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September-October 1985

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Features

20 The Coming Breakthroughs in Biophysics

Jonathan Tennenbaum

Research breakthroughs in the frontier areas of biology as well as beam defense require developing a new physics based on force-free, least action principles—and tossing out the theory of thermodynamic and statistical equilibrium.

27 Insects and the Battle of the Beams

Philip S. Callahan

From the enemy U-boats of World War II to the enemy insects attacking man and crops today, Philip Callahan tells the fascinating tale of how an understanding of electromagnetic radiation can lead one to victory.

38 The Soviet 'Star Wars' Program: Full Speed Ahead Since the 1960s

Criton Zoakos

While the Soviets have mobilized all their international assets in the "peace movement" to stop the U.S. Strategic Defense Initiative, they are racing ahead with their own research and deployment of directed energy beam weapons.

News

SPECIAL REPORT

- 10 Petra Kelly: Profile of the Green Party Chairman

NUCLEAR REPORT

- 13 The Argentine Plan to Mass-Produce Small Nuclear Reactors

FUSION REPORT

- 15 Reversed Field Pinch Advances to Next Step
16 Multi-Beam Heavy Ion Accelerator Moves to Forefront in Fusion
18 High Energy Plasma Accelerator Proposed
19 Livermore Gets Go-Ahead for Laser Isotope Separation Plant

THE YOUNG SCIENTIST

- 44 Why the Credit for Halley's Comet Belongs to John Flamsteed
48 Halley's Comet: When and Where to See It
50 What the Comet Probes Are Looking for
51 Equipment for the Amateur Astronomer

WASHINGTON

- 52 SDI Status Report: The Tests the Soviets and Friends
Want to Stop at Geneva
54 Congress Watch: New 'American System' Poll Rates Congress

BEAM TECHNOLOGY REPORT

- 56 An SDI Spinoff That Can Help Feed the World

FEF CONFERENCE REPORT

- 59 Space Pioneer Krafft Ehrlicke Honored at Conference on SDI

Departments

- 2 EDITORIAL
3 LETTERS

- 6 VIEWPOINT
8 NEWS BRIEFS

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On the cover: A tent caterpillar (*Malacosma americana*) feeding on Japonica. Photo courtesy of Philip S. Callahan; cover design by Virginia Baier.

The Moon-Mars Mission Assignment

We can be confident that during the next 50 years all scientific and technological progress will be shaped primarily by the interrelationship among the three frontier areas of scientific research: controlled thermonuclear fusion, coherently directed electromagnetic impulses, and optical biophysics. There will be important advances in other scientific and technological areas, but it is these which will be determining.

The implications of these frontier areas of science are shown most immediately, most clearly, and most exhaustively by examining the role that they play in interplanetary colonization. Consider the question of space flight. Fusion-powered spaceships will be necessary if we are to colonize Mars, and such fusion propulsion is highly desirable in its own right. To maintain a space colony we will need the most advanced technology, including fusion power, laser machining, and advanced biotechnology.

Since this is the case, we propose a mission to begin the industrialization of the Moon within a decade and the colonization of Mars by the year 2010. Such a mission orientation will subsume all of the goals that are otherwise appropriate today as guides to science policy, not least of which is the development and deployment of President Reagan's Strategic Defense Initiative on a crash basis.

Today, we can foresee the clear possibility that colonies totaling millions of persons will exist on Mars by the middle of the coming century. With sufficient density of energy per capita, with lasers and similar devices as tools, and with aid of optical biophysics, millions of colonists will live, work, and produce trees and foodstuffs in the cities and greenhouses of Mars. Once such technologies are developed for Mars, the colonization of the Sahara and Gobi deserts on Earth then become relative child's play.

Scientific experiments require appropriate materials and instruments. If we are to have the sort of crash program implied by the Moon-Mars project, then industrial firms will have to assign some portion of their research-and-development capabilities to pilot projects to develop the necessary new species of materials and instruments. We will need to develop lines of production of necessary components, even before the final stage of the assembled object is clearly in mind. In other words, we will be developing new capabilities.

Such a private initiative in support of the intermediate phase of the Moon-Mars mission assignment will in and of itself inevitably produce an array of by-products readily suited to immediate large-scale production within the economy.

For example, we know that the next general advance in industrial technology, for the Moon-Mars project and for production generally, will increase the energy density of

production at least fourfold, straining our ability to supply materials like steel and thus requiring new qualities of ceramics that can begin to supplement and replace steel.

Nuclear Power a Prerequisite

Then there is the question of energy and production of electrical power. There is no way to increase productivity generally without the proliferation of nuclear energy plants. The most important limiting factor in efforts to increase productivity is the energy density of production, as measured in both energy density per capita and energy density per unit area. Since we cannot reach the level of technology needed to launch a thermonuclear fusion economy without large-scale increases in average energy density of production, and since no such expansion could be accomplished without the proliferation, first, of nuclear energy, the human race is doomed to starve on the scrapheap of "postindustrial society" unless the present trend to shut down nuclear power plants is rapidly reversed.

Another by-product of the project would be the introduction of a hydrogen-based fuel as a source of power for automobiles and trucks. This would give us a nonpolluting fuel, and at the same time preserve our petrochemical stock for future industrial use.

Most challenging are the advances required to solve the problem of creating a biosphere for man on Mars. Obviously, the breakthroughs in this area would have incalculable immediate benefits for medical science and for increasing the food supply here on Earth.

Reaching for the Stars

It is a profoundly mistaken, but unfortunately popular view today, to estimate that scientific work is essentially "logical," and therefore dispassionate. In other words, scientific work is judged to be "academic," in the worst sense of the term. Yet, any intelligent and reflective person must recall as the most joyful moments of his or her life as a student in primary and secondary schools those moments of discovery in which the act of discovery was associated with an emotion at once impassioned and sublime. The point is to shift man's sense of identity above hedonistic, Hobbesian squabbling over the mud of our home planet, and to prompt mankind to locate its destiny in work in the universe more generally.

Let us henceforth define scientific progress as an ordered succession of ever-more-ambitious grand-scale mission assignments. Let "science" be defined in such a task-oriented way during each generation. Let "science" signify both the current grand-scale crash program Moon-Mars project and the work of defining the successor to this mission assignment.

Letters



'Ignorance Is Bliss' Vs. Hitler

To the Editor:

Ignorance is bliss and you are obviously very ignorant on a subject you have the audacity to write about. I'm referring to the report in the Jan.-Feb. 1985 *Fusion* ("Hitler's Euthanasia Policy: Today's Nazis Want to Make It Legal," by Linda Everett, p. 13).

I can tell you have never been personally confronted with the situation. Well I have. I lost my father in March 1985 to cancer. Toward the end when he woke in the morning he said, "Damn, I'm here for another day." My father probably would have taken his own life if he was capable but he wasn't. He was completely paralyzed. He was developing bed sores and pneumonia. If you were in that condition along with unbearable pain do you really think you would choose to exist?

Nancy L. Gavin
Phila., Penna.

The Editor Replies

The point is to look beyond your own personal situation to what is happening to a whole nation. America is being conditioned to kill its sick and elderly as a cost-cutting measure, the same way Hitler's Germany began its extermination of "useless eaters." This murder has nothing to do with "compassion" or anyone's "right to die." It is planned by the same advocates of postindustrial society who are shutting down America's heavy industry, its nuclear plants, and its advanced science capability, and who want to return this country to primitive living standards.

Twenty years ago, there would have been no debate about trying and sentencing the likes of Colorado Governor Richard Lamm for advocating euthanasia. Think back. During World War II, when a child ruptured his appendix and peritonitis took over, some families put their houses up for sale just to get

enough expensive antibiotics to keep their six-year-old alive (service men and women had priority over civilians for antibiotics).

After the war, the nation launched one of the greatest periods of cultural optimism and growth this country has known. Today, with even greater medical breakthroughs in sight, we have the potential to bring the entire world to a level where every human being can develop his or her capabilities to the fullest—or we can follow the murderous course of Nazi economics. Which side will you be on?

An Airlift for Africa

To the Editor:

Inspired by Col. Molloy Vaughn's paper "Proposed Guidelines for Transporting 25 Million Tons of Food into Africa" [May-June 1985, p. 39], I want to outline here how to solve the biggest problem for Africa right now, namely, distribution of food aid.

Where there are hardly any railways or streets, transport must be done by airplane.

The great precedent is the Berlin airlift. On June 24, 1948, the Soviets enforced a total blockade of West Berlin, a city that had some 2 million inhabitants at that time with a rather tough climate. Not only food was needed, but also clothing and heating fuels. On June 26, 1948, Gen. Clay ordered 225 tons to be flown in daily. But that was only a fraction of what was needed. After three days, tonnage flown in daily reached 384 tons. The Allies also loaded commercial planes with food and coal.

Although totally unprepared for the airlift operation, the Allies managed in a few weeks to obtain 227 transport planes bringing in 1,500 tons per day. In Berlin itself, two new landing tracks were built; 17,000 Berlin citizens volunteered to do the construction job. Since concrete was much too heavy to be flown in, they used rubble.

The Allies—mainly the Americans—drafted the major part of their transport planes into West Germany. That made it possible on one record day in April 1949 to fly 13,000 tons of goods into Berlin on one single day! This required 3,946 starts and landings in Berlin—one flight every 22 seconds. The Berlin airlift ensured that the Berlin

population was not harmed by the Soviet blockade.

The main departure airport was Frankfurt, and the average flight distance was 500 km. The types of planes deployed for the airlift were primarily DC-3s with a 5-ton loading capacity and DC-4s with a 10-ton capacity. Average flight velocity was 270 km per hour.

Thus was it proven that a population of millions of people can be supplied entirely from the air.

The Case for Africa

What was possible in the case of Berlin is also possible for Africa. However, the conditions are much different. In particular, we are dealing with a vast area geographically. But, if one takes a closer look at the map of Africa, the problem no longer appears insurmountable: No place anywhere in Africa is more than 2,500 km distant from the shore. And, in contrast to 1948, today's strategic transporters have a reach of 5,000 km with full loading (for example, a Galaxy with 92 tons). This means that one can reach by plane all points in the continent from the shore without refueling.

For such long-distance deployment, the Western air forces now have about 350 planes available, which each can load between 40 and 92 tons. This provides a total transport capability of 17,000 tons. If commercial planes were also deployed, they would add to that capacity.

Two flights per day might even be possible, since one flight over a distance of 5,000 km takes about 6 to 10 hours. And such rescue flights might be eventually supported by Radar (AWACS) in order to make night flights possible. Given two flights per day, and allowing a certain ratio of fall-outs (repairs, etc.), a daily total of 25,000 tons of transported goods per day should be feasible. And this concerns only those areas very distant from the periphery.

The hunger zones closer to the shore, like Somalia, Ethiopia, and Sudan, can be supplied by short-distance transport planes, of which NATO has about 600, with an added transport capacity of 10,000 tons. The flight times for these planes is much shorter (2,000 km in about 3 hours), so three starts per day are feasible. After allowing for routine fall-outs, this equals an addi-

tional 20,000 tons per day in transport capacity. Therefore, conservatively estimated, it is quite possible to transport 40,000 to 45,000 tons of goods from the shore to the hunger zones in the interior of Africa.

Four Port Cities Mapped Out

To get goods to ports and airports on the shore has not been a problem so far, once the aid has been granted. The big problem has always proved to be how to distribute these goods before they rot in the ports.

Even weak port structures could be used, if special *Docklandungsschiffe* are used; that is, ships that bring their docks with them.

I chose four port cities as departure places for the strategic transport planes: Algiers, Algeria; Alexandria, Egypt; Dar es Salam, Tanzania; and Duala, Cameroon. From these four port cities, no place on the continent is more distant than 2,500 km. . . . For the smaller planes, like the Transall and C130, I chose Djoubouti and Port Sudan. Of course, the planes could also depart from a large number of other

suitable cities. . . .

There is no doubt that such an airlift would work, once the political will is there to deploy it. The West German and British Air Force planes deployed recently in Ethiopia confirm that it can work.

Only a program of this scale can stop the death by starvation of 30 to 50 million human beings, and bridge the gap until other programs to rebuild the agriculture and economic infrastructure would go into effect. . . .

Andreas Ranke
Munich

The writer is a grandson of Gustav Heinemann, former president of the Federal Republic of Germany.

Exposing Edison's Slanderers

To the Editor:

Recently I was sent a copy of the July-August 1983 issue of *Fusion* by a friend who thought I might be interested in the article on Edison by Michael Tobin ["Thomas Alva Edison: The Scientist

Who Created the Electric Light and Power Industry," p. 16].

As I have done some research and a little writing about Edison, particularly on the phonograph, and also a monograph on Charles Batchelor, Edison's chief partner, I know of the difficulties Edison had in financing his work, and which also involved his chief associates adversely. However, I never expected an eminent engineer from the post-Edison period in the lighting industry to tell this important story so effectively!

. . . Much the same treatment was meted out to Edison by the research organizations which emulated Edison's Menlo Park and West Orange laboratories in everything but Edison's policy of permitting associates not only to thoughtfully contribute, but in many cases also to apply for patents without assigning them to Edison or his companies.

The misrepresentation in many technical papers in the era of acoustical recording concerning the achievements of Edison are many, and his be-

"It is essential that articles in the journal are of such a nature that they bring about the birth of new concepts. That would be very unlikely to occur with the referee system of judging papers for acceptance that is now in use in most scientific journals. The referees always base their reviews on what is known in physics, biology, or biophysics as it stands today; but often there is a greater understanding, new interpretations, new explanations for scientific phenomena that should become known and discussed. It is the IJFE editorial policy to give authors with a new concept a chance to defend their ideas and theses before acceptance for publication."

—Dr. Robert J. Moon
Editor-in-Chief

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lated entrance into the disc competition was eventually responsible for his most painful decision—to close down all phonograph and record production in the late fall of 1929.

Under separate cover I am sending a copy of the Batchelor monograph. . . . Chapter VII tells of the relationships of Edison with various partners, which corresponds well with Michael Tobin's exposé of the stifling controls imposed on Edison's lighting and power industry. Michael Tobin's knowledge of the vicious cabal of recent anti-Edison writers deserves further exposure such as you have recorded it.

Walter Welch
Curator
Syracuse University Libraries
Thomas Alva Edison Re-Recording
Laboratory
Syracuse, N.Y.

Shock Waves and Phase Changes

To the Editor:

The March-April 1985 *Fusion* is highly interesting for its display of different aspects of geometry in its varied articles.

Specifically I am writing to you about shock waves and phase changes that occur in different phenomena. When a system has a shock wave and then goes into a phase change, is this situation in mathematics and physics an exhibition of a pseudosphere geometry that has a relationship to angles less than 180° for a triangle with the lines of the shock wave behaving like two inverted bell horns? . . .

Jerry O'Neill
Brooklyn, N. Y.

The Editor Replies

We have developed a much simpler model for economic processes, which appeared in the July-August issue in a series of articles on "The Economics of Growth."

Major phase changes in technology appear as a shift from one hyperbolic cone to another; for example, in this century, the transformation of the economy with the adoption of electricity as the dominant form of energy use. Each such horn may be mapped upon a sphere, by a stereographic mapping or some similar device, to

represent an ordered series of singularities. These singularities will appear on the sphere as loops of increasing or decreasing size.

The rate of change of the density of singularities will represent the rate of negentropy.

In answer to your particular question, a "hyperbolic" mapping might have interesting applications, but you should be wary of attempts to represent it as an axiomatic equivalent to Euclidean geometry. The essential element in developing a geometric model is the ability to map increases in the rate of transformation.

On the Concepts of Energy and Work

To the Editor:

I have been following with interest the reconceptualization of physics as discussed by Lyndon LaRouche and elaborated by Jonathan Tennenbaum. . . .

The concepts of energy and work as helical and spiral functions on the cylinder and cone present me with some difficulties, which are probably common to those of us whose physics education stopped in high school.

(1) If we are to understand energy and work as geometric entities rather than scalar quantities, what role remains for numerical measurement of these concepts? Do we continue to use units such as "foot-pounds" or "kilowatt hours" and if so what meaning do we ascribe to them? Do "energy" and "work" continue to be numerically expressed in identical units?

(2) What is the physical meaning of the helix and the conical spiral? Do we understand these as representing the characteristic shape of energy and work processes in literal physical space or are they to be referred to a phase space? If the latter, what quantities are we to understand as forming the dimensional axes of such a space?

I have an additional question which bears only tangentially on the above. I have noticed in the course of my own reading that the concept of "temperature" appears to be remarkably slippery. It appears to refer to the central tendency of a *distribution* of energies (radiation frequencies) with the precise shape of such a distribution vary-

ing in a fixed way with the "temperature. . . ."

Steve Crocker
East Lansing, Mich.

The Editor Replies

The key, related, concepts in measuring energy are energy flux density—the flow of energy through an area of work surface, energy per capita (with regard to the whole population, and to operatives in industry), and net work. Net work represents the surplus available for economic growth, over and above the maintenance of the economy.

We must take all of the above and the geometric organization of the work flow into account as one unified concept. The more we understand economics, the better we are able to meaningfully translate disguised statistical concepts such as temperature, into the real form in which work is accomplished—by coherent electromagnetic radiation. In the mean time, concepts such as kilowatt hours are useful, if expressed in terms of ratios, as above.

The Geometry of Life

To the Editor:

. . . You say in your article ["The Geometry of Life" by Ned Rosinsky, Sept.-Oct. 1984, p. 39] that "A 'frequency' is usually thought of as some sort of back-and-forth oscillation motion, but in fact such motion is actually always rotational in character."

. . . In regard to the logarithmic spiral on a cone as a work function: Is this concept your own particular view? My question is whether this is purely theoretical speculation.

Eleanor MacGregor
Livermore, Calif.

The Editor Replies

The ideas we are elaborating were first advanced in their modern form by Leonardo da Vinci. He is usually treated as a hapless dreamer when it comes to science, but this is just typical of the frauds that are circulated in the name of "history of science." In fact, Leonardo not only laid out the program for the industrial revolution by his studies of automation, but also initiated the serious study of hydrodynamics.

The problem you raise about the
Continued on page 7

Japan is the first and only country that has experienced the nuclear bomb: Hiroshima and Nagasaki, in 1945, the end of World War II. Now the Japanese Constitution stipulates that our country should be neutral and should not have any armaments. Therefore, our people have a very strong reaction to armaments, sometimes a kind of hysterical reaction, especially toward nuclear weapons.

We cannot develop any nuclear weapons. But our country, of course, is an engineering-developed country now, so we have the potential capability of constructing nuclear weapons and also beam defenses. But when we do that kind of thing, there are very strong reactions not only from our people, but also from neighboring Asian countries, who recall the bad image of World War II.

The SDI Is Different

The Strategic Defense Initiative (SDI) is different from other kinds of military weapon developments, because the SDI can lead to the abolition of nuclear weapons, which is our country's goal. Also, it is only a defensive weapon. Therefore, my personal opinion is that it is very suitable for Japan to develop the SDI. It is not offensive, and there should be no opposition from our neighboring countries. I think it should be a new type of peace movement, not by demonstrations with placards, but with the development of new technology, new high technology.

Let me summarize the response of the Japanese people to the SDI. In March 1983, President Reagan's announcement was made, but there was

Dr. Kawashima is a professor of physics at the Tokyo Institute of Space and Aeronautical Science and a project participant in the electron beam experiment with the U.S. Space Shuttle, studying the interaction of the beam with an ionospheric plasma. This Viewpoint is adapted from his presentation at the June 16-17 conference in memory of space scientist Krafft A. Ehrlicke, sponsored by the FEF and the Schiller Institute.

Japan's Attitude Toward the SDI



by Dr. Nobuki Kawashima

no reaction at all. Then, the Fusion Energy Foundation published its book *Beam Defense* in the fall of 1983. I found that book in the airport, and I found it very interesting, so I wanted to translate it into Japanese. Unfortunately, Mr. Kiyoshi Yazawa already had the rights of translation. I only joined the translation with some technical advice, and the book was published in Japanese in June 1984. Still, at that time, the reaction of the Japanese was nothing.

The book did not sell well, and now it has disappeared from the bookstore shelves. Now, at the beginning of 1985, the reaction has started. Prime Minister Nakasone visited and talked with President Reagan, and at that time he said that he understood the importance of the SDI. Later on, from April to May, at the time of the Bonn summit, there was a very active debate on beam defense in Japan. Every day in the newspapers and on television, we could see and hear about the SDI.

The final response of the Japanese people is not yet known; it's not settled. The Liberal Democratic Party, which controls our cabinet, said that it can understand the SDI, but it still hasn't said that it will support or join the SDI. And the other parties, especially the Socialist Party and the Communist Party, as it is expected, will oppose it strongly. The party in the middle, and the Socialist Democratic Party, have not decided their attitude, but were a little negative.

I am not a politician; I am a scientist. So I cannot say much about the politi-

cal and economic response to the SDI. But at this moment, Prime Minister Nakasone has expressed five principles. First, the SDI should not claim one-sided superiority over Russia: There should be always a balance between the United States and Russia. Second, the SDI should be considered within the framework of an overall preventive force against nuclear war. Third, a drastic reduction of offensive missiles should be performed at the same time. Fourth, it should be within the framework of the ABM Treaty. And last, the SDI should be negotiated with Russia when it is actually stationed.

The Weapons Taboo

I must explain something about the background of the environment for scientists in Japan. It may not be easy for you to understand; it's a very peculiar situation. First, for scientists to talk at all about weapons or armaments, or even the *defense* of our country, is taboo. One example is the Japanese Physical Society, which corresponds to the American Institute of Physics. It has about 30,000 members, but no one can be a member who belongs to an organization related to defense.

More than that, no papers can be presented that are related to defense-supported research. Often in international conferences held in Japan, there are many contributions from the United States, and in an acknowledgment the author writes down that the research is supported from some Navy or Department of Defense source. Then the Japanese Physical Society requires the author to delete this. That kind of thing often happens.

Government and university researchers—I am one of them—cannot be supported by any defense grant, directly or officially.

However, I think we have a very strong scientific and engineering capability for the SDI, especially in thermonuclear fusion research. For example, in lasers, we have a very big potential in Osaka University, a glass laser fusion device, and also the carbon dioxide laser. The glass laser had been the largest in the world, until re-

cently, just this April or March, when the Nova at Lawrence Livermore National Laboratory started to work. But until that time, the Gekko XII laser fusion machine was the biggest.

We also have many laboratories doing particle beam fusion research. And although it's not directly related to the SDI, one of the world's biggest tokamaks, the JT-60, was completed this spring, and has started to work. It's competing with the TFTR at Princeton Plasma Physics Laboratory, and the JET in Culham, England. We are also constructing a very big accelerator—it's called Tristan—a 30 GeV beam accelerator.

In this sense, we have a very strong potential capability for the SDI. But we are not allowed *explicitly*, in the university or research institute, to say that we are going to do research related to the SDI. However, we need to find some "excuse." I will give you some examples.

Potential Research Areas

Electron beam experiments, electron beam propagation in the air: This is one of the important research areas in the SDI, but it has a very nice scientific purpose. Our Space Shuttle experiment emits an electron beam, and it goes into the atmosphere. However, when we emit an electron beam in the opposite way, then the electron beam travels along the magnetic lines of force and it comes back again, not at the same place, but a little displaced.

From this experiment, we can see how the magnetic field is, or how the electric field is, near Earth. We can study the magnetosphere. This is one of the major purposes of the Space Shuttle experiment. But when it is done using the Space Shuttle, it's very expensive. One Space Shuttle flight costs \$80 million. When we can do this experiment from the ground, then it's very cheap. The Space Shuttle can fly only once a week or once in 10 days. But if we can do the experiment from the ground, we can do stationary observation of space.

Another example is in kinetic energy weapons, or the electromagnetic rail

Continued on page 18

Letters

Continued from page 5

reality of rotational motion, when we appear to see merely an oscillation, can be answered simply, as Leonardo would have answered it. Leonardo drew sketches of vortices and the development of shock waves in fluid flow, in storms, and as they would appear in airplane flight. Clearly he could only "see" these flow lines with his mind's eye, but he understood the limits of his perceptive apparatus, and was never bounded by these limitations.

To us, space is "Euclidean," made up of straight lines and planes filled with objects. We are unable to perceive physical reality as it is, as a continual process of transformation acting upon itself. We can know the geometry of this process because we ourselves can be agents of this process of transforming the universe. To model such geometrically—that is, truly—demands that we violate the axiomatic frame of reference of Euclidean geometry. Not to do so, means to be trapped within the world of appearance.

Induction, Deduction, And Stale Positivism

To the Editor:

Your article in the May-June 1984 *Fusion* ["The Origins of the Universe" by Jonathan Tennenbaum, p. 19] was very interesting. However, you miss one crucial point. The laws of science are derived inductively, not deductively. Practically every generalization you have made in your article has been derived deductively. Deduction is a main principle used in mathematics, not in science.

This is a crucial point because induction validates quantum mechanics and the Heisenberg uncertainty principle. Plato was a great thinker. However, he never stumbled upon the philosophical foundation that makes science possible. For this reason, it is erroneous to apply Platonic principles to understand modern science.

... Overall, your article was a fresh approach to the stale positivism of a lot of science writers.

John Shobris
Indian Head Park, Ill.

The Editor Replies

The basis of all knowledge is neither

"deduction" nor "induction" nor some combination thereof. These are categories of logic. We know the universe only as we are able to purposefully transform it. We have an objective standard by which to measure the success of our actions. If we act to the good, then we have helped the universe to grow. When we hinder that growth, then we have sinned.

What is that measure? Simply the reality of our own existence, and the potential existence of our progeny and theirs. We can measure the tendency of the universe to transform itself negentropically, by man's capacity to increase the potential relative population density of his own species, man.

We Need a Renaissance In Science Education

To the Editor:

I believe that the article by Dr. Jonathan Tennenbaum, "A Mathematics Curriculum for Creating Citizens" [*Fusion*, March-April 1983, p. 26], does not begin to cover the myriad reasons that science education in this country is in such trouble. The answer also lies in the way we run our science organizations, the universities, R&D, and student science fairs.

Easily the most popular science fair for the junior high students, the Student Exposition on Energy Resources (SEER) is a perfect example of why scientists are taught not to make discoveries. In this science fair, which is sponsored by the National Energy Foundation, experiments are actively discouraged, with the emphasis placed on models. These models must be equipped with data, which are usually copied directly out of some book.

Furthermore, the science project itself is by no means of paramount importance in the SEER fair. The most important part of winning is attendance at the social events the National Energy Foundation runs and good relations with the college freshmen who actually decide who gets most of the prizes.

This process tends to weed out any actual young scientists and send the bootlickers on to college with special honors. . . .

In high school, very little changes. The few science fairs that refuse to

Continued on page 18



John Isaac UN Photo

Famine victims in Ethiopia in 1984: sentenced to die by the Malthusians.

News Briefs

UN OFFICIAL: UN AGENCIES CONTRIBUTING TO AFRICAN STARVATION

"We call ourselves civilized! We're the most barbaric group of people in the world," Eugene F. Whelan, the former head of the United Nations World Food Council, said about the starvation situation in Africa. In a Paris interview with the weekly *Executive Intelligence Review* June 14, just after Whelan completed his two-year UN post, he said: "I think the World Food Council should admit that it's failed, the same as most UN agencies have failed. The ones that are the oldest are the biggest failures. . . . When we see this terrible tragedy, it is difficult for me to understand, in 1985, how that could even be allowed to happen. We could turn the desert around if we really wanted to! . . . Look at the deserts of the southwestern United States . . . how they have made them like the Garden of Eden. . . . You could build a road or a railroad from Algeria down to Niger, and that area, so you'd have other ways of bringing food in, or, as they develop, to export their products out for trade.

Whelan, a former Canadian minister of agriculture, gave particular examples of how the UN agencies made the situation worse: "In Niger, when I was there, the president of Niger pointed out the infrastructure of his systems. . . . This man had a pretty good system of warehousing, and of making sure that in a case of tragedy he'd be able to take care of his people. But . . . the IMF said: 'You have too much grain on store. Get rid of it.' And he did, and now he's begging. . . . In Zimbabwe . . . the IMF or the World Bank, said, 'You're spending too much money on education.'"

How to reverse the situation? Whelan proposed: "The African economies have to be protected. . . . Half the debt could be canceled and a moratorium [put] on the other half, because we're economically stabbing them to death. They can't possibly make those payments and do the things that are necessary for themselves. . . . With no postharvest storage or processing, they waste a lot of food . . . no infrastructure for roads . . . a marketing system, or any of these things that we take for granted. All that has to be built, that's why it has to be a massive effort, not that piecemeal operation that we're involved in. . . ." In Europe, the European parliament passed a motion against killing baby seals. I haven't seen them pass one about killing babies in Africa, though in essence, that's what we're doing."

OUA CALLS FOR CRASH PROGRAM TO MAKE AFRICA SELF-SUFFICIENT

"Africa cannot let its children die of starvation, just to pay back its debts," Tanzanian President Julius Nyerere told the annual meeting of the Organization of Africa Unity in Addis Ababa, Ethiopia, July 18. The African heads of state endorsed a statement, the Addis Ababa Declaration, which has two goals: a five-year crash program to make Africa self-sufficient in food, and dialogue with the West to bring about economic recovery.

Nyerere pointed out that Africa's debt of approximately \$170 billion was increasing by 20 percent per year, and that interest payments alone amount to \$30 billion of the total \$170 billion. He stressed that the economic fight to overcome famine and recession was "more difficult than the political fight" to free Africa from colonialism.

'ENVIRONMENTAL AGENDA' DEMANDS POPULATION REDUCTION

"Excessive population growth" is a matter of "national security." This is the message 10 top U.S. environmentalist groups presented at a June 24 press conference in Washington, D.C., to publicize their new book, *An Environmental Agenda for the Future*. Among the Malthusian organizations celebrating the renewal of their campaign against science and growth were the National Wildlife Federation, the National Audubon Society, Friends of the Earth, and the Sierra Club. The book's major proposals are that the U.S. government should: "establish formal goals for the stabilization of the U.S. population at a level that will permit sustainable management of resources"; embark on a "soft energy" program, eliminating fossil fuel and nuclear power; stop giving federal funds to



Camerapix

Nyerere: Africa cannot let its children die to pay back the debt.

new domestic water projects and start implementing "user fees" for water use; take at least 30 million acres of cultivated farmland out of production and turn it into "forests or wildlife habitat"; and discourage lending to developing sector countries for any infrastructure projects.

TED TURNER INAUGURATES NEW 'ONE WORLD' TV ORGANIZATION

Cable television magnate Ted Turner, owner of the Cable News Network and considered by some to be a supporter of so-called conservative causes, has recently launched a project to produce global television programming that will push population control, environmentalism, and disarmament for the West. The project is called the "Better World Society," and its board includes such Malthusian enthusiasts as Jimmy Carter, Lester Brown of the Worldwatch Institute, Russell Peterson of the Audubon Society, and the Soviet Union's Georgii Arbatov.

TANAPURA PRESENTS KRA CANAL REPORT TO THAI PARLIAMENT

Pakdee Tanapura, representative of the Fusion Energy Foundation in Bangkok, was called by a special Thai parliamentary committee to testify on the feasibility of building a canal through the Kra Isthmus in Thailand. His comprehensive report to the committee covered the importance of the canal in the development of the Indian-Pacific ocean basins; the shipping pattern in the Malacca Straits and projected shipping traffic through the future Kra canal; the projected revenue from tolls; route selection, construction costs, and payment time; and the economic and social return for Thailand. The canal would create 3 to 5 million jobs, spurring the rapid industrial growth of Thailand, Tanapura said.

Tanapura also addressed 70 trade union leaders brought together by the Thai Trade Union Confederation, presenting the Kra Canal project as the keystone for an alternative to the World Bank and International Monetary Fund zero-growth austerity proposals.

FEF INTRODUCES PEDAGOGICAL SCIENCE MUSEUM TO YOUNG THAIS

An FEF pedagogical museum titled "There Are No Limits to Growth" was the highlight of a July science exhibit in Bangkok in commemoration of the 50th Anniversary of Dr. Thaeb, the founder of the science graduate program of Chulalongkorn University. The Bangkok FEF prepared displays on Plato and the origin of geometry, growth and geometric progressions, Leibniz and the principle of least action, Kepler and the harmony of the universe, fusion energy for the 21st century, and the Kra canal for Thailand's future. The museum drew crowds of children and teachers, and the FEF was invited to organize similar exhibits at high schools and technical institutes.

SWISS SHOULD JOIN THE U.S. SDI EFFORT

"The economic engagement of Switzerland in space is for her a vital question and a historical necessity," wrote Yvon Bordet, in the May-June issue of the regional *HEC Review*. He proposes that the Swiss join the U.S. Strategic Defense Initiative program on the economic and scientific level, since Switzerland is a neutral country. Bordet, a school teacher and an FEF member, has become recognized as a specialist on the SDI in Switzerland.

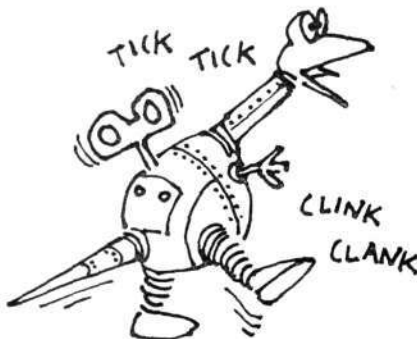
LOUSEWORT LAURELS TO CARL SAGAN

This month's Lousewort Laurels award goes to television scientist Carl Sagan for his campaign to stop man from going to Mars. There are "no scientific reasons" to have a manned mission to Mars, Sagan told a July 16 conference called "Steps to Mars." The same science can be done by "robots for one-tenth the cost of sending people." Sagan advocated a joint U.S.-Soviet manless project on Mars as an alternative to the Strategic Defense Initiative which, he said, would only "militarize space." Sagan was seconded on this point by the Soviet representatives at the conference, who said that the Mars mission is "only possible if space remains a peaceful environment."



Philip Ulanowsky

Tanapura: The Kra Canal project will spur the rapid industrialization of Thailand.



Petra Kelly: Profile of the Green Party Chairman

by Charlotte Vollrads

This profile of the chairman of the West German Green Party first appeared in the German newspaper Neue Solidaritaet June 10, 1982. Petra Kelly sued the newspaper for libel on 26 counts, but lost her case on 25 counts. The court upheld only one count, enjoining Neue Solidaritaet from calling Kelly a "NATO agent." Now Kelly is pursuing the same lawsuit in the United States against the English-language New Solidarity newspaper, protesting a headline that called her a "political whore." She brought suit in New York state, which has a law making it libel per se to question a woman's chastity. We are reprinting the original article, translated from the German.

* * *

The portrait of the Greens' chairman Petra Kelly, as issued with great fanfare in a cover story by the Hamburg magazine *Stern* in May, is, to put it mildly, a bad joke. One could almost be moved to tears, reading about how this little thing, only 5'3," spent 10 whole years in Brussels, eating nothing but bread and apples in order to finance her numerous trips for the Green cause—and this, even though her health was already unstable: she has "a little heart problem."

Her selfless exhaustion of her physical powers, in fact, arouses feelings of inferiority among those around her. And what is more, the poor creature sleeps at least twice a week on the sofa (or something worse) of some Green commune. This little thing with a doll's figure drags suitcases full of reports and the like across railroad platforms from one train to another, since, naturally, on principle she does not own

an automobile. When it is 11 PM and even the most diligent Greens at the Bonn headquarters give themselves a little break and go out to eat a pickled cutlet, then—according to *Stern*—"Petra Kelly just bites into a sour apple" . . . and gets right back to work!

Truly, she is an "angel of the troubled and burdened," and a "figure of unity for the resistance," and—here *Stern* lays it on even thicker—"she is a candle constantly burning at both ends, and always for others. Human beings as good as she are rare indeed."

All joking aside, on closer investigation of this apple-munching "angel of the burdened," we can discern outright un-Christian, careerist features coming to the fore, and nary a trace remains of this allegedly self-made and self-sacrificing career of the little lady with the weak heart.

After Petra Kelly was picked up and passed around by the elder gentlemen of the Eastern Establishment, she took up, at the tender age of 24, with the president of the European Community Commission, Dr. Sicco Mansholt, married and a generation her senior, who not only shared a bed with her, but also started her off with the necessary green and peacenik ideas—along with the necessary European and international connections.

An additional advantage was her generous salary as administrative adviser to the European Community, and the regular trips, made necessary by her job, to Brussels—which, after all, is not only the seat of the European Commission, but of NATO in Europe as well. Petra Kelly's regular trips to Brussels might have aroused some



suspicion among some of her peacenik colleagues—but this was, after all, the best way to justify herself.

Her Rise

Petra Kelly, now 34 [in 1982], has an interesting, if by no means particularly unique, career. The nuns of the English Sisters' Order in Guenzburg on the Danube—where delicate Petra wrote out her lessons and later wanted to become a Dominican nun to help the poor and ladies of fallen virtue—would scarcely believe the rocket-like rise of this rather unremarkable child.

Her actual father, Siegfried Lehmann, was a journalist, and must have been a rather shiftless fellow, since he disappeared without a trace in the early 1950s, leaving Petra alone with her mother and grandmother. As happened with many women those days, her mother married an American officer. When Petra Kelly was 13 years old, the entire family moved to the United States. In 1966, Petra Kelly entered the American University in Washington, D.C., where she majored in political science.

We are reminded of publisher Rudolf Augstein's words, that his magazine *Der Spiegel* is a "child of the Occupation," when we follow Petra Kelly's subsequent career. She is brought onto the first television talk shows as an academic "girl wonder." She meets with Senator Hubert Humphrey, an older gentleman, who suddenly has nothing better to do than hire the "young German lady" as a "European

adviser," and bring her into his campaign staff. During 1969 and 1970, she works with Humphrey, and is passed around from senator to senator, from ambassador to ambassador. Senator Kennedy, too—infamous for his affairs with the ladies—also invited her home.

