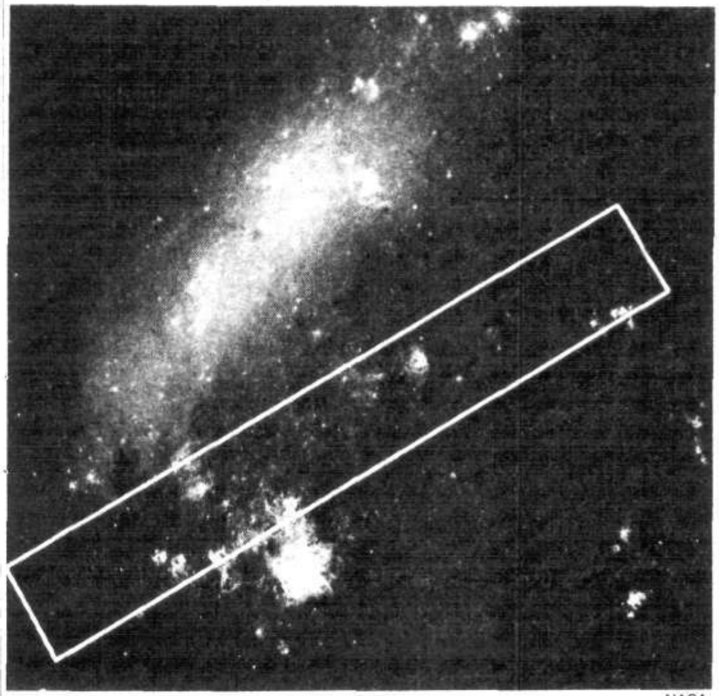
Looking in the Infrared

In the year 1800, the astronomer Sir William Herschel was experimenting with sunlight broken into its separate colors by a prism. He used a thermometer to measure the temperature of the sunlight's different colors.

To his surprise, he found that higher than expected temperatures were registered on the thermometer just beyond the red light that he could see. There was no more visible light, but there was energy creating heat. Herschel realized that an invisible form of thermal, or heat, radiation was being measured and named it "infrared."

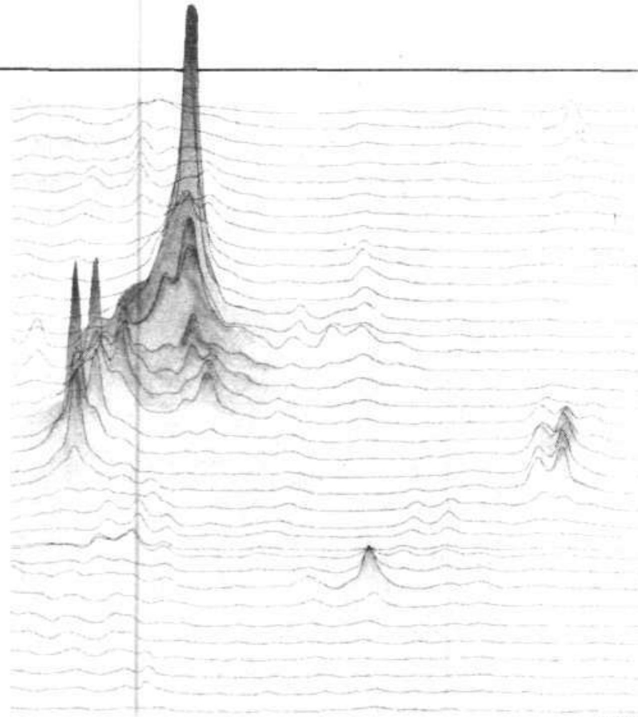
Today astronomers believe that infrared radiation is emitted by stars that are being born or are dying out. But looking at the sky for objects that emit infrared radiation is a frustrating task from the Earth.

The Earth's atmosphere filters out most of the infrared radiation from space. So until IRAS was launched, astronomers could see only a small number of infrared sources in the



NASA

This photo, taken from the Schmidt Telescope in Australia, shows a region scanned by the Infrared Astronomical Satellite across the Large Magellanic Cloud, a galaxy 155,000 light years from Earth. The objects inside the rectangle are described in the computer image at right.



NASA

Each line across this computer mosaic map shows how the strength of the signal seen by one of IRAS's wavelength detectors changes with time as the telescope tracks across the sky. The mountain-like lines indicate very intense and complex infrared emissions, where a new cluster of massive stars, each 10 to 100 times heavier than the Sun, has probably been born.

sky, though they knew there were more there.

What We Know So Far

The brief surveys that astronomers have been able to make of infrared radiation sources have indicated that older stars seem to shed a larger amount of their mass, or substance, out into the interstellar medium of space than do younger ones. The same appears to be true of star-forming dust clouds.

One of IRAS's earliest discoveries was the first newborn star that has ever been observed. It is buried deep within the nebula, or dust cloud, in the sword of the constellation Orion, 1,500 light years away from the Earth. (A light year is the distance that light travels in one year—5,878 billion miles.)

Using optical telescopes on Earth, astronomers were able to see this new star only as a very dim dot. But they had indications that if they could "see" it in the infrared, it would be very bright. Named for its discoverers, it is called the Becklin-Neugebauer Object. Using IRAS, scientists hope to find many more newborn stars.

