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Fusion by the 1990s?

Soviet program says yes; U.S. program, classification policies say no

It is a bitter irony of the Carter administration's policy to shut down this nation's nuclear capacity and potential that even as that policy propels the U.S. toward a strategic confrontation with the Soviet Union, it also weakens the overall economic and military capabilities which the U.S. must be able to deploy in such a confrontation. This holds true not only for the policy of eliminating existing nuclear technologies, but also for the policy of retarding those pace-setting areas of fusion research that will determine the ultimate strategic, civilian, energy, and military capabilities of this nation.

A prime example of such research is electron-beam fusion. The Soviet effort in this area was recently featured on the front page of the *New York Times*. There it was reported that the research team under Dr. Leonid Rudakov had successfully completed and tested the first stage of the Angara-5 multi-electron-beam fusion machine. That result is significant in two ways: first, in terms of Soviet plans for a net energy producing machine by the early 1980s (compare the more modest U.S. effort in the accompanying chart), and, second, because of how such research is scientifically classified in the United States.

The Soviet's fusion coup

What the Soviet Union announced was a schedule for completion of a pilot facility and the beginning of an actual program based on the successful pilot project. Speaking on Oct. 5 at the dedication of the first of 48 electron beam units for the Angara-5 facility at the I.V. Kurchatov Laboratory in Moscow, Dr. Rudakov said: "When it is completed, we hope to obtain a controlled thermonuclear reaction as a result of which the facility will be producing more energy than it consumes. Angara-5 will demonstrate that an industrial pilot plant can be built."

Thermonuclear fusion, the most promising advanced energy resource for the future, is based on the principle of the fusion of nuclei in fuel that can be extracted from sea water. The prerequisite to making this clean, cheap and virtually unlimited energy commercially available is achieving breakeven, or a reaction in which more energy is produced than consumed.

The Angara-5 results are an impressive milestone in one of the crucial approaches to fusion energy (the Soviets have several other mainline approaches as well), but they are not unexpected. Rather, they fulfill a long-stated schedule and confirm the Soviet commitment to investing in advanced technology even where there is no short-term "pay-off." That commitment was also strengthened in the recently announced Soviet Five-Year Plan.

The technological advances embodied in Angara-5 also imply important applications to Soviet nuclear war-fighting capabilites.

Neither point was lost on the editorial board of the *New York Times* whose coverage of the Angara-5 results is indeed unusual, given their generally hostile attitude toward any kind of advanced technology approach to energy, including fusion. The *Times's* editorial board is dominated by members of the New York Council on Foreign Relations which is pushing a policy of a "New Dark Age" through a halt to technological advance, including the denial of nuclear energy technology to the Third World.

At the very moment that the Third World economic crisis is bringing the world closer and closer to a superpower confrontation, the authors of the "Dark Age" policy are faced with fresh evidence that the ongoing Soviet insistance on scientific progress places Moscow in a superior strategic position.

As Dr. Rudakov states, when the full 48 module Angara-5 electron beam system is completed within about four years, several million amps of very high energy electrons (several million volts) will be utilized to compress and heat a pellet of fusion fuel two centimeters in diameter to the extremely high densities and the 100-million-degree temperatures found in the interiors of stars. A minihydrogen explosion will result, which will generate more energy than that used to

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Inertial confinement fusion—when breakeven?

Date	Achievement	Experiment	Location	Description
U.S. programs				
1984	Breakeven	Shiva Nova	Lawrence Livermore Laboratory	Glass laser with a pulse energy of 100 kilojoules and a pulse power of 100 terawatts
1984	Breakeven	Antares	Los Alamos Laboratory	CO_2 laser with a pulse energy of 100 kilojoules and a pulse power of 100 terawatts
1984	Breakeven (with ion beam, a gain of 10-20)	EBFA	Sandia Laboratory	Electron beam with a pulse energy of 1000 kilojoules and a pulse power of 30 terawatts
U.S.S.R. programs				
1983	Gain over 100	Angara-5	Kurchatov Laboratory	Electron beam with a pulse energy of 5,000 kilojoules
Early-mid-1980s	Beyond breakeven	Delfin and Slab lasers	Lebedev Institute	Glass laser with a pulse energy of 10-15 kilojoules and a pulse power of 20-30 terawatts
Early-mid-1980s	Beyond breakeven	CO_2 laser	Kurchatov Institute	CO_2 laser
Early 1980s	Breakeven	Fast Liner	"Red Square" Laboratory	Imploding liner
Early 1980s	Breakeven	Gribkov's "Flora"	Lebedev Institute	Electron beam from plasma focus that could, if vigorously pursued, reach breakeven first

The Soviet inertial confinement fusion program is not only broader in scope than the American, but also geared to producing net energy at an earlier date. Pulse energy is the energy imput. When pulse energy equals energy output, breakeven is achieved and every increment of output above input is "gain." For instance in the case of Angara-5, a gain of over 100 means a fusion reaction output of over 500,000 kilojoules.

generate the electron beam fusion reaction—"breakeven."

