FUSION

SCIENCE • TECHNOLOGY • ECONOMICS • POLITICS

May-June 1984

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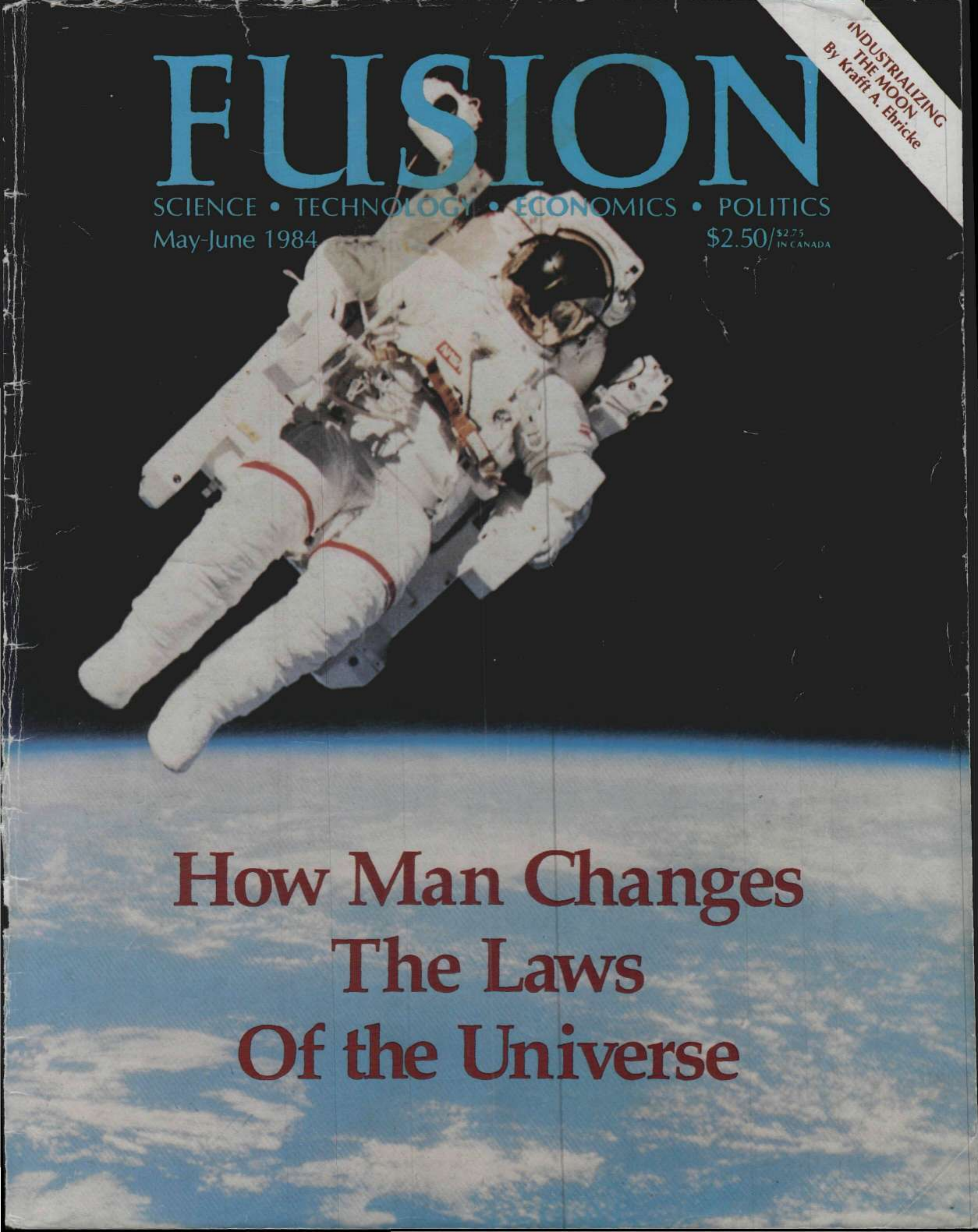

How Man Changes The Laws Of the Universe

FUSION

SCIENCE • TECHNOLOGY • ECONOMICS • POLITICS

Vol. 6, No. 1 May-June 1984

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FUSION (ISSN 0148-0537) is published 4 times a year by the Fusion Energy Foundation, 304 West 58th Street, Fifth Floor, New York, N.Y. 10019. Tel. (212) 247-8439. Dedicated to providing accurate and comprehensive information on advanced energy technologies and policies, FUSION is committed to restoring American scientific and technological leadership. FUSION coverage of the frontiers of science focuses on the self-developing qualities of the physical universe in such areas as plasma physics—the basis for fusion power—as well as biology and microphysics, and includes ground-breaking studies of the historical development of science and technology.

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

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Note to Libraries and Subscribers

We apologize for irregularity in our printing schedule, but we assure readers that the only pronuclear science magazine in the country intends to continue publishing! Because of financial difficulties, the FEF published only 4 issues of FUSION in 1983. The FEF will now regularly publish 6 issues a year, but only 4 issues in 1984, beginning with Vol. 6, No. 1, May-June 1984.

Subscribers who purchased a 10-issue subscription and those who purchased a 6-issue subscription will receive the number of issues they paid for.

Contributions to the FEF are welcome (and tax deductible).

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On the cover: Bruce McCandless II makes history Feb. 7, as the first astronaut to walk in space without a tether, using a nitrogen-propelled, hand-controlled backpack called the Manned Maneuvering Unit, MMU. Cover design by Virginia Baier; cover photo courtesy of NASA.

Editorial

In Honor of 'Crelle's Journal'

The explosion of science which occurred in mid-19th-century Germany owed much to the content and circulation of a single scientific publication, popularly named "Crelle's Journal," formally titled *Journal fuer die reine und ungewandte Mathematik* (Journal for Pure and Applied Mathematics), whose first issue appeared in 1826. The Fusion Energy Foundation's *International Journal of Fusion Energy* (IJFE) would have to go far to begin to match the role which "Crelle's Journal" performed for advancement of science, but we may expect to make a more modestly useful contribution of the same general type.

Briefly, the history of "Crelle's Journal" was this.

The 1815 Congress of Vienna's creation of the "Holy Alliance" was a disaster for democracy and science throughout the world. What had been the world's leading center of fundamental scientific progress, France's Ecole Polytechnique, was demolished in quality of teaching and work by LaPlace and Cauchy, while the founder and leading spirit of the Ecole, Lazare Carnot, was exiled from France, to Magdeburg in Germany. Fortunately for science, Carnot did not remain confined to Magdeburg; he slipped off to Berlin frequently, until his death in 1823. Carnot and his colleagues in Paris worked and conspired with Alexander von Humboldt, and successfully transplanted the quality of scientific work being suppressed in France, by LaPlace and Cauchy, into the environs of the university at Berlin. One of the figures associated with the Carnot-Humboldt conspiracy was August Leopold Crelle, the founder and original editor of "Crelle's Journal."

Even with the backing of men of such prestige in Germany as the Humboldt brothers, establishing science in post-1815 Prussia was hard going. The visible center of the opposition at the university in Berlin was Metternich's spy, recently become the "Prussian state philosopher," G.W.F. Hegel, and Hegel's accomplice, Savigny. Humboldt was obliged to use various subterfuges, both to bring qualified professors of science into the university and to establish a scientific journal, through which scientific work could be widely disseminated.

For example, unable to bring qualified scientists into the official science departments at Berlin's university, Humboldt was obliged to draw upon his allies in the Prussian military, to habilitate some of his professors at the military schools. The center of science at Berlin university became the department of classical philology. To launch "Crelle's Journal," Humboldt again turned to the Prussian military, who purchased a sufficient number of subscriptions to get the journal off the ground in 1826.

In this way, the precious work of Legendre, Fourier, Poncelet, and others from Carnot's Ecole circles was merged with the contributions pouring out from Karl Gauss and his circle at Göttingen. "Crelle's Journal" was the chief literary institution which nurtured and spread this collaboration.

The Fusion Energy Foundation is confronted with a problem today somewhat analogous to that faced by Carnot, Humboldt, et al. in the wake of the 1815 Congress of Vienna. On the one side, present work on the frontiers of science brings us to some of the most fundamental advances in scientific knowledge in more than a hundred years; yet, the political environment is increasingly pro-Malthusian and antiscience, increasingly so since President Johnson's introduction of the "Great Society" packages back during the middle 1960s.

True, apart from the IJFE [present circulation 500 subscriptions], there are numerous scientific journals, many quite prestigious, which devote portions of their pages to scientific papers on subjects of special interest to the Fusion Energy Foundation and its collaborators. However, none of these is taking the point for the cause of science in the same way "Crelle's Journal" did during the critical phase of the 19th century. We examined the situation, and confirmed our hypothesis that the Fusion Energy Foundation was well qualified to take responsibility in one of the several areas of scientific work which must be pushed more energetically at this time.

In addition to the IJFE, there are editions of *Fusion* magazine now published in the United States, Ibero-America, France, Italy, West Germany, Sweden, and India. Although each of these magazines is published by a separate private organization constituted in each of those countries, the magazines are produced in collaboration with one another, with all authorized to republish items originally published in any one of them. *Fusion* in the United States has currently 100,000 subscribers, and a total per-issue circulation of 175,000. Combined, all issues of *Fusion* have presently a circulation per issue of approximately 250,000. Since many of the subscribers to *Fusion* are among prominent scientific workers, students, and related categories of institutions and professionals, the time has come, obviously enough, to upgrade the IJFE to a quarterly publication of between 64 and 128 pages.

The Three Subject-Areas Covered

To do the job efficiently, the IJFE must limit itself to a range of scientific subject matters. We have chosen three principal subject areas: (1) controlled thermonuclear fusion, our traditional, leading concern; (2) directed energy processes; and (3) areas of biological research whose physics is of the same character as fusion and directed energy processes. These are the three areas of scientific breakthroughs now in progress which will dominate changes in technology on this planet—and in space exploration and colonization—for 50 to 100 years yet to come. In all three areas, the mathematical physics required is of the variety typified by the successive work of Gauss, the Webers, Dirichlet, and Riemann into the 1860s. They three areas are functionally interrelated, as well as interrelated in the choice of mathematics best employed. In other words, this choice of subject matters lends unity of direction and conception to the work of the journal overall.

The practical coherence among these three areas is shown most readily by examining their relevance to such tasks as man's colonization of the Moon and Mars, beginning early during the coming century. By thinking of what these technologies mean in terms of creating and maintaining Earth-simulated artificial environments on other bodies in our solar system, we are prompted to see the combined impact of those same technologies for improving the environment and condition of individual life on this planet Earth itself.

Today, the best large-scale energy generation occurs at between 40,000 and 70,000 kilowatts per square meter of energy-flux density. "Second generation, commercial" fusion will bring us to or in sight of energy-flux densities in the order of perhaps 500,000 kilowatts per square meter. This power makes continuously powered space flight feasible, reaching up to relativistic speeds of space travel: regular flight between Earth parking-orbit and Mars parking-orbit becomes feasible, and manned exploration of the moons of Saturn, for example, becomes eminently practicable. This is the energy-flux density needed for creating and maintaining Earth-simulated environments on the Moon or Mars.

"Directed energy" processes are the species of tools we require to employ efficiently the kinds of energy-flux densities progress in thermonuclear fusion implies. These are the technologies we need to produce economically the needs of human colonists on Mars.

We cannot transport food from Earth to colonies on Mars, nor can we envisage transporting more than a part of the total food supplies required for extended space-exploration voyages. Here, breakthroughs in biology are needed. We must produce food on Mars (and the Moon), and must produce much of the food supply needed on extended exploration voyages. Colonists on Mars will demand some forms of trees and so forth within their Earth-simulated environment, another task for "biological engineering."

If we can do this in space, how much more easily we can accomplish greater advances in the quality of environment and condition of life on Earth itself.

This choice of subject matters carries with it, therefore, a clearly implied sense of direction as to practical and scientific purpose, akin to the work of NASA in the successful Apollo venture. This is sometimes described as a "science driver" approach. A better example is the work of the Ecole Polytechnique under the direction of Lazare Carnot and Gaspard Monge, an example closer to the heart of the kernel of dedicated volunteers who developed the Fusion Energy Foundation.

During the period 1671-1716, Gottfried Leibniz created the foundations of economic science, by focusing on the principled features of the way in which heat-powered machines increase the productive powers of labor. From the hypothetical case, that two heat-powered machines, employed for the same kind of work, enable the operator to accomplish more work with one than the other, with the same amount of coal consumed to power this work, Leibniz set forth a rigorous definition of the term "technology." The French name for Leibniz's "technology" during the 18th century and into the 19th, was polytechnique. The Ecole Polytechnique was established to work through Leibniz's conception of technology, treating physical science as being the "production of advances in technology." Under Monge and Carnot, the Ecole more or less perfected the principles of design of machinery elaborated earlier by Leonardo da Vinci, established thermodynamics, and followed through on the work of Benjamin Franklin and his colleagues in establishing the elements of electrodynamics, as continued by Gauss, the Webers, and Riemann. From Gauss's work on electrodynamics, begun during the 1820s, through Riemann's work into the early 1860s, the entire thrust of breakthroughs in mathematical physics was supplied chiefly in connection with going beyond the pioneering work of Legendre et al., to establish the mathematics of the complex (conical) domain essential to comprehending electrodynamics.

It is illustrative of this, that the leading American spy, Samuel Morse, developed the telegraph through his collaboration with his superior, Gilbert Marquis de Lafayette, a collaboration which brought him into contact with the work on electrodynamics by French scientists of the Ecole Polytechnique tradition. The telegraph was developed to solve a critical military problem of the United States: communications, creating a commercial system which automatically provided the U.S. military and intelligence services greatly needed resources for their patriotic work. Without the task-oriented impetus supplied by the work of Carnot and Monge, this small but important achievement of Morse would not have been possible.

The approach taken by the Fusion Energy Foundation, as typified by the case of the LaRouche-Riemann method of economic analysis, is of singular appropriateness in all three subject areas indicated. The current of mathematics traced from La Place, Cauchy, through Clausius, Helmholtz, Kelvin, Maxwell, Boltzmann, et al., to modern statistical thermodynamics, is able, up to a point, to describe some among the phenomena of fusion and directed energy processes, but this current fails critically in face of what are sometimes called "anomalous" phenomena. In the case of living processes, the attempt to "explain away" the occurrence of living processes by means of the doctrine of "statistical fluctuations," is a cumbersome sort of abomination, as is also the case with the definition of "negentropy" supplied by the Wiener-Shannon dogma of "information theory," a definition derived from Boltzmann's doctrine of statistical fluctuations. It is indispensable to take up afresh the "radically geometrical" approach associated with Gauss, Dirichlet, Riemann, et al.

In the domain of plasma physics work, the accomplishments of Dr. Winston Bostick and his colleagues, largely in connection with plasma focus experiments, has proven itself one of the most efficient (in money, effort, and mental exertion) in isolating in a comprehensible way the "anomalous" features of such processes. Although rigorous experimental work from any standpoint of mathematics-method is to be encouraged, and published, it is by placing such contributions into juxtaposition with findings developed from a more or less radically geometrical standpoint in choice of mathematics that the net result of all papers contributed is more likely to become a fruitful one.

In the case of directed energy processes, the choice of the radically geometrical variety of mathematics is obvious from the start. Riemann's approach to electrodynamics, with its inherent emphasis upon retarded potential and induced self-transparency of the medium of propagation, needs to be revived and built upon.

In the case of living processes, the fundamental questions can be addressed only from the radically geometrical standpoint. Luca Pacioli and Leonardo da Vinci were the first known to have recognized that living processes are distinguished from nonliving by the fact that the living processes' morphology of growth and function was harmonically congruent with the golden section. This was also elaborated by Kepler. The golden section in the visual perceptual domain is, however, nothing but a characteristic of the projection of a self-similar conical form of spiral action upon the perceptual domain. This signifies that the proper definition of "negentropy" is not the definition proposed by Norbert Wiener et al., but must be stated in the radical geometrical terms of Gauss, Dirichlet, and Riemann, defining as "negentropic" processes which are functionally self-similar conical modes of spiral-action in the complex domain.

As Ned Rosinsky, M.D. and others have already compiled some of the work on irradiation of DNA accomplished thus far, the double-helical form of DNA is essentially an energy function, implicitly a self-similar cylindric spiral-action as might be projected onto a cylinder from a torus. If the irradiation of this DNA by light, for example, acts as the geometrical physics of the double-helical form implies, then the accumulation of energy by the DNA must generate a topological singularity, to the effect that the excited DNA emits energy at higher energy flux densities than those of its excitation. This does, in fact, occur. This suggests the general character of the mininum condition for negentropy in such a chemical process, to the effect that the indicated form of excitation of the DNA produces a conical function generating the added singularity, and so forth and so on.

The indicated fundamental problem of biology is that of redefining chemistry from the standpoint of Riemannian electrodynamics, treating atoms, molecules, and elementary particles as complex hydroelectrodynamic processes, rather than as assemblies of discrete particles per se. The connections of this approach to biology with plasma physics and the physics of directed energy processes is elementary, to the effect that fundamental progress in any one among the three areas nourishes valuable insights into the other two.

Instead of treating life as an anomaly, as the standpoint of statistical mechanics requires one to do, we must define life per se, following, from a modern vantage point, the same pathway pioneered by Pacioli, Leonardo, and Kepler. Instead of treating life as a statistically improbable variation within the domain of dead processes, we must emphasize the point that the organic compound, like the dead body on the dissecting table, is not alive; that nothing bearing upon the principle of life is to be adduced from such evidence, however useful to biology that evidence might be. We must isolate the simplest case in which the principled characteristic of the physical phase-space explored experimentally is of the "species" of transformation congruent with self-similar conic spiral-action referenced as the mathematical functional expression for "negentropy."

It appears that this approach to laboratory work is best coupled with creating a new, comprehensive medical research protocol covering the area of diseases of aging of tissue as a whole. We must examine the immunological functions of the whole organism to master the phenomena associated, for example, with cancerous growth as opposed to healthy growth. Laboratory work on the "energetics" of cell processes and of immunological mechanisms, must be task oriented in respect to the kind of clinical practice such a comprehensive research protocol specifies. Such a task-oriented approach to achieving fundamental breakthroughs in biology will supply us, as "by-products," as it were, the broader benefits to be sought.

The Editorial Policy

With assistance of a team of qualified referees, the Fusion Energy Foundation will endeavor to publish every useful paper in the indicated three subject areas, either in entirety or abstract, and to survey other scientific journals, and list papers elsewhere published bearing upon these three areas. This will be done chiefly by means of expanding the publication of the IJFE to become a quarterly publication, and expanding the size of the journal to between 64 and 128 pages quarto-size as available material requires.

Where this is suitable, some of these papers will also be published in one or more editions of *Fusion* magazine, or a special *Fusion* article summarizing the crucial features of one or several papers on a topic will be produced. The items published in the IJFE will be announced in the form of an advertisement in *Fusion*. This will be governed by a continuation of *Fusion*'s existing editorial policy governing the range of feature articles suited to the needs of the magazine's readership.

We summarize the editorial policy of *Fusion* magazine as we view it in our experience to date. *Fusion* has three leading functions: (1) to present reports on the state of the art in areas of science and technologies which are well-established as *Fusion*'s adopted areas of special concern; (2) to provide readers knowledge of the internal history of science, mathematics, and technologies, as this bears more or less emphatically upon the principal subject areas of concern to the Fusion Energy Foundation; and (3) to report on such activities of governments and private organizations and individuals as should be of interest to significant portions of *Fusion*'s readership.

By coupling the distinct, but somewhat overlapping functions of *Fusion* and the IJFE in this way, we hope to contribute something in the spirit of the example of "Crelle's Journal." By making the IJFE more efficiently a meeting-place for scientists from the three indicated areas of work, we would hope to accelerate the progress of each and all among them. We aim to be a better catalyst for progress.

News Briefs

FEF BEAM DEFENSE BOOK WINS TOP AWARD

The FEF's book *Beam Defense: An Alternative to Nuclear Destruction* won the top award of the Aviation/Space Writers Association this year. The book describes the feasibility of new beam technologies that can knock out nuclear missiles in the first few minutes of their lauch. *Beam Defense* took first place in the category of books and technical training, as well as the Robert S. Ball Memorial Award for overall excellence in space writing. The Ball award includes a trophy and an honorarium provided by Aeroject-General.

Published in October 1983 by Aero Publishers, Inc. of Fallbrook, Calif., *Beam Defense* is going into its third printing.

CAROL WHITE APPOINTED EDITOR OF FUSION MAGAZINE

Mrs. Carol White, who has led the educational work of the FEF, has replaced Dr. Steven Bardwell as editor-in-chief of *Fusion*. White, a mathematician and former college instructor, is the author of *Energy Potential: Toward a New Electromagnetic Field Theory* (1977) and *The New Dark Ages Conspiracy* (1980). More recently she has authored a series of articles on synthetic geometry and the history of the Pugwash Conference.

Bardwell, a plasma physicist who has been with the FEF since its founding in 1974, is now working as a private consultant and pursuing research in weather modeling and astronomy.

Carol White Stuart K. Lewis

NEW SCIENTIFIC JOURNAL LAUNCHED IN ASIA

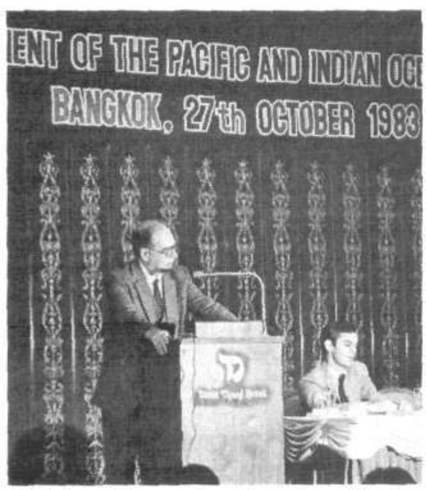
Fusion has gained another affiliate—*Fusion Asia*, an English-language quarterly, now being marketed throughout Asia. Written in collaboration with the FEF, *Fusion Asia* is published in New Delhi, with distribution points in Sri Lanka, Bangladesh, Pakistan, Thailand, Malaysia, Singapore, Indonesia, the Philippines, and Japan. The first two issues include a cover story on the history of India's fusion program by editor Ramtanu Maitra, a first-hand report on Japan's laser fusion program, a development program for the Indian and Pacific Ocean basins; a report on plasma physics research in Malaysia; and a technical comparison of energy sources showing the inappropriateness of the so-called soft energy alternatives. U.S. subscriptions to *Fusion Asia* are $20.

PARIS BEAM EVENT DRAWS EUROPEAN SUPPORT AND SOVIET IRE

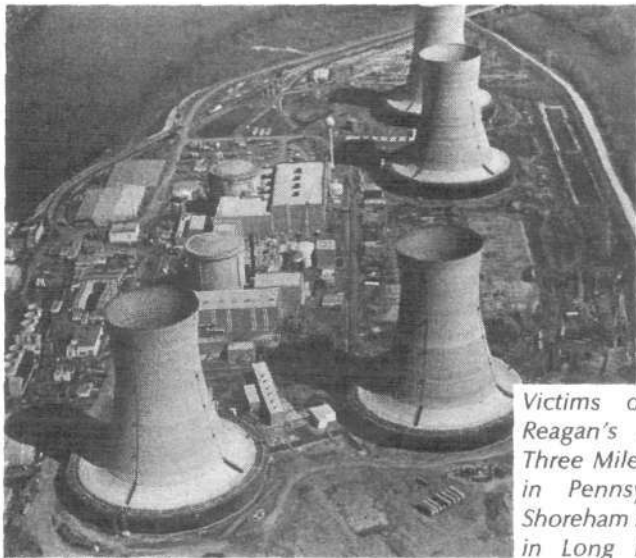
Forty military officers and political representatives attended an FEF conference on beam weapons in Paris March 23-24, one of a series of European conferences. The event, which occurred on the first anniversary of President Reagan's announcement of the new doctrine as U.S. policy, heard some of the leading authorities on beam defense, included FEF board member Lyndon H. LaRouche. Reaction from the Soviet press was immediate. The weekly *Literaturnaya Gazeta* titled its article "A Colloquium of Murderers" and described it as "a startling assemblage devoted to the 'business-like' discussion of the question of which method of mass destruction of people would be more preferable."

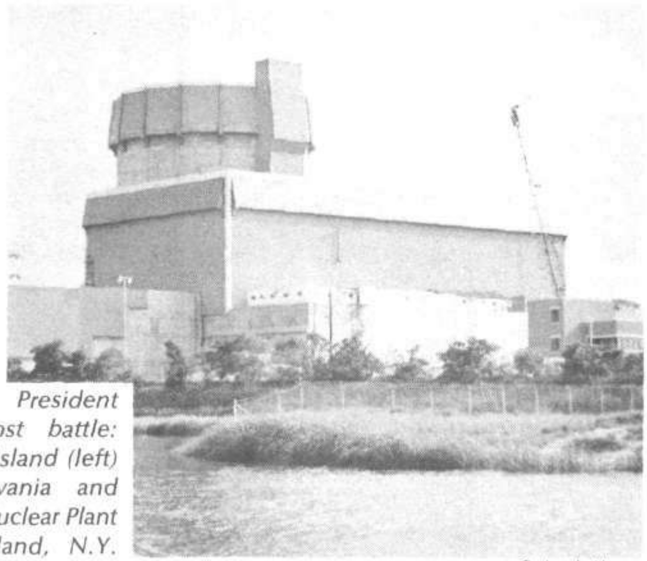
FEF FORMS ORGANIZATION IN BANGKOK, THAILAND

The Fusion Energy Foundation has opened an office in Bangkok, shared with the weekly *Executive Intelligence Review* magazine, and has sponsored two large and successful science conferences there, one on beam weapon defense and the other on the development of a sea-level canal through the Isthmus of Kra. More than 200 leaders of the Thailand Armed Forces attended the Feb. 8-9 conference on beam weapons. Addressing the meeting were FEF director of research Uwe Parpart Henke, who has spent several weeks in Thailand this year; Dr. Robert Budwine of the Lawrence Livermore National Laboratory; and Dr. Friedwardt Winterberg of the Desert Research Institute of the University of Nevada. A feature article on the Kra Canal project and the development of the Pacific Basin will appear in the next issue.



FEF board member Lyndon H. LaRouche keynoting the Bangkok conference on the development of the Pacific and Indian Ocean basins. At right is Uwe Parpart Henke.





Metropolitan Edison Co.,

Victims of President Reagan's lost battle: Three Mile Island (left) in Pennsylvania and Shoreham Nuclear Plant in Long Island, N.Y.

Carlos de Hoyos

Nuclear Power: How Reagan Lost the Battle

Despite its pronuclear intentions, the Reagan administration has lost the political battle on nuclear energy to Federal Reserve chairman Paul Volcker and to the Democratic political machine grouped around the ancient friend and asset of the Soviet politburo, Averell Harriman.

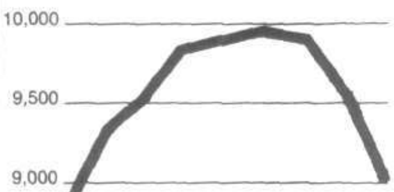
The Harriman-Cyrus Vance grouping controlling the Democratic National Committee and associated thinktanks and political action committees has pointed openly since the Carter presidency to a "new environmentalist world order." Their nuclear freeze movement—led in Congress by New York and New England Harriman protégés like Ottinger, Solarz, Tsongas, and Weiss—has made no distinction between nuclear weapons and nuclear power plants in its assaults against administration policy.

The White House has refused to fight back, repeatedly "hanging out to dry" Department of Energy spokesmen for initiatives to revive nuclear power, as soon as those spokesmen came under attack by the Harrimanites. President Reagan himself has not promoted nuclear power development in a public speech since taking office, a reversal of his entire previous political career.

The most flagrant case is the Nuclear Regulatory Commission (NRC), which despite a so-called pronuclear majority appointed by Reagan, has connived for two years to halt the completed Shoreham nuclear plant in New York and destroy its owner, Long Island Lighting Co. This purely political vendetta was run by New York governor Mario Cuomo, a Harriman protégé, and like-minded officials. The real power at the NRC, in fact, is a supposedly neutral technocrat, commissioner Victor Gilinsky, a 20-year veteran of the Pugwash Conference movement associated with Harriman and Lord Bertrand Russell.

PER CAPITA KILOWATT HOURS OF ELECTRICITY CONSUMED IN THE UNITED STATES

Electricity usage has dropped dramatically since the 1970s, the first such drop in the nation's history.



Three Lost Years

In three years, the administration has been unable to bring on line any significant amount of nuclear power. Volcker's high interest rates and tight credit policies have forced nuclear plant construction costs to skyrocket, while antinuclear politics on a local level and inside the NRC have strangled nuclear power plant operation in a regulatory web. At Three Mile Island unit 1, Shoreham, and elsewhere, the NRC has acted in partnership with governors and local politicians to prevent plants from operating.

Approximately 70 percent of the total capital costs of building a nuclear plant represents unnecessary waiting time caused by environmentalist and regulatory delays that average eight years. With capital borrowed at Volcker's 12 to 18 percent interest rates, the typical nuclear plant today needs three times as much construction capital and five to six times as much in total capital costs, compared to a plant built in the 1960s. Interest costs now total more than five times the already inflated capital costs.

As a result, the nation is slated to become just what Volcker and the antinuclear movement want: A postindustrial society, where small is beautiful and where there is not enough electric power available to power heavy industry. In fact, the destruction of the U.S. power grid puts all current electricity usage in jeopardy (see box).

Turning Off the Lights

The facts are startling. Since electric power use reached its peak in 1979, usage has fallen continously, collapsing 8 percent per capita since 1980 (see figure). Given the growth of both the population and the labor force since then, this collapse in per capita electricity use is the equivalent of *turning off 40 full-size 1,000 megawatt power plants*.

In fact, combining the nuclear plant cancellations and plants refused licenses, this is virtually what has been done: We have turned off the equivalent of forty 1,000-MW power plants that would otherwise be newly operating. As demonstrated by the recent case of the Washington Public Power Supply System, the process of reopening plants or restarting construction becomes very difficult once a utility has been forced into bankruptcy.

In the beginning of his administration, President Reagan vowed to put nuclear back into the energy picture, and Department of Energy head James Edwards promised that the 33 or so nuclear plants then in construction would be rapidly licensed to go on line. In three years, however, only 11 plants have been licensed, 6 in 1982 and 5 in 1983. Worse, since 1982, 24 nuclear plants have been canceled or indefinitely mothballed.

Since January 1984 alone:

- Public Service of Indiana has scrapped two units at its Marble Hill nuclear site, despite investment of $2.8 billion. Marble Hill-1 is almost 60 percent complete. Retroactive regulatory changes demanded by the NRC, combined with cost run-ups have created severe cash problems for the utility.
- The NRC told Commonwealth Edison of Illinois, the nation's most experienced nuclear operator, that it could not operate its nearly completed $3.4 billion Byron Nuclear Power Station near Rockford because of alleged inadequate construction quality controls. This is an unprecedented preemptive move by the NRC.
- Philadelphia Electric Co. has ordered work on its Limerick II plant halted for at least 18 months, forcing 2,200 construction workers onto the unemployment lines. The plant is almost 40 percent complete.
- Cincinnati Gas & Electric Co. has halted work on its William Zimmer nuclear plant, more than 97 percent complete. The utility plans to convert the unit to burn more expensive coal, despite the $1.6 billion spent to date.

One official with the Bechtel Corp., the world's largest nuclear constructor, summed up the situation bluntly: "You've got the potential for a $50 billion crash in the nuclear industry. It hasn't sunk in yet, but it will . . . over the next few months."

The New York Example

New York state provides a case study in how the squeeze policy of the environmentalists and Volcker has destroyed nuclear power. Ironically, amid a regular stream of headlines on the "cost overrun" of the Shoreham nuclear plant on Long Island and the near bankruptcy of the Long Island Lighting Co. (Lilco), is the little publicized story of how Canadian nuclear exports are filling the power shortfall in the U.S. Northeast. The Canadians state that the total cost of Canadian nuclear-fueled electricity is less than the cost of fuel alone for electricity produced at an efficient oil-fired power station.

The man responsible for blocking New York's nuclear starts, with the exception of one upstate plant, is Governor Cuomo, who is touted as up-and-coming presidential material by the 90-year-old Harriman, dean of the Democratic Party. In his two years of office, Cuomo has also killed two coal-fired plants.

The Vulnerability of the Power Grid

The nation had a near-disastrous though little publicized national power failure on Christmas Eve, when the electromagnetic frequency of the grid dropped to 12 cycles per second; 14 cycles per second is the threshold for shutdown. This near-miss along with a recent West Coast brownout underscore the fragility of the U.S. electricity grid and the need for more electrical capacity, not less.

After the great Northeastern blackout of 1979, systems engineers studying the cause and propagation of the initial system failure discovered a remarkable similarity between the dynamics of an overloaded electrical network and many complex mathematical systems. In both cases, the behavior of the system is very sensitive to small external changes at certain critical "thresholds."

In physical systems this behavior is evident in phase changes (the crystallization of a supersaturated solution, for example), in the sudden onset of turbulence in fluids, and in the appearance of singular phenomena like shock waves. Over the past decade, physicists have come to the surprising conclusion that all these systems are fundamentally similar: they are able to "metabolize" chaotic energy from their surroundings and perform "work" in the form of structure creation.

In the case of the electrical system operating at less than 20 percent "excess capacity," a similar but destructive phenomenon becomes possible. The electrical grid becomes more and more sensitive to small changes in load or to small perturbations like the loss of some circuits by lightning. If there is insufficient "excess capacity," any of these perturbations can push the grid past the threshold—or freezing point—and cause a phase change in which all the switches turn from on to off (much like the ordering of molecules in a crystal as it freezes). The mathematics used to describe this phase change are identical to those used in the case of crystallization of solidification.

Energy functions in the economy as a whole in much the same way as capacity does in the electrical grid: a small change in the availablity of either can have disastrous consequences, all out of proportion to the size of the change.

Cuomo pulled the plug on the Shoreham nuclear plant, a $4 billion venture now ready to go on line, with the aid of local antinuclear politicians. The governor appointed a 13-man commission to study the beleaguered plant. The antinuclear faction of the commission issued a report in December 1983 over strenuous objections from its other members. "The Long Island Lighting Co. should never have built the Shoreham reactor and is not ready to run the plant," the report concluded.

Cuomo immediately adopted this conclusion as his own. He then decided not to step in to break the deadlock between Lilco and local politicians, who had refused to participate in an emergency plan for evacuating Long Island in case of an accident, as a way to prevent the plant from coming on line. The NRC also refused to act, although it has the power to license the plant.

Each day that Shoreham sits idle costs Lilco $1.5 million, and on March 6, the new Lilco chairman announced 1,000 layoffs and cancellation of stockholder dividends. Wall Street insiders are now awaiting Lilco's bankruptcy in the immediate future. As a result, the high technology firms on Long Island have been forced to buy electricity from Canada. In all, Northeastern U.S. power companies spent $1.2 billion to import electricity from Canada last year, and Canada estimates that its electrical exports could double by 1986 and redouble by 1990.

A National Security Issue

The inability of the United States to power the industrial growth necessary for a healthy economy or to guarantee the necessary power for a crash program to develop a beam weapon defense are both questions of national security. The machinations of the NRC to strangle nuclear power domestically and the actions of antinuclear congressmen to curb nuclear technology exports cannot be explained away as harmless "free enterprise" activities. The U.S. electric power grid is collapsing, and if the situation is not rectified, we could face blackouts and brownouts in the near future.

For this reason, the Fusion Energy Foundation called for an investigation of the NRC around specific instances of NRC officials leaking internal reports on plant safety to antinuclear groups before these reports were reviewed by the NRC or made available to plant management.

How an agency ostensibly set up to regulate nuclear power has been turned into a sabotage operation can be understood by looking at the career of NRC commissioner Victor Gilinsky, the first and the only continuously reappointed commissioner. Gilinsky came from the Rand Corporation (1969-1974), and was brought in by his Rand colleague James Schlesinger to constitute the NRC out of the Atomic Energy Commission in 1975. Privately, according to an AEC source, Gilinsky was known as "Jim Schlesinger's axe man," because he fingered those within the AEC who were likely to make waves in the new agency. Schlesinger's premise was that the AEC was inherently corrupt because of its close ties to the nuclear industry.

Gilinsky comes out of Rand's California Seminar on Arms Control and Foreign Policy. This group includes leaders of the Pugwash disarmament faction and has orchestrated every disaster in U.S. defense strategy from the days of Robert McNamara. Through the Rand California Seminar, Gilinsky has waged a campaign for a U.S. nonproliferation policy that rules out separation and reprocessing facilities and thus makes nuclear weapons nations the only source for enriched or reprocessed nuclear fuel.

Victor Gilinsky: Rand's man on the Nuclear Regulatory Commission, and chief mover behind the NRC policies that have regulated the U.S. nuclear program out of business.

Gilinsky has also consistently attacked the 1956 Atoms for Peace policy, demanding a return to the 1949 Acheson-Lilienthal Report. This discredited plan would place world uranium processing and enrichment facilities under control of a designated agency of a so-called neutral world body. A rehash of the old Bertrand Russell-Leo Szilard proposals to establish a world government with private monopoly on the deployment of nuclear weapons, the plan would set up, in effect, a privately controlled United Nations with an exclusive nuclear capability.

A 150 Gigawatt Remedy

In a recent study, the FEF concluded that the nation needs 150 gigawatts of nuclear power by 1990, if the economy is to recover. The study demonstrates that U.S. nuclear construction can be revived only by restoring the high target for plant construction set in the 1960s—only that level of nuclear power development will generate the productivity increases and other economic benefits needed to bring down capital costs. According to FEF estimates, the U.S. nuclear industry can produce more than 200 nuclear units (at 1,000 megawatts) by 1990, leaving a significant capacity for export above the 150 gigawatts needed for domestic industrial recovery.

The prerequisite for such a program would be a top-priority commitment by the Reagan administration to set a national construction goal and squeeze out the delays to meet it. France did this in 1974, and has built full-size nuclear units ever since at one quarter to one third the cost of construction here.

Given a favorable political and interest rate climate, the cost of a 150 gigawatt U.S. program would be about $200 billion. Ironically, if the country continues the downward plunge, it is likely to spend the same amount of money getting fewer or no new plants built.