Scientists believe that before the gas cloud of the nebula becomes dense and hot enough to begin the fusion process that makes them stars, they are emitting light, but this light is absorbed by the dust around it and does not reach our telescopes.

The infrared radiation emitted by these forming stars, however, is not trapped by the dust cloud. If we can look at these nebulae in the infrared we will see new stars.

In our own galaxy, the Milky Way, scientists estimate that the dust is so thick, that for every 10 billion photons of starlight emitted, only one photon of light reaches the Earth.

Cold Enough to Measure Heat

The infrared radiation that IRAS is measuring from the far-away galaxies is registered as heat in the telescope. To make sure that any heat they are measuring is out there, and not inside the telescope, the satellite with the telescope is kept very cold.

The telescope will be kept at only 2 degrees above absolute zero (−273 degrees Celsius) and is carrying 154 pounds of superfluid helium as a coolant. Any heat that is generated by the instruments in the satellite will evaporate some of the helium, and the heat will be carried away.

The 154 pounds of helium will be able to keep IRAS cold for about 10 months, during which time it will do all-sky surveys. It will look in all directions but never directly at the Sun, because the Sun's heat would vaporize all of the helium coolant almost at once.

Ancient man could see about 6,000 stars on a clear night, just with his eyes. Until now, scientists have identified only 2,000 objects in the sky that are emitting infrared radiation. Astronomers estimate that IRAS may observe 10,000 infrared sources *per day* and identify a total of 1 million sources during its less than one-year operating life.

Recently, the European Space

Continued on page 58

TALES OF SCIENCE

Carolus Linnaeus

by Marcia Merry Pepper

Until the mid-19th century—the beginning of the era of the "specialist"—it was the practice for amateurs of all levels of education to study nature and circulate their observations to others in order to improve the general knowledge of the world.

The scientist who developed an overall system for classifying such observations of nature as animal, vegetable, or mineral was the 18th-century Swedish medical doctor and botanist Carolus Linnaeus (1707-1778), whose works are still used today. Linnaeus (pronounced Lin-ay'-us) was a contemporary of Benjamin Franklin and shared Franklin's general outlook that knowledge should be constantly increased to provide a way for mankind to grow both in numbers and in the quality of its knowledge. As Linnaeus wrote, "The Three Kingdoms of Nature [animal, vegetable, and mineral] are made for the use of Mankind. . . ."

Linnaeus's most famous work, written in Latin when he was still a student, was called *Systema Naturae* (The System of Nature). It presented orderly categories by which all plants, rocks, and animals could be systematically grouped and named, by observing their shapes and how they reproduce. For example, Linnaeus categorized each member of the plant kingdom (*Regnum vegetabile* in Latin) according to the number and arrangement of its stamen, that part of a flowering plant that produces the pollen or seeds that enable the plant to reproduce.

Salen Lindblad

Here is a contemporary Swedish exploration of the remote northern areas that Linnaeus explored, organized by Lars-Eric Lindblad, a Swedish-American who provides cruises to remote parts of the globe in the old tradition of observing nature scientifically. Lindblad's company, Lindblad Travel, Inc., for 25 years has pioneered small group tours to the Antarctic and even the Galapagos Islands and other regions, stressing study of the geology, flora, and fauna.

Recently, the Swedish shipping company Salen acquired Lindblad Travel, Inc. and now operates three ships under the Salen Lindblad name for what it calls "cruising expeditions." This summer the M.S. Lindblad Explorer, *shown here, will make two voyages to the high Arctic, starting from Reykjavik, Iceland, stopping at Greenland, Baffin Island, and ending at Nanisivik. The luxury liner is equipped with a lecture hall, five-man landing rafts for field work, and guest scientists who conduct the observatory work. The intention of the expedition, according to the head office of Salen Lindblad Cruising in New York, is "to provide a learning experience that is more than just a transient holiday."*

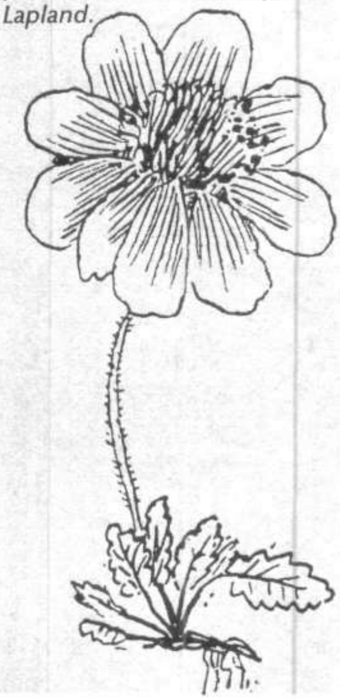
Linnaeus in Lapland dress, as painted by Martin Hoffman in 1787. Linnaeus visited this northern region of Sweden for several months in 1732 to study its plants, animals, and geology. It was a rough and dangerous trip, but one he convinced the Swedish government to fund because he felt it was important to survey these most northern areas.

The classification system uses two terms, where the *genus* refers to a broader biological grouping and the *species* to a sub-grouping; for example, *Homo sapiens,* where the genus name is homo, man, and the species is sapiens, intelligent. This ordering process, which provides an easy way both to group and specify characteristics, is called *taxonomy*.

