Soviets launch crash SDI-fusion program?

Charles B. Stevens and Robert McLaughlin review recent developments which indicate possible initiation of a crash magnetic fusion program by the Soviet Union.

After a decade of dormancy, the U.S.S.R.'s magnetic fusion program has suddenly sprung to life with what can only be described as a crash effort to obtain fully ignited thermonuclear plasmas within the coming months, according to leading Western fusion specialists and Soviet official announcements. The program has both major direct and indirect applications to the Soviet "Star Wars" beam weapon ballistic missile defense effort. The Soviet program is focused on achieving a fully ignited magnetic fusion plasma with the T-14 compact high field tokamak within the coming year—a goal which will not be attained until the 1990s with the existing schedules of the U.S. and Western magnetic fusion programs.

Ironically, the high field tokamak concept was pioneered in the United States by Dr. Bruno Coppi of MIT in the early 1970s, though Dr. Coppi's proposals for a compact ignition fusion experiment were ignored until recently. But the United States is only discussing compact ignition tokamak designs while the Soviets are completing construction of theirs.

The primary potential application of the compact tokamak to beam weapon missile defenses is to provide a compact, low-weight source of high-density, high-power energy which can be utilized to directly power laser and particle beam weapons. One possible variant includes using the compact tokamak for efficient storage of high energy particle and antimatter beams.

'Surprising speed'

This year marks the 10th anniversary of the groundbreaking for the construction of the Princeton Tokamak Fusion Test Reactor (TFTR), which was the last major magnetic fusion research facility to be brought into operation within the United States of America, and possibly the year of the initiation of a Soviet crash fusion effort. Within a year of the groundbreaking for the TFTR, researchers working on the Princeton PLT tokamak experimentally demonstrated, to their great surprise, the most optimistic scientific projections of a 1973 U.S. Atomic Energy Commission (AEC) study for a five-year crash program to realize a demonstration fusion energy electric power plant.

Since the 1978 PLT success of achieving reactor grade, 70 million-plus temperatures in a stably confined fusion plasma, the U.S. fusion program has been put on ice, while, nevertheless, ongoing experiments and technological progress have transformed the "high risk" projections of the 1973 AEC study into "off-the-shelf" capabilities. The magnetic fusion program has been frozen into constant, inflation-deflated budgets and an endless cycle of paper studies for an ever cheaper engineering test reactor (ETR), while the inertial confinement fusion (ICF: laser "pellet" fusion) program has been buried under a leaden cloak of security classification and secrecy.

Soviet breakout

The most shocking, and possibly sinister, recent development has been the sudden turn-around of the Soviet fusion program. Like the U.S. program, the U.S.S.R. fusion effort too went into a deep freeze in 1977, though for slightly different reasons. The plurality of leading posts in the Carter administration was populated by the authors of the New York Council on Foreign Relations' *1980s Project*, which advocated a strict anti-technology, malthusian program for the United States and the Western world. This tendency was clearly demonstrated when then Secretary of Energy James R. Schlesinger fired Dr. Stephen O. Dean, the DOE manager most responsible for the achievement of the Princeton PLT 1978 breakthrough, on the Monday following the public release of the Princeton scientific data.

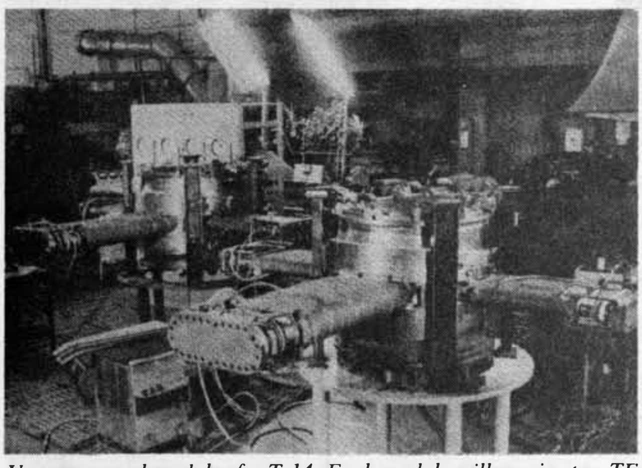
In the case of the Soviet fusion program, the late 1970s marks the point where the U.S.S.R.'s "Star Wars" program was accelerated into an all-out crash effort. This reallocation of scientific manpower and resources was confirmed in 1981 to Fusion Energy Foundation representatives by academician, doctor, Nobel Laureate, and Major General of Rocket Forces Nikolai G. Basov and his colleagues. At the time, Dr. Basov said that the reallocation was in response to the then-imminent deployment of medium-range U.S. missiles in Western Europe—the Pershing IIs and cruise missiles.