—William Engdahl and Marjorie Hecht

10 Gigawatts Nuclear by 2000

India Selecting Sites for Four Nuplexes

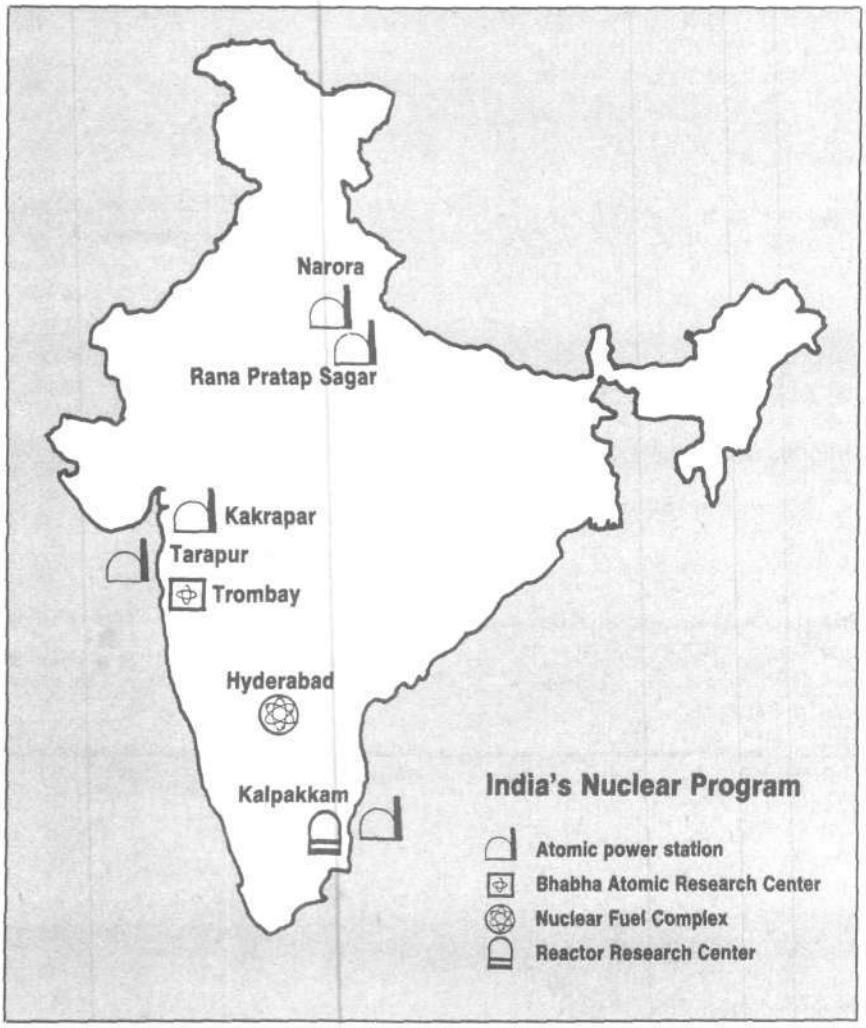
by Susan Maitra

India's Department of Atomic Energy (DAE) has begun site selection for four huge nuclear power complexes, a major step forward in the Indian government's plan to bring on line 10 gigawatts of nuclear power by the turn of the century. Each nuclear complex will consist of a cluster of four 500-megawatt heavy water or breeder reactors.

Insufficient power has been the principal infrastructural bottleneck in developing India's economy. The new plan—for nuclear energy to provide 10 percent of total electricity supplies by 2000—is critical to the future well-being of its people. With a population of 780 million and a growing industrial base, India now has only 30 gigawatts of electrical power capacity, most of it coming from coal. But the logistical and environmental problems associated with thermal power generation in India, where the coal is of low quality, are enormous and growing. Hydroelectricity generation, the other major source of industrial power, has its own natural constraints.

Shortly after Prime Minister Indira Gandhi announced the new program last December, India's Atomic Energy Commission chairman, Dr. Raja Ramanna, launched a campaign to rally the population behind the government's nuclear power plan. In a series of lectures in the nation's capital, New Delhi, Ramanna explained that the exploitation of nuclear power was "inevitable" for India's continued development as a modern industrial nation.

Last July, India successfully completed and started up a 235-megawatt nuclear reactor at Kalpakkam, the first almost completely indigenously built heavy-water reactor in the country. The Kalpakkam milestone gave nuclear scientists, as well as the population, renewed confidence in the program for self-reliance in nuclear technologies that had been outlined by the brilliant physicist and science policymaker Dr. Homi Bhabha and adopted by Prime Minister Nehru's government after India's independence in 1947.



This past year the Bhabha Atomic Research Center (BARC), the "brain" of the Indian nuclear research program, celebrated its 25th anniversary with a host of additional "milestone" accomplishments: a Beryllium Pilot Plant was commissioned; a new research reactor, the R-5 at Trombay, was near completion; reprocessing of the spent fuel from the Rajathan Atomic Power Station began at the reprocessing plant in the Tarapur complex; plans were laid for the new Center for Advanced Technology, which will focus on laser fusion research among other "thrust" areas; a cosmic ray experiment for the Space Shuttle was planned; a community rural cancer diagnostic scheme was launched; and plants for upgrading heavy water were set up.

A 'Nuplex' Approach

The concept of putting four large 500 megawatt nuclear reactors in a single cluster generating 2,000 megawatts of power is a marked advance in planning. In the early 1960s, Dr. Vikram Sarabhai developed the concept of establishing such clusters; he suggested that they would help optimize power consumption efficiency and would be the center around which agroindustrial complexes, "nuplexes," could be built and townships rise. But even as late as last August, Indian experts were comtemplating clusters of only 235-megawatt reactors.

The new thinking is based upon the notion of efficient consumption of electrical power locally. The plan will enable immediate utilization of the existing regional grids without spending too much in upgrading them. Moreover, it will provide the necessary balance of power sources in the regional grids, which would otherwise be reliant on the large "superthermal" (nonnuclear, nonhydro) power stations now under construction.

As the government told Parliament when the plan was announced in December, the added investment required to develop many separate sites will thus be avoided. And the time required to construct the plants will be reduced by "clustering" the large-size reactors.

Energy Independence

The Indian nuclear program started in the 1950s with the goal of becoming self-sufficient in nuclear energy generation. A long gestation period proved necessary to develop manpower and research facilities and to gather sufficient data to channel the research experience into building commercial reactors. But during this period, Indian scientists and engineers built two nuclear reactors: one at Kalpakkam—which is about 95 percent indigenous—and a second, which the Indian government completed after it had been left unfinished by the Canadians, who walked out of their contract in 1974 to protest India's peaceful nuclear explosion.

Obstacles notwithstanding, India has proceeded to master the complete nuclear technology fuel cycle in accordance with the long-term program developed by Homi Bhabha. Based on India's limited uranium deposits and more abundant thorium deposits, the strategy has been first to use natural uranium with heavy-water type reactors, followed by fast breeder reactors that will use thorium fuel in their second generation.

The logic of Bhabha's program is straightforward. First, it is based on utilizing the fuel resources India has—namely, the third largest supply of thorium in the world. Second, by basing the program on the heavy-water fuel cycle, India is spared the enormous expense of building enrichment facilities. Finally, the program gives India complete energy independence; the country will not have to depend on any other nation for fuel.

A Fast Breeder Test Reactor will be commissioned this year at the Reactor Research Center in Kalpakkam, and work is already under way on preliminary design of a prototype fast reactor for commercial production. The Indian fast breeder will operate on a new kind of carbide fuel developed by Bhabha Atomic Research Center scientists which, if successful, will represent a significant Indian contribution to fast reactor-development worldwide.

Moreover, Bhabha was one of the first scientists to foresee the development of fusion power and to champion its tremendous potential. India is now building a tokamak machine and will have an experimental laser fusion facility in the new science center at Indore, with the view of preparing scientists and technicians to rapidly adopt fusion power as soon as it is proven commercially.

The selection of eastern India as one of the nuplex sites also marks a shift in policy. Eastern India, the most power-starved region in the country, is rich in poor-quality coal deposits. It had been a conscious policy of the government *not* to build nuclear power stations in this region, but to exploit coal for electricity generation instead. This policy was championed by the neo-Malthusian lobby in India and boosted by cost estimates showing that a coal-fired plant is cheaper than a nuclear-powered one.

Two facts seem to have helped shift the old policy. First, coal-based power generation had given the eastern region the lowest capacity utilization rates in the country. Second, and even more decisive, Ramanna demonstrated in his recent lectures that nuclear power is competitive with coal—even at the pithead.

In the 1950s, when India started its nuclear power development program, a cost estimate was made comparing the relative capital cost of nuclear power plants and thermal plants. It was calculated that a nuclear power plant was viable only at a distance of more than 800 kilometers from the coal pithead. Over the years, however, the cost gap has narrowed, principally because India's low-wage, labor-intensive coal mining sector remained so inefficient.

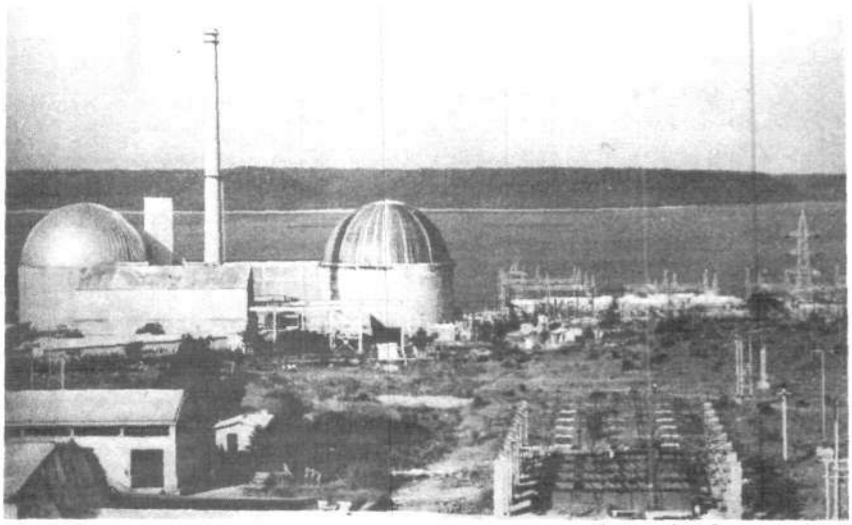
In a public lecture this February, the India atomic-energy chief documented that at 1977 capital costs, nuclear and coal-based energy generation were comparable. A comparison of the cost of electricity from nuclear power, coal-fired thermal power at the pithead, and coal-fired thermal plants at 800 km from the pithead is striking: 5 cents, 5.3 cents, and 6.2 cents per kwh respectively. With the construction of more plants, Ramanna explained, their cost and construction time would decrease. He put the 10,000 MW program's financial breakeven point at the year 1996.

Ramanna announced that he would convene a forthcoming meeting of in-

The Cost of Not Going Nuclear

According to a study by the Fusion Energy Foundation, at least 115 million lives have been lost—most of them in the Third World—as a result of the obstruction of nuclear power development worldwide.

FEF researchers estimated that economic growth worldwide could have been at least 3 percent higher a year between 1965 and 1980 if the 200 or more plants scheduled had in fact been built. Instead of investing in nuclear power, most nations diverted capital into less efficient modes of energy production—oil and coal-based electricity—resulting in lower economic growth and lower productivity increases. The result could be counted in human lives.



Courtesy of the Government of India

The Rajasthan Atomic Power Station reached a milestone in Indian self-sufficiency last year when reprocessing of spend fuel from this station began at the Tarapur complex.

dustry leaders in Madras to mobilize their involvement in the program. For the first time, Indian industry will be assured of repeat orders for reactors and components to justify their development costs. Current plan projections call for an additional 5,000 MW of power from existing 235-MW reactor designs, and the balance from 500-MW units now under design development for commercial production—in all, more than 30 units over the next 20 years.

The Tarapur Lesson

The highly publicized difficulties India faced with the Tarapur atomic plant rebounded against the nuclear power program, creating confusion and opening the door for spurious attacks. But, as Ramanna recently emphasized, the problems with Tarapur have no bearing on the basic nuclear power program since it is not based on light-water reactors. Furthermore, he added, the Tarapur plant has been functioning well for many years, and since BARC scientists have developed an alternative mixed-oxide fuel (MOX), any future cutoff of enriched uranium fuel supplies will not force a shutdown of the plant.

From the beginning, Tarapur's difficulties were political, not technical. In the 1960s, India bought the two light water reactors from the United States, signing a contract whereby the United States would supply enriched uranium for the lifespan of the reactors. However, in the mid-1970s, the Carter administration, with the rallying cry of "nonproliferation," called a halt to the supply of enriched uranium for Tarapur. It was clear that President Carter, during whose reign the U.S. nuclear industry was bankrupted, was using nuclear technology as a political weapon against India and the entire developing sector.

The Tarapur experience was a bitter lesson for India. Recently, Prime Minister Gandhi renewed India's determination to achieve scientific and technological self-reliance. Gandhi also harshly condemned the London group of nuclear weapons states' use of what she called the "bogey of nonproliferation" to block nuclear technology transfer for energy and other peaceful uses to the developing sector.

Ramanna echoed the prime minister in his recent lectures in New Delhi. Today, Ramanna explained, it has come to the point that it is impossible to import even nuts and bolts for a nuclear power plant!

For India, this is not only an annoyance that causes unnecessary delays. It is also a strong factor preventing the development of mutually productive relations at the highest level with the United States. For those developing countries without India's scientific and technical capability to proceed independently—and that's the majority—it means genocide.

Dr. J. Gordon Edwards

An Interview with Dr. J. Gordon Edwards

How the Environmentalist Campaign Against Pesticides Kills 100 Million People a Year

Dr. J. Gordon Edwards is a professor of entomology at San Jose State University in California, where he has taught biology and entomology for 31 years. 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. His article "Pesticides and People: How Environmentalist Politics and Bad Journalism Banned DDT" appeared in the May-June 1983 issue of* Fusion, *Edwards is interviewed here by managing editor Marjorie Hecht.*

Question: The latest statistics of the World Health Organization (WHO) show that 210 million people are suffering from malaria, 160 million of them in Africa south of the Sahara. Yet WHO's current policy on malaria has given up on eradicating the disease and talks about simply trying to "control" it. There seems to be no mention of pesticides as part of this policy of control.

Could the use of DDT or other insecticides in a "brute force" effort eradicate malaria by entirely getting rid of the mosquito population that carries the disease?

It's most unfortunate that the use of DDT and other insecticides to eradicate malaria throughout the world is impossible now, I think, because of the great delay we've had. At the time that the effort to eradicate malaria in the world was announced by the World Health Organization back in 1954-1955, there was really a very good chance that we could have eradicated malaria.

Looking back at what happened, we see the great anti-DDT movement in the United States. This was boosted by Rachel Carson's book, *Silent Spring*, published in 1962, and by 1972, this led to the Environmental Protection Agency's ban on the export of DDT in the United States. Then other countries around the world, seeing that the United States was so worried about DDT and its effects on people that it was willing to ban it, had to explain to their citizens why they were still going to use DDT. In this way, the anti-DDT campaign and the subsequent EPA ban on DDT exports led to a great cutback worldwide in the use of DDT.

United Nations

A young malaria victim in Terai, India in 1950. His enormously enlarged spleen is one of the symptoms of malaria infection.

For example, in Ceylon, which is now Sri Lanka, where they had a good malaria program going, the government was so worried that it cut out the use of DDT completely. In 10 years of Ceylon's DDT program, the total number of malaria cases had dropped from about 2 million down to 17, and the number of deaths from malaria dropped from 12,000 per year to zero. But shortly after Rachel Carson's book was published, Ceylon cut its DDT program and then began to see a rapid resurgence of malaria, going up quickly from a low point in 1962-1963 to 3,000 cases in 1967, to over 1 million cases in 1968, and 2½ million cases in 1969. This is a very good practical example of what happens when a country stops using a useful pesticide like DDT.

To eradicate malaria, you not only have to control the mosquitoes that bite people in their houses, but you have to use medication to get rid of the disease itself. The combination of these two things is needed to eradicate the disease. Now, if you cut out the use of DDT and have nothing to replace it, the number of people with the disease jumps very drastically, as we saw in Ceylon, because the DDT was eliminated before the job of eradication was completed there. Other countries did complete eradication programs. In the United States, we're in pretty good shape and in most of Europe, but we're now in for some very unpleasant surprises even here, I'm sure.

Let me quote a comment made in 1972 after the EPA banned U.S. exports of DDT by the head of the London School of Hygiene and Tropical Medicine, L.J. Bruce-Schwatt: "The rich countries preoccupied with their own environmental problems," he said, "should be reminded of the fact that the old plagues have not been banished from the world. Any apparently beneficial move may have an unexpected rebound effect and jeopardize the health gains achieved elsewhere over the years."

I think that's just what is happening now. All of a sudden we have falsiparum malaria, the most virulent form of the disease, resistant to our medication. In the past, people from the United States could travel anywhere they wanted to, use insect repellent, and if bitten by mosquitoes and stricken with malaria, come home, be treated with medication, and get well. Now we're facing the fact that falsiparum malaria is resistant to almost every medication we have. In many parts of the world, if Americans go traveling now, there is no assurance that we can survive either.

We're faced with the prospect of malaria deaths right here in California now. We have about 5,000 Pakistani farmers in San Joaquin Valley. They came from a malarial country and we're worried about the fact that they're living there surrounded by malarial mosquitoes, the very common anopheline mosquito, throughout the Sacramento Valley. So we're facing a real threat to this country of having malaria break out in forms such as falsiparum malaria that cannot be treated with any medication we have.

Question: Not even with quinine?

No, quinine is also showing signs of failing as a treatment. Besides, the quinine has such bad side effects, especially in blacks. For example, inadequately treated falsiparum malaria was the major cause of black-water fever, a severe disease and frequently very fatal.

To summarize: we're facing some real problems in this country as a result of what we've done to allow malaria to remain out of control and get even worse overseas. I think we're going to be paying the price in the long run.

Question: Does the fact that so many countries stopped using DDT and other insecticides several years ago affect the ability today to return to a policy of all-out war on the malaria mosquito?

That's the whole problem. So many countries did stop using DDT because of the environmental scare—Rachel Carson's book, the EPA efforts, and so on. Then, after they found malaria immediately going out of control again, they had to try to use DDT again. Of course it's never as easy the second time, because the mosquito population has developed tremendously, malaria has spread to millions more people, and these people, in turn, are developing resistance to the medication.

"Directly or indirectly 200 million people per year are dying as a result of the antipesticide campaign by the environmentalist groups in the United States."

We also have to look at the larger problem that was created. It was not just the use of DDT for mosquito control that was halted. The same philosophy spread to the use of other insecticides for other purposes such as controlling plague, typhus, yellow fever, and many other diseases. Perhaps even more significant in the long run is the effect of halting pesticides on crop production and agricultural productivity. If the people suffering from these various diseases are not healthy enough to get out and bring in a good crop, we get malnutrition. This in turn, leaves people in a weakened condition exposed to diseases that otherwise they might survive.

For example, take India. In the 1940s, India had a high rate of malaria—over 100 million cases a year. At that time, the country was not able to produce very much in the way of crops—less than 25 million tons of wheat per year. Twenty years later, after the malaria had been knocked down to only 300,000 cases, Indians were living longer and they were also producing more—production quadrupled to more than 100 million tons of wheat a year. Obviously a population that is able to produce its own food stops starving to death, stops being malnourished. As you know, children that are malnourished never do recover brain capacity, which is another problem. In the long run, these other things, which are adjuncts to the control of malaria, may be just as bad or perhaps even worse than the debilitating malaria problem per se.

I think we can blame a lot, therefore, on the *Silent Spring* mentality that took over here and created this situation.

Question: The head of the British Agrochemicals Association once said: "If the various pressure groups had succeeded, if there had been a world ban on DDT as many sought, 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." Do you agree?

I certainly agree with that. It's almost on the way to happening right now.

Question: WHO's statistics show that malaria is one of the five leading causes of mortality in the world. What is your estimate of the death count worldwide as a result of the cutbacks in the use of DDT and other pesticides?

Certainly malaria is one of the five leading causes of mortality in the world, and it's getting worse every day. As far as an estimate, it's a very hard thing to do with certainty. If you consider just malaria alone, we can say that at least 10 million people die yearly from malaria. That's a very conservative estimate. If you add in all the other preventable and treatable diseases which all take their toll, and then you add in starvation and malnutrition and the effects of general weakening, then I think that it would not be out of line to say that directly or indirectly 200 million people a year are dying as a result of the antipesticide campaign by the environmental groups in the United States.

Question: That's a staggering number of deaths. . . .

If I had to estimate it again, I might come up with a smaller or larger figure—it's so hard to get a definite number. But I can say for sure that it's a massive number of human deaths that are unnecessary, deaths which otherwise would not be occurring.

I want to point out that some DDT is still being used overseas and has continued to save the lives of hundreds of millions of people, even though we're losing a lot. WHO is still trying hard to control various diseases. But the environmentalist groups were not satisfied. Six years ago, environmentalist groups filed suit to force the U.S. Import-Export Bank, for example, to stop financing the use of pesticides in the underdeveloped countries.

The National Legal Center for the Public Interest opposed these efforts by the Audubon Society and the Natural Resources Defense Council in federal court, and after four years they finally got a federal court ruling against the environmentalist groups. As a Legal Center spokesman put it, "The federal court order against the environmentalists, together with the court decision means that American exports will not be curtailed and our nation will not be practicing environmental imperialism."

This financial assistance for exports is a big item. In the 1970s, there was more than $20 billion in financial assistance to the Ex-Im Bank, of which more than $3 billion was spent on pesticides. The environmentalist groups also filed a lawsuit against the Agency for International Development which would force it to write environmental impact studies for all pesticides that were shipped to underdeveloped countries. You know what delays an environmental impact study can be. It would have effectively meant that even the countries that really needed and wanted pesticides would find it very difficult to get them because they wouldn't have the facilities or time to write environmental impact studies for each outbreak of disease that required a pesticide.

Question: It's as though they are protecting the mosquitoes and other insects at the expense of people's lives.

Right. It was certainly well known that anything that inhibits the use of these insecticides for controlling diseases that are fatal to people is going to lead to a great increase in the number of human deaths. And it's the poor nations that don't have the money to buy the medications to treat these diseases after they have them, that don't have very many doctors. It almost looks like these environmentalist efforts were directly pointed at the poor nations as such to cut their population down.

The same people that have been leading the fight to prevent those poor countries from getting any insecticide to save lives are trying to prevent it by convincing the United States that we should not import anything from those countries that has been contaminated or treated with insecticides that have been restricted or banned in the United States. This is just a back-door method of getting these countries not to buy or use the insecticides.

"I can't see any good reason for these actions except that the environmentalists intend to cut the population in the poorer nations of the world."

Again, I can't see any good reason for these actions except that the environmentalists intend to cut the population in the poorer nations of the world who really can't protect themselves.

Question: What about the use of other chemicals to replace DDT and other restricted insecticides?

Even these chemicals are in the process of being banned by the EPA. Toxaphene was banned Oct. 18 [1982]. Next to DDT, toxaphene was the most commonly used insecticide in the United States. It's not so much valued because of its medical purposes; it was a very good agricultural insecticide. Toxaphene and DDT combined were the number one insecticide used on cotton.

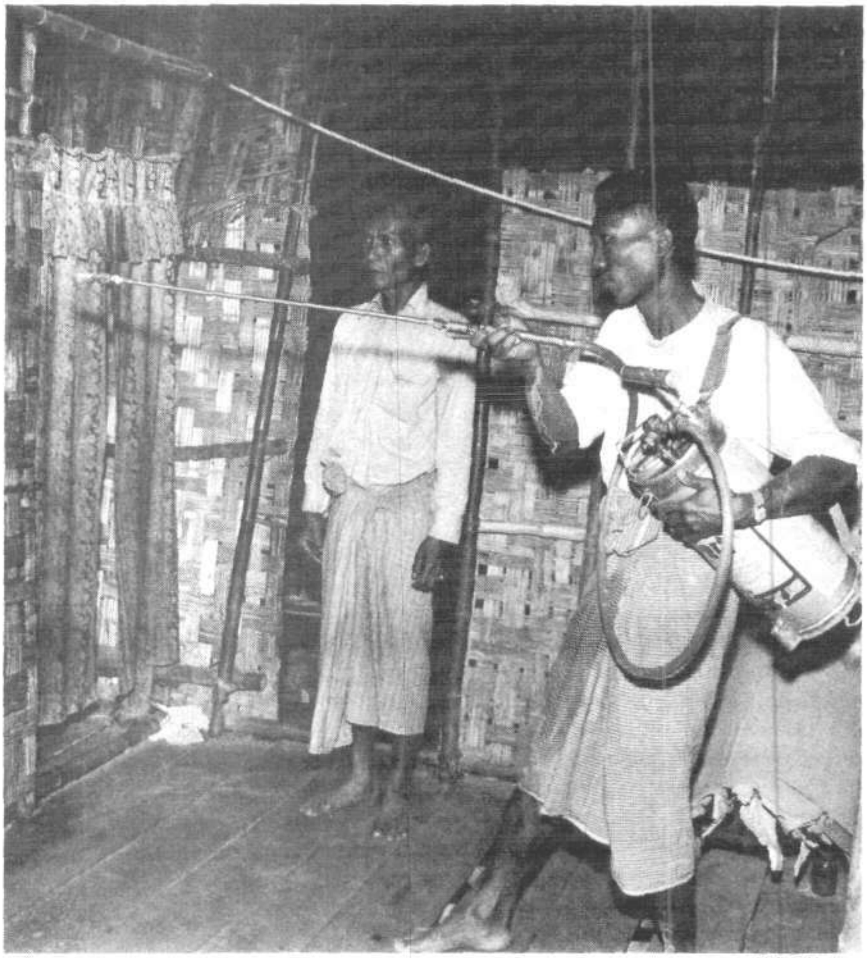
Question: How does the cost of these alternative chemicals compare with the cost of DDT?

The cost of saving a human life in the 1950s by using DDT in the malaria control program was only about 20 cents per year. Prices did go up considerably as a result of the oil embargo in 1973-1974. They usually say that the price of DDT has quadrupled. Looking back at the price of control of malaria, in 1972, the total cost of the DDT used by the World Health Organization for its malaria programs was $72,000 in U.S. money. That actually was only 21 cents per person per year.

WHO found substitutes for DDT—they screened 1,400 possible substitutes and found about three that were really reasonable, but they were much more expensive, three to four times as costly as DDT. Furthermore, they didn't do the good job that DDT did. They had to be applied three or four times a year instead of once or twice a year, and they were poorer in many other ways because they were more toxic to people than DDT was.

Of course, DDT hasn't killed anybody yet. Even the people that sprayed the DDT—130,000 spray men every year—none of them ever got sick. None of the people in the houses that were sprayed ever got sick. I don't think you'll find a record anywhere near that in using substitute insecticides, even though they are effective controlling the malaria mosquito in various places.

Now on the cost: The cost of malathion for use in 1972 would have been $371,000. The cost of carborol would be $1.3 million. Now if you figure you're going to quadruple the cost because of the expense of making the material, that means if you spent $300,000 a year for DDT, it would be about $5 million for doing an equivalent job with carborol. The cost is obviously so high now, with this substitute, that the WHO really cannot afford it. They could not even afford an eradication program back in the 1950s, but now it is completely beyond their financial range to try to afford a real worldwide malaria eradication program.



United Nations

One of 760 antimalaria mobile teams in Burma in 1958 thoroughly sprays the walls inside a house. The government program to eradicate malaria operated with assistance from WHO and UNICEF. Today WHO's policy has given up on eradicating the disease and talks about simply trying to "control" it.

Question: But when you think of it, even if the cost in 10 times higher than the 20 cents it was in the 1950s, that's just $2 per person to save a life. . . .

I'm sure that there's money available; it's being spent for much less worthwhile programs. Also, if people in these countries are being made productive because they are healthy, then they can produce crops and so on and have more money for their own purposes. So if you can permit people to be healthy, then they can contribute a lot more to their own defense.

The real problem behind all this now, what will be coming home to haunt us in this country, is the resistance of the falsiparum malaria to all the known medications we have, even the newest one, methlaquin has already developed large amounts of resistance. Chloratrim and trimiquin and the previous medications they were using are practically worthless in many parts of this country.

First, the resistant form of falsiparum malaria was found only in Vietnam and then it spread throughout the South Pacific and then into Africa, and, finally, into South America—it's bad in Brazil right now. There really aren't many places in the tropics that you can travel and feel so superior that you're from the United States and have good medication to cure your malaria.

It's no longer that safe. And I think this is what's going to be the final blow. Perhaps eventually people will begin to put some blame on the environmentalist groups for this situation.

Question: Could you say a bit more about the resistance of the mosquito to the insecticide? The environmentalists are fond of saying that the mosquito became resistant to DDT and will to any other insecticde, so therefore, it doesn't matter that we don't use DDT and other insectides against malaria, because they won't work anyway. What are the facts here?

Let me comment on resistance in general. Each individual insect cannot develop resistance. They are just as easily killed after they have been exposed to very light doses of insecticide as they were before. They never change their own resistance. The reason that some mosquitoes don't die after being sprayed is that they have enzymes that break down DDT, or other pesticides. This enzyme is inherited through the mosquito's genetic system. Now if that mosquito meets another mosquito of the same genetic background and they mate, then the offspring are likely to have the same resistant genes, with enzymes that break down pesticides.

Therefore, if you spray fields every year with DDT, you will end up in a relatively few years with many resistant pests—not because each individual insect has changed and become resistant, but because the mosquito population has changed genetically: The ones that are susceptible to DDT have all died, and those that are resistant have lived to reproduce.

The value of the DDT eradication method was that the anopheline mosquito, after it feeds, fortunately likes to stay inside and rest on the walls while it digests the victim's blood. By spraying just the walls with DDT, they were able to kill the mosquitoes that rested on the walls, which took in the pesticide through their feet. Sometimes, a resistant mosquito in somebody's cabin or house would later fly outside and meet another resistant mosquito and mate, but this was quite infrequent. In fact, in WHO's worldwide program, fewer than 1 percent of the species of mosquitoes that were a real health problem had developed any resistance to DDT.

The resistance problem began to develop, however, out in the fields. Some of the countries, again, because they had no money and because of the cheap price of DDT, couldn't resist using it to control pests in household gardens and in fields, and that did lead to an increase in resistance among the

Continued on page 18

Livermore Lab Prepares for X-Ray Laser Demonstration

Scientists at Lawrence Livermore National Laboratory in California report that they are gearing up for the demonstration of the first laboratory X-ray laser.

In December 1980, Livermore scientists for the first time successfully generated X-ray lasing using nuclear explosions as the laser pump. These Nevada-based tests provided the scientific information for developing X-ray laser devices pumped by a nuclear bomb that could defend against nuclear-armed missiles. In experiments this spring, Livermore scientists plan to create X-ray lasers on a much smaller scale in the laboratory, utilizing the high-power Novette glass laser system as the energy pump.

Seeing Living Cells

One of the most exciting applications of the laboratory X-ray laser will be X-ray microholography of living cells—literally taking three-dimensional pictures of the atoms of living material. The only existing method of obtaining atomic-scale resolution is the electron microscope. But in order to use this system the cell material must first be killed, frozen, and made into thin samples. The X-ray laser beam, on the other hand is capable of easily penetrating relatively thick samples of living matter and imaging atoms on a sufficiently short time scale—trillionths of a second—such that nothing moves—even on an atomic scale.

Like other laser systems, the X-ray laser beam is capable of generating three-dimensional pictures—holograms. Various techniques for recording atomic resolution holograms are currently being researched. Some methods call for the computer reconstruction of the X-ray hologram.

Many scientists consider that X-ray microholography of living cells will revolutionize all biological and medical research. Besides leading to major advances in existing areas of concern such as cancer research and genetic engineering, this new diagnostic will open up entirely new areas of research in biochemistry.

The Livermore group will begin by making large-resolution holograms with nonliving subjects when the X-ray laser is first demonstrated on the Novette system. When hard X-ray laboratory lasers become available with the larger Nova system, the Livermore team plans to attempt X-ray microholography of living cells.

The Tests

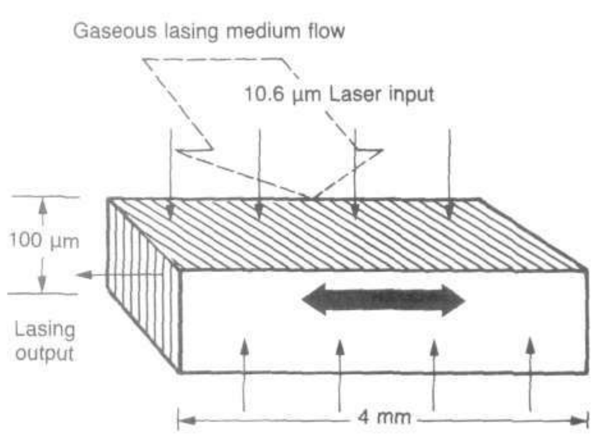
The laboratory X-ray laser configurations to be tested are based on designs developed by the O-group at Livermore, which is headed by Dr. Lowell Wood. The configurations consist of chambers through which various gases are passed. The chamber wall consists of thin layers of metal and other material foils.

The intense Novette laser beams—tens of trillions of watts each—are focused on the outside of the chamber where the beam is absorbed by the thin foils. This absorbed laser light is then reemitted by the foils as X-rays, which irradiate the gas flowing through the interior of the chamber. Depending on what material the foils are made of, these foil X-rays have wavelengths near a particular "color" or spectral line. This line X-ray radiation is capable of efficiently inducing X-ray lasing in the flowing gas.

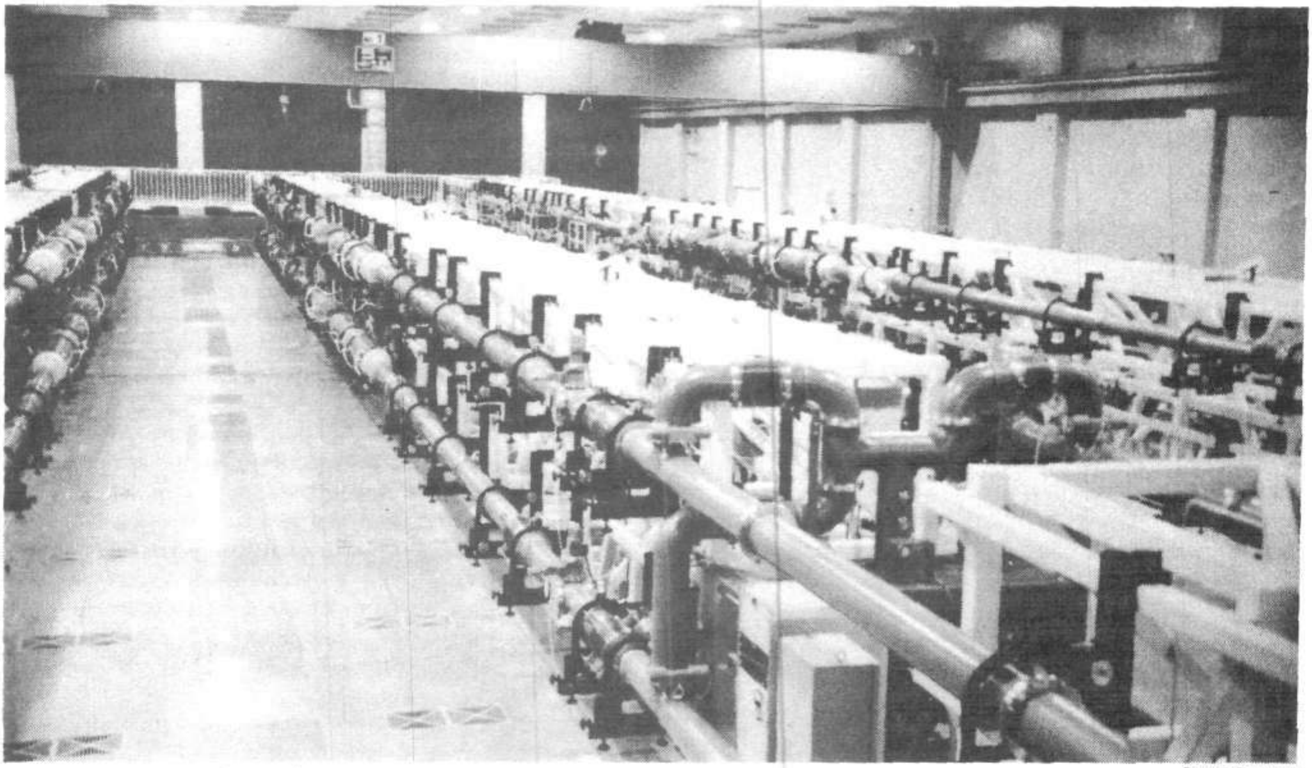
Most of the schemes being contemplated for creating laboratory X-ray lasers pumped by the Novette fall in the longer wavelength, soft X-ray region. When the much larger Nova laser system is brought on line this fall, Livermore scientists plan to extend laboratory X-ray lasers to the shorter wavelength, hard X-rays. (Novette is a 2-beam prototype of the 10-beam Nova glass laser system.)

Ironically, although both Novette and Nova were primarily designed for carrying out laser fusion and related experiments for nuclear weapons, their most significant scientific impact could come first in the biomedical area with the advent of X-ray microholography.

—*Charles B. Stevens*



X-RAY LASER LABORATORY CONFIGURATION
This configuration was used in recent laboratory experiments for X-ray laser generation with the Lawrence Livermore National Laboratory's Novette laser. The top and bottom of the box are irradiated by the two laser beams of the Novette system. Metal waffers at both top and bottom absorb these beams and generate specific lines of X-rays. This X-ray "flash lamp" output then irradiates the flowing gas within the box, and the flowing gas then generates the X-ray laser beam (at left).



The 12-beam system for Japan's Gekko XII, the most powerful laser in the world. Steven Bardwell

Japan's Gekko XII Laser Gears Up for Fusion

EDITOR'S NOTE

Dr. Steven Bardwell, former editor-in-chief of Fusion, *visited Osaka University's Institute of Laser Engineering in December 1983 and wrote this article in January 1984. A longer report by the author on the theoretical achievements of the Japanese laser program appeared in the July-August 1983 issue of* Fusion.

The most powerful laser in the world today, Japan's Gekko XII glass laser, began experiments in December 1983 on laser-initiated nuclear fusion. In the first series of experiments, designed to produce maximum temperatures, Japanese researchers set a new world record for the production of fusion energy from fuel heated and compressed by laser light, more than doubling the number of energy-releasing reactions previously achieved in U.S. experiments several years ago.

After several weeks of activity as a new entrant in the "neutron derby," Prof. Chiyoe Yamanaka, the director of the Institute of Laser Engineering, will begin experiments on achieving maximum compression.

In March, the initial calibration and testing of the facility will be completed, and Yamanaka plans to begin a research program that may lead, in the next year, to achievement of "breakeven"—the production of as much fusion energy from the fuel as was required to heat and compress the target.

The Gekko XII laser is a massive device, consisting of miles of complex computer-aligned glass disks that amplify laser light. Its 12 beams produce a 30-trillion-watt pulse of laser light lasting 100-trillionths of a second. Each beam is identical, with greater than 95 percent coincidence of power and pulse shape. The spatial uniformity of each spot has also met specifications.

The Osaka Cannonball

The initial series of experiments has concentrated on the nonablative Japanese target design called the Osaka cannonball. The newest Japanese experiments indicate that the record results come not only from using a larger laser, but, more important, from this unique cannonball target design.