The *Systema naturae* was first published in Leyden, Holland, in 1735,

Exploring the Globe and Ordering Nature

Linnaeus made beautiful drawings of the species he identified. Here, Tipula Rivosa *(above) and* Dryas Octopetala, *from his manuscript on Lapland.*



but since that time there have been at least 30 editions and countless reprintings. Linnaeus was called "God's Registrar," because he found a simple and practical way to classify everything on earth—including things still to be discovered.

Botanical Experiments

Linnaeus experimented with growing flowers and plants in test gardens in Stockholm and Uppsala, Sweden, and he assembled thousands of dried and pressed plant specimens from the world over, sent by his readers and correspondents. He began the practice of naming newly identified plants after their discoverer. For example, there is a green bush in North America called the Franklinia, named after his good friend. And according to the Linnaean system, the famous pointsettia plant is named after the 19th century American General Poinsett.

When you visit a botanical garden today and notice an "L." attached to the Latin name of a plant, that confirms its original naming by Linnaeus. Eighteenth century observers used his system for classifying the animal world so widely that the number of animal species identified in the *Systema naturae* grew from 549 in the first edition in 1735, to 5,897 in the eleventh edition in 1766. As Linnaeus wrote in a letter to a friend in 1762, "Now the whole world is obsessed with writing in the field of botany, now they can get ahead without difficulty, thanks to my method; I cannot manage to read as fast as they publish; then I have to fit all this into my system."

Exploring the Globe

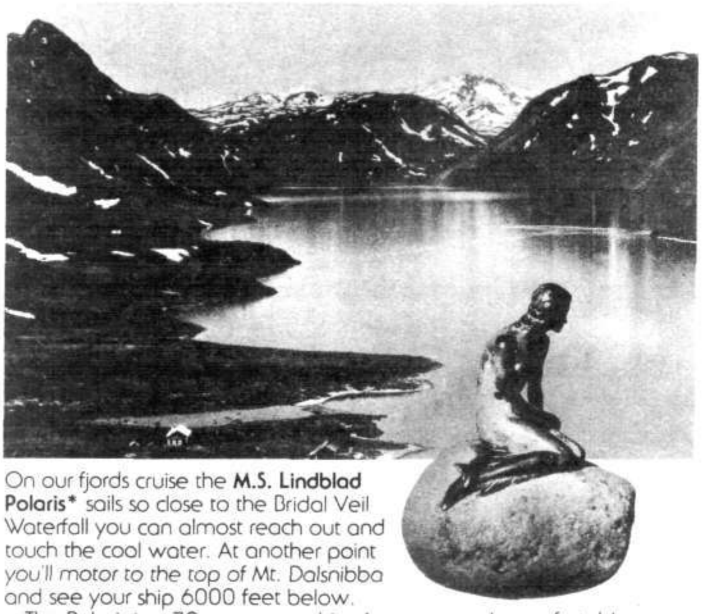
As part of his effort to categorize the Three Kingdoms of Nature, Linnaeus sent his best students on far-reaching field trips to explore the globe. Young Peter Kalm, for example, toured North America from 1748 to 1751, stopping in Philadelphia for guidance from Benjamin Franklin. Linnaeus himself traveled on various expeditions to the far northern reaches of Gotland, Lapland, and Iceland to observe and collect specimens. In 1741, he presented a government-commissioned lecture in Stockholm called "On the Necessity of Travels Within One's Native Land," in which he reported observations on geology, flora, and fauna from the point of view of potential economic use for population growth.

Linnaeus also corresponded with a wide international network of scientists, intersecting Franklin's collaborators in St. Petersburg, Russia; Göttingen, Germany; Philadelphia; and other scientific centers, who shared his global growth viewpoint. One of his major writings was a dissertation "Concerning Increase in the Habitable World."

The explicit purpose of all this global exploration and analysis of nature by Linnaeus and collaborators was to determine which areas of every continent were most suitable for expanding human settlement. He stated his views very clearly on the need for population growth in a 1741 lecture called "Concerning the Increase in the Habitable World." This was the thinking that motivated the new settlers in the colonies then beginning to grow in North America. Ten years later, in 1751, Benjamin Franklin published a study giving population growth predictions for North America called, "Observations Concerning the Increase of Mankind, Peopling of Countries, Etc." At the time, Franklin's work enraged the British government and the scientists in the British Royal Society, whose view was that more people meant less prosperity.

Linnaeus and his cothinkers in Sweden were harassed by this London group, especially when the Swedish government sided with Franklin and the American colonies in their successful Revolutionary War against Britain. Linnaeus, however, did not engage directly in diplomatic activity, but served at different times in his life as a medical doctor—his area of professional training—as a university teacher, and as a researcher of world standing, whose method of describing the Three Kingdoms of nature laid the basis for a vast increase in man's knowledge of the world.

From a deck chair the fjords are impressive. From the Polaris they're awesome.



On our fjords cruise the **M.S. Lindblad Polaris*** sails so close to the Bridal Veil Waterfall you can almost reach out and touch the cool water. At another point you'll motor to the top of Mt. Dalsnibba and see your ship 6000 feet below.

The Polaris is a 79 passenger ship. An enormously comfortable one that shows you the fjords better than larger vessels. We sail into small inlets, drop anchor in out-of-the-way ports, and actually take you right out on the water and ashore in our sturdy Zodiac landing craft. All shore excursions are included at no extra cost. (Most other ships charge more than $400 for them.) And you are accompanied by experts on the history and culture of Scandinavia, people who become your traveling companions.