While studying at the International Service School, where many U.S. State Department people are trained, she became acquainted with Henry Kissinger and Walter Rostow, among others. So, who could be surprised when Henry Kissinger, in a recent address to the West Berlin Aspen Institute, lavished praise on the peace movement in Europe, saying that they are "people to be taken seriously," who "are concerned about the world's future." What fitting words from the likes of Kissinger.

Kelly was also given ample opportunity to get to know the "left." And anyhow, people in the United States did not, and still do not, take the terms "left" and "right" as seriously as we do here in Europe—at least until recently. She was introduced to the "Institute for Policy Studies" group around Richard Barnet, the consumer lawyer Ralph Nader, the disarmament expert Paul Warnke, and many others.

After accumulating her wealth of experience and contacts in the United States, she then had to be prepared for her mission in Europe. She received a stipend to attend the European Institute in Amsterdam, where she was

supposed to work on problems of European integration. She worked up a study for the European Community on European unification movements, and was then employed by the European Community through the *personal intervention* of Commission president Dr. Sicco Mansholt.

Here began her involvement with the Young European Federalists, where she was active along with two other noteworthy creatures of the Establishment, Roland Vogt and Jo Leinen. Together with Roland Vogt, she promoted the ECOROPA organization, which was founded by the Club of Rome.

The Malthusian Establishment

Sicco Mansholt is no babe in the woods. It was Mansholt who, from his base in Brussels, coordinated and built up the Green movement throughout Europe. Even before the founding of the Club of Rome, he and Aurelio Peccei, Prince Bernhard of the Netherlands, and Prince Philip of Great Britain were promoters of the "Population Crisis Committee/Draper Fund," which was to play such a pivotal role within the worldwide environmental movement. The Committee's goal is to reduce the world's population by 2 billion, using the Chinese method of population control as a model.

NATO strategy planner Aurelio Peccei, who founded the Club of Rome in 1968, knows Petra Kelly well. He and other Club of Rome members know Kelly and Vogt from their work for the ECOROPA organization. Peccei is also

on the executive board of NATO's "Committee on the Challenge to Modern Society," which was already calling for an environmental movement while Petra Kelly was still a student in Washington. And—will wonders never cease—the NATO General Secretary himself, Joseph Luns, called for a worldwide environmentalist movement.

Violence

From her home base in Brussels, and with the help of her influential backers, Petra Kelly was catapulted into the leadership of the National Citizens' Initiative and the "Greens." Still a relatively unknown figure in 1979, by 1982 she had become an internationally renowned and touted figure of unity for the peace movement—built up, as *Stern* writes, "because she emanates the charisma of political credibility." How is that for low morals! Wearing her mask of the lovable, smiling little lady, she is espousing a policy that has already cost the lives of millions of human beings in the Third World, and has eliminated thousands of jobs!

In 1980, on the day after the state parliamentary election in North Rhine-Westphalia, Kelly stated that the Greens' poor election results only proved that "wherever the trade unions are strong, the Greens can't win. . . ."

The nonviolence that she ceaselessly emphasizes as the means through which her goals will be realized is a farce. In May 1980, Kelly said: "Laws must be broken. Our allegiance is entirely to nonviolent civil disobedience; by nonviolent, we mean that no one is to be injured or killed. But we shall break laws, we shall occupy construction sites, we shall block vehicles transporting radioactive material. . . ."

Only a few days ago, shortly before a visit by U.S. President Reagan to the Federal Republic and West Berlin, she said: "We must be very radical in our resistance. Words alone won't help prevent the arms race." And in a joint statement with the Jesuit Berrigan brothers, whom she invited to the Federal Republic, she says that "dissent without civil disobedience means capitulation." These Jesuit excrescences from the United States are famed for their "direct actions," such as destroying two missile warheads, spilling



Stuart K. Lewis
 "Laws must be broken": Petra Kelly smiles at her companion, Gen. Gerd Bastian (left).

blood over blueprints, and—one wonders how they managed it—penetrating into the inner offices of Secretary of State Haig and spattering them with blood.

Of particular concern is the increasingly tight intermeshing of the peace movement circles around Roland Vogt and Petra Kelly with the German-based Libyan circles allied to Col. Qaddafi. Here their oft-cited nonviolence degenerates into an outright lie. Roland Vogt, at the alternative "Hambach Festival," recently introduced a whole carload of Libyans from the Bonn embassy to activists from the peace movement.

Of his personal meeting with Qaddafi, Vogt said that the Libyan dictator is a serious politician with a background in philosophy. Qaddafi had nothing to do with the frightening image attached to him by the international press, Vogt said.

Both Vogt and Kelly refuse to speak in terms of "right" and "left." Only a few days ago, when they were both at a meeting of the Citizens Party in New York, Vogt once again spoke in favor

of "direct actions" and demanded that both "left" and "right" had to be unified around a single goal: Europe of the Regions—the Third Way.

Personal Life

The fact that for two years Petra Kelly shared bed and board with her boss, Sicco Mansholt, does not bother *Stern* in the least. But leading circles are slowly growing uneasy about Petra Kelly. A leading member of an important wing of the peace movement from West Berlin said in a recent private discussion that an ever-increasing number of people "are fed up with what she's doing!"

The same individual explained, "For quite some time now, she has been spreading lies and disinformation within the peace movement. . . ." Amid other interesting details, he added, "After all, the Greens are interested in only one thing—and that is elections, and not peace!"

Later, the same source volunteered: "And then there's another, quite disgusting matter, and that's her relationships with men. Perhaps you've read about it in *Stern*, about Sicco Mansholt and so forth. I really don't like to talk about others' private lives, and mess it up with political questions, but she herself isn't making that distinction. I know all about her relationship with [retired General Gerd] Bastian—that's what I mean. . . ."

Having been brought up without a father, Petra Kelly does indeed have an odd relationship to men, which is increasingly getting on her colleagues' nerves. Some time ago she said that she would never marry, because she did not want to lose her political independence—whatever that means to her. And in the debate over Paragraph 218, the abortion law, she demanded that the guilty men be sterilized! No wonder people are getting uneasy.

The General's Transformation

We can only agree completely with Major General (ret.) Gerd Bastian, when he says that the stationing of the Pershing II and Cruise Missiles will cause a fundamental change in the strategic situation between the two superpowers—a kind of Cuban Missile Crisis in reverse for the Soviet Union, which will have potentially catastrophic consequences. But the personal and political conclusions Bastian

draws from these correct insights, are entirely false. . . .

It is certainly infantile for a former division commander to let Petra Kelly present him with a book titled *The Myth of the Vaginal Orgasm* bearing the personal dedication, "A feminist classic! Your P."

Their visit last December to Washington and New York was the occasion of the most degraded scenes between Kelly and Bastian.

"I always have to look out for him," Kelly says. "He is like a child; he trusts everybody. . . . He gives everyone his telephone number. . . . When I point this out to him and tell him so, then he thinks I am a witch and flies into a rage, like a child." Privately, she went on to describe how she worked for two years to change the General into an infantile creature entirely dependent upon her. At first, she attacked him, shocked him, sent him literature he had to read. Then his children were turned against him, by winning them over to the Greens and the peaceniks. "The first step occurred," she said triumphantly, "when he signed the Krefeld Appeal."

The key to Bastian at that point, was his passionate desire to prevent the outbreak of a new war. "The turning point came," Kelly continued, "when we organized a trip to Hiroshima for him and his children."

While this sad conversation was going on, Petra Kelly was feeding the General some chocolate cake she had ordered, munching on a little herself. She kept on calling him the "lovable old man." Kelly proudly concluded that rejection by all his old friends meant that "we are now the only friends he has left!"

The witch image was not so far off, after all!

If all those who sincerely want peace ever had the opportunity to follow their leaders to the United States or other power centers (like Brussels), they would probably turn away from them in disgust. When Petra Kelly was confronted with some of the above-mentioned facts, her "independent" mask fell away. In private, she confessed: "You just can't believe how I felt in front of all those people. There were the people from NATO and the Congress, and I had to answer to these accusations!"

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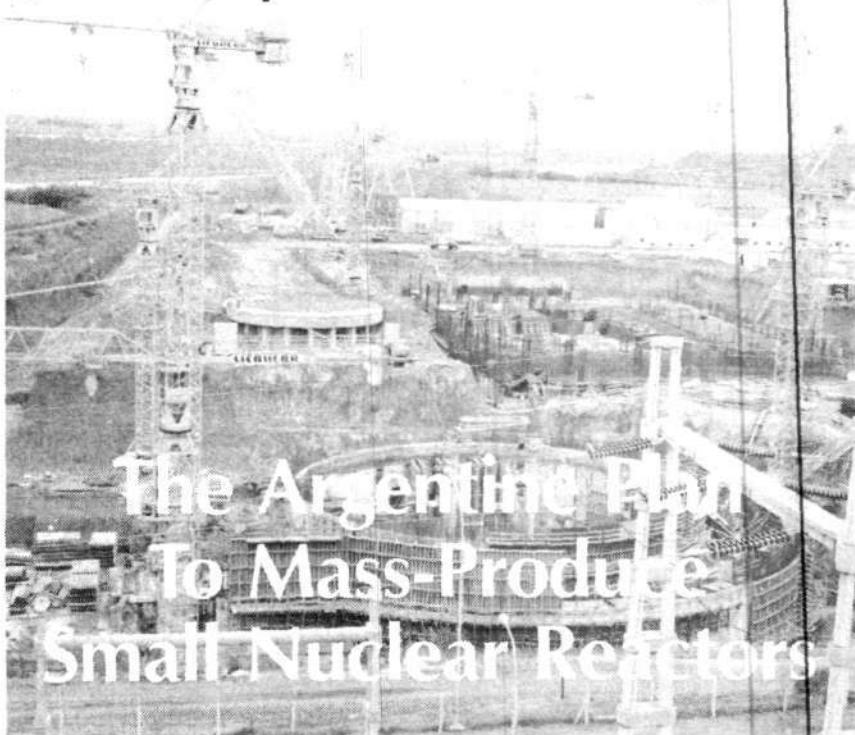


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'Proyecto Carem':



The Argentine Plan To Mass Produce Small Nuclear Reactors

Dennis Small

While the International Monetary Fund has increased the pressure on Argentina to kill its nuclear energy program, the Argentines are pursuing a ground-breaking plan to mass produce small-scale, modular nuclear reactors ideally suited for use in developing countries.

Within a year, INVAP, S.E., headquartered in the southwestern city of Bariloche near the research center for the Argentine nuclear program, expects to complete a working prototype of a pressurized-water nuclear reactor "module" of 15 megawatts-electric. Using light water as a moderator and Argentine enriched uranium as fuel, the module will be able to operate as a self-enclosed power plant for isolated areas or regions with underdeveloped transmission facilities. It can also be combined with other modules of 15 to 30MWe, to build electrical power facilities of up to 150MWe total power.

In a "technical information" document issued in September 1984, INVAP gave general design characteristics of the project, which it calls "Proyecto

Carem." Work on the prototype module has progressed rapidly since then, along with more preliminary work on a second module design of 30MWe.

The importance of the Argentine initiative centers on three immediately obvious implications of such a "small module" approach. First, it opens the way to serial production of nuclear reactors in many regions of the world. Second, the modules can be immediately integrated into less developed power grids of the underdeveloped world and provide greater security against disruption of supplies by war and terrorism.

And third, if pooled production credits were made available, "Proyecto Carem" could be built and fueled entirely with the industrial resources of Ibero-America, centered around a production partnership of Argentine and Brazilian firms and agencies.

Mass Production Potential

The "Proyecto Carem" prospectus states as its primary criterion that "building nuclear plants composed of small modules, [can] assure their serial

The IMF has frozen Argentina's ambitious nuclear program. The Atucha II nuclear reactor, due on line in 1986, is now on "hold."

production, the only possible way to succeed in the qualitative reduction of costs." The modular process of construction also reduces the relative infrastructural costs for each definite increment in installed electrical capacity in underdeveloped areas. Another crucial factor in its favor is the probable great reduction in "downtime" for small simple units.

As nuclear construction has collapsed in the United States under Paul Volcker's regime at the Federal Reserve, exports to the Third World have been shut off completely by International Monetary Fund conditionalities. Nations such as Egypt, Nigeria, and Mexico, which had ambitious nuclear plans, have had all their sources of credit ruthlessly stopped.

Argentina's own nuclear program, which at the start of the Malvinas War was at the verge of technology transfer and export to other Ibero-American countries, has been virtually frozen by President Alfonsín's domestic austerity measures mandated by the IMF. Yet, except for the unusual case of South Korea, the industrial potentials of Argentina, Brazil, Colombia, Mexico, and the other republics of Ibero-America, constitute the densest market for high-quality nuclear energy and process heat in the underdeveloped world.

The 15MWe-reactor module being pioneered by INVAP is the "least action" path to increasing installed capacity in many locations at once, with minimal startup time and cost. The module's power production would serve a small city of about 10,000 at current per capita rates of the industrialized nations. In less developed areas, one module might serve several towns at first, adding modules as industry is built. Such a reactor could be installed on a site within a year—rather than the minimum of approximately four years required today for large reactors under the best circumstances—if standardized elements like pre-

The State Department says the Soviet Union is ready to make a deal with the United States.

The Congress says we are spending too much money on defense.

Executive Intelligence Review proves that Soviet Russia has a plan for world domination by 1988—and is rapidly developing the military capabilities to win a nuclear war by that date.

EIR

SPECIAL
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GLOBAL SHOWDOWN



**The Russian Imperial
War Plan for 1988**

July 24, 1985

GLOBAL SHOWDOWN

The Russian Imperial War Plan for 1988

Preface by
Lyndon H. LaRouche, Jr.

The only comprehensive documentation of the Soviet strategic threat publicly available in any language. This 368-page report includes 34 maps, plus tables, graphs, index, and extensive documentation. \$250.

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stressed concrete elements were adopted.

Modules of this size will also lend themselves to rapid production and modular expansion in "navy yard" marine construction sites, allowing them to then be rapidly floated along Ibero-America's coasts and up rivers on barges to power-hungry sites. Some of the first U.S. Navy reactors were built during the 1950s in approximately this size and barge configuration, as floating plants. One such barge provided electrical power for the Panama Canal Zone for nearly 15 years.

Experts on Ibero-American nuclear capabilities estimate that mass-production of 15MWe or 30MWe nuclear modules could be carried out entirely by the nuclear-cycle industries of Argentina and Brazil alone. This would require unblocking the vast market for such units by new trade and infrastructure credits among the American nations, as proposed in "Operation Juaréz," a joint development program for North and South American put forward by economist Lyndon H. LaRouche, Jr. two years ago. These units could go immediately into isolated areas, regions with underdeveloped transmission facilities, and port industrial zones, and soon they could become universally used in modular "packages" of various sizes up to approximately 150MWe.

The only attempts at nuclear reactor mass production in recent decades have involved very large-scale facilities designed to produce as many as four large, 1,000-MWe reactors per year. The Westinghouse-Offshore Power Systems floating plant production facility at Jacksonville, Fla., was completed and then immediately mothballed in 1983, after nuclear plant orders had collapsed almost everywhere in the world. The Soviet Atommash facility on the Volga River has suffered massive quality control problems trying to achieve mass-production rates for very large reactor units.

The French nuclear industry's highly *standardized production* (as opposed to *mass production*) is thus the world's current standard, still consuming an average of six years in production of a full-sized reactor.

The Nautilus Example

The Navy's experience in building

reactors to power nuclear submarines demonstrates that much higher rates can be realized for smaller reactors. During the 1960s, the naval production program realized production of as many as four reactors in four years at a single yard, with a workforce of less than 1,000 and 70 inspectors—tiny figures by standards of today's nuclear construction sites.

Furthermore, because these naval reactors were much smaller than those later built for power utilities, operated at 25 percent lower pressure, and had greater relative roominess between reactor, pressure vessel, and containment walls, they generally operated flawlessly with very little downtime, and with simpler control rooms for operation. All these factors are likely to contribute as well to the success of the "Proyecto Carem" proposed by Argentina's nuclear industry.

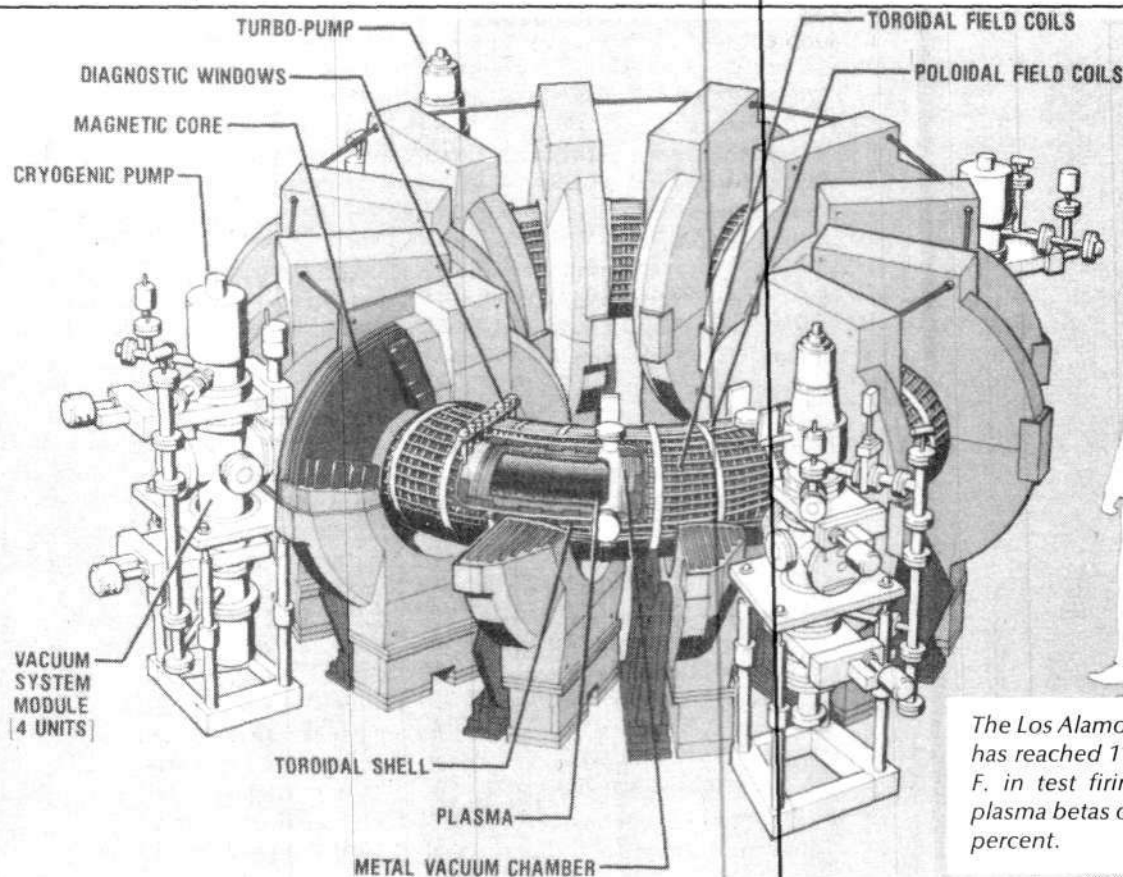
In fact, the economics of scale, universally assumed to lower nuclear power per-kilowatt costs continuously as plants got larger, has not been conclusively demonstrated above 500 to 600MWe even in the advanced industrial nations, according to experienced nuclear engineers. The increasing downtime characteristic of higher-pressure operating conditions, even before operating regulations became an environmentalist absurdity during the 1970s, is merely one obvious factor suggesting the smaller, "modular" approach to mass production.

As long ago as 1965, at a Atoms for Peace conference held in Mayaguez, Puerto Rico, and attended by most nations of the Western hemisphere, Mexican, Argentine, and Brazilian delegates argued for aggressive R&D on small power reactor modules, using as models the research reactors (TRIGA) then being built by Westinghouse and offered for export.

At a conference of nuclear experts last year in Buenos Aires, Argentine speakers pointed out that the economies of scale expected from the largest reactors were clearly not being realized, and cited the long delay in meeting the obvious need for a small reactor for potential mass production in and for the Third World. "Proyecto Carem" is now readying the potential answer to that need.

—Paul Gallagher

Fusion Report



The Los Alamos ZT-40M has reached 11 million° F. in test firings, with plasma betas of 15 to 20 percent.

Los Alamos National Laboratory

Reversed Field Pinch Advances to Next Step

Despite serious cutbacks in the U.S. Department of Energy magnetic fusion budget, Los Alamos National Laboratory is moving ahead with plans for the next stage of the extremely successful Los Alamos Reversed Field Pinch system, the ZT-H proof-of-principle experiment. The current Los Alamos reversed field pinch device is the ZT-40M, which has exceeded its original goals by orders of magnitude.

In addition to offering a direct route to compact magnetic fusion power plants, the reversed field pinch promises to revolutionize the entire science of magnetic confinement of fusion plasmas. The reversed field pinch is a toroidally shaped magnetic bottle in which an intense electrical current carried by the hot hydrogen plasma creates both the confining magnetic field and the means to heat the plasma to

fusion temperatures.

During its initial startup, the reversed field pinch proceeds from an unstable linear configuration to a stable reversed configuration in which the highly pitched magnetic field undergoes reversal of direction in the outer portion of the plasma column. This field-reversed configuration can either be self-generated by the plasma or programmed by the experimentalists.

The ZT-40M reached 11 million° F. in test firings lasting up to .0027 second. Most significant, the ZT-40M has attained plasma betas of 15 to 20 percent. Plasma beta measures the efficiency by which the magnetic field confines the hot fusion plasma. It directly determines the potential power density of the fusion plasma. (Tokamaks currently operate with plasma betas less than a few percent.) This high

power density makes it possible to build a compact fusion power plant.

Plasma Dynamo Effect

An added feature of the reversed field pinch is that of the plasma dynamo effect. This was seen earlier on the Italian Eta Beta II experiment, but became more pronounced on recent ZT-40M experiments. Because the reversed field pinch plasma current is generated by induction, it was believed that this system would have to operate in a pulsed mode. However, the plasma dynamo makes possible a continuous mode of operation. By oscillating the external magnetic fields of the system at the proper frequency it is found that the plasma current can be sustained indefinitely.

The ZT-40M now operates with a plasma current of 0.4 megamperes, while the ZT-H will operate with multi-megampere plasma currents. This will provide the basis for approaching fusion power reactor conditions in the reversed field pinch.

—Charles B. Stevens

A TOUR OF LAWRENCE BERKELEY LABORATORY

Multi-Beam Heavy Ion Accelerator Moves to Forefront in Fusion

Fusion Technology editor Charles B. Stevens and German-language Fusion editor Ralf Schauerhammer recently toured the Lawrence Berkeley Laboratory in California. Here they review some of the activities of the lab.

* * *

Scientists at the Lawrence Berkeley Laboratory in California are pushing heavy ion beam accelerators to their limit to develop the technology that can potentially provide the most economical fusion reactor system.

Although light ion beams and lasers are currently the frontrunners in inertial confinement fusion research, it is generally agreed that heavy ion beam accelerators offer the best prospects in the long run for economical fusion power generation. This is because heavy ion beam accelerators have demonstrated high efficiencies and a mature technology over the past 30 years.

There are two basic approaches to heavy ion beam fusion, a radio frequency linear accelerator (linac) patterned on existing, conventional designs and a single-pass induction linac in which amplification of the beam current takes place continuously during acceleration.

In the radio frequency linac, a 100-milliampere beam of heavy ions is accelerated to an energy of 10-billion electron volts. It differs from today's conventional ion linacs in that it has a low charge-to-mass ratio and a high current (100 milliamperes compared to 5 milliamperes), and it requires several parallel injectors.

The single-pass induction linac that is being developed by Berkeley consists of a sequence of nonresonant pulsed ferromagnetic cores, each of which supplies an energy increment to the beam by transformer action. This structure is particularly well suited to acceleration of very high beam currents in a repetitive pulsed fashion. This is extremely important because, even though a reactor-scale heavy ion beam



Lawrence Berkeley Laboratory

Berkeley's heavy ion facility is the most powerful in the world. Here, a transport line where beams of heavy particles, accelerated in the SuperHILAC, race to the Bevatron where they are boosted to even higher energies.

device would have a high capital cost, its high repetition rate would allow it to fire a large number of inertial fusion reactor modules.

Multiple, Simultaneous Beams

Working under the direction of Dr. Denis Keefe, Berkeley researchers are demonstrating the technology for simultaneously accelerating four separate ion beams in the same induction linac. The program is designed to show that this technology can be taken to its known limits, maintaining control of

multiple, simultaneous beams. The system achieves both energy and current amplification by compression of the beam pulse during its acceleration.

Four space-charge-dominated cesium ion beams are accelerated from an injected energy of 0.2-million electron volts, 5 milliamperes per beam, 3-microsecond pulse length, and 1.6-meter pulse length to 0.8 million electron volts, 15 milliamperes per beam, 1-microsecond pulse length, and 1.1-

meter pulse length. By next year tests will be complete on the Berkeley device, and then a 16- to 20-beam accelerator could be built for actual high-temperature fusion target experiments.

In 1983, Dr. John Nuckolls of Lawrence Livermore National Laboratory demonstrated that inertial fusion has the potential of producing electricity at a cost less than half that for nuclear fission and fossil fuel power plants. A major component of Nuckolls's analysis was the rapid development of heavy ion beam technology as demonstrated by the Berkeley program.

Neutral Beam Program Scrapped

While the heavy ion beam program is moving forward, the Berkeley lab is being forced by budget cutbacks to close down its neutral beam accelerator test facility. This facility is the major magnetic fusion effort carried on at Berkeley and was previously operated as a national user facility for the development of neutral beam fusion plasma

heating technology. The shutdown means essentially that a leading 20th century U.S. science center is being shut out of the U.S. magnetic fusion research program.

The Berkeley laboratory was founded by E. O. Lawrence, the inventor of the cyclotron particle beam accelerator and the U.S. scientist who realized his 1930 pledge to demonstrate the useful production of nuclear energy during the World War II Manhattan Project.

In the 1950s, Berkeley and Lawrence Livermore National Lab pioneered magnetic fusion energy research. Much of the expertise and technology developed under Lawrence's direction during the Manhattan Project for Calutron accelerator uranium isotope separation provided the basis for the realization of neutral beam heaters at both Berkeley and Oak Ridge National Lab in Tennessee. It was with neutral beam heaters that the Princeton Plasma Physics Laboratory's PLT tokamak

achieved fusion reactor temperatures for the first time in 1977.

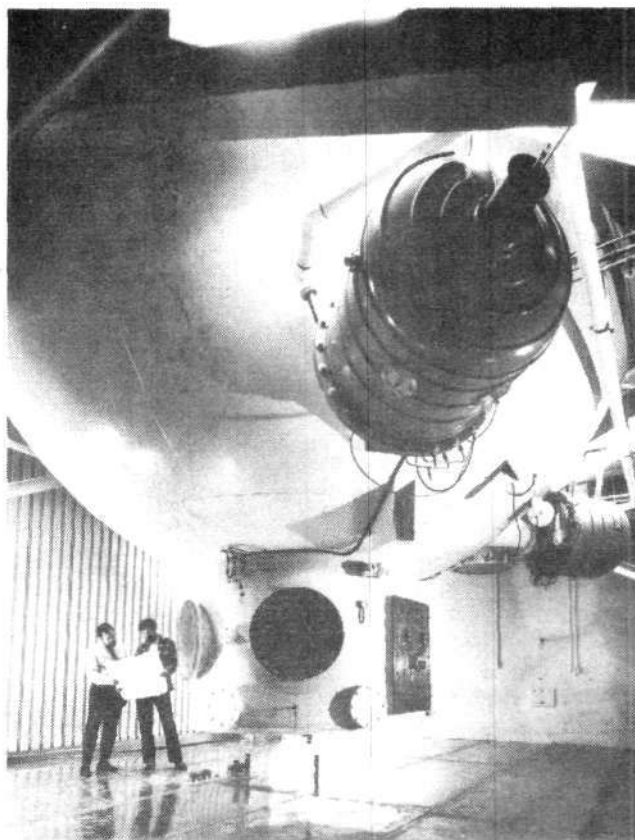
Neutral beams are also used on a wide variety of magnetic fusion systems ranging from tandem mirrors to toroidal stellarators.

In the 1970s, neutral beam technology was considered a "black art" because the beam operation called for highly skilled inputs. The Berkeley National User facility was developed to perfect neutral beams and make their operation routine. The premature shutdown of the Berkeley facility will significantly undermine the U.S. ability to realize commercial magnetic fusion energy.

Advanced Light Source Proposed

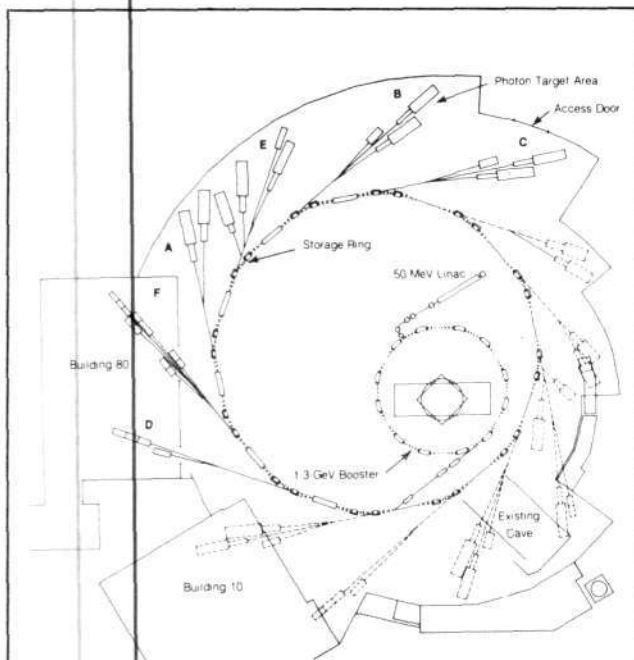
Another area that Berkeley intends to develop is synchrotron radiation. The lab is proposing the construction of a new synchrotron accelerator, the Advanced Light Source, to provide the testbed for realization of 21st-century materials and biological science.

Continued on page 19



Lawrence Berkeley Laboratory

Berkeley Laboratory's neutral beam test apparatus, shown here in 1976, is now being scrapped because of budget cuts. Berkeley's research helped the Princeton PLT tokamak reach record temperatures in 1977.



SCHEMATIC OF THE PROPOSED ADVANCED LIGHT SOURCE

Lawrence Berkeley has proposed this new synchrotron accelerator with a 6 billion electron volt upper energy capacity. The electron beam storage ring has sections for 12 insertion devices with different spectral characteristics.

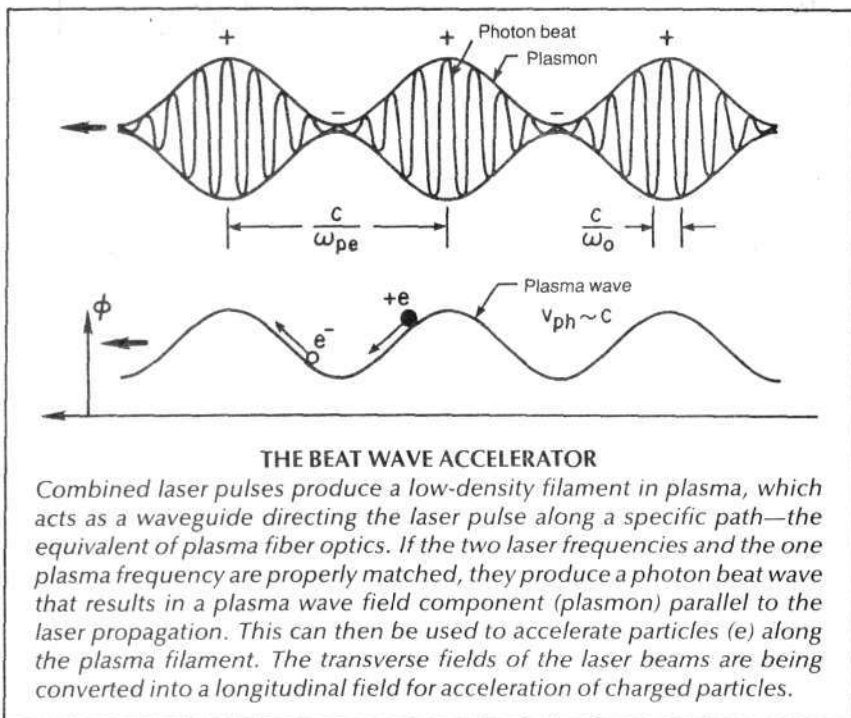
Viewpoint

Continued from page 7

gun. This is not only useful for weapons, but also for studying the impact of a meteorite on the planetary surface, which planetary physicists are very eager to do. Also, it is useful to study high-pressure material physics. I am now going to construct a 200-kilojoule machine for a rail gun, which I think will be completed at the end of this fiscal year. In these ways, I think that scientists in Japan can be involved in some sense, not directly, but indirectly, in the SDI.

In conclusion, the Japanese attitude to the SDI is not yet decided; it is changing, it is much in debate. But I think the industries will surely be interested in it: It's high technology.

Perhaps by the end of this year, our country's attitude toward the SDI will be decided.



THE BEAT WAVE ACCELERATOR

Combined laser pulses produce a low-density filament in plasma, which acts as a waveguide directing the laser pulse along a specific path—the equivalent of plasma fiber optics. If the two laser frequencies and the one plasma frequency are properly matched, they produce a photon beat wave that results in a plasma wave field component (plasmon) parallel to the laser propagation. This can then be used to accelerate particles (e^-) along the plasma filament. The transverse fields of the laser beams are being converted into a longitudinal field for acceleration of charged particles.

Letters

Continued from page 7

conform to the pattern do not have the college prestige or the funds to make entering worthwhile. For the most part, SEER still dominates the scene until the senior year, when the dominant force becomes Westinghouse. . . .

The two choices open to the scientists after college are postgraduate research work or a job in an R&D lab. Those who do not make great discoveries will be left where they are, permitted to carry on their work between papers, lectures, and symposia. However, the moment they make a breakthrough, rather than being left to make more, they are promoted into management positions, effectively putting an end to any creative work they might do, and their breakthroughs remain undeveloped.

This is the reason we lag behind. We have prototype robots, we have what we need for fusion power and electric aircraft. But we have barely touched on what we can do. There is only one way to achieve the goals we set in the 1940s and 1950s: Reform the way we manage science and treat scientists.

Michael Masterov
Bronx, N.Y.

High Energy Plasma Accelerator Proposed

Continuing progress in free electron lasers and plasma technology is rapidly converging to provide the basis for super-charged particle beam accelerators. One specific proposal along these lines was recently reviewed in a report on high energy plasma accelerators by T. Tajima at the the University of Texas Institute for Fusion Studies (IFSR #190).

Tajima's basic idea is to shine two laser beams of different frequency, like those generated by free electron lasers, onto a plasma filament that acts as a "waveguide." The plasma filament would focus and shape the incident laser energy and generate extremely intense electric fields to accelerate charged particle beams. Because the system is based on interaction of the two different laser frequency beams with a plasma—an interaction that generates a "beat wave"—the concept is called the plasma beat wave accelerator.

The potential level of energy flux density of this proposed system can be judged by the fact that it should be capable of focusing energy into the

nucleus itself, opening up an entirely new physical domain.

Free electron lasers are currently based on converting the energy of high-energy electron beams into coherent electromagnetic energy. When passed through a magnetic field, which causes the relativistic electron beam to "wobble" and clump up into particle bunches, the electrons radiate coherently and produce a laser beam output. For some time it has been known that this process could also be reversed, permitting the efficient conversion of laser light back into electron beam energy. The plasma beat wave accelerator is based on a further modification of this reversal of the free electron laser action.

Fundamentally, the electron beam in the free electron laser constitutes a highly directed, low-density plasma. The crucial advantage of utilizing plasmas over more conventional materials like copper and steel in accelerators is that plasma can be held together by intense electric and magnetic fields. Conventional materials in an ordinary, un-ionized state disintegrate when

strong electric and magnetic fields interact with their atomic bonds.

In a plasma, the opposite can be the case; the plasma can become more strongly bound together in the presence of intense fields. And intense electric fields are essential to achieving the efficient acceleration of charged particles like electrons and heavy ions.

In Tajima's proposed beat wave accelerator, a less directed, denser plasma is utilized to focus incident laser energy and geometrically transform it into intense longitudinal electric fields to accelerate charged particles along a plasma channel. This can be achieved by using two laser beams whose separation in frequency is tuned into the frequency of oscillation of the electrons in the plasma. With plasma densities of 10^{18} per cubic centimeter, Tajima projects longitudinal electric fields on the order of 1 billion electron volts per centimeter in the plasma beat wave accelerator.

Tunability of laser input will be essential for achieving beat wave acceleration over significant plasma lengths; the tuning provides the means of controlling the plasma channel and the accelerated particle beam within the channel. Therefore, the high power, tunable, free electron lasers currently being developed by the Strategic Defense Initiative could be essential for achieving this advanced accelerator.

Tajima notes the numerous applications of the beat wave accelerator to fusion, such as providing a means of continuous current drive in tokamaks. Even more exciting, he describes his proposal as "a speculative idea whose central theme is a direct coupling of the macroscopic beam structure with collective modes of the strong interaction [with the] subnuclear system. . . ."

If this proves feasible, it would represent an incalculable increase in the levels of energy flux density available to scientists. Currently, subnuclear modes can be accessed only by using extremely short wavelength electromagnetic gamma radiation or subnuclear particles like neutrons. The direct coupling of the accelerator fields to the nucleus would open up entirely new vistas in nuclear physics and energy.