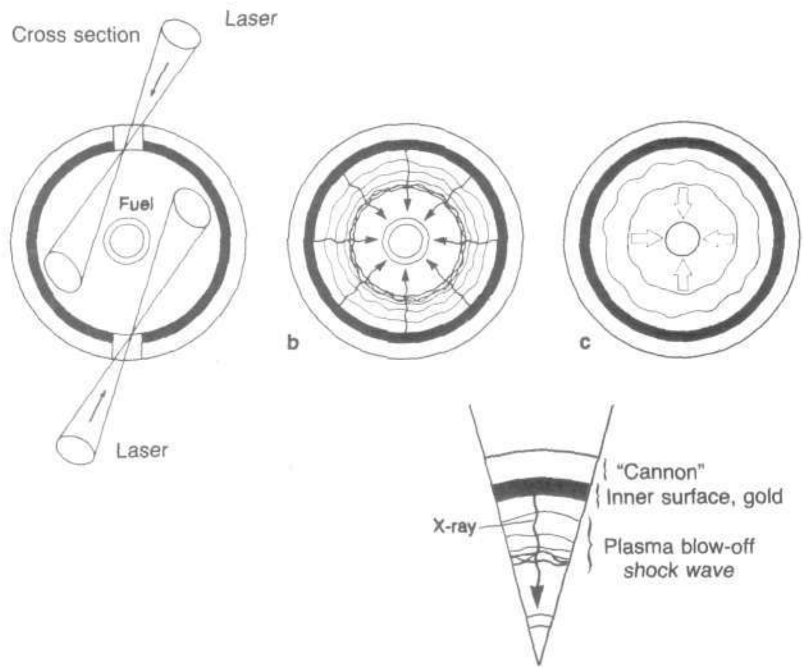
In traditional target designs, the laser beam is used to explosively heat the outside of the target. As the outer layer of the target is vaporized, the blow-off (ablation) of this layer propels a shock wave into the center of the fuel. This shock wave simultaneously heats and compresses the fuel, in a mechanical reaction similar to the thrust provided by a rocket engine.

In the Japanese approach, the rocket engine impulse is replaced by a "cannon," which uses the pressure of a confined gas to push a heavy mass to high velocities. The expanding gas from outside the fuel assembly is contained within a larger sphere (the cannon). This contained "nonablative" compression is more efficient and applicable to a much wider class of heating and compression schemes, which can use radiation as well as for compression (see figure).

Significant Breakthroughs

The Japanese have made a series of significant engineering breakthroughs in their latest experiments:

(1) The Osaka laboratory has developed the ability, using new target



THE OSAKA CANNONBALL—A NONABLATIVE LASER FUSION TARGET
*The target consists of a hollow sphere (the cannon) with two holes in the shell and a fusion fuel target in the center (the cannonball). Laser light (**a**) is focused through the holes, illuminating the inside of the cannon. The deposition of this laser energy creates an intense burst first, of X-rays, and second, of plasma (**b**). This "gas" of radiation and plasma quickly closes the two holes through which the laser light entered, and then begins to compress the target of fusion fuel (**c**). In the beginning, this compression consists of a shock wave generated by the ablation of the surface of the fuel assembly as it absorbs the X-rays; added to this is the compression caused by the slightly later arrival (and reflection) of the plasma blast from the cannon.*

fabrication techniques, to produce the complex cannonball targets on a large scale. These cannonball targets are now produced in three versions: (a) with two holes—the 12 beams are first bunched into two bundles of 6 before being focused on the target; (b) with four holes—having the geometry of a tetrahedron; and (c) with twelve holes—having the geometry of a dodecahedron. The dodecahedral target has produced especially promising results in initial experiments.

(2) The Osaka research team has developed techniques for filling the inside of the cannon with different materials to optimize the efficiency of compression. Various mixtures of heavy metals, foams, and radiation-tailoring materials (like tantalum metal powder) are being experimented with. The recent series of experiments also demonstrated the efficacy of coating the inner surfaces of the target with gold (for example) in achieving controlled compression of the fuel.

(3) The laboratory has perfected automated technologies for the computer alignment and management of the thousands of optical components of the laser-target system. The Japanese equipment, built by Nippon Electric Company, is in the final stages of adjustment to a completely automatic mode of operation in which one target irradiation can be completed each hour. This rate is 10 times that achieved in other large laser fusion experiments.

—*Dr. Steven Bardwell*

Special Report

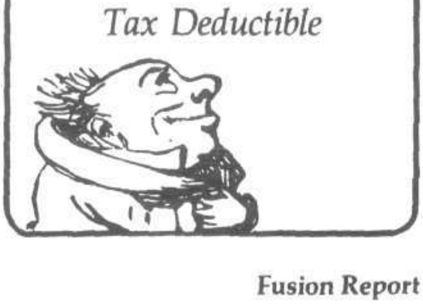
Continued from page 15

mosquito populations in those areas; that is why they had to start looking for other pesticides. DDT was still good, but in some areas they had to switch to other insecticides that would be more effective.

If the use of DDT could have been restricted to inside dwellings, as WHO had wanted to do and urged people to do, and used only for mosquito control in houses, then we would have had no problem with resistance on the part of the mosquito.

It's too bad that we couldn't have done this. But I have to say, that if I lived in a country with an average income of $200 to $500 a year, and I was starving and my family dying, then I'm certain I wouldn't listen to some of these arguments; I'd use the DDT on my fields to help my crops. So, resistance in mosquitoes has built up. But there are new insecticides that are available, and even though their costs are higher, you figure the cost of a human life, which we keep hearing is so dear in this country, is worth it. Certainly we should be able to save people's lives and make them more productive, enable them to grow their own crops and protect themselves with the money that they make. I hope that will come about.

If the people in this country realize what the hazards are and what the apparent motives are on the part of the people trying to deprive them of these life-saving chemicals, then perhaps we'll see a change—I hope before it's too late.



The Universe Is Negentropic:

NASA

How Man Transforms The Laws of the Universe

by Dr. Jonathan Tennenbaum

Three opposing views of the nature of the Universe have dominated recorded history to date.

One view, which has grown to virtual hegemony over the last 100 years, holds that the Universe is a great empty space—a great "pot"—filled with various kinds of objects, such as particles, force fields, atoms, molecules, planets, stars, and galaxies. These objects are assumed to be "interconnected" by *fixed, unchangeable physical laws*, in such a way that the entire Universe might be likened in its time-evolution to a gigantic machine.

This view of the Universe seems so natural and self-evident, that most of us could hardly imagine that it might be totally wrong! Is it possible that the Universe might be a *completely different sort of being* from anything our habitual modes of thought permit us to conceive? Busy with our daily lives, most of us are happy to hold on to habitual prejudices concerning the nature of the Universe. We go through life, so to speak, with a big pot over our head. Not so for Plato, Nicholas of Cusa, Leonardo da Vinci, Kepler, and Leibniz. These founders of modern science conceived of the Universe in a different way, as an "ontological transfinite," a *process of creation*. The Universe—according to this view—is not a "thing" or collection of "things," but an ongoing "composition," unfolding in agreement with an invariant creative principle, according to which *every momentary state of creation is limited as to perfection only by the lack of what is yet to be created*. The Universe continually modifies its own characteristics of action, inevitably diverging from the machinelike behavior prescribed by any fixed set of mathematical laws.

This quality of development, called "transfinite" by the 19th century Platonic mathematician Georg Cantor, is not merely a property of the Universe. On the contrary, transfinite development is the substance of the Universe; it is ontologically primary. Man is able, through the exercise of his divine potential for creative thought and action, to intervene into this process and willfully transform and accelerate it. Thereby, man acts as "God's little helper" in the ongoing composition of the Universe. This does not mean that the Universe obeys no law, but rather that the successive transformations of the universe, corresponding roughly to ordered series of changing physical laws, are ordered according to an invariant principle, a principle congruent with Plato's "Hypothesis of the Higher Hypothesis," the "Non-Other" of Cusa, and the "Principle of Sufficient Reason" of Leibniz.

As difficult or even obscure as this second view of the Universe might seem to many people today, it constitutes, demonstrably, the most essential basis of Judeo-Christian civilization for two millennia. However, it would be wrong to ascribe the "ontological transfinite" uniquely to Western culture, to consider it as a mere religious issue, or otherwise to attempt to circumscribe its domain of application. Not only is the essential conception of the "ontological transfinite" far older—perhaps tens of thousands of years older—than Plato's Academy: *This notion is the common heritage of mankind insofar as man distinguishes himself from the beasts.* It forms, in particular, the methodological foundation for the entire development of science and technology, from the very earliest times until today.

Throughout history, there have been people who disliked the notion of the "ontological transfinite," circles who devoted and continue to devote tremendous efforts in attempts to stamp it out of existence. In Greek times, the evil Hesiod demanded that science and technology be outlawed, and concocted a falsification of the ancient saga of Prometheus to gain authority for his demand. To this day, the successors of Hesiod, the advocates of enslavement of the world to the arbitrary will of a tiny oligarchy, have always regarded the "ontological transfinite" and the included Promethean view of man as the most dangerous of all political ideas. The "limits to growth" propaganda of the infamous Club of Rome, the efforts of Bertrand Russell and the Vienna positivists to destroy the Platonic current in continental science, and the periodic epidemics of religious fundamentalism of all kinds, are all products of the millennia-old oligarchical inquisition against the "ontological transfinite."

Today, this inquisition gloats over what it believes to be its final victory. A tidal wave of irrationalism threatens to sweep civilization off the face of the Earth—irrationalism typified by Ayatollah Khomeini's Islamic Revolution, sending its children and older people to be "purified" through human wave assaults against Iraqi machine guns; or by the blood and soil "Mother Russia" ideology of the Soviet Union, obsessed by the dream of building a world empire upon the ruins of Western civilization; or by the so-called peace movements in the West that demand that what is left of this great civilization be abandoned, defenseless, to fascist holocaust. Not content to merely suppress the concept of the "ontological transfinite" within our culture, the oligarchists have cultivated and propagated a third, *irrationalist view of* the Universe, *a view that radically rejects any comprehensive lawfulness.* Each process has its own lawfulness, independent of all others except insofar as it partakes of a mystical "unity of all things." So, we are witnessing a replay of the declining Roman Empire's pagan orgies, a revival of Hitler's "Triumph of the [Irrational] Will." Even qualified scientists, blinded epistemologically by the suppression of the "ontological transfinite," fail to recognize this irrationalist assault within the body of science itself, an assault typified by Nobel laureate Jacques Monod's *Chance and Necessity* and Nobel laureate Ilya Prigogine's *New Alliance*.

The purpose of this article is to assist the reader in attaining a grasp of the "ontological transfinite." In doing so, we hope to make a contribution to the survival of civilization.

Our discussion proper begins with a proof, developed by Johannes Kepler on the basis of a line of thought going back to Plato's *Timaeus* dialogue, that the universe is negentropic: *The universe as a whole has the same characteristics of self-development that otherwise characterize living organisms.* Kepler's proof provides the basis, in turn, for elaborating a *geometrical language*, by whose means the distinction between *energy* and *work*, crucial to the notion of the "ontological transfinite," can be precisely formulated. This result is accomplished through an examination of several profound, though entirely elementary contributions of Gottfried Leibniz, Karl F. Gauss, Bernhard Riemann, and Georg Cantor. Then, we apply the geometrical language to the consideration of the entire Universe as a single work-process, a system doing work upon itself so as to generate new singularities and increase its potential to do work. To pose this point in as provocative a fashion as possible, we have chosen to treat it in the context of a consideration of how mankind might, one day, accomplish a net change in the laws (or characteristics of action) of the Universe. The article closes with a brief review of the process by which, over the last 100 years, the notion of the ontological transfinite has all but been eliminated from the teaching and practice of science.

Kepler's Proof: The Universe Is Negentropic

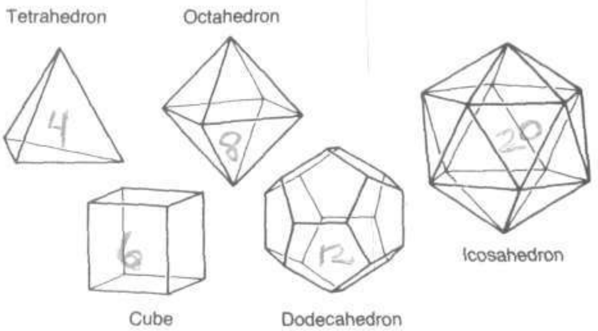
In the years 1595-1621, Johannes Kepler assembled conclusive proof that the Universe as a whole shares the same fundamental characteristics of growth and development that otherwise characterize living processes within the Universe. In other words, not only does our Universe contain negentropic processes, but the Universe itself is negentropic, or self-developing.

Although the proof is experimental, no expensive equipment is required. The necessary crucial experiments were carried out starting around 500 BC, and completed in their essentials by Kepler himself at the beginning of the 17th century.

Experiment Number 1: Determination of the fundamental characteristics of visual space. This experiment was completed some years ago by the priests of the Egyptian Temple of Ammon, and reported on by Plato in the dialogue *Timaeus*. To set up the experiment, we consider first the manner in which the processes of the Universe present themselves to our visual-sensory apparatus. At this level, we see the Universe in terms of motions of discrete object-images sitting around in empty space (visual space). Call this manifold of appearances the *discrete manifold*—the manifold that naive and unsuspecting people often tend to confuse with the whole Universe. The priest-scientists of

Figure 1
INCIDENCE MATRICES OF THE PLATONIC SOLIDS

Solid	Number of Sides	Number of Edges	Number of Vertices	Edges per Side	Sides per Vertex
Tetrahedron	4	6	4	3	3
Cube	6	12	8	4	3
Octahedron	8	12	6	3	4
Dodecahedron	12	30	20	5	3
Icosahedron	20	30	12	3	5



the Temple of Ammon posed the question: does the discrete manifold have identifiable, invariant characteristics, from which conclusions might be drawn concerning the nature of the Universe?

Considering that the characteristics of a manifold are revealed or expressed by those constructions that are possible or impossible within it, the Ammon investigators examined the construction of simple symmetric bodies, the regular solids. The significance of the regular solids is best located, in terms anticipating the later development of elementary topology, as follows: A body bounded by plane surfaces possesses four orders of singularities: the body itself (the interior), the bounding surfaces (faces), the line segments formed by the intersections of the faces (edges), and the points formed at the intersections of the edges (vertices). The simplest case arising for consideration is that of a "homogeneous" body in which all faces have the same number of edges, and every vertex adjoins the same number of faces.

For example, a rectangular box possesses six faces, each with four edges; each of the eight vertices formed at the intersections of the edges adjoins three faces. The array of integers that give the numbers of the various types of singularities and their mutual relations (that is, the number of faces adjioning a vertex) is called the *incidence matrix* of the body. Now, we can ask, given a proposed array of numbers, is it possible to actually construct a body in discrete space having the given array as its incidence matrix? If so, can the construction be realized by a perfectly symmetric body, a regular solid, in which all faces and edges are identical?

The Ammon scientists provided the crucial part of the answer: Out of all conceivable incidence matrices, there are only five that actually correspond to constructible regular solids in the discrete manifold! These five types of solids, now known as the Platonic solids, have the incidence matrices shown in Figure 1.

In the 18th century, Leonard Euler completed the Temple of Ammon's solution by showing that these five incidence matrices completely exhaust the possibilities of bodies (regular or not) constructible in the discrete manifold. In other words, every homogeneous body that can be constructed in the discrete manifold is just one of the five Platonic solids, possibly deformed out of symmetrical shape. (For example, the rectangular box is a deformed cube). The five Platonic solids are thus the "normalized" models of all constructible homogeneous bodies in the discrete manifold.

The implications of the Temple of Ammon discovery are earthshaking. The discrete manifold must be limited in some way, such that any attempted construction of a "sixth" regular solid runs into a curious obstacle—the discrete manifold is not "big enough." The five Platonic solids exhaust the possibilities of visual space, they are characteristics for the discrete manifold and its peculiar limitation, its "boundedness."

The courageous mind draws a further earthshaking conclusion: If the discrete manifold is bounded in a certain way expressed by the five solids, then the discrete manifold cannot be the whole Universe; there must be an unseen, underlying process that generates the discrete manifold in such a way that its characteristics are those discovered by the Temple of Ammon, and none other. In particular, physics like that of Ludwig Boltzmann, which attempts to interpret reality in terms of "interactions" between discrete bodies in visual space, is absurd. Reality lies outside the manifold of appearances, in unseen processes that determine not only the apparent behavior of discrete objects, but the form of visual space as a whole.

"Wait a minute! Why must you invoke mysterious, unseen forces to explain the Platonic solids?" the skeptical reader might ask. "The reason that there are no more regular solids is just because space is three-dimensional; our space is completely described by a Cartesian coordinate system, where the position of every point is specified by its coordinates x, y, z. Space is just the set of all triples (x, y, z) of real numbers. What could be more basic than that? What is there to explain? Why do you insist on making everything so complicated?"

Dear reader, you are suffering from a mind-dulling disease known as "mathematical indifferentism." Just because something seems self-evidently simple and basic does not make it so in reality. To the victim of "mathematical indifferentism" nothing could be simpler than a point or a number, nothing more self-evident than a pointlike "elementary particle"; yet, in reality, points and numbers are not simple, and the so-called elementary particles are actually tremendously complicated. Nicholas of Cusa settled the issue in 1440 in his epistemological treatise *Docta Ignorantia*: Only the Universe as a whole, reality itself, is elementary—everything within the Universe is more complicated, more composite. No part of the Universe can exist by itself; the existence of everything in the Universe is predicated on the existence of the Universe as a whole, which is the "minimum," the irreducible quantum of reality. Points exist only

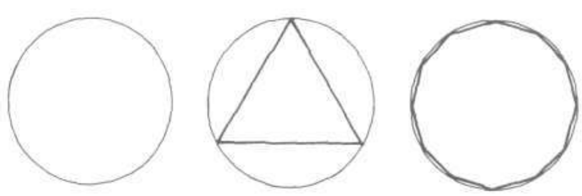


Figure 2
CUSA'S CIRCLE
Nicholas of Cusa's geometrical representation, showing that human reason is not attainable through mere logical thought: If we attempt to approach a circle (reason) through construction of polygons with more and more sides (logical thought), it might be thought that we would actually get closer and closer to a circle. Nonsense! A circle has no angles; the more angles we add to the polygon, the further we are from a circle.

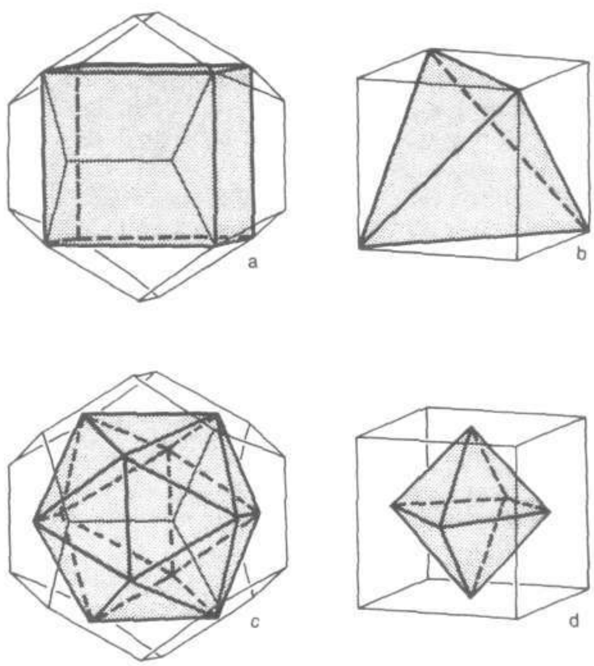


Figure 3
PRODUCING THE FOUR OTHER PLATONIC SOLIDS FROM THE DODECAHEDRON
If a diagonal is drawn through the pentagonal face of the dodecahedron, a cube is produced (a). Proceeding in the same way, a tetrahedron can be produced from the cube (b). If the midpoints of the faces of the dodecahedron are joined, an icosahedron is produced (c), and in the same way, an octahedron can be produced from the cube (d).

as determined singularities of processes; numbers exist only when some process generates singularities to count and measure. Three-dimensional Euclidean space *only* seems self-evident and elementary to you because your culture and your state of mind have so far determined that it should seem so. Science begins, on the other hand, with the questions: What makes things the way they are and not *some other way? How can we intervene* to change them for the better?

As long as mathematical indifference does not blind us, the implication of the five Platonic solids is inescapable: Some process is responsible for the observed characteristics of the discrete manifold—characteristics that are summed up in the existence of no more and no less than five regular constructible solids in that manifold.

Experiment Number 2: The proportion of the golden section. Chief among the proportions defined by the five regular solids is the golden mean or golden section, which is expressed mathematically by k, or $(1 + \sqrt{5})/2$, or 1.682. The golden section is found to predominate among the proportions assumed by living processes in the visual domain but is not found among the proportions typically assumed by inorganic processes *on* the Earth. The investigations leading to these results were begun in Greek times (or earlier), *investigated in* great detail by Leonardo da Vinci and his mathematics teacher, Luca Pacioli, and completed by Johannes Kepler.

Figure 3 shows how all the Platonic solids derive from one of the solids, the dodecahedron. The pentagonal faces of the dodecahedron are characterized by the golden section proportion, whose basic properties are summed up in Figure 4. In particular:

(1) The internal symmetries of the pentagon dictate that if B denotes the diagonal and A denotes the side of the pentagon, then $A:B = B:(A + B) + B$. The proportion $A:B$, which is uniquely determined by this relation, is called the *golden proportion or* golden section (4a).

(2) Successive addition, beginning with a golden proportion $A:B$ and generating $A + B = C, B + C = D, C + D = E$, and so on, creates a self-similar geometric series: that is, a series satisfying $A:B = B:C = C:D = D:E =$, and so on. This series corresponds to various series of pentagons that can be generated from a single pentagon by extension (4b).

(3) This form of growth, in which previously generated dimensions are added in such a way that the sequence of derived shapes grows by a constant proportion, is called simple homothetic growth. Such a process always leads to golden section proportions.

(4) Detailed study of simple living organisms reveals a wealth of homothetic growth processes and related variations. Correspondingly the golden proportion is found throughout nature in the forms of single-celled organisms (for example, pentagonal plankton), flowers, trees, animals, and even in man (Figure 4 e).

(5) The simplest schemes of population growth—for example, the progeny of a pair of rabbits—lead to the so-called Fibonacci series—1, 1, 2, 3, 5, 8, 11, and so on—whose successive ratios—1/1, 1/2, 2/3, 3/5, 5/8, and so on—converge very rapidly to the value of the golden section. Many-celled organisms governed by such cell-population

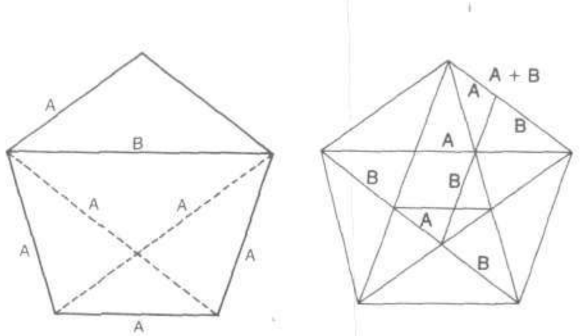


Figure 4a
THE PENTAGON AND THE GOLDEN SECTION

The proportion B:A of the length of a diagonal of a pentagon to one of its sides is the golden section. The triangle that this diagonal makes with two sides of the pentagon is called a golden triangle. If the sides of the pentagon are extended, then a larger pentagon is produced with side (A + B). The proportion (A + B):B of the length of side of the second pentagon to the diagonal of the first is also the golden section. The diagonals of the second pentagon are of length (A + B + B). The proportion (A + B + B):(A + B) of the length of these diagonals to the sides of the second pentagon is also the golden section, so that:

$$B{:}A = (A + B){:}B = (A + B + B){:}(A + B).$$

This geometrical construction illustrates the simultaneous additive and proportionate properties of the golden section. The progression of lengths in golden section proportion to each other—A, B, A + B, A + B + B—is obtained by addition. If A = 1 and B = k, the golden section, then $1 + k = k^2$.

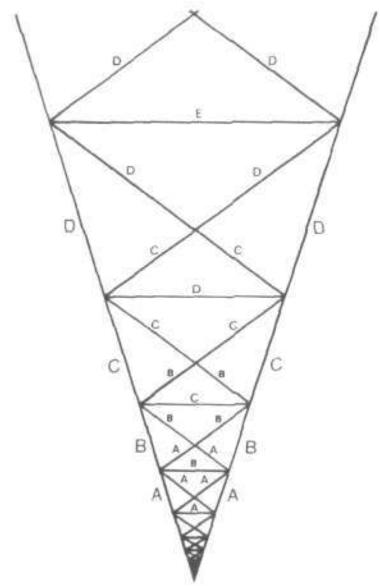


Figure 4b
PRODUCTION OF A SELF-SIMILAR SERIES FROM A GOLDEN SECTION

Constructed according to the procedure outlined in 4a, every triangle symmetric to the axis of the cone is a golden triangle.

C = A + B, D = B + C, E = C + D, and so on, and A:B = B:C = C:D = ...

growth laws therefore automatically tend toward golden section proportions. (See Figure 4 f.)

(6) On the other hand, inorganic bodies such as crystals show no preference for the golden section. Typical symmetries in the inorganic domain are cubical and hexagonal, not pentagonal. Comparing the hexagonal form of crystals such as the snowflake, with the pentagonal form of the starfish (or simple plankton), Kepler was led to conjecture that the emergence of living organisms was accompanied by a shift away from "dead" crystalline hexagonal symmetry toward the golden-mean dominated pentagonal symmetry (Figure 5).

What conclusion must we draw from the above evidence? The discrete manifold is characterized as a whole by the dodecahedron-golden mean proportion, a proportion that otherwise is shared only by living processes manifested "locally" within the discrete manifold. Hence, the underlying process responsible for the characteristics of the discrete manifold as a whole must be a growth process akin to that of living organisms. This is Kepler's proof of the negentropic character of the Universe. Given this, the whole hierarchical construction of post-1865 physics tumbles to the ground.

Thanks to the efforts of Kepler, his predecessor Nicholas of Cusa, and his successors Wilhelm Gottfried Leibniz and Karl Gauss, we are now in a position to develop a geometrical language—the language of conical functions—by means of which we can formulate precise hypotheses concerning the nature of negentropic processes and work in the Universe. We shall now present the essential steps leading to the creation of that language, and return at the end of our labors to specify, using that language, how the predicted changes in the laws of the Universe will be accomplished.

Rotation and Work

In his *Harmony of the Universe*, Kepler expanded his proof of the negentropy of the Universe to discover the necessary connection between the underlying action of creation in the Universe and the action of *rotation* in the visible, discrete manifold. Specifically, Kepler observed the following: The harmonic ordering of the discrete manifold, as expressed by the five Platonic solids, can be entirely derived from the circle, by rotation. Because the circle itself is generated by rotation, that means that rotation—taken as a process of generation—uniquely coheres with the underlying negentropic action responsible for the observed characteristics of the discrete manifold.

The generation of the elementary geometrical construc-

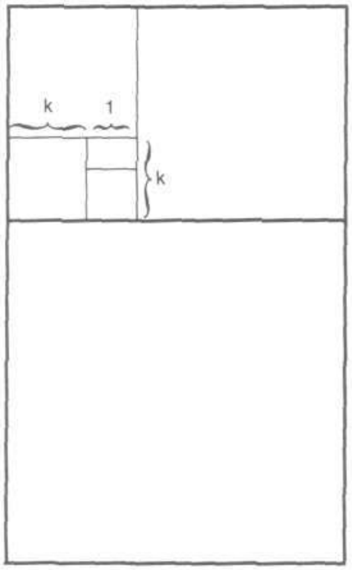


Figure 4c
SELF-SIMILAR GROWTH CORRESPONDING TO THE GOLDEN SECTION

Begin with the smallest rectangle. Adding a square to a golden rectangle produces another, larger golden rectangle. Now, add a square to the larger golden rectangle, producing another. As the figure shows, this process can be continued indefinitely. The rectangles trace out a logarithmic spiral.

Now look at any intermediate golden rectangle. The proportion of its longest side to its shortest is the golden section, k, so that if the short side is 1, the long side is k. Now add a square to produce another, larger golden rectangle. This one will have a long side of $(k + 1)$ and a short side of k, with a proportion $(k + 1):k = k$, or $(k + 1) = k^2$. This again demonstrates the additive-proportionate nature of the golden section.

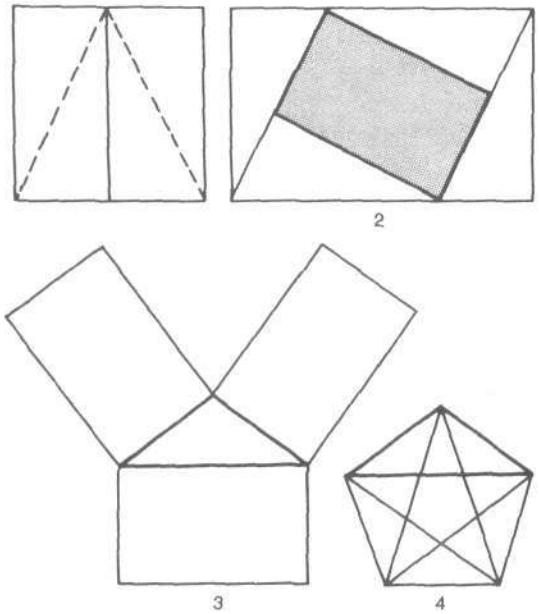


Figure 4d
CONSTRUCTION OF THE PENTAGON

The first step in this construction is to make a golden rectangle with the square. A golden rectangle is one in which the proportion of its long side to its shorter side is the golden section. Fold the square in half, and then fold the result along its diagonal. If you open the figure up again and cut along all the creases, you produce four right triangles. Arrange these triangles as shown in the second figure above and the result is that they form two golden rectangles, one on the inside of the figure and the other marked by its outside. Now with three golden rectangles, form a golden triangle as shown in the third figure. Five golden triangles make up a pentagon.

tions from rotation is illustrated in Figure 6. First, we generate a circle. Then, by folding the circle—another rotation—we generate a straight line, the diameter of the circle. At the same time we have defined the action of one half a complete rotation (180 degrees). Folding again determines a second diameter whose intersection with the first determines a point. Therefore, points are generated by rotations, points are not simple. The center-point requires three rotations for its determination. The two perpendicular diameters just created divide the circle into four equal arcs, defining a quarter-rotation (90 degrees) and also generating a square. A further folding operation (a 180-degree rotation) determines points dividing the circle into three equal arcs, defining an equilateral triangle. A somewhat more complicated sequence of rotations suffices to generate the pentagon (Figure 4 d). This construction of the pentagon proves that the golden section proportion is subsumed under the characteristics of rotation, provided that rotation is regarded as a process of generation. Furthermore, the rotation of a circle around one of its determined diameters generates a sphere, the primary solid. Additional steps lead to the five regular solids whose triangular, square, and pentagonal faces have already been constructed.

The procedure just sketched is known in modern times as synthetic geometry: Starting from a basic law of generation, we construct a series of constructions, using already accomplished constructions as "tools" for further constructions. All such further constructions "inherit" the fundamental characteristics of the generation process employed. Kepler insisted that only rotation qualifies as the basic action of generation in geometry. Indeed, there is no geometry without the circle, and no circle without rotation. On the other hand, as the Greek geometers, Nicholas of Cusa, Luca Pacioli, Kepler, and, later, Jacob Steiner showed, all of Euclid's geometry is derivable from rotation alone without recourse to axioms concerning straight lines and points.

"Wait a minute!" the skeptic says. "How can you claim that rotation generates the geometry of the discrete manifold? After all, how can you have rotation without some-

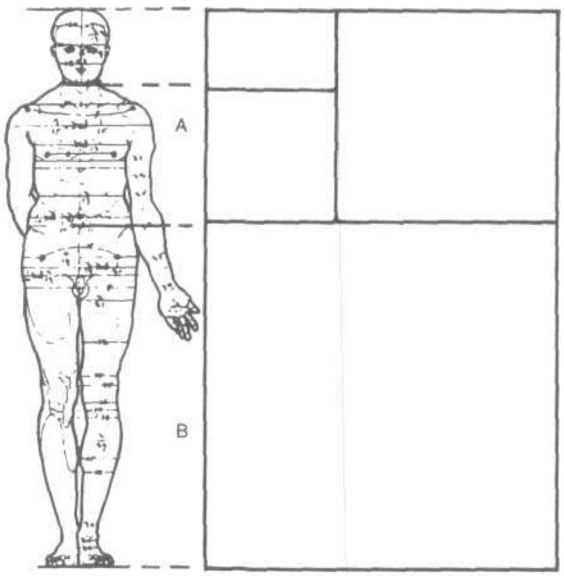
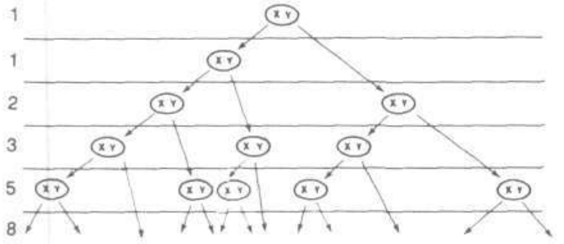


Figure 4e
THE HUMAN BODY AND THE GOLDEN SECTION
The divisions of the whole body by the navel, and of the part above the navel by the neck, are determined by the golden section.

thing that turns, without a center-point and without a space in which to rotate? Aha! You see, I have caught you in circular reasoning!"

Not really. It only appears that way, because you are accustomed to thinking of rotation in terms of motion of objects within the discrete manifold. Drop this image for a moment, and think instead of rotation from the standpoint of the isoperimetric theorem developed by the Greeks and redeveloped by Nicholas of Cusa (Figure 7). Imagine, first quite abstractly, any completed process. Such a process might be represented, abstractly, by a closed curve—a curve that returns to its starting-point (completion). Now, think of the area enclosed within the curve as representing the work completed by the process; we think of that interior surface as the total work (creation) generated by the process in the course of its completion. The efficiency of the process is the ratio of the enclosed area (useful work done) to the length of the closed curve (effort expended to do work).

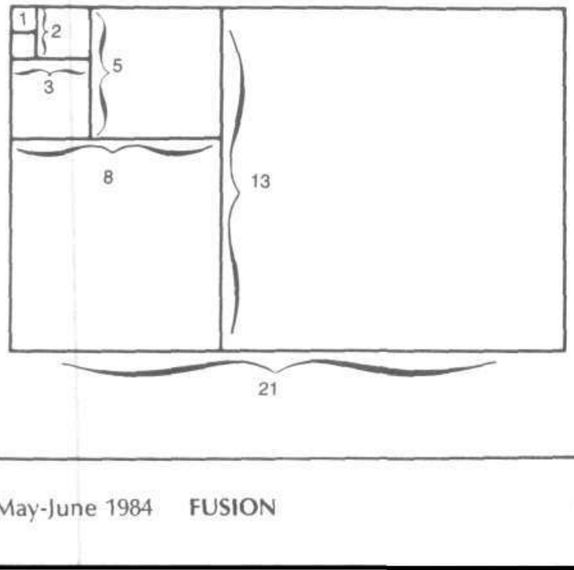
Under this representation, the most efficient process for a given quantity of effort expended is that represented by a circle; this is the statement of the isoperimetric theorem, which states that among all closed curves of a given length, the circle encloses the greatest area. True, the known proofs of the isoperimetric theorem seem at first sight to assume as given the determination of lengths and areas, of points and lines, and so on. However, a closer examination shows that rotation itself is the only self-evident assumption uti-



Generation	New Born Young	Dead	Total Number of Pairs
1	(1)	0	1
2	1	0	2
3	2	1	3
4	3	1	5
5	5	2	8
6	8	3	13

Figure 4f
GROWTH IN ACCORDANCE WITH THE FIBONACCI SERIES
In this simple case, the assumption is made that every pair (xy) lives for two generations and produces one pair of young during each generation. Each of these pairs lives for two generations and dies after producing the second pair of young. If, additionally, each pair of young consists of a male and female animal, which again produce two generations of young, then the growth of this animal population corresponds to the Fibonacci series.

In the Fibonacci rectangle, the proportions (short side to long side) of the ordered rectangles approach the proportion of the golden section.



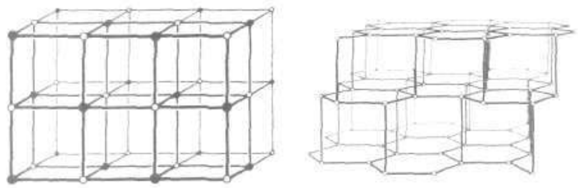


Figure 4g
TYPICAL INORGANIC CRYSTAL FORMS
Common salt crystal (left); carbon crystal, diamond.

lized. (As for length and area, it is only assumed that they are invariant under rotation; no numerical value need be assumed.)

Another way to state the isoperimetric theorem is to say that the circle corresponds to the *least action* required to generate a singularity (the enclosed area). What does this imply? Aha! It means that we can turn around and "re-create" the visual space of the discrete manifold, starting only with the primitive notion of a completed, least action process as the definition of "rotation." We "rebuild" the geometry of space relativistically; that is, everything is defined exclusively by what is imposed by the least action process itself, working the isoperimetric proof "backwards."

The reader at this point will probably have noted, perhaps not without a certain amount of apprehension, that we have entered a new, unfamiliar realm of thinking. We are defining space entirely in terms of processes, completely reversing the usual procedure of defining processes in terms of space and moving objectlike images. We are doing the analogue in geometry of what the great ancient Sanskrit scholar Panini developed as the origin of literate language: Panini claimed that Sanskrit, in particular, developed exclusively from verbs as the fundamental building-blocks of language. So, Panini derives the nouns from the verbs, rather than verbs as relationships between nouns, as today's cultural bias would dictate.

Imagine a totally formless void—it has no points, no dimension, no up or down, no differentiation whatsoever. This void is not even a space; it is only potentiality.

Now let our primary rotation act upon this void. A singularity is created—the primary area—which so far has no measurable extent or parts whatsoever. Someone looking into the void might "see" this primary area as an irregular, twisted surface with bumps. From inside the now transformed void, however, as measured "relativistically" by the primary rotation itself, the primary area is perfectly symmetrical—it has no bumps or other differentiations since none is definable by least action (least action defines only one singularity, the primary area itself). Next, let the primary rotation act upon the void once again, this time "folding the primary area in half." A new singularity emerges, that which we before identified as the "diameter" of the circle, a straight line. Now, we have a primary diameter defined as the result of two successive primary rotations. Someone might ask: "But isn't there an arbitrary choice here? What determines which of the infinitely many diameters is determined as the primary diameter?" The answer: There is only one primary diameter, because until some orientation is imposed by action upon the formless void, all diameters are the same. Once the primary diameter has been generated, an orientation exists in the void, against which further constructions can be "measured." So, the creation of space continues.

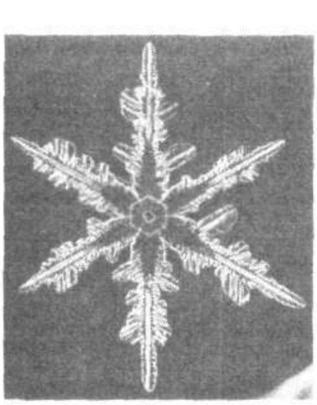
The reader may find this imaginary construction intolerably abstract. From the standpoint of the ontological transfinite, on the contrary, we are doing something very concrete: We are developing the means of thinking about the process of creation, self-reflexively, in terms of creation itself.

We have put aside the realm of mere appearences and are attempting to conceptualize the underlying reality of the Universe, the domain of negentropic process known as the "continuous manifold."

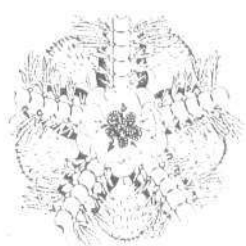
Riemannian Geometry

Anyone who thinks he can learn anything of fundamental importance from textbooks is a fool. Original contributions to science have invariably been made by insolent fellows who scorned textbook knowledge and concentrated on fundamental questions of method. Such insolent fellows generally educate themselves by studying the writings of the most hubristic of their predecessors, with an eye not to what their predecessors thought, but *how* they thought.

