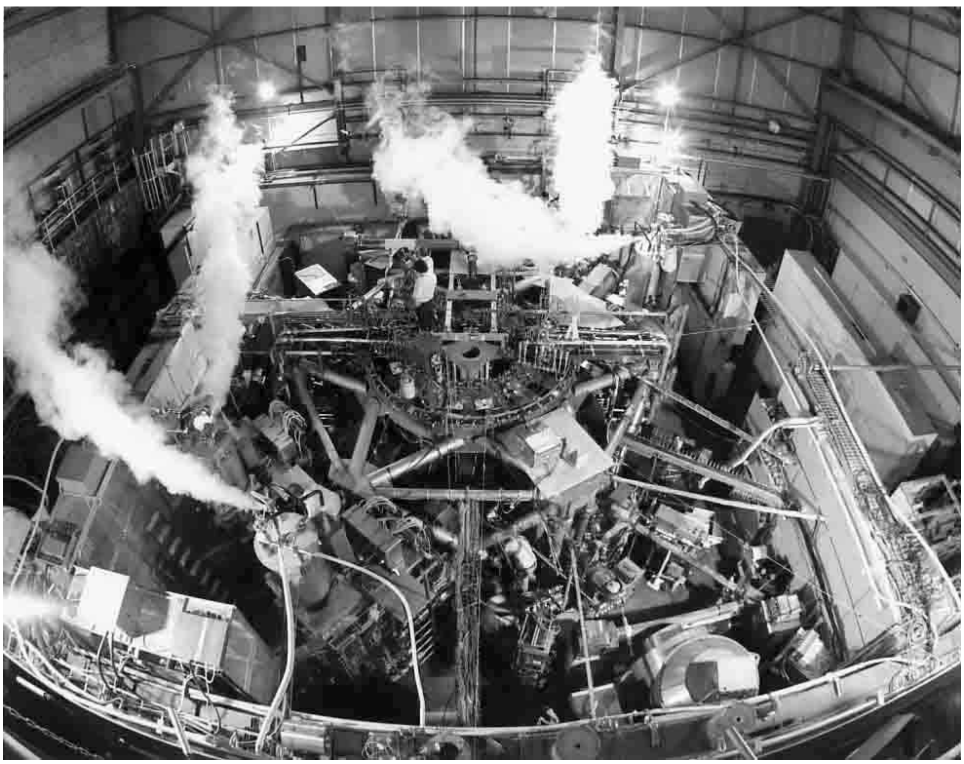
How the Malthusians Crushed The U.S. Fusion Program

by Megan Beets


PLT

Princeton Large Torus (PLT), Plasma Physics Laboratory, Princeton University.

The achievement of controlled fusion has been at mankind's fingertips for decades. Had the trajectory established in the early decades of the U.S. fusion program continued, mastery of fusion as a power source would already be providing nations of the world with virtually unlimited energy, would have created a qualitative transformation in our powers of industry, transportation, and medicine, and would have completely revolutionized our species' power to transform the conditions of life on our planet through unprecedented rates of physical economic growth and development.

The failure to realize this promise is not due to its impossibility, nor to a lack of capability on the part of fusion scientists, engineers, and scientific institutions. Fusion is not "always 50 years away"; it has been deliberately suppressed under a top-down imperial policy, carried out via the mechanism of intentionally crippling budget cuts, which have created a factor of attrition strong enough to delay for decades what would have surely already been achieved. One merely has to envision where we would have been as a species today had fusion been achieved by the 1990s, as intended by leading fusion scientists in 1976.[1]

The undermining of fusion, typified by the dismally low FY15 budget request of the Obama Administration, which proposes to shut down key fusion experiments in the U.S., must immediately cease. A fully funded, accelerated fusion program as a priority national mission is at the foundation of the survival and progress of our nation, and mankind as a whole.

Fusion: A New Era for Mankind

It was only at the end of the 19th Century that mankind entered the Atomic Age and began to understand and harness the power of the atomic nucleus, a characteristic of matter inaccessible to the understanding gained from simple chemical processes. Radioactivity was first discovered in the 1890s, and it was in 1905 that Einstein proposed that a small amount of mass could be converted to a large amount of energy (in proportion to the speed of light squared, $E=mc^2$). Here was the conceptual birth of fusion power. Whereas nuclear fission harnesses the energy released when a heavy atom (such as uranium, plutonium, or thorium) is broken apart, fusion reactions bring together the lightest elements (such as isotopes of hydrogen or helium), and is millions of times more energy-dense than coal, oil, or natural gas, and an order of magnitude more energy-dense than fission fuels. The fuels of fusion are also incredibly abundant, being found in seawater (in the case of deuterium, an isotope of hydrogen) or scattered throughout the lunar soil (in the case of helium-3), and could power the human species on Earth for billions of years.

It was determined in 1955 by John D. Lawson in the U.K., that three basic theoretical parameters would have to be met for a successful, sustained fusion reaction to produce energy over time. This is known as the Lawson criterion, and determines a minimum product of the temperature (energy) of the fusing ions, their density, and the minimum confinement time necessary to create conditions for a sustained, energy-producing fusion reaction to occur. Given that the fuel would have to be heated to temperatures hotter than the Sun, no ordinary material could contain it. However, since the fuel is made up of charged particles, a different type of "wall," a magnetic field, can be used to contain the reactants. Hence the birth of the "magnetic bottle."[2]

The U.S. Fusion Program: Beginnings

The U.S. fusion program was born in the cradle of the U.S. national scientific laboratories, first with an attempt at Langley Memorial Aeronautical Laboratory (now, NASA's Langley Research Center) in 1939 by two young scientists, Arthur Kantrowitz and Eastman Jacobs. This very early attempt failed to produce fusion, but was followed up throughout the 1940s by work at both the Los Alamos Scientific Laboratory (now, Los Alamos National Laboratory) and Princeton University (today, the Princeton Plasma Physics Laboratory). By 1946, it was concluded at Los Alamos that in order to achieve net energy from fusion, a steady-state plasma would have to be heated to a temperature of around 100 million degrees[3]—ten times hotter than the center of the Sun, and far beyond anything ever achieved on Earth.