And indeed, the Soviet magnetic fusion program has gone into an even deeper freeze than that of the United States since that time. In 1977, the U.S.S.R. initiated their T-15 tokamak project—a far less ambitious machine than the Princeton TFTR, even though more advanced, superconducting magnets were designed into the T-15. The TFTR has been operating for several years and the T-15 has not yet even begun operation.

But the April 1987 issue of the *Executive Newsletter* of Fusion Power Associates carries a report of a complete turnabout in the Soviet fusion program by Prof. Daniel R. Cohn of MIT. Professor Cohn, who is a specialist in high field tokamaks, reveals:

"Moving with surprising speed on the construction of a new fusion experiment called T-14, the U.S.S.R. announced plans to operate the new facility by the end of the year. The compact, copper-coil device is designed to use deuterium-tritium fuel and to approach fusion breakeven conditions. . . . Compared to the almost ten years the Soviets have taken to complete the superconducting T-15 tokamak, a device still not in operation, the new T-14 device was conceived only two years ago."

The photographs document the progress on the crash construction of the T-14, donut-shaped high field tokamak that accompanied Professor Cohn's report.



Vacuum vessel modules for T-14. Each module will receive two TF coils, one on either side of the diagnostic ports. The two angled rings on each module are titanium support rings from which the vacuum vessel (0.5 mm nickel alloy) is suspended by a series of hooks. The titanium rings, in turn, are suspended from the TF coils. The vacuum vessel sectors are explosion formed.

What and why

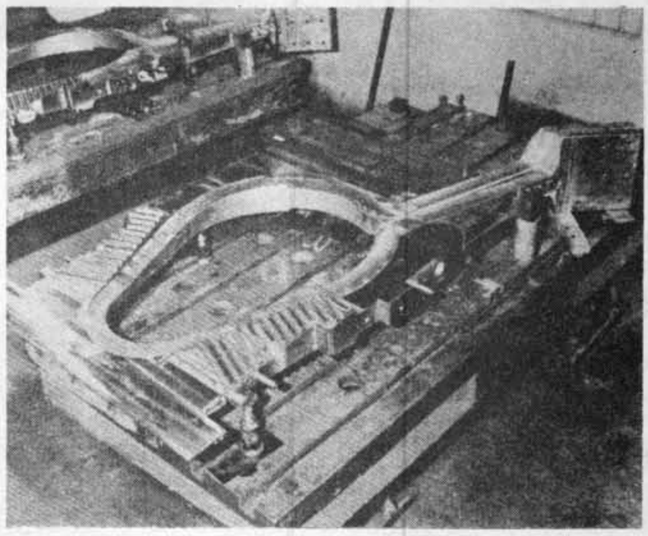
It is now widely accepted among senior U.S. defense planners that the U.S.S.R. is currently implementing "Plan B" of Soviet Marshal Nikolai Ogarkov. This Plan B was first revealed in the West in *EIR*'s July 1985 *Special Report,* "Global Showdown: The Russian Imperial War Plan for 1988." As detailed there, Marshal Ogarkov's Plan A called for a near-term success by 1988. Plan B was a backup to be implemented if the West initiated a serious missile defense effort like that of the Soviet Union and maintained a strong defense of Western Europe. It included a medium-term technological and scientific build-up to achieve a military success by the mid-1990s.

The sudden emergence of a Soviet crash fusion program and the T-14 in particular is quite ominous. It is most probable that the T-14 is directed toward realizing specific, near-term technological components for powerful beam weapons.