This expedition also visits the fairytale land of Denmark and rolling green countryside of Sweden, with plenty of time for shopping, sightseeing, meeting the people and savouring the food.

Departures are from Copenhagen on June 11, July 9 and August 6. Prices range from $3,520 to $7,420.** For reservations see your travel agent, call **800-223-5688** or send in the form below.

Salén Lindblad Cruising, Inc., 133 E. 55th St., N.Y., N.Y. 10022 U.S.A.
I would like to reserve space on the following expedition

____June 11 ____July 9 ____August 6.

____My totally refundable deposit of $250 is enclosed.

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Name

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*Registered in Sweden
**Per person double occupancy. Airfare extra.

TO LEARN IS TO LIVE.

M.S. LINDBLAD POLARIS

SALÉN LINDBLAD CRUISING

IRAS

Continued from page 55

Agency announced that its next scientific project will be an infrared telescope that will focus in on the new objects that IRAS identifies in its all-sky surveys.

The field of in-space astronomy is just beginning. In 1986 NASA will launch the Space Telescope that will see farther away than man has ever seen, and other telescope satellites that are planned after that will revolutionize the way we "look" at the sky.

PROFESSOR VON PUZZLE

In the last issue I gave you the patterns for constructing the five regular Platonic solids—the only figures that can be made with all faces, edges, and angles equal. If you built the five figures and counted the vertices, faces, and edges of each one, you would have been able to fill out the chart I gave you as follows:

Figure	*Vertices*	*Faces*	*Edges*
Tetrahedron	4	4	6
Cube	8	6	12
Octahedron	6	8	12
Dodecahedron	20	12	30
Icosahedron	12	20	30

The mathematician Leonhard Euler is credited with the discovery of a formula that relates the vertices, faces, and edges of all the regular solids. It is:

$$\text{Vertices} + \text{Faces} - \text{Edges} = 2$$

If you try substituting from the chart above, you will see that Euler's formula works for all the Platonic solids.

We will be discussing more of the fascinating properties of the regular solids in future issues, so save your models. I keep mine hanging over my desk all the time, for easy reference.

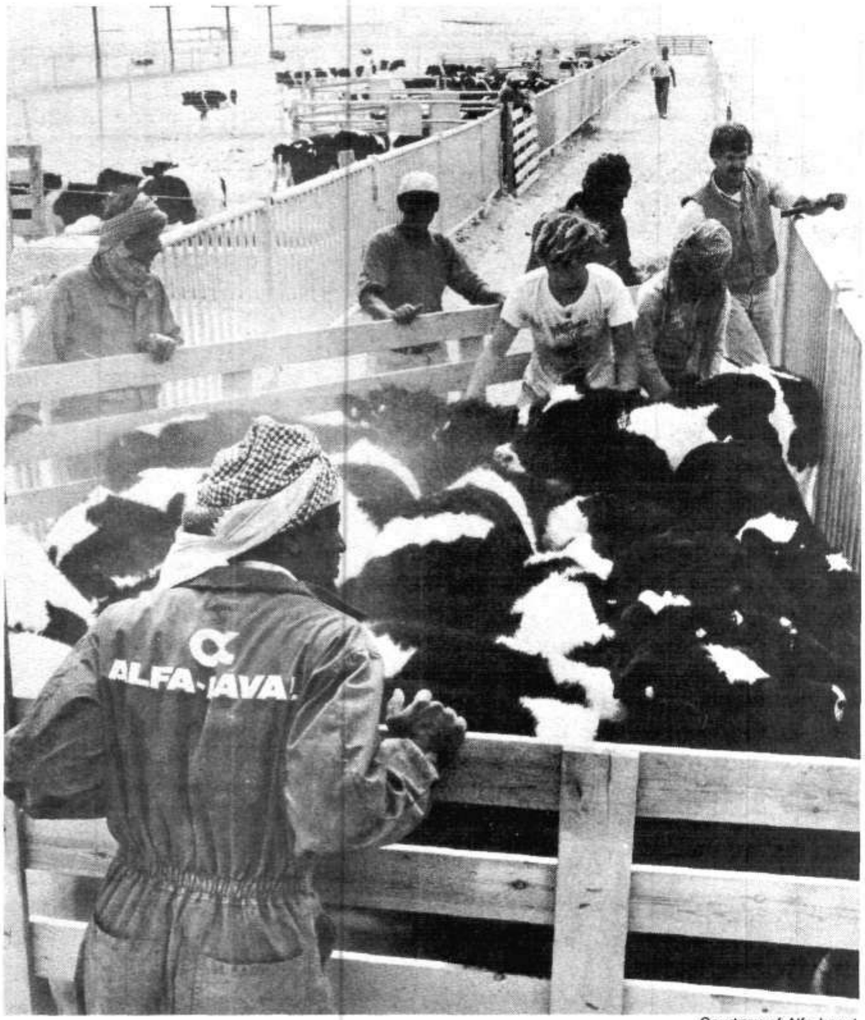
Producing Milk for a Growing World

Ten thousand contented cows, chewing their cuds in the afternoon shade. Is this a giant farm in Denmark or in Wisconsin? No, the cows are in the Saudi Arabian desert, and they supply the population of Riyadh on a daily basis with fresh milk and an important source of calories and protein. Opened in 1981, the dairy will soon have a total of 20,000 dairy cows plus another 5,000 meat animals.