—Charles B. Stevens

A Tour of Lawrence Berkeley Laboratory

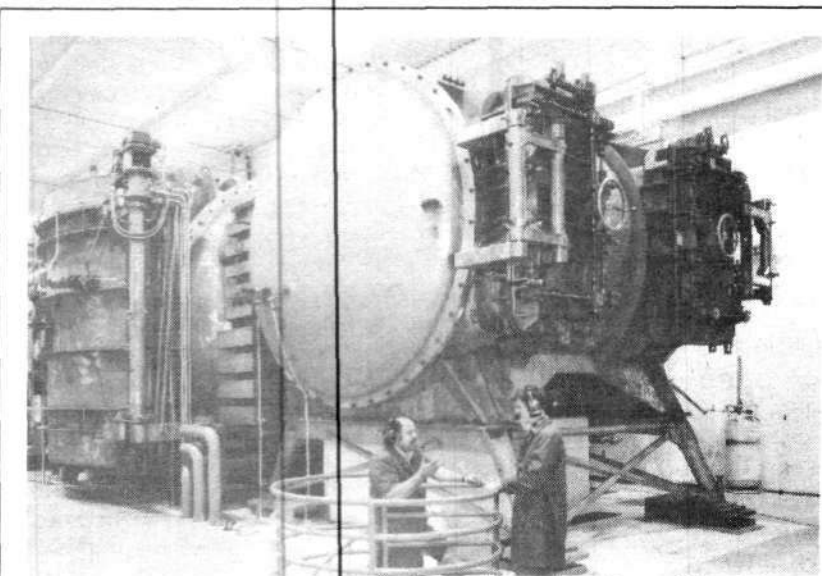
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Until synchrotron radiation became available as a by-product of high energy physics and accelerator research, sources of ultraviolet and X-ray radiation lacked the intensity, coherence, and tunability needed for achieving the mastery of the electromagnetic spectrum that had been attained with lasers in the visible and infrared regions.

The Advanced Light Source will further extend this capability to gamma ray energies. The accelerator consists of a 1.3-billion-electron-volt electron

beam storage ring with long straight sections for 12 insertion devices with different spectral characteristics. The first six beam lines for general users are slated to cover the energy spectrum from 5 to 15,000 electron volts.

The system, with its 6-billion electron volt upper energy capability, will be a research tool of unparalleled power and will offer a unique opportunity for collaborative research on advanced materials, biological imaging, X-ray optics, X-ray lasers, and free electron lasers.



James E. Stoots/Lawrence Livermore National Laboratory

The Separation Demonstration Facility, a key part of Lawrence Livermore's Atomic Vapor Laser Isotope Separation process, was completed in April 1985. Inside the 300-ton device, uranium is vaporized and separated into fissionable U-235 and nonfissionable U-238.

Livermore Gets Go-Ahead for Laser Isotope Separation Plant

The Department of Energy announced June 5 that the Atomic Vapor Laser Isotope Separation (AVLIS) plant in Livermore, Calif., part of Lawrence Livermore National Laboratory, had a green light to proceed with commercial-scale demonstration. At the same time, the DOE slashed funds for existing facilities for uranium enrichment. The Oak Ridge gaseous diffusion plant will be closed, and work on the Advanced Gas Centrifuge will be abandoned. The Livermore AVLIS prototype plant is almost completed, and now all isotope R&D funds will be focused on finishing the facility. AVLIS is the first major industrial plant based primarily on lasers. Although it will be directed at demonstrating the economic enrichment of fission isotopes such as uranium-235 and plutonium-239, the same technology can also be applied to the removal of nuclear wastes and the cheap generation of nuclear isotopes.

The Coming Breakthroughs in Biophysics

Research breakthroughs in the frontier areas of biology as well as beam defense require developing a new physics based on force-free, least action principles—and tossing out the theory of thermodynamic and statistical equilibrium.

by Jonathan Tennenbaum

There is a new scientific revolution in the making in biophysics that is bound up most intimately with the physics of beam defense; it's called nonlinear spectroscopy or optical biophysics. As Dr. Edward Teller has stressed, the spectacular advances of the beam defense program are based on the discovery of what he called "new physical principles." The exploitation of these principles will not only give us Mutually Assured Survival, but a new understanding of life processes.

The intimate relationship between beam physics and biophysics shows how foolhardy it would be to attempt a crash program for the Strategic Defense Initiative on the narrow basis of developing high-powered beam technology per se. The only way to ensure the necessary rate of breakthroughs to get to operational beam defense systems in three years, and to get to a full-area defense of the United States and its allies within less than a decade, is an all-out, no-holds-barred assault on the fundamental frontiers of science as a whole.

The emergence of new physical principles that are at variance with textbook physics is long overdue. Many of the central points of these new principles were broadly identified by the Fusion Energy Foundation in the late 1970s. At the time, as the FEF documented in its publications, Soviet scientists were acutely aware of certain of these new physical principles, in particular, certain implications of Bernhard Riemann's 1859 work on shock waves and of the

Figure 1

EFFICIENCY AND NEGENTROPY IN BIOLOGICAL SYSTEMS

Contrary to the conventional view of systems equilibrium, biological life is negentropic and extremely efficient. This 41,000-times magnification of chloroplasts developing in Phaseolus vulgaris represents billions of transformations per second in each of the minute photosynthetic organs or chloroplasts in each cell of a leaf when it has sunlight on it. There is no noise and no energy loss.

Source: Science Source Photo Researchers, Inc., © Biophoto Associates

crucial work on polarization of physical processes. In fact, the Soviet publications in this area provide decisive evidence that the Soviets were, and remain, engaged in intensive efforts to develop laser and particle beam technology for antimissile defense. This internal methodological evidence, as noted by Lyndon LaRouche, actually provided a much "harder" and more decisive proof that the Soviets were engaged in a crash program for beam weapon development, than other kinds of evidence (such as, for example, that submitted by Air Force intelligence's Gen. George Keegan in 1977).

The reason is that when a nation decides to go for a crash program in science, a very crucial side of that is the jettisoning of certain kinds of ballast, certain preposterous theories that simply don't work when you have to build things. In this sense, Soviet attention to Riemann's work and its implications for a nonstatistical thermodynamics is crucial evidence of the Soviet crash program. It would be just as if in the United States people would stop watching soap operas on television—probably the thing that would frighten the Soviets most. It is quite obvious that a nation addicted to "Dallas" is not going to be able to defeat the Soviets.

The Least-Action Principle

One of the main new principles on the level of atomic and nuclear physics, which must be part of this scientific revolution, requires a reversal of the widely held notion that physical processes naturally tend toward what is known as "thermodynamic and statistical equilibrium." Most processes in the universe, and most emphatically those in biology and in high-energy-dense plasmas, can be forced into statistical or thermodynamic equilibrium only by such massive intervention that we might justly say the process itself has been "killed."

Physical processes tend in general not toward equilibrium, but toward states best described as least-action and force-free states. This means, roughly speaking, that under boundary conditions providing for the undisturbed maintenance of the process, the process will pass through an ordered series of phase changes of increasing frequency and density. These changes will tend to be force-free, least-action in the sense that a minimum of action in the system is directed against the system. In other words, *the system works for itself rather than against itself*. In phase-space geometrical terms, the free energy transforming the process to a higher state always acts perpendicularly or orthogonally to the energy maintaining the process.

This principle of force-free least-action was enunciated by Nicholas of Cusa in his work on the isoperimetric theorem of geometry in the 15th century. Cusa identified circular action as the primary self-evident geometrical manifestation of force-free least-action in physics. Leonardo da Vinci exploited this work of Cusa in his design of machines, and da Vinci's drawings of machines illustrate this principle; he built machines that work for, and not against, themselves (Figure 2). Man learned this very early, in inventing the wheel: It is better not to try to slide or drag things with friction, where the process is working against itself, but to make a wheel that rolls and does not slide—a very simple principle. Later, at the French Ecole Polytechnique in 1793-

1795, this same principle was the basis of Lazare Carnot's teaching of geometry in physics and his definition of geometrical motions, which was his word for force-free least-action systems.

Crucial to Leonardo's study of least-action force-free systems is his study of how the human body works, and in particular the principles of least-action that are employed in the construction of the human body to obtain the maximum efficiency of work. Now we are essentially mastering the same principles of design of machines as Leonardo pointed out, as Carnot pointed out; however, we are doing it on the level of atomic and nuclear physics, in the physics of plasmas. Indicative of these force-free, least-action systems is ongoing work on superconductors, lasers, and semiconductors, where you see exactly the kind of phenomena of maximum efficiency, zero or next to zero friction, and next to zero loss, which in fact characterizes the efficient design of machines.

In hydrodynamic terms, we see this in what is called a force-free vortex, or Beltrami vortex (Figure 3). This is a vortex where every flow line is at the same time a vortex

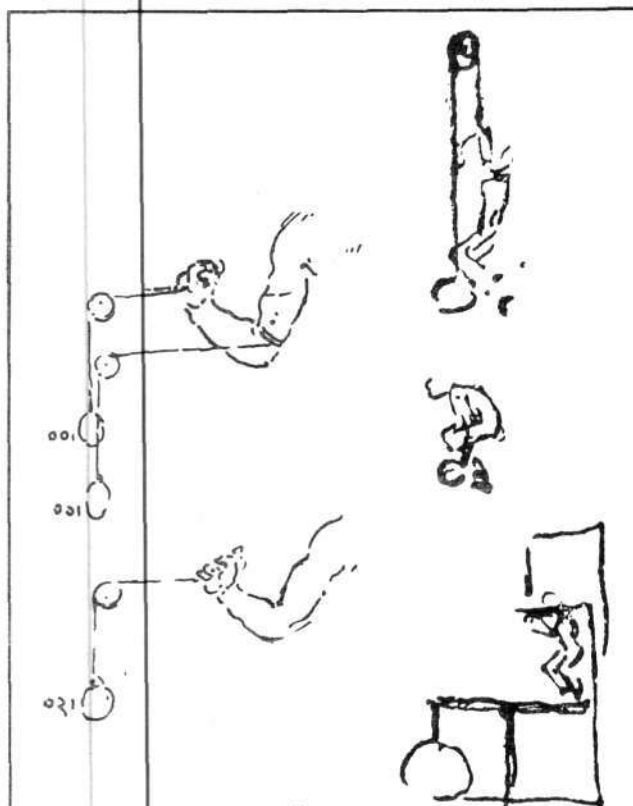


Figure 2
LEONARDO'S MACHINES AND
THE PRINCIPLE OF LEAST ACTION

Leonardo studied the principle of least action in the human body and in animals to design machines that would have the maximum work efficiency. Here are some of his sketches estimating human muscular effort.

Source: Ladislao Reti and Bern Dibner, *Leonardo Da Vinci Technologist* (Norwalk, Conn.: Burndy Library, 1969), p. 69.

line, and the fluid is also actually rotating around every flow line. This corresponds in plasma physics to an organization of current in such a way that the current does not have to do any work against the magnetic field.

This is the same kind of geometry that occurs in superconductors, a self-organization of a plasma so as to transform the ionized gas into a kind of superconductor. For example, the vortex filaments created in a plasma focus machine are force-free filaments that carry enormous currents and focus energy to extreme intensities (Figure 4). The energy density in some of these filaments compares with that created by a hydrogen bomb explosion—in a device that can fit on a desk top! That shows what force-free, least-action dynamics can do, working for itself and not against itself, to focus energy.

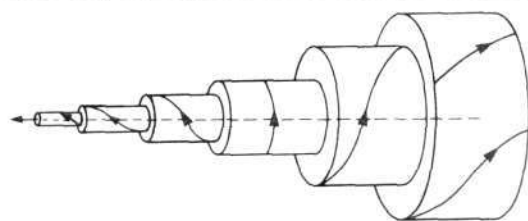
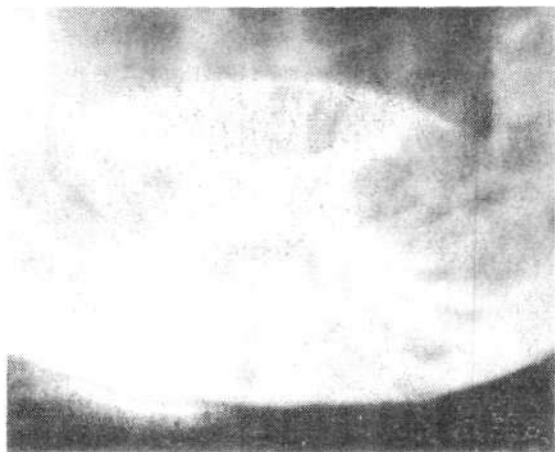


Figure 3
FORCE-FREE ACTION

In this diagram of Beltrami force-free flow, the direction of the arrows represents the velocity vector of the fluid as well as the vorticity vector. The fluid is actually rotating around every flow line.

Source: Winston Bostick, "The Morphology of the Electron," *International Journal of Fusion Energy*, Jan. 1985, p. 38.



Courtesy of Winston Bostick

Figure 4
**VORTEX FILAMENTS CREATED IN
A PLASMA FOCUS MACHINE**

This photograph of tiny plasma filaments was taken in fusion scientist Winston Bostick's plasma focus machine at the Stevens Institute of Technology. The filaments carry enormous currents and focus energy to extreme intensities—an example of force-free, least-action dynamics.

Biological Systems

Biology provides the most dramatic proof that in fact, systems in nature tend into force-free systems. The crucial point, which Riemann also made in his 1859 paper, is that when we are talking about force-free systems, we do not mean something that just sits there. The superconductor will conduct current, it seems, for a long time, but that's an exception. Biological systems are really the rule; they are force-free systems that generate a whole series of singularities of increasing density. This is what happens when biological systems grow—this is what life is all about, growth.

Take photosynthesis. If you look at a leaf on a tree, it seems pretty peaceful—it doesn't make a lot of noise—but if you were to calculate the rate of negentropic transformations going on in that leaf when it has sunlight on it, you would arrive at billions of transformations per second in each of the minute photosynthetic organs, the chloroplasts, within each cell in the leaf. And yet, there is no noise, no vibration, and little or no loss.

In fact, studies done by Professor Fritz A. Popp at the University of Kaiserslautern in West Germany on light emission from cells have shown that plant cells, if you put them in the dark for a long time, emit a very weak light. The amazing thing is that if you damage the cell, the amount of light emission *increases*. In fact, it increases when the cell is dying. How do you figure that out? The machine makes more noise when it's going awry, when it's not going right. In other words, the characteristic of biological processes is their absolute perfection in terms of efficiency. It is as if you were to walk into the middle of a huge industrial plant, a gigantic power plant of 2 billion megawatts, a steel mill and a machine shop, and not hear a single noise. That is what's going on in biological systems.

These phenomena are really the exact opposite of what would be expected from the standpoint of statistical gas theory, which sees all phenomena as motion of molecules. In other words, the statistical gas theory approach basically sees life as no more than jiggling—you are born, you jiggle a certain number of times, and you die. According to this view, life is just a "break dance" for molecules.

The crucial epistemological point here is that processes, and certainly any interesting processes, cannot be reduced to fixed properties of fixed objects. This is the tendency of the school of thought known as *reductionism*, or *Cartesianism*: to try to deny that there is real change in the universe, and even more, to deny that change and transformations are the whole substance of the universe.

Consider a couple of examples from optical biophysics. This is a very entertaining field, because it challenges us directly and concretely with the shortcomings of present physics. The life process comes out and says, "Hey, you'd better change your way of thinking!"

First, let's consider work on what is called "biophotons," very weak light emission from cells. There's a wealth of experimental work here that goes back to the 1920s when evidence was accumulated that cells produce light, in particular ultraviolet light, of very specific characteristics and frequencies, for the communication between cells. In particular, there is the discovery of something called mitogenetic radiation, tuned ultraviolet light, which, according to

experiments, allows a light emission from one cell to trigger the division of another cell. Evidence accumulated that these light emissions play a crucial role in the coordination of cell activity in tissue. It was shown that this radiation in fact must be ultraviolet, because if a quartz window were put between the two cells involved, it works; and if a regular glass window were used, it would not work. Quartz lets ultraviolet through, and regular glass does not.

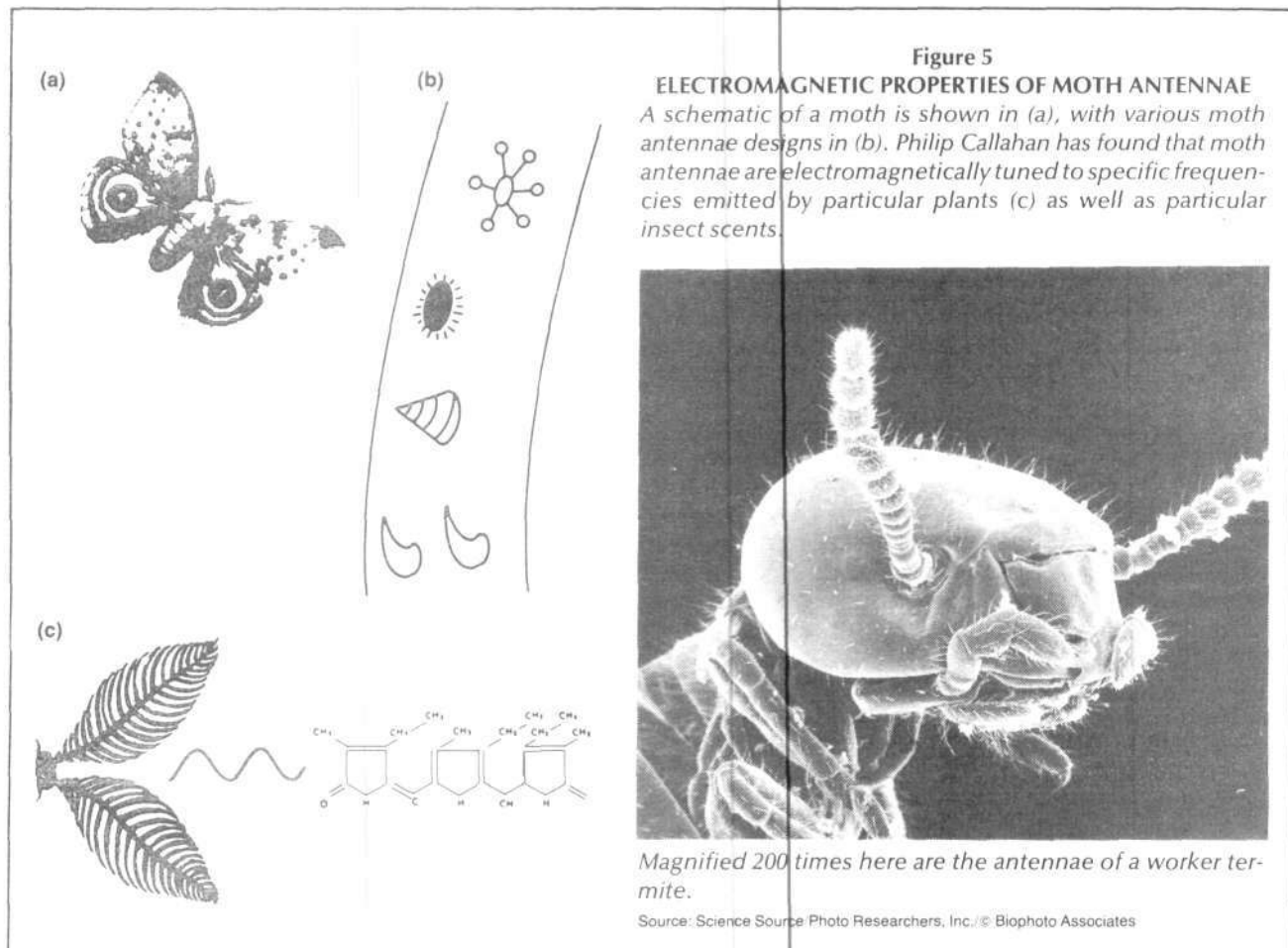
Studies have been made of this radiation. In the 1920s, researchers could not measure it directly—they did not have the photomultiplier tubes that we have now—but in the postwar period, this light emission could be measured directly. The cell is put in a dark room and allowed to quiet down; otherwise it will produce fluorescence. (A cell put into the light will absorb that light and reemit light, as is seen in nonliving processes.) But if the cell is kept in a dark room, the fluorescence dies down, and leaves merely a very, very weak emission of light. There is substantial evidence that this light, at least in large part, is generated by the DNA molecule in the cell, the double helix.

How does this work? For a long time there was a paradox in genetics, called the c-value paradox, which was one of the major problems for the funny fellows who have been trying to prove that living processes function like digital computers, with DNA playing the role of the "computer program." One problem is that if you look at the sections

of the DNA that can be traced to particular genetic information, you find that this is only a small percentage of the total base pairs, of the total molecules and atoms in the DNA. There are large sections, which apparently have a periodic structure, for which the geneticists could give no explanation.

The discovery of light emission from the DNA has largely solved this paradox. Specifically, the DNA is acting like a laser that has a very particular geometrical structure and properties that allow the molecule to absorb electromagnetic radiation of low quality in the cell, in the infrared region, and reemit that radiation at a shorter wavelength, ultraviolet. That ultraviolet light represents a higher energy-density than the infrared light that was put into the DNA. This high-quality ultraviolet light, in turn, runs the metabolic processes of the cell.

Popp and his research group have corroborated this remarkable hypothesis with a wide variety of evidence, including that provided by the structure of water in cells. What is structured water? Well, the standard textbook statement, "living organisms are mostly composed of water," is highly misleading, because the water in a living cell is not at all the same as the water in a drinking glass. It's the same old Cartesian problem again, thinking too much in terms of objects instead of processes. In the inner fluid, the cytoplasm of the cell, the water is "polymerized" by the



polarization of the water molecules, forming fibers that in turn create a network of channels able to conduct laser light with no loss. In other words, they are waveguides. And that water is structured in particular through the action of certain trace elements, especially minerals and metals in very low quantities in the cytoplasm of the cell. This vast network of "light pipes," it appears, conducts coherent light pulses from the DNA to various sites around the cell.

Another line of research with revolutionary implications concerns carcinogens. Many studies have been made on substances that apparently cause cancer. You cannot understand carcinogens from the standpoint of ordinary chemistry; trying to find a chemical property that the various carcinogenic molecules have in common and that makes them cancer-inducing could drive you crazy. Taking a nonlinear approach, the group around Popp in West Germany has done studies of the spectroscopy—that is, the spectrum of light emission and absorption—of a broad range of molecules that induce cancer and have found remarkable similarities in the ultraviolet spectrum of these molecules. The molecules may be shaped very differently, and they may have completely different chemical properties, but their ultraviolet spectrum is very similar. And we know that ultraviolet light plays a crucial role in all of the processes in the cell.

Electromagnetism: The Case of the Moth

Other work, in particular work done by entomologist Philip F. Callahan, has confirmed massively the extent to which we must get away from the so-called lock-and-key, building-block notion of chemistry. When somebody asks, "what do you consist of?" in the building block tradition, you would answer, "molecules sticking together in various ways." But "sticking together" is not enough; the problem has to be looked at in a completely different way.

What Callahan did is observe very carefully the sense organs of insects, in particular moths. Moths are able to sense each other through certain scents, certain smells, in

particular sex attractants or pheromones. Female moths will emit a certain pheromone into the air. The male moth will pick up this scent, and will home in on the female moth. Callahan, a radar engineer during the war who designed radar antennae, was struck by the similarity between the way the male moth homes in on the scent, and the way in which a plane follows a navigation beam, going in kind of a spiral motion back and forth. He came up with the hypothesis that perhaps it's not really smell in the ordinary way that keeps the male moth on course to the female.

Again, the usual theory of smell is the Cartesian "lock-and-key" theory: A cell membrane has certain active sites

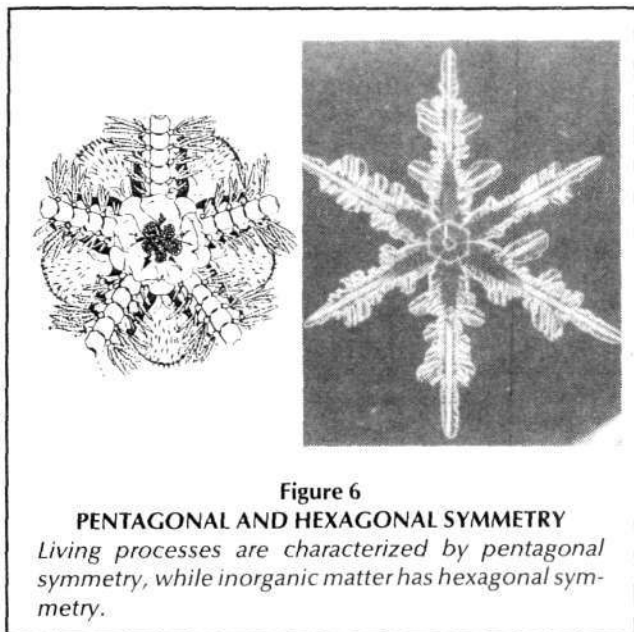


Figure 6

PENTAGONAL AND HEXAGONAL SYMMETRY

Living processes are characterized by pentagonal symmetry, while inorganic matter has hexagonal symmetry.

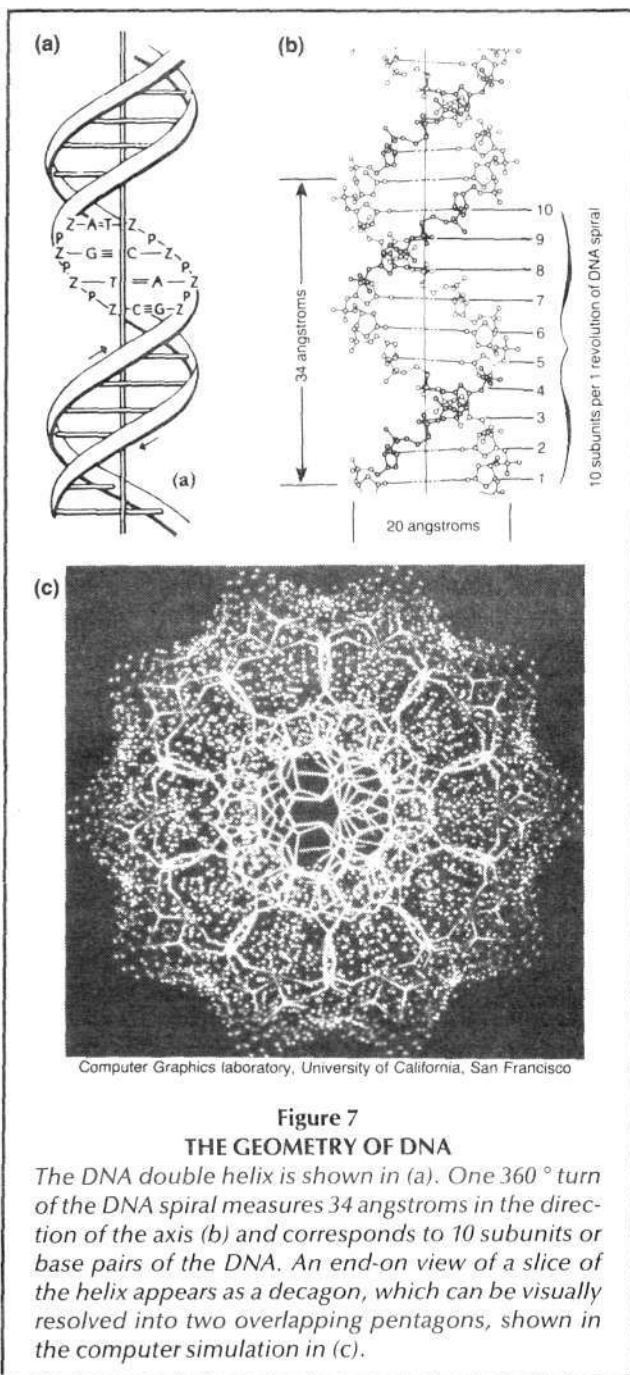


Figure 7

THE GEOMETRY OF DNA

The DNA double helix is shown in (a). One 360° turn of the DNA spiral measures 34 angstroms in the direction of the axis (b) and corresponds to 10 subunits or base pairs of the DNA. An end-on view of a slice of the helix appears as a decagon, which can be visually resolved into two overlapping pentagons, shown in the computer simulation in (c).

and the molecule one is smelling is actually bound into one of the sites chemically. That's how one is supposed to smell different molecules, through chemical reactions.

Callahan took electron micrographs and had a look at the fine structure of the antennae on the moth. As an experienced radar engineer, Callaghan found every single type of well-known radar antennae reproduced on a smaller scale on insect antennae: for example, pit antennae, log periodic antennae, phased arrays, and so on (Figure 5). The difference is that the insect antennae are much smaller—on the order of about 10 microns. This would correspond to receiving signals in the infrared light range, as opposed to the microwave range covered by radar antennae.

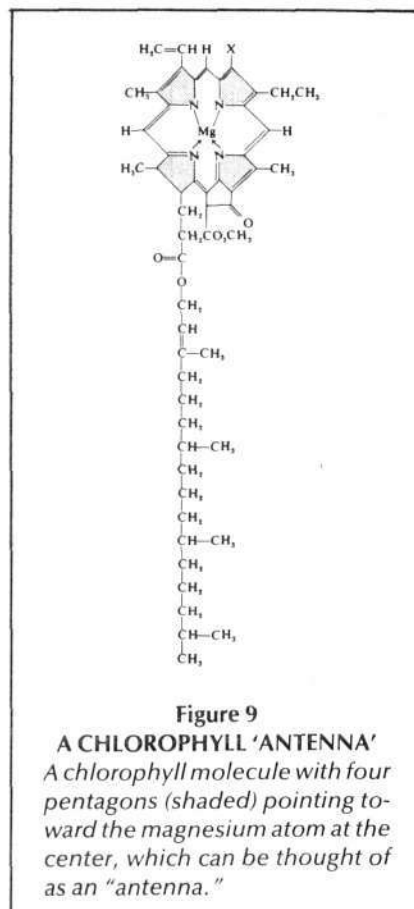
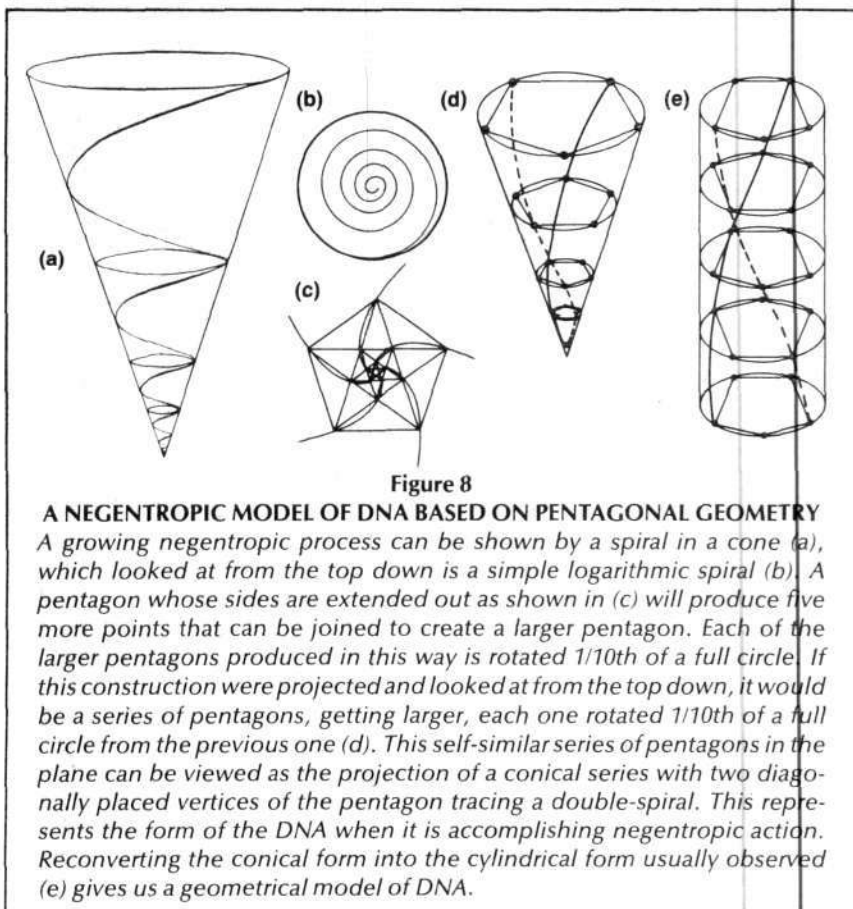
Callahan's hypothesis is that the moth is picking up an electromagnetic wave—light—and that the moth antennae are actually tuned to specific frequencies. He took a spectrograph and watched the light spectra from the pheromones and other scents emitted by plants and so forth, and he found very particular spectral lines. He also found that these spectral lines are strengthened very much when the molecules involved are vibrated in a certain way through an acoustical signal, or are excited by ultraviolet light.

Callahan then was able to match these things. He did a critical experiment: He took the pheromone from a female moth and put it in a bottle and closed it tightly. Then he shined an ultraviolet lamp or a flickering ordinary lamp of fairly high power onto that bottle. He found that the pheromone molecules emitted the particular spectral lines and

that the male moth responded as if the scent of a female moth were right there. Yet there was no scent; there was only light. And if the excitation energy for the pheromone was turned off, the male moth did not see anything anymore; in other words, you can turn the male moth on and off.

Callahan's work has dramatic implications, not the least for agriculture. What comes out of this, in fact, is the way in which our biosphere is organized, and the amazing specificity of biological processes—that one insect will fly only to one very particular species of plant, that one virus will attack only one particular species of cell, and so on. We may be unlocking the mystery of how the whole biosphere is organized! This means that if we want to control insects, we could simply jam the frequencies that they are tuned to. And this could be a very revolutionary way of solving some of our problems in agriculture.

One last example is work on enzymes, which are very crucial to these least-action, force-free processes. How is it that the chemical reactions in the cell apparently occur at rates sometimes millions of times faster than scientists can get them to occur in the laboratory? It has something to do with these so-called enzymes; the geometry induced by these enzymes speeds up these processes and makes them force-free. Work by the French physicist J.P. Biscar and others has begun to unravel the "mystery" of protein enzyme structure, by showing that the various chains in the enzyme molecule function as tuned antennae, matched in



such a way as to focus electromagnetic energy onto active sites on the enzyme. It is found that certain frequencies of light greatly stimulate enzyme action.

The point is that the universe does not consist of bumps and lumps; the universe consists of action, transformation. In fact, you can't see anything without seeing a transformation. If there weren't any transformation, you wouldn't see anything. You never see an object; you see only a transformation, a change.

The Challenge Facing Mathematics

We must develop a mathematics that addresses this reality about the universe—in other words, an honest mathematics. This is very upsetting to certain pragmatic scientists who say, "Look, my statistical theory works. I can calculate this and that, so what are you bothering me about? Why bother me with the question about whether my terms and my concepts actually correspond to something that's actually there? Don't bother me about that, because what I have, works." Pragmatism.

To develop a true mathematical physics with a greater approximation to the way the universe works, we have to take into account the fact that the substance of the universe is process and transformation; there are no inert objects. In order to do this, we have to, of course, get rid of algebra. Once one understands something, one can do some calculations on it, but one shouldn't calculate before one understands it—a very simple principle. We have to think about how to develop a mathematics of transformation, and of least action, force-free processes.

We can use synthetic geometry to grasp how physical processes work, using the principle of Leonardo. How is it that Leonardo was one of the greatest painters in all of history and also one of the greatest scientists? What defines a scientist? Rigorous thinking! And what derives from rigorous thinking? A very acute eye for the kinds of things that most people overlook, but are right in front of their noses. If you read Leonardo da Vinci's writings, he will explain to you, in terms of painting, that every painter must be a scientist, and every scientist a painter. Because when you are drawing you are re-creating the process you are drawing. And when you create something, you understand how it works—very simple.

The first thing is the role of the golden mean proportion and the pentagon, which characterize, as proportions in visual space, living processes as opposed to nonliving processes (Figure 6). As Kepler pointed out, normally in inorganic nature five-pointed symmetry is not found; five-pointed symmetry characterizes life. Of course, someone could build a pentagon, but that's life playing tricks.

If we look at the DNA molecule, the double helix, the crucial thing for someone who has a nose or an eye for geometry is the fact that a DNA molecule in the B form, the active form of DNA, has a whole series of base pairs adenine, guanine, and so forth. Each single rotation, each cycle of the double helix, corresponds to exactly 10 base pairs (Figure 7). If you were to take that section of the DNA and look at it end-on, you would see two pentagons. So each step rotates 1/10th of a circle. This immediately says, "Ah! The DNA is not just sitting there as an inorganic molecule."

The DNA, and all molecules in biology, are not the same in the cell as they are in crystalline form, in dead form. They are different in the cell, because they are a process.

Now how would we create a DNA molecule by geometry? Our model for a growing negentropic process, a spiral growing inside a cone, is shown in Figure 8. If you look at it from the top, it looks like a simple logarithmic spiral. If you take a pentagon, extend its sides out, you'll get five more points; join them, extend those sides—and you can grow a whole series of pentagons. Each one, as you go outward, will be rotated 1/10th of a full circle. If you think of this drawing as a projection, looking at it from the top, you get a series of increasingly larger pentagons, each one rotating 1/10th of a full circle, going from one to the next. Now imagine that this self-similar series of pentagons in the plane is just the projection of a conical series, with two diagonally placed vertices of the pentagon tracing a double-spiral [Figure 8(d)].