So it is for the question of the ontological transfinite. There is not a textbook on Earth that can teach you anything of significance about the "continuous manifold." Surely, the latter was the main preoccupation of the greatest mathematical physicists of the last 200 years, particularly Karl Gauss, Bernhard Riemann, and Georg Cantor. But, although you will find the names of these men throughout any mathematical physics textbook—Gaussian curvature,



Hexagonal symmetry of a snow flake



Pentagonal symmetry of an actinozoa organism

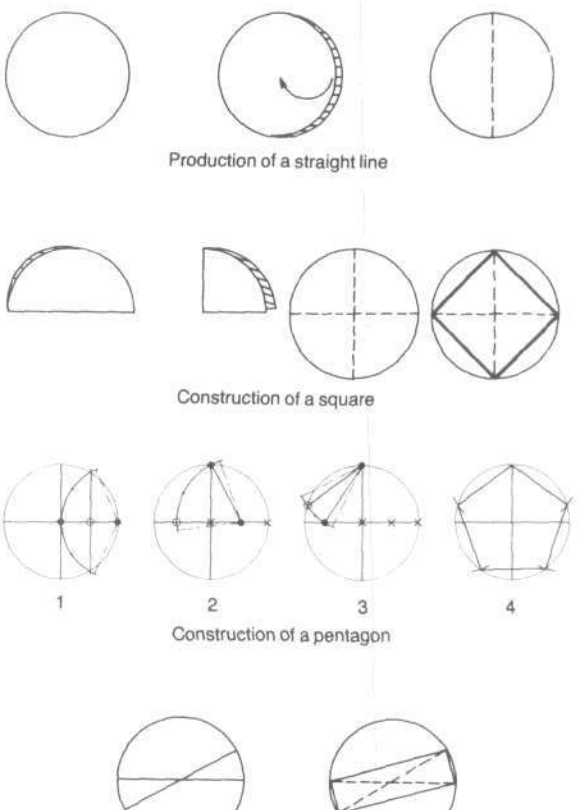
Figure 5
SYMMETRY IN ORGANIC AND INORGANIC LIFE

Gaussian distribution, Riemann integral, Riemannian manifold, Riemann mapping theorem, the Cantor set, and so forth—you will find nothing, or next to nothing, about the essential ideas that led these scientists to their discoveries.

With insolent disregard for elaborated technical details—which tell us nothing anyway of fundamental importance—we shall now briefly examine Bernhard Riemann and Georg Cantor's 1854-1882 attack on the problem of the "continuous manifold." Looking from their vantage point backwards at the work of Karl Gauss, we shall thereby be advantaged to appreciate the significance of Gauss's contribution to the theory of conical functions. It is the conical functions, discussed in the last section of this article, that provide the most powerful means so far devised to conceptualize the "congruent" notions of ontological transfiniteness, negentropy, and the continuous manifold.

Bernhard Riemann is generally regarded by educated scientists as one of the great inventors and masters of the mathematical methods utilized until now in theoretical

Figure 6
ELEMENTARY GEOMETRY CONSTRUCTION FROM THE CIRCLE BY FOLDING (ROTATION)



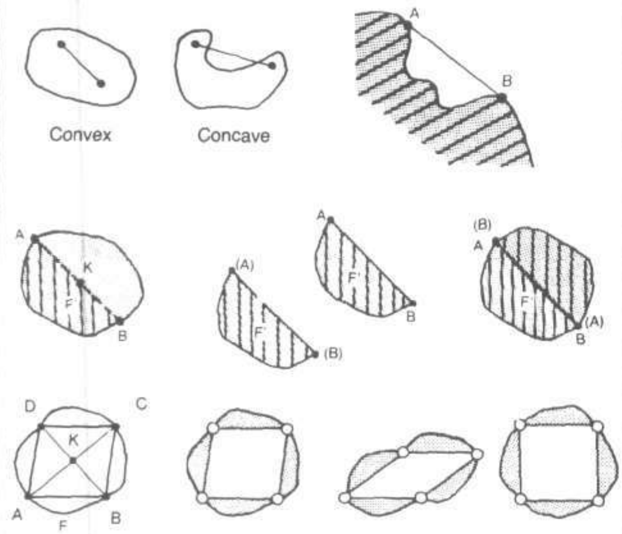


Figure 7
THE ISOPERIMETRIC PROPERTY OF THE CIRCLE

Jacob Steiner demonstrated, without use of any algebraic axioms, that the circle is that figure which encompasses a maximum area for a given perimeter. If it is assumed that another figure has been discovered that has this property, then this must at least be convex, for otherwise a connecting line could always be drawn from A to B that increases the area of the figure and decreases the perimeter.

Take an arbitrary figure. The first step—if it is concave—is to transform it into a convex figure by wrapping a string around the figure. This increases the area by the amount shown but decreases the perimeter. Therefore, the last step here is to expand the figure by a continuous amount along its entire edge to bring the perimeter back to its original length.

The second step is to make the figure symmetrical. To do this, divide the perimeter into two parts of equal length, AB and BA (for example, by measuring the perimeter with a string and then folding the string in half). Then the figure can be divided along the straight line that joins A and B. Choose the larger of two halves. Cut the other half out and rotate the chosen half 180 degrees from A to B. Then a symmetrical *figure is produced with the perimeter of the original figure and possibly with a greater area. If the new figure is no longer convex, it can be made so by application of the first step.*

Next, fold the resulting figure in half twice (as in the illustration) creating the points A, B, C, and D. Join them with straight lines. They will form either a square, or a rhombus parallelogram as shown. If it is a square, we are finished and have transformed the figure into a circle. If it is a rhombus, then the area of the figure can be increased by "straightening" the rhombus into a square, while the the perimeter does not change.

If this procedure is repeated, then the figure will get closer and closer to a circle. The circle is the only figure whose area cannot be increased in this way.

physics. As a matter of fact, Riemann's more significant contribution was to prove that these standard mathematical methods don't work!

The crucial experiment involved was reported by Riemann in an 1859 paper titled "On the Propagation of Plane Air Waves of Finite Amplitude." To a first approximation, an ordinary sinusoidal sound wave propagates with unchanged form thorugh the air. Under certain conditions, however, an intense sinusoidal air wave will change its form as it moves, transforming itself into what Riemann called a *Verdichtungsstoff,* a shock front across which a discontinuous change of pressure occurs (Figure 8). This is essentially the same as the familiar sonic boom caused by supersonic aircraft. Up to the point of formation of the shock front, the propagation of the wave appears to be adequately described by the usual differential equations of hydrodynamics. At the formation of the shock front, however, the hydrodynamic equations break down—some of the parameters assume infinite values—and the further behavior of the wave becomes, from the standpoint of the earlier apparently valid equations, indeterminate. The process has assumed new characteristics; a singularity has been formed. The newly formed shock front behaves differently; it is able to do new things, to perform forms of physical work that the original wave could not.

Eureka! Riemann with his crucial experiment brought out a universal law of the continuous manifold: The underlying processes of the Universe have the potential to fundamentally change their characteristics of action through the mediation of singularities—what appear in the discrete, visible manifold as "individuals" (for example, a shock wave). At the same time new potentialities, or "degrees of freedom," are opened up for further transformations. The same law of the continuous manifold is revealed in the familiar phase changes in matter, such as the freezing of water, where the transformation from liquid to solid is accompanied by the appearance of a new singularity-type, the water crystal.

The breakdown of the standard hydrodynamical equations at the point of formation of Riemann's shock front is caused by no specific fault of these particular equations. Rather, the transformations of the continuous manifold constantly tend to "diagonalize" any fixed set of equations in a manner described by Georg Cantor.

If ordinary mathematical physics breaks down at all the really interesting points, what kind of mathematics must we then develop to help us master the continuous manifold?

Riemann showed the way to the required "mathematics of negentropy" in his 1854 essay "On the Hypotheses Upon Which Geometry Is Based." The general theory of higher-order manifolds, developed by Riemann in that paper, is generally viewed as the basis for Einstein's discovery, some 50 years later, of relativity theory. This is true, but Einstein and almost everybody else stupidly refused to recognize the most shocking, most revolutionary point in Riemann's essay: Throw away all geometrical axioms, insists Riemann, to anyone willing to listen; the only admissible basis for geometry is the process by which a manifold of order n is transformed into a manifold of order $n + 1$! The subject of geometry is not a point, nor a line, nor a surface, nor a solid, but the process of transformation from point, to line, to surface, to solid and so on (see Figure 9). That is, the proper subject of geometry is negentropy.

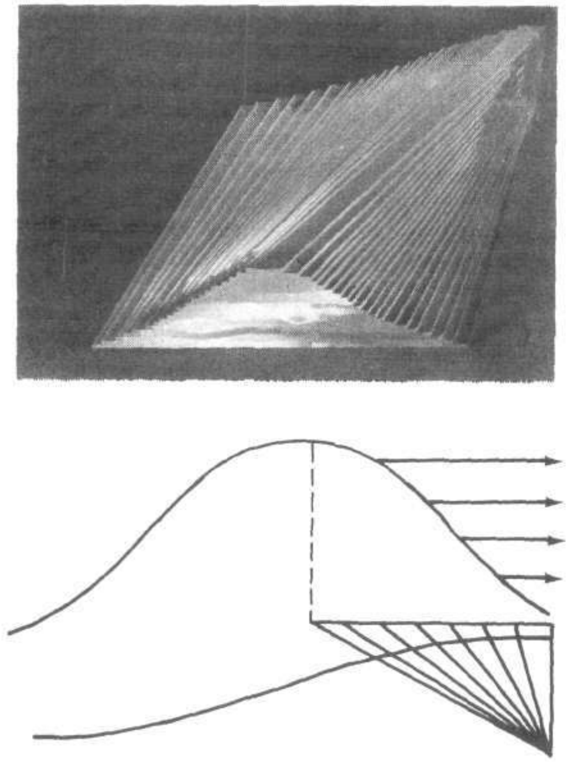


Figure 8
RIEMANNIAN SHOCK WAVES
The model and diagram show the production of an acoustical shock wave as Riemann had predicted in his 1859 paper.

Actually, Riemann's point was more than implicit in Wilhelm Gottfried Leibniz's creation of the infinitesimal calculus. Leibniz's chief point of departure was Pascal's study of the orders of generation of number-series. So, for example, we can regard the series 1, 2, 3, 4, 5, . . . as a series of the first order; 1, 4, 9, 16, 25, 36, . . . that is, the series of squares, as a series of the second order; and 1, 8, 27, 64, 125, . . . as a series of the third order. We can also consider Pascal's triangular array:

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1

as a series of growing, increasing order, a series of series.

Now, look at the successive differences of the series terms as corresponding to the process of transformation from one term to the next

series: 1, 4, 9, 16, 25, 36, 49, 64, . . .
differences: 3, 5, 7, 9, 11, 13, 15, . . .

The derived series of differences 3, 5, 7, and so on, represents a changing process of transformation for the original series. Taking the differences of the derived series, you find

derived series: 3, 5, 7, 9, 11, 13, 15, . . .
differences: 2, 2, 2, 2, 2, 2, . . .

Thus, the derived series has an invariant law of transformation; each term is derived from the preceding by addition of 2. Now reversing the preceding derivation, we can reconstruct the original series by "integration"; that is, successive summation:

0, 0, 0, 0, 0, 0,
invariant law: 2, 2, 2, 2, 2, 2, 2, . . .
first "integral": 1, 3, 5, 7, 9, 11, 13, 15, . . .
second "integral": 0, 1, 4, 9, 16, 25, 36, 49, 64, . . .

Any victim of modern mathematical analysis courses should immediately recognize the origin of differential and integral calculus in the operation of formation of differences, and the reverse process of summation. However, the essential point has yet to be stated: Where do these series of numbers come from?

In science—as opposed to superstitious pastimes of "number magic" such as lotto or corrupt statisticians' concoctions of "economic indicators"—numbers arise from the counting of singularities. In fact, Pascal and Leibniz left no room for doubt on this question: their number series were intended to study the characteristics of negentropic processes, by counting singularities generated by processes of the type of Riemann's "n to $n + 1$" transformation of manifolds.

Figure 9 illustrates various simple examples of the geometrical origin of the Leibniz-Pascal difference series. As an elementary physical example, consider the growth of crystals through the addition of new layers of molecules while maintaining the same overall shape; the molecules are singularities of the growth process. Now what happens when a chemical change modifies the crystalline growth pattern of a substance? We have a transformation of the associated difference series. This is, implicitly, the method followed by Mendeleev in his discovery of the periodic system of elements.

The Fibonacci series and the series associated with a self-similar growing pentagon provide further, higher-order examples (Figure 4).

The Leibniz-Pascal work anticipates the principal question raised by Riemann in his "Hypotheses" paper: How do we measure negentropy? What is the metric in an expanding Riemannian manifold? All measurement, Riemann noted, involves the generation and counting of singularities—there is no "passive" measurement, no measurement without transformation. (If more physicists had read Riemann, fewer would have fallen for Niels Bohr and Werner Heisenberg's so-called epistemological paradox: the claim that because any measurement necessarily changes the process being measured, objective knowledge is therefore impossible.) On the contrary, we are delighted when we accomplish a change in a physical process—transforming the Universe is what science is all about! Scientific knowledge is knowledge bearing on the transformation of physical processes.

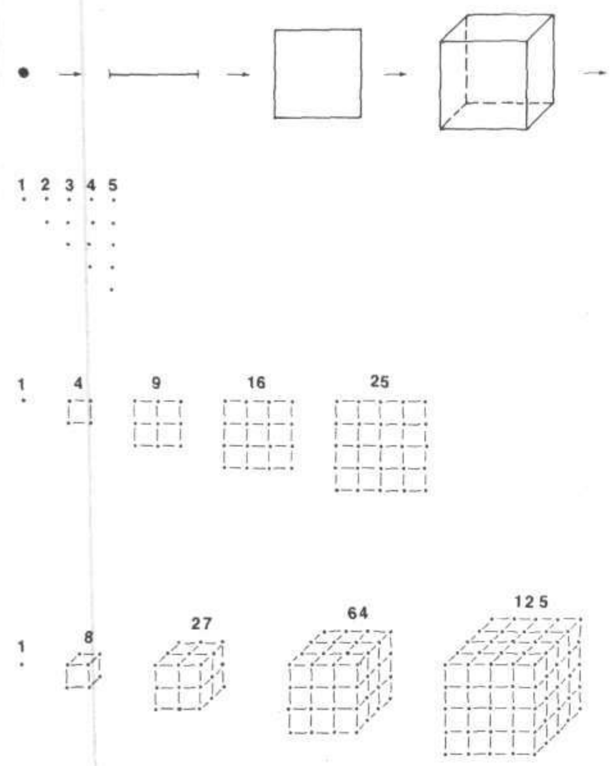


Figure 9
RIEMANNIAN TRANSFORMATIONS N TO N + 1

If the continuous manifold, in a given stage of development, is dominated by a series of process-singularities S_1, S_2, . . ., then any transformation of the continuous manifold, including the emergence of a new process-singularity, will be reflected in changes in the characteristics of action of S_1, S_2, . . in terms of the singularities they generate within the visible, discrete manifold; hence, ultimately in the difference series of numbers counting singularities in the discrete manifold. But, what happens between two successive terms in such a difference series? What happens in the interval during which no new visible singularities have yet appeared? The continuous manifold is in the act of evolving new characteristics of action, but the transformation is not completed—we don't "see" it yet, it is an infinitesimal relative to our metric. This is the origin and true meaning of Leibniz's "infinitesimal quantities" dx, ∂x, δx, and of the term "infinitesimal calculus."

Our revelation of the original significance of Leibniz's infinitesimals will probably send some professional mathematicians—and some others—into an apoplectic fit! The reason is, that during the early decades of the 19th century, the Jesuit August Cauchy undertook to destroy Leibniz's conceptions, by replacing the infinitesimals by a "theory of limits." In Cauchy's concoction, there is no generation of singularities, only the lifeless, banal continuity of the real number system, the supposed continuous process of a small real number becoming smaller and smaller until "in the limit" it becomes equal to zero. In mathematics education this takes the form of a pagan ritual, an act of supplication to the Buddha-like figure of August Cauchy known as "checking through an epsilon-delta proof." After performing this ritual for several years, the unfortunate victim of Cauchyism can no longer rid himself of the fanatical belief that the limit process of continuous convergence to zero is the ultimate reality of the Universe.

Nonsense! Cauchy's form of simple continuity has no counterpart in reality: The so-called real numbers should be renamed "artificial" numbers. The only numbers deserving the name "real" are the counting numbers, which count singularities, and the complex numbers corresponding to the elementary negentropic functions, which we shall introduce shortly in the section on conical functions.

In the context of Leibniz's true infinitesimals, the mystery surrounding the famous "quantum of action" disappears. Strictly speaking, there is no such thing as one half of a singularity! There is only one, two, three, and so on, singularities. The generation of identifiable individuals—as processes, or the objectlike "shadow"-images of processes in the discrete manifold—is just that: generation of whole, completed individuals. A rotation of 180 degrees does not enclose one-half of a circle; it encloses nothing. Contrary to statistical fictions, it is not possible to employ one-third of a worker, or to generate power from three-fourths of a nuclear power plant. What happens when a living cell divides? When can we say that there are two cells, rather than one? Obviously, only when we can count two complete, functioning, living cells.

There is only one condition under which it is permissible, by a figure of speech, to associate fractional, noninteger numbers to the ongoing generation of a singularity: that is, when the process of completion of generation of the singularity is mediated by the generation of countable lower-order singularities, thereby "dividing" the original action of creation. So, the growth of an organism is mediated by the division of its cells. But, beyond the finest available division of singularities in the continuous manifold, there can only be a "jump" from one term of a number series to the next: the corresponding, least division of action in the quantum of action.

Cantor's Transfinite and the Curvature of the Universe

Had Albert Einstein been confronted with the full implications of Riemannian geometry, it would have—to use the now proverbial expression—"blown his mind." By the time Einstein entered the university, the operations of Helmholtz and others had largely succeeded in obliterating all traces of the ontological transfinite from the teaching and practice of theoretical physics.

Riemann's methodological ideas might have been completely lost had it not been for the work of Riemann's student Georg Cantor. Cantor elaborated exactly those aspects of Riemann's work that were most hated and feared by the Jesuits, by the Viennese, and by British philosophical barbarians such as Bertrand Russell. Therefore, Cantor was subjected to one of the most intense campaigns of slander, isolation, and abuse in the history of science. Bertrand Russell, for example, took large amounts of time from his busy schedule of evildoing to try to bury and distort Cantor's work. So was born the monumental 1901 *Principia Mathematica* of Russell and Whitehead, a book on mathematical logic that set the stage for the disastrous "new math" and "set theory" brainwashing imposed on millions of schoolchildren after the 1960s educational reforms. Russell wished to ensure that no one even capable of comprehending the ontological transfinite could ever emerge from the world's school systems.

Fortunately, these operations were not entirely successful—otherwise you would not be reading this article right now. Cantor's ideas continued in the work of the late Professor Kurt Gödel, who, in his famous 1931 "Incompleteness Theorem," demolished the attempts of the positivists to deny the transfinite quality of the human mind and equate mathematics with a formal-logical lattice structure. Unfortunately, a proper understanding of Gödel's work and its implications remained restricted to a very small circle among his students, owing in part to the circumstance that the ruling positivists, refusing to acknowledge that they had been demolished, continued to preach the identity of the human mind with a large digital computer.

In the 1950s, the American economist Lyndon H. LaRouche, Jr. rediscovered the broader significance of the Riemann-Cantor work, while attempting to refute the Wiener-Shannon "information theory" approach to human intelligence and find a mathematical apparatus capable of describing the effect of technological revolutions on an economy. Realizing the implications of Riemann-Cantor for mathematical physics, LaRouche later set in motion an international science project directed at reviving the Riemann-Cantor method of the "ontological transfinite" in mathematical physics around the concrete tasks of mastering the plasma physics of controlled nuclear fusion, relativistic beam physics, and the process of life and aging. The work embodied in this article grew out of LaRouche's efforts.

Cantor's work is crucial because it explodes any attempt to submerge Riemannian geometry in the tiny, flat world of algebraic formalism. In particular, no one who understands Cantor can possibly fall for the commonplace characterization of Riemann's geometry as a mere generalization of Euclidean geometry to the case of more than three dimensions.

The first crucial point is that a single process-singularity may subsume a potentially infinite series of lower-order singularities. This is illustrated by the geometrical difference series and by the golden mean pentagon generation of infinitely extendable self-similar series. It is already implied by the fact that the circle, considered from the standpoint of rotation, subsumes an infinite series of polygons, in particular the polygons of 4, 8, 16, 32, . . . sides obtained from the circle by successive foldings. Cantor called this kind of singularity an actual infinite.

The second point is that in the Riemannian transformation N to $N + 1$, the number N is not an ordinary whole number counting objects or even mathematical dimensions, but is what Cantor called a transfinite ordinal, a number defining an order of singularities. Recall the Leibnizian difference series corresponding to growing line segments, growing squares and growing cubes (Figure 9). The first series we assigned the ordinal "1," the second "2," and the third "3." Each successive growth process corresponds to a faster rate of growth in the difference series. Now, consider the entire array of difference series of order 1, 2, 3, and so on:

x: 1, 2, 3, 4, 5, 6, . . .
x^2: 1, 4, 9, 16, 25, 36, . . .
x^3: 1, 8, 27, 64, 125, 218, . . .
x^4: 1, 16, 81, 256, 625, 1308, . . .
. . .
. . .

All of these series belong to a class or order of singularities defined by a geometric process of expansion; denote this order of process-singularities by N. Next, consider the column series 2, 4, 8, 16, 32, . . . ; 3, 9, 27, 81, ... These are exponential series, corresponding to simple exponential growth. Each of these series grows faster than any of the row series belonging to class N. Denote, therefore, the class of simple exponential series by $N + 1$. Finally, consider series such as the "diagonal" series 1, 4, 27, 256, . . . corresponding to the mathematical function x^x. This series grows faster than any of the series of order N, and faster than any of the simple exponential series (order $N + 1$). Denote the order of these diagonal series by $N + 2$. Now think about the implications of the transformations $N \rightarrow N + 1 \rightarrow N + 2$. Think about how an entire series of orders of singularities $N, N + 1, N + 2, N + 3, \ldots$ might be subsumed within a "super" ordering principle M, and how the preceding consideration of diagonals and columns might generate new orders of orders, $M + 1$, $M + 2$, and so forth. Finally, consider the highest, invariant principle which continually leads beyond any order of singularity to higher orders. Now you have some notion of Cantor's idea of the transfinite. Is this a mere abstraction? Is Cantor's transfinite just a fantastical construct fluttering around in our heads? Is it a mere mathematical tool for solving equations? No! The Universe itself is ordered this way.

Decisive proof of this is furnished, as LaRouche points out, by economic science: by the "great experiment" of man's physical existence by means of his productive activity within the Universe.

The basis of economic science is the observation that technological revolutions are necessary for the continued existence of the human species. Every "order" of technologies, developed by society at a given point of its existence, defines certain aspects of nature as "resources." Now, as a result of what might be described as the "curvature" of nature, or of the peculiar "curved" characteristics of man's relationship to nature (namely, that the rate of negentropy in a growing society exceeds that of the surrounding inorganic and organic nature), continued utilization of a fixed range of technologies eventually leads to a marginal exhaustion of resources. This manifests itself, prior to the actual physical disappearance of the resources in question, by a rise in the social costs of mining or equivalent activities required to access the resources. Therefore, unless new technologies are created, opening up a new resource base for the economy, society would "run down" and eventually collapse in mass starvation and disease. How do we get these necessary new technologies?—through the progress of science.

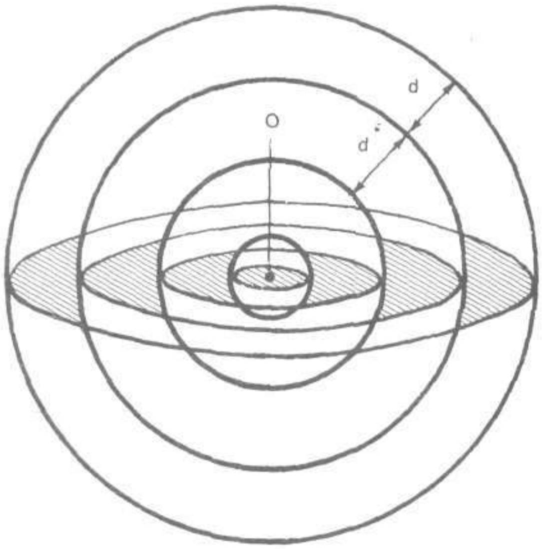
The progress of scientific knowledge occurs in successive sets of "higher hypotheses"—fundamental breakthroughs, in which preceding more or less axiomatic assumptions are overthrown in favor of better, more correct assumptions. Thus, fundamental progress occurs as a sequence of mutually contradictory sets of hypotheses.

After the discovery of a new set of higher hypotheses, a scientific and technological revolution occurs. There is a more or less vast elaboration of "simple hypotheses": discoveries and improvements in practice based axiomatically

United Nations

Decisive proof of Cantor's transfinite is provided by the economic "great experiment": man's continued physical existence by means of his productive activity within the Universe. Here, a desalination research project in Kuwait, designed to supply fresh water for a growing population in a country that is oil-rich but water-short.

Figure 10
THE GAUSS-OLBERS PARADOX



The Gauss-Olbers Paradox is a proof that the universe is finite in mere extent. It demonstrates that if the universe were infinite, the night sky would not be dark but of infinite, blinding intensity. To the believers in an infinitely expanding universe created from a "big bang," this proof is "paradoxical"; in other words, they refuse to accept it.

The amount of light reaching an observer on the Earth from any direction is dependent on the number of stars in that general direction. If you first assume that the average density of stars in space is constant, then if the universe is infinite in extent, there will be an infinite number of stars in any direction from any point on the Earth. Therefore, an infinite amount of light will strike the Earth from any direction so that the night sky will never be black.

Divide space into a series of concentric spherical shells about the Earth, going outwards. The number of stars contained in one shell of radius R *and thickness* d *will be approximately proportionate to the volume of the shell. Imagine that from the Earth outwards space is filled with such concentric shells, with continually increasing radii, always of thickness* d*; the observer is at their common midpoint O. The volumes of a shell with radius* R *is proportional to the surface of the sphere with radius* R *multiplied by the thickness of the dome,* d. *Since the surface grows with the square of* R, *the shell volume—and thus the number of stars in the dome—grows proportionally to* $d \times R^2$.

The energy density of the light that reaches point O from a star of distance R *decreases with the square of the distance, thus* $1/R^2$. *The total energy density that the stars in a dome with radius* R *produce at point O is thus in the order of magnitude of*

$$(\text{number of stars in the dome}) \times 1/R^2 \approx (d \times R^2) \times 1/R^2 = d.$$

Thus, for greater values of R, *each additional shell makes approximately the same contribution to the energy density observed at* O. *If we add the contributions of an infinite series of shells, then we will have an energy density at* O *of infinite value.*

on the assumptions of the new higher hypotheses. (We might think of the last 50 years of development of the automobile as a paradigm for "simple hypothesis".) Textbooks are written, educational programs reformed, new industries called into life, and so forth. As a result, society takes a leap forward in productivity.

But, although the hierarchical elaboration of simple hypotheses might theoretically go on forever, society cannot continue to exist in this way. For, although simple hypotheses may lead to improvements in the existing range of technologies—for example, the modern car as compared to Ford's Model T—mere elaboration of knowledge leads eventually to technological stagnation, and via stagnation to collapse under the pressure of marginal exhaustion of resources. Hence, the continued existence of mankind requires an unending series of scientific-technological revolutions, based on overthrowing existing accumulations of simple hypotheses and introducing new, higher hypotheses—higher orders of knowledge. Now, think through what has just been said from the standpoint of Cantor's transfinite. The history of progress in scientific hypothesis, the history of technological progress, and the history of society in periods of scientific-technological progress, are all ordered in the same "transfinite" manner. Cantor's invariant principle of transfinite generation corresponds exactly to Plato's "hypothesis of the higher hypothesis," the principle of human creative discovery by means of which the ordered series of successive higher hypotheses for continued human existence is generated.

If human progress is ordered according to the transfinite, then what about the Universe as a whole? What does the existence and transfinite development of man within the Universe tell us about the form of the Universe itself? Kepler's proof already gives us the beginning of the answer. But we can go a step further, and demonstrate a most provovative thesis: Man's "transfinite" activity will eventually lead him to transform the Universe itself, to change the laws of the Universe.

Conical Functions

Up to the recent period, man's productive activities have basically imitated nature. Man has identified, reorganized, assembled, and ordered into networks of production, fundamental physical processes that do occur elsewhere—on other planets, in stars, and in those portions of the biosphere not controlled by man. However, this need not remain the case.

We must assume that our solar system, our entire galaxy, and so forth, are all developing, "producing" a kind of development that is beneficial to the rest of the Universe.

With the emergence of life and especially human activities on Earth, this seemingly slow, seemingly diffuse negentropic process of the Universe appears "locally" to have accelerated tremendously. Now, through the crash development of beam technologies and of nuclear fusion, man will soon command energy densities hundreds of times larger than those of any process found in our solar system, and perhaps even in our galaxy. Is it not possible that man's productive activity will one day generate a shock wave in the Universe, cause a singularity that will transform the characteristics of fundamental processes of nature?

Archimedes seemed to have this possibility in mind when he said, "give me a place to stand and I will move the world." Archimedes also implied, as Plato had already stated before in the *Timaeus*, that the creation of the Universe is not finished. In particular, in his brilliant treatise "The Sand Calculation," Archimedes claims by implication that the Universe is essentially finite—its development up to now can be measured by a very "large," but in principle specifiable number *N*. Cantor's transfinite numbers define more precisely the notion of "finiteness" implied by Archimedes' argument. Ostensibly, the subject of the "Sand Calculation" was to settle a long-standing controversy of Archimedes' time as to whether or not a specifiable upper bound could be given for the number of grains of sand that might fill the sphere of the fixed stars—whose radius Archimedes identifies with the orbit of the then-known other planet, Saturn. Today's scientific professionals, with their typically tiny minds, would for the most part dismiss Archimedes' proof as a triviality. They would thereby miss three essential points embedded in Archimedes' method, which touch on the most fundamental scientific questions concerning the Universe:

(1) The measurability of the macrosphere (the sphere of the fixed stars) by the microsphere (the grain of sand), of the largest (then specifiable) singularity in visible space by the smallest singularity, means not only that the Universe is in some sense bounded in the large and in the small. It implies further a connection, a coherence between the finest and largest divisions in the Universe.

(2) The possibility of specifying a number far beyond anything that could ever be in practice reached by simple, one-by-one counting of objects depends on the construction of self-similar, exponential series of orders of magnitude. Archimedes' construction anticipates not only the modern decimal system of number-notation (based on the self-similar series 1, 10, 100, 1000, . . .) but also anticipates the modern physicist's use of orders of magnitude to specify characteristic length scales for physical processes. The fact that the Universe indeed manifests such self-similar series of characteristic scale-lengths implies that the generation of such series for number-notation coheres with the underlying negentropic process of the Universe. As we shall see, the best expression of this is to say that least action in the Universe is self-similar spiral action.

(3) Archimedes had a serious reason for "collapsing" the Universe outside our solar system onto the "sphere of the fixed stars." A very simple observation demonstrates that contrary to the naive impression that visual space (and, therefore, for the naive, the Universe) is limitless, in fact

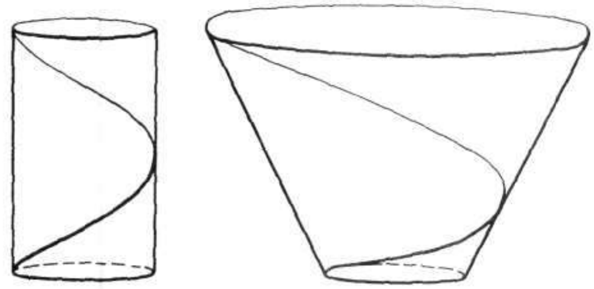


Figure 11

CYLINDRICAL WORK AND NEGENTROPIC WORK

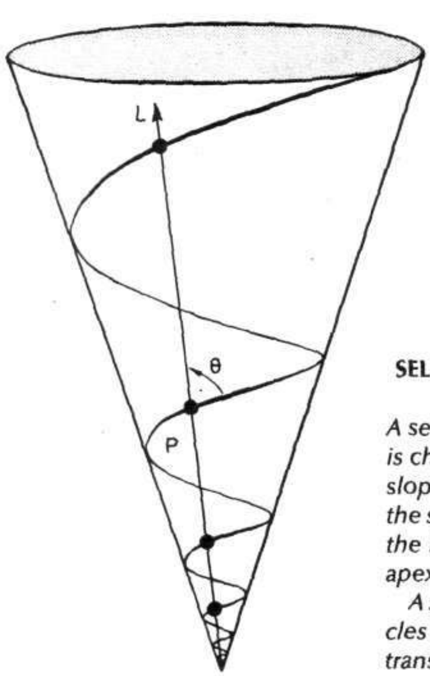
A helix on a cylinder (left) represents the virtual work of a system, that required to keep the system operating, without producing any free energy or accomplishing net work. The ratio between the circular area that the spiral sweeps out and its rate of rise (or, work per unit energy) is constant.

A self-similar spiral on a cone (right) represents the production of net work The ratio between the circular area that the spiral sweeps out and its rate of rise increases. Net work is accomplished by a combination of rotation and extension.

the entire material Universe must be organized in a space-manifold essentially equivalent to a sphere of finite radius. The observation is known today as the Gauss-Olbers paradox, although it was almost certainly well known to Archimedes (Figure 10). In fact, the calculation required was made by Archimedes in the "Sand Calculation."

Do the following experiment. Look up at the sky on a clear night. What do you see? The sky is black. Now suppose that the Universe were really infinite, and that (there being then no reason to the contrary) there were an infinite number of stars, distributed roughly uniformly in all directions throughout infinite Euclidean space. On that assumption, one can easily calculate how much light would come from any direction to an observer looking up at the sky. The result of the calculation is astonishing: If the Universe were infinite in the same specified sense, then a uniform, blinding white light of infinite intensity would meet the observer from every direction. So, since the sky is not white but black, our Universe must be finite.

The other proofs of the finiteness of the Universe deserve brief mention at this point. One is implied by the simplicity of language, as language was understood by the tradition of the classical Sanskrit grammarian Panini. Although the number of words in literate language may have grown in the course of the development of civilization, nevertheless, the generation of new words out of verbal roots occurred according to a quite small finite number of language principles. Because, on the one hand, literate language has shown itself to be efficient in its development, to mediate man's increasing mastery over the Universe there must be some correspondence between the principles of language and the order of the process-singularities underlying the



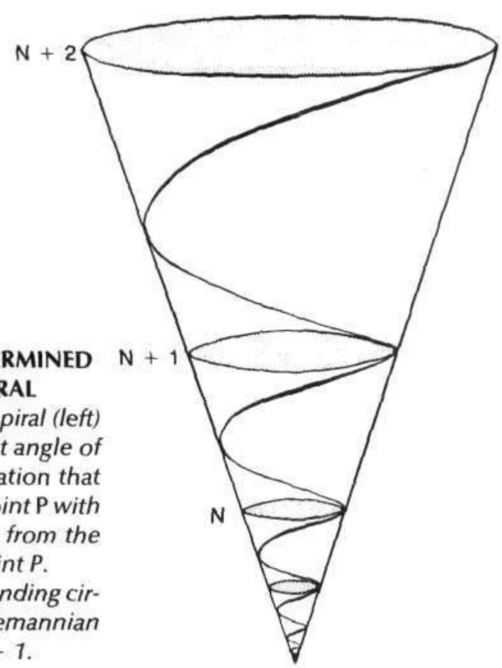


Figure 12
SELF-SIMILAR CIRCLES DETERMINED BY A SELF-SIMILAR SPIRAL
A self-similar, or logarithmic spiral (left) is characterized by a constant angle of slope θ—the angle of inclination that the spiral makes at a given point P *with the radial line* L, *which runs from the apex of the cone through point P.*

A self-similar series of expanding circles (right) represents the Riemannian transformation from N to N + 1.

measurable action of the Universe. The order of complexity of literate language, therefore, must be, in some sense, in correspondence with the "Archimedes number" *N* for the Universe.

The second proof, more familiar to physicists, is Planck's discovery of the least quantum of action. If we start with a given quantity of action, there is a limit to how finely that action can be divided, a smallest wavelength at which that action might be manifest as a simple, continuous electromagnetic wave. Were this not the case, we would have an "ultraviolet catastrophe" the equivalent in terms of wavelength to the Gauss-Olbers paradox for the amplitude of radiation in the Universe. Namely, if action were infinitely divisible in the Universe, we should expect initially red light to be transformed successively into shorter wavelengths—through the visible spectrum, from blue to ultraviolet, and from there into X-rays and gamma rays—like the water wave in a pond created by tossing in a stone, which breaks up upon reflection at the shore into smaller and smaller "wavelets." So, why do we see anything but high-energy gamma rays in the Universe? Because the Universe is finitely divided, not infinitely divided, in terms of action. In that sense, the Universe is finite.

Therefore, we must conclude with Plato and Archimedes that the Universe is finite, though growing and developing. Implicitly, this means that man might assist in accelerating or changing the direction of that development. But how?

Let us now consider action on the Universe. We return for that purpose to the previous discussion of creation in terms of rotational action on a formless potential void. That discussion was fine for the first steps of creation. But how must we think about a series of acts of creation, each acting on the entirety of previous creation to "adjoin" a new process-singularity? We must perform a geometric integration.

There are two cases to consider. Let us consider a circular area as representing the work done in creating the Universe so far, corresponding to a certain Archimedes number *N* of global degrees of freedom of negentropic action. First, we may consider the action required to maintain the Universe in its present form. There is one unique geometrical image corresponding to this situation: a cylinder with the given circular cross-section (Figure 11) and a helix on the cylinder. The helix represents continued, repeated rotation without additional work done. The volume contained between the circular sections in one rotation represents the "energy of the Universe"—the action required to maintain the Universe at its present state of development. The resulting circular section at the end of a rotation is identical to the original one—no new singularity. The simplest manifestation of this would be a sinusoidal wave. In a more complicated Universe, the appearances might look quite different, but basically things are just moving around, in an elaborate projection of what is ultimately equivalent to a sinusoidal wave.