The 'Rudakov' case

Dr. Rudakov's team was the first to obtain ignition of minute amounts of fusion reaction in 1975, using the electron beam pellet approach. He came into the public limelight back in the summer of 1976 when he conducted the first of several tours of U.S. research facilities. On these tours, he summarized the Soviet e-beam research results and some of the physical processes hypothesized to be involved in e-beam driven fusion.

His lectures and the subsequent commentary and evaluation by a number of U.S. scientists were immediately classified top secret by the Department of Energy. All efforts initiated at that time and pursued since then by the Fusion Energy Foundation (a New York based nonprofit institution committed to the research and development of all forms of advanced technology energy production) to obtain release of the Rudakov documents have been rebuffed by the government. Most recently, the DOE handed down a several-page decision which cited every possible pretext and legal precedent for not releasing the Rudakov papers.

At the same time, the Energy Department faction under James R. Schlesinger was engaged in another "legal battle" whose intended purpose was to retard U.S. research in the very areas Dr. Rudakov had discussed so freely during his U.S. tour. The case: the *Progressive Magazine* and thier intention to publish the so-called secret of the hydrogen bomb.

As the *Progressive's* editor Samuel Day stated in a signed editoiral in the latest issue of this publication, what was really on the mind of the government officials like James Schlesinger before and during the *Progressive* case, was whether or not to take on the Fusion Energy Foundation.

In its monthly publication, *Fusion*, the FEF had provided in-depth coverage of the Rudakov case from the outset. It pointed to special U.S.-British nuclear intelligence arrangements as a controlling factor in the decision to classify and reviewed the central scientific questions and results in each of the areas of inertial confinement fusion research that were being brought to a standstill by the abuse of classification. *Fusion* pub-

lished a series of articles which made public for the first time the scientific origins of the H-bomb in the 1859 paper by Bernhard Riemann on shock waves, and the development of those ideas by leading German hydrodynamicists and aerodynamicists during the 20th century.

Rather than prosecute the FEF, the government took injunctive action against the *Progressive* to prevent publication of much more general material already available in the public domain. If the government won its case, the precedent would be set for legal action against the FEF on issues secondary to those raised by the foundation's reports.

The FEF entered an *amicus curiae* brief in the *Progressive* case based on the stated intention of the Atomic Energy Act of 1954 to promote the proliferation of peaceful uses of nuclear energy and of scientific knowledge. This legal intervention was followed by the publication in several newspapers of letters written by one Charles Hansen on H-bomb "secrets." Immediately, the government withdrew its case against the *Progressive* and author Howard Morland. It nevertheless restated its intention to continue to vigorously use its classification and punitive action prerogatives.

In the past week, sources within the American Civil Liberties Union (which defended the *Progressive*) have reported that the government is bitterly divided between those in the DOE who want to stop the spread of fusion "secrets" and those in the Justice Department who consider this a risky proposition. At stake is whether the proliferation and classification issues will continue to be used to kill advanced nuclear development, or whether the way will be cleared for the fundamental scientific research necessary to achieve economical fusion in this century.

—Charles B. Stevens and
Dr. Morris Levitt,
Fusion Energy Foundation

Rudakov: 'Fusion research at a turning point'

Dr. Leonid Rudakov's dedication address at Moscow's I.V. Kurchatov Laboratory was covered by the Oct. 6 issue of the Soviet daily Pravda. *The following are excerpts from that article.*

Today, our area of science (fusion research) finds itself at a turning point; we are building prototype thermonuclear plants. One of these is the Angara-5. When it is completed...we hope to achieve a driven thermonuclear reaction that will produce more energy than the plant requires to operate. Angara-5 should prove that it is possible to build a commercial demonstration reactor.

Why is the experiment called "Angara"?

There are several explanations, but I like this one: Many rivers flow into Lake Baikal, but only one, the Angara, flows out. It's the same in our area of science; there are a number of different approaches under investigation, but we hope that ours will be the most effective.

We are working to create and control low power thermonuclear explosions. For example, in an automobile engine there are about 100 million microexplosions before the cylinder—the combustion chamber—is destroyed. For a thermonuclear plant to be economically profitable and to last a long time, it must do about the same. There already are chambers that can withstand rather powerful explosions.

The compression (of the fuel) must be a thousandfold above normal. Under that condition, the fuel can burn up before it flies apart.... The surface layer of the target must fly to the center with a velocity two orders of magnitude greater than that of a Kosmos rocket...The comparisons with Kosmos goes farther, in that we think of the surface layer as if it were a multitude of rockets aimed at the center of the target. It is necessary to guarantee that the rocket motors begin to work simultaneously, which means that energy is concentrated in a small volume in a short time. The target dimensions are about a centimeter. We store energy in capacitors, then we increase the pulse power to a huge value and direct it onto the target. It is enough to say that the energy thrown at the target in the Angara-5 module exceeds the power of all the electrical generating plants in our country (Don't forget that this is all happening in tenths of a millisecond!). The surface layer flares, its temperature reaches millions of degrees, and, like a multitude of rockets, it speeds to the center of the target. A very low power thermonuclear explosion follows that is nevertheless fully able to produce more energy than is expended in the reaction.