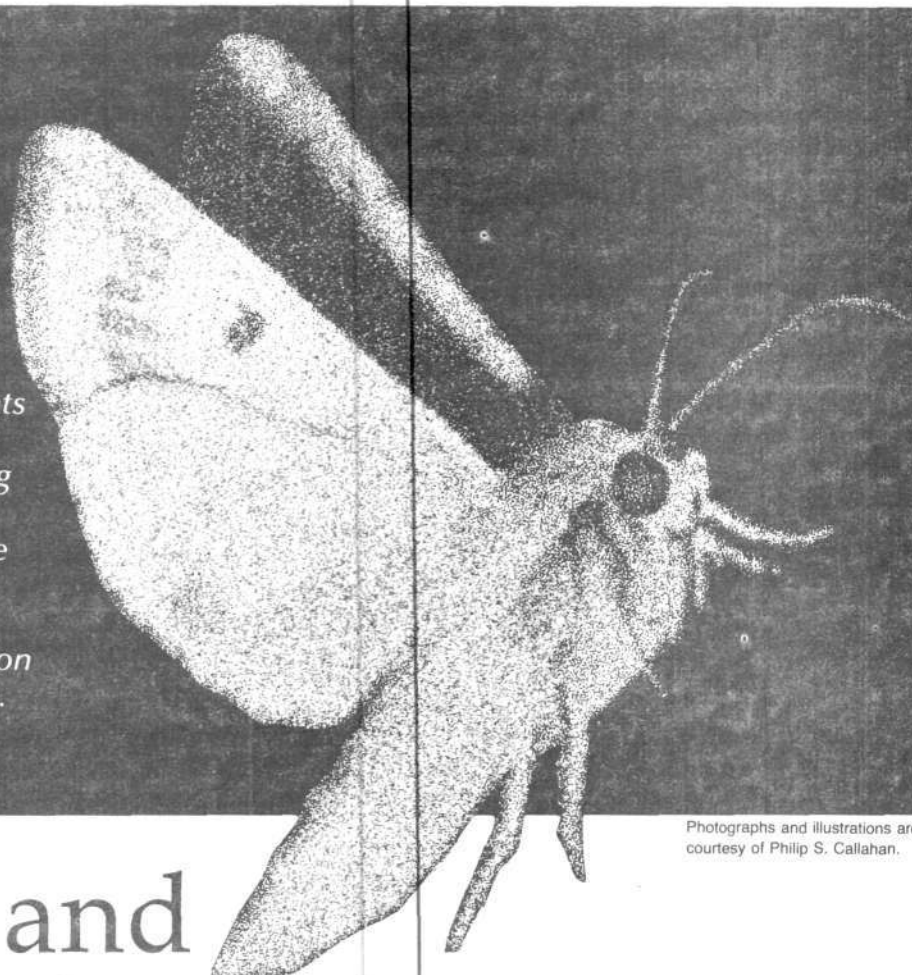
This, we hypothesize, is the form of the DNA when it is accomplishing negentropic action: swallowing a few photons and shooting out a beam of shorter wavelength. The frequency upshift by a factor of 10,000, observed with DNA, coheres well with the pentagonal model, where the ratio of sizes between the first pentagon and the 10th one (one rotation) is approximately 10,000. If we reconvert the conical form into the cylindrical form usually observed, then we obtain a geometrical model of DNA that reproduces the observed proportions of the molecule [Figure 8(e)].

Let me take one last example of geometrical modeling of biology, the wonderful thing called chlorophyll (Figure 9). Chlorophyll is the active molecule in photosynthesis. As you can see, it has an array of four pentagons, with a magnesium atom at the center, which must play a crucial role. And what is the magnesium atom doing in the center of the molecule? It's got to be an "antenna." In fact, in plants, the chlorophyll molecules are organized in antenna arrays that capture the Sun's light and focus it down into active centers. So we can get into some very fascinating hypotheses and experiments on this.

The processes of optical biophysics, these highly tuned, least-action, force-free processes, also provide the paradigm for how you make beam weapons. For example, how to produce a laser beam that is so tuned that it can pass through the atmosphere with no loss (least action), can be absorbed in the target, and can transform that target in the most efficient way is the same kind of problem as figuring out how the chlorophyll molecule transforms sunlight.

To sum up: what we have to do to mobilize this nation is to launch a science mobilization based on fundamental, new scientific principles. What this means can be seen in Friedrich Schiller's poem on hope, where he says, "Zu was besserem sind wir geboren"—we were born for something better; we were born for something better than the kind of misery that we have on this Earth. And the answer is science.

Jonathan Tennenbaum is the editor-in-chief of the German-language Fusion. This article is adapted from his presentation to the June 16-17 conference in memory of Krafft A. Ehrlicke, sponsored by the FEF and the Schiller Institute.



From the enemy U-boats of World War II to the enemy insects attacking man and crops today, Philip Callahan tells the fascinating tale of how an understanding of electromagnetic radiation can lead one to victory.

Photographs and illustrations are courtesy of Philip S. Callahan.

Insects and The Battle of the Beams

by Philip S. Callahan

The night sky is filled with waves of electromagnetic radiation. Sometimes it is bright with light from the Moon, sometimes dimly streaked with the early light of false dawn; sometimes low clouds cause darkness to shroud the lands.

Strangely enough the night sky is also filled with vivid colors. Red, blue, orange, and green colors bathe the Earth from the thousands of suns (stars) that irradiate our atmosphere. Infrared colors (wavelengths) and ultraviolet are emitted by constellations and are reflected from our own Sun to the surface of the Moon and back to Earth. At various times during the night, the gaseous molecules that compose our many atmospheric layers are stimulated to glow, at very low intensities in beautiful hues of red, green, near-infrared, or ultraviolet. We cannot see these low-intensity colors with our eyes. The cones of our retina, which work so well in bright daylight, cut out at low intensities of light. Our eye cannot see ultraviolet or infrared light during daylight or night light.

The human eye is completely restricted to the narrow, visible portion of the electromagnetic spectrum. The fact that we cannot see these many night radiations does not mean that they have no effect on our lives or on nature around us. I was witness to the effect of such low-intensity night light on earthly life many years ago.

I had set out on a hike across the wild, uninhabitable moorlands of southwest Donegal, Ireland. I began my hike at the little crossroad village of Ballintra and cut southeastward cross country toward Lough Erne in County Fermanagh. This area of Donegal is called the Pullan (Figure 1). It is a stretch of moorland 8 to 10 miles across and far more desolate than the Dartmoor of England. The Pullan is dotted with bogs and small lakes or loughs. Pullan means puddle in Gaelic. Red grouse, merlin, corncrakes, and lapwings inhabit its marshes, moors, and lush vegetation.

As evening fell, the persistent "crek-crek" of the corncrake filled the darkening sky. Halfway between Ballintra and Lough Erne a mountain called Breezy Hill rises 2,500

feet above sea level. I used Breezy Hill as a central landmark to guide myself across the bogs and heather-covered highlands.

The 'Hour of the Wolf'

During summer at 55° N latitude (New York City is 42°) there are still streaks of light at midnight. It was almost midnight when I stopped to camp in a sheltered spot between the great rocks on the side of Breezy Hill. As the last glimmer of light faded away I spread my bedroll between the huge gray-colored boulders. Suddenly the heather-filled crevice between the boulders was filled with dancing moths. They seemed to fly out from the nearby rock-face.

It is too long ago to be certain, but they may have been the gray mountain carpet moth (*Entephria caesiata*). E.B. Ford in his book *Moths* says that the gray mountain carpet will take to the wing if the collector throws a handful of small stones against a moorland rock-face. The larvae of the gray mountain carpet feed on heather.

What I am certain of is that as "the hour of the wolf" approached, the moth creatures of the night behaved as if possessed. Just before dawn—the Moon hung low in the west—I awoke to see them flitting between the boulders in a frenzy of activity. It was almost as if they were afraid the rising Sun might catch them before they found a suitable hiding place among the rocks. We have all heard the old folk belief that it is darkest just before dawn. Urban dwell-

ers take no notice of such things, but hikers, campers, or rural dwellers, who spend much of their time out of doors, are apt to experience a mysterious uneasy feeling at that hour of the darkening. That is why in folklore it is recorded as the "hour of the wolf."

Astronomers avoid taking photographic plates of the stars during this period of nighttime because they wish to avoid fogging their plates by the ultraviolet light that floods the predawn sky. This phenomenon usually occurs at least an hour before any trace of dawn. The ultraviolet concerned is close to the visible light portion of the spectrum and is called *black light*. The human eye cannot detect such black light, but moths can see in that region of the spectrum in addition to being sensitive to visible light. This has been demonstrated numerous times by detecting nerve impulses from the retina, when it is radiated with visible and near-ultraviolet light.

Professor Lewis Epstein, a physicist at Louisiana State University in New Orleans, has what is for me a good explanation for the haunting sensation of the hour of the wolf. He reasoned that this black light ultraviolet disturbs the night adaptation of the human eye and thus induces the sensation of darkening. The effect can be experienced by looking at a commercial black light bulb and then looking away at another object. Black lights are used in discoteques to create the same uneasy manifestation in the customers. The moth, of course, would be at the peak of its visual

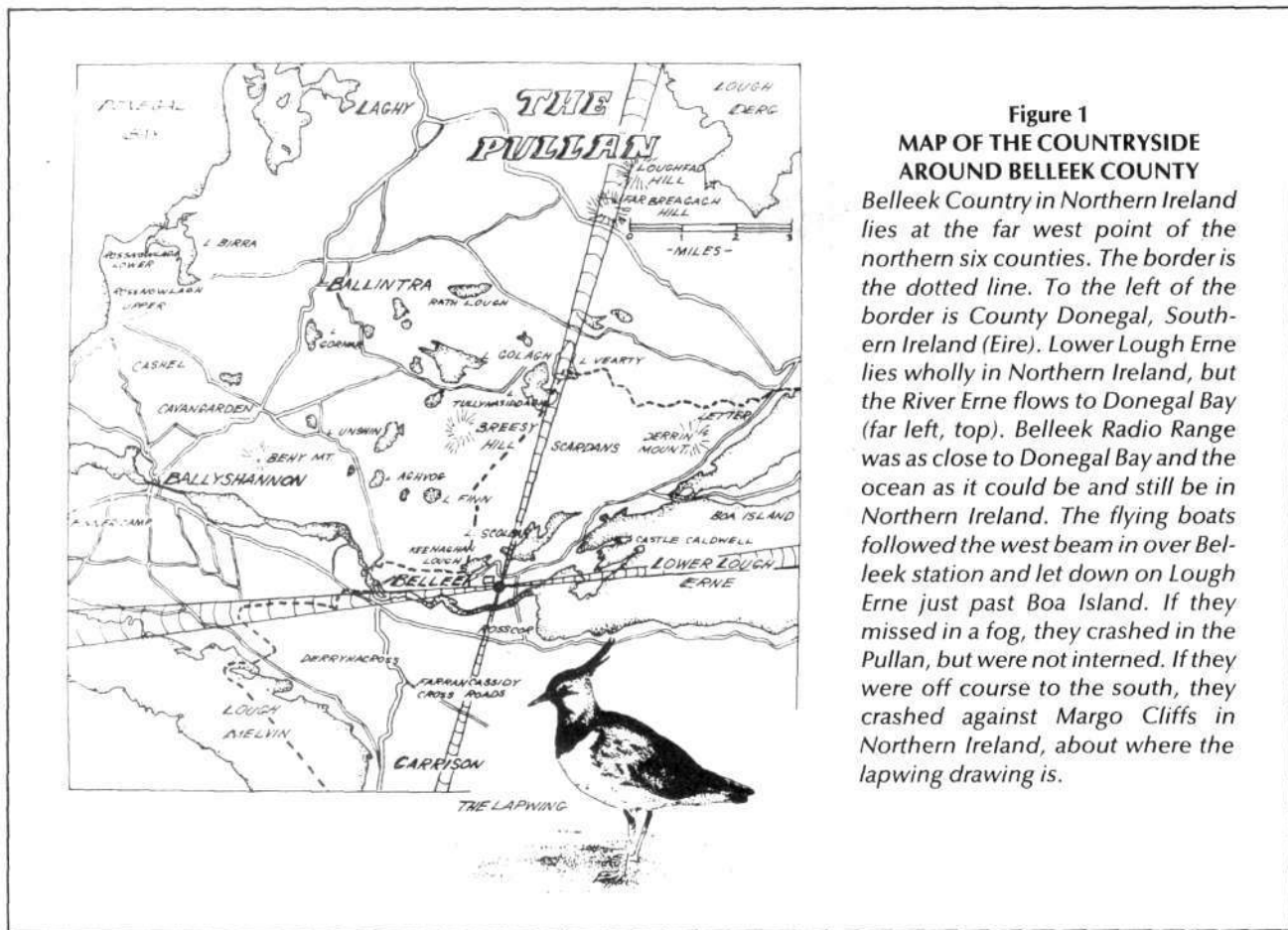


Figure 1
MAP OF THE COUNTRYSIDE
AROUND BELLEEK COUNTY

Belleek County in Northern Ireland lies at the far west point of the northern six counties. The border is the dotted line. To the left of the border is County Donegal, Southern Ireland (Eire). Lower Lough Erne lies wholly in Northern Ireland, but the River Erne flows to Donegal Bay (far left, top). Belleek Radio Range was as close to Donegal Bay and the ocean as it could be and still be in Northern Ireland. The flying boats followed the west beam in over Belleek station and let down on Lough Erne just past Boa Island. If they missed in a fog, they crashed in the Pullan, but were not interned. If they were off course to the south, they crashed against Margo Cliffs in Northern Ireland, about where the lapwing drawing is.

power in predawn black light since the moth eye works as well or better in that portion of the spectrum as in the visible.

The 'Ultra Station'

My hike across the Pullan took place during World War II when I was attached to an U.S. Army Air Force Unit that maintained a radio beacon for antisubmarine patrol aircraft.

The land south of the Pullan where I was hiking rises to a low plateau before dropping to the River Erne. At the south end of this highland sat the ghostly remains of Maghera-men Castle. The rocky masonry of the square keep has broken away now and is piled in heaps on the lush grazing-land below. What is now cow pasture was, during World War II, a broad, well-kept lawn that swept to the banks of the river Erne.

During the war, on overcast days the elegant crested lapwings flew in from the west, wheeling and circling below darkening skies. Even through the misty air the black and white of their graceful wings flashed against the sky to signal their landing approach. Like a squadron of Spitfires with lowered gears, they dropped as a single compact group into a corner of the grassy landing strip. About the time the lapwings had settled down to feed on the broad lawn, the distant drone of Royal Air Force Sunderland and Catalina flying boats would fill the still morning air (Figure 2). They

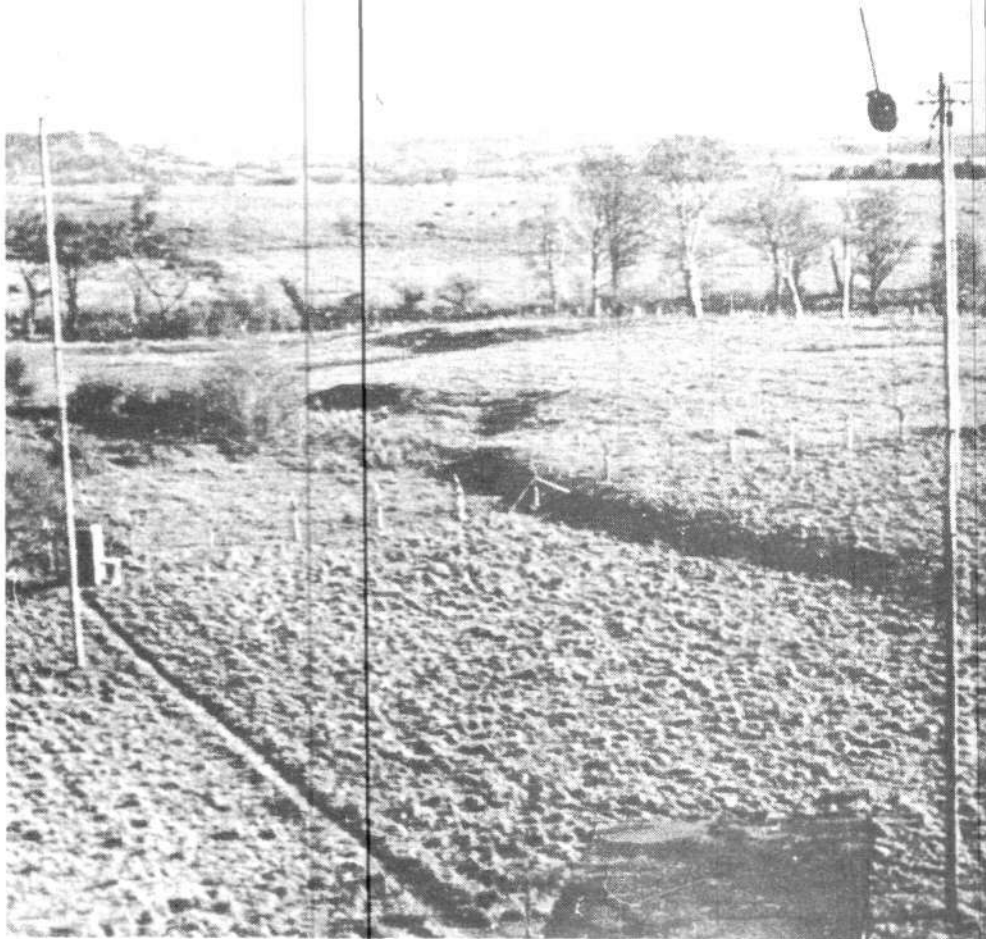


Figure 2
THE RAF FLYING BOAT



The author and friend, Belleek, 1944.

The Belleek radio-range beam antenna in a photo taken by the author while working at the top of one of the antenna poles. To the right (top) are the Margo cliffs, which overlook the south bank of Lower Lough Erne, where the RAF Coastal Command flying boats landed. The installation was very inconspicuous. The low-frequency transmitters were in the flat-roofed building (bottom of photo).



broke out in the west below the stormy clouds at dawn, and like lumbering albatrosses followed the river across the 10 miles of land that lie between the Atlantic and the safety of Lough Erne. It was a dangerous 10-mile stretch of land, for most of the aircraft had pushed their fuel to the limits. They were armed for submarine hunting across the North Atlantic. Overloaded with depth charges and bombs, there was no second chance if they missed the calm surface of their sheltered lough. Once in a while one missed, and the bodies of the crew were carried across the Irish Free State border by an honor guard. However, most of them made it back to Lough Erne.

Even today we do not understand how the lapwings can navigate for hundreds of miles back and forth between their feeding grounds, but we know how the Catalinas and Sunderland flying boats did it, for the pilots were tuned to the radio beam of the "Ultra Station" on Magheramena Castle grounds. Ultra Station was not the real name. That's what I call it today after reading *The Ultra Secret*, F.W. Winterbotham's intriguing book about the brilliant way in which British Intelligence decoded Germany's "Enigma" code. Once they broke the code, the RAF Coastal Command knew where every German submarine was located and could sink them from the air at will. The Ultra Station was really Belleek Radio Range and was maintained by an Air Force group called AACCS. The letters stood for the Army Airway Communication System, and AACCS operated a worldwide network of our navigational aids.

Belleek Radio Range Station was a very low frequency homing beacon. It sent a narrow beam of 330-kilocycle waves out over the North Atlantic and was a part of what Churchill called the "battle of the beams." It was a resonant system based on a fundamental principle of radio wave generation called a "tuned" or resonant circuit. The tuned circuit was invented by the great electrical genius Nikola Tesla in 1889. In 1890, Tesla built a low-frequency station similar to the Belleek Ultra Station and sent a low-frequency radio wave around the world. Technically speaking, the Belleek radio

range and moth pheromones (sex scents) have much in common. We may understand these similarities if we look back into the history of World War II.

Radio Warfare

Few persons today realize that during World War II there existed, concealed beneath the surface of the more visible war, a totally separate and secret electronic war. The electronic war was fought in the minds of a few communications wizards on both the German and Allied sides. Late in the war, after radar was perfected, it was fought with high-frequency radar systems designed by the secret groups. Early in the war, however, and, in fact, during major portions of the famous "Battle of Britain," right up to the bombing of Coventry, it was fought with homing beams similar to the one utilized in Belleek, Ireland, by Coastal Command, only at higher frequencies.

In the early 1940s, the Germans developed electronic systems that emitted 50-megacycle (50 million cycles) narrow radio beams. They directed these beams out over the major cities of England so that the Luftwaffe could fly straight to their targets. The German bombers did not have navigators on their crews as did the American and British bombers. The German pilot would fly the beam until he hit another radio signal that intersected the main "pathfinding" beam (Figure 3). He would then automatically release the bombs. Because the bombing took place at night, and often through overcast skies, the German pilots never actually saw the target. The English countered the German pathfinding beam in the sky in a very ingenious manner. They generated a beam on the same frequency as the second beam but directed it across the pathfinding beam over the wide open country south of London (Figure 4). When the German pilot hit the false marker, he thought he was over London and dropped his bombs. The London blackout was very rigidly enforced so that it took a long time before the Luftwaffe caught on. The English also very obligingly lit fires in the open fields so the Germans would believe they had

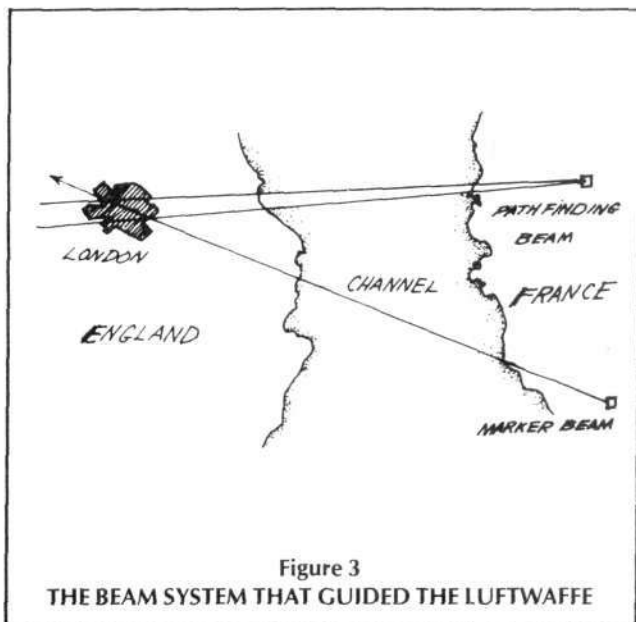


Figure 3

THE BEAM SYSTEM THAT GUIDED THE LUFTWAFFE

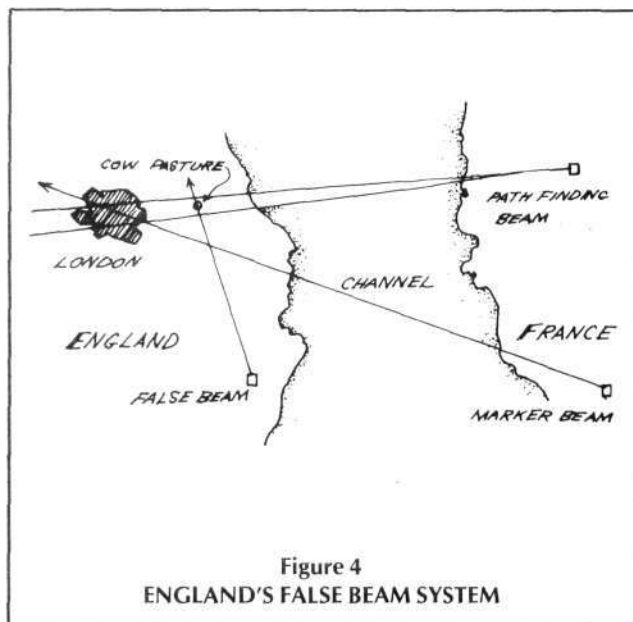


Figure 4

ENGLAND'S FALSE BEAM SYSTEM

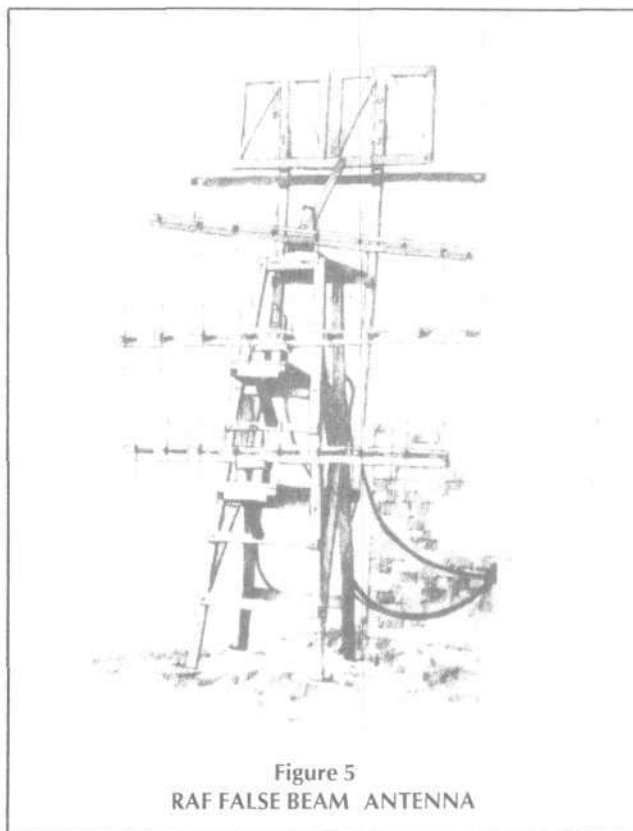


Figure 5
RAF FALSE BEAM ANTENNA

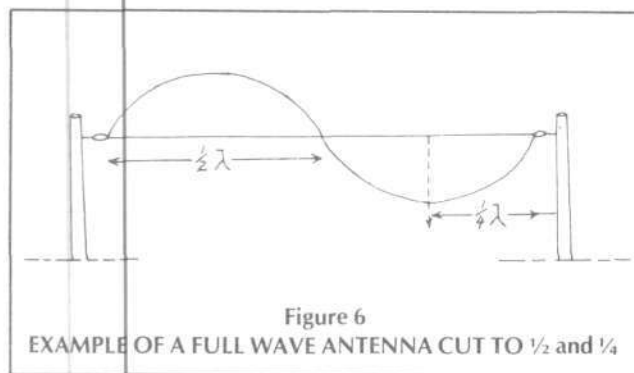


Figure 6
EXAMPLE OF A FULL WAVE ANTENNA CUT TO 1/2 and 1/4

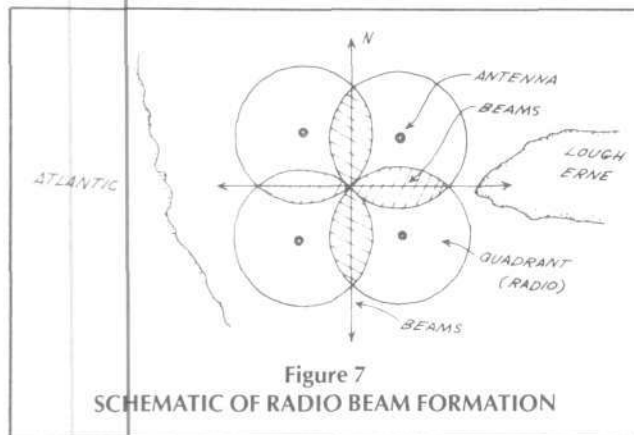


Figure 7
SCHEMATIC OF RADIO BEAM FORMATION

hit their target. (A very clever people these English!) The fascinating electronic war of World War II is documented by Winston Churchill in Volume 2 of his series on World War II, *Their Finest Hour*.

A drawing of one of the 50-megacycle antennae used to produce the false beam is shown in Figure 5. Its resemblance to certain moth antennae is obvious to any entomologist! Since the antenna (Figure 5) looks like a moth antenna with sensilla, we should try to understand how the antenna and tuned circuit works. It might be that the moth antenna really is an antenna!

The Tuned Circuit and Antenna

Just as a lens collects light and focuses it on a detector system, an antenna collects and focuses the longer radio waves on a receiver detector. Radio and optics have much in common, including a law called the "reciprocal law." The reciprocal law states that any antenna that makes a good transmitting system (putting out waves) also makes a good receiving antenna (collecting waves); the same goes for a lens.

We will discuss the antenna as a transmitting system, but the same principle holds for all receivers of radio waves.

An antenna is cut to equal the same length as the frequency being emitted. Such an antenna is called a full wave antenna. Antennas can also be cut to 1/2 or 1/4 wavelength and still work (Figure 6). Since the Belleek radio range was a low-frequency beam, the Belleek Radio Range station operated at 330 kilocycles, emitting waves 9.09 kilometers long. A 9-kilometer-long wire antenna would be a little awkward; it would stretch from Belleek to Garrison and back again

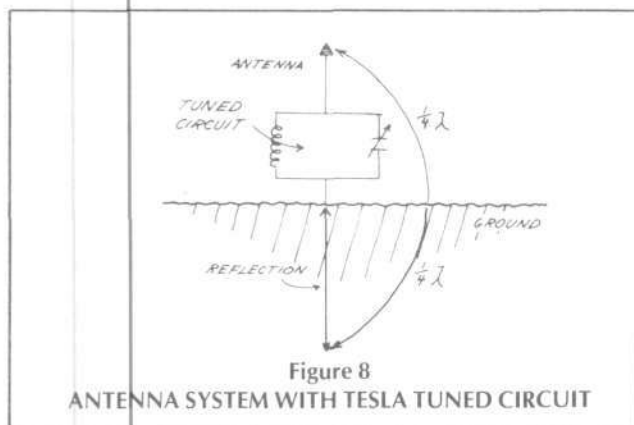


Figure 8
ANTENNA SYSTEM WITH TESLA TUNED CIRCUIT

(see Figure 1). A 1/4 antenna would still be 2.27 kilometers long. Since a low-frequency radio range beam required four antennas placed in a square to produce four right-angle beams, that would equal four times the wire of 2.27 kilometers—or 9.09 kilometers of strung antenna.

We will not go into the details of forming a radio beam but, simply put, each 1/4 antenna transmits a circular radio wave. Where each radio wave overlaps the other, the 330-kilocycle radio beam is formed (Figure 7). Thus, there are four radio legs emitted by such a station. At Belleek, the west leg led out over the Atlantic where the flying boats could intersect and fly the leg straight in. The east leg lay lengthwise along Lough Erne in order to guide the planes to a safe landing on the lough (see map).

To practically construct such a long wavelength system

so that one doesn't have to use 9 miles of wire, the antennae are electrically shortened or lengthened by utilizing a Tesla "tuned" circuit in the line that feeds each antenna. The circuit consists of a coil and a condenser in parallel. The bottom part of the coil and condenser is grounded and the top connected to the antenna (Figure 8).

One-fourth of the wire is represented by the antenna and the tuned circuit, and the other $\frac{1}{4}$ by radio reflection from the ground, so the whole system represents a $\frac{1}{2}$ wavelength antenna system. The ground can be compared to a mirror in the visible in that it reflects the other $\frac{1}{4}$ of the half-wave being emitted. The tuned circuit can be likened to your fingers on a violin string, and the antenna to the instrument's resonant sound box. When resonance is reached, by adjusting the condenser, the radio waves oscillate back and forth in the circuit similar to sound waves in a resonant box. The tuned circuit in effect electrically lengthens or shortens the wire antenna depending on frequency, the same way as your fingers do the vibrating violin string.

You reach resonance on the violin by shortening or lengthening the particular vibrating string with the fingers. At the right resonance points, all the sound waves go out in "tune." The same is true of the electrical resonant circuit. When the condenser is set right, all the radio waves go out together at 330 kilocycles from the Belleek Station.

On the violin, the vibrating string is the oscillator, the fingers the tuned circuit, and the wooden box the antenna for "focusing" the sound. In the radio circuit we must still have an oscillator (vibrator) before the system is complete. The vibrating electric oscillator is connected to the tuned circuit of the antenna by a second tuned circuit.

The Crystal Oscillator

Instead of a cat gut string, which vibrates to emit sound waves, the Belleek station had a quartz crystal oscillator (vibrator). Such a crystal is known as a piezoelectric substance. When the crystal is placed between two plates with an electric voltage across the plates, it is electrically stimulated to oscillate and emit radio waves. In other words, a piezoelectric crystal converts mechanical vibrations into electromagnetic vibrations. The frequency of vibrations depends on the temperature and the thickness of the crystal. The 330-kilocycle crystal is cut to a definite thickness just as the violin string is cut to a definite length.

If the temperature of the quartz crystal is kept constant, so that it does not expand or contract, then it keeps vibrating at the fixed 330-kilocycle frequency and the 9.09-kilometer-long waves are constantly emitted from the tuned wire antenna of the radio range station. Such a transmitter, in its basic form, consists of the antenna and tuned circuit coupled to the oscillator by a second tuned circuit. There is a vacuum tube to control the system. When the condenser in the antenna tuned circuit is adjusted right for 330 kilocycles, the antenna is electrically 9.09 kilometers long and all the waves go out from the antenna current, which is now oscillating along the length of the wires strung from telephone poles. In this manner, the small quartz crystal sends its message hundreds of miles out to sea and across the surface of the lake. The low-frequency beam guides the pilots of RAF Coastal Command safely home.

History records the Battle of Britain as being won by radar. During most of the battle, radar was not even perfected to the point of reliability. Winston Churchill called the real battle the "Battle of the Beams." Churchill ought to know, for he stated the following in *Their Finest Hour* (p. 338):

Of course, there would in any case have been much inaccuracy, but the whole German system of bombing was so much disturbed by our counter-measure, added to the normal percentage of error, that not more than one-fifth of their bombs fell within the target areas. We must regard this as the equivalent of a considerable victory, because the fifth part of the German bombing, which we got, was quite enough for our comfort and occupation.

Regarding the U-boat menace, he states (p. 608):

At the same time, however, we gave orders to the RAF Coastal Command to dominate the outlets from the Mersey and Clyde and around Northern Ireland. Nothing must be spared from this task. It had supreme priority. *The bombing of Germany took second place.* All suitable machines, pilots, and material must be concentrated upon our counter-offensive, by fighters against the enemy bombers, and surface craft assisted by bombers against the U-boats in these narrow vital waters [emphasis added].

It was not radar that saved Britain from bombers over its cities or from U-boats cutting it off from its American allies. Instead, Britain, as history truly records from the mouth of Winston Churchill, was saved by the Battle of the Beams!

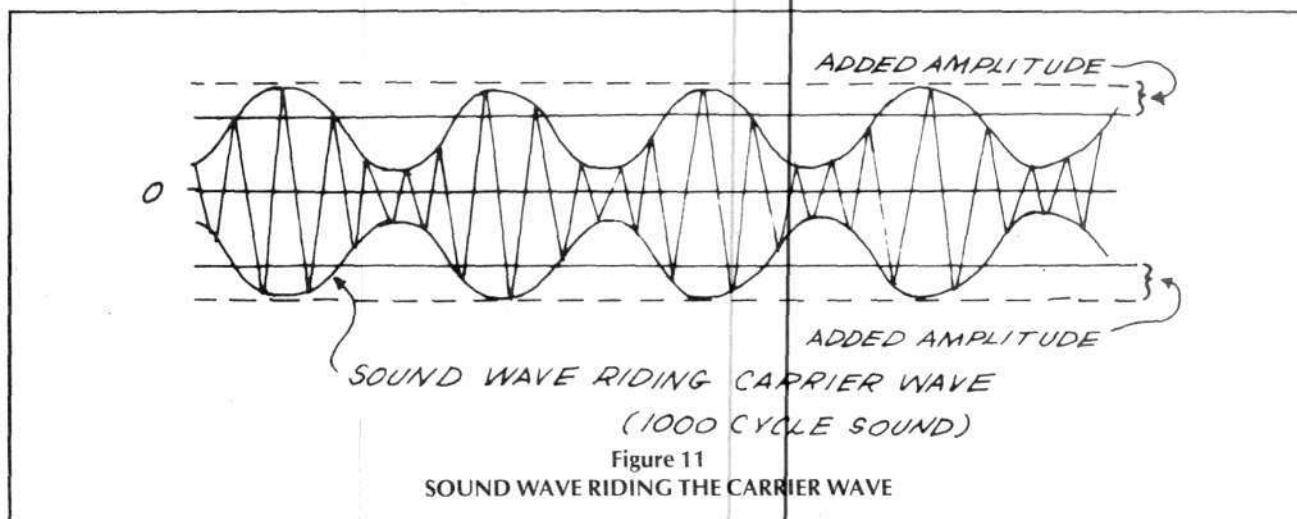
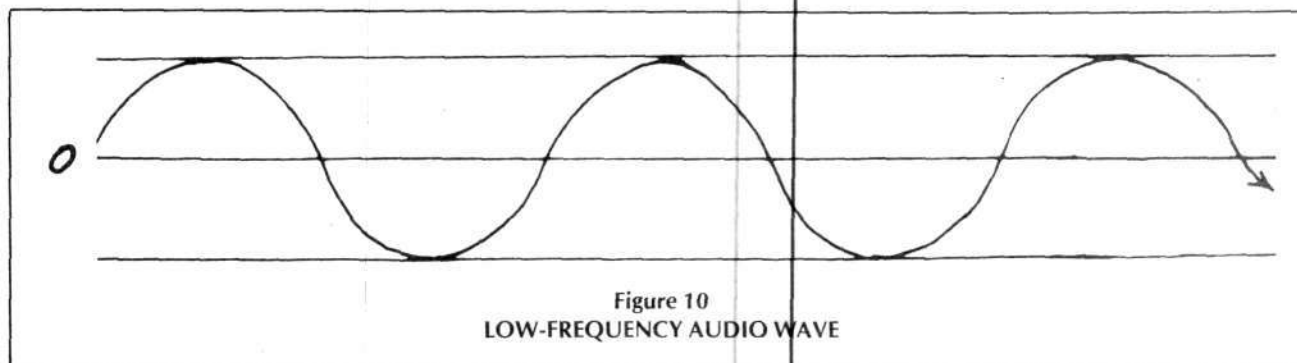
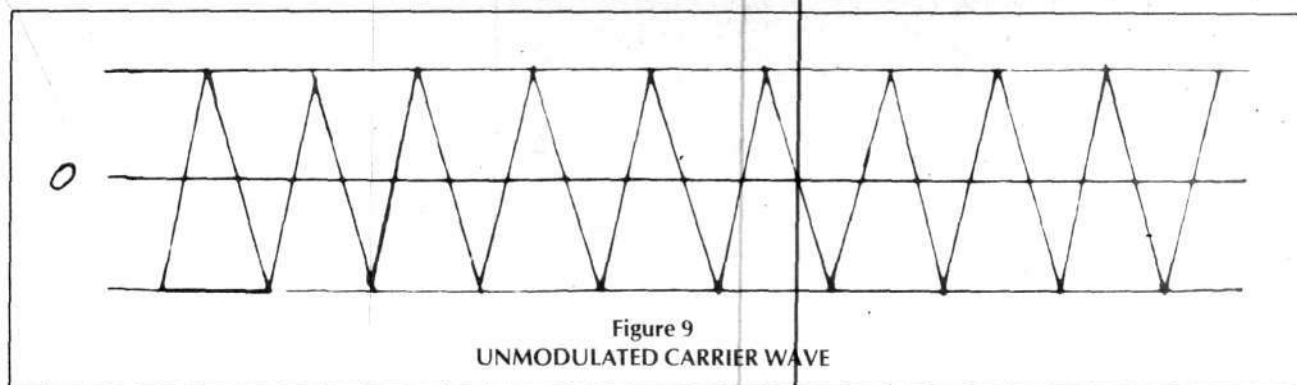
Magheramena Castle "Ultra Station" was such an important part of that battle of the beams that after the war the Belleek transmitter was mentioned by Churchill himself. The irrefutable fact is that he considered the U-boat war of the North Atlantic far more important than the bombing war.