How does action look in the Universe for this case? First, we have a global, process-singularity *S*, of order equal to the Archimedes number *N*, which subsumes all other existing or potentially generated singularities for the mode of existence of the Universe maintained by the cylindrical action in question. Second, we have a division of that global action in terms of nested chains of subsumed process-singularities, down to the least action which manifests itself in the discrete manifold. Such least action corresponds, as we saw at the end of the preceding section on Riemannian geometry, to a single, indivisible rotation-cycle in terms of

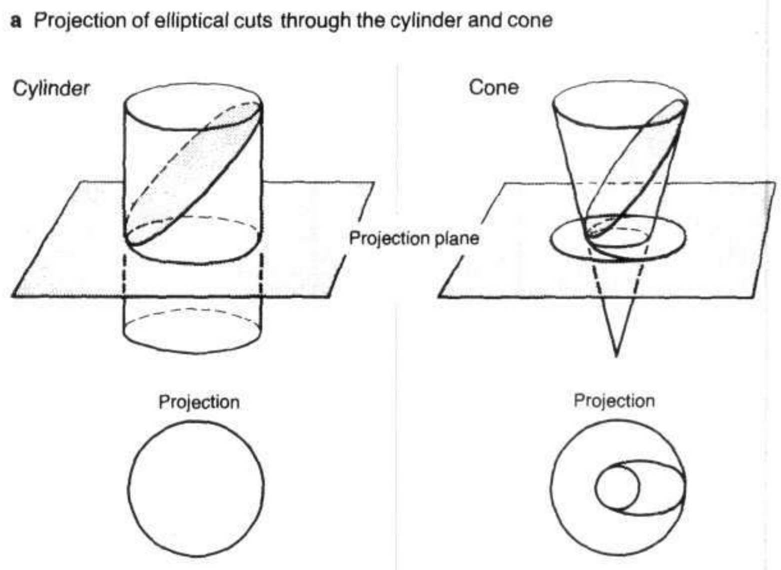
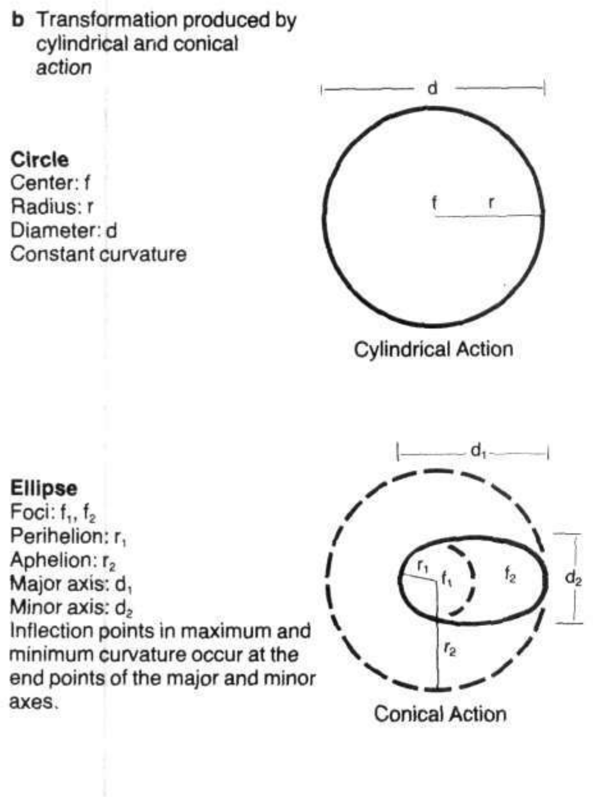


Figure 13
CONICAL VERSUS CYLINDRICAL ACTION

The shift from cylindrical to conical action produces a shift in the characteristics of action. The qualitative difference between cylindrical and conical action is seen in the projections of elliptical cuts through the cylinder and cone (a). The cut through the cylinder projects as a circle; that is, cylindrical action does not transform the universe. The conic section, however, projects as an ellipse, whose perihelion is the radius of the cone's circular cross-section at the base of the cut and whose aphelion is the radius of the circular cross-section at the top of the cut. The ellipse demonstrates the transformations produced by conical action.

The shift from one to the other is characterized by a "splitting up" of every singular characteristic (singularity) of the circle (b): Its center goes over into two foci in the ellipse, its radius into perihelion and aphelion, the diameter into major and minor axes, and the constant curvature into maximum and minimum curvatures.



some lower-order process-singularity *p*. Hence, there must exist a finite number of process-singularities, $p_1, \ldots, p_n$—where *n* is the number of degrees of freedom—such that any division of action is equivalent—up to an unobservable fraction of the least quantum—to a combination of the form $p_1^{a_1} \ldots p_n^{a_n}$, $a_1, \ldots, a_n$ are counting numbers counting the number of rotation-cycles accomplished by the corresponding process-singularities. According to Archimedes' principle, there must be a lawful correspondence between the order *N* of the global-singularity *S*, the number of degrees of freedom *n*, and the maximum number of cycles of the microsingularities $p_1, \ldots, p_n$ which "fit into" a single cycle of cylindrical action for the whole Universe (corresponding to the minimum wavelength or maximum frequency attainable in division of a single global cycle of action). These relationships characterize the "laws of the Universe" in the given mode.

In actuality, the only hypothesis coherent with Kepler's proof is that, strictly speaking, no purely cylindrical action exists. What appears to be mere maintainance of the laws of the Universe as we observe them, is, in fact, a relatively slow rate of change of those laws, a slow rate of negentropy relative to the time scale of human observation.

Therefore, we must consider a second type of action: negentropic action of the Universe upon itself to generate a new, global process-singularity. There is one unique, simplest geometrical image corresponding to this form of action: rotation acting upon a circular area, to generate a larger circular area (Figure 11). This action generates a conical volume, as opposed to the cylindrical volume considered above; the lower circle represents the new singularity, and the conical volume is the work done to create the new singularity. Instead of the helix on the cylinder, we have a spiral, accomplishing a single turn around the cone in passing from the lower to the upper circle, and representing the negentropic action of combined rotation and expansion.

How, then, must we view a continuing series of negentropic action? In the simplest normalized case, we obviously have a cone with a series of circular sections proportioned in a self-similar series according to the golden mean (Figure 12). The apex-angle of the cone corresponds to the rate of negentropy, the ratio of work of creation of new singularities to the "maintenance-energy" of the Universe in a given mode. The continued negentropic action corresponds to a spiral making one turn of rotation between each set of circles. There is exactly one form of spiral that accomplishes this in a least action manner—the so-called self-similar spiral characterized by a constant angle of ascent to any radial line from the apex of the cone. (Any other type of spiral requires additional determinations, beyond the self-similar series of circles, to account for its deviation from an invariant law of ascent.)

Comparing this case to the previous, cylindrical case, we observe that conical action necessarily involves a shift in the characteristics of action in the Universe, as viewed in terms of existing process-singularities, even before the new global singularity emerges. This shift is most simply characterized by examining projections of a diagonal, elliptical cut between the upper and lower circles in the cylindrical and conical cases. The elliptical cut represents the characteristics of the volume generated by the rotational action in both cases. The projection of the elliptical cut onto the horizontal plane through the lower circle represents the characteristics of the action as viewed "within" the old Universe. We find that for cylindrical action, the projection of the diagonal ellipse is just a circle coinciding with the original lower circle.

For conical action, however, the projection is an elliptical orbit, whose perihelion coincides with the radius of the lower circle and whose aphelion corresponds with the radius of the upper circle. The creation of a new global singularity in conical action is reflected in the "splitting" of the unit-singularities of the circle into pairs of singularities for the ellipse.

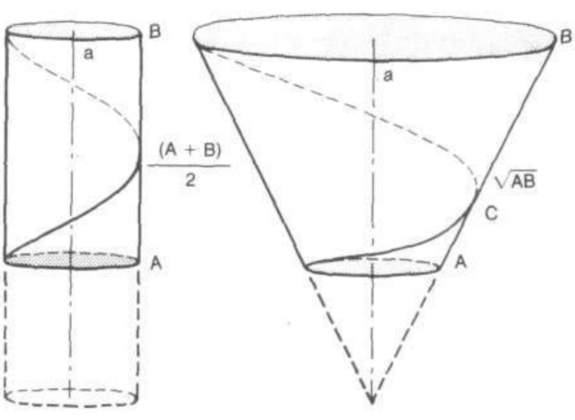


Figure 14
COMPARISON OF CYLINDRICAL AND CONICAL WORK THROUGH A 180° ROTATION
The magnitudes A, B, (A + B)/2, and $\sqrt{AB}$ correspond to the height, which is measured along the central axis a. Since the spiral at right is self-similar, the proportion of its height at A to its height at a half-rotation C is equal to the proportion of its height at C to its height at B, or

$$A:C = C:B, C = \sqrt{AB}.$$

Next, consider the nature of willful intervention to increase the rate of negentropy of the Universe.

Approximate the prevailing, relatively slow rate of negentropy by a cylindrical function of the type described above. To change the laws of the Universe, we must transform that cylindrical action into negentropic, conical action. These two forms of action afford us the rigorous distinction between mere *energy* (cylindrical action) and *work* (conical action). Our task is to induce that action that now appears as "energy of the Universe" to do work on the Universe, thereby increasing the energy of the Universe in the new mode. We thereby unmask the fraud of Helmholtz's "conservation of energy" principle, which is based on the completely arbitrary assertion that the Universe is not capable of doing work upon itself. On the contrary, if the aim of the Universe were to conserve energy, Helmholtz (and the rest of us) would not exist!

The paradigm for transformation of energy into work is Riemann's shock wave; in that sense, Riemann's 1859 paper is a crucial experiment proving that the "conservation of energy" thesis is false. A simple sinusoidal wave (corresponding to cylindrical action) is transformed in propagation through the medium (air in the acoustical case, the manifold of existing creation in the universal case), into a shock front, a new singularity, that modifies the characteristics of the medium. How does this occur? Riemann distinguishes between an initial wave of infinitesimal amplitude, which remains sinusoidal in propagation, and a wave of finite amplitude, in which an additional margin of action is present that modifies the condition of propagation even before the actual shock front is formed. It is this additional, negentropic quantum of action that has transformed a cylindrical process into a self-amplifying conical process.

Riemann implies, therefore, that the action of negentropic transformation of cylindrical into conical action may be divisible: It is not necessary to grab hold of the Universe and bend it by brute force to generate a new global singularity. It is instead possible, by intervening at a lower level of the process, by activating certain marginal transformations of action, to efficiently transform the characteristics of the Universe and induce the formation of a global "shock wave" as a causal consequence of those changed characteristics. A small amount of the right kind of work can set in motion an incomparably larger amount of work.

The decisive elements for a geometrical analysis of this kind of negentropic transformation were contributed by Karl Friedrich Gauss in his early work on the arithmetic-geometric mean and elliptic functions.

Compare cylindrical and conical action for a single cycle of action (Figure 14). In case this cycle is indivisible, that is, not mediated by lower-order singularities, the negentropic transformation required is an elementary quantum of negentropic action: We must simply directly create the new singularity to be generated by the conical function. In case the cycle is divisible, the first division possible for least

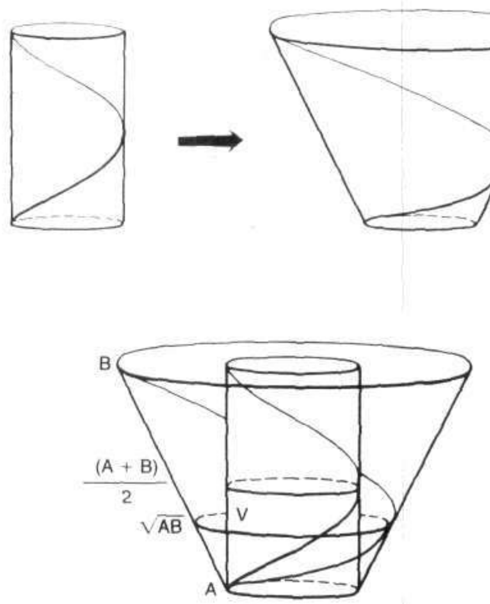


Figure 15
TRANSFORMATION OF CYLINDRICAL WORK INTO CONIC (NEGENTROPIC) WORK
The difference between the volume V of the cone and that of the cylinder represents the work that is produced through negentropic transformation.

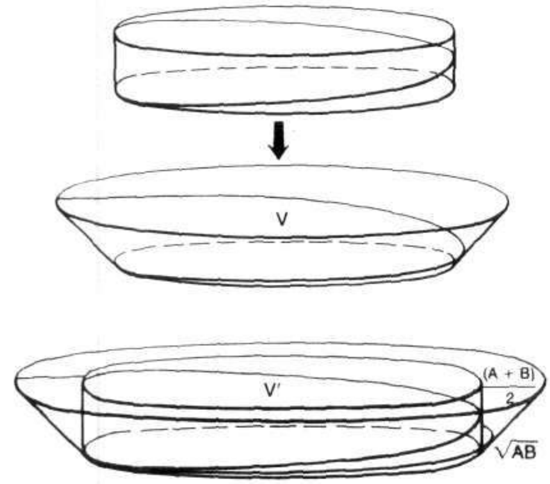


Figure 16
THE ARITHMETIC/GEOMETRIC MEAN AND NEGENTROPIC TRANSFORMATION
Two steps in the Gaussian "arithmetical-geometrical" chain of negentropic transformations. Production of a work volume V. The new work volume V' represents the work that is produced by the negentropic transformation of the second step.

action, as we saw in our discussion of the circle, is halving the action; that is, dividing one rotation of the helix or spiral into two half-rotations of 180 degrees.

In the latter case, the displacement from cylindrical to conical action already manifests itself with the creation of a characteristic singularity at the midway, 180-degree point of the rotation. Comparing the points along the vertical axis reached by the helix and spiral respectively, we see that the point reached by the first half-rotation of the spiral lies somewhat below that reached by the helix. Counting distance reached along the conical axis as line of reference with the lower and upper circles at heights A and B respectively, we find that the helix reaches the height $(A + B)/2$ after 180-degree rotation, while the spiral reaches the point $\sqrt{AB}$. The origin of the discrepancy is the characteristic acceleration of self-similar, negentropic action: While the helix progresses linearly upward at a constant rate, the spiral accelerates exponentially upward and outward as a function of the angle of rotation around the conical axis. In particular, the work done by the second half-rotation on the spiral is larger than the work done by the first half-rotation (Figure 15).

$(A + B)/2$ and $\sqrt{AB}$ were known to the Greek geometers as the arithmetic and geometric means, respectively, of A and B. As one can show, these same two means appear, up to a constant factor of proportionality (depending on the apex angle of the cone), as the major and minor axes of the ellipse obtained by projecting the diagonal cut on the cone onto the plane of the lower circle. Thus, the discrepancy between the arithmetic and geometric means is characteristic of the manifested shift in the characteristics of action in the Universe undergoing negentropic transformation.

Now, cut the cone by horizontal planes at the levels corresponding to the arithmetic and geometric means, the heights corresponding to the work done by the first 180-degree division of the cylindrical action and the first 180-degree division of the conical spiral action. These cuts define two circular sections of the cone, bounding a volume V that thereby corresponds to the displacement from cylindrical to conical action in terms of the midpoint of that action. Imagine a continuous deformation from the cylinder to the cone, keeping the heights of the original upper and lower circles fixed: As the helix deforms into a spiral, the halfway (180-degree) point shifts downward. Hence, the volume V represents work done in transforming cylindrical action into conical action. The "downward" direction of the displacement indicates that this work takes the form of a marginal portion of action "invested" to induce that transformation, and "paid back with profit" by the self-amplifying acceleration of conical action in the second half of the rotation.

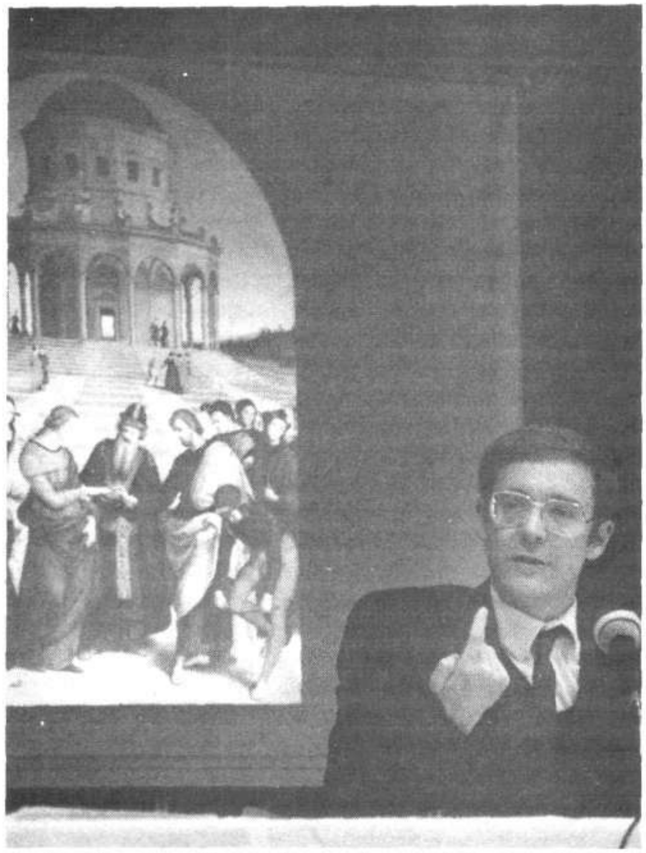
Obviously, we now have a problem of exactly the same form as the original one: Either the negentropic transformation required to produce the work V is indivisible, or the same arithmetic-geometric mean process, applied now to the smaller cylindrical and conical sections, identifies an even smaller margin of action whose execution would efficiently cause the generation of V. The corresponding elliptical projections identify, implicitly, the lower-order singularities that must be acted upon to generate the negentropic transformation.

Continuing this process, we generate a chain of arithmetic-geometric means, up to the point where the original action cannot be more finely divided. By Archimedes' principle, that point is arrived at after a finite number of steps, corresponding to the degree of elaboration of the Universe up to the given point of action. The last, smallest transformation in the chain is the least quantum of negentropic action necessary to efficiently cause the Universe to generate the new singularity, as required. If we are able to perform that least quantum of work, a chain of negentropic transformations, corresponding to the arithmetic-geometric chain run in reverse, propagates through the continuous manifold, amplifying to the point of transforming the laws of the Universe. This is the process addressed by Riemann and his school by the concepts of "retarded potential" and the Dirichlet Principle, which describes how the introduction of a singularity forces a continuous manifold to transform its global geometry.

How much work must we do to accomplish this change? Must we change the orbit of a planet, or cause certain stars to oscillate in a certain manner? Or perhaps it will suffice, using the new relativistic beam technology under development, to generate a single, new type of "wave-particle." The preceding considerations, carried out at the level of the "hypothesis of the higher hypothesis" give us so far no concrete answer, but only a way of thinking about the problem. In fact, the method sketched here applies not only to changing the laws of the Universe, but to transforming any physical process, whether it concern the transformation of the climate of the Earth, the creation of new forms of living processes, or any other interesting and useful task of this sort.

When we consider how man might accomplish the least quantum of negentropic action to change the laws of the Universe, we measure the Universe by the productive activities of man. Indeed, as LaRouche argues, this is the only rigorous measure of the Universe that we possess: the measure of the relationship between man and nature elaborated by LaRouche in his definition of "potential relative population density." The continued existence of human civilization for the generations to come—whose assurance uniquely defines the moral purpose of our individual lives, the "good" in human practice—is only possible through continual increase in man's productive powers, measured as increases in the potential relative population density of the human species. At some point, we will necessarily change the laws of the Universe, to improve the Universe as a basis for continued human existence. Otherwise, if man becomes "bad" and refuses to do the necessary work, mankind will cease to exist.

What does this mean about the ultimate form of the lawfulness underlying nature? There are no fixed laws of the ordinary mathematical type, no tyranny of Helmholtzian physics. Rather, the lawfulness of the Universe is ultimately knowable to man as moral law, as the lawfulness that governs man's participation in the ongoing composition of the Universe: to be free to exist, we must be good.



Author Jonathan Tennenbaum demonstrates to a German FEF audience the use of the golden section in Renaissance art. The illustration is Raphael's "Marriage of the Virgin."

EPILOGUE

The Unfortunate Case of Ludwig Boltzmann

Thus we arrive at the end of our introductory, geometrical treatment of the ontological transfinite. In attempting to address merely the bare essentials of the matter, we have left out many important points, which the reader can profitably follow up.[1] In closing, however, we shall add one matter that connects the previous discussion to the threatened collapse of science and humanist culture today.

The preceding discussion of the ontological transfinite should properly raise the question: If this fundamental notion was understood by Bernhard Riemann and Georg Cantor a mere century ago, how is it that we find today's science (and our culture as a whole) almost totally ignorant on this point? Rather than attempt to give a comprehensive historical account of the process behind this remarkable case of collective amnesia, we shall elucidate the matter with a revealing special case—the conquest of mathematical physics by the statistical doctrines of Ludwig Boltzmann.

Following the ugly resurgence of oligarchism in Europe in the wake of the 1815 Treaty of Vienna, a vast campaign was mounted to crush the networks of continental science that had been built up by Gottfried Wilhelm Leibniz and his followers, from approximately 1667 on. The main instruments of this renewed Inquisition against science were the continental Jesuits and Dominicans on the one side, and the Jesuit-linked networks of Scottish Rite Freemasonry that ran the British Royal Society on the other. In France, the Jesuit-controlled Royalist August Cauchy acted effectively to destroy the remnants of France's leading scientific institution, the Ecole Polytechnique.

In Germany, however, the Leibnizian tradition was maintained into the middle of the 19th century, in spite of opposition, through the efforts of Gauss, Jacobi, Dirichlet, and the Humboldt brothers, in particular. These efforts, part of the general cultural renaissance of the Weimar Classical period, came to fruition in the production of generations of extraordinarily gifted scientists and engineers.

However, although German scientific excellence continued into the 20s of this century, the cumulative effect of Jesuit and Royal Society operations was to cause a shift in the *methodology* taught and practiced by leading German scientists, away from the ontological transfinite toward what might at best be termed the "methodological transfinite." After the suppression by Hermann Helmholtz and Leopold Kronecker of the ideas of Bernhard Riemann and Georg Cantor, scientists abandoned the concept of the Universe as a creative process. Instead, they saw development chiefly in the improvement of mathematical methods, by means of which an "asymptotic" approximation to the supposedly *fixed* Laws of the Universe might be achieved.

Without such a shift in methodological outlook, the scientific community would never have tolerated the frauds put out by Helmholtz and Lord Kelvin under the heading of the supposed universality of the Second Law of Thermodynamics. Helmholtz not only denied the developing nature of the Universe, but was dishonest enough even to assert that the opposite had been proven:

> . . .[I]f the Universe is abandoned to the undisturbed competition of its physical processes, the entire store of energy will finally be transformed into heat and all heat will arrive at equilibrium in temperature. Then every possibility of further change is used up, then a complete cessation of all natural processes of any possible kind must occur. . . . In short, from then on, the universe will be condemned to eternal rest.
>
> *On the Interaction of the Powers of Nature*, 1854

This is the famous "heat death" thesis, a piece of sophistical nonsense whose fallacy becomes immediately evident as soon as the implications of the ontological transfinite are understood.

Throughout the second half of the 19th century, the Berlin-centered "mafia" around Helmholtz and Kronecker succeeded in imposing one methodological fallacy after the other upon the prevailing practice of mathematical physics. The Göttingen-centered Leibnizian school (Gauss, Dirichlet, Wilhelm Weber, Riemann) was reduced to a minority tendency in the scientific community. Chief among these damaging fallacies was Helmholtz's elimination of the crucial distinction between "energy" and "work" in his treatment of the so-called principle of conservation of energy. A second, disastrous blow was dealt to the Göttingen school when Helmholtz succeeded in winning over the German physicists to James Clerk Maxwell's misleading formulation of electrodynamics—an axiomatic approach which Maxwell cooked up by rewriting the work of Gauss, Weber and Riemann while systematically eliminating their essential ideas. We can thank Helmholtz, because of this operation, for the epistemological horrors unleashed on physics by Niels Bohr et al. in the 1920s. The so-called wave-particle paradox exploited by Bohr to sell his insane "Copenhagen interpretation" of quantum mechanics had already been solved, in essence, by Dirichlet and Riemann in their 1830-1860 work on potential theory! The influence of Helmholtz, Maxwell, and others was so great that by the turn of the century, even those who, like Felix Klein, still read Riemann, failed to grasp the most important ideas in the earlier work. As a philosopher once said, "There are no secrets, only blindness."

By the last decades of the 19th century, the methodology of mathematical physics had so degenerated, that no one in Germany was capable of perverting it to a lower level. Therefore, the center of methodological discussion shifted to Vienna, whose rich heritage of cultural decadence provided the raw material for several generations of famous philosophers of science: Ernst Mach, Ludwig Boltzmann, Ludwig Wittgenstein, and the Vienna circle took up where Helmholtz left off.

Boltzmann attempted to prove that development in the Universe is a mere illusion—an appearance based on statistical effects among a vast assemblage of "elementary particles" interacting according to fixed laws. The fundamental laws of the Universe, according to Boltzmann, are the laws of chance—the laws that govern the assignment of odds in a poker game or gambling house. In Boltzmann's universe, we are nothing but swarms of billions of tiny particles fortunate enough to have been tossed together in a certain way.

Of course, this view is nothing but the atomism of Epicurus, propped up by the intervening development of two impressive mathematical apparatuses called "the theory of probability" and "analytical mechanics." In fact, Boltzmann's views would hardly have been taken seriously in the raw form just described. However, by an impressive exercise of mathematical virtuosity, Boltzmann was able to derive some of the already known empirical properties of heat—in particular, the apparently entropic process of equilibration of temperature differences by heat conduction—as logical consequences of his "molecular chaos" hypothesis. Thereby, he created the vast mathematical structure called "the statistical molecular theory of heat." So impressed were Boltzmann's contemporaries by the power of his equations, that many readily accepted the idea that the statistical theory applied not only to the dissipation of heat, but to every physical process in every corner of the Universe. After all, what else could there be in the Universe except lots of little particles?

For a late-19th-century Viennese thinker such as Boltzmann, however, there remained an essential difficulty. According to Boltzmann's statistics, the Universe must progress to more random states—just like a pack of cards initially arranged in order and then mixed up by shuffling into more and more random arrangements. This fit completely with Helmholtz's prediction of the "death of the Universe," its ultimate degeneration into an equilibrium state of maximum chaos. But, worried Boltzmann, if the amazing ordered processes observed in living processes, in crystals, and in the solar system exist today, that means the Universe must originally have been created in a highly ordered state. This idea offended Viennese cultural sensibilities, which preferred to assume that the world had been, was, and ever would be as decadent and degenerate as it was then. Therefore, Boltzmann was led to invent a novel "solution" to this difficulty, the "theory of fluctuations." According to this theory, the Universe is already "dead," already completely chaotic. However, in any random process, there are fluctuations by chance, in which ordered arrangements will "pop up" in the middle of chaos. So, for example, under the assumptions of probability theory, if every day you throw a die 100 times, then it will happen approximately once every 10^{75} years that the same number comes up on the die each of those 100 throws! If there are enough elementary particles in the Universe, and if you wait long enough, thought Boltzmann, then once in a while an island of order and coherence will emerge amid the chaos—a chance fluctuation doomed to dissolve and disappear again as soon as its good luck runs out. So, Boltzmann triumphantly concluded, our world must be such a fluctuation!

Alas! After having reached this pinnacle of scientific insight, Boltzmann himself began to "decay." He was beset by illness and deepening depression. Even some of his fellow Viennese were skeptical; the great Ernst Mach, for example, objected that he had never seen any of the tiny particles. Isolated and dejected, Boltzmann finally committed suicide. Indeed, what human identity could remain for someone convinced that his very existence was an accident?

Were we to take Boltzmann's ideas seriously, we must conclude that his death was a chance occurrence. In reality, it was a lawful consequence of the post-1866 abandonment of the ontological transfinite. From a rigorous scientific standpoint, the statistical mechanical theory of the Universe is pure insanity.

Today, nevertheless, physics professors all over the world receive large salaries for teaching exactly the statistical world view that drove Ludwig Boltzmann to suicide! If anything, today's "improved" statistical doctrines, typified by the work of Ilya Prigogine, are even more insane than the original version. In the 1920s, Max Born and Niels Bohr imposed "statistical interpretation" upon the work of Planck and Schrödinger. Bohr laid down the dogma that the interactions between Boltzmann's little particles—which in the meantime had been identified as electrons, photons, protons, and so forth—are *by nature* incapable of being described in any way but by statistics! As evidence for this assertion Bohr produced a great quantity of philosophical hot air (since uplifted to the title of the famous "Copenhagen interpretation"), whose only actual content was the remark that the experimental evidence completely disproved Boltzmann's atomistic view. Indeed, the "wave-like" empirical phenomena associated with the electron hardly resemble Boltzmann's tiny little balls flying through space and colliding with one another.

What Bohr, Heisenberg, Born, and Pauli then did was to devise a clever algebraic formalism that subsumed *both* the formal aspects of Boltzmann's work and the observed "wave" characteristics of electrons and so forth. A contradiction? By no means, answered Bohr, incorrect theories can be "complementary." The resulting concoction was crowned "quantum theory" and has been rammed down the throats of unfortunate students ever since.

Statistical physics took a further more vicious turn in the recent work of Nobel laureate Ilya Prigogine, a Club of Rome member and a White Russian aristocrat. Since 10^{75} years is longer than anyone would be willing to wait, even for 100 identical throws of a die, Prigogine introduced "nonlinear effects" to speed up "structure formation" in Boltzmann's dead Universe. According to Prigogine, life is a parasitical phenomenon, "feeding" on existing energy flows and accelerating thereby the growth of entropy in the Universe. The apparent creative, inventive aspect of human mentation and biological evolution is caused by random fluctuations on the molecular level, amplified macroscopically by nonlinear structures. In his recent books, Prigogine stresses the philosophical and political implications of his neo-Boltzmannian theories. What we need, concludes Prigogine, is an anarchist society, giving free play to "fluctuations" such as separatism, terrorism, and assorted sexual perversions! This is Teilhard de Chardin's Omega Point.

It is no accident that Prigogine is cited in the book by Marilyn Ferguson *The Aquarian Conspiracy* as a leading ideologue of the new plague of pseudo-religious cults that has recently descended upon the world. The oligarchical Inquisition—of which Prigogine is a prominent representative—is not satisfied with the mere suppression of the ontological transfinite within science: The Inquisition regards its work as completed only when *the institution of science itself is converted into a pagan cult*. Fritz Capra and Carl Sagan are typical of the "high priests" of the new cults. Presently a "great unification" is promised, fusing atomic physics with astrology, parapsychology, witchcraft, and mystical Eastern religions into a single, "organic" unity. We are promised initiation into these marvelous secrets if we just agree to give up our "old-fashioned hangup," the criterion of scientific truth.

Fortunately, the cultish concoctions promoted by Prigogine and others will not last very long. Sooner or later, the fraud of Boltzmannian statistical physics will be swept away, by a new scientific renaissance. We cannot predict exactly what form this renaissance will take, but we state with certainty that a revival of the ontological transfinite will be among its principal features.

Jonathan Tennenbaum, a professor of mathematics, directs the Fusion Energy Foundation work in West Germany.

Notes

1. A full discussion of the hypothesis of the higher hypothesis in Plato appears in "The Science of the Human Mind: A Treatise on Fundamentals," by Lyndon H. LaRouche, Jr. in *Campaigner* magazine, Feb. 1984, (available from Campaigner Publications, 304 West 58 St., New York, N.Y. 10019, for $5 postpaid).

First-generation beam defense systems and other ABM defenses are not pie-in-the-sky or "Star Wars" fantasies, but something that the United States can begin to deploy in the 1980s.

Antimissile Defense Systems for the 1980s

by Charles B. Stevens

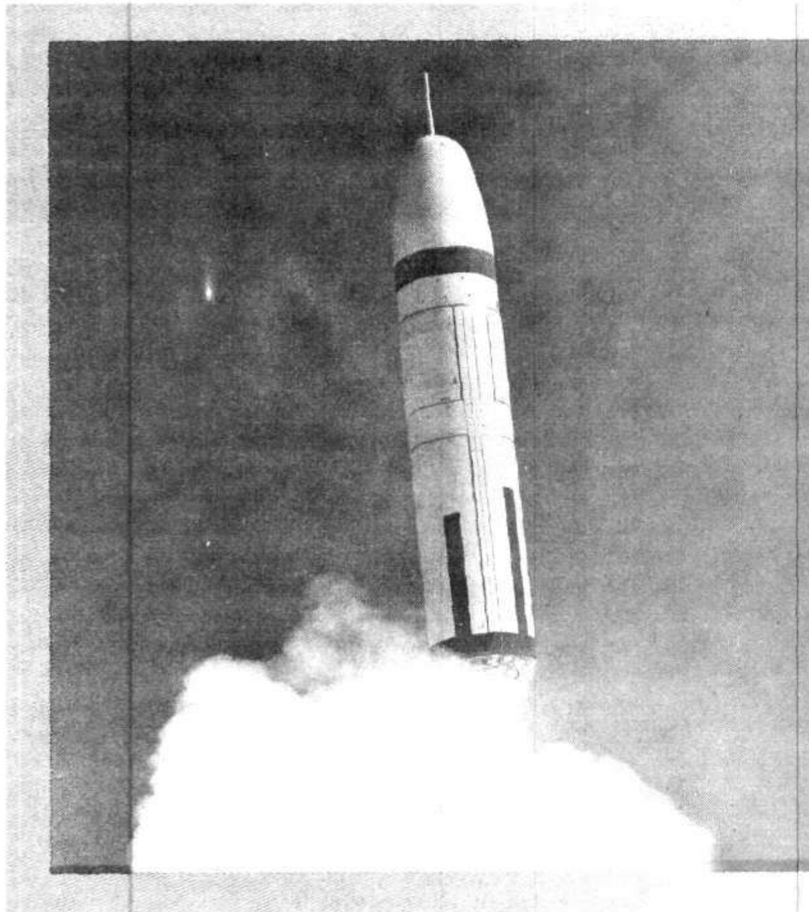
Since the 1960s, the concept of mutually assured destruction or MAD—promoted by James Schlesinger, Henry Kissinger, Robert McNamara, and others—has prevailed in the United States to prevent the nation from developing a defense system against nuclear intercontinental ballistic missiles. President Reagan's speech in March 1983—announcing that new advanced technologies, directed energy beam systems, would now make nuclear missiles obsolete—broke the stranglehold of MAD and again put ABM systems into public view. This article will demonstrate that many ABM systems, some admittedly crude, could be deployed almost immediately, and that the first-generation of directed energy beam weapons could be in operation within the 1980s.

Since the President's March speech, breakthroughs in scientific research in a wide range of fields, combined with the deteriorating global political situation, have prompted defense experts like Dr. Edward Teller to move up to this decade the date on which they expect to see the first generation of defensive weapons in place. Teller, who has publicly advocated development of a beam weapon defense since a Washington press conference at the National Press Club in October 1982, has consistently emphasized the urgent need for an "open"—nonclassified—crash program to develop beam weapon defense, on the scale of the Manhattan Project. At the same time, he has also stressed that the research obtained from the development of such systems "will have enormous benefits for civilian economies."

Some types of defensive nuclear weapons could be deployed in a crude form in the next "several years," according to Teller and others, and substantial levels of defense could be achieved within three to five years. Even President Reagan's science advisor, Dr. George Keyworth, who is not noted for his scientific optimism, has stated that strategic defenses could be in place before the end of this decade.

In particular, defense against short-range missiles, such as the missiles the Soviet Union has ready in submarines located off both the East and West coasts of the United States, could be operational in a short time span. Such a deployment would not violate the letter of the 1972 ABM treaty, because this treaty deals only with defense against *intercontinental* ballistic missiles (ICBMs). And, as those endorsing the plan point out, such a defense against rapid delivery short-range missiles would mean that the United States would not have to resort to an automated nuclear hair-trigger as the only means of preventing such a threat. This would be the beginning of a shift in the global strategic geometry from mutually assured destruction to mutually assured survival. At the same time, the experience gained from such a defensive deployment would provide the basis for more advanced and effective antimissile defenses, using laser and particle beams.

U.S. Navy



Shifting global strategic doctrine to mutually assured survival depends on the development of directed energy defensive weapons as well as conventional defensive weapons in this decade. Here, the Trident I C-4, a submarine-launched missile.

From a military-logistical standpoint, nuclear energy is far more economical than any other form of stored energy. One reason that offensive nuclear weapons have dominated international strategic policy for the past 30 years is that a single H-bomb costing $1 million could easily and reliably be delivered to a target and wreak billions of dollars of damage.

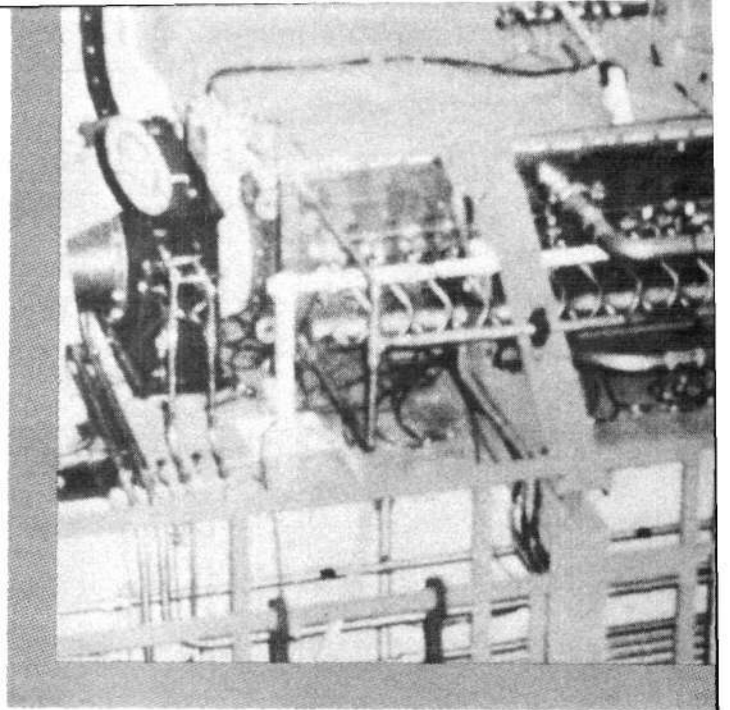
But recent and continuing breakthroughs in plasma, laser, and particle beam physics and technology are rapidly transforming this situation and giving defensive weapons the strategic advantage. If the huge amounts of energy output from nuclear explosions—hundreds of millions of times more energy than that which can be derived from conventional power sources—can be transformed into "directed" beams of energy traveling at the speed of light, this makes possible the cheap and efficient interception of all forms of offensive delivery systems. And, since the vacuum of space is generally the best, and in some cases the only, environment in which directed energy beams can usefully function, directed energy defensive nuclear weapons will be limited primarily to operations in space, where no civilians or cities will be harmed. Thus, space, which has been the sanctuary for the chief vehicles of thermonuclear terror, will be transformed into the graveyard of ICBMs.

Directed energy nuclear weapons will provide the main-line defense against massive nuclear missile barrages, but they will be supplemented with various nonnuclear technologies such as conventional interceptors, lasers, and particle beams. These less powerful systems will provide the backup defense to destroy any offensive delivery systems that leak through the main-line defense. They will also provide the capability for a limited, surgical response to accidental launches and limited attacks.

The Energy Spectrum for Beam Defense

The ABM systems developed in the 1960s were based on utilizing offensive types of nuclear weapons in a defensive role. And like offensive nuclear systems, these early ABM defense systems had to rely on a missile delivery system to carry the defensive explosive to within a few kilometers of the target. The destructive power of the defensive warhead was essentially limited to a simple "thermal"—undirected—energy method of target kill. (Directed energy means that the energy is output in a highly organized, intense form.) Because nuclear energy has an inherent, higher quality of organization than more primitive forms of energy (like that from chemical explosives), it can be transformed from thermal, undirected forms into "tuned," directed energy forms. It has what can be termed a higher negentropy. Simple quantitative comparisons do not reveal the almost infinitely greater capability of nuclear energy to perform work—which in a military context means the capability to incapacitate or destroy enemy targets.