History of the high field tokamak

With the success of the Soviet-designed tokamak in the late 1960s, the United States and other Western countries built their own tokamak experiments. At this time, Prof. Bruno Coppi of MIT initiated a small, high-risk experiment which was designed to take the tokamak to its technological and scientific limits by utilizing the highest strength magnetic fields possible. This was the MIT high field Alcator tokamak, an experiment which was so small, it could virtually fit on a table top and had an operating plasma volume 100 times smaller than the largest U.S. tokamaks at Princeton Plasma Physics Laboratory.

Despite this, by 1974, the Alcator broke all experimental records by exploding through the previous theoretical limit



One of the 32 one-turn copper coils for T-14. Outer coil support shows teeth to react against over-turning moments. Scale size of the coil opening is of the order of 1/2-meter. Maximum field in the coil is 23 Tesla. Center of tokamak will be toward lower left in photo, electrical tabs at upper right will connect to inductive store below tokamak.

of tokamak plasma densities by more than an order of magnitude. Shortly thereafter, the Alcator approached the energy confinement time-density product needed for fusion breakeven—the point where the plasma can produce more fusion energy than the heating energy needed to maintain the plasma at fusion temperatures.

These spectacular results were ignored for almost two years because of the small size of the Alcator. When program reviews finally woke up national fusion managers to the fact that the Alcator results were real, they responded by setting up a major, new Fusion Institute at MIT and removing Professor Coppi from management of the Alcator program.

On the basis of the early 1970s Alcator data, Professor Coppi designed an experiment to go all the way; that is, to produce a fully ignited fusion plasma. This is a fusion plasma in which not only net fusion energy is generated, but enough of the fusion energy output is absorbed by the plasma to keep the plasma above fusion reaction temperatures. At that time, the Coppi proposal represented a high-risk proposal costing tens of millions of dollars, to leap-frog the magnetic fusion program decades ahead of schedule. More conventional, low-field, larger-scale ignited tokamak experimental designs were estimated to cost in the range of $500 million to $1 billion.

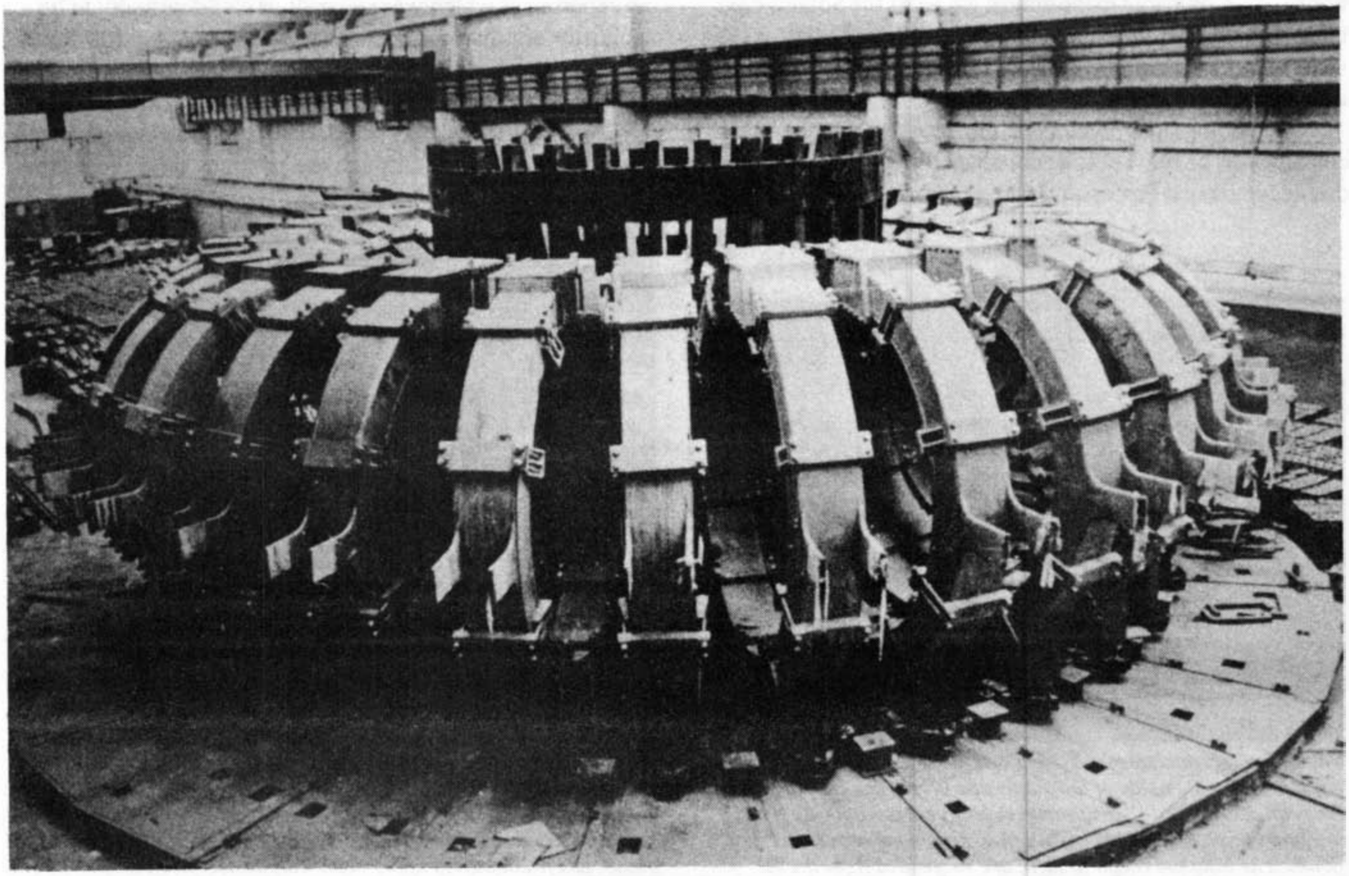
Despite the fact that Professor Coppi's concepts were not followed through, other smaller experiments carried out over the last decade did essentially confirm all of his "high risk" projections. And now, the Soviets have carried through on Professor Coppi's ideas.