Tap Dancing on Molecules

The "battle of the beams" is important for another reason. It is a quirk of fate (or God) that the very same battle led me to a concept that I today call "tap dancing on molecules"!

The battle of the beams has been over for 40 years, but in a very true sense I am still in a battle of beams. My battle today does not involve German subs and RAF flying boats, nor does it depend on low-frequency radio beams. It is an agricultural battle of the beams and it is directed at an adversary whose ability to outwit man is far more subtle and elegant than that of our German adversaries in World War II. For the last 20 years I have been busy decoding the "Enigma" code and navigation beam from insects that fly to and attack man and his crops. Today it is an entomological battle of the beams. To understand what I am talking about, we need to understand one more important concept of electromagnetic radiation, the concept of *modulation*.

The Belleek Ultra Station sent its beam of electromagnetic energy out over the Atlantic as pure radio frequency, or



RF as it is called in communications jargon. Such a wave is known as a *carrier wave* and can be tuned to by a tuned circuit and antenna. It is useless of itself, however, for it carries no information. It tells the Catalina pilot nothing. In order for him to get information he must be able to see or hear the beam. It must be translated into a system that his biological sensors can detect. It is translated by the process of *modulation*.

For the pilot to hear the radio-range beam from Belleek, we must superimpose a sound wave on the pure carrier wave. Put simply, we must vibrate the carrier wave with another vibrating wave of sound. The sound wave will ride the radio carrier wave—piggyback so to speak. In radio broadcasts this is accomplished by a microphone connect-

ed to vacuum tubes, or transistors that cut on and off with vibrations of the diaphragm in the microphone. The pressure waves in the air from the voice cause the diaphragm to vibrate according to the strength, called amplitude of the voice pressure wave. If the vibration is strong, then the amplitude of the signal on the grid of the vacuum tube goes up high and is added to the carrier wave emitted from the antenna. If the sound is weak, then the amplitude drops accordingly. The unmodulated carrier wave is a straight electromagnetic vibrating wave (Figure 9). The sound is a low-frequency pressure wave (Figure 10). When the two are added on the grid of a vacuum tube, it looks like the drawing in Figure 11.

We see then that the pressure wave from the sound has

been converted to a strong or weak (+ or -) electrical signal on the grid of the vacuum tube, or inside the transistor. The audio wave adds to, or subtracts from, the carrier wave. Thus, the audio wave not only adds an audio signal to the transmitter system, but also amplifies the electromagnetic wave.

In order for the pilot to hear the Belleek radio range, we modulated each of the four towers with a 1,000-cycle audio tone. Two of the opposite towers sent out an A (. -), and the other two opposite ones transmitted an N (- .) Morse code tone signal (Figure 12).

Since each tower sent out a circular pattern, the pilot heard an N (- .) if he were in one quadrant and an A (. -) if he were in another. He would turn at an angle until, as he approached the area where the two patterns overlapped, the A and N would begin to blend together into a steady tone in his headset. He then turned and flew along the steady tone beam to Lough Erne. If the pilot drifted to an A or N quadrant, he would turn back into the steady tone; thus, his flight course was a gentle undulating pattern (Figure 13).

The entire system then depended on four fundamentals of electromagnetic navigation:

- (1) a stable electromagnetic carrier wave being transmitted;
- (2) an audio modulation system;
- (3) a resonant circuit and antenna to collect or focus on the carrier wave;
- (4) tracking in and out of the system to fly it.

The German bombing beam operated in exactly the same way, except that the two overlapping patterns were 50 megacycles instead of 330 kilocycles.

Keep these four requirements of a good navigation system in mind as I explain why I call my work "tap dancing" on molecules.

The Molecular 'Radio Range'

After the war, I left the Army Air Force and took a job as civilian chief of maintenance for navigational aids in the Far Pacific Air Force in Japan. I was responsible there for installing and maintaining 16 or more such systems scattered around Japan and the Far Pacific. American aircraft flew the system until it was replaced by more modern systems years later. I spent literally hundreds of hours in the air flying in and out of such beams to check their courses and keep them in tune. I was a biologist at heart, however, so after a few years I left to return to college, where I trained as a field biologist in ornithology and entomology.

Forty years of watching moths fly to lights and candles, and watching the gyrations the male executed in finding his mate (Callahan 1957; 1958), convinced me that insects fly a molecular beam of scent in exactly the same way that I flew the radio range beam when I was installing them.

I spent hundreds of nights in the field and lab watching the corn earworm moth, *Heliothis zea* (Boddie), fly to its mate using the same tracking system as an aircraft. I also knew that visible light had to be very important to the system, so I wrote my PhD thesis on the effect of light on the mating and egg-laying of the corn earworm moth.

There was another even more important indication that insect scent (olfaction) had to operate as an electromagnetic system, and that is the shape of the moth antenna. As pointed out above, the moth antennae resembled in every way the shape of the antennae used by the RAF to fool the Luftwaffe (Figure 5). The moth antenna, in fact, looks very

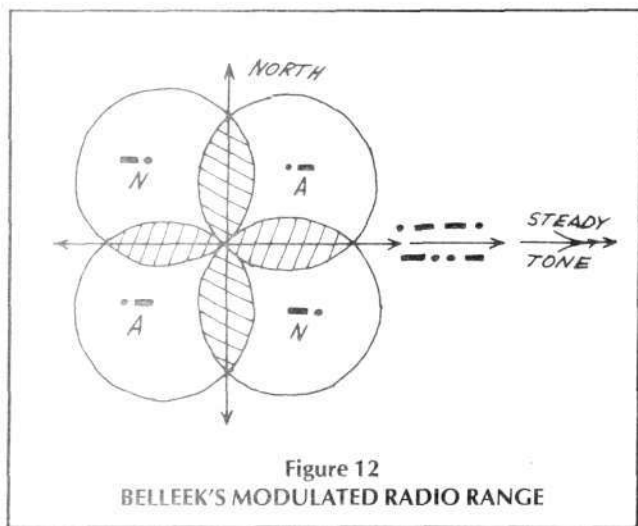


Figure 12
BELLEEK'S MODULATED RADIO RANGE

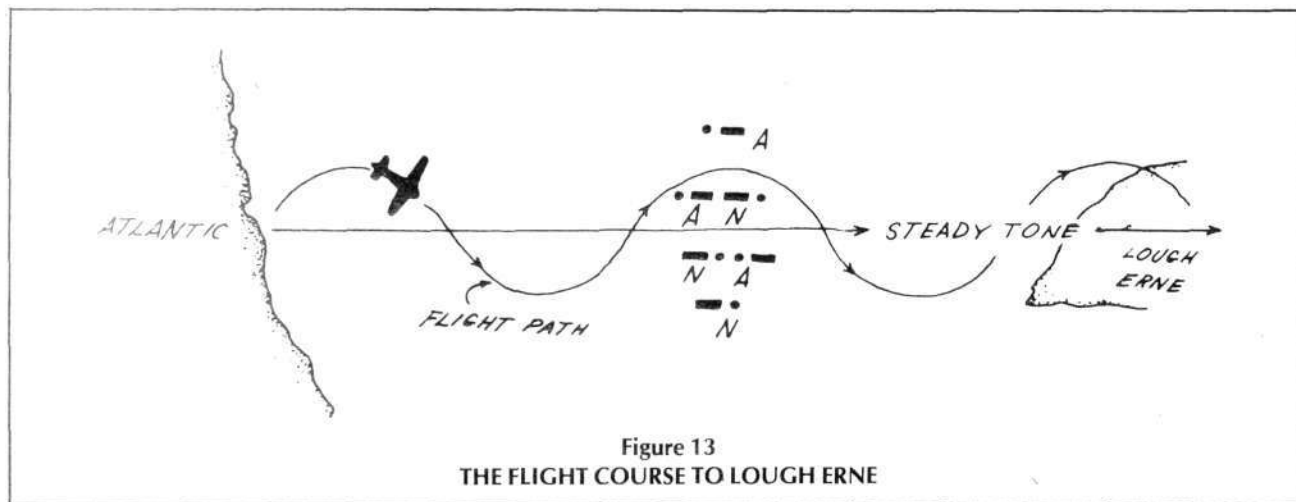


Figure 13
THE FLIGHT COURSE TO LOUGH ERNE

much like a TV antenna—long bars (spines) at the base for long waves, and short bars (spines) at the tip for shorter waves.

By the time I finished the morphology of the corn earworm moth antenna, I realized it was designed to operate as what today is called a *log-periodic* antenna. Without discussing the mathematics of logarithmic spacings, essentially the bars or spines get closer and closer together from the base to the tip (Figure 14).

The shape indicated that any plant or sex scent that blows through the air must emit electromagnetic wavelengths and that the length and diameter of the spines could tell me where the wavelengths lay in the electromagnetic spectrum. A few simple mathematical calculations told me that I should be exploring the infrared spectrum.

Because the spines on the moth antenna average between 8 and 80 microns long, I knew the wavelength would lie in that region. Remember, the antenna must match or be a multiple of the length of the wave to be transmitted or collected by the antenna. In the case of the *corn earworm* and *cabbage looper* moths, the wavelength fit was perfect for the 15-micron to 30-micron region of the infrared spectrum. From my experience working with the low-frequency radio-range system, I had another excellent clue as to how an insect sex scent might work as it drifted like a plume of smoke through the air.

An oscillator, whether it be a small molecule or a large crystal, can be stimulated to give off electromagnetic waves. In the case of the molecule, and the short visible and infrared waves, high-energy radiation from the short end of the spectrum "pumps" the system by raising (absorbing) the electrons of the molecule to a higher energy level. As they drop back down, they emit wavelengths in a longer wave portion of the spectrum. We call this phenomenon *fluorescence* or in the case of molecules colliding with a surface, *scattering*. In the case of radio, the crystal in the oscillator is stimulated by electricity (voltage across the plates) to emit radio waves.

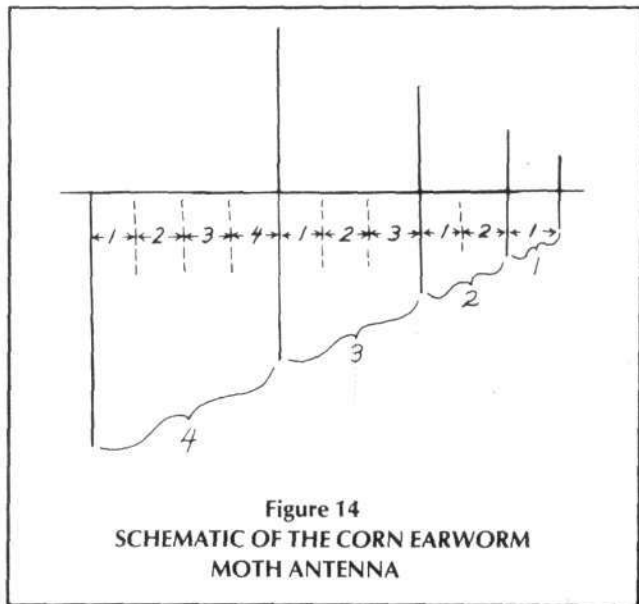


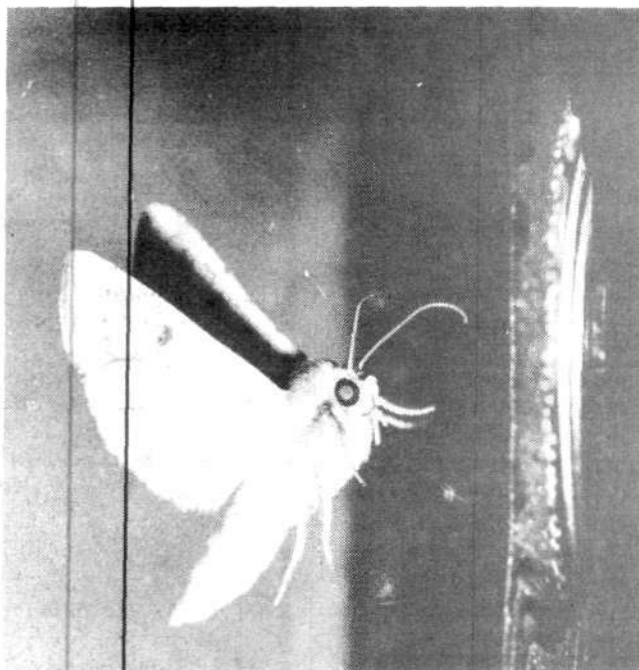
Figure 14
SCHEMATIC OF THE CORN EARWORM
MOTH ANTENNA

At Belleek we had to constantly check the temperature of the crystal oscillator. The temperature of the crystal is controlled very closely because the frequency of emission shifts with temperature. If the crystal heated up, it expanded, and because wavelength depends on thickness, the frequency would shift higher or lower depending on the cut (shape) of the crystal. The change in an X- or Y-cut crystal, as they are known to radio engineers, is not a straight line but jumps around. In other words, it is nonlinear, just as in the case of oscillating molecules in a laser system. I reasoned that if a quartz crystal oscillator can change in frequency according to its temperature, then surely the same holds for a molecular oscillator.

Later on, work by laser scientists told me that I was right and that any nonlinear, narrow-band wavelength from a scent molecule should shift both with the concentration of the molecular oscillator in the air and with the air temperature. Since organic dye lasers emit longer waves at higher concentrations and higher temperatures, so also should the free-floating emitting molecule.

We have now come full circle back to my own "hour of the wolf" on the Pullan in Ireland. Consider the following in the light of what I have presented about good communications systems:

(1) The blue and near-ultraviolet light floods the night sky, and the moths that see with their eyes in that ultra-



The corn earworm moth, *Heliopsis zea*, flying to a window lit with low-intensity blue light. The low intensity blue "pumps" the corn scent in the chamber causing it to emit coherent (maser-like) lines just in front of the window. The insect is not going to the light because of its eyes, as is commonly believed, but to the pumped infrared lines in the airspace in front of the light. These infrared lines are detected by the insect's log periodic antenna spines, called *sen-silla*.

violet-visible region fly out into the night light.

(2) The females release an organic sex scent, called a pheromone by entomologists, into the night air.

(3) At the female body, the scent is at high concentration and warm, and at a distance it is at lower concentration and cooler, depending on how far it is blown by a gentle breeze.

(4) The scent is radiated by the ultraviolet and blue sky as it is pumped to a high energy level.

(5) The sex scent (pheromone) drifts through the water molecules in the air and they knock against one another; thus the system is modulated by air pressure movement in the same manner as voice pressure waves knock against a microphone diaphragm. This is called *gasdynamic modulation* by laser physicists. As the scent flows, it collides with the insect antenna and scatter out coherent Cabannes infrared wavelengths to which the spines resonate.

(6) As sex scent (pheromones) float through the air, each one is primed like a free-floating maser (a maser is a microwave laser), but is also cooling (thermodynamically) according to distance and concentration (Figure 15).

(7) At a distance from the female the sex scent is cooler and less concentrated, so shorter wavelengths are emitted. Close by, at the tip of the female abdomen where the sex gland is located, longer wavelengths are emitted.

(8) The male flies into the scent and the molecules flow past and collide with the short spines on his antenna, which are the proper length to resonate to the short wavelengths. If he strays too far from the floating infrared scent, the system cuts off because the concentration of sex molecules in the water vapor of the air is too dilute. He turns back into the plume of the sex scent. As he gets closer and frequencies shift to longer waves, the longer spines take over (Figure 16).

(9) The male flying the sex scent has an additional powerful means of modulating the free-floating infrared scent besides the gasdynamic principle. He vibrates his own antenna at audio frequencies. All insects vibrate when they fly, and different species vibrate at different frequencies.

The reader can appreciate by now that the only difference between the RAF flying the Belleek radio range beam and a moth flying a sex scent beam is that the radio beam is emitted from one point—the radio station—whereas the molecular beam is formed by millions of little free-floating oscillators (radio stations) whose wavelength and frequency depend on concentration and the temperature in the night air. The beauty of this God-made infrared “radio range” is that it not only tells the male moth direction, but also, depending on temperature and concentration, distance from the female. It is an elegant navigation system that contains both direction and distance information and is modulated by the vibrating flying insect and also the night breeze.

Of course, the system is not limited to sex scents alone; the same system will work to lead a cabbage looper moth to the scent from a cabbage field, or a corn earworm moth to a corn field, and even a house fly to the scent from a rotting carcass.

The Proof of the Pudding

How would one prove that the cabbage looper pheromone emits infrared radiation of the proper resonant frequencies and that such emitted frequencies shift with temperature and concentration?

For many years I could not prove it, for we did not have any instruments with high enough resolution to “see” these narrow maser radiations from scent molecules. In 1969, however, an instrument called a Fourier Transform Spectrometer was invented. When I tuned to the cabbage looper sex scent with this instrument, I found the nonlinear maser emissions exactly where I predicted. Furthermore, they shifted with concentration and temperature just as I predicted (Callahan 1967, 1969, 1975, 1977 abc; Callahan and Hamilton 1977).

I have since experimented with many different insect attractants, and in every case I have found nonlinear maser radiation that matches the insects’ antenna spines. Fire ants,

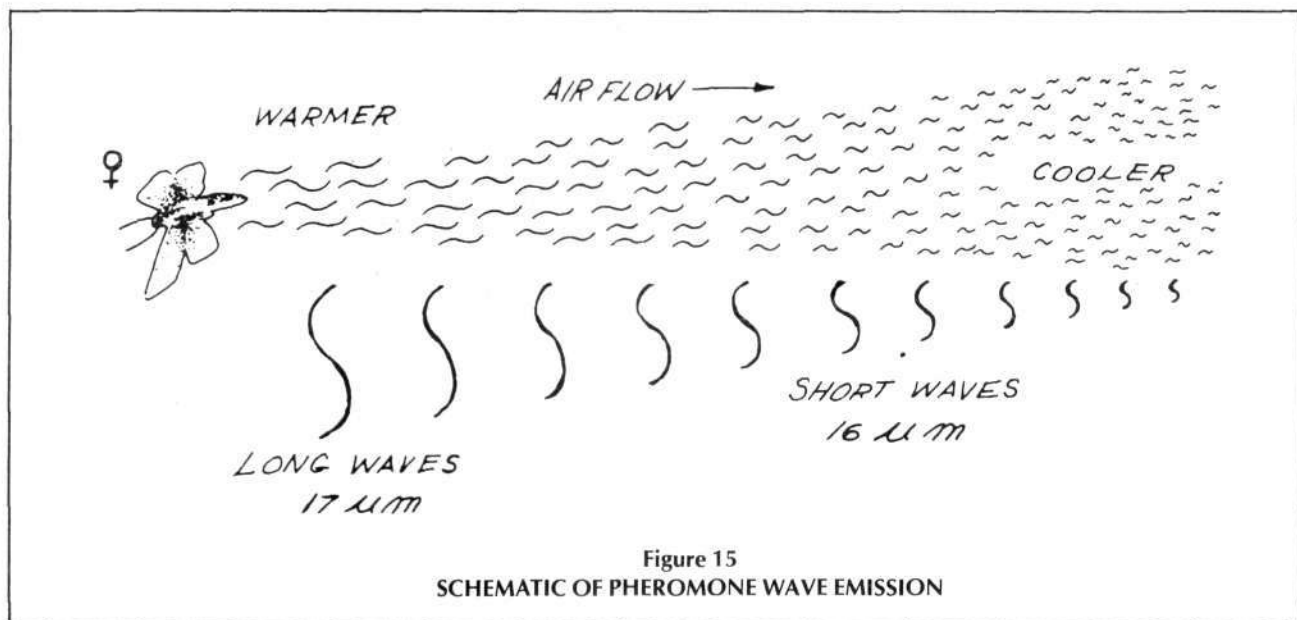


Figure 15
SCHEMATIC OF PHEROMONE WAVE EMISSION

for instance, follow their trail by vibrating their antenna and modulating the chemical trail at 15 cycles per second. They also tap the thin layers of molecules on each other's bodies and cause these "body identification" molecules to emit maser radiation. Because these antenna vibrations and tapings modulate small concentrations of identification molecules, whether in the air or as thin layers on plants or other insects' bodies, I call such insect modulation techniques "tap dancing on molecules."

If you do not believe that insects tap dance on molecules, then the next time you are in a fruit market watch closely a little fruit fly walking over the plums and strawberries. His feet have spines or antennae on them and every once and a while the fly will stop and drum them against the skin of the fruit. House flies are constantly vibrating their antennae and feet, and if we listen closely, we can hear the hum from almost any vibrating flying insect. Insects are vibratory creatures and entomologists must measure the frequency of these vibrations in studying insect attractants!

The implications of this system are revolutionary for control of those unwelcome insects that feast on our agricultural crops as though man had set a vast table for their dinner. We can electronically duplicate the frequency to which the insect is attracted, thereby bringing them to a central spot where they then can be killed. Or, we can come up with a beat frequency, a jamming frequency, that would mask the insect attractant of the crop, keeping the insects away from the crops and sending them back to feed on the weeds from which they evolved.

The advantage of this elegant and useful system is that unlike pesticides, these frequencies can be switched on and off. If a particular frequency were to resonate to something that could cause damage—which is highly unlikely, since these are weak infrared frequencies—it could be switched on only at night or according to need. What more useful way to revitalize the Silicon Valley computer recession than giving the industry the task of devising the small diode lasers required to emit the frequencies that will pre-

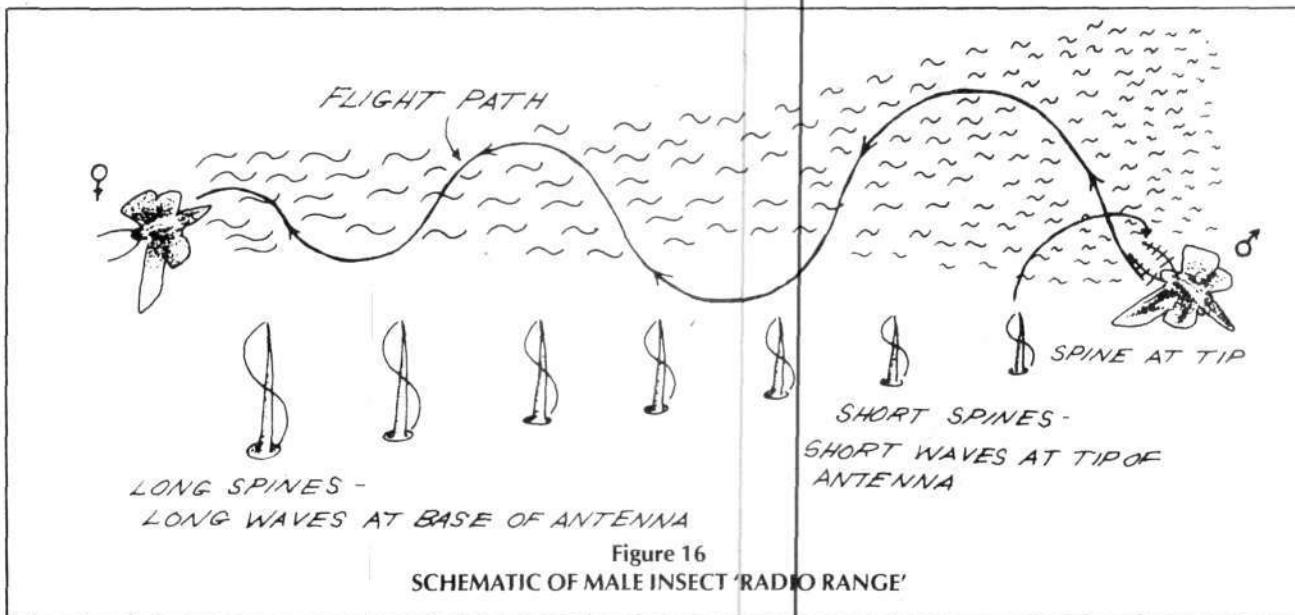
vent insect and pest damage.

From what I have written about insects, the reader may understand that I am the first person in the world to decode the insect molecular communication system. I did it by exploring the spectrum, and it all began in World War II with the battle of the beams.

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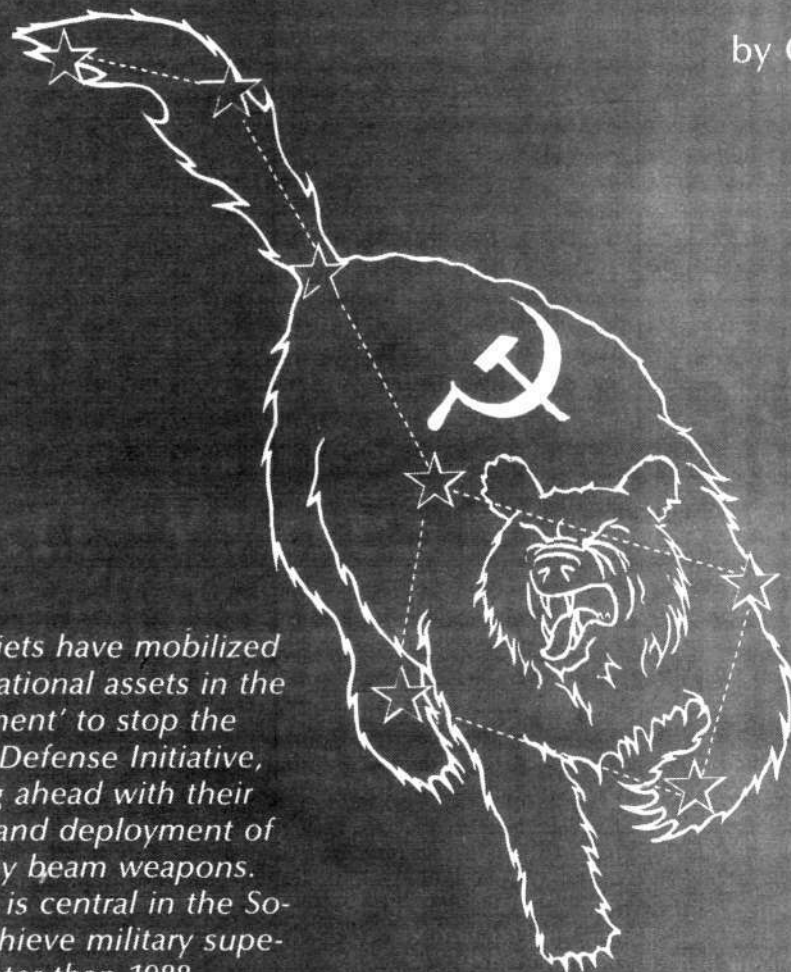
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The Soviet 'Star Wars' Program:

Full Speed Ahead Since the 1960s

by Criton Zoakos



While the Soviets have mobilized all their international assets in the "peace movement" to stop the U.S. Strategic Defense Initiative, they are racing ahead with their own research and deployment of directed energy beam weapons. Beam defense is central in the Soviet plan to achieve military superiority by no later than 1988.

The "Star Wars" capability of the Russians based on directed energy weapons is at least 10 years ahead of the American Strategic Defense Initiative: As of the end of 1984, it had completed its "research" phase and had entered its development and deployment phase. It is expected that the Russians might deploy their first, crude, space-based antimissile laser weapons some time toward the end of 1985.

The Soviet Strategic Defense capability is made up of a "High Frontier" component and a "Star Wars" component. The Soviet "High Frontier" strategic defense (so labeled after General Daniel Graham's eponymous proposal, which attempts to build an antimissile defense based principally on conventional, nonlaser technologies), is extensive and has been in existence since the 1970s. Soviet Strategic Defense is the assigned combat mission of a branch of the Armed Services that has no equivalent in the United States, called the Air Defense Troops (*Voiska Protivovozdushnoi Oborony*, formerly called National Air Defense, or *PVO Strany*). The PVO has approximately 550,000 men under arms, 7,000 radars, more than 3,000 interceptors, more than 13,000 surface-to-air missile (SAM) launchers (most with reload capability), a great number of early warning satellites, integrated battle management radar stations, and other capabilities.

Within the National Air Defense are two subdivisions which, though established in the mid-1960s, are little discussed and maintain a low public profile because their very existence violates the 1972 anti-ABM Treaty. They are the Anti-Space Defense (PKO) and the Anti-Rocket Defense (PRO).

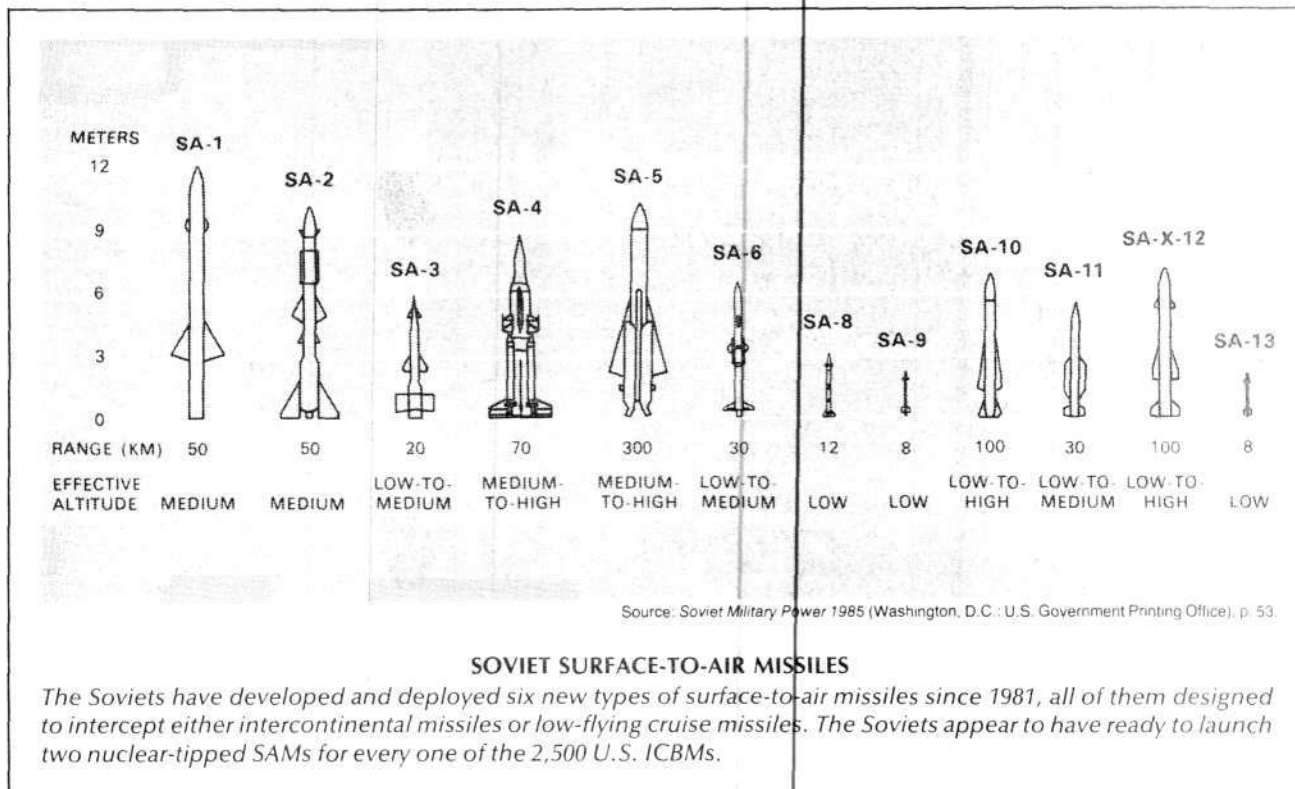
The more than 13,000 Russian SAM launchers service 12

different types of surface-to-air missiles deployed to defend an estimated 400 to 500 strategically important locations. These defended locations are, primarily, the land-based ICBM sites, all primary and secondary command-and-control centers, major industrial and major political/administrative assets. The different combat-ceiling altitudes of the various SAMs provide a kind of layered area defense that can operate from exoatmospheric altitudes all the way down to altitudes expected to be used by low-flying cruise missiles. The Soviet SAMs most versatile and most appropriate for antimissile defense appear to be the 54-foot, 22,000-pound, nuclear-tipped SA-5s, deployed in an estimated 100 different sites in numbers of approximately 2,000 launchers.

Since 1981, the Soviets have developed and deployed six new types of surface-to-air missiles, all of them designed to intercept either intercontinental missiles or low-flying cruise missiles. Of these, the versatile, super-fast SA-10 is considered by the Soviets as the "critical National Air Defense weapon of the 1980s." For lower-altitude defenses, it is complemented by the SA-11. Faster, higher-flying, and electronically more sophisticated and more maneuverable (also more reliably integrated in the Soviet early-warning and radar system), are the more recent SA-X-12, SH-04, and SH-08.

The earlier-generation SA-1, SA-2, and SA-3 launchers, which during the 1970s constituted the backbone of Soviet strategic air defense, are reported to be in the process of being replaced by the modern, reloadable, ABM-capable SA-10.

These systems and the Soviets' known antisatellite systems are the backbone of their "High Frontier" strategic



defense, as distinct from the directed-energy-based, budding "Star Wars" capability. How much effective, active defense the Russians' dense surface-to-air missile deployment can offer against incoming ICBMs is a matter of speculation. The only realistic assumption one can make under the present strategic circumstances, is that the most difficult task these forces would have to face would be to defend Soviet assets after a Soviet first strike against U.S. land-based ICBMs. If the American ICBMs are caught on the ground and killed, and if (a generous) half of the American nuclear missile submarines are able to launch their weapons, the Soviet SAM force will have to seek and destroy approximately 2,500 nuclear low-yield, not very accurate, not very long range warheads.

At this time, the Soviets appear to have ready to launch something like two nuclear-tipped SAMs for every one of these warheads. If the American retaliation is organized in successive salvos and not in one instantaneous barrage, then the Soviet strategic defenses would be able to reload and thus deploy more than two SAMs per American warhead. If Soviet antisubmarine operations succeed in pinning down or otherwise neutralizing American nuclear missile submarines, the ratio of defending SAMs against incoming American warheads would further improve for the Soviet defenders.

The Question of Soviet 'Breakout'

The Soviet antimissile missile capability, however, is only a small portion of the Soviet Strategic Defense program. Its space-based, directed energy ballistic missile defense program has been growing by leaps and bounds during 1984 and 1985:

Jan. 16, 1984. *Aviation Week and Space Technology* reported that, according to a high administration official: "What seems clear is that there is in progress a pattern that places Soviet activity very close to the line in terms of a breakout. . . . We might find this year that we have zero time to respond to an ABM Treaty breakout by the U.S.S.R. with no way to provide in a timely way a parallel capability."

March 28, 1984. U.S. Admiral Elmo Zumwalt testified before the Subcommittee on Defense of the Senate Committee on Appropriations: "The Soviet Union is 10 years ahead of the United States in antiballistic missile defensive capabilities. The Soviets may, in just another year's time, be able to defend over one-third of both their population and offensive forces from the U.S. retaliatory deterrent. The Soviets may also at any time launch the first antiballistic missile battle station in space, where they have long been superior in antisatellite capabilities."

April 2, 1984. *Aviation Week* reported that the Soviet Union has launched an intensive program at the Lebedev Physics Institute and the Kurchatov Institute of Atomic Energy to develop a nuclear-pumped X-ray laser. Progress is also reported in computerized guidance systems, laser communication with submarines, and laser optics.

July 25, 1984. Cosmonauts aboard the Salyut-7 space station took a space walk and tested a 66-pound industrial laser.

Soviet progress in ballistic missile defense during 1984 was summarized by the planning chief of the West German

defense ministry, Dr. Hans Ruehle, in a Jan. 22, 1985 article in the daily *Frankfurter Allgemeine Zeitung*, headlined "Chernenko's Star Wars." Ruehle wrote:

While the Soviet missile programs silently continued, the American activities were buried formally and *de facto* by the Anti-Ballistic Missile Treaty. Thus, this treaty prevented any progress toward an efficient American missile defense system, without stopping Soviet research programs and modernization measures.

Since the 1960s, the Soviet Union has been undertaking an impressive military research and development program in the field of beam weapons. . . . On the basis of this work, one has to assume today that the Soviet Union has the potential and the technology for building militarily efficient beam weapons.