This remarkable project is the biggest of its kind in the world and a model for the rest of the developing sector. It began in 1978, when SAADCO (the Saudi Arabian Agriculture and Dairy Company) signed a contract with the Swedish-based multinational Alfa-Laval, which specializes in dairy farm and milk processing machinery as well as industrial and marine equipment. Alfa-Laval agreed to create and operate the farms, the dairy, and distribution depot, as well as to train the Saudi Arabian staff to take over management after seven years.

The project started in a desert wilderness just outside the Al Kharj oasis, 80 miles from Riyadh. A road and temporary buildings were constructed to receive goods. Wells were dug, water found at 100 to 120 meters, and irrigation machinery installed. By December 1979, the first 90 hectares, out of a future 2,500 hectares, were green with oats. In April 1980, 80 gravid black and white cows arrived at Riyadh airport from the Netherlands aboard a DC-8 cargo plane. Six more plane loads brought an additional 480 cows before the summer heat shut down the airlift, which resumed in the fall, when relatively cooler temperatures make it easier for the animals to acclimatize. Calving began on course during the first summer, and the project grew on schedule.

In 1974, Saudi Arabia's per capita annual dairy food supply in terms of energy (kilocalories) and protein (grams) was only 83 kcals and 5 grams, respectively, compared with 381 kcals and 23 grams in the United States and an even higher intake of dairy products in some European countries. Prior to the SAADCO project, what dairy supplies were available in Saudi Arabia were mostly from canned or reconstituted powdered milk.



Courtesy of Alfa-Laval

The largest dairy project in the world, in the Saudi Arabian desert, supplies Riyadh with fresh milk daily.

Exporting Protein

Millions of the world's people, especially in Asia and Africa, have average dairy food supplies way below Saudi Arabia. If their intake were increased, these populations would show dramatic improvements in general health and in particular in infant mortality. In the short term, the way to effect this improvement would be to export vast amounts of dairy supplies to areas in need, from the high production regions in North America and Western Europe, as well as from New Zealand and other smaller dairy industry centers.

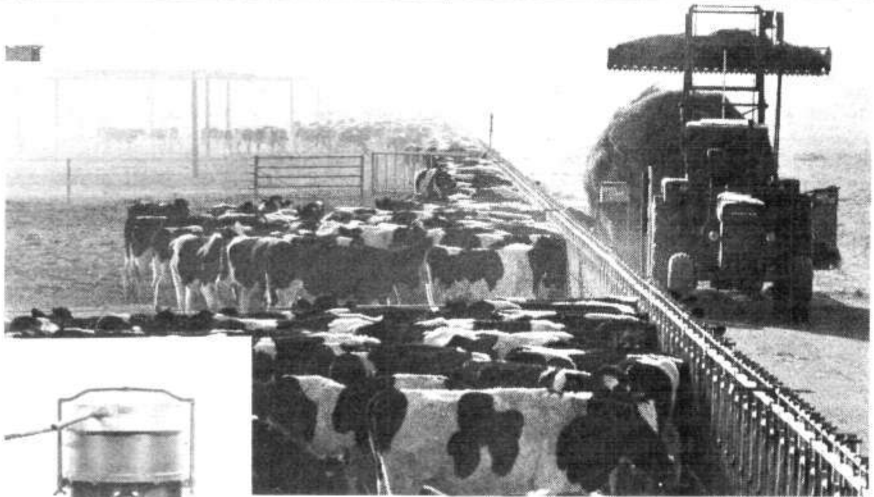
In 1982, total world dairy production (for the major 36 producing nations, not including China) was 390.2 million metric tons of cow milk. Sixteen percent, or 61.6 million metric tons, was produced in the United States and 28 percent, or 108.6 million metric tons, in the European Community. (If India's output of buffalo milk were added to its annual output of cow milk, the percentages would be smaller.) But almost none of the U.S. production is currently exported. A greater percentage of the European Community's dairy production is exported, to Africa and elsewhere, but not nearly as much as could be, without in any way limiting home consumption.

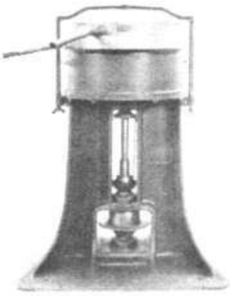
Such an export policy would be equally in the interests of the advanced world's agricultural sector. The United States now has a powdered milk "mountain" of about 1.4 billion pounds of nonfat dry milk product, and Europe has its famous "butterberg." Though the figures sound large, these "surpluses" would disappear in a season if anything approaching real world demand were met, including necessary improvements in the American diet to reverse long-standing deficiencies and the recent upturn in infant mortality in economically depressed industrial cities.

Long Life Milk

At the same time, the technology exists to easily export whole milk long distances without expensive refrigeration by using UHT—ultra high temperature—pasteurization. This process preserves liquid food products by exposing them briefly to intense heating, normally temperatures in the range of 135 to 140 degrees Celsius (275 to 285 degrees Farenheit), which kills the microorganisms present. Packed in sterile containers—usually paperpacks with foil lining—this "long life" milk can last for six months to a year without refrigeration, until, when opened, it must be treated like fresh milk and consumed directly, or kept cool.