Recent breakthroughs have led to the increasing ability to harness this advantage of nuclear energy. First, the nuclear energy output can be efficiently transformed into various types of beams of directed energy—such as the X-ray laser or microwaves—that travel at the speed of light. This means that the nuclear-pumped defensive weapon delivers its punch at a speed 10,000 times faster than the velocity of the offensive missile. Second, the directed energy output can be "tuned" to specific ranges of the energy spectrum. This means that an offensive warhead can be incapacitated or destroyed with much smaller quantities of energy than those required for "thermal" kills. This second characteristic makes the early deployment of a crude defense capability imminently feasible.



U.S. Navy

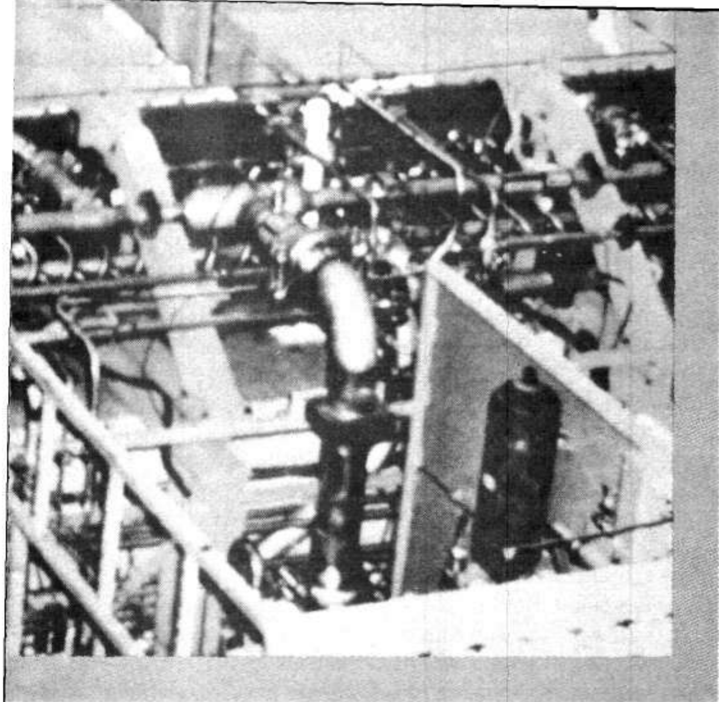
The Mid-Infrared Chemical Laser, Miracl, developed in the U.S. Navy Sealite program. According to the Department of Defense, if its nozzle were organized in cylindrical configuration, it could put out over 10 megawatts, bringing it within the range of requirements for a first generation beam weapon.

These two features combined now give strategic defense the same sort of superiority that the offense has had for the past three decades. Theoretically, one defensive nuclear weapon system is capable of intercepting thousands of offensive delivery systems at relativistic velocities and over ranges of tens of thousands of kilometers.

The ability to "tune" in on a target means that defensive nuclear weapons can be continuously improved so that deployment of effective countermeasures becomes increasingly difficult. In fact, exposing offensive delivery systems to a wide range of different wavelengths of the energy spectrum that are generated by a series of differently tuned defensive nuclear weapons makes it impossible to harden offensive delivery vehicles against defensive weapons. In particular, this ability to tune the energy output of defensive nuclear weapons will make early deployment of crude strategic defense capabilities extremely effective. The reason is that in their initial prototypes, these defensive nuclear weapons will be limited in their ability to focus energy into directed energy beams. Therefore, utilizing a number of different types of defensive weapons with different wavelengths, destruction of offensive systems can be achieved using very low energy depositions on the target. If the offensive weapon is protected against one range of the energy spectrum, it will be vulnerable to another range.

Near-Term Deployment Possibilities

As noted in the study by the Fletcher Commission, the interagency panel commissioned by President Reagan to report on the feasibility of beam defense, any missile de-



fense system must consist of a number of layers, such that a missile penetrating the first layer is caught by various back-up defense systems. There are four phases in such a multilayered defense system: (1) interception during the first few minutes after launch when the offensive missile is most vulnerable because its large rocket booster is easy to detect and destroy; (2) interception during the "bus" phase, before the individual warheads and their reentry vehicles are released; (3) midcourse intercept in space; and (4) terminal defense when the warheads reenter the atmosphere. Each of these phases of interception involves differing problems of target detection and destruction.

A second, more general division in defense capabilities is that between countering a massive offensive barrage and a small number of missile launches. The first is most easily detected and verified by its very nature. The second involves great ambiguities, such as the possibility of an accidental launch or a false alarm. Nonnuclear antiballistic missile interceptors and conventionally powered types of beam weapons will be able to deal in an effective and measured way with such limited attacks. However, the critical issue is whether massive surprise attacks can be met in a credible manner. And it is in defense against this kind of mass attack that directed energy defensive nuclear weapons will play the leading role—even at the earliest phases of deployment.

Contrary to the "Star Wars" disinformation propagated by much of the news media in the last year, the main line of defense against ballistic missiles will not be a weapon based in space; it will be a weapon launched into space on fast rising missiles only *after* a massive offensive barrage has been detected.

This "pop-up" kind of defense has numerous military advantages. First, it is difficult, if not impossible, for the aggressor to distinguish between defensive missiles ready to launch and offensive ones. (Once launched, though, the two are easily distinguished because of differences in their trajectories.) Second, any system already deployed in space is quite vulnerable to attack, because it can be observed at leisure during peace time and its weaknesses determined. Furthermore, such a system is out in the open and quickly accessible to attack. Although deployment of limited defense capabilities in space may be useful, the main line of defense will be held in reserve in missile silos and submarine launch tubes.

Conventional ABM Systems

The United States is currently capable of accelerated development and deployment of two conventional, nonbeam antiballistic missile systems:

Low altitude defense system (LoADS). Types of LoADS systems include environmental defense, in which buried nuclear bombs explode when incoming warheads approach hardened targets, throwing dirt and rocks in their path and thus destroying them before they can detonate near their targets; conventional short-range intercept with missiles; and dense pack. Many of these systems could be deployed to provide point defense for hardened military targets within one to two years.

Homing overlay experiment (HOE). HOE combines a conventional ABM intercept with advanced infrared target diagnostics and compact, computer-chip control. HOE consists of a multistage rocket that pops into space an interceptor guided by long wavelength infrared telescopes and other diagnostics to collide with an ICBM or its bus or warhead. HOE deploys as a large "net" of material (the composition of which is classified) to intercept the target. Its high relative velocities, tens of kilometers per second, lead to certain destruction of the ICBM once a collision course is achieved. HOE is capable of both point and area defense roles. Because of its long range and rapid pop-up deployment, HOE would be particularly useful against accidental or third-party launches in the near future. A crash program could achieve the deployment of hundreds of HOE units over the next two years.

Beam Systems

There are three bands of the electromagnetic spectrum usable with present technologies for ABM systems.

The chemical laser. Producing energy in the infrared band, chemical lasers can be used to heat up and pyrolize ballistic missiles as they are launched. The power density of the infrared light is low, so that these lasers would not be effective against reentry vehicles. They would, however, be very effective against missiles in the boost phase, as well as against satellites and other soft targets.

Short wavelength lasers. Such lasers as the excimer and free electron laser destroy their targets with shock waves.

Microwaves. High intensity relativistic electron beams can be used to generate microwave beams of sufficient intensity to destroy either missiles in the bus phase or reentry vehicles.

In addition, particle beam systems, firing beams of subatomic particles of velocities near the speed of light are being researched. These include electron beams, neutron beams, and high energy muon beams (muons are identical to electrons, but 400 times heavier).

Defensive Nuclear Weapons

The first generation of defensive nuclear weapons, some of which have already been developed in primitive forms, will primarily be based on producing tuned energy outputs that can only be crudely focused into directed beams. Among the most probable types are simple neutron bombs, electromagnetic pulse (EMP), diffuse X-ray laser beams, long wavelength electromagnetic radiation, microwave generators, plasma jet and crude particle beams, and hypervelocity projectile accelerators. All of these have potential capabilities at every phase of missile intercept and can be continuously perfected into longer range and more lethal directed-energy weapons.

These first-generation defensive nuclear weapons will function as follows: When a massive missile launch is detected, rapid acceleration defensive missiles will be popped-up into near space as close to the trajectory of the offensive barrage as possible. The defensive nuclear weapons will be detonated in space and generate an entire series of differing ranges of tuned energy. Each of the ranges of the energy spectrum to which the offensive missiles are exposed will generate different types of effects.

For example, crudely focused, intense microwave bursts and EMP can be efficiently generated with nuclear explosions by utilizing cathodes made of plasma and other methods of explosive pulsed power generation. These will irradiate offensive delivery systems hundreds of kilometers from the point of detonation. Since the entire missile will be exposed, it is quite likely that an unshielded rocket will have some cracks and crevices properly oriented such that the incident radiation from the beam is trapped and focused as in a wave guide tube (a hollow tube made up of a conductor that holds an electromagnetic wave to a specific path, like a pipe for water). This will lead to the generation of intense local electrical currents on the interior of the missile, as if it were hit by a bolt of lightning.

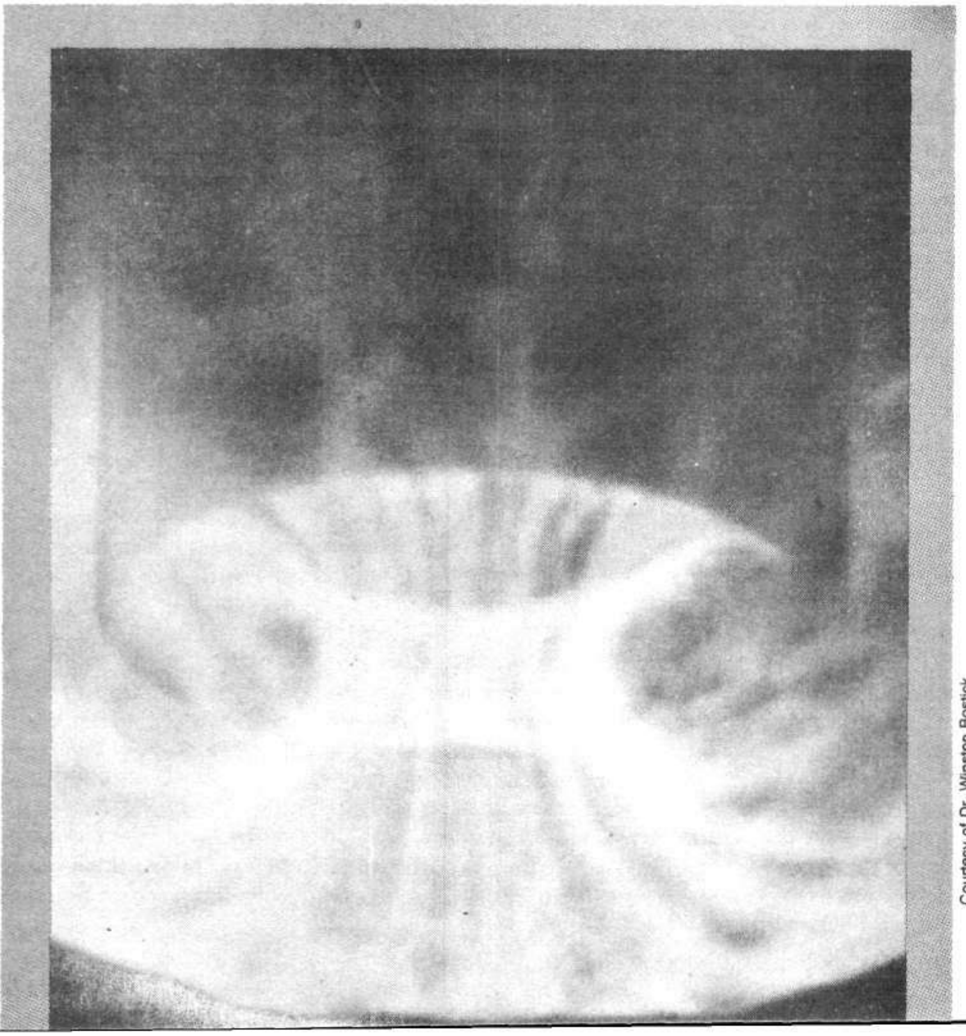
If the missile is shielded against EMP and microwaves—which can be done by surrounding it with an insulated metal skin—then it is far more vulnerable to diffuse X-rays. X-rays are a shorter wavelength form of electromagnetic radiation than microwaves. When X-rays are deposited in a short pulse on an insulated metal layer, they generate large transient electrical currents. This, in turn, generates EMP and microwave-type emissions on the interior of the shield. This type of EMP generation is often called system-generated EMP, or SGEMP.

The larger the offensive vehicle, the more difficult it is to shield it against the full range of the electromagnetic spectrum. And all defensive shielding involves incorporation of large amounts of added weight to the missiles, which makes them more difficult and more expensive to launch.

A third form of defensive nuclear weapon might generate long wavelength, intense, and rotating electromagnetic waves. These would cause the offensive vehicle to begin to tumble out of control.

The target acquisition, pointing, and tracking needed for these "diffuse" beam defensive nuclear weapons are minimal. But as these systems are further perfected and more precisely focused, such capabilities will become increasingly important. At the same time, the power and effective

"Recent and continuing breakthroughs in plasma, laser, and particle beam physics and technology are rapidly transforming the situation and giving defensive weapons the strategic advantage." Here, a photograph of vortex filaments from the current sheath in the discharge of a plasma focus machine. Many of the scientists who deny that directed energy beam defense is possible, also deny the existence of such self-organization in plasmas.



Courtesy of Dr. Winston Bostick

range of these focused beams will be greatly increased. Two of these more focused, nuclear-generated beam systems are the X-ray laser and microwaves.

X-ray lasers: Current information indicates that the United States is months to a few years away from perfecting the nuclear-bomb-pumped X-ray laser to a sufficient level for pop-up deployment against launch vehicles. Even in the early stages of development, the X-ray laser will have sufficient power densities at ranges of several hundred kilometers to make it an effective interceptor of missiles in their launch phase. Popped-up from launch pads in the United States, the first-generation X-ray laser could be quite effective against short-range missiles. Popped-up with submarine-launched missiles in the Arctic, the X-ray laser would be effective against Soviet ICBMs.

Given the rapid rate of scientific progress in X-ray laser development, more intense, longer-range systems could be realized in the near future. These would be effective against all phases of missile flight at ranges up to tens of thousands of kilometers.

Microwave systems. Recent developments in plasma physics and pulsed power generation of relativistic electrons strongly indicate that significant fractions of the energy output of nuclear explosions can be transformed into very intense bursts of microwaves. These systems can either directly generate microwaves by utilizing plasma instabilities or virtual plasma cathodes, or by first converting the detonation's energy into an electron beam and then generating microwaves in a more conventional manner. Plasma microwave "masers" are another possibility.

The power densities achieved in laboratory devices are already enormous. Reports of power densities exceeding 1 gigawatt per square centimeter exist in the open literature. Because of the physical principles of these devices, they can in many cases be scaled up several-million-fold to energies associated with nuclear pumping. For example, a laboratory megajoule pulsed power system will generate 100,000-joule microwave bursts, but a kiloton nuclear detonation will generate 100 billion joule bursts.

The Polarized Neutron Bomb

A good example of how defensive nuclear weapons can be perfected is the polarized neutron bomb. High energy fusion neutrons are unable to do damage over a range of more than 500 meters in the Earth's atmosphere, but they are among the most lethal forms of energy against nuclear warheads in space, and the most difficult to shield against. It would take several yards of concrete or several feet of lead shielding to prevent these high-energy neutrons from penetrating to the interior of the warhead. And the neutrons will generate copious amounts of nuclear fission reactions in the plutonium and uranium present in the warheads. This does *not* cause the warheads to detonate—just the opposite. In fact, from the standpoint of nuclear reactions, the nuclear fuel constitutes the most vulnerable part of the warhead, and even minute transformations will first degrade and then totally incapacitate the warhead.

Utilized in space, ordinary types of neutron bombs probably have effective ranges of several score kilometers. But this could be greatly extended by using polarized fusion fuel in such devices. Polarized fuel is magnetically aligned to speed up desirable reaction cycles and suppress those that are undesirable.

Last year, when polarization of fusion fuel was being intensively examined for application to magnetic fusion, Fusion Energy Foundation analysts suggested that polarized fuel could have a much more significant impact on inertial confinement fusion, which uses intense laser, ion, or electron beams to ignite small pellets of fusion fuel. It was also pointed out that polarized fuel could have major defense applications, given the close scientific relationship between laboratory inertial fusion and H-bombs.

As reported in the recent scientific literature, researchers at the national laboratories have confirmed that polarized fusion could theoretically be of great importance to inertial confinement fusion. Preliminary results indicate that the laser input needed to generate a specific fusion energy output could be reduced by almost an order of magnitude utilizing polarized fuel. But, for military applications, it is a fact that polarized fusion leads to a directed energy output that is of greatest importance.

For example, a burning pellet of ordinary fusion fuel generates an even, *isotropic* output of fusion, generating neutrons in all directions. If polarized fusion fuel is used instead, with the spin of the hydrogen atoms all aligned in the same direction, then the neutron output from the fuel pellet would be *anisotropic*; that is, it would take the shape of an expanding disk coming out of the equator of the pellet. In the case of the neutron bomb, this crude directionality may be sufficient to increase its effective range from 500 meters to the order of 100 kilometers. Despite this still short range, a simple polarized neutron bomb would be extremely effective because it could incapacitate all warheads lying in the plane of the disk over an area of 30,000 square kilometers.

It is possible that this range could be further enhanced by modifying the geometry of the burning fuel. There is some evidence to suggest that one design for a neutron bomb consists of a dense magnetic pinch. By arranging the curvature of the magnetic fields, which determine the alignment of spins of the polarized fuel, it should be possible to focus the fusion-generated neutrons. In this way, the effective range could be extended to hundreds of kilometers.

A directed neutron bomb, however, is only the most primitive type of application of polarized fusion's directed energy output. Utilizing more advanced fusion reactions, such as deuterium-helium-3, it may be possible to directly generate intense beams of high energy protons. These could then be used directly against offensive delivery systems, or could be used as the input for other forms of directed energy.

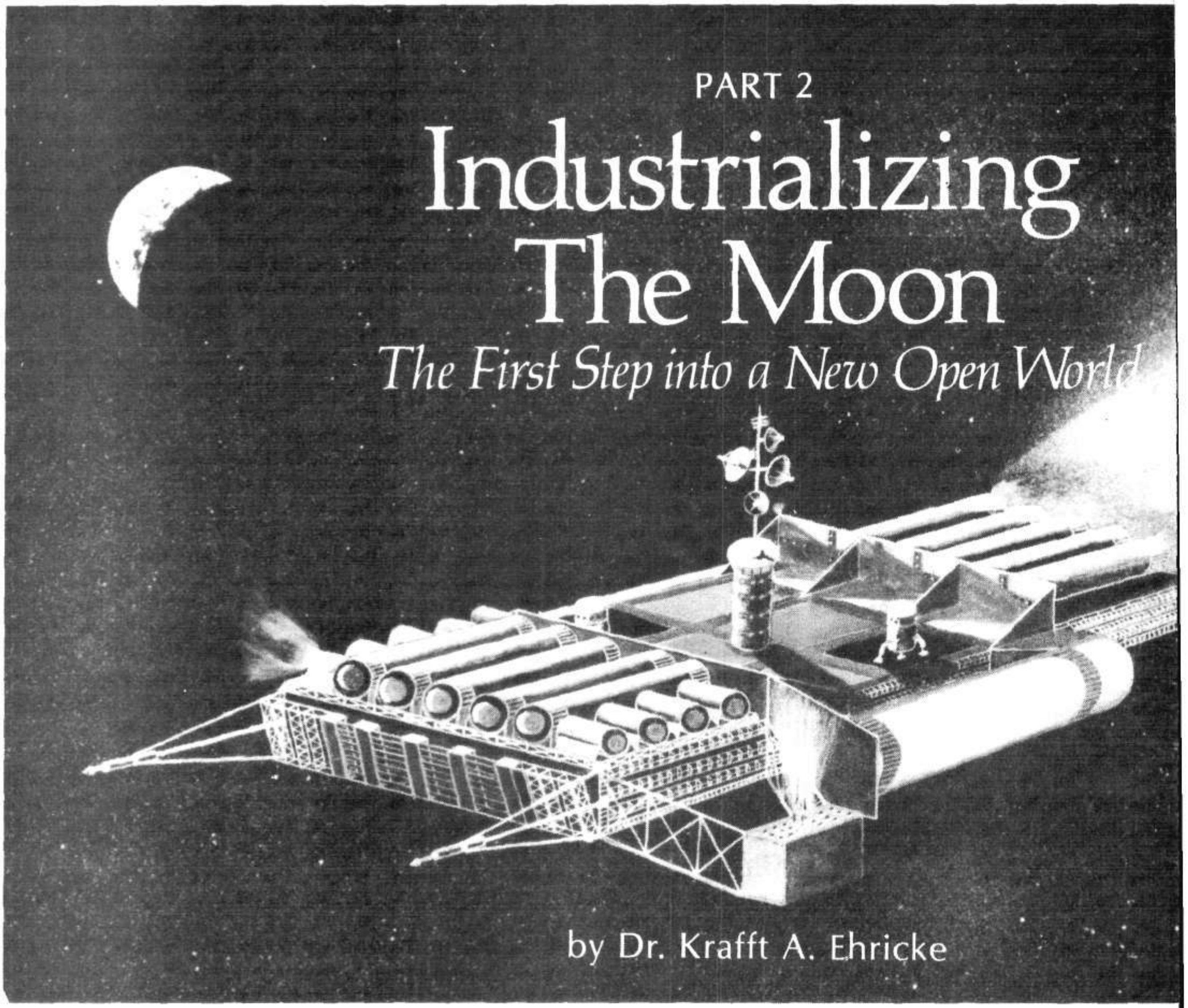
It should be noted that the response of Soviet scientists to the Western publications on polarized fusion—which has been one of complete silence—strongly indicates that the Soviet Union may have known about polarized fusion for some time, and that polarized fusion is a military secret in the Soviet Union.

Charles B. Stevens is director of fusion engineering for the Fusion Energy Foundation.

PART 2

Industrializing The Moon

The First Step into a New Open World



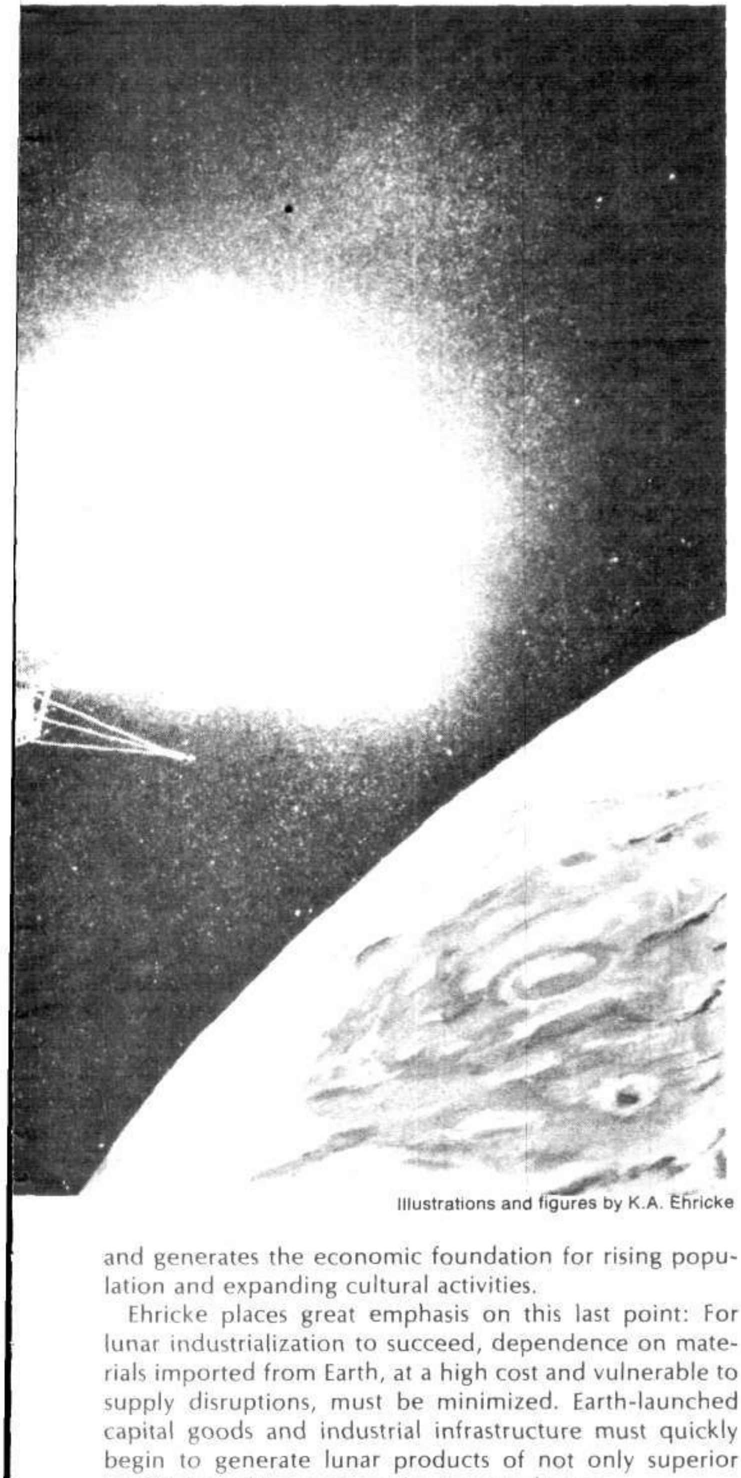
by Dr. Krafft A. Ehricke

EDITOR'S NOTE

In the first part of this article (see Dec. 1981 *Fusion*), space scientist Krafft A. Ehricke posed the challenge before man of industrializing other bodies in the solar system, beginning with our Moon, as the prerequisite for supporting a growing human population of eventually 11 to 12 billion people and allowing the continued development of physical and biological life—the notion of the extraterrestrial imperative, on which he has worked intensively for the past 15 years.

Ehricke's program for lunar industrialization, described in detail in part one, has five interlocked stages (See Figure 2): In the first, exploratory stage, synoptic prospecting is undertaken to detect the Moon's metallogenic and mineralogenic provinces. In stage two, a space station is established in low circumlunar orbit, to serve as habitat and operations center for surface missions (at a much lower cost than if these missions were undertaken from Earth), an engineering and biological laboratory, and a training center for ground personnel. In stage three, large-scale production begins in the first-generation nuclear-powered Central Lunar Processing Complex (CLPC). In stage four, production is undertaken on a larger scale through the development of feeder stations in remote metallogenic provinces, from which strip-mined raw materials are shot ballistically to a receiver crater near the CLPC. These stages lead to the establishment in stage five of Selenopolis, self-sustaining lunar civilization, founded on a powerful fusion energy base, which is roughly in trade balance with the Earth.

Each stage of development lays the economic basis for the succeeding one. The no-frills development of lunar industry is like that of an organism that, over the course of time, evolves progressively more complex capabilities



Illustrations and figures by K.A. Ehricke

and generates the economic foundation for rising population and expanding cultural activities.

Ehricke places great emphasis on this last point: For lunar industrialization to succeed, dependence on materials imported from Earth, at a high cost and vulnerable to supply disruptions, must be minimized. Earth-launched capital goods and industrial infrastructure must quickly begin to generate lunar products of not only superior quality but of many times the imported mass.

Happily, this requirement can be met because the lunar surface contains abundant amounts of industrially valuable raw materials in a shallow gravitational well. Their utilization in the process of developing cislunar and lunar space eliminates high launch costs from Earth and permits lunar industrialization to proceed on a cost-effective, economically sound basis.

Part one discussed in detail the diversity of raw materials

Figure 1
CISLUNAL SUPERFREIGHTER

A cislunar superfreighter, powered by lunar oxygen and aluminum powder, carries lunar bounty to terrestrial markets.

and semifinished and finished industrial goods that lunar industry will produce, as well as techniques for mining, reducing, and processing the Moon's abundant resources. For the reduction and processing of lunar crude, Ehricke has proposed the use of nuclear energy, including underground atomic ovens (UAOs), stoked by small fission or fusion detonations. Low-entropy nuclear detonations are particularly well suited because of the high ratio of energy output to input mass (drills, tubing, valves, cooling systems, etc.). Certain apparent deficits of the lunar environment are advantageous for this highly effective reduction method: Because the rocks are totally dry, there is no steam generation and hence no cracking and cooling of the underground cavern (which, together with low gravity, should prevent chimney formation); and the low heat-conductivity of the lunar crust keeps the heat concentrated in the walls and lava pools at the bottom of the oven. Intense thermal radiation around the clock reduces lunar sands and fines fed into the oven, assuring high productivity. It is also fortuitous that the lunar crust is poorer than the Earth in elements that could be turned into undesirable isotopes by the neutrons released during detonation.

Part two takes up two other critical aspects of Ehricke's lunar industrialization strategy: the production by lunar industry of an important isotope resource for the future fusion economy on Earth, the Moon, and space, and the transportation arrangements that will be put into operation in stage three, radically lowering the cost of getting to and from the lunar surface and across cislunar space.

* * *

WITH THE ESTABLISHMENT of Selenopolis in stage five of lunar industrialization and urbanization, the development of lunar habitation has reached its conclusion, in the sense that an environmental niche, a lunar biosphere, has been created, honeycombed by ecological niches. On the other hand, Selenopolis is itself open-ended; it grows as the lunar population grows and its civilization rises with technological advances. In principle, the overall complex could eventually house many hundred million people. Such a large complex is never completed, in the same way that the development of a continent is never completed. Like the giant cathedrals of the Middle Ages, Selenopolis will be the work of many generations. Only the Moon is large enough to support the first human civilization in space.

The nature and size of the Moon, its abundance of raw materials, and the security of its surface offer extremely favorable conditions for *rationally* and *effectively* exploring and developing all aspects of building a whole new world, the precursor of future, still larger constructions

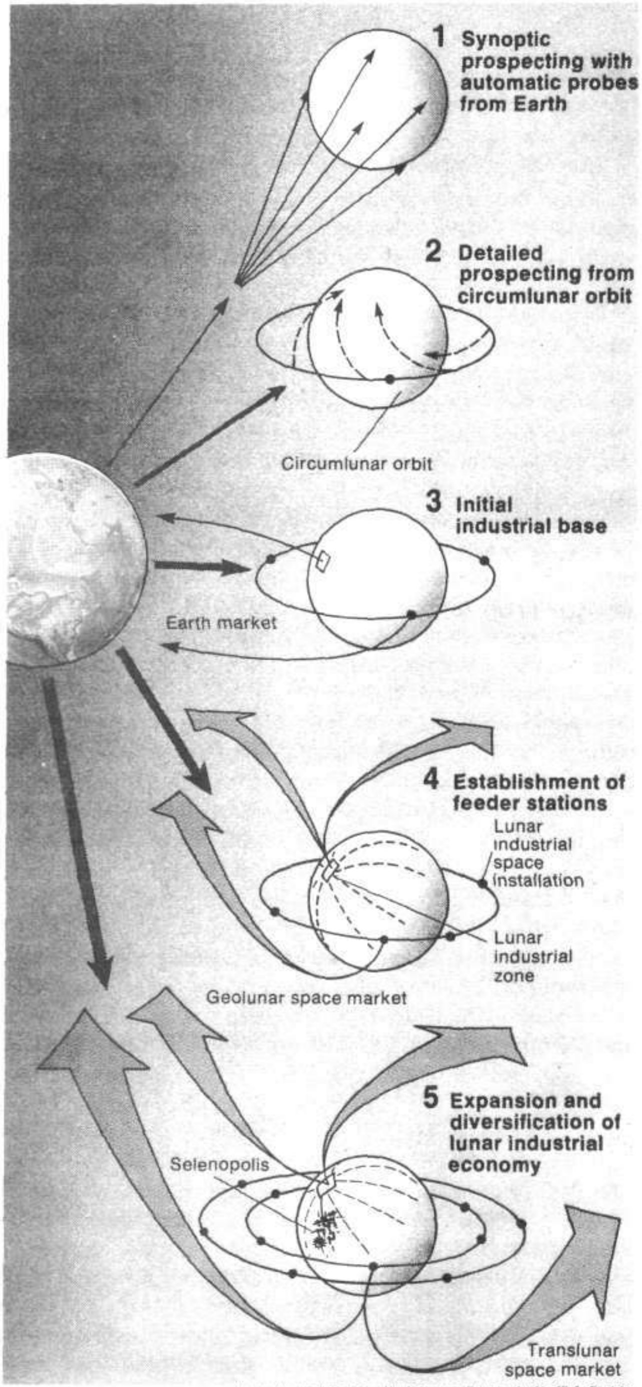


Figure 2
THE FIVE LEVELS OF LUNAR DEVELOPMENT
In stages one and two of lunar development, the Moon is the recipient of Earth-launched capital equipment and associated infrastructure. By stage three, this investment is generating a wide range of products for the Earth market; and in stages four and five, the Moon begins servicing the geolunar and translunar space markets, far more economically than could Earth. In stage five, Earth and Moon are roughly in trade balance. The arrows in the diagram represent this process schematically.

on more distant worlds. These aspects range from the complex questions of establishing and balancing new biological ecosystems, and the intricacies of human macro and microsocial and psychological behavior in the changing reference system of extraterrestrial existence, to the vast technological and managerial infrastructure required—encompassing material management, sanitation, fire protection, environmental control—from macro and microclimate control, vacuum preservation "outside" on the primordial Moon, through leakage control—and, last but not least, emergency provisions associated with failures anywhere in the vast and growing array of integrated and interrelated operations.

Beyond the biosphere, Man has to go it alone without the help of the terrestrial womb environment of his embryonal evolutionary phase. On the Moon, the human being and his technosphere arrive first. The biosphere has to be created and, therefore, follows. Creation is the new "trade," requiring an intensive learning process, particularly for a life form that also possesses extraordinarily destructive tendencies.

Helium-3 Production for Moon and Earth

For Selenopolis, *fusion energy* is as indispensable and fundamental as the Sun's energy is for the terrestrial biosphere. Selenopolis cannot be built with yesterday's technology. Of course, real sunlight illuminates the interior of Selenopolis, reflected by the ceiling through a system of mirrors. Since the lunar day is 14 Earth days long, some of the mirrors are colored and can be rotated into the main reflection path at given time intervals to provide changes in lighting. At night, the Sun is replaced by a lighting system powered by fusion energy, among other sources.

Conditions for fusion power plants are more favorable in the high vacuum on the lunar surface than on Earth in several respects. The maintenance of a high vacuum in the plasma region (at least 10^{-6} torr) is a major problem on Earth because of the high air pressure. The larger the vacuum volume, the more difficult is its maintenance. This limits the size of reactor chambers, enhancing wall erosion by neutrons, and in turn complicating the maintenance of ultrahigh vacuum conditions. Such problems do not exist on the Moon, where a vacuum of 10^{-8} to 10^{-12} torr can readily be maintained *without* volume restrictions. Moreover, the lunar high vacuum simplifies the use of superconductive magnets for plasma confinement and the removal of impurities caused by wall erosion from the intense neutron flux produced in the fusion reactor by the deuterium-tritium reaction. These neutron-wall interactions impose material and operational problems, although solvable, to maintain the first (inner) wall, with corresponding impact on the economy of operation. The larger plasma reactor volumes possible in the lunar high vacuum are advantageous, since the neutron flux density per unit wall area is reduced, and hence the thermal burden on the wall material, erosion, embrittlement, and the influx of impurities are also reduced.

The deuterium-tritium (D-T) reaction is the comparatively "easiest" realizable fusion reaction. About 80 percent of the reaction energy is lodged in high-energy neutrons (14.1 million electron volts [MeV]), whereas the rest consists of 3.5 MeV alpha particles (helium-4). Deuterium can be stored, but tritium has a half-life of only 12.3 years, decomposing into helium-3 (He-3) and an electron. The tritium, therefore, must be bred by using the high-energy neutrons that interact with lithium. Natural lithium is composed of 92.6 percent lithium-7 and 7.4 percent lithium-6. High-energy neutrons (above 2.5 MeV) react with lithium-7, slowing the neutron down and generating one tritium nucleus (triton) and one helium-4 nucleus. Lithium-6 readily absorbs slow neutrons (the slower, the better the absorption), decaying into a second tritium and helium nucleus. Two tritons can be bred for each triton burned. When other materials are present that compete for the neutrons, the yield may be less than 2 (initially, probably 1.2 or better). Still, the tritium is more than replenished. Under lunar conditions, with lower wall loadings, less neutron-detracting material would be required. Moreover, by proper layering of natural lithium with lithium-6-enriched lithium, a yield of 2 appears to be attainable in lunar fusion plants.

The point of breeding an excess of tritium is to obtain He-3 from the decay of tritium that does not have to be fed back into the D-T reactor. He-3 is an important fuel for a D-He-3 fusion reaction. This extremely rare helium isotope is practically nonexistent on Earth. The D-He-3 reaction is the next more difficult fusion process to attain after the D-T reaction; but, as soon as the D-T reaction is operative, it becomes important for terrestrial fusion technology to advance to the D-He-3 reaction, because no radioactive tritium is employed and the reaction is almost completely "clean," as only about 7 percent of the released energy is carried away in neutrons so that virtually no radioactive isotopes are generated. The reaction essentially produces protons and alpha particles; that is, charged particles that can be confined magnetically. Wall loading problems practically disappear, resulting in greatly improved power plant economy. Moreover, the proton-helium reaction plasma is a highly valuable resource for processing heat for material extraction and waste recycling, as well as for generating further electric power. Therefore, it will be highly desirable to develop the techniques for generating the higher temperatures needed to ignite a D-He-3 plasma.

But the He-3 must be produced somewhere. On the Moon, the best candidate, the large-scale operation of D-T reactors is easier and environmentally compatible. Therefore, large D-T fusion power plants become the logical base power source and valuable export production facilities for the lunar industry and civilization, beginning in the latter part of stage four and reaching full capacity, as required, in stage five. In addition, D-He-3 power plants are also of interest for lunar development in stage five, because the proton output, combined with the electron output from tritium decay and with lunar electrons, forms hydrogen—a valuable reducing agent and component of water when combined with lunar oxygen.

Finally, the D-He-3 reaction is best suited for a steady-state fusion drive for interplanetary and possibly cislunar spacecraft. The D-He-3 reaction can operate in a magnetic mirror reactor whose aft end permits discharge of the reaction plasma, heating up deuterium and producing thrust by the exhaust of a very hot plasma-deuterium mix. This is possible only because almost no energy is lodged in neutrons that cannot be confined or directed and would generate a virtually insurmountable heating problem and little thrust in a fusion engine that must be lighter than a stationary reactor.

Steady-state fusion drives may not be admitted into the radiation belt. Depending on traffic volume, their proton exhaust would be trapped in the magnetic field, gradually intensifying the proton belt, rendering its crossing more hazardous for human beings and creating a tougher environment for radiation sensitive equipment on satellites in the belt. These vehicles can transport large payloads, although not at the same high thrust acceleration as pulse drives; but they can carry personnel and fairly large payloads at very short transfer times (months instead of years, years instead of decades) to Mars, asteroids, and into the outer solar system. The more distant the destination, the more superior they are to nuclear-electric spacecraft. It appears likely that there will be a big demand for He-3 in the future and for the production of this rare resource by lunar industry.