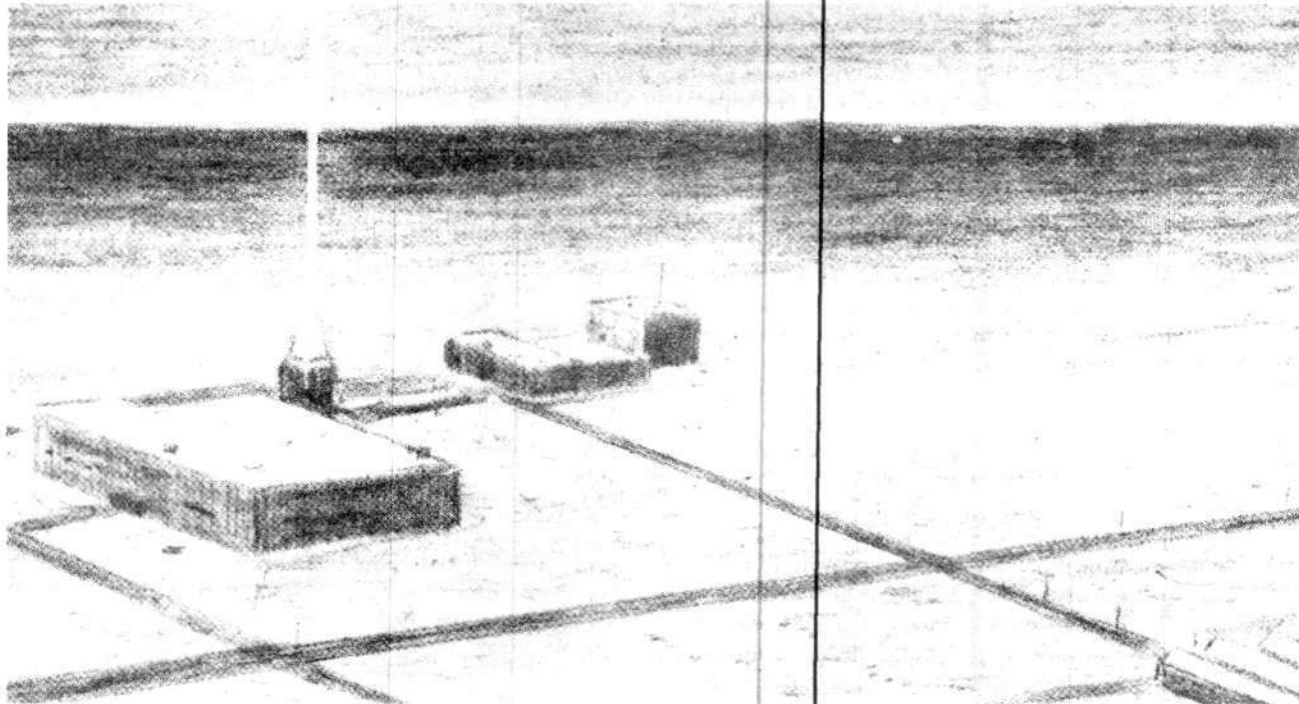
This is true especially for laser weapons, where the Soviet Union has invested three to five times as much as America has done. They have 12 big research centers and 6 big testing facilities. In Troisk, they have built plants for the production of laser weapons. In Saryshagan, a huge ground-based laser has been under construction since 1971. . . .

No less alarming are the massive research programs in the field of producing radiofrequency beams and particle beam weapons. . . . It can be taken for granted that the Soviets are ahead. . . .

They are also in the process of building heavy transport rockets. In the works is a rocket of 100-meter length with a transport capacity of 150 tons. This would enable the Soviet Union to transport very heavy weapon systems into space within a very short period, without engaging in any complicated assembly work.

Approximately one month after Ruehle's report, U.S. government defense intelligence analysts announced that the Soviet Union had completed the technology research phase of its high-energy laser program and had now begun developing prototype laser weapons. Some are of the view that the Soviets might deploy at least one such prototype space-based weapon in 1985. Their ground-based laser point-defense capability is suspected to be much more advanced. For example, during the June 1985 flight of the U.S. Space Shuttle, a Soviet ground-based laser "painted" the American spacecraft for approximately five minutes, thus demonstrating sophisticated targeting and tracking capabilities.

During 1984, the Soviet space budget was over \$22 billion and had been growing at a rate of 15 percent per year. Though the Soviet laser weapons program was placed under strictest secrecy classification in 1977, numerous un-concealable features have been made known since then. For example, it is known to employ more than 10,000 scientists in 12 major research facilities and at least 6 testing and development facilities. From 1983 onward, the Soviet space-laser weapons program conducted a number of spectacular experiments in outer space that were deliberately underplayed by Western government and news agencies. The Salyut-7 space station is known to have repeatedly



Soviet Military Power 1985 (Washington, D.C.: U.S. Government Printing Office), p. 58.

U.S. Defense Department illustration of the Soviet directed-energy R&D site at the Sary Shagan proving ground includes ground-based lasers that "could be used in an antisatellite role today and possibly a ballistic missile defense role in the future."

carried out laser experiments, including one with electron beams conducted by cosmonauts Dzhannibekov and Savitskaya.

The existence of the Soviet program for space-laser defense is not exactly a secret. In fact, the existence of the Soviet beam weapon program has even been officially admitted by former Foreign Minister Andrei Gromyko who, in answering a direct question from Italian Foreign Minister Andreotti, acknowledged that the Russians are indeed building beam weapons. Andreotti's response was to propose that the matter be taken up at the summer 1985 international scientific discussions held at Erice, Sicily. Gromyko's recent admission, which was widely reported in the Italian press, has caused no change whatsoever in official Soviet propaganda, which continues to refuse to admit the Soviet exertions going on in this field.

What is secret are merely the various detailed features of the Soviet program and its proximity to a strategically significant "breakout." Marshal Sokolov, for example, the new Soviet defense minister after Ustinov's death, reported in one of his first public statements in May 1985: "The U.S.S.R. is conducting scientific research in space, including for military application" [emphasis added]. This statement was made in a lengthy interview to the Soviet news agency TASS, published in the May 5, 1985 issue of the military daily *Krasnaya Zvezda*.

On an earlier occasion, Marshal of the Soviet Union Aleksandr Koldunov, commander-in-chief of the Soviet Air Defense Troops, boasted that his troops "are equipped with cruel weapons and the most modern combat technologies

capable of tracking and destroying present as well as future weapons of air attack in all heights, day and night, in any weather."

To estimate just how advanced the Soviets are on their way to a "breakout" from the 1972 ABM Treaty, we shall take into account two sets of considerations: First, what are their known technological breakthroughs, and second, what are the military/doctrinal imperatives that propel them to acquire Ballistic Missile Defenses based on "new physical principles"?

On the first: The exact state of progress by the Soviet researchers is not available in the open literature in either this country or the Soviet Union, but the following facts are known:

Soviet Laser Capabilities

(1) The Soviet Union has developed a land-based laser capable of "blinding" U.S. surveillance satellites. Using an intense beam of visible light, the Soviet weapon can overload the sensitive cameras in the spy satellites, and, in some cases, can destroy the delicate optics. This weapon has been available for at least the last six years.

(2) The Soviet Union has developed a land-based high-powered laser capable of destroying pilotless, subsonic aircraft. These experiments have been observed by Western reconnaissance for several years.

(3) The Soviet Union has now available extremely high energy power sources ideally suited for beam weapon use. As the Department of Defense has put it, "They have de-

veloped a rocket-driven magnetohydrodynamic (MHD) generator which produces 15 megawatts of short term electric power—a device that has no counterpart in the West.”

(4) The Soviet Union has developed a high-energy microwave technology that has been used for ionospheric modification. An exotic weapon using beam technology, this microwave generator would enable the Soviet Union to “tailor” the upper atmosphere so as to block radio transmissions, destroy radar reception, and conduct electronic warfare on a global scale.

(5) The Soviet Union has tested a plasma beam weapon that generates discrete plasma “bullets” capable of long-distance travel. Similar to ball lightning, these plasmoids carry large energies in an electromagnetic field-plasma complex sufficient to destroy a ballistic missile.

(6) The Soviet Union has tested a high-energy iodine laser, which has successfully downed a ballistic missile. This experiment was a test of a strategic beam weapon, not intended for battlefield use as an antitank or anti-aircraft weapon, but as a ballistic missile defense system.

Soviet Commitment to Beam Weapons

On the second consideration, the military-doctrinal reasons for which the Soviets have always been committed to development of high-energy laser strategic missile defense, the following should be reiterated and noted.

The seminal 1962 book by Marshal V.D. Sokolovskii, titled *Military Strategy* and employed as the basic textbook for the selection, formation, and training of Marshal Ogarkov's current generation of Soviet military leaders, made unmistakably clear the role assigned to strategic defense by the Soviet High Command. Here are some of the most important pronouncements of the Sokolovskii book's 1962 and 1963 editions (now withdrawn from circulation):

An antimissile defense system for the country should obviously consist in the following: long-range detection of missiles using powerful radar [ground and airborne] or other automatic technical equipment [on artificial Earth satellites] to assure the detection of missiles during the boost phase [at the moment of lift-off or while the engines are operating]; working out the coordinates of the flight trajectory of the missiles; timely warning, and application of active measures; antimissile batteries; jamming devices to assure deflection of the missile from its intended target and, possibly, to blow it up along its trajectory.

Possibilities are being studied [back in 1962!] for the use, against rockets, of a stream of high-speed neutrons as small detonators for the nuclear charge of the rocket, and the use of electromagnetic energy to destroy the rocket charge in the descent phase of the trajectory or to deflect it from its target. Various radiation, antigravity and antimatter systems, plasma ball lightning etc., are also being studied as a means of destroying rockets. Special attention is devoted to lasers; it is considered that in the future, any missile and satellite can be destroyed with powerful lasers. All this work which is being conducted in other countries deserves great attention.

The creation of a reliable system of antispace defense became an important task in modern conditions. . . .

Ballistic missiles employed en masse are still [that is, in 1962] practically invulnerable to existing means of PVO [National Air Defense] and their employment is almost independent of weather conditions. Only as special instruments of PRO [Anti-Rocket Defense] are developed will it be possible to combat the massive use of missiles in the air. . . .

On March 31, 1967, a few weeks after President Lyndon Johnson went public with Robert S. McNamara's project to conclude an ABM treaty with the U.S.S.R., General Major N. Zavyalov reiterated, in an article published in the military daily *Krasnaya Zvezda*:

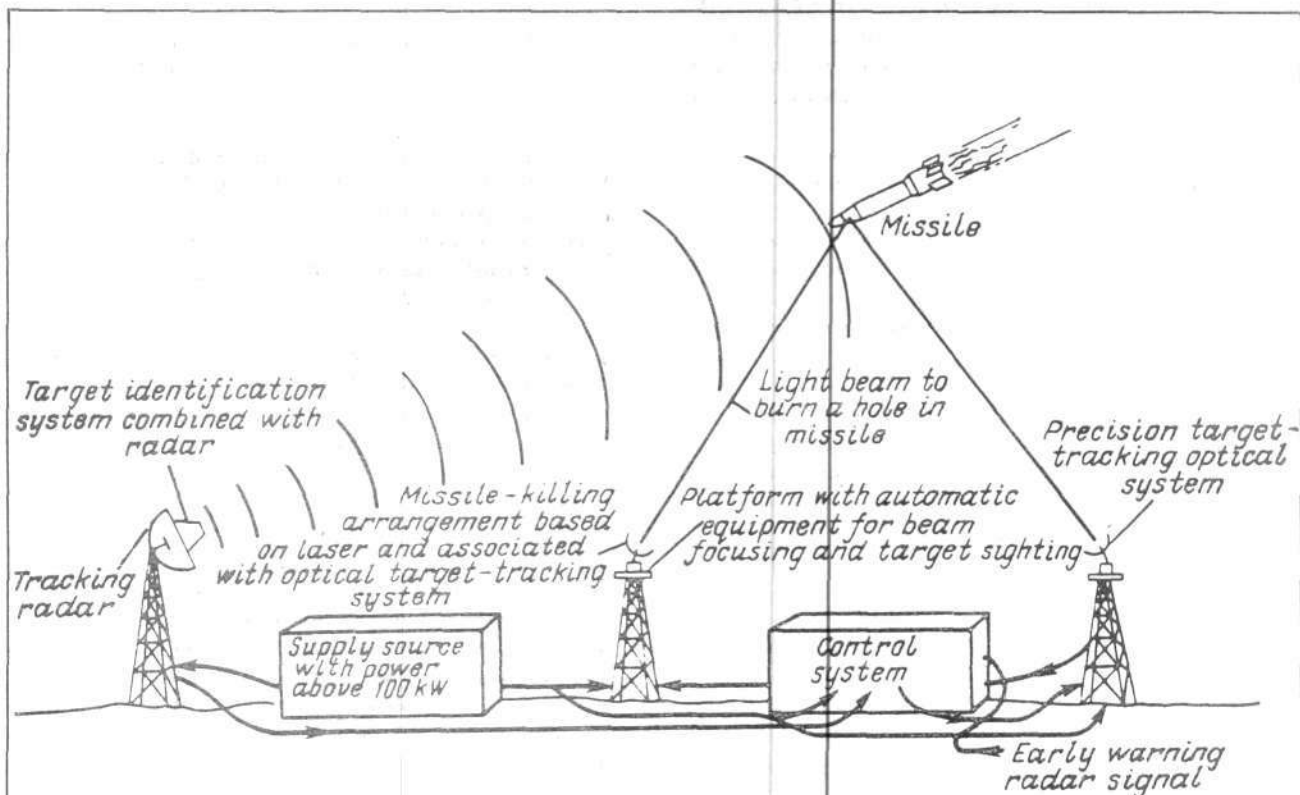
Soviet military doctrine does not leave out of account the possibilities of defense. . . . In this, it should be stressed that we recognize not passive, but active defense, built on a new technical foundation, brought to life by the appearance of modern means of conducting war; a defense directed above all against the enemy's nuclear means of attack. Such a defense takes on extraordinarily important state, strategic significance.

In contrast to Moscow's present pious denunciations of President Reagan's Strategic Defense Initiative, the Russian military command has always been outspoken in preserving its prerogative of developing strategic defense systems. Major General N.A. Talenskii, theoretician of the Soviet General Staff, is such a representative spokesman:

Antimissile systems are purely defensive and not designed for attack. It is quite illogical to demand abstention from creating such weapons in the face of vast stockpiles of highly powerful means of attack on the other side. Only the side which intends to use its means of attack for aggressive purposes can wish to slow down the creation and improvement of antimissile defense systems. . . . The creation of an effective antimissile system enables the state to make its defenses dependent chiefly on its own possibilities, and not only on mutual deterrence, that is, on the good will of the other side. And since the peace-loving states are concerned with maximum deterrence, in its full and direct sense, it would be illogical to be suspicious of such a state when it creates an antimissile defense system, on the grounds that it wants to make it easier for itself to resort to aggression with impunity.

Some say the construction of antimissile defense systems may accelerate the arms race. . . . Such a development is not at all ruled out. . . . In any case, there is this question: What is more preferable for security as a result of the arms race, a harmonious combination of active means of deterrence and defense systems, or the means of attack alone?'

But did such Soviet statements on the feasibility, nay



This Soviet diagram of an antimissile system appeared in 1974, two years after the ABM Treaty was signed, in a pamphlet by N. Sobolev titled "Lasers and Their Prospects" published in English in Moscow.

desirability, of ballistic missile defense cease after the signing of the 1972 ABM Treaty? No, they did not. Soviet military writers still wrote quite frankly about warfighting and war-winning, including "defense of the homeland."

The crucial element was "new technologies." In this realm, excluded from specific limitations by the ABM Treaty, the Soviets saw the future. In 1974, two years after the ABM Treaty was signed, the Mir (Peace) Publishing House in Moscow issued in English a pamphlet by N. Sobolev titled "Lasers and Their Prospects." In an ample chapter on military applications, from which the figure is taken, Sobolev explained rudiments of ground-based beam-weapon defense against nuclear missiles:

To destroy an enemy missile, not to let it reach the target, it is sufficient to put its control system out of action. This can be done by burning through the missile shell or rudders by a laser beam. This will cause vibrations in the missile and result in its complete destruction.

Figure 81 [see above] shows a block diagram of an antimissile system based on the use of lasers. Such a system must have a receiving unit for processing the signals incoming from the early warning and target tracking radar stations. These signals contain information on the coordinates of the approaching missile. The tracking station must aim at the target an optical radar

in which a laser serves only for determining the distance to the missile.

Such an optical radar can furnish very precise data on the coordinates of the target, and these data are used to actuate another system employing a high-power laser, designed for destroying the target. The optical radar will focus and aim the powerful laser beam during the period of time required for a hole to be burned through the missile. . . .

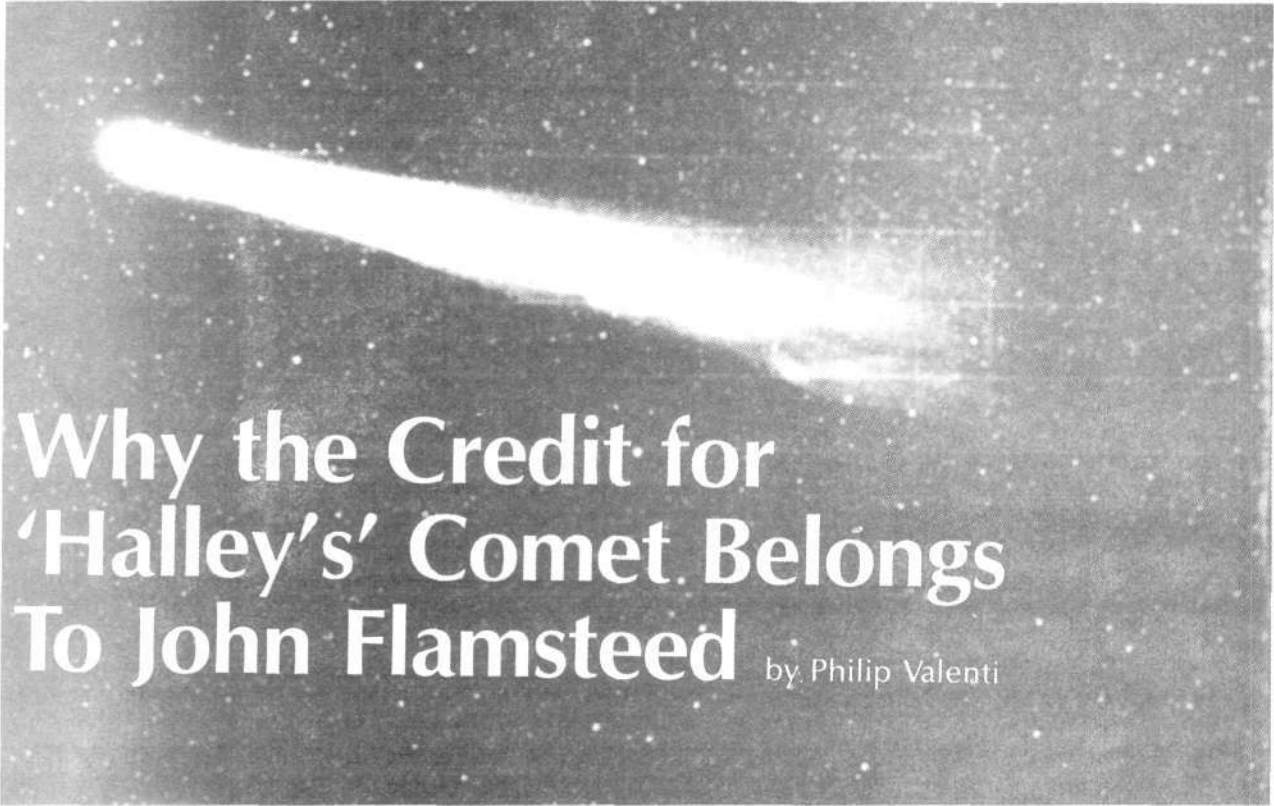
Another possible antimissile laser defense system is a project of an orbital space station equipped . . . as well with lasers. . . .

This text leaves no doubt as to the purpose of the phased-array, battle-management radar now under construction in the locality of Krasnoyarsk, Siberia—it is designed for use as part of a beam weapon defense system against U.S. ICBMs.

Criton Zoakos is the editor-in-chief of the weekly Executive Intelligence Review. This article is adapted from the news magazine's special report "Global Showdown: The Russian Imperial War Plan for 1988," published in July 1985.

Notes

1. N.A. Talenskii, "Anti-Missile Systems and Disarmament," written before 1972 and printed in English in *The Future of Soviet Military Power*, ed. L. Whetten (New York: Crane, Russak and Co, 1976).



Why the Credit for 'Halley's' Comet Belongs To John Flamsteed

by Philip Valenti

Halley's Comet 75 years ago: The comet was photographed in 1910 in South Africa.

Later this year, the attention of the world will be captured by a spectacular celestial phenomenon, known for the past 200 years as Halley's Comet. The comet will be visible from Earth from the beginning of December 1985, until late January 1986, then again from the beginning of March through April.

The comet was named after Isaac Newton's young protégé, Edmund Halley, who succeeded Newton as president of the Royal Society in Britain. Halley helped to establish Newton's scientific reputation by personally financing the publication of the first edition of Newton's system of physical laws, called *Principia Mathematica*, in 1686.

Nearly all history books say that Halley "was the first to realize that comets orbit the Sun and that they come back again and again." Let us

take this opportunity of the comet's appearance—available only once every 76 years—to report that Halley's claim to this discovery was a fraud perpetrated by Halley and his sponsor, Isaac Newton. The real credit belongs to another Englishman, John Flamsteed.

This is the story of the first correct explanation of a comet.

Aristotle and Kepler

Comets, like the stars, have been studied since ancient times. In fact, all science, all civilization, begins with an understanding of the celestial bodies and their motions through the heavens. In the fifth century B.C., Aristotle claimed that the planets and stars circled the Earth, embedded in perfect, unchanging, concentric spheres of transparent crystal. This crystal, according to Aristotle, kept the stars from falling to the ground, while it also restricted mankind for-

ever to its tiny earthly fish-bowl. Aristotle prevented the unusual phenomenon of comets from disturbing his system by asserting that comets are mere "exhalations" within the Earth's atmosphere.

The comets had their revenge on Aristotle when Tycho Brahe proved in 1577 that they are true celestial bodies. As Johannes Kepler pointed out in his 1621 *Epitome of Copernican Astronomy*: "Tycho Brahe disproved the solidity of the spheres. . . . For if the spheres were solid, the comets would not be seen to cross from one sphere into another, for they would be prevented by the solidity; but they cross from one sphere into another, as Brahe shows."

Kepler went on to establish the power of Plato's method of hypothesis, unveiling the true principles of the composition of the universe in his books *Mystery of the Universe*

and *Harmonies of the World*. Kepler's hypothesis of an elliptical orbit for each planet, with the Sun at one focus of the ellipse, had been completely supported by the star catalogues and studies of Mars painstakingly composed by Brahe. But observational precision had not advanced sufficiently to completely master cometary motion. The best measurements still seemed to show that comets traveled in nearly straight-line paths out past the Sun.

In 1675, King Charles II of England, concerned to make English naval power supreme, founded the Royal Observatory at Greenwich, near London. The King appointed the Reverend John Flamsteed (1646-1719), a self-taught astronomer, as the "astronomical observator," with a token salary of £100 a year. Over the next 15 years, after designing and paying for all of his instruments himself, Flamsteed made more than 20,000 observations with the sextant, with an accuracy many times greater than that of Brahe.

Flamsteed's Hypothesis

Since no number of observations by themselves can add up to even one idea, some bold and well-reasoned hypothesis was also required to finally master the motion of comets. This John Flamsteed also

provided in November 1680, when he boldly predicted that the comet then observed heading toward the Sun would soon reappear, traveling in the opposite direction!

On Dec. 15, 1680, Flamsteed reported that he had indeed "espied a very small tail under [the constellation] Aquila" heading away from the Sun, precisely as predicted. He proceeded to draw up tables of the comet's motion, with a diagram clearly tracing an elongated parabolic or elliptical path around the Sun. He applied the same hypothesis to his earlier observations of the comet of 1677, which had appeared in the same part of the sky as the comets of 1653 and 1665, and asked, "what conformity there is betwixt the motions of this and them and whether it may probably be the same returned hither after two revolutions."

Thus, Flamsteed developed the necessary concept—"that comets orbit the Sun and that they come back again and again"—along with volumes of measurements fully confirming the hypothesis. Then what exactly did Isaac Newton and his follower Halley have to do with the accomplishment of this breakthrough, the breakthrough for which they are credited today? Nothing! In fact, at the time, Newton insisted that Flamsteed was totally wrong, and that comets must travel in straight lines.

Newton wrote on Feb. 28, 1681, "I am further suspicious that ye Comets of November and December which Mr. Flamstead accounts one and ye same Comet were two different ones." He dismissed Flamsteed's idea with dozens of objections such as, "that in November had a brighter head than ye other. . . ."

Although Flamsteed patiently explained and carefully documented

his discovery, Newton insisted that the comet's path must have been a straight line. Newton wrote: "Did it go in such a bent line other Comets would do ye like, and as yet no such thing was ever observed in them, but rather the contrary. The Comets of 1665, 1677, and others which moved towards ye Sun, or some of them at least, had they twisted about ye Sun and not proceeding on forward gone away behind him, they would have been seen coming from him. . . ."

Newton's Attack

Newton attacked Flamsteed's discovery in the most violent and foolish terms for nearly five more years, until, in a letter to Flamsteed on Sept. 19, 1685, he conceded that "taking that of 1680 into fresh consideration, it seems very probable that those of November and December were ye same Comet." He then went on to beg Flamsteed for his table of observations. Newton had admitted his error just in time for the publication of his *Principia Mathematica* in 1686, in which he reproduced Flamsteed's work and painstaking calculations with only a few footnotes of acknowledgment.

Of Halley, Flamsteed wrote in 1691: "He has more of mine in his hands already, than he will either own or restore: and . . . I have no



John Flamsteed
1646-1719

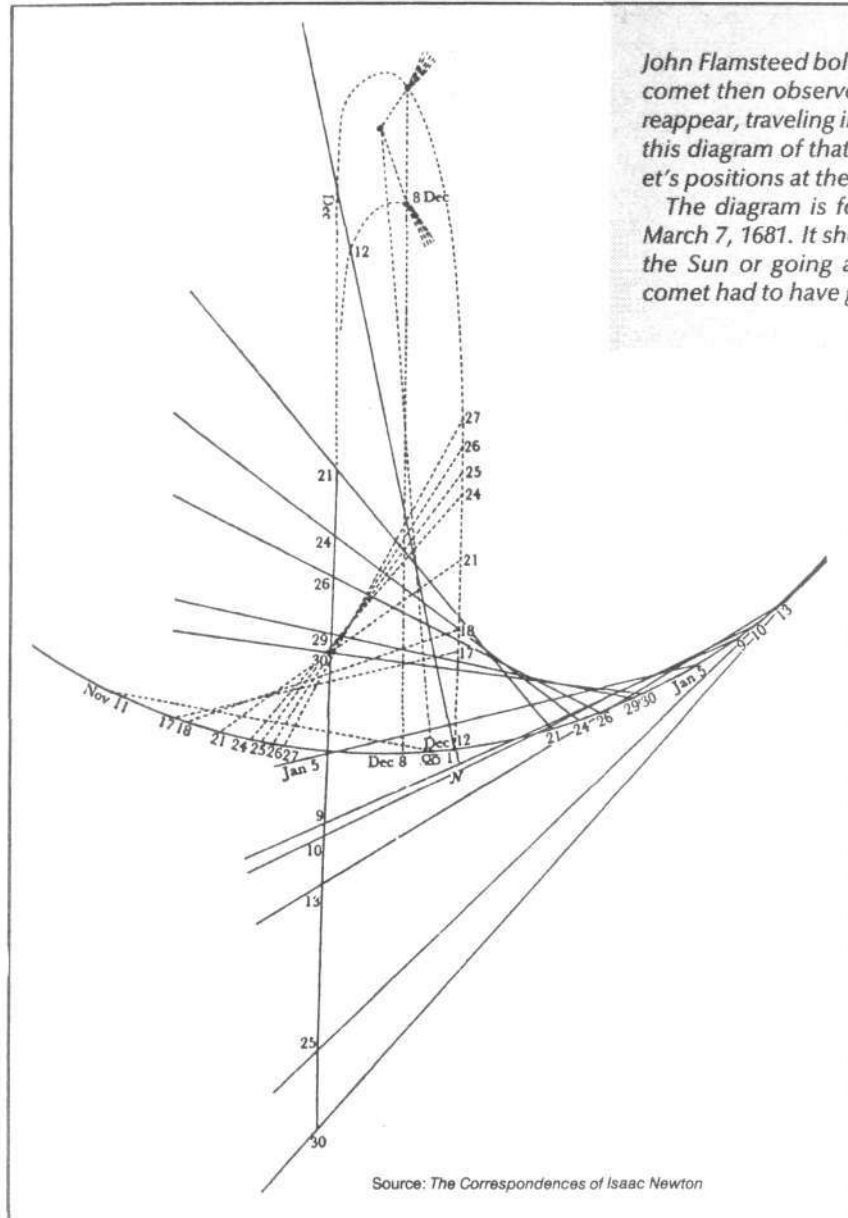


Edmund Halley
1656-1742

In 1680, John Flamsteed proposed that comets travel in elliptical orbits around the Sun. Isaac Newton and Edmund Halley attacked Flamsteed's work for several years, but then appropriated it as their own. Using Flamsteed's theory and observations, Halley predicted that the bright comet of 1682 would return in 1758.

John Flamsteed boldly predicted in November 1680 that the comet then observed heading toward the Sun would soon reappear, traveling in the opposite direction. Flamsteed drew this diagram of that comet's orbit, complete with the comet's positions at the dates of his sightings.

The diagram is found in a letter he sent to Newton on March 7, 1681. It shows the comet passing either in front of the Sun or going around it. Flamsteed believed that the comet had to have gone around the Sun.



Source: *The Correspondences of Isaac Newton*

proved correct: "Wherefore," he wrote, "if it should return according to our prediction about the year 1758, impartial posterity will not refuse to acknowledge that this was first discovered by an Englishman."

By 1710, Newton had mustered sufficient political influence to seize Flamsteed's observations by force, under the powers granted to him by a Royal Warrant issued by Queen Anne on Dec. 12 of that year.

Flamsteed recounted his personal showdown with Newton on Oct. 26, 1711: "I have had another contest with the President of the Royal Society, who had formed a plot to make my instruments theirs; . . . I complained then of my catalogue being printed by Raymer [Halley], without my knowledge, and that I was robbed of the fruits of my labors. At this he fired, and called me all the ill names, puppy, etc., that he could think of. All I returned was, I put him in mind of his passion, desired him to govern it, and keep his temper."

A Political Vendetta

Newton and Halley finally succeeded in 1712 in publishing the observations stolen from Flamsteed, and also found time to attack the inventor of the calculus, Gottfried Leibniz. On April 12, a special committee of the Royal Society—guided by Halley—officially condemned Leibniz for supposedly plagiarizing the calculus from Newton, and established Newton as the true "first inventor." This Committee's decision was written by the actual plagiarist, Isaac Newton himself. In a further effort to cover up his sources, Newton eliminated both Leibniz's and Flamsteed's names completely from the second edition of his *Principia Mathematica* in 1713.

esteem of a man who has lost his reputation, both for skill, candour, and ingenuity, by silly tricks, ingratitude, and foolish prate."

In his diary, Flamsteed explains his reluctance to agree to Newton's demands to surrender more of his data to the Royal Society: "I had formerly tried his [Newton's] temper, and always found him insidious, ambitious, and excessively covetous of praise, and impatient of contradiction. . . . I considered if I granted what he desired, I should put myself wholly into his power, or be at his mercy, who might spoil all that came into his hands, or put me to unnec-

essary trouble and vexation about my labours."

Newton became president-for-life of the Royal Society in 1703. For the next 10 years, Newton and Halley struggled relentlessly to appropriate Flamsteed's life's work as their own.

In 1705, using Flamsteed's data and hypothesis, Halley announced—as if unaided—that he himself had noticed the similarity in the orbits of the bright comets of 1531, 1607, and 1682, and that he himself had concluded that they were the same object returning each 76 years. Halley hoped for much political advantage in the event that his prediction

The Newtonian vendetta against Leibniz was motivated in large part by a very immediate political concern, since Leibniz had positioned himself in Hannover, Germany, to become the Prime Minister of the likely next Queen of England, Sophia.

Leibniz's political allies in England included both "Honest Whigs," like Daniel Defoe, and "Honest Tories," like Jonathan Swift, all grouped around the republican leader Robert Harley. William Penn, the founder of Pennsylvania and architect of the city of Philadelphia, was also a member of Harley's faction, and looked to him to protect Pennsylvania from hostile influences in Britain. Penn's personal secretary, James Logan, was therefore in London in 1710 on important business, and had an opportunity to observe Newtonianism riding high.

In 1713, Logan wrote from America: "We see by all the public news how high division and distractions are in Britain, but I have lately seen a particular instance of it beyond what could have entered into the heart of man (mine at least) to imagine; tis in the new edition of Newton's Principles which I had a few weeks ago from England. The author in the first edition (which I also have) in the third book, 'The System of the World,' generally quoted Flamsteed's observations where he had occasion to make use of any, but since that time, poor Flamsteed has appeared a violent Whig and therefore an opposite to Halley, etc., for which he was, not a little, persecuted three or four years ago by the head of the Society, and the better (I suppose) to express their abhorrence of his principles, they have now almost everywhere left out his name."

The American Challenge

Thus Flamsteed was persecuted by the Newtonians because of his political beliefs. By the time of Newton's death in 1727, the Royal Society by such means as these had imposed dictatorial control over almost all scientific thought in the budding British Empire. Halley, who had been appointed Astronomer Royal at Flamsteed's death in 1719, then personally ruled British science, having also succeeded Newton as president of the Royal Society.

But Logan, for one, whose stout defense of Leibniz constituted an early declaration of American independence from the British establishment, refused to bow down.

In 1727, when his protégé Benjamin Franklin formed the Junto, "a club established for mutual improvement," Logan began the experimental work that first put Philadelphia on the map as an independent center for scientific work. While Franklin and his friends improved themselves with the help of Logan's 3,000-volume classical library, Logan himself, in communication with Linnaeus and other great European scientists, demonstrated for the first time that the wind-blown pollen of maize plants is necessary for the generation of the fruit.

The British establishment was taken totally off guard by this unexpected intellectual "threat" from America, much as they would be surprised by every future American initiative, through to the 1781 battle at Yorktown. The arrogant Edmund Halley, much like George III's ministers 50 years later, tried at first to suppress Logan's work outright, through heavy-handed tactics. Those of Logan's writings that Halley could not completely suppress were published in the Royal Society's *Transactions*, after being edited in a way to discredit Logan's ideas. When these tactics failed to daunt the Americans and scientific advances continued to flow from the colonies, Halley finally resorted to the classic Newtonian method of theft.

Godfrey's Quadrant

Logan wrote to inform the Royal Society of yet another American discovery in 1732. Franklin had a young friend, the glazier Thomas Godfrey, a founding member of the Junto who had trained himself in mathematics at Logan's library. Godfrey invented "an instrument for taking the distances of stars by reflecting speculums [mirrors], which he believed might be of service at sea." In his letter, Logan included a detailed description of Godfrey's Quadrant, including diagrams illustrating its superiority over the sextant, and suggested that Godfrey deserved financial support to continue his work.

Soon after, an article appeared in

the *Transactions* of the Royal Society by one of the members, John Hadley, who claimed that he had just invented a quadrant identical to the one diagrammed in Logan's letter! When Logan protested, Edmund Halley, now president of the Royal Society, accused the Americans of trying to steal the idea from Hadley! In this early skirmish of the War for Independence, Logan and Franklin gathered affidavits throughout Pennsylvania swearing to Godfrey's priority of invention. Halley not only refused to admit fault, but brazenly ruled Godfrey and Hadley to be "co-inventors," awarding each a prize of £200. In a final insult to the Americans, Halley accused Godfrey of drunkenness. The American invention is known as "Hadley's Quadrant" to this day.

An Appeal for Justice

Logan later issued an appeal for justice against Newtonian methods in an American magazine:

"All civilized states have thought it their honor to have men of great ingenuity born or bred among them . . . since nothing redounds more to the honor of any state than to have it said that some science of general utility to mankind was invented or improved by them.

"Nevertheless, it often happens that the true authors of many a useful invention, either by accident or fraud lose the credit thereof; and, from age to age, it passes in the name of another. Thus it happened heretofore to Columbus and many others; and thus also it happened to a native of Philadelphia. . . .

"It is therefore submitted to the world whether . . . they ought not in justice to call that instrument for the future Godfrey's, and not Hadley's quadrant?"

Today, in the name of justice, I also issue an appeal: We should rename Halley's Comet as Flamsteed's Comet, to honor the man who did the real work.

Coming in the next issue
**How to Make a Star:
The Promise of
Laser Fusion**

Halley's Comet: When and Where to See It

You will probably be able to see Halley's comet with your naked eye in early December this year. Look for it in the evening sky in the constellation Pisces, which is near the bright Square of Pegasus (Figure 1).

At this stage the comet will be visible as a fuzzy ball. A small tail might be visible, but the really long tail will not develop until it passes around the Sun in January and February. The "fuzzy" look comes from a cloud of water vapor, other gases, and dust that are vaporized from the surface of the comet by the heat of the Sun.

The technical term for this cloud of gas and dust around the comet is the *coma*. At this point, the comet will have only a very short tail.

As the comet gets closer to the Sun, it emits more vapors and some dust. The Sun blows a "wind" from its surface, called the solar wind, composed mostly of hot hydrogen gas. As the comet passes through the solar wind, the wind blows on the coma, forming a tail.

When the comet approaches the Sun, the tail is behind the comet. But since the tail is created by the solar wind, the tail must always blow in the direction of the wind. So when the comet leaves the Sun, the tail actually moves out in front of the comet!

Where Do Comets Come From?

Comets come from within the solar system, but from far beyond the farthest planet. In ancient times it was thought that comets originated high in the Earth's atmosphere. But in 1577, the astronomer Tycho Brahe proved that a large comet then visible (not Halley's) had to be farther away from Earth than the Moon is.

The modern theory is that comets, including Halley's, originate from among billions of chunks of ice and dust that are believed to orbit the Sun far beyond Pluto. According to this theory, one of these bodies is occasionally bumped into an orbit that brings it near the Sun. Scientists do not know exactly what "bumps"

would start a comet moving in toward the Sun, but think it might be the gravitational pull of a passing star or Jupiter, the largest planet.