This technology is 20 years old and has been used by European dairies for the last 15 years to supply both the export trade and European consumers, who, until recently, have not had the large refrigeration capacity available in the United States. Long life milk is just now being introduced in the United States as a convenience food for camping or to minimize frequent grocery shopping.





Courtesy of Alfa-Laval

Since 1878, when Gustav de Laval patented the hand-cranked centrifugal cream separator (inset), the name de Laval has been a household word in the dairy industry. Today Alfa-Laval produces all types of fluid processing and temperature control equipment. Shown here, feeding time at the Alfa-Laval/Saudi Arabia joint dairy venture.

The newest American UHT dairy plant was opened in 1982 in Savannah, Georgia by Dairymen, Inc., an 8,000-member farmer owned cooperative that markets milk from 17 southeastern states. Construction began in 1981 for the 80,000-gallon-a-day facility, whose equipment came from Alfa-Laval, builder of many of the European long life milk plants. If Dairymen, Inc. reoriented its output from the domestic market—where it sells "Farm Best" long life milk in urban areas—to include the international market, it could ship directly out of the ocean port of Savannah to western Africa, for example, and other importing nations without refrigerated distribution systems.

The long life milk could be transported inland into the country by river, and distributed from bunker depots—large holes in the ground, cool enough to allow maximum "shelf life" for all the UHT supplies. Infant mortality would be reduced significantly. UHT plants could be located at other selected American port cities to tap the major "milk shed" hinterlands, especially the high production Northeast and Northwest milk regions.

More Milk Per Cow

Nor have the limits to milk output per cow been reached, thanks to continuing research into animal physiology. In 1982 in the United States, 57 percent fewer cows (11 million) produced 15 percent more milk than in 1944, a time when cow numbers were at a peak (28 million).

"Our ability to produce is barely tapped," according to Carl Gerhardt, the head of the Alfa-Laval Agrigroup, based in Kansas City, with reference to "almost all areas of food production in the United States."

"Our ability to produce comes from our technological capability," he said in a recent interview. "More important than that, we have the infrastructure here to support the kind of technological development needed and then also to carry it all the way through to the end of the food chain, from coming up with new ways to do things, all the way to putting the product in finished form for consumption, and then also getting it there, which has become more of a problem."

The company's latest measure to improve productivity is computerized cow monitoring, a practice it pioneered commercially with the "HerdMaster" and related systems. This system uses a farm computer to store data on each individual cow, with readings taken automatically at each stall at milking time for milk yield, feed requirements, stage of the reproduction cycle, and so forth. The computer issues instructions to the herd manager: "Don't milk. . .dry cow; mastitis. . .dump milk; time for vet check."

A small percentage of American dairy farms have now installed the first module of this system, which controls and monitors cow feeding. Farmers report output increases of up to 20 percent per herd. An average cow now produces 12,000 to 13,000 pounds of milk a year. The average per cow in a good herd is 15,000 to 16,000, and a cow at the top end of the herd will produce 16,000 to 20,000 pounds a year. There are now exceptional animals that can produce 40,000 to 50,000 pounds in one lactation in one year—an amount unheard of even 10 years ago.

Genetic improvements, due to artificial insemination techniques, have been very important in these productivity increases. Newer techniques involving "superovulation" will yield continuing productivity increases.

Increasing Shelf Life

Except for the cow herself, all of the UHT and refrigeration-based processing and shipping could be as outmoded as the hand-cranked cream separator by the end of the century, with the onset of "plasma age" irradiated food treatment. In pilot plants, this process has been perfected to irradiate fresh milk for a shelf life of *three years* without refrigeration. Raw meat, poultry, and seafood will stay fresh for months, as will raw vegetables and fruits.

The prospect of this revolutionary new technology means that for the next eight years, existing UHT technology and refrigeration-based infrastructure should be used to the maximum to improve world nutrition levels—to preserve and ship milk, cheese, and other dairy products, at the same time that we increase grain and meat supplies generally. Simultaneously, irradiated milk and food systems should be rapidly phased into the farm-food chain in the existing high-production regions. In the developing sector, dairy farm operations should be initiated regionally—using the SAADCO model where appropriate and otherwise using a family farm approach. At the same time irradiated dairy processing centers and non-refrigeration-based distribution channels can be created. Lack of refrigeration in the developing sector is one of greatest limiting factors to potential agriculture development there. An estimated 50 percent of the world's annual food output perishes for want of proper storage and shipment. Irradiated food treatment will allow a worldwide "leap" into a new level of global food and population growth.