Potential SDI applications

I. Pulsed power and switching

One of the major requirements for effective anti-missile beam weapons is that of energy-dense power. It takes about one megawatt average power of beam weapon output to destroy one missile per second. And an effective beam weapon must be capable of destroying scores to hundreds of missiles per second. This requires scores to hundreds of megawatts of average power of beam output. And laser and particle beams generally need from 5-20 times more power input than they achieve as an output. Therefore, effective beam weapons require from hundreds to thousands of megawatts of average power input. And this power input must generally be delivered at peak powers ranging up to millions of megawatts and at extremely high voltages.

There are three existing ways to provide this energy input in a repeatable form: 1) chemical; 2) nuclear fission reactors; 3) stored energy (capacitors, flywheels, inductive magnet systems). Because a compact tokamak can produce bursts of hundreds of megawatts of high-voltage output in a device with a mass of tens of tons, it can outperform these three



Mock-up assembly of coils for the inductive energy store for T-14. The tokamak itself will sit on top of this inductive coil assembly.

existing methods by orders of magnitude.

Not only can the compact tokamak develop the required high power outputs needed to drive beam weapons, but it can do it in time increments most efficiently matched to the operation of the beam system itself. This is because the tokamak fusion plasma can be "turned on and off" in very short time increments and therefore can be matched to the excitation times of a laser medium, for example.

II. Lasers

The main output from a deuterium-tritium fusion plasma is that of neutrons. These neutrons can be utilized in at least two ways to pump laser beam weapons. These fusion neutrons have an extremely high energy—14 million electron volts. More significantly, they have a large chemical potential because of their zero electrical charge. It therefore follows that these high energy fusion neutrons can be ideal for directly producing the atomic and molecular excitations needed for various types of lasers.

A second laser pumping scheme involves placing fissionable material in the laser medium. The fast fusion neutrons produce fission reactions and the resulting high energy fission reaction products excite the lasing medium.

Both applications have been demonstrated experimentally. But only fusion has the potential to realize large enough fluxes of neutrons to make this a practical method of pumping laser beam weapons.

III. Particle beams

A more speculative application of the compact tokamak is that of providing an efficient means to store a high-energy, high-current electron beam. The Alcator's early experiments in 1974 demonstrated a new regime, termed the slide-away regime by Professor Coppi. In this regime, the tokamak plasma develops into two components: 1) a low-density, low-temperature plasma; 2) a high-energy, intense electron beam.