Comets usually orbit the Sun in elliptical orbits, as planets do. But unlike planets, comets can move in either direction around the Sun and the planes of their orbits can be tilted from the planetary plane by as much as 30° or more (Figure 3). This is another indication that comets have a different origin—beyond Pluto. All the planets orbit in the same direction and in about the same plane. They do this because when they were formed with the Sun, some of the rotational energy was carried with the planets as they spun off from it. But many comets, including Comet Halley, orbit the Sun in a *retrograde*, or opposite, direction to the planets.

When to Expect It

Halley's orbit is highly elliptical—closer to cigar-shaped than egg-shaped—and so it will travel far into

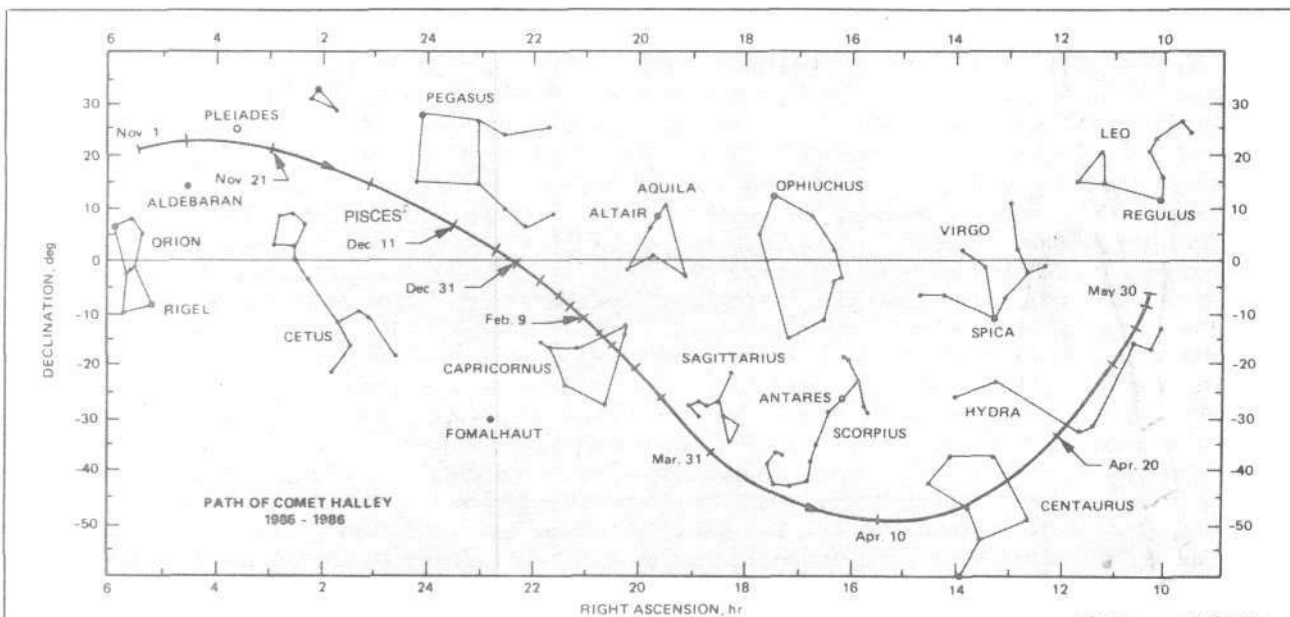


Figure 1

THE PATH OF HALLEY'S COMET, NOVEMBER 1985-MAY 1986

While Halley's Comet approaches, moves around the Sun, and then retreats again, our observing post, the Earth, is also moving in its own orbit around the Sun. This chart is the result. It shows where observers on Earth will find the comet among the stars and constellations as the weeks go by. Some areas of the chart will be below your horizon and not visible.

D.K. Yeomans, NASA-JPL

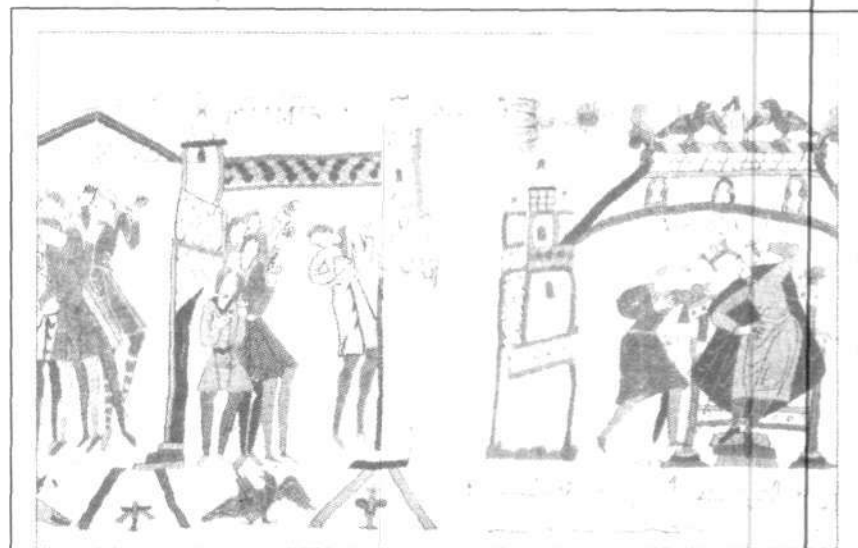


Figure 2
HALLEY'S COMET IN THE YEAR 1066

Halley's Comet—and some reactions to it—are stitched into the famous Bayeux Tapestry, which commemorates the Norman conquest of England in the year 1066. The comet had appeared several months before the conquest. The Latin words next to the comet say, "There they wonder at the star." The earliest certain appearance of Halley's Comet was reported by Chinese astronomers in 240 B.C.

space before it begins to turn around and return. Its period (the time required for one orbit) is 76 years, so you will not see it again until you are much older.

Halley's Comet will pass closest to the Sun when it is on the other side of the Sun from the Earth. This means that you will be able to see it starting in December (or as early as July if you have a telescope) until late January. Then it will disappear behind the Sun in February and reemerge in March. At this time, Halley will be sporting a long tail, stretched out over as much as 30 degrees of the sky.

If you live in the Northern Hemisphere, the view will not be as good as below the equator. In the Northern Hemisphere the easiest time to see Halley will be in the middle of January in the evening sky in the constellation Aquarius. However, there will be no spectacular tail at this time; the tail will develop as the comet rounds the Sun.

When it reemerges in March, the long tail will be there, but you will be able to see it only very close to the southern horizon just before dawn. In the United States, the farther south

you go, the better will be your view. Much international scientific work will be centered on the study of Halley's Comet. Japan, Europe, the Soviet Union, and the United States are all sending satellites to get a closer

look. Also in the United States, NASA and the Jet Propulsion Laboratory (which has designed many of our satellites) are coordinating a program that will gather data from all over the world about the comet. These professional scientists are calling on amateur astronomers and students to help make observations.

Making It a Science Project

They have published a manual called the *International Halley Watch Amateur Observers' Manual for Scientific Comet Studies*. The manual explains different methods for observing the comet and specific experiments that you can perform. Included are observation forms to fill out after each experiment and mail to the Halley Watch headquarters. The results of all the thousands of observations made by both professionals and amateurs will be studied for years to come.

If you would like a copy of the manual, send \$9.95 to Sky Publishing Corporation, 49 Bay State Road, Cambridge, MA 02238-1290.

Beginners in astronomy might start with *The Comet Book—A guide for the return of Halley's Comet*, by Robert D. Chapman and John C. Brandt, available at your library, or at your bookstore for \$14.95 (Boston: Jones & Bartlett, 1984).

—Jim Everett

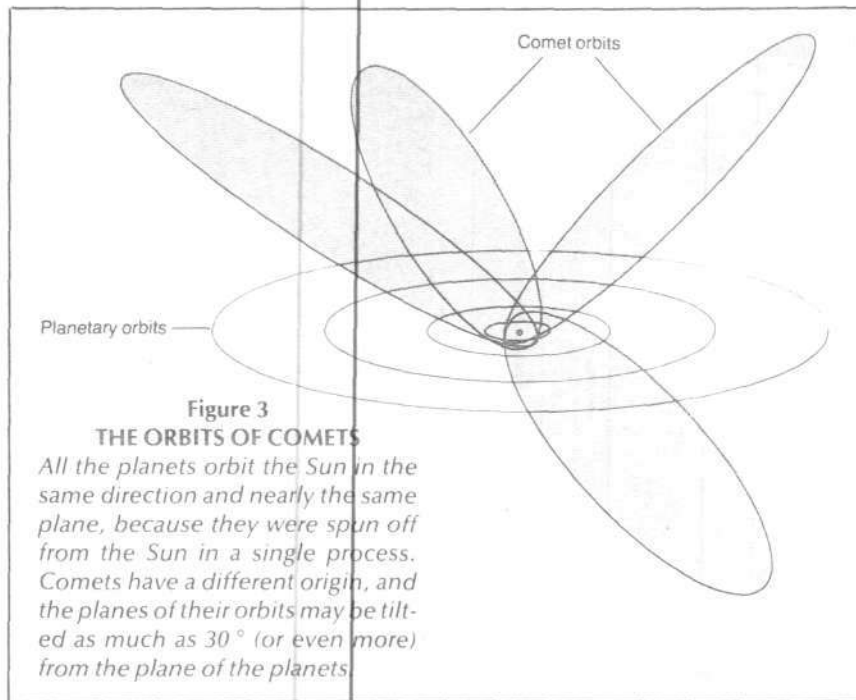


Figure 3
THE ORBITS OF COMETS

All the planets orbit the Sun in the same direction and nearly the same plane, because they were spun off from the Sun in a single process. Comets have a different origin, and the planes of their orbits may be tilted as much as 30° (or even more) from the plane of the planets.

What the Comet Probes Are Looking for

What are comets made of? The best theory we have is astronomer Fred Whipple's idea that comets are "dirty snowballs." According to Whipple's theory, comets are balls of ice mixed with small amounts of frozen gases (like carbon dioxide and methane) and have dust grains embedded in them. This idea comes from the information gathered by scientists who have aimed spectroscopes at comets to identify the elements and molecules they contain. But the information from the spectroscopes varies, so scientists still don't know exactly what comets are made of.

Remember that comets are a part of the solar system. Like everything else in the universe, comets carry with them some clues to their beginnings. When scientists find out what comets are really made of, it will help us understand how they began, and how the solar system itself was created.

Comet Structure

The comet's nucleus warms up as it approaches the Sun and begins evaporating, releasing large amounts of gas and dust to form the head or coma. The coma may have a diameter of 100,000 miles, even though the diameter of the nucleus is only 1 or 2 miles!

Comets have two kinds of tails. Look at a sharp photograph of a bright comet like Halley's or Comet West (see the back cover). You will probably be able to see two different tails. One is a narrow, straight tail, and another, going away from the coma at a slightly different angle, is broad and very slightly curved.

How do scientists propose to explain these tails? We know that the broad, slightly curved tail is made up of dust particles. It is thought that they stream out behind the comet under the pressure of sunlight. There is no atmosphere out there to make them fall behind.

We also know that the gas atoms in the coma, as they get hotter, become electrically charged. A gas in this condition is called a plasma, and

the second, straight tail is a plasma tail. Because the plasma is electrically charged, it is influenced by the magnetic field of the solar wind, and the field is influenced by it.

Why doesn't the plasma tail fan out like the dust tail? Is it possible that the electrical charge of the plasma tail "captures" some of the magnetic field lines of the solar wind and then travels along them?

A plasma should be invisible, like an ordinary gas. Why can we see the plasma tail? The explanation may be that if the charged gas atoms of a

plasma spiral down magnetic field lines at high speed, they will emit light, and we see that light.

The Comet Probes

The European comet probe Giotto and the other comet probes (see box) are seeking more detailed information to prove these theories. What if the new information disagrees with one of the theories? Scientists can use the new information to think through the problem again and create a better theory.

The probes are equipped with spectrometers to detect elements



Illustration courtesy of British Aerospace Dynamics Group

The European spacecraft Giotto approaches Halley's comet in this artist's drawing of the event. In the actual encounter in March 1986, the spacecraft will have its dust shield toward the comet. Giotto will come within 600 miles of the comet's nucleus—closer than any other probe. The storm of dust particles hitting Giotto at 43 miles per second may destroy it.

Giotto is named for the Italian painter Giotto di Bondone, who saw Halley's Comet in 1301. He painted it as the Star of Bethlehem in his "Adoration of the Wisemen."

and molecules. They have photopolarimeters to measure the polarization of light. Magnetometers will measure the strength of the magnetic field. Charged-particle detectors and dust impact detectors will also be on board, and, of course, cameras.

Since Giotto will be getting much closer to the nucleus than any other probe, it may be able to detect the comet's nucleus, which is too small

to be visible to the best Earth telescopes.

Giotto's camera will snap one color picture of the nucleus every 4 seconds during the encounter.

The best pictures will be taken at a distance of less than 600 miles. Those pictures should show features on the nucleus half the size of a football field—if the dust and the light-emitting plasma do not blind the camera!

—David Cherry

Giotto: Closing in on Comet Halley

On July 2, 1985, the European Space Agency rocket Ariane-1 took off from Kourou, French Guiana (near Venezuela), launching the Giotto comet probe to a "parking" orbit around the Earth. After a bit less than three revolutions around the Earth, the European Space Agency Control Center in Darmstadt, West Germany, ordered ignition of the supplementary booster. The European spacecraft left its Earth orbit for an orbit around the Sun, leading to a planned encounter with Halley's Comet in March 1986.

Europe's Giotto is only one of five space probes sent to encounter the comet. The others are two Soviet ones, VEGA-1 and VEGA-2 (which are studying the planet Venus on their way), and two Japanese ones, MS-T5 and Planet-A.

The United States missed this chance of a lifetime to contribute its full scientific strength and has no special Halley's Comet probe. However, it did reassign its ISEE-3 (International Sun-Earth Explorer-3) from an Earth orbit 900,000 miles out, to an encounter with another comet now nearing the Sun. That required a tricky maneuver around the Moon, after which ISEE-3 was given a new name, the International Cometary Explorer (ICE).

ICE will fly through the tail of Comet Giacobini-Zinner, passing through at 6,000 miles from its nucleus on Sept. 11. This will be the first visit to a comet in history.

The name Giacobini-Zinner comes from the modern procedure of naming comets after the individual or individuals who first report sighting them—in this case, Giacobini and Zinner. Many amateurs have successfully identified new comets.

International Cooperation

The comet probes will become much more effective as a result of international cooperation. The exact course of Halley's Comet is known only to an approximation of 18,000 miles, so an encounter at closer range requires detection and maneuvering. The ICE and another U.S. spacecraft will be the first to detect with precision the exact position of the comet, and will allow the Soviet and Japanese missions to redirect their flights to come closer to the comet.

Then the Soviet VEGA spacecraft, which will fly closer to the comet, will supply the European Space Agency with a more precise position of the comet, allowing the final targeting of the Giotto spacecraft, which comes closest of all to Halley.

Giotto will actually get so close to the comet's nucleus that it may be destroyed by the constant shower of dust particles. The particles will be traveling at 43 miles per second relative to Giotto. European planners hope the spacecraft has a chance to radio a great deal of information back to Earth before that may happen.

—Laurent Rosenfeld

Equipment for The Amateur Astronomer

From time to time we will review equipment useful to young scientists. In this issue we review for amateur astronomers a telescope, a sighting device, and two nebula filters.

The amateur astronomer quickly learns that high magnification in a telescope is often neither useful nor desirable. Two instruments suited to the astronomer's need for low magnification are reviewed here: one is a low-power, wide-field telescope, the Comet Catcher made by Celestron; the other is a unique aid to sighting called Telrad.

In addition, we tested two Lumicon filters that are useful for observing faint, low-contrast nebulosities.

The Comet Catcher

Conventional 6" or 8" telescopes are actually not the best instruments to use when you want to see large celestial objects in their entirety. Experienced observers know that the best view of the Pleiades in the constellation Taurus, or the Double Cluster in Perseus, for example, is through a good pair of binoculars. The reason is that telescopes designed to look into deep space for double stars, nebulae, and galaxies cannot also give you a wide field of view.

Celestron's Comet Catcher is designed as a low-cost answer to the need for observing large celestial objects in their entirety. It takes its

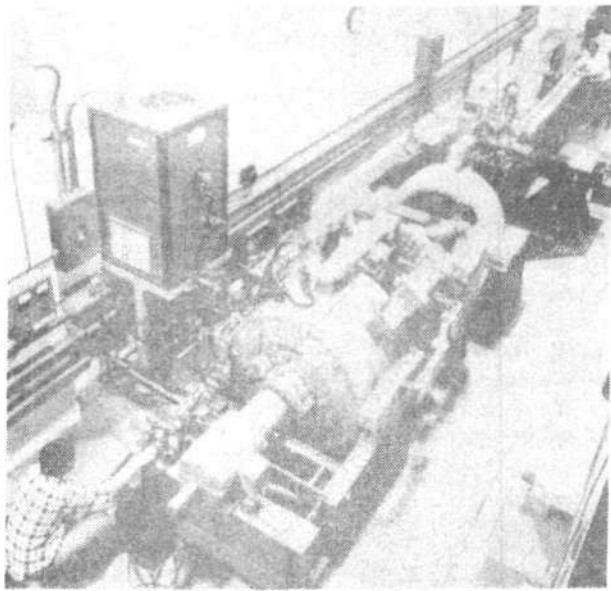
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HALLEY'S COMET APRIL, 1986

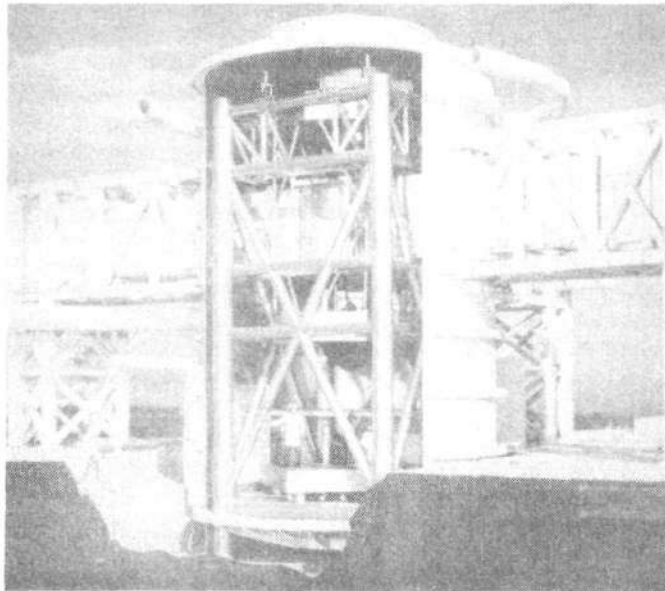
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Source: "SDI: A Technical Progress Report," June 1985



At left, hypervelocity projectile accelerator at the Picatinny Arsenal in New Jersey. Right, a model of the large, cylindrical Alpha chemical laser, which will be located at TRW's San Juan Capistrano, Calif., test site.

SDI STATUS REPORT

The Tests the Soviets and Friends Want to Stop at Geneva

In late June, the Strategic Defense Initiative Office announced a series of tests and technology demonstrations of ballistic missile defense in the next 90 days "to convince the Soviets to accept the concept," in the words of SDI director Gen. James Abrahamson.

No sooner were these advances reported than the rumors began flowing from the U.S. State Department and the Soviets about a "Geneva deal" to limit the Strategic Defense Initiative (SDI) solely to research. If the tests are not stopped to appease the Soviets, over the next 90 days the SDI program will demonstrate laser tracking of missiles from the ground and from space, high-power laser focusing at long distance, warhead interceptions in the upper atmosphere, and other missile defense requirements.

Visible Tests

Since President Reagan decisively turned back Democratic presidential candidate Walter Mondale's attack on

the SDI in the final days before the 1984 election, the Soviets and their friends in Congress and elsewhere have demanded that the SDI be barred from any active testing and demonstration phase, and limited to endless research. Visible tests and demonstrations build massive citizen enthusiasm, industrial interest, and grudging acceptance from even the ivory towers of university scientists.

The imminent beam defense tests are outlined in "SDI: A Technical Progress Report," submitted by Abrahamson's office to Defense Secretary Weinberger at the end of June. The report was the basis for a classified briefing to a large group of industrial representatives and lab scientists July 11, held by the SDI and the American Astronautical Society, ironically in the Dean Acheson auditorium of the State Department.

Photographs and drawings within the report illustrate the tests that will oc-

cur this summer and fall and the rapid laboratory experimental progress of the SDI, which is making them possible.

Beam Defense Test Plans

- Following up the June 1984 demonstration of interception of a warhead in space, "fully guided tests of a small radar homing interceptor against nonballistic-missile targets" within the upper atmosphere will demonstrate capabilities for the terminal phase of a layered ABM defense.

- From the Hawaii site that tracked the Space Shuttle with a spot of laser light, ground-based lasers will track Navy rockets rising much more rapidly, to much greater altitudes (400 miles) than the Shuttle. This will demonstrate both the tracking of the laser and compensation for atmospheric disturbance of the beam. The ground-based laser tests will then be repeated from aircraft. The required pointing accuracies have already been demonstrat-

ed at Hawaii for low power; these tests will be at "high average power."

• A large, flat mirror has been built and is being tested, which is only 1/10th the density and weight of the mirror of NASA's space telescope and "meets the requirements for space relay mirrors."

• A new test series is planned of firings of the large MIRACL chemical laser at White Sands, N.M., which has several megawatts of power; its tests are already demonstrating "our ability to focus the laser beam onto a small spot at long range," according to the report.

In addition, the SDI report announced a number of successful technology demonstrations by the national scientific labs and by industries, which change the expectations of both the feasibility and time scale of building an effective layered antimissile defense.

Spectacular Breakthroughs

The most spectacular breakthroughs have been on the Advanced Test Accelerator at Lawrence Livermore Laboratory, a 50-million-volt electron beam accelerator. This machine has "demonstrated that charged-particle [electron] beams can be guided by a laser-created channel in a low-pressure environment such as the Earth's upper atmosphere, [without] bending caused by the Earth's magnetic field. . . . This success has implications for charged-particle beam weapons for use at altitudes from 85-600 kilometers."

As the laser can guide the electron beam in the Advanced Test Accelerator, so the electron beam can amplify a laser in the same channel, making an "electrically powered" free electron laser. Extremely powerful beam pulses have already been generated by the free electron laser at microwave wavelengths. The program's goal is now to scale this technology to higher, visible light wavelengths needed for antimissile defense.

Similar achievements are reported from Los Alamos and Oak Ridge National laboratories, which are working together on the Neutral Particle Beam Accelerator, whose use will be to destroy electronic circuits on ballistic missiles. Both labs, developing different stages of the accelerator, have achieved significant current levels for up to 5-second bursts, using small,

lightweight devices.

Meanwhile, at Picatinny Arsenal in New Jersey, an electromagnetic projectile accelerator, or "rail gun," has shot dense clouds of small metallic particles at speeds of 40 kilometers per second, and at five "refires" in half a second. Now about 20 meters long, if this rail gun can fire at such speeds from space down at boost-phase missiles, it can destroy them either with particles or with small rocket projectiles.

All of the SDI tests are technically "demonstrations," since the devices involved have different sizes, weights, power levels, or materials characteristics from actual prototypes. They can clearly demonstrate the working principles by which the layered antimissile shield will function. Multiple, simultaneous series of such tests, conducted by many firms and labs with inno-

vative or competing approaches, could rapidly converge on actual prototype development.

This is the current stage of the Soviet antimissile defense program; it is the stage they demand the U.S. SDI never enter.

Such an accelerated approach would take a larger budget, but more important, it would require defense mobilization credits at long terms and low rates of interest for firms and labs that wanted to demonstrate their capabilities for later development and production contracts.

By contrast, this latest status report shows that the SDI program, starved of funds by Congress and with no backup credits to stimulate its industrial base, is overseeing only a single major experiment for each area of antimissile defense technology.

—Paul Gallagher

The SDI on the Political Battlefield

Fidel Castro, July 18, 1985:

The U.S. government "throws money down the sewer on crazy things like Star Wars."

Soviet leader Mikhail Gorbachov, May 30, 1985:

"We suggest that . . . the Soviet Union and the United States will make, during a specific period of say, one to two months, their practical proposals on all questions under consideration [at the Geneva arms control talks], including the levels to which they would be prepared to reduce their strategic offensive armaments, naturally on condition that attack space weapons [the SDI] are banned."

E.P. Velikhov, vice president of the Soviet Academy of Sciences and head of the Soviet beam defense program, May 31, 1985:

The United States "should declare a moratorium [on the SDI] on August 6—the 40th anniversary of the U.S. nuclear attack on Hiroshima—or earlier."

Dr. Edward Teller, July 1985:

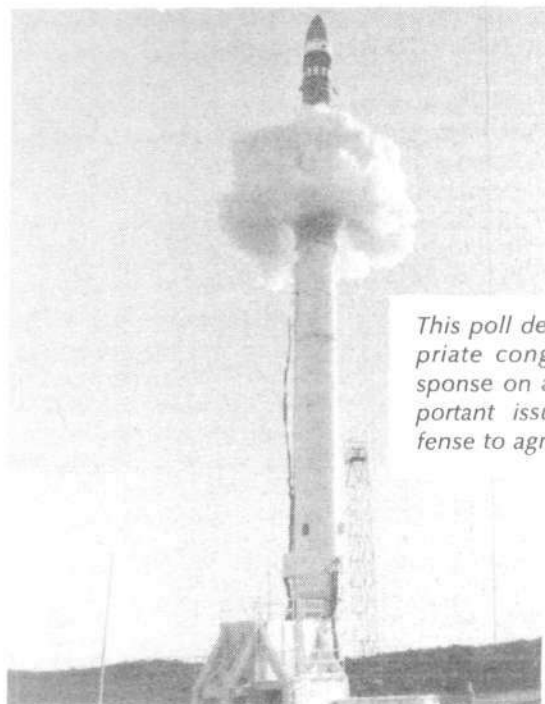
"We must not decrease SDI funding, but we must increase it. The Soviets are way ahead of us. Defense is the wave of the future. To cut the SDI now, is absolutely the wrong thing to do."

Jürgen Todenhöfer, Christian Democratic parliamentarian, West Germany, July 9, 1985:

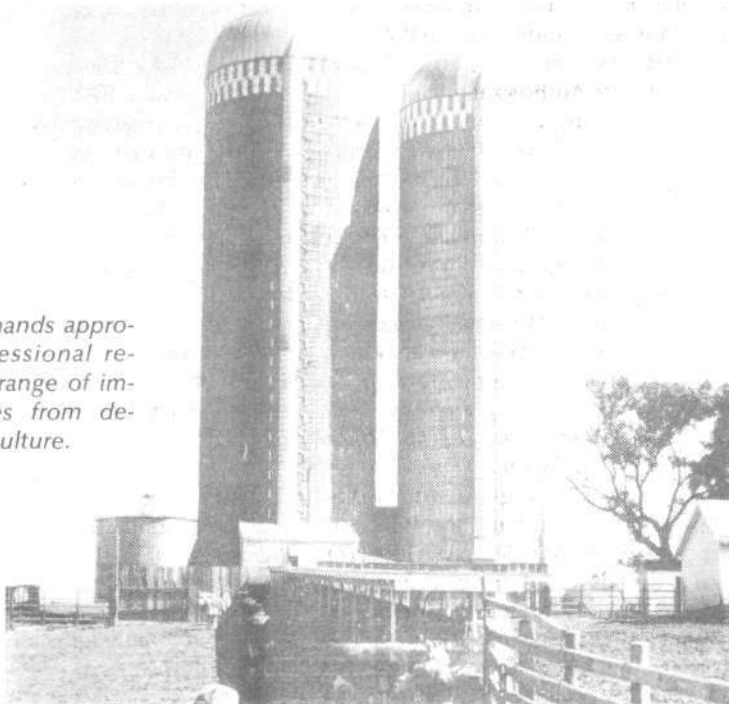
"While Western Europe is still arguing whether to participate at all in space weapons research, Moscow is already working with its allies to push ahead with its own research begun about 10 years ago. To top it all off, they are accusing the USA of militarizing space."

General Gallois, France, July 2, 1985:

A former critic of the SDI, the general recently proposed a ground-based laser-beam defense system against short-range missiles, that "consists, in a sense, in the Europeans adding to the SDI a Tactical Defense Initiative, TDI, both of them becoming in the future, complementary, technically and militarily."



U.S. Army



USDA

This poll demands appropriate congressional response on a range of important issues from defense to agriculture.

CONGRESS WATCH

New 'American System' Poll Rates Congress

"Any rating system that has a Rockefeller coming in dead last has got to be on the mark." This was the response of one radio commentator in Washington upon the hearing news of the new congressional rating system reflecting "American System" criteria.

The new rating card of congressional performance, proposed by economist Lyndon H. LaRouche, Jr., a board member of the Fusion Energy Foundation, was released July 20. It represents the first competent attempt to measure the ability of Congress to respond to key issues across the whole scope of crises facing the nation.

The rating card includes not only key defense votes—like the Strategic Defense Initiative and MX missile—but also votes related to economic policy, national infrastructure, energy, and agriculture. In short, it covers those crucial policy decisions that determine

whether the nation continues the American System of industrial development and growth.

On the Senate side, the top ratings go to Republicans McClure and Symms of Idaho and Helms of North Carolina, while Rockefeller (D-W.V.) is joined by Biden (D-Del.), Simon (D-Ill.), Harkin (D-Ia.), Kerry (D-Mass.), Levin (D-Mich.), Bradley (D-N.J.), Lautenberg (D-N.J.) and Pell (D-R.I.) on the bottom with a flat zero percentage. This means that on 19 key votes, these men did not vote the right way one single time!

Why This Poll Is Unique

Other congressional ratings systems are uniformly limited either by fixation on special interests or rigid ideological postures. Those in the defense industry, for example, think that votes on defense issues suffice to measure congressional performance as far as they are concerned. The agricultural

sector has a similar outlook. And ideologically "right" or "left" groups will rate congressmen on votes that they think reflect their rigid ideological categories of thought, such as "human rights" or "noninterventionism."

This American System poll, however, breaks down this rigidity, reflecting the coherent, historical "American System" perspective. This poll demands appropriate congressional response not only to the strategic threat facing the nation militarily, but also to the grave threat to the nation's economy and quality of life posed by the International Monetary Fund, population control, and the demise of U.S. basic industry and farming.

This American System rating is potentially a powerful kind of political weapon for educating and mobilizing constituents, precisely because it puts the broad interests of the nation—with baseline commitments to the per capita standard of living of the population and rate of technological advance in the economy—ahead of special interests and ideological prejudices.

A Who's Who for Progress

Here is what the poll shows:

In the Senate, the 19 votes analyzed in the poll were the 1983 nomination of Paul Volcker to head the Federal Reserve, two 1983 votes on the Interna-

tional Monetary Fund, three votes on the MX missile, four votes on the Strategic Defense Initiative, three Omnibus Defense Authorization bills (two on ASAT testing and one, the Nunn amendment of 1984, on NATO troop withdrawal), the June 1985 nomination of Richard Burt as ambassador to West Germany, the 1985 Helms amendment to curtail U.S. support for international population control, the 1984 McClure amendment to allow nuclear exports to certain developing sector countries, two 1984 agricultural price support amendments, and the 1983 Humphrey amendment on the Clinch River Breeder Reactor.

High scores were granted for votes opposed to Volcker and the IMF; full support for the MX, SDI, ASAT testing and maintaining full troop strength in Europe; opposition to Burt and population control; support for nuclear exports, grain price supports, and the Clinch River breeder.

Idaho's McClure scored 94 percent on this poll, tripping over the agriculture price support votes (not voting on one bill, and voting wrong on the other). Helms and Symms both voted "no" on the same two bills, dropping their percentages to 89 percent.

Next in order is Gramm (R-Tex.) who got 86 percent, but was present for only 7 of the 19 votes, so that he lacks enough "at-bats" to make this a fair rating.

A breaking point occurs at 79 percent. The only senators scoring above this, along with McClure, Helms, and Symms, are Wallop (R-Wyo.), Heflin (D-Ala.), Denton (R-Ala.), Zorinsky (D-Neb.), Abdnor (R-S.D.), Hatch (R-Ut.), and East (R-N.C.). Of these, it is noteworthy that only Zorinsky does not trip over the two crucial agriculture votes.

The Bottom of the Barrel

On the other end of the scale, joining the "flat zero" contingent with less than 20 percent, is a hefty list. We have listed them here in order, ranging from 19 percent to 5 percent: Eagleton (D-Mo.), Glenn (D-Oh.), Packwood (R-Ore.), Kennedy (D-Mass.), Bumpers (D-Ark.), Mathias (R-Md.), Nunn (D-Ga.), Ford (D-N.Y.), Gore (D-Tenn.), Hart (D-Colo.), Inouye (D-Hi.), Stafford (R-Vt.), Bentsen (D-Tex.), Chiles (D-Fla.), Hatfield (R-Ore.), Matsunaga (D-Hi.), Sarbanes (D-Md.), Riegle (D-

Mich.), Metzenbaum (D-Oh.), Cranston (D-Calif.), Dodd (D-Conn.), Moynihan (D-N.Y.), Dixon (D-Ill.), Mitchell (D-Me.), Leahy (D-Vt.), Bingaman (D-N.M.), and Proxmire (D-Wisc.).

There are two interesting and constructive insights the poll provides: first, the bipartisan nature of the lists both at the top and (especially) the bottom of the scale, indicating that political party, by itself, means almost nothing; and second, the lies of certain senators who try to pass themselves off as "moderates," but whose scores are among the worst. Glenn and Bentsen are examples of this last group.

The House Poll

In the House, the 12 votes chosen to rate congressmen roughly paralleled the votes analyzed for the Senate, with the addition of two waterway user charge votes and the 1984 so-called Baby Doe vote. (High scores were given for opposition to user charges and support of protection for severely handicapped infants.)

In the House, 100 percent ratings were given to Callahan (R-Ala.), Shelby (D-Ala.), McCain (R-Ariz.), Stump (R-

Ariz.), Rudd (R-Ariz.), Pashayan (R-Calif.), Dornan (R-Calif.), Hunter (R-Calif.), Hutto (D-Fla.), Holt (R-Md.), Lott (R-Miss.), Vucanovich (R-Neb.), Carney (R-N.Y.), Cobey (R-N.C.), Edwards (R-Okla.), S. Hall (D-Tex.), R. Hall (D-Tex.), Boulter (R-Tex.), and Slaughter (R-Va.).

"Zero percent" ratings went to Boxer (D-Calif.), Berman (D-Calif.), Levine (D-Calif.), Dymally (D-Calif.), Kennelly (D-Conn.), Morrison (D-Conn.), Hayes (D-Ill.), Yates (D-Ill.), Frank (D-Mass.), Atkins (D-Mass.), Markey (D-Mass.), Studds (D-Mass.), Wolpe (D-Mich.), Clay (D-Mo.), Ackerman (D-N.Y.), Schumer (D-N.Y.), Towns (D-N.Y.), Solarz (D-N.Y.), Weiss (D-N.Y.), Stokes (D-Oh.), Edgar (D-Penna.), Kostmayer (D-Penna.), Gray (D-Penna.), Leland (D-Tex.), Jeffords (R-Vt.), Miller (R-Wash.), and Moody (D-Wisc.). A good many others did not do much better.

—Nicholas Benton

For a copy of the complete poll, send a stamped, self-addressed envelope to the Fusion Energy Foundation, Box 17149, Washington, D.C. 20041-0149.

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ELECTRON BEAM FOOD IRRADIATION:

An SDI Spinoff That Can Help Feed the World

The small linear induction accelerator now sitting in a special swimming pool at Lawrence Livermore National Laboratory could revolutionize the field of food irradiation—even before the first-generation technology is off the ground. Scientists at Lawrence Livermore and the University of California at Davis are now testing this spinoff of the beam defense program that promises to provide a mass-produced, cheap, mobile, and efficient source of processing, using electron beams or X-rays as the radiation source.

The first generation of commercial food irradiation plants will use cobalt-60 or cesium-137 as the source of radiation. Some food irradiation facilities using these radionuclides are ready now and others are on the drawing boards just waiting for the government's green light. It is likely that the Food and Drug Administration will finally give its approval for U.S. food irradiation up to 100 kilorads by fall 1985—after years of delay.

However, if this technology is to fulfill its promise, the supply of these radionuclide sources will not be able to keep up with the demand. As the Lawrence Livermore team calculated it, if all the cesium and cobalt available in the world were used to irradiate food, we would be able to process only 6 ounces per person in the United States—hardly enough to make a dent in the world food supply.

The high-power induction linear accelerator, designed by Livermore physicist Dan Bix, could dramatically change this. Excerpted here is an interview with Dr. Stephen M. Matthews, a senior physicist at Lawrence Livermore who has been working on the development of the accelerator for food processing. Asking the questions is managing editor Marjorie Mazel Hecht.

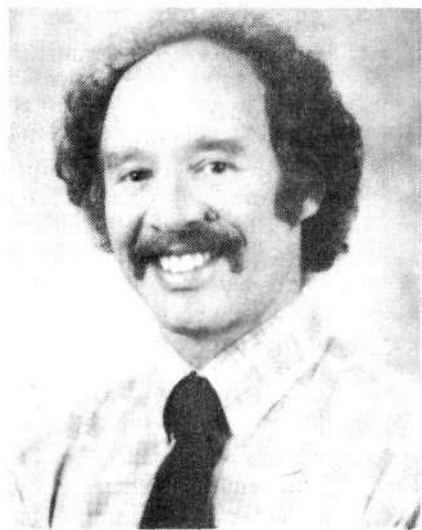
Question: What's most exciting to me is that this project is a spinoff of the beam defense program. Two years ago FEF did a study that showed that if we actually took the technologies from the beam defense program and applied them to industry we would get an enormous increase in productivity, and what you have done is actually quantify this in one particular area.

That's true. Any time one deals with new technology, there are all kinds of spinoffs. I believe that's the way it's been throughout the history of mankind, starting with the invention of bronze.