Relative to real world demand and

Continued on page 64

Books

History of Inertial Confinement Fusion: Errors and Omissions

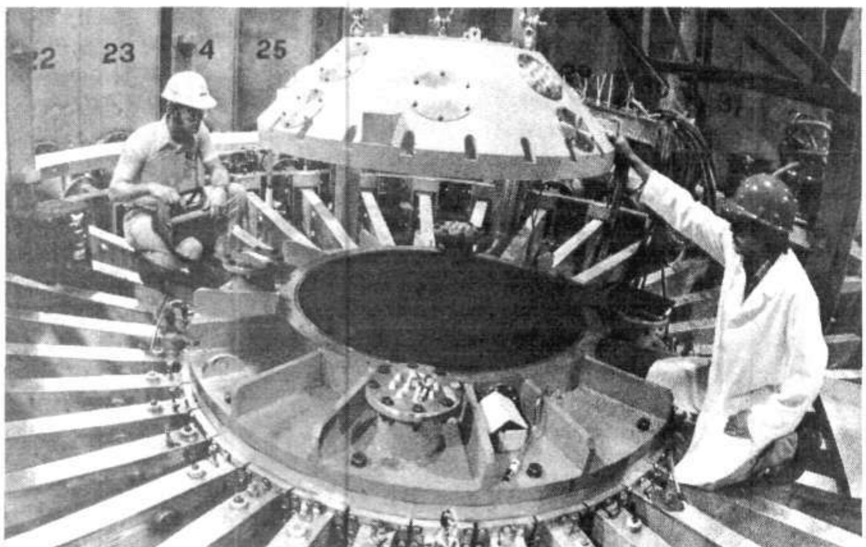
Inertial Confinement Fusion
by J. J. Duderstadt and G. A. Moses
New York: John Wiley & Sons
1982, $49.45

Any research involving large amounts of money is political. For inertial fusion research this problem is enlarged, because it involves not only big money but in addition government imposed secrecy. Where so much power and special interests are at stake, mistakes are made, as can be readily seen in the book *Inertial Confinement Fusion* by J. J. Duderstadt of the University of Michigan and G. A. Moses of the University of Wisconsin.

The authors are apparently newcomers to this area of research, with *no important publications in this field* to their credit. The errors come to light in their chapter on historical developments. For example, they believe that Bethe recognized in 1931 that nuclear fusion is a primary energy source in stars. Bethe may have recognized it, but the idea was published several years earlier by Atkinson and Houtermans in *Z.f. Physik*, Vol. 54 (1928), p. 656. Furthermore, the final theory of thermonuclear fusion reactions was not done by Fermi, Tuck, and Teller at Los Almos in 1940, but rather published by Gamow and Teller in 1938 (*Physics Review*, Vol. 53, p. 608). This theory corrected the simple one-dimensional tunnel effect theory of Atkinson and Houtermans. Bethe and von Weizsacker contributed by proposing the thermonuclear carbon cycle for main sequence stars.

Substantial Omissions

In addition to these historical errors there are many others, of which I only want to mention a few. To begin with, Duderstadt and Moses overlooked, or rather simply ignored, the work of almost every scientist who had laid the groundwork for ideas for which the authors give credit to other scientists who rediscovered, or at best made improvements on, these ideas. The most important scientists who remain unquoted are: (1) Dr. J. C. Martin, from England, who initiated the modern electric pulse power technique; (2) Dr. F. Ford, from Physics International,



Sandia National Laboratories

PBFA I, a particle beam accelerator at Sandia National Laboratories, utilizes the generator concept developed by inertial fusion pioneer Erwin Marx.

who built the first large electron beam machine and proposed its application for inertial fusion; (3) Dr. J. G. Linhart, the originator of the fast liner inertial fusion concept; and (4) Drs. A. Mascke and R. Martin, who proposed heavy ion fusion using storage rings and linacs.

In presenting the important concept of the Marx generator, which was the basis of Martin's work, the authors do not identify the inventor as Erwin Marx, but leave it up to the reader to wonder if it was perhaps Karl Marx who invented the Marx generator. In addition, it appears that the authors are victims of the widely distributed Naval Research Laboratory propaganda that claims that NRL scientists invented the magnetically insulated diode, leading to the successful generation of intense ion beams. This idea was proposed in a paper I delivered in 1969 to the Enrico Fermi School in Physics, which was published by Academic Press in 1971 (*Physics of High Energy Density*). The actual authorship of the idea was also recognized in a historical review on light ion fusion by *Physics Today* (December 1980, pp. 21-22).

In the chapter dealing with inertial confinement reactor concepts, credit is given to several scientists, including self-quotations by the authors, for papers in which previously published microexplosion reactor concepts were rediscovered. (For an admission of this, see the 1982 article by M. Monsler in *Nuclear Technology/Fusion*, Vol. 2, p. 431.)

In the chapter describing applications, the extensive work of the British Interplanetary Society (Project Daedalus) on thermonuclear microbomb rocket propulsion is completely ignored. The authors instead quote the paper by Hyde at al. that is largely a rehash of much older published work. (For references on thermonuclear bomb propulsion, see the historical review by A. Martin and A. Bond, *J. British Interplanetary Society*, Vol. 32 [1979], p. 283.)

An Incomplete Account

That the book is incomplete is apparent on several fronts:

First, the interesting impact fusion concept is dealt with in one short paragraph, and the authors incorrectly believe that the best prospect for the required high velocities is by laser ablation acceleration. The credit for impact fusion is given to Dr. Peaslee, whose main contribution was that he organized a meeting on this topic in 1979. It also appears that the authors are unaware of the fact that the idea of impact fusion is about as old as J.

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Nuckolls's high density inertial fusion concept, with the important difference that papers on impact fusion were already published in the early 1960s, with Nuckolls's 1961 unpublished memorandum still unavailable for critical evaluation by the scientific community.

Second, the important concept of magnetic inertial fusion targets fares no better. It is hardly mentioned but should have gotten a large exposure, because it is the only hope in case $\sim 10^3$ times solid density compression cannot be reached, as it is needed in Nuckolls's scheme.