If Earth depends on Moon for its He-3, Moon depends on Earth for its deuterium and lithium—a case of mutual self-interest, which historically has formed more enduring and reliable arrangements among peoples than ideology or idealistic cooperation.

A 1,000 gigawatt-year (8,760 billion kilowatt-hours, almost four times the electricity consumed in the United States in 1980), generated by a D-T fusion reaction at a thermoelectric conversion of 0.33 and a triton yield of 2, produces 168.9 metric tons of excess tritium. Of that about 84 tons are converted to He-3 12.3 years later and more each year thereafter, if the D-T fusion process continues at that level or increases. Eighty-four tons of He-3 suffice to generate more than a 500 gigawatt-year in D-He-3 fusion reactors on Earth at a profit of $44 billion annually per $0.01 of profit on the kilowatt-hour.

In terms of mass, the supply requirements are no problem at all, because of the extremely low-entropy level of the fusion plasma. For the generation of a 1,000 gigawatt-year at 100 percent efficiency, 112.6 tons of deuterium and 777 tons of natural lithium are consumed annually, assuming a yield of 2 tritons for each triton burned. If the fusion reaction operates at 50 percent efficiency, and if in this case all the unused deuterium is lost (an unlikely possibility), 225 tons of deuterium must be supplied annually.

In the first case, the transportation requirement is a modest 13 ascents annually with a derivative of the Shuttle (see below), at 68-ton payload; in the second case, it is 15 ascents, at a cost of about $1 billion plus procurement of the deuterium and lithium. Selling He-3 can therefore be quite profitable for the Selenian economy and is an example that demonstrates the continuing growth from stage two through stage five. At a conversion efficiency of 0.33, which is very conservative considering this state of technology, the waste heat per 1,000 gigawatt-year of a D-T power plant complex amounts to some 4.1×10^{13} kilocalories per 24 hours. This is enough energy to warm the atmosphere in almost 155 km^2 of 1,000 meter-by-500 meter Selenopolis half cylinders, from 0 to 25 degrees centigrade, or to heat 2 billion tons of water by 20 degrees centigrade. Because of insulation and thermal flux control, one such power complex could climatize a 30,000 square kilometer-sector of Selenopolis, capable of accommodating a population of 1 to 10 million (at U.S. to European population density).

Lunar Access—The Slide Lander

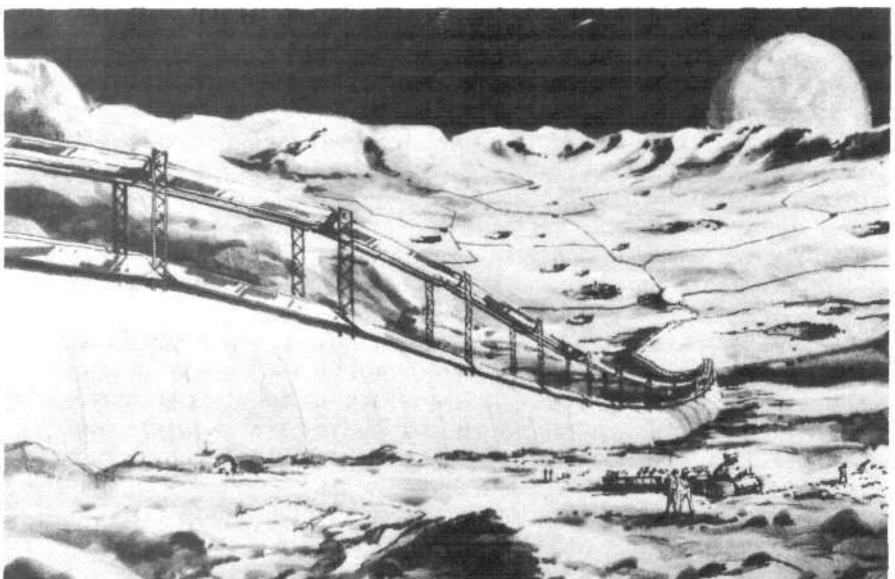
The production of low-entropy fusion energy becomes a major consideration in the latter part of stage four. However, the first prerequisite for lunar development is low cost access to the lunar surface. This depends on the development of a novel class of vehicles that take advantage of special features of the lunar environment: vacuum, one-sixth terrestrial gravity, and flat areas covered with snowlike sandy surfaces.

Because the lunar gravitational field is weak, the energy per unit mass required to escape the Moon is only 4.5 percent of that required to escape the Earth, and only about 4.1 percent if gravitational losses during ascent are taken into account. This means lunar escape can be achieved at about 25 times the payload per unit propellant mass as Earth escape (at equal specific impulse—that is, equal exhaust velocity, indicating the power—energy flux—of the propulsion system; the higher the specific impulse, the lower the propellant consumption).

A mission from circumlunar satellite orbit in 100 km altitude to geosynchronous orbit and back requires an overall velocity expenditure of about 4,000 meters/second (m/s). The round-trip from near-Earth orbit requires about 10,500 m/s with retrothrust on return into near-Earth orbit or about 7,000 m/s with aerodynamic braking on return into near-Earth orbit. Coming from the Moon, the energy requirement is therefore 15 or 33 percent, respectively, where the lunar vehicle is much lighter than the one required for aerodynamic braking. Considering ascent from the respective surfaces and return into the respective orbits, the lunar energy requirement amounts to 9 and 14 percent. The economic significance of this is that the amount of cargo transportable per unit propellant is 11 to 7 times as large, not counting the effects of shielding for twice traversing the radiation belt and of aerodynamic braking, both of which increase this ratio further.

If oxygen/hydrogen (O_2/H_2) propulsion with lunar oxygen is used, the price for the above advantage is the cost of importing the H_2 from Earth. It is therefore of vital economic importance to minimize this import. Fortunately, this can be done. Lunar descent and ascent, by conventional mode, are prime consumers of hydrogen. By reducing these amounts to small fractions, terrestrial supplies are reduced greatly; the effect of the lunar gravitational field is practically eliminated; and the Moon becomes essentially accessible as an orbiting facility.

The consumption of hydrogen for lunar descent can be reduced to a small fraction of that required for conventional landing by a new concept, the lunar slide lander. The hydrogen consumed for lunar ascent can be captured for reuse by using an enclosed launch track (ELT), taking advantage of the lunar surface vacuum. It takes about 1 kilogram of O_2/H_2 propellant per kg payload delivered from about 100 km satellite orbit to lunar surface—that is, the propellant factor, p, is equal to 1; for equal payload delivered to the surface and back, p is about 2.5. At a mixture ratio of $O_2/H_2 = 6$, this means that the hydrogen factor p_H is 0.14 and 0.36 kg H_2/kg payload, respectively. At least that much must be supplied from Earth for conventional descent and ascent. However, by transferring the momentum of the descending Moon Ferry to the surface material, very little propellant is consumed. This concept



◀ **Figure 3**
ROTATING SOLAR REFLECTOR ARRANGEMENT IN SELENOPOLIS
Different sections of the solar reflector are joined at dome-shaped nodal intersections, containing power substations, vital equipment, storage space, and transshipment facilities. The view is from the western rim toward the east, across the southern segment of crater Hevelius.

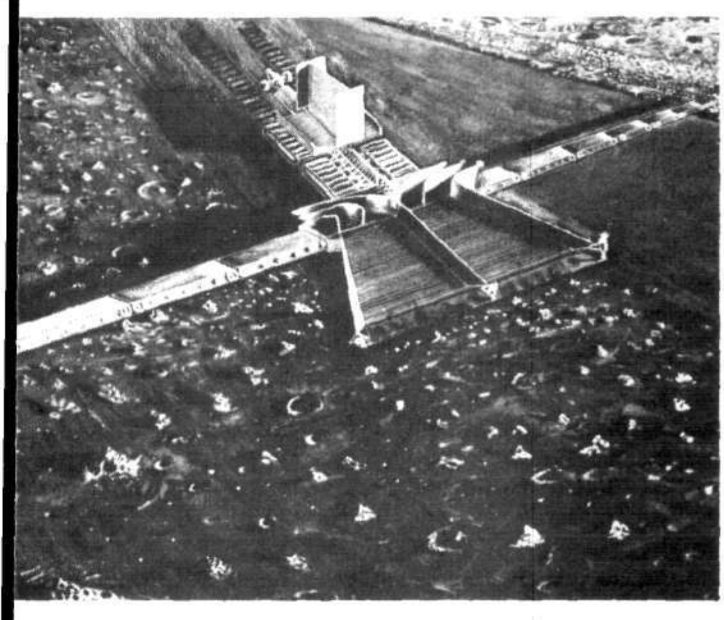
Figure 4 ▶
NUCLEAR-POWERED MAMMOTH SWEEPER
The sweeper, designed for the low-gravity lunar environment, prepares and maintains an 80-kilometer long lunar runway for the slide lander.

is not only decisively cost-saving; the release of increasing amounts of exhaust gas into the lunar environment as the traffic picks up is avoided, preserving the valuable high vacuum on the lunar surface for cost-effective ascent and industrial uses.

Stretches in the lunar plains, the maria, offer surface conditions suitable for slide landing: rather flat terrain, few craters of relevant size, and a thick layer of soft loose material, of which only the largest pieces need to be removed by a sweeper to generate a suitable landing strip (Figure 4). Touchdown at velocities of up to 5,500 km/h, bringing the vehicle to a halt along a 60 km to 100 km-long landing strip, through interaction with glassy-sandy material, introduces a new branch of space flight dynamics, for which I propose the term harenodynamics (from *harenosus*, the Latin for sandy). Harenodynamics encompasses the dynamics of flow; boundary layer formation; and pressure, temperature, and gas (oxygen) release conditions in the boundary layer, at high speed flow of sand along harenodynamic brakes. The material for the brake linings is determined by boundary layer temperature and abrasive characteristics of the lunar fines, and by the possible release of oxygen in a sufficiently hot boundary layer. Fortunately, the Moon is rich in supplies for a variety of refractory materials. The assessment of candidate materials, approach navigation, and other aspects are discussed elsewhere (Ehricke 1979, 1981).

The vehicle descends from low circumlunar orbit along an elliptic path, sweeping down as close to the ground as mountain formations in the nearer and wider surroundings of the landing strip permit. For elliptic descent from 10, 20, and 40 km, the supercircular velocity excess at perilune is approximately 5, 10, and 20 m/s. Therefore, a retromaneuver of only a few meters per second reduces the speed to subcircular and causes the lander to approach the ground at a shallow downward path angle.

The approach phase is followed by a supporting, vertical thrust phase, whose purpose is threefold: control of the touchdown point; fine adjustment of the vertical velocity component for smooth touchdown; and initial support of most of the lander weight, to control deceleration and stability during the high-velocity phase.



The vertical thrust serves the same function as aerodynamic lift in airplane landing. Initially, the effective ground contact weight is very small, balancing the need for stability against some irregularities in the landing strip (which requires momentum control) with deceleration control. The initial contact weight may be as small as 0.1 percent of the lander weight. A 100 ton (Earth ton) lander, for example, weighs 16 tons on the Moon. The initial contact weight is then 160 kg (weight). As the velocity decreases, the contact weight is increased by progressively decreasing the supporting thrust.

Eventually, the vertical thrust is terminated in the third and final phase of the landing process. The slide time is about 2 minutes, of which supporting thrust is needed for at most 90 seconds. The average weight of the lander during this period is about 0.8 of its full weight, because of the centrifugal effect during the high-speed phase. The supporting thrust of a lander at 16 tons full lunar weight requires, under these conditions, a propellant consumption equivalent to a velocity change of less than 120 m/s—much less than the almost 1,700 m/s that must be eliminated at conventional landing. The propellant consumption of the slide lander is therefore reduced to less than 10 percent of that required in conventional landing, corresponding to a hydrogen expenditure per unit mass of payload of $p_H \sim 0.01$.

Figure 5 shows the frontal view of one particular lunar slide lander concept. The front is a multiple-injection slot nozzle, whose thrust can be varied from the value specified for retrothrust prior to touchdown, to maximum thrust at reascent in the ELT. Supporting thrust is generated by the vertically mounted modules. Pitch and yaw control is provided by separate control thrusters; roll control by differential vertical thrust on both sides of the lander.

Controlled touchdown begins with the aft edge, which, together with the supporting thrust, stabilizes the vehicle for careful ground contact of the main drag vanes. These are spring supported, inclined, and in adjustable yaw position, in order to throw the lunar material away from the vehicle structure. The load on the vanes increases with decreasing supporting thrust. The process is controlled by feeding a deceleration profile into the landing computer, a profile determined primarily by the physical tolerance of the drag surface materials, and secondarily by limitations (if any are relevant) of payload and vehicle structure.

The right side of Figure 5 depicts the lander in the third landing phase, when it is no longer supported by thrust. The lander concept shown hurls the soft top layer of lunar material to the side and off the landing strip, eventually requiring the replenishment of the strip. Alternate concepts deflect the material in such a manner that it falls back onto the slide path.

A multitude of other aspects involved in the slide landing process have been examined—navigational, harenodynamic, emergency options, and so forth. Suffice it

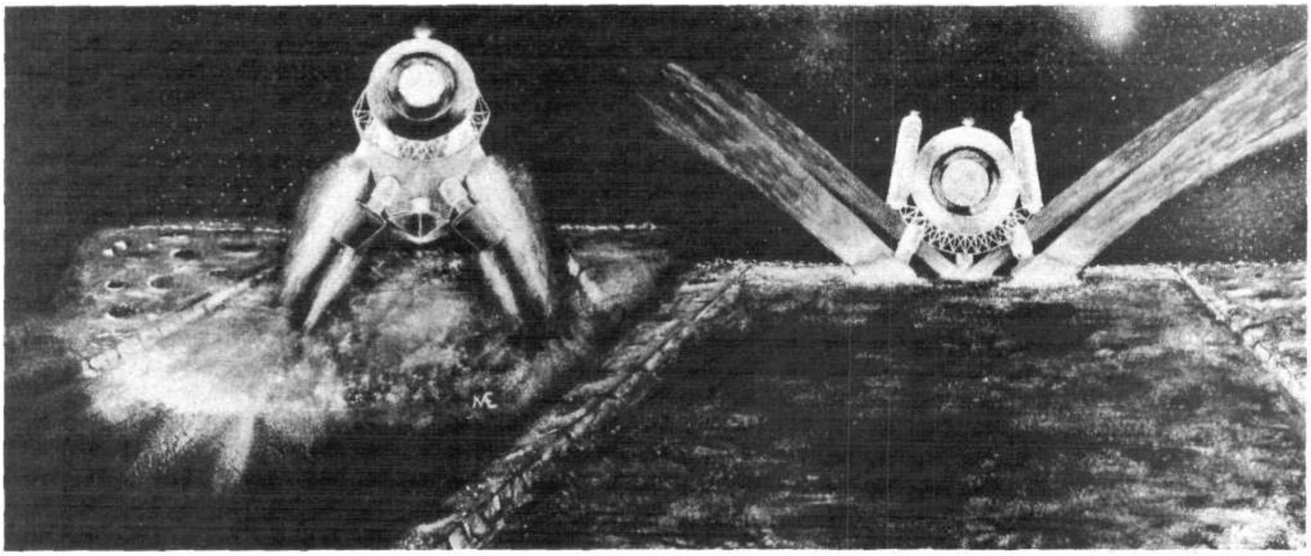


Figure 5
SLIDE LANDING ON THE MOON
The slide landing on the lunar dust ocean upon descent from orbit minimizes propellant consumption and release of gases into the industrially valuable high vacuum on the surface. At left, touchdown of the slide lander aft cone at a speed of 5,000 kilometers per hour or less; vertical thrust substitutes for aerodynamic lift. At right, the lander slides down the runway, hurling reams of dust into ballistic paths in the airless, low-gravity environment.

to say that none appears to pose serious problems. All in all, lunar conditions—vacuum, low gravity, and sandy surface—are favorable for slide landing.

Lunar Access—Drop Delivery

The lunar industrial build-up outlined in part one of this article offers the opportunity for drop delivery of a large portion of the needed equipment. Drop delivery involves free fall, hence a more or less hard landing. A typical drop delivery profile is shown in Figure 6. A first stage that does not land eliminates the orbital velocity and induces free fall of the payload module, which is equipped with only a small propulsion module to eliminate a larger or smaller portion of the free fall velocity. Only a small maneuver is required, even at complete elimination of the free fall velocity (about 200 m/s at free fall from 10 km altitude).

Energetically, drop delivery is slightly less efficient than conventional retrothrust descent; however, this deficiency is more than compensated for by several factors: The structural mass actually landed is a minimum. The first stage can be lighter than if designed for landing and can be returned to circumlunar orbit at a lower propellant expenditure than if it were landed. Following separation of the payload module, the first stage enters into a close circumlunar orbit from which it departs at the appropriate place for rendezvous with the space station, either by minimum energy transfer or by "overshooting" the circumlunar orbit. Finally, most of the exhaust gas released by the space stage (the bulk of the propellant expended at drop delivery) escapes the lunar gravitational field immediately, protecting the lunar vacuum, since the exhaust speed is added to orbital velocity. In all, drop delivery is more favorable than conventional landing and can be applied before the slide lander is operational. The landing payload module delivers 40 to 45 mass units of payload per unit of structural mass, and the small dead mass is left on the surface for industrial utilization.

Lunar Access—Ascent

Growth of exports is the bottom line of the lunar industrial economy. Thus, after the initial industrial build-up, ascent loads must exceed descent loads by a widening margin. Besides preserving the lunar vacuum, it is necessary to avoid the dissipation of as valuable a resource as water, the combustion product of O_2/H_2 propulsion. At first, the exhaust material is used to accumulate water for the habitats and for industrial purposes, making the oxygen and hydrogen (and later, as lunar oxygen is supplied, the hydrogen) do double duty—as propellant and valuable import.

Analogously, O_2/CH_4 propulsion can be used to import carbon and hydrogen. In this case, the combustion products CO_2 and H_2O are collected. Water and carbon dioxide are decomposed electrolytically, so that H_2, O_2, CO, and C are obtained. H_2, CO, and C are industrial reducing agents. H_2O from either propulsion system can be decomposed electrolytically and recycled as propellant at a corresponding savings in transportation costs for not having to import more than a very small amount of make-up hydrogen, considering some unavoidable losses. The import- or supply-related specific impulse in this case reaches values of 80,000 seconds or more, compared to 470 seconds for O_2/H_2 propulsion without propellant recovery or even 1,500 seconds for an advanced nuclear gas core reactor drive, which would require respectively 170 and 53 times the propellant supply from Earth per unit mass of payload

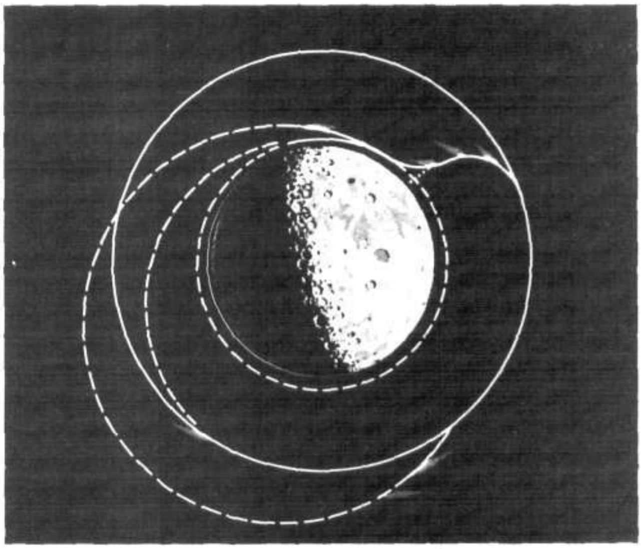


Figure 6
DROP DELIVERY
The lunar industrial buildup makes use of drop delivery of a large portion of the needed equipment. A first stage, which does not land, eliminates the orbital velocity and induces free fall of the payload module.

transported from lunar surface to circumlunar orbit. Propellant recycling represents an enormous benefit for the lunar export economy.

Recycling is achieved by use of an enclosed launch track (ELT), In the ELT, the vehicle is accelerated to some 1,700 m/s. The exhaust velocity of the engines is in the order of 4,000 m/s. The gases, therefore, flow backward in the funnel at velocities of ~ 4,000 (at start) to ~ 2,300 m/s (at emergence from the ELT) into collection points along the ELT, where the superheated steam is quenched with liquid oxygen (later with water because it is more easily condensed than O_2), collected as wet steam, and condensed subsequently in a radiation cooling system shadowed against the Sun and especially effective at lunar night.

By far the bulk of the transportation requirements are for cargo, not personnel. Therefore comparatively high accelerations can be employed, thereby reducing the length of the ELT. Lowering the specific impulse also contributes to a shortening of the ELT by cutting the burning time.

Construction of the ELT is greatly facilitated by the use of local materials and extensive automation. Lunar surface material, serving as the basic structural material to be coated inside the ELT, can be cut out of the ground and compressed into building blocks like slightly wet snow, somewhat akin to the use of snow as construction material by Eskimos. It is also likely that lunar materials can be processed into cementlike bricks by compression and heating, to melt lunar sulphur into a binding agent.

The ELT is large enough to accept the entire vehicle. An alternative is the concept of a partially enclosed launch track (PELT). This arrangement is more a tube than a tunnel. The tube contains a monorail track on which a propulsion system is guided magnetically. Connected with the propulsion system by means of a dorsal fin is a transportation platform that carries the ascending vehicle. The fin, of course, requires a slot atop the tube. During launch, the slot is closed magnetically behind the fin, preventing exhaust gases from escaping from the tube. The internal propulsion system accelerates platform and load. Following the attainment of the terminal velocity, the ascent stage is launched from the platform. The launch unit is then slowed down, hooked to a cable system, and pulled back by an electric winch; it is then refueled and readied for another launch.

The PELT carries slide lander and cargo atop the transportation platform. Because it does not have to launch itself, the horizontal propulsion unit (engine and propellant containers) of the slide lander can be smaller. Less dead mass is carried back and forth. The open platform imposes few restrictions on the size or shape of vehicle and cargo launched into circumlunar orbit.

One may assume an initial phase in which the slide lander returns to orbit as a cargo carrier with high launch acceleration in a relatively short and simple ELT. The still small personnel traffic is handled by conventional vertical landing and take-off. Subsequently, the PELT is built and, as it grows in length, is used at progressively lower acceleration levels down to values suitable for acceleration-sensitive cargo and personnel. The PELT eventually will become the track for electromagnetic propulsion, once sufficiently high power levels are available to release about 60 million Kw-hr in 3 minutes.

Geolunar Transportation: The Diana Fleet

While of course indispensable, transportation represents a tax on the lunar economy—indeed, a generally much larger tax than in the terrestrial environment. It is, therefore, essential to minimize this tax by deriving from every transportation expenditure a maximum of productive capability. Sometimes, this can be achieved only through the development of a new, more efficient propulsion system. In this case, the large up-front expenditures and the lead times must be weighed against the effect on the overall schedule (and possible associated cost increases) and against the length of time (and added cost, because of lower performance) for which the older system would anyhow be needed within the overall program plan.

The lunar access modes described are of central importance. In addition, a fleet of ships is needed, which may appropriately be dubbed the "Diana Fleet," for carrying out all aspects of lunar and cislunar development. In the early stages of lunar industrialization, the vehicles for Earth launch are the Shuttle and a Shuttle derivative, the Heavy-Load Launch Vehicle (HLLV), with a large payload section mounted atop the External Tank, in lieu of the orbiter but with orbiter engines (which can be made recoverable). If otherwise unchanged, this modification increases the payload capacity of the Shuttle by 129 percent. If solid boosters are replaced by O_2/H_2 boosters, the payload capacity is increased by about 183 percent.

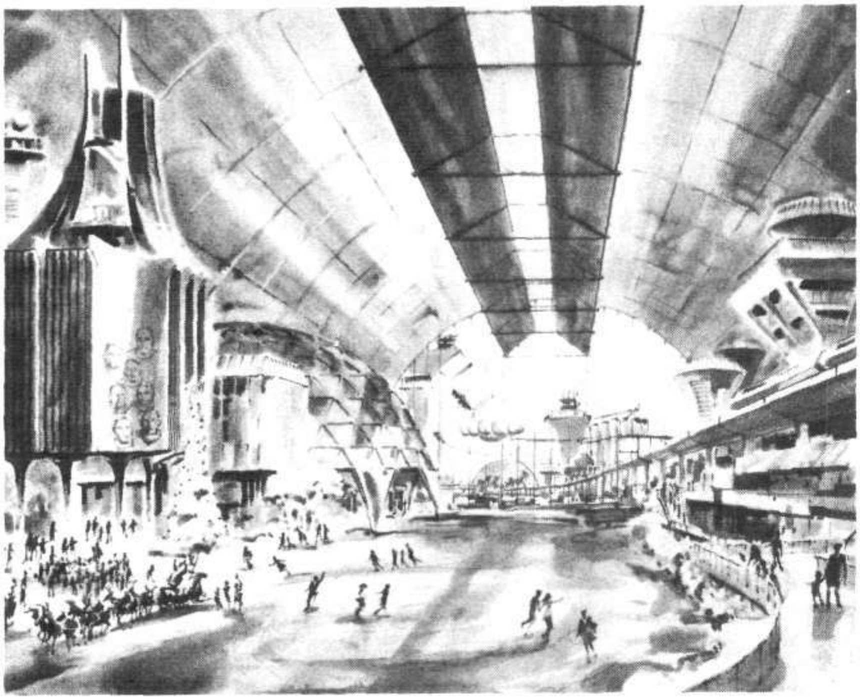


Figure 7
CHRISTMAS IN SELENOPOLIS, 2031
Twenty-first century Selenians enjoy Christmas in a climatized Selenopolis half cyclinder. At left is the Hall of Astronauts; at right, an elevated monorail. The nodal dome behind the transparent insulation houses supplies and life support and climatizing equipment. On the far side of the dome is the entrance to a tropical habitat.

NASA has decided to enhance the present Shuttle performance by adding to its fleet a Centaur O_2/H_2 deep-space stage, modified to fit the orbiter payload bay (here referred to unofficially as Centaur II). The Centaur design allows sizing for various mission requirements. With a small maneuver module (storable propellants) for lunar capture, Centaur II can deliver between 5.6 tons and 12 tons into circumlunar orbit, depending on specifics of the modification.

The Shuttle with a Centaur II is an adequate capability for the one-way transportation of automated systems during stages one and two of lunar development.

In stage two, the capability of the Shuttle is assumed to be increased to that of the HLLV, and that of Centaur II to a cluster of Centaur II rockets as the drive for a large, first generation "Geolunar Transport-I," to establish a circumlunar space station. Moon Ferry and a highly cost-effective nuclear-electric geolunar freighter are two new transportation systems for stage two.

In stage three, there is still no overriding need for a launch vehicle larger than the advanced HLLV. However, an enlarged Geolunar Transport-II is needed, implemented by a lunar liquid oxygen (LLOX) depot in circumlunar orbit. By not having to carry the return oxygen from near-Earth orbit, the mass of terrestrial oxygen needed by the transport is reduced by 71 percent; hence, the hydrogen requirement is reduced also. Together, the propellant loading in near-Earth orbit for a round-trip mission with equal payload both ways is reduced to 30 percent of the mass required if the LLOX depot were not in circumlunar orbit. Thus, assuming a performance specific impulse of 470 seconds, the Earth supply-related specific impulse is some 1,500 seconds; this means that the reduced propellant supply requirement from Earth corresponds to the round trip of a space freighter (one that does not refuel near the Moon) with a much more powerful, advanced nuclear propulsion system (with high thrust) of 1,500 seconds.

The nuclear-electric geolunar freighter of stage two is likely to be enlarged by the addition of thrusters and a larger reactor; it still has an important economic-transportation function in stage three, since its propellant supply requirement is only 42 percent of that of the chemical Geolunar Transport, even with an LLOX depot in circumlunar orbit. Its only disadvantage is the characteristically low thrust level, resulting in transfer times of one to three months. However, for transporting freight, this disadvantage is more than compensated by the lower propellant supply requirement. If it has to come from Earth, this supply is a major cost factor, due to costly transportation to near-Earth orbit. As propellant for the nuclear-electric freighter, sodium is selected, which, in the course of development stage three, will be supplied from lunar resources.

For serving installations in the geosynchronous and other distant circumterrestrial orbits, a solar-electric cislunar freighter is the simplest and most economical concept. The freighter is exposed to the Sun virtually without interruption, since it does not operate in the closer vicinity of the Earth. It operates in a very weak gratitational field and hence requires less thrust and electric power and still achieves reasonably short transfer times—such as 10 to 14 days between circumlunar and geosynchronous orbits, at a propellant consumption of only 40 percent of even the nuclear-electric geolunar freighter, which has to overcome the much more intense gravitational field closer to Earth both ways. The cislunar freighter, therefore, is also suitable for the transport of service personnel to maintenance jobs in geosynchronous orbit and back to their lunar home.

The propellant consumption for deliveries from circumlunar to near-Earth orbit can be reduced greatly by eliminating the retromaneuver at injection into near-Earth orbit, the maneuver requiring the bulk of the propellant expended in this transfer. This maneuver can be eliminated by using the atmosphere. As already proposed by Walter Hohmann in 1925, an incoming spacecraft can lose its velocity excess without propellant consumption by one or more passes through the upper atmosphere. The Apollo spacecraft applied this technique on return. However, at lower aerodynamic braking, the vehicle reemerges from the atmosphere with just enough excess velocity to reach and insert itself with a small maneuver into near-Earth orbit.

It is obvious that a Hohmann maneuver braking of this type results in particularly large savings of fuel delivered from Earth, since the expendables needed for the final maneuver of the round-trip mission must be carried as dead mass through all preceding maneuvers of the mission, at considerable propellant expense. The savings well exceed even the effect of the heavier mass of such a freighter, which must be designed to withstand atmospheric heating and pressures.

Beyond these transports, we can envision two types of high-thrust superfreighters, capable of carrying several thousand tons of cargo. A chemical superfreighter, burning lunar oxygen and lunar aluminum powder, is independent of terrestrial propellant supplies and can service facilities in distant and near-Earth orbits (see Figure 1). The other type, a nuclear pulse powered superfreighter, provides far superior specific impulse, but is not likely to be permitted to operate near Earth in the radiation belt, because it releases large amounts of charged particles, especially at higher traffic rates. However, its capability of transporting economically—that is, at low propellant consumption—very large masses of cargo at short transfer times may nevertheless be used advantageously for deliveries to Earth or into near-Earth orbit (Ehricke 1969, Nance 1965, Taylor 1972, Winterberg 1981).

Such a profile uses the pulse freighter to launch a large payload mass into a controlled entry path to a predetermined Earth landing site, or into an aerodynamic braking corridor to a near-Earth orbit, while the freighter passes outside the atmosphere, returning along an elliptic path into lunar space for capture in lunar satellite orbit. In this profile, the pulse freighter does not use its powerful propulsion system inside the radiation belt—in fact, not inside some 50 Earth radii distance.

As for the steady state D-He-3 fusion drive, the pulse drive's most appropriate field will be the heliocentric "ocean," reaching and making possible the economic exploitation of Mercurian, Martian, asteroidal, and particularly Jovian and Saturnian satellite resources, which the lunar experience will make possible.

The Moon as Cause and Consequence

Ours is a binary planetary system. There is no reason that only half of it should be inhabited, merely because life originated there. As part of Earth, lunar granite would have amounted to no more than a small continent between Antarctica and Australia in size. Placed in our sky, this continent-world matches the area of the Americas. It offers even more than important contributions to overcoming our present problems and achieving essential technological advances. Selenopolis, symbol of a civilized Moon, is a new beginning of such magnitude that it can be compared only with man's emergence from the shady shelter of forests into the light of the open savannas. The Moon is the touchstone of human future. Instead of searching for and speculating about life elsewhere, we will put it there. Forthwith, civilization will be three-dimensional and life polyglobal. Living at the ethereal shores of heliocentric space, the Selenians will be the cosmopolynesians of the solar system, navigating between worlds—bridging a dim past under terrestrial skies, where the great legends of human emergence tower, and deathless civilization in a stellar future whose shadows beckon and long to be given substance.

Krafft Ehricke has been involved for more than 40 years in the study and development of space technology, exploration, and utilization. During his professional career he has been involved in the development of many "firsts," including the German V-2 missile; the Atlas, the first U.S. ICBM; and the Centaur, the world's first oxygen-hydrogen upper stage rocket, whose development he conceived and directed.

Ehricke has done studies for NASA on many advanced concepts—from large reusable launch vehicles and space habitats to advanced propulsion systems and planetary missions. For his ideas on the inevitable integration of Earth and space environments (the extraterrestrial imperative) as a process following evolutionary laws, he received the I.B. Laskowitz Award of the New York Academy of Sciences in 1972, among others.

Ehricke is founder and president of Space Global Co. in La Jolla, Calif. The author of numerous articles, he is currently finishing two books for a German publisher, one dealing with the industrialization and settlement of the Moon, the other with the disposal of nuclear waste in space. A long-finished work, The Extraterrestrial Imperative—From Closed to Open World *awaits publication.*

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DOE Pushes 'Flat' Budget; Fusion Program Foundering

For the past three years the Reagan administration has used every possible excuse to prevent the nation's magnetic fusion program from progressing toward the goal of commercial fusion energy development. The Department of Energy's 1985 fiscal year budget request is no departure from this record.

Under the auspices of Dr. George Keyworth, the president's science advisor, fusion scientists have been told that fusion is "not ready" for engineering work. This contradicts the judgment of the scientists engaged in fusion research, and also countermands the Magnetic Fusion Energy Engineering Act of 1980, which specifies that the nation build a fusion engineering reactor by 1990 and a commercial prototype reactor by 2000.

Bowing to economic pressure from the Office of Management and Budget, DOE spokesmen have recently stated that the fusion budget will be held "level" for at least the next five years, because of financial pressures from the large federal budget deficit. Even when DOE spokesmen agree that fusion is ready for the next step, they claim that the resources do not exist to go forward.

The U.S. fusion program is now facing a situation where scientific break-even will be reached in the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory in 1986, but there will be *no* next-generation machine ready to go on line to bring fusion into the engineering development phase. Without this next step, the fusion program will never develop a commercial power reactor.

The Next-Step Device

Opening congressional hearings Feb. 29 on the fusion budget, Rep. Marilyn Lloyd (D-Tenn.) stated that she would not let her subcommittee on Energy Research and Production "be a victim of budget deficits." The $483 million fiscal year 1985 DOE request will not even keep pace with inflation, stressed witnesses from the fusion labs and industry.

Interested in the proposal from the fusion community that a Tokamak Fusion Core Experiment (TFCX) be initiated this year, Lloyd stated that members of her committee "don't accept flat budgets in the out years" for fusion.

The proposed TFCX would produce long pulses of fusion power in an ignited plasma that burns when outside heating sources are removed. All the scientists testifying at the hearings agreed that the TFCX experiment would demonstrate the practicality of going ahead with a commercial reactor prototype.

If this next step is initiated within a flat budget, however, other existing fusion programs will have to be canceled, scaled down, or delayed. Nearly everyone at the hearings except the DOE found this to be unacceptable.

A National Security Issue

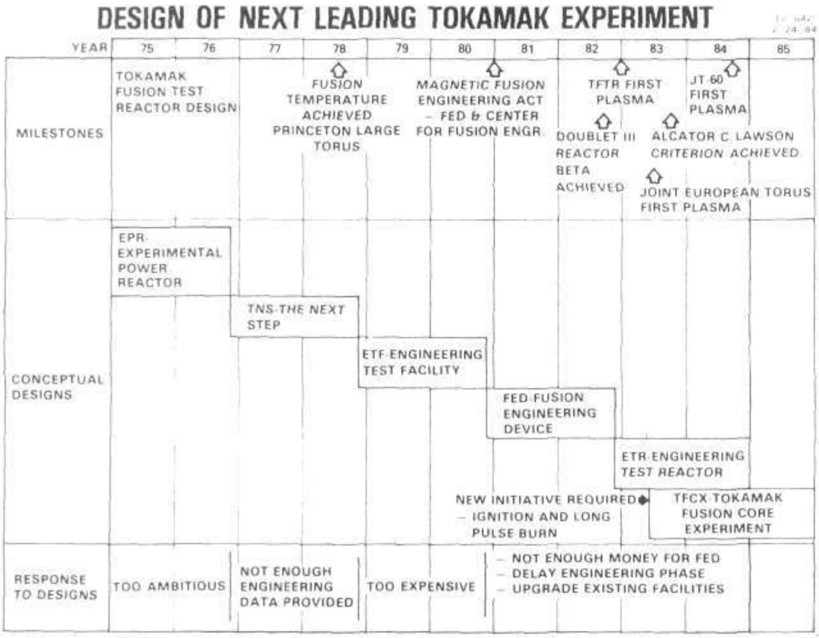
Testifying at the hearings, *Fusion* Washington editor Marsha Freeman identified the fusion program as key not only in providing an inexhaustible source of energy, but also in pushing foward the frontier areas in plasma physics and related fields for the directed energy beam weapon program.

"It is time for the fission and fusion communities to reunite to tackle and solve these challenging problems, to protect this nation and its allies from nuclear attack. We cannot slow down fusion research without affecting national security," Freeman said.

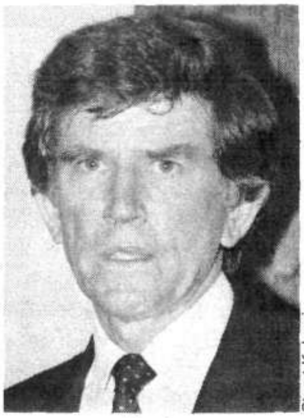
The economic benefits of both fusion research and beam weapons would reverse the current industrial collapse, by bringing dozens of new high-productivity technologies into basic industry, agriculture, and energy production, Freeman stated.

The FEF urged Congress, which for the past few years has increased the DOE request to try to keep the fusion program growing, to once again take a policymaking role and make sure the momentum in the fusion program is maintained.

—*Marsha Freeman*



This McDonnell Douglas chart contrasts fusion milestones to the negative responses to successive U.S. conceptual designs for magnetic fusion.



Stuart K. Lewis

Hart

Stuart K. Lewis

Jackson

Philip Ulanowsky

LaRouche

Stuart K. Lewis

Mondale

Where the Candidates Stand On Energy and Defense

EDITOR'S NOTE

Fusion *polled the Democratic presidential candidates, asking them two basic questions on energy and defense policy. We asked them to confine their responses to 50 words or so. Here are their answers, compiled by Lydia Cherry.*

We also asked the same questions of President Reagan's reelection campaign staff, but they were unable to give us a policy statement by press time. We plan a more extensive questionnaire to the candidates before the presidential election, which will include Reagan. The candidates are listed here in alphabetical order.

Question 1: What is the policy on the mix of energy technologies needed for the United States, now and in the next few decades?

GARY HART

According to a campaign spokesman, Hart proposes establishing a five-year, $13 billion program to finance improved energy efficiency in 20 million American homes, while eliminating $28 billion in current subsidies for nuclear power and synthetic fuels. Hart has proposed a tax credit for homebuilders using "passive" solar designs in new homes.

Hart led the fight to terminate the Clinch River breeder reactor, and proposed halting a $6 billion program to develop a new technology for enriching uranium for nuclear power plants.