To me, it's an evolution of an old idea: that is, that man is driven to learn how to control the forces of nature. That's very constructive work for him. And with these beam technologies, we now have the capability to control, for the first time, unprecedented amounts of power. Of course, the driving force to develop these technologies—as was the driving force to develop bronze or many of the other things we've developed—is to protect ourselves from hostile invaders. It's always been that. But if we can put the threat of nuclear war behind us, then I see these technologies as providing a new opening for doing things that could not be done before.

Question: How did you get involved in this project? What were you working on?

I got involved in it when I was working for a private company. I was hired by this company to investigate possible commercial applications of military and defense types of technology. . . . During the California medfly crisis, I was dealing with electrical machines that produced very intense radiation pulses, and a neighbor of mine, who was a manager for one of the ag-



Dr. Stephen M. Matthews: "Man is driven to learn how to control the forces of nature."

ricultural research stations here in California, asked me if I knew anything about food irradiation. I certainly had never heard of it, but that's how I got started in it, back in 1981.

Since that time I have learned a little bit about it, and one of the things I found was that practically all of the people who are interested in food irradiation, who have been doing work on it in the past, are people whose knowledge is with food, and not with radiation. I found that there was room for some technical expertise that could be contributed to the field, and that's what I've been doing.

Question: What is your technical background?

I'm a physicist and my background is very varied. I have had a lot of experience in designing and building detectors and detection equipment for various types of nuclear radiation. I have been involved with some very advanced technologies, which are the types of things that we're looking at now, and I have always been interested in ways of utilizing these technologies for commercial benefit.

Question: The kind of things that you reported in your paper have tremendous

commercial benefits. As you calculated it in paper you presented a year ago at the food irradiation conference in Hawaii, an electron beam accelerator of the sort Lawrence Livermore Laboratory is developing can mass process irradiated food at a cost of \$5.98 per ton.

I've just done a reevaluation of that, and as a matter of fact I'm presenting a paper next week at the Fifth International Radiation Processing Conference in San Diego, titled "Comparative Economic Factors on the Use of Radionuclides and Electrical Sources for Food Processing with Irradiation." I've written this paper with Dr. Manuel Lagunas-Solar at the University of California at Davis, and we've gone over the costs of processing food with cobalt and cesium as the nuclear sources compared to doing it electrically—with electron beams. It turns out that the price electrically, according to the assumptions we've made, is significantly better than the \$5.98.

Question: What does the cost come down to?

For using a portable electron beam accelerator facility, we've now found that the operating cost of processing a ton of produce at 100 kilorads is \$3.25 per ton. That's a little more than half of what we had before, because we now have a better estimate of the accelerator cost.

Question: That makes it much cheaper than current chemical methods of disinfection and fumigation for grains, for example, and for fruits.

Yes. I'll give you some details from a table in our current paper titled "Comparative Processing Costs for Pest Control in Raisins." We picked raisins because there is available comparative data in a University of California report on alternative processing techniques for raisins.

When EDB, ethylene dibromide, was removed from use by the EPA, the growers went into a little bit of a panic here. They have compared the costs of alternative fumigants—methyl bromide, phosphene, low-oxygen atmospheres, and nitrogen atmospheres—and we just added to that table the cost of doing it with radiation. For the current processes, methyl bromide is \$8.37 a ton, phosphene is \$10.75 a ton, and

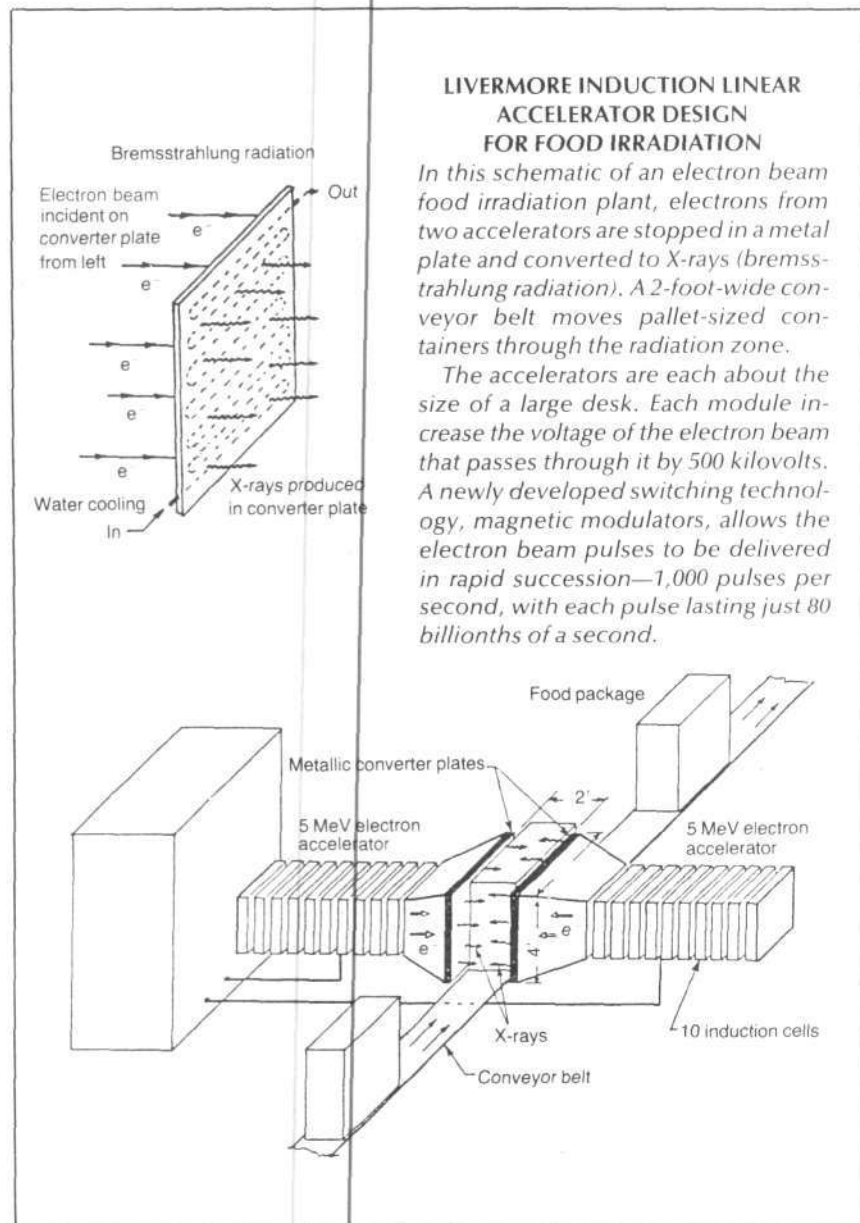
the other alternatives go way up to as high as \$17.83 using liquid nitrogen. The fumigation costs include a charge of \$5.42 per ton to stack the raisins so that the processing atmosphere can circulate through the stack. Stacking is not required with radiation processing.

For the radiation technologies, even the cobalt is cheaper than the bromide. It's possible that people may disagree with some of the assumptions we've used. Nevertheless, I think the costs are reasonable here.

Question: How does the accelerator you

are developing at Lawrence Livermore differ from the electron beam accelerators that have been used in the past for testing with food irradiation?

There are a number of different types of electron accelerators. The types that have been used in the past for commercial applications have been radio frequency linear accelerators—they're called RF Linacs. These linacs have a resonant cavity, which is basically a metal box—a waveguide, if you like. A radio frequency standing wave, an electromagnetic wave, is placed inside the box, and this wave accelerates electrons down the length of the box,



and they come out one end. That's how an RF Linac works.

This type of machine has been used very successfully in the past. However, it has certain problems if you try to make the beam intensity high, which arise from the fact that the accelerator has a resonant cavity. Now all cavities have what is called the *Q* factor, which is how well they can support the wave before it damps out. Since the cavity for a high-intensity machine will have to have a very intense radio frequency wave, the *Q* factor has to be very high.

This means that the mechanical tolerances for building the cavity are severe. You have to build that cavity just right; it has to be precisely the right size, and you can't handle it too roughly. Also, the material out of which the box is built has to have a very high conductivity. Otherwise the *Q* begins to drop, and this means that some of the energy goes into heating up the walls of the accelerator and you lose energy from the propagation of the beam.

Now, at let's say 5 megavolts—which is the voltage you'd want to have an electron beam accelerator to drive an X-ray machine—at 5 megavolts, a typical machine that you can buy will put out a power of the order of maybe 1 to 2 kilowatts, and that machine will cost about \$1 million. Well, for the same price, we can build a machine that will put out 1,000 times the power at 5 megavolts and has far better commercial properties.

For example, an induction linear accelerator doesn't depend upon a resonant cavity. There are no high voltages that are built up inside the machine. The machine is made out of modular construction, so that all you have to do is put together a bunch of parts and then link them together.

Question: Does that mean it can be mass-produced?

It can be mass-produced.

Also, the vacuum tolerances are very relaxed. For example, a radio frequency accelerator has to have extremely good quality vacuums; otherwise you get a breakdown and you get an arcing inside the machine. Since relatively low voltages are used inside this machine, the vacuum tolerances are relatively mild, and you can have what is called a commercially obtainable vacuum. A

dirty vacuum, so to speak, something like a micron is perfectly sufficient. You can obtain this with a mechanical pump; you don't need fancy oil-diffusion pumps or vac-ion pumps, or whatever.

Question: Did this new accelerator come specifically out of the beam program?

It was an outgrowth of the beam program, that's right. We needed to have an accelerator that could produce intense beams to study, and this is what came out of it.

Question: How does the machine work?

It is called an induction linear accelerator, and it really works as a series of one-to-one transformers. You have a group of modules, and each module

"A fixed electron beam accelerator could irradiate the food so fast that you could not move it through the machine fast enough—almost a ton per second."

will increase the voltage of an electron beam that passes through it by 500 kilovolts, half a megavolt. In exactly the same way that a transformer works, you have a primary and a secondary circuit. In this accelerator, the primary circuit is a 500-kilovolt pulse, which is placed through the module.

The secondary circuit is the electron beam itself passing through the module. You hook up a whole bunch of these modules—one module for each 500 kilovolts that you want to increase the beam energy. For a 5-megavolt machine you need 10 modules. You hook up the 10 modules and launch an electron pulse at one end of the accelerator. Every time the electron pulse passes through a module, you then pulse that module with an external current. In this way, the electron beam will be increased in energy by 500 kilovolts, or by half a megavolt at each of the 10 modules.

Question: How high is your outside current?

The outside current is delivered by a capacitor through a switch that puts a pulse into the external circuit. The pulse is 10 kiloamps. So you've got a ½-megavolt, 10-kiloamp pulse which increases the energy of the electron beam by half a megavolt. Now you have to fire these modules in succession. You have to fire the first module when the electron pulse gets to that module, and then a very short time later you fire the second module, and then the third module—exactly the same way that the lights on a theater marquee march down the marquee. This is exactly the same thing: You fire the modules one after the other, as the electron pulse gets to the particular module.

When the electron pulse gets to the far end of the machine, it has picked up the energy it has accumulated after traveling through all these modules.

To make 5 million volts, you only need voltages of half a million volts, and you just keep building it up. Then you have to launch one pulse after the other in rapid succession, so that you have a whole bunch of pulses coming out of the end of the machine.

In order to do that, you have to have a special type of switching technology called magnetic modulators—a magnetic switch. It's a new type of switch—actually it's a very old type of switch but uses new materials—that enables the linear accelerator to deliver pulses in very rapid succession. That's what gives it the very high average power.

You see, the idea of a linear accelerator has actually been around since about 1968, and we built linear accelerators here around that time. The problem with them was that they could only put out one pulse at a time.

Question: But you have now solved that problem.

Now with the magnetic switches the accelerator can put out 1,000 pulses per second, for long periods of time.

Question: What dose will you use for food irradiation?

We are considering applying doses of 100 kilorads to fresh produce. And in order to do 100 kilorads, we had considered a little portable machine

Continued on page 62

Space Pioneer Krafft Ehrlicke Honored At Conference on SDI Mobilization

"Let us proceed to colonize the Moon and Mars, as Krafft Ehrlicke committed himself to implementation of this process. Along the way, we have a military problem to solve, which the technologies of space colonization are best suited to solve. Being patriots and world-citizens, we shall solve that intervening task, but we shall solve it best by never taking our eyes away from our primary mission assignment. Once civilization is secured, and the productivity of labor throughout this planet increased greatly by the technological revolution flowing through our Strategic Defense Initiative Task, we shall have established the more powerful economy we require to begin actually the colonization, first of the Moon, and then of Mars. All this we shall do best,

if we view the practical task of colonization of Mars as a necessary way of bringing to all of mankind a vision of man as man in the universe, and thus fostering the opening of the long-awaited Age of Reason."

With this statement, FEF board member Lyndon H. LaRouche, Jr. summarized in his keynote address the purpose of the Krafft Ehrlicke memorial conference, June 15-16 in Reston, Va. Sponsored jointly by the Fusion Energy Foundation and the Schiller Institute, the conference drew 450 participants, including leading military, scientific, and diplomatic representatives from four continents, plus greetings from many prominent individuals who were unable to attend.

It was precisely the type of interna-

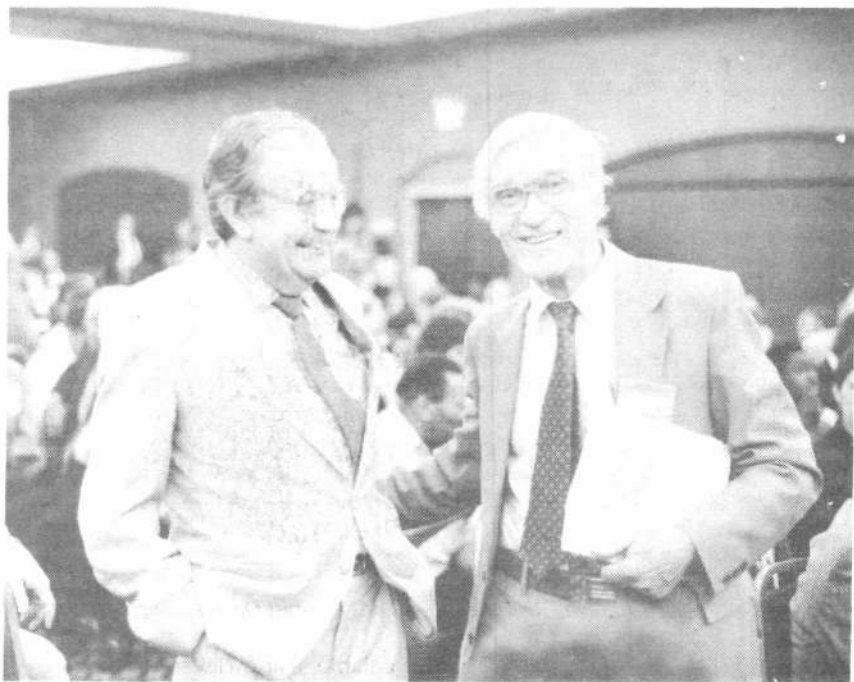
tional grouping capable of putting together, *on a private basis*, the ideas and organization necessary to institute a crash program for beam weapon defense. Such a private initiative was a specific proposal LaRouche made to participants at the end of the conference proceedings. As a first step, conference participants adopted two resolutions. The first was a telegram to President Reagan and other heads of state urging that "The Strategic Defense Initiative must be realized in a crash program that draws on the scientific, technological, and industrial capabilities of the entire Western world."

Second, conference participants called on President Reagan to overrule the Office of Special Investigation's



Photographs by Stuart K. Lewis

Lyndon LaRouche (at podium): We have to launch a crash program for a Moon-Mars mission and the SDI now on a private basis. From left, Uwe Parpart-Henke, Helga Zepp-LaRouche, Michael Lebig.



Fusion scientists Friedwardt Winterberg (left) and Winston Bostick.

witch-hunt against German-born U.S. space scientists, which is now operating to prevent the participation of these scientists in the SDI program.

German Scientific Method

Throughout the conference, it was emphasized that without the classical German tradition—which Ehrlicke and his colleagues from Peenemünde exemplified—there would be no U.S. space program. FEF research director Uwe Parpart-Henke made this point most vividly in his presentation on the Göttingen tradition and the work of Ludwig Prandtl in hydrodynamics.

Parpart-Henke dramatically contrasted the Göttingen hydrodynamic method with that of Theodore von Karman. "Von Karman is associated with the statistical turbulence theory and with the idea of making certain linear adjustments in the classical hydrodynamic theory in order to get away from the nasty singularities that plague this kind of research. He's associated with precisely with the outlook, which, if adopted in principle, will not allow any significant advances in the physical sciences, and has never, in fact, been responsible for the development of such advances."

Two themes prevailed during the two-day proceedings: the urgency of the current strategic crisis—in partic-

ular, the hostage situation in Beirut—and the profound optimism of space scientist Krafft Ehrlicke that man has the capacity to reach the age of reason. As Schiller Institute president Helga Zepp-LaRouche put it in her address to the conference, "man is capable of reason and overcoming every crisis."

Particularly moving in this context were the greetings sent to the conference by space scientist Hermann Oberth, now 91. Oberth's work in the 1920s inspired the pursuit of space exploration and created the team of scientists at Peenemünde, Germany, who later built the U.S. space program. Expressing the hope that man could eliminate the growing threat of World War III, Oberth said, "I only hope that we shall have enough time to raise the sails to realize Ehrlicke's vision of 'Homo Sapiens Extraterrestris,' so that man may leave his berth in the flaming harbors of the Earth and steer a new course into the world of unlimited growth."

The Peenemünde Approach

LaRouche, Parpart-Henke, and others stressed that only the crash program approach of Peenemünde and the German classical tradition could succeed in establishing an effective defense. In this context, the fact that the U.S. Justice Department's Office of Special Investigation (OSI) is now con-

ducting a witch-hunt against the German-American scientists from Peenemünde who built this country's rocket and space program after World War II came under attack as "treasonous."

The OSI came under particular fire by General Bruce Medaris, former commander-in-chief of the Army Ballistic Missile agency at the Redstone Arsenal in Huntsville, Ala., who was responsible for producing the first Earth-orbital satellite and the first ABM, the Nike-Zeus. The OSI is waging an unconstitutional campaign of "guilt by association" against German-American scientists like Arthur Rudolph, Medaris said in a taped statement to the conference.

Among the European speakers in the first conference session were Admiral Karl Adolf Zenker, former commander-in-chief of the West German Navy; General William Kuntner, commander of the Austrian General Staff Academy; and Senator Vincenzo Carollo, a Christian Democrat from Italy. In addition, a speech by Dr. Juergen Todenhöfer, member of the West German Bundestag and spokesman of the Christian Democratic caucus of the Foreign Policy Committee, was read.

The second conference session included two personal reminiscences of Krafft Ehrlicke. Konrad Dannenberg, former director of the Redstone Rocket production at the Redstone Arsenal and former deputy program manager of the Saturn booster project, reviewed how he met Ehrlicke at Peenemünde and then recounted the development of rocket science from the Peenemünde days and the V-2 through NASA's Apollo Project.

Next, Arnold Ritter, a personal friend of Ehrlicke who worked with him at General Dynamics, reviewed Ehrlicke's contributions to the U.S. space program. In particular, Ritter discussed Ehrlicke's role in developing liquid hydrogen fuel for space travel and his difficult decision to leave the Centaur project in order to concentrate on his theoretical work concerning the industrialization of the Moon.

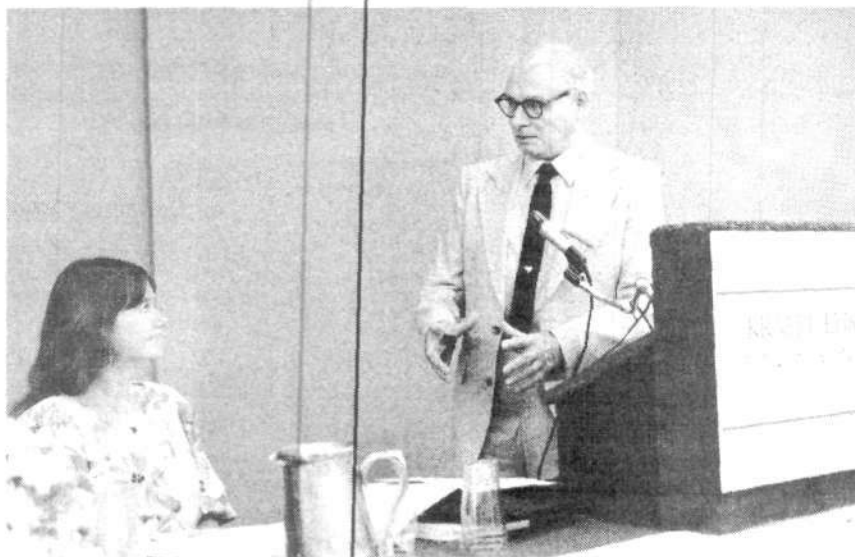
The morning panel on the second day covered the scientific frontiers opened up by SDI research. Jonathan Tennenbaum, head of the FEF in Europe, noted Edward Teller's recent speech in Washington, D.C., where he

emphasized that the SDI was based on "new physical principles," and then discussed some of these new principles in nonlinear spectroscopy and optical physics.

Dr. Luis Carrasco, professor of astronomy at the University of Mexico in Mexico City, reviewed the frontiers of astrophysics, stressing the need for a "new physics" to understand phenomena in the universe. Dr. Friedwardt Winterberg, fusion scientist and professor at the University of Nevada Desert Research Institute, discussed the current breakthrough areas of the SDI and where future breakthroughs have to come—such as in prolonging life.

Defending the Western Alliance

In introducing the afternoon session, Helga Zepp-LaRouche stressed the need for a new U.S. foreign policy that treated allies as allies, equal partners, and not simply "assets" to be used. The present U.S. economic and foreign policy, she said, was making enemies of our friends. The United States must reinstitute the principles of the American Revolution that created this country as a "true republic, where each citizen is created equal . . . there is no oligarchy, no princesses." The SDI, because it has the capability of lifting our eyes to the future of humanity, is a vehicle for putting the Western Alliance on the basis of true republicanism, she said.



Helga Zepp-LaRouche chats with Konrad Dannenberg.

Two European speakers, Michael Leibig of the *Executive Intelligence Review* and Heinz Horeis of the German-language *Fusion* magazine, outlined what Europe's contribution to the SDI could be as an "equal partner" concentrating on tactical defense. Such a Tactical Defense Initiative, or TDI, would focus on developing defenses against Soviet weapons in the endoatmosphere—cruise missiles, tactical (medium-range) missiles, and aircraft.

"Before the end of this decade, we have to be able to make the risk of a Soviet first strike against Europe incal-

culable, using a layered approach with fixed and mobile ground-based and space-based and hybrid systems," Leibig said.

"We are talking about flight times of just a few minutes," Horeis said. Three lines of defense are conceivable, he said, airborne high power lasers, ground-based medium-range lasers, and mobile point defense. He stressed that Europe has the potential to develop the TDI if it mobilizes to do the job.

Japanese space scientist Nobuki Kawashima then discussed the potential for Japanese participation in the SDI. Japan is the first and only country to experience the nuclear bomb, he said, and now the constitution prohibits any armaments funding or production. However, technologically, he said, Japan has the potential capability for both nuclear weapons and beam defense.

Fusion Energy Foundation executive director Paul Gallagher next reviewed the state of the U.S. SDI program—how the budget that the Reagan administration requested for the SDI for fiscal year 1986, \$3.7 billion, is what the Soviets spent on such defense back in 1980, the last year that the Soviet Union made public any information on its defense expenditures. Now both the Senate and House have cut this requested budget by one third.

In spite of budget limitations, however, the program is making breakthroughs, he said. For example, large,



Arnold Ritter commenting from the floor during the discussion period.

lightweight mirrors of the sort necessary for space basing can now be mass produced easily. Previously, he said, the United States was capable of turning out about 2 square meters' worth of the proper quality mirror per year, and the space telescope mirror, to be deployed next year, took six years to produce.

What these breakthroughs imply was discussed by Uwe Parpart-Henke, who said that what the enemies of the SDI feared was not so much the military aspects of the program but its potential for transforming the economy.

"The SDI is a military program, he said, but if it is seen only as that it will not succeed. It has to be seen as a broad-based reconstruction program for the world. The advances in produc-

tivity from the application of SDI technologies will not be the normal 2, 3, 5, or even 10 percent per year—but tens of thousands of percent, 15,000 percent, by applying high power lasers to industry."

"The principal spinoff of the space program was in computer technologies," Parpart-Henke said, "but this has not produced the in-depth transformation of the economy that laser technologies will." It is precisely this potential transformation of the economy that is most feared by the Soviets as well as the zero-growthers, he said.

'We Are at War'

The hour and one-half question period at the concluding session of the conference was dominated by discussion of the current war danger and how to wake up the population.

"We are in a state of war right now. The Soviet Union officially is in a state of war against the United States. They are mobilized completely; their command and control is ready. One morning the Ogarkov plan may go into effect," Lyndon H. LaRouche, Jr., told the audience.

"Will some missiles get through our beam defense? Yes, maybe two or more will get through. But war is war. Maybe 70 million people will die. . . . The question is not can you avoid casualties, the question is first, can your nation survive as a nation, and second, if you have survived war, can you also win it. Therefore, you must do war planning, walking the line. . . ."

"Under the present situation, the Soviets would win, not because they have superior technology but because we have superior stupidity—stupidity in our command. Our stupidity got us into this war. Now, we have to buy time. . . ."

LaRouche proposed that the proceedings of the conference be produced as soon as possible to give to the Reagan administration and for participants to use in organizing a "private" level crash program for beam defense.

—Marjorie Mazel Hecht

The complete conference proceedings are available now from the FEF in book form and can be ordered at \$9.95 per copy, plus \$1.50 for postage.

Electron Beam Irradiation

Continued from page 58

that was rated at 100 megarad/tons per day. This is what we presented in a paper last year in Hawaii. Well, now we've upped that to closer to 200 megarad/tons per day, and the only reason we can't make it higher is that we're limited to a 1-megawatt portable generator. If we could get a bigger portable generator, we could run the thing higher; the limit on it now is how much electricity we can feed through it.

Question: Why are you limited to a 1-megawatt generator?

A 1-megawatt portable generator is what's easily available. And if you use a 1-megawatt portable generator, then the machine will put out half a megawatt of electron beam. And 8 percent of that energy gets converted to X-rays. So it sounds like a very wasteful thing, energetically; but it turns out that even that amount, even 8 percent of the energy converted to X-rays, is far, far better than what you can do with radioactive isotopes.

For example, let's take the portable accelerator that I just described, with a 1-megawatt generator. Even suffering the fact that half the energy is lost when you convert from the electrical energy to the electron beam, and that of the energy in the electron beam only 8 percent is converted to X-rays—even then, the amount of X-rays available for processing is equivalent to 4.5 megacuries of cobalt, which is something like 5 percent of the world's supply. . . .

A fixed electron beam accelerator could irradiate the food so fast that you could not move it through the machine fast enough—almost a ton per second, if you can move it that fast. In other words, the limitation with a fixed facility is not in the radioactive material nor in the radiation source: The limitation now is how fast you can move the food through the machine!

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Equipment for the Amateur Astronomer

Continued from page 51

name from the comet hunter's practice of surveying large sections of the sky quickly, looking for some new feature that may prove to be a comet. The Comet Catcher will also serve as a good scope for viewing Halley's Comet, since the comet will become very large and extended as it approaches the Sun this year.

The Comet Catcher is light enough to use piggy-back on a larger telescope as a super finder-scope or for taking wide-field photographs.

As a first telescope, especially for children, the Comet Catcher makes sense in that it is affordable, has good optics, and its wide field makes it easy to locate things without the bother of a separate finder scope. But keep in mind that you will not be able to increase the magnification enough to get good views of most deep-space objects like galaxies. It is not sold with an equatorial mount, but many first-time users like the ease of an altazimuth mounting like a camera tripod.

We found the optics to be quite crisp, especially for a telescope at this price. Its principal drawback is in the focusing mechanism. The novel feature of the focus control is that the diagonal mirror and eyepiece move back and forth along the axis of the telescope. But since the rack and pinion gears are made of cheap plastic, they can be stripped very easily (for example, if you try to focus while forgetfully leaving the focus-lock tightened).

If Celestron corrects this focus control problem, the Comet Catcher will be excellent wide-field telescope at a very reasonable price.

The Telrad Sighter

The field of view in most amateur telescopes is usually about $\frac{1}{2}^\circ$. Although this is the apparent angular size of the Sun and Moon, it can often be a frustrating experience to find just the small patch of sky you are looking for, especially if there are either no bright "landmarks" or too many, as in many areas along the Milky Way, to help you locate your target.

Most observers zero in on their targets by first using the telescope

tube itself as a pointer, then perhaps sighting along some set screws on the finder-scope for closer alignment, and finally using a low-power finder-scope that typically gives you about a 4° field of view. If the finder is aligned properly, you should now be pretty close to your target; you can switch to your regular eyepiece.

The Telrad sighter was designed to overcome certain problems that arise when this usual finding procedure does not work well. One problem arises in trying to point the large (13" or larger) Dobsonian reflectors—especially when aiming straight overhead at the zenith. On telescopes with equatorial mounts, maneuvering around the Pole Star can present the same problem. This ingenious device provides a way to see much of the neighboring sky for better orientation even while you zero in on your target.

Telrad projects a "bull's-eye" onto a glass screen. You look through the bull's-eye to aim, but it does not block your view of the surrounding sky. The glowing red concentric circles define fields of $\frac{1}{2}$, 2, and 4 degrees; these are the usual fields of view of the regular eyepiece, and high power and low power spotting scopes, respectively.

Telrad can be attached without screws using cord or elastic bands. I found this impractical, since it is too easy for Telrad to get out of alignment. The base, however, is detachable from the finder and can be permanently mounted on your scope.

Telrad is not a substitute for the traditional finder-scope. Since there is no magnification, you would not be able to use star charts to full advantage in finding deep sky objects. But if you sometimes need a little extra assistance in pointing, Telrad is a good buy.

Lumicon Nebula Filters

The spread of city lighting in the 20th century has meant that generations of city dwellers no longer can see the Milky Way or the thousands of stars visible to an observer at a dark viewing site. And not just naked-eye astronomy has suffered. Telescopes collect and focus not just star light but also any ambient light that

is scattered in the atmosphere. Unless you travel far from metropolitan areas, the faint nebula you are searching for is likely to be lost in the general background glow.


One solution to the problem is to selectively filter out light coming from mercury vapor lights and other types of street lights, and to allow into the telescope eyepiece the light that is most strongly emitted by stars and nebulae. Lumicon offers a series of filters that do just that.

We tested the Deep-Sky and Ultra High Contrast filters. The Deep-Sky passes light in the 442 to 532 nm wavelength band; the UHC filter allows only the narrower band of 484 to 505 nm. The filters screw into the eyepiece.

When using the filter, the background sky becomes dramatically darker—light pollution is being screened out. But the light from celestial objects also gets filtered, although more selectively, resulting in a fainter image. This is where the wonderful ability of the eye to perceive dim light comes into play. What is most important is not the brightness of an object, but the contrast of the object with its background. Reduce the light from a nebula but place it on a dark background, and it will shine like you have never seen it before.

When I used the UHC filter to view the North American Nebula in my 13" Dobsonian, I was able to trace the "continent" completely around. "Florida" glowed strongly against a jet black "Gulf of Mexico." Even the very dim, nearby Pelican Nebula was perceptible. Although the North American Nebula is visible to the naked eye in areas with extremely dark skies, it is almost impossible to see it anywhere near a major city without this type of filter.

—Jim Everett




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 Dew shield **\$45** Solar Filter **\$126**

80mm REFRACTOR **\$495**



Model 310 (\$700 list) **\$495**
 Excellent for both terrestrial & astronomical viewing 80mm (3.1") f/11 refracting telescope includes 1 1/4" focuser, 6x30mm finderscope, 36X and 100X 1 1/4" eyepieces, adjustable height tripod with accessory tray, and alt-azimuth mount with slow motion controls.
Model 320 (\$900 list) **\$630**
 Identical to 310, but has equatorial mount with setting circles. Quartz motor drive \$169 Basic camera adapter \$32 Easy-Guider (state camera) **\$149**

OPTIONS BOOST PERFORMANCE

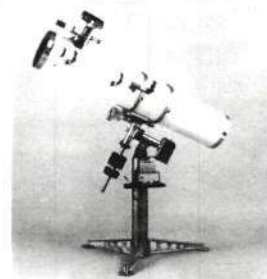
LUMICON UHC Filter for nebulae, Standard 1 1/4" **\$79**
 Prem 1 1/4", **\$99**; Std 48mm, **\$149.50**; Prem 48mm, **\$189.50**
LUMICON Deep-Sky Filter, 1 1/4" Premium **\$79**
 48mm Prem Deep-Sky **\$119.50, \$99.95 w/ Easy-Guider**
 Adapter for viewing w/ 1 1/4" eyepiece **\$20**
 Dust Covers, Keep optics clean, For 6" **\$18/pair**
 8" **\$20/pair**; 10" **\$18**; 16" **\$24**
LUMICON Rich-Field Viewer (2080) **\$120**
LUMICON Newtonian Easy-Guider, 1 1/4" or 2" **\$149**
 #122 2X Barlow (\$60 list) **\$48**
 Dual-axis drive corr. and elec. dec. for 2080/LX2 **\$298**
 for Model 628, 826, DS-10 **\$310** for DS-16 **\$420**
 Tele Vue 32mm Plössl 1 1/4" eyepiece **\$88**
LUMICON Cassegrain Easy-Guider for 2080/LX2 & LX3 (state camera) **\$199**
 Illuminated reticle eyepiece & battery pack **\$69.50**

All foreign orders add 6% (\$8 minimum)
 California residents add 6% tax
 Prices subject to change w/o notice
 Set Meade and LUMICON Catalogues \$4
LUMICON, 2111 Research Dr., #5
Livermore, CA 94550.
 Call (415) 447-9570 for information & orders
 Store Hours: M-F 9am - 5pm; Sat 11am - 3pm

8" f/6 NEWTONIAN **\$890**

BEST VALUE!

IDEAL FOR COMET HALLEY



Model 826, 8" f/6 Telescope w/ accessories
Model 628, 6" f/8 with motor drive (\$1220 list) **\$785**
 —Best telescope for all visual use, superb optics.
Model 826, 8" f/6 with motor drive (\$1396 list) **\$895**
 —Collects 78% more light than a 6" telescope
Model 826C, 826 w/ 2" focuser, 8x50mm finder (\$1530) **\$995**
 These Meade Deluxe Series reflecting Telescopes have superb image quality at low or high power. They include an equatorial mount with motor drive, pier, legs, setting circles, 1 1/4" rack & pinion focuser, 6x30mm finderscope, 25mm (48X) and 9mm (135X) 1 1/4" eyepieces, altitude and azimuth fine adjustments for polar alignment.
 #43 drive corrector uses 12VDC (\$120 list) **\$96**
 #47M Dual-axis drive corrector & elec. dec. **\$340**
 1 1/4" or 2" EASY-GUIDER (state camera) **\$149**

LUMICON® FILTERS

STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter™** improves both visual and photographic contrast on all deep-sky objects including galaxies. The **LUMICON UHC Filter™** is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.



Filter	UHC	Deep-Sky
For 1 1/4" eyepieces	\$99.50	\$79.50
48mm for 2" eyepieces	\$189.50	\$99.50
For 2" eyepieces & photography		\$99.50
Set, 1 1/4" UHC & Deep-Sky Filters		\$139.20
H-Beta Filter, 1 1/4"	\$79	48mm \$169

16" f/4.5 NEWTONIAN **\$1995**

GET READY FOR COMET HALLEY



Meade DS-16A with Accessories
 The DS Series of 10" and 16" reflecting telescopes are ideal for deep-sky viewing and photography.
DS-10A, 10" f/4.5 with motor drive (\$1510 list) **\$995**
 —Gathers 56% more light than an 8" telescope
DS-16A, 16" f/4.5 with motor drive (\$3050 list) **\$1995**
 —Gathers 400% more light than an 8" telescope
 Both the DS-10A and DS-16A telescopes include an equatorial mount, #680 2" focuser, motor drive, setting circles and 25mm 1 1/4" eyepieces.
 6x30mm finderscope with brackets (\$46 list) **\$39**
 8x50mm finderscope with brackets (\$114 list) **\$89**

In This Issue

BEAMS, INSECTS, AND SAVING CROPS

Entomologist Philip S. Callahan explains how insects "sense" each other and plants by beaming and receiving electromagnetic radiation in the infrared range. His pioneering work not only gives us new insights on sense perception, but also opens the way for an elegant method to stop the millions of dollars of insect damage to crops: Jam the insect "radar" with a particular frequency that will mask the emission of the crop the insect eats.

Another crop-saver that will vastly increase the world food supply by protecting food from spoilage is a spinoff of the Strategic Defense Initiative beam defense research. Scientists at Lawrence Livermore National Laboratory have developed a unique electron beam accelerator to irradiate food products. As Dr. Stephen Matthews explains in an interview, the accelerator is compact, portable, and able to irradiate large quantities of food extremely cheaply.



*Small-eyed sphinx moth *Calasymbolus myops*, which eats willow leaves, flies toward a red low-intensity beam. The box chamber is filled with willow leaves for scent. The red light pumps the scent, causing far infrared*

LLNL



maser-like lines in the airspace in front of the red beam light.

Lawrence Livermore Laboratory's electron beam accelerator shown here in the lab's swimming pool, where initial food irradiation experiments are being conducted.

Betty and Dennis Milon



A NEW NAME FOR HALLEY'S COMET?

For 200 years, Halley's Comet has carried the name of Edmund Halley, a protégé of Isaac Newton. In our special Young Scientist section on comets, Philip Valenti proposes that the comet, which reappears late this year, be renamed for the man who did the actual scientific work—astronomer John Flamsteed.

The Young Scientist section also tells you what comets are and when and where to look for Halley's Comet.

Comet West, photographed from New Hampshire on March 7, 1976. The dust tail shows as white; the gas tail as blue.