Prof. S. Yoshikawa of Princeton University has proposed utilizing this regime to produce an extremely efficient, very high-power compact electron beam storage ring. If successful, this approach would improve the total stored power of the electron beam a thousand-fold over existing, conventional storage rings. But in terms of stored beam energy per kilogram of mass of the storage ring system, the improvement could be much greater than a million-fold.

Existing storage rings are both large and inefficient. The plasma in the tokamak permits the electron beam to be stably confined in an extremely small space with great efficiency.

In order to be maintained, an electron beam moving in one direction must be matched by a positive return-current in the opposite direction. In conventional storage rings and accelerators, the return-current is carried along the inside wall of the vacuum chamber. This type of return-current setup experiences high resistances and thus produces significant overall power losses. In the tokamak, the positive return-current is carried in the plasma and the plasma has an extremely low resistance to the flow of the return-current. In this way, the tokamak could become an extremely efficient means of building up and storing a high-power electron beam.

Experiments at Lawrence Livermore National Laboratory over the past several years have demonstrated that plasmas are extremely efficient at focusing electron beams and curbing beam instabilities.

The resulting high-power beam could either be utilized directly as a beam weapon itself, or to energize another beam system, such as the free-electron laser.

IV. Antimatter

Leading scientists at Princeton Plasma Physics Laboratory in New Jersey, who have pioneered many of the concepts above, point out that the storage ring system could also have

Closing of FEF an attack on science

by Carol White

On April 21, the offices of the Fusion Energy Foundation (FEF) in Leesburg, Va., were sealed by federal marshals under a Chapter 7 involuntary bankruptcy law. A Chapter 7 ruling does not even apply to nonprofit foundations like FEF, but the Justice Department has summarily stopped publication of the FEF's 114,000-circulation magazine, *Fusion*, and its quarterly, the *International Journal of Fusion Energy*.

As readers of *EIR* are no doubt aware, the staff of FEF, myself included, have been frequent contributors to this magazine and have been involved in producing the *EIR Quarterly Economic Report*. The staff of FEF, and the scientists with whom we collaborated to produce *Fusion* magazine and the *International Journal of Fusion Energy*, have joined together to form a Committee to Defend Scientific Freedom, which will be bringing this arrogant abuse of judicial proceedings by the Justice Department, before the international scientific community, as well as to citizens in general, and to the two houses of the Congress. Appropriate action on the legal front is being taken as well.

In Europe, Dr. Jonathan Tennenbaum, director of the Fusion Energy Foundation, Europe, is circulating a letter to the scientific community there, for endorsement. The following are excerpts:

"I am writing to call your attention to a monstrous violation of elementary rights of free speech and scientific enquiry, committed by the government of the United States of America in illegally taking over and shutting down an independent, nonprofit scientific institution, the Fusion Energy Foundation (FEF).

". . . In what U.S. Attorney Henry Hudson called 'the first move of its kind in U.S. history,' the 'involuntary bankruptcy' order was granted by a Virginia court in a secret (*ex parte*) proceeding without knowledge or representation of the FEF. The court order was granted and is being carried out in blatant violation of the elementary constitutional rights of the FEF, its employees and officers, and in spite of the fact that: 1) as an officially designated nonprofit organization, the FEF is legally not subject to the 'involuntary bankruptcy' clauses invoked; 2) the legitimacy of the fines in question is presently under appeal before a U.S. court which has agreed to hear the case; 3) no evidence was given of financial difficulties of the FEF which could justify bankruptcy proceedings against the Foundation.

"In the course of their actions against the FEF, Attorney Hudson and other U.S. Department of Justice officials have made no secret of the fact, that they are committed to shutting down the FEF by any means, regardless of constitutional and legal 'details.' The entire proceeding is being carried out in a manner typical of a totalitarian police-state.

". . . Suddenly and without warning, one of America's major applications to the storage of antimatter. Again, the stored antimatter could either be utilized directly as a beam weapon or as a means of powering a second beam weapon.

Soviet plans

The three photos show the Soviet T-14 compact tokamak under assembly at the Troitsk site outside Moscow. According to Soviet scientist V. Golant, the T-14 should begin operation this year. The machine is under the scientific direction of Prof. Valerii A. Chuyanov of the Kurchatov Institute. Engineering of the machine is under the direction of Dr. Oleg G. Filatov of the Efremov Institute of Leningrad.