Hart also "supports further research and development on fusion as a source of energy in the future."

JESSE JACKSON

"A rapid phase out of nuclear power plants will be a sometimes difficult, but achievable first step. The history of the nuclear power industry has been one of lies and deceit, from the first Atoms for Peace project. . . . The Atomic Energy Commission tried to get us to live with the testing of atom bombs in the deserts of Utah and Nevada [but] the high rates of leukemia and cancer and birth defects in surrounding areas continue to remind us what radiation really means to people.

"My energy program program calls for local and regional energy planning, low and no interest loans for home owners, landlords, farmers, small business and industries so they can take advantage of conservation and alternative energy measures. My program will further include low-interest loans for cost effective solar systems like ethanol distilleries, wind generators, small-scale hydroelectric generators, and co-generators. We need a major federal commitment to the purchase of solar-cells for government projects."

LYNDON H. LaROUCHE, JR.

"The United States needs approximately 10,000 gigawatts of increased industrial energy-output capacity by the year 2000. Some part of this will be covered by hydroelectric generation developed as a byproduct of large-scale fresh-water management. Most must come from nuclear fission or coal.

"By the close of the century, controlled thermonuclear fusion must begin to emerge as the principal source of mankind's industrial energy supplies. In the use of fossil fuels, such as coal, magnetohydrodynamic and other technologies are urgently required."

WALTER MONDALE

"I believe that we must resume our national effort to achieve a balanced dependence on renewable energy, conservation, and conventional supply. Emphasis will be in the short term on promoting the use of proven, cost-effective existing technologies and in the longer term on shifting from reliance on fossil fuels to renewable energy. For this reason, I support full implementation of the solar and conservation bank. . . .

"Fusion power offers the potential for unlimited supply of energy and at present I would support continued research in its development. In the

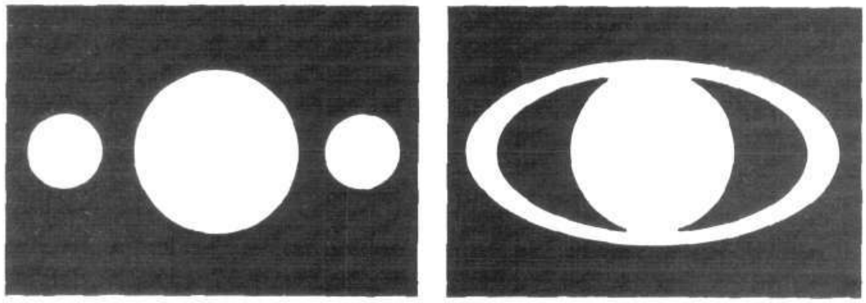
Continued on page 64

The Young Scientist

TELESCOPES— A Closer View of the

by Jim Everett

The development of the astronomical telescope began in earnest in the 17th century, although Leonardo da Vinci had designed a telescope 150 years earlier. In 1609, Galileo Galilei popularized the device, using a Dutch design. This simple instrument consisted of two eyeglass lenses, one at each end of a slender tube: At the eye end was a concave lens, thinner at the middle than at the edges; and at the other end of the tube, a convex lens, thicker at the middle than at the edges (Figure 1a).



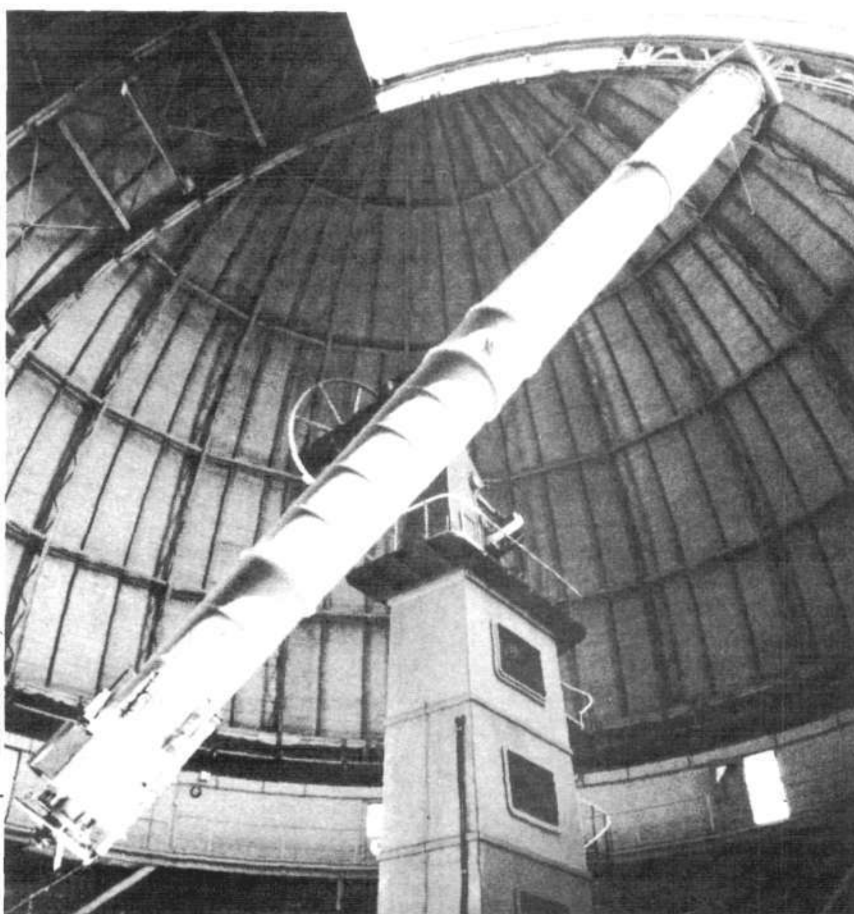
a b

When Galileo observed Saturn in 1610, he thought the rings were two other planets (a). Later, he described them as "cup handles" (b).

Exactly who invented the telescope is still being debated. It is known, however, that a number of illustrious scientists, including da Vinci (1452-1519) and Roger Bacon (1214-1294), had written about and sketched designs of instruments "in which men myght see thynges that were doon in other places," as Bacon wrote.

Within the first three years of its use, astronomers made many dazzling discoveries that confirmed the new world view of scientists Copernicus and Kepler. A short list of these discoveries includes:

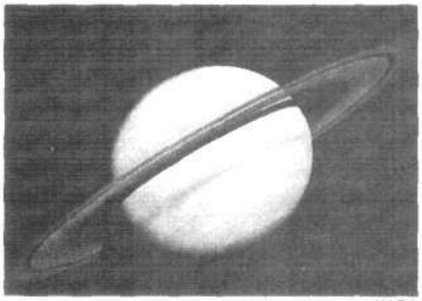
- The moon is not a smooth sphere, but is full of mountains and jagged craters.
- The Milky Way is not a haze but consists of myriad stars too small to be seen with the naked eye.
- The planet Jupiter is a miniature "solar system" with four large moons circling it.
- The planet Saturn has a ring around it (although at first it looked to Galileo like two little moons).
- The Sun has dark spots on its surface.
- The Sun rotates, which was de-



Yerkes Observatory

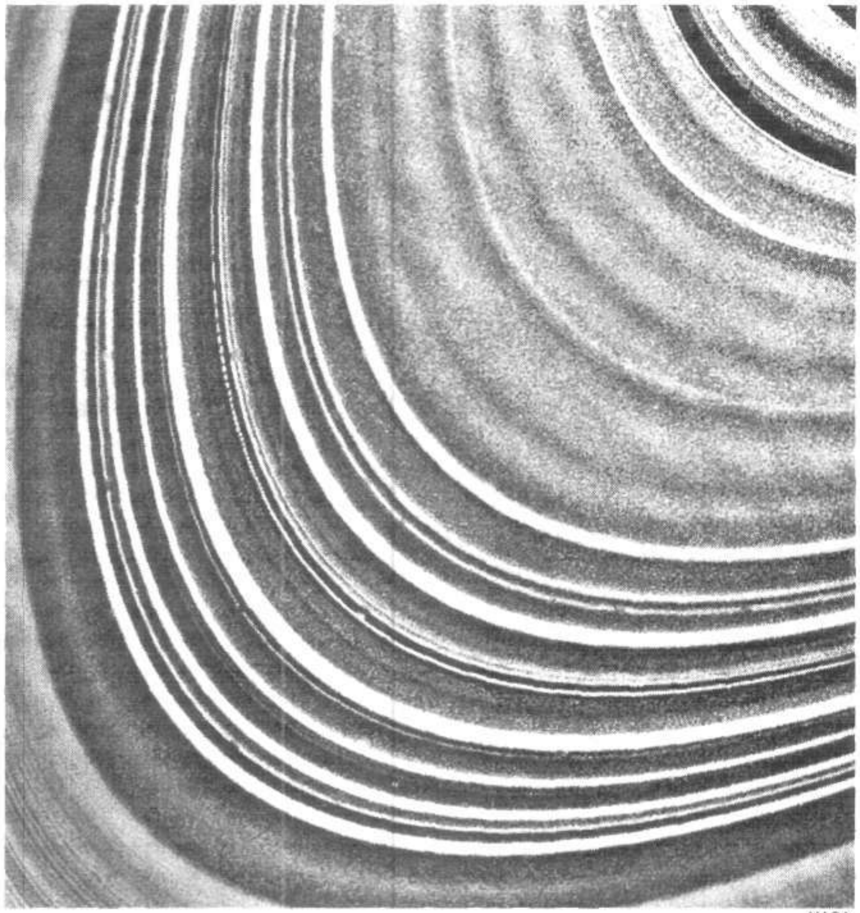
A modern refractor telescope at the Yerkes Observatory in Wisconsin. Its objective lens is 40 inches in diameter.

Universe



NASA

A view of Saturn taken by Voyager 2 in July 1981. With a small telescope on a clear night you can see Saturn and its rings.



NASA

Today, after NASA's Voyager 1 and 2 missions, we know that Saturn has more than 100,000 rings. This view of the rings was photographed in Voyager 2's closest approach to the planet, Aug. 25, 1981. The narrowest bands here are about 10 miles wide.

termined by watching the movement of the sunspots on the Sun's surface.

All of these discoveries were made with the Galilean telescope, although it was small and gave rather fuzzy images. But this instrument was soon improved by Johannes Kepler. Although Kepler's major discoveries did not depend upon use of the telescope, he created an improved design that gave less distortion and this became the most popular telescope among astronomers (Figure 1b).

The next major advance in telescope making came when astronomer Johannes Hevelius found that sharply curved lenses produced the most distorted images. Around the same time, another scientist and astronomer, Christian Huygens in Holland, built several telescopes using the flatter lens suggested by Hevelius. The problem with this type of telescope was that it had to be very long in order to focus the image: Huygens used an instrument 123 feet long to make the discovery in 1656 that confirmed that the puzzling feature around Saturn is a ring. Hevelius built a telescope in 1647 that was 150 feet long, but this "celestial machine" was impractical to use since every little breeze made it shake.

In 1672, two new types of telescopes were designed. The first was by N. Cassegrain in France. He used two mirrors, one concave and the other convex, instead of glass lenses. In the same year, Isaac Newton in England built another variety of telescope that used two mirrors, a primary mirror shaped like a parabola (see Figure 2) and a flat secondary mirror. At first, the difficulty of making high quality mirrors made these telescopes hard to build. But once the technical problems were overcome, these instruments became very popular because they could be more compact and have a larger field of view than previous telescope designs.

The main purpose of a telescope is to gather light from a broad area in the sky to give the viewer information about the source of the light, such as a distant star. All telescopes work using a simple geometrical principle: Incoming light is shaped by an optical surface, such as a mirror or lens, into a cone (Figure 3). All the light that enters at the base of the cone is focused to a point, where the viewer observes the concentrated light through an *eyepiece*. In this way, we can observe not only the planets and the Moon, but also stars, nebulae, and galaxies that are much too faint to be seen with the naked eye.

The Reflector

The most widely used telescope today is the *reflector*. This was first designed by Leonardo da Vinci, but named after Isaac Newton. The re-

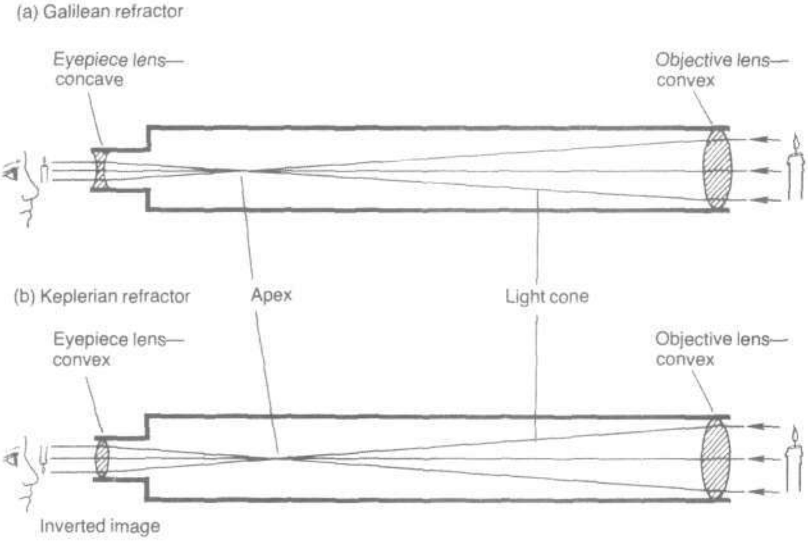


Figure 1
GALILEAN AND KEPLERIAN REFRACTORS
In the Galilean refractor telescope (a), light enters the objective lens where it is shaped into a cone of light. The eyepiece, a concave lens, intersects the cone of light near its apex, and magnifies the image. We use the image of a candle as an illustration.

Galileo's telescope was later improved by Kepler (b) who placed convex lenses at both ends of the tube. Although Kepler's version turned the image upside down, it provided a clearer image. Besides, astronomers do not care if the stars are seen upside down.

flector creates its cone of light by using a lens that has the geometrical shape of a *parabola*. The parabola has the unique property of focusing all incoming rays to a single point (Figure 4).

As Figure 4 shows, the reflector around an automobile headlight or flashlight uses this property in reverse; in a headlight, a lightbulb is placed at the focus of the parabolic-shaped reflector and the rays of light from the bulb are focused into a beam.

The reflector telescope consists of a round mirror that has a paraboloid surface and an elliptical mirror that has a flat surface. In the reflector telescope, the incoming light passes through the telescope tube (the tube serves only to keep stray light out and to support the mirrors). When it reaches the parabolic mirror, it is reflected back in a cone of light (Figure 2). With this type of telescope, the viewer cannot look at the light at the focus point, for his head would be blocking the incoming light.

The shape of this small mirror is interesting in itself. To make the mirror as small as possible yet able to capture all the light at the end of the light cone, the flat mirror must be in the shape of an ellipse. The ellipse, like the parabola, is a *conic section*, which is created by slicing a cone, as in Figure 3.

The biggest advantage of the reflector is that a large primary mirror may be constructed at a reasonable cost. Another advantage is that the reflector telescope may be mounted rather low to the ground, because you look through it at the top of the tube. One disadvantage is that the

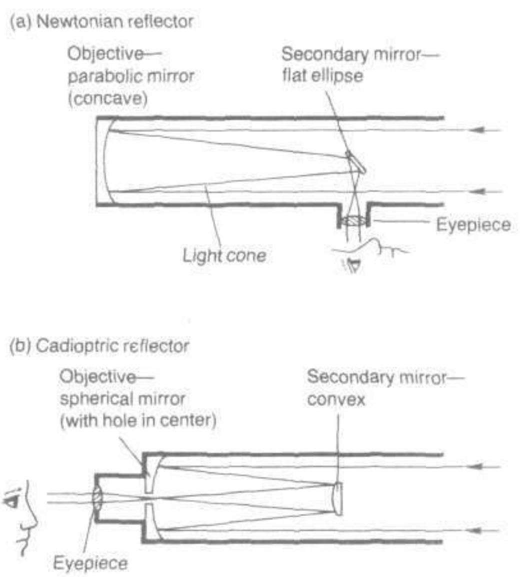
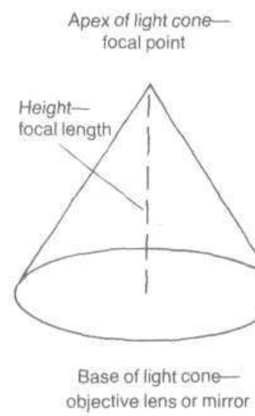


Figure 2
REFLECTOR TELESCOPES—NEWTONIAN AND CATADIOPTRIC
The reflector uses two mirrors, the objective and the secondary. The objective mirror is concave; it focuses the light to a cone. In the Newtonian reflector (a), a flat secondary mirror, turned at 45 degrees to the axis of the cone, diverts the light to one side of the telescope where the eyepiece magnifies the image.

In the ingenious reflector telescope invented by N. Cassegrain (b), called a catadioptric, the objective also creates a light cone. Here, however, the secondary mirror is convex. This convex mirror directs the light back down toward the objective where it passes through a small hole in the objective mirror to the eyepiece.



reflector telescope's tube is open, permitting disturbing air currents, dirt, and dust to enter.

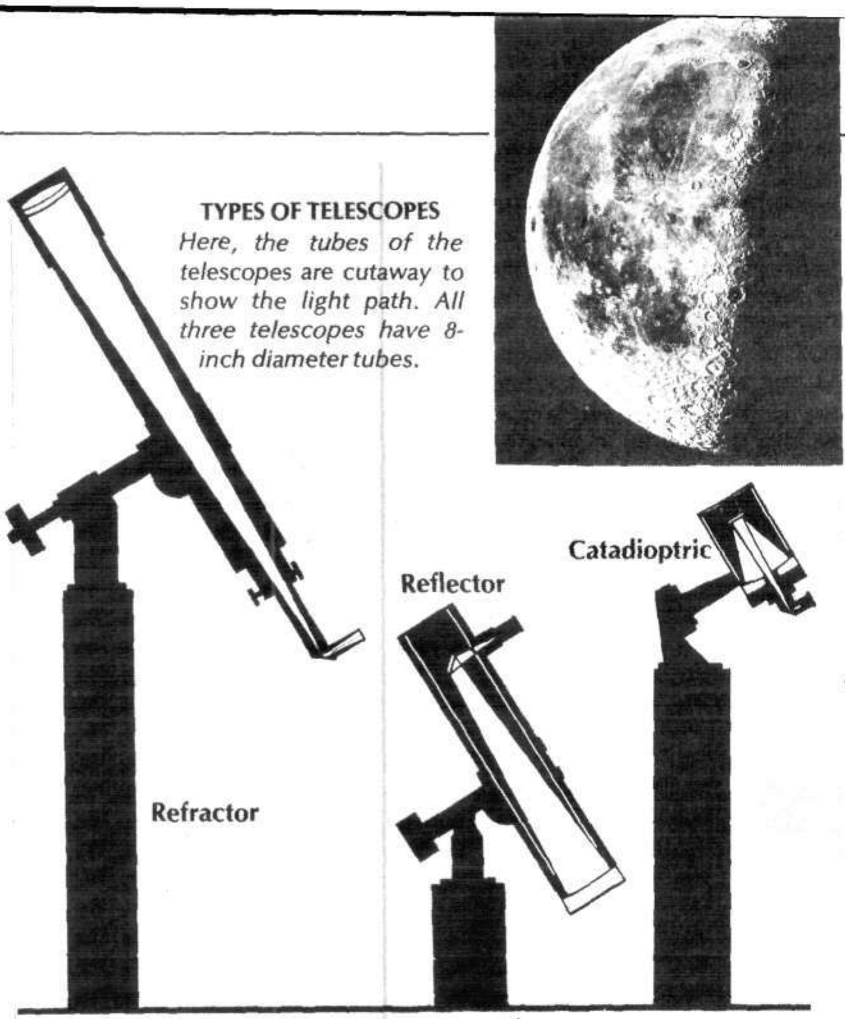
Refractor Telescopes

The *refractor* telescope was the type used by Galileo, and was the first to be used in a systematic study of the heavens. This instrument also works by creating a cone of light, the base of which is at the first lens. This lens bends the light toward the apex of the cone, where the eyepiece of the telescope is located (Figure 1).

The optical principle of the refractor is that the direction of light can be changed when it passes through a transparent material such as glass. The refracting lens, called the *objective*, is shaped in such a way that all the light entering it is bent toward a focal point. The eyepiece of the telescope, which is itself a series of small refracting lenses, is located near the focal point. The eyepiece magnifies the image and projects it out to the eye.

The bending property of refracting lenses carries with it an important drawback. The white light that is generated on the surface of a star (or reflected to us from the Moon and planets) is actually composed of a range of wavelengths, from the ultraviolet to the infrared. Each of these wavelengths is bent slightly differently by the lens, with the result that the light exits the lens separated into a rainbow of colors. This prismatic effect, called *chromatic aberration*, can destroy the clear image of a star. Fortunately, chromatic aberration can be corrected by adding a second lens composed of a slightly different material. This second lens recombines the separate colors into white light.

A more serious drawback to the refractor is the expense of grinding



TYPES OF TELESCOPES
Here, the tubes of the telescopes are cutaway to show the light path. All three telescopes have 8-inch diameter tubes.

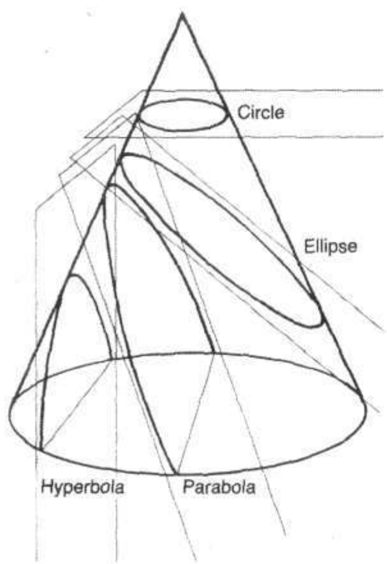


Figure 3
THE LIGHT CONE AND CONIC SECTIONS

All telescopes use the geometry of the cone to focus light into a bright image. At the base of the cone is the objective, which may be either a mirror or a lens. The apex of the cone is the focal point.

Newtonian reflectors use a flat secondary mirror to intersect the cone near the apex. The outline of the secondary mirror is an ellipse, which is one of the four conic sections created when you slice a cone. The objective mirror of the Newtonian is in the shape of another conic section, the parabola, which has the unique property of passing all reflected light rays through a single focus (see Figure 4).

You can create ellipses and parabolas by slicing a cone made out of clay (or a cone-shaped carrot). If you hold the knife (or plane) parallel to the base of the cone, you will slice a circle. If you tilt the knife from this parallel position you will slice an ellipse. There are many different shaped ellipses possible, until you tilt the knife so that it is parallel to one of the sides of the cone. When the knife is parallel to a side of the cone, you will slice a parabola. The fourth conic section, the hyperbola, results from holding the knife parallel to the axis of the cone.

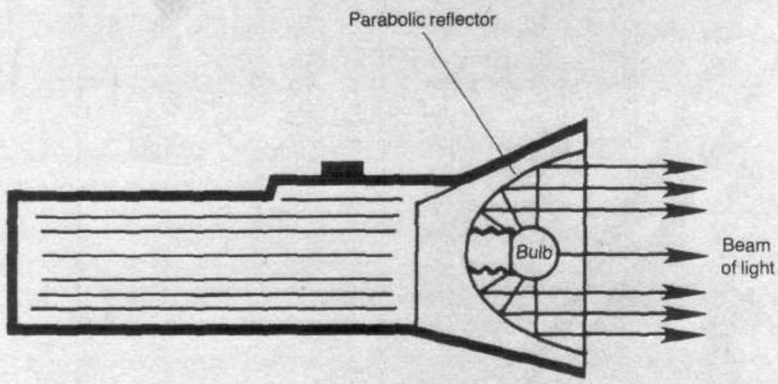


Figure 4
THE PARABOLIC PRINCIPLE OF A FLASHLIGHT OR HEADLIGHT
The flashlight or headlight uses the same principle as the reflecting telescope, but in reverse. Instead of gathering light to a focal point where the image is then viewed, the flashlight or auto headlight places a bulb at the focus, surrounded by reflecting material in the shape of a parabola. All the light rays from the bulb that hit the parabolic reflector are then reflected back out into a beam of light.

the required highly accurate lenses. The major advantage of the refractor telescope is that it has no obstruction in the light path, such as that of the secondary mirror in the reflector, which can reduce the contrast between the black sky and the object being viewed. As a result, the image quality is extremely sharp and clear.

The Catadioptric Telescope

The *catadioptric* is the most compact and portable of all telescopes. This clever design, invented by N. Cassegrain in the 1600s, permits the telescope to be short yet have the advantages of the longer telescopes.

The catadioptric works like a reflector telescope, with the following addition: When the light reaches the secondary, flat mirror, it does not reflect out to the side of the telescope. Instead, the light bounces back toward the primary mirror. There, a small hole in the center of the primary mirror allows the light to pass through the mirror, out to the eyepiece (Figure 2b).

The image on the catadioptric telescope, however, is not as clear and crisp as a reflector telescope of the same diameter, because the catadioptric telescope has more reflecting surfaces.

The Telescope's Power

Magnification is not the only thing that counts in a telescope. Its power also depends on the telescope's light-gathering capability and its resolution or image quality. A telescope should not develop any one of these properties at the expense of the others. For example, a small refractor telescope may be capable of high powers of magnification. But if the diameter of the objective (primary mirror) is small, light interference patterns will blur the image and make the magnification useless.

The light-gathering power of the telescope depends on the shape of the light cone, which is called the *focal length*. For a given base, the cone may be long and skinny (long focal length) or it may be short and fat (short focal length), as shown in

Figure 5
FOCAL LENGTH, MAGNIFICATION, AND BRIGHTNESS
The shape of the light cone is determined by the width of its base and the height of its apex (focal point). If the diameter of the base is kept constant, as shown, the shape of the light cone changes as the height of the cone is lengthened or shortened. A short cone has a short focal length and vice versa.

A short focal length light cone views a larger segment of the sky and therefore has less magnification, but since more light enters from the wide view, the image is brighter. A long focal length light cone views a narrower portion of the sky, thus giving greater magnification, but less brightness of the image.

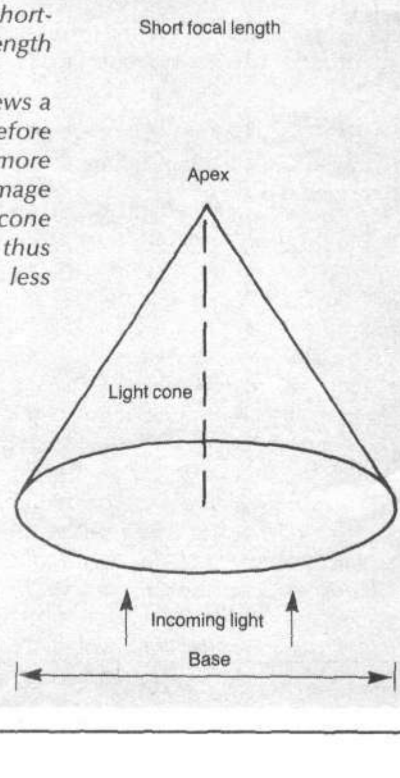
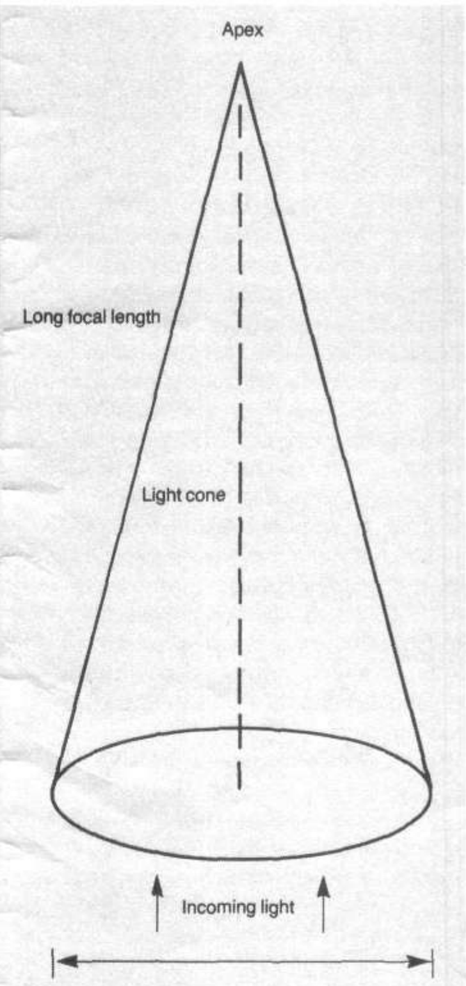


Figure 5. If you trace the light path of an instrument with a short focal length, you will see that it can encompass a wider field of view in the sky. And since the field of view is wider, more light enters the telescope, making for brighter images.

This is important for amateur astronomers in seeing more distant objects more clearly. The problem with short focal length optics, however, is the difficulty of shaping the lens or mirror so that it can sharply bend the light rays without distorting the image. Long focal length optics deliver higher quality images but give narrower fields of view and thus less light.

The ideal telescope is one that for a given diameter of the primary mirror or lens, combines a relatively wide field of view with lack of distortion and a set of eyepieces that give a range of magnifications.



Candidates

Continued from page 57

meantime however, I believe our nation should intensify its efforts to increase its energy efficiency.

"I do not see nuclear energy as feasible at this time. Until we can dispose of nuclear wastes more predictably, more safely, we should not move ahead in this direction."

Question 2: What do you see as the optimal war-avoidance policy?

GARY HART

"The first test of security for America and its allies, must be to freeze and then reverse the nuclear arms race. I see no need, for example, for systems such as the B-1 bomber or the MX missile, which are expensive and strategically obsolete and, in the case of the MX, essentially destabilizing to the strategic balance.

"I have prepared an alternative defense budget stressing military reform. I believe that a modern bomber employing advanced technology could be an effective, stabilizing element of our strategic deterrent."

Hart describes space-based weaponry as "a cruel hoax, because technically there is no basis for believing a completely effective nuclear defense system can be built. . . . Even though it will not work, we still might believe that it did and would act accordingly with surprising but terrible consequences."

JESSE JACKSON

"Modernization of C3I [command, control, and communications] systems can be double-edged swords. While we must guarantee the reliability of warning systems, we must not develop C3I systems that are designed to improve our ability to fight a nuclear war. Systems to improve target acquisition, retargeting, and strategic communications in a postattack environment for example, can be construed as improving our ability to fight and win a nuclear war. Though this adds, in some sense, to deterrence . . . it increases our propensity to fight more than it decreases the Soviets' propensity to attack . . . . The only way to avoid these dangers is to move aggressively to halt both sides' development of such systems, as we have a technological lead in most of these areas. . . .

"I oppose President Reagan's efforts, . . . to carry on the arms race in outer space. I would end the development of antisatellite technologies and all ballistic missile defense systems. Creating the illusion of invulnerability only increases our vulnerability. . . . Our safest bet overall is to restrain to the minimum necessary development of new and better weapons, conventional as well as nuclear."

LYNDON H. LaROUCHE, JR.

"The doctrines of Nuclear Deterrence and Flexible Response have brought us to the brink of total thermonuclear war. We must rebuild our defense capabilities and doctrines around the pivot of a $200 billion, five-year program to deploy a first-generation, layered Ballistic Missile Strategic Defense (BMSD).

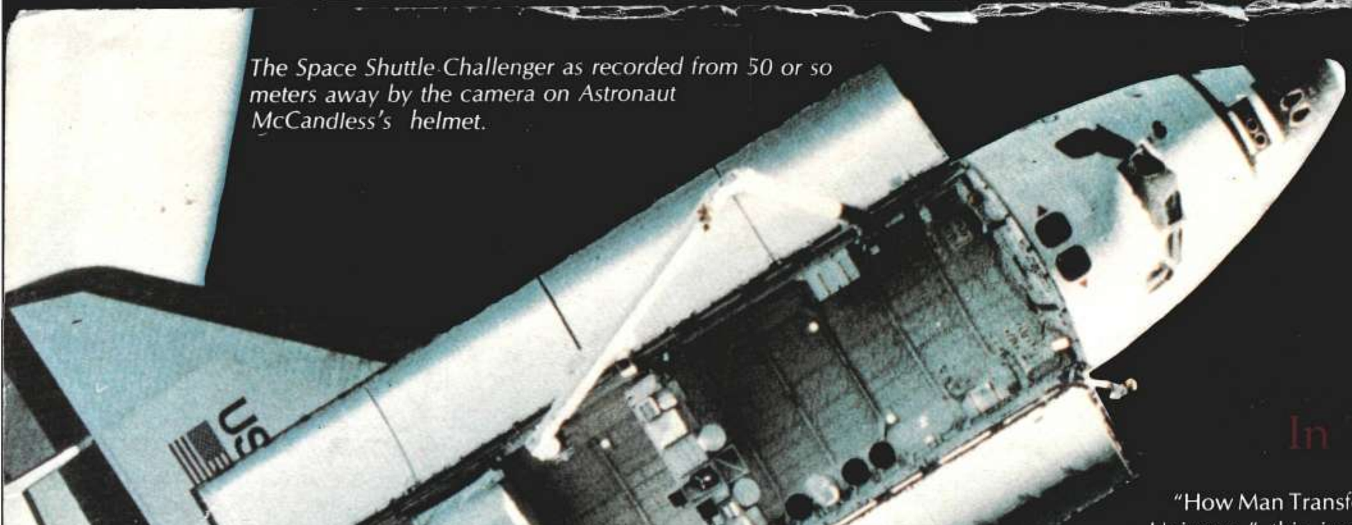
"Both superpowers must agree on such a shift away from the present Soviet escalation of the thermonuclear missile race."

WALTER MONDALE

"I've no illusions about the Soviet threat, yet our two nations must open up a dialogue and pursue arms control. In addition, I would affirm the doctrine of deterrence and the crucial consensus for sustainable real defense growth. That growth begins with a modernized strategic triad: I oppose the MX missile as destabilizing, and the B-1 Bomber as unneeded. Subject to a mutual and verifiable arms control treaty including a nuclear freeze, I support the Midgetman, cruise missiles, Trident submarines, and accelerated B-5 submarine missile program, Stealth bombers, improved Minuteman, and enhanced NATO conventional capacity.

"We must be strong but we must also seek to assert the strength of our values, not just our weapons. For this reason, I advocate an American foreign and defense policy based on human rights as well as military preparedness."

A Mondale representative said the candidate "opposes" a beam weapon defense system.



NASA

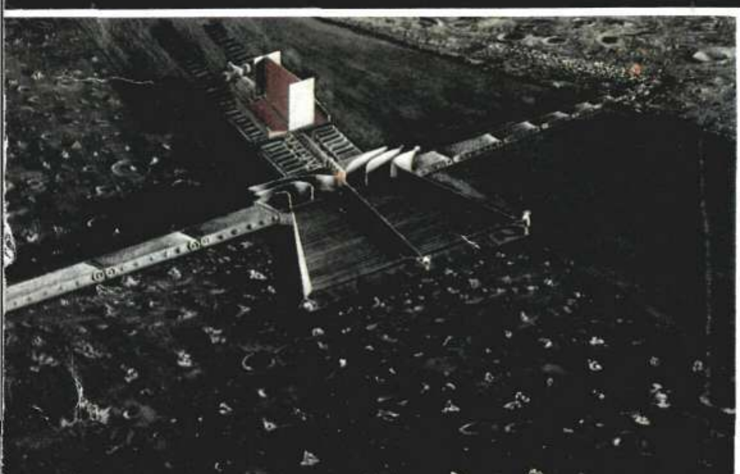
The Space Shuttle Challenger as recorded from 50 or so meters away by the camera on Astronaut McCandless's helmet.

In This Issue

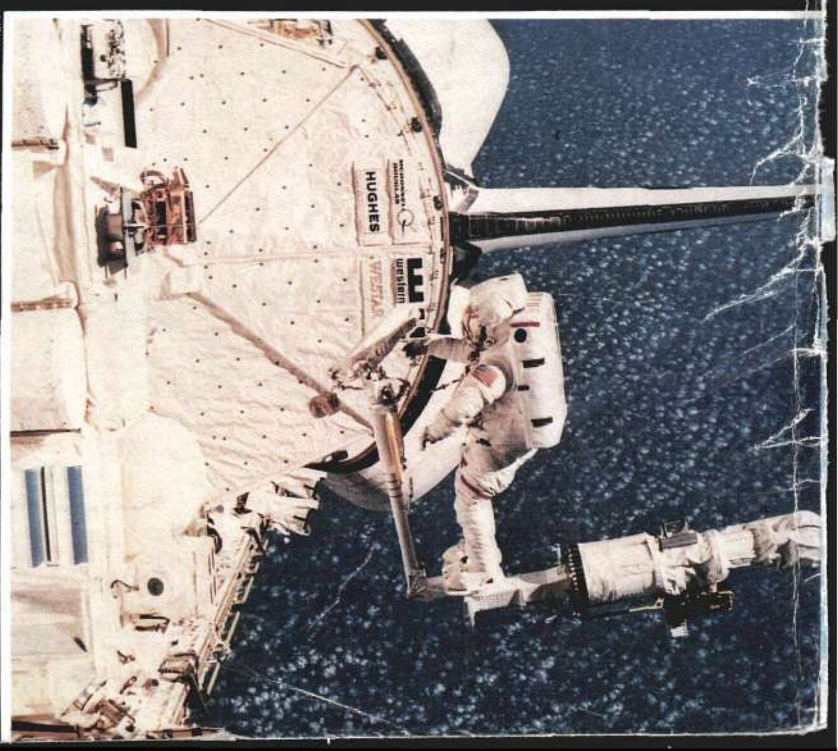
"How Man Transforms the Laws of the Universe," this issue's cover story, is splendidly illustrated by the NASA photograph of Astronaut Bruce McCandless II. McCandless is walking in space independent of the Space Shuttle Challenger. There were many who doubted that man would ever make this walk in space. Every age has had its cultural pessimists, including prominent scientists, who defend the laws of the Universe as fixed, deny the possibility of continuing development and growth, and proclaim the undesirability of progress. As Dr. Jonathan Tennenbaum demonstrates in the cover story, the Universe is negentropic—a process of creation where every momentary state of creation is limited in its perfection only by the lack of what is yet to be created. Tennenbaum reviews the 2,000-year-old Platonic tradition that has centered on this negentropic view of man and debunks the opposition, particularly the more recent promoters of irrationalism.

Our second feature is by renowned space scientist Krafft A. Ehricke, who continues the theme of perfectibility of the Universe, presenting an exciting case study of how man can transform the totally undeveloped Moon into a thriving Selenopolis. Ehricke emphasizes that developing the Moon depends on partnership with a growing Earth economy. Appropriately, he has titled his major work on the subject that awaits publication: "The Extraterrestrial Imperative—From Closed to Open World."

A third feature, "Antimissile Defense Systems for the 1980s" by Charles B. Stevens, again raises the question of doing what the skeptics pronounce as impossible: developing a defensive weapons system that will make nuclear missiles obsolete.



K.A. Ehricke



NASA

Above: The nuclear-powered sweeper, conceived of and painted here by Krafft A. Ehricke, prepares a runway for the lunar slide lander, a vehicle designed to touch down at extremely high velocities, transferring its momentum to the lunar dust ocean.

Right: Astronaut McCandless in a mobile work station attached to the remote manipulator arm, experimenting with the "cherry-picker" method for repairs in space.