Third, on page 21, the reader learns that with targets of a "classified nature" 100-fold compressions have been reached. No mention is made that some of these "classified" target designs can be found in the open literature, for example in the paper by S. L. Bogolyubskii at al. (*JETP Letters*, Vol. 24 [1976], p. 182), or in papers I published several years ago on blackbody radiation implosion targets (*Nature*, Vol. 286 [1980], p. 364; and *Z.f. Physik A*, Vol. 296 [1980], p. 3).

Finally, no mention is made of the important cannonball target concept advanced by Yabe and the Japanese school.

The omission of the first two concepts makes the book incomplete, but the omission of the last two concepts makes it largely obsolete, because the direct bombardment concept has now been abandoned for the most part in favor of indirect bombardment by blackbody radiation through beam energy conversion.

In the area of light ion drivers, the authors have given great attention to a scheme by which ion beams are propagated in ionized plasma channels. To my knowledge this idea was first proposed by G. Yonas, but the authors give the impression that it was invented by Ottinger at al. However, more recent experiments on such ion diodes show beam emittance as small as 0.5°, and therefore make it likely that ballistic focusing can be used, as I had proposed it many years ago (*Nature*, Vol. 251 [1974], p. 44; *Plasma Physics*, Vol. 17 [1975], p. 69).

—*Friedwardt Winterberg*
Desert Research Institute
University of Nevada

Beam Conference

Continued from page 53

cept under investigation for applying the X-ray laser to microscopy. The laser beam, a coherent, monochromatic beam, would be subdivided by a crystal, one beam traveling through the recording medium and the other through the material to be examined. The beam traveling through the material would be slightly changed, so that when the two beams come back together they are out of phase.

This extremely sensitive technology could enable us to investigate the most basic questions about cell differentiation—questions that must be answered to really conquer cancer and diseases of the immunological system, Rosinsky said.

Mobilizing the Economy

David Goldman, economics editor of the *Executive Intelligence Review*, opened the final panel of the conference with a presentation on the full array of laser technologies and their potential to raise manufacturing productivity by as much as 1,000 percent.

He began by showing a slide of a strange looking device about the size of a minicomputer, which is housed in a New York office building. This little machine, an advanced plasma furnace, can produce 1 ton of steel per day, he said. A larger version could produce 8 million tons a year.

We have hardly begun to apply lasers—a 20-year-old technology—to industry, he said. One large laser costs $1 million to build today, because we still custom build them. Goldman cited the computer, whose cost has been dramatically reduced over the past 20 years, as an example of how mass production methods can allow the cheapening and widespread application of a technology.

The second speaker on the panel, Richard Freeman of the *EIR* economics staff, discussed the mobilization of the U.S. economy during World War II as a model for the gear up required today.

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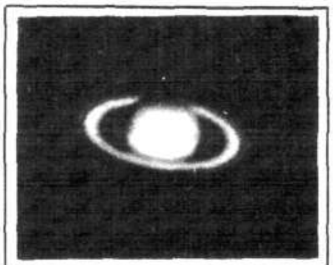

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What made the mobilization possible, Freeman said, was that the United States shifted into a command economy. Resources were allocated to priority areas, and an enormous amount of credit was injected into the economy. The Reconstruction Finance Corporation put out $9.2 billion at 3 to 4 percent interest rates.

In 1938, the United States produced only 5,000 aircraft per year, Freeman reported. Critics of President Roosevelt said it was the equivalent of "Buck Rogers" thinking to say that we could ever produce 50,000 aircraft per year. But in 1944, we produced 96,000 aircraft.

The last speaker on the panel was Nicholas Uwazie, a Nigerian nuclear engineer who is a professor at the Technical Institute of Berlin. Uwazie said President Reagan's mobilization of U.S. scientists and technicians to eliminate the threat of nuclear war must be extended to a commitment to fully industrialize the Third World.

The most important input for Third World development, he said, will be nuclear energy. Nuclear energy holds the promise of prosperity not just for a minority of the world's population, but for all the peoples of the world. A revival of the Atoms for Peace policy of the 1960s must accompany President Reagan's beam weapons development program, Uwazie said.

—Lydia Schulman

A videotape of the conference presentations is available from the FEF.

Milk

Continued from page 61

production technologies, there are no dairy surpluses today, only stockpiles created by political and financial policies that limit trade and enforce austerity and starvation. An alternative course can be charted through treaty arrangements between nations for mutually beneficial large agricultural and infrastructural projects to meet nutrition demands worldwide as the prerequisite to industrializing the globe.

The interesting question will then become, how contented will cows be in the new space colonies on the Moon?

—Marcia Merry Pepper

In This Issue

BEAM WEAPONS CAN PREVENT NUCLEAR WAR

The X-ray laser device shown on the cover will make nuclear-armed ballistic missiles obsolete. Editor-in-chief Steven Bardwell tells you how this defensive beam weapon will work and refutes, point-by-point, the objections to beam weapons popularized by MIT physicist Kosta Tsipis.

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THE TRUTH ABOUT DDT

In 1972, Environmental Protection Agency administrator William Ruckelshaus banned DDT after a seven-month EPA hearing concluded that the pesticide was both safe and necessary. Leading pesticide authority J. Gordon Edwards presents the facts about DDT and the shocking story of Ruckelshaus's admittedly "political" decision.