The T-14 follows the original specifications of Dr. Bruno Coppi. It has a minor radius of one-half meter and a major radius of slightly more than a meter. The copper magnet coils develop a maximum field of 230 kiloGauss.

Following the specifications developed at MIT—in particular, the Zephyr design developed jointly between scientists from MIT and West Germany—the T-14 will utilize plasma compression to achieve fusion ignition. This concept of plasma compression was first demonstrated at Princeton Plasma Physics Laboratory on the ATC tokamak in the early 1970s, and has since been explored on the Princeton TFTR.

The concept is to initially run the T-14 in a low plasma-density, low magnetic-field mode. This permits the plasma to be penetrated and heated by microwaves from gyrotrons set to the plasma electron cyclotron frequency. Once the plasma is heated sufficiently, the magnetic field is suddenly increased. This compresses the plasma column, causing further heating and an increase in density. This is projected to produce the conditions for full fusion plasma ignition—a condition where enough of the fusion energy generated is absorbed within the plasma to maintain the plasma at fusion temperatures.

The Princeton TFTR is currently scheduled to achieve simple fusion energy breakeven with deuterium-tritium fuel in about two years. The Western European JET tokamak is scheduled to reach the same goal also in about two years, and JET has the possibility of also achieving the more advanced goal of fusion plasma ignition. (Both TFTR and JET began operating several years ago.)

It is far more likely, however, that the Soviets will achieve both goals first, later this year. And the Soviets will have accomplished this with a machine whose design did not even exist until after TFTR and JET began operating, and 10 years after construction on TFTR and JET began.

few truly independent scientific institutions has been forced out of existence. Founded in 1974, the FEF soon gained wide recognition for its promotion of accelerated research and development of peaceful uses of fission and fusion energy, for its advocacy of applications of directed energy technology to antimissile defense and to new production methods in civilian industry, and for its detailed proposals for a revived U.S. space effort centering around the long-term exploration and colonization of Mars. The FEF is also noted for its opposition to the 'limits to growth' propaganda of the Club of Rome, and for its many published studies and scientific conferences devoted to applications of modern technology to agricultural and industrial development of the so-called Third World. The LaRouche-Riemann econometric model was elaborated by an FEF team of economists, physicists, and mathematicians, and applied to the design of economic development programs for a number of nations and regions of the world, including Africa, the Middle East, India, Mexico, and Peru.

"Most recently, the FEF has circulated detailed proposals for incorporating advanced biophysics methods into a scientific crash program to find a cure for AIDS. Through a series of private scientific seminars and public conferences, the FEF has played a pioneering role internationally in bringing together specialists in different fields of biology, biophysics, and medicine, to discuss the AIDS problem.

"Apart from these and other concrete accomplishments, it is the FEF's catalytic role in formulating and disseminating *scientific ideas* which has earned it the greatest recognition among researchers in diverse domains. Aided by extensive studies of the history of science, the FEF pioneered the application of the 'phase-space geometric' methods of Gauss, Riemann, and Cantor to the mastery of nonlinear processes in physics, astrophysics, biology, and economic science.

"Support for the FEF's work has come from tens of thousands of subscribers to FEF publications, and supporting members of the Foundation throughout the United States. The FEF was granted and has maintained the official status of a nonprofit scientific organization, to which contributions are tax-deductible.

"The forced closing-down of the FEF is not an isolated event, nor merely part of a political witchhunt against one of its directors. These actions are a direct attack upon freedom of scientific research and freedom of speech in general. My colleagues in the United States have observed in recent months an ominous decline in independent scientific research. Laboratories and research programs, not fully controlled by government bureaucracy or giant corporations, are rapidly disappearing. Instead of free scientific enquiry and the fearless search for truth, it is increasingly peer-group pressure, fear of losing contracts, and compulsion to please the 'scientific mafia' controlling major research budgets, which determines the activities of American scientists. Unfortunately, this trend is not limited to the U.S. alone. Where scientific freedom declines, so does political freedom."

My former colleagues of the FEF, and I, are currently circulating a similar letter in the United States. Those of *EIR*'s readers who wish to directly support our efforts, either financially, or through political action, may write to me in care of this magazine.