In 1951, Lyman Spitzer at Princeton was given a $50,000 grant by the Atomic Energy Commission (AEC) to construct his design for a "stellarator," a modified magnetic bottle, designed to counteract the "drift" of the plasma which arose in simple toroidal configurations and prevented fusion conditions from being reached within the plasma. The original stellarator program at Princeton included four proposed phases, Models A through D, with Model D being a planned demonstration reactor.

James Tuck at Los Alamos led the building of a project in the Winter of 1952-53 which he named the "Perhapsatron."[4] The Perhapsatron was a toroidal magnetic bottle which would try to achieve fusion using a "pinch" concept.[5] The pinch and the stellarator designs,

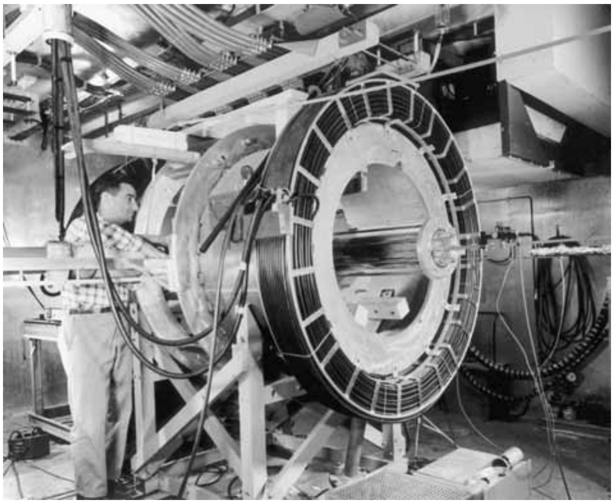
1. S.O. Dean, "Fusion Power by Magnetic Confinement: Program Plan," U.S. Energy Research and Development Administration Report, ERDA-76/110 (July 1976).

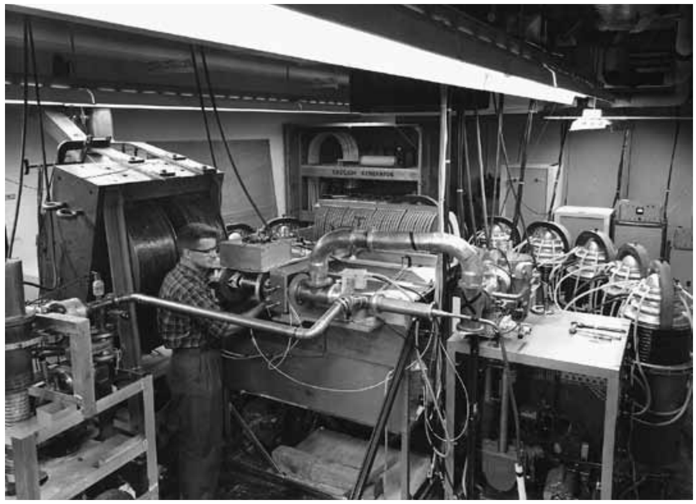
2. Another approach to confining the fusion fuel is called inertial confinement, where a fuel target (e.g., a pellet of deuterium-tritium fuel) is heated and compressed by the effects high energy beams delivered to the outside of the target.

3. All temperatures are given in Celsius.

4. Perhaps it would work. Perhaps it would not. The Perhapsatron did not work, but ended up laying the basis for the next stages of fusion designs.

5. A "pinch" uses the natural tendency of an electric field, induced within a flow of plasma, to compress the material of the plasma toward the center of the plasma column, which then collapses under the force into a very dense, thin filament structure. The idea was to utilize this phenomenon to reach the temperatures and densities required for fusion





The Table Top mirror machine at Livermore (left) and the Scylla machine at Los Alamos (right), during the 1950s Project Sherwood days.

along with the "mirror machine," led by Richard Post at the University of California Radiation Lab at Livermore (later, Lawrence Livermore National Laboratory), formed the backbone of what became the U.S. classified program to achieve controlled thermonuclear fusion: "Project Sherwood."

Funded by the AEC under the auspices of President Dwight Eisenhower's "Atoms for Peace" policy, and led by the same scientists who had harnessed the power of the atom in the form of nuclear weapons during the war, Sherwood sought to utilize the groundwork in nuclear research laid during wartime, for purposes of peace and development. As stated by AEC Chairman Lewis L. Strauss in 1954, "Our children will enjoy in their homes electrical energy too cheap to meter.... It is not too much to expect that our children will know of great periodic regional famines in the world only as matters of history, will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds, and will experience a lifespan far longer than ours, as disease yields and man comes to understand what causes him to age."[6] Such was the natural optimism surrounding the scientific prospects of fusion.

The existence of Project Sherwood was announced to the public leading into the IAEA's (International Atomic Energy Agency) first International Conference on Atomic Energy, held in Geneva in 1955, and limited international cooperation began in 1956.[7] The project was fully declassified as part of the second International Conference on Atomic Energy in 1958. The same year, an experiment at Los Alamos became the first in any laboratory to produce neutrons from thermonuclear fusion: the Scylla I.[8]

Strauss, who as chairman of the AEC, increased the fusion budget from $7.3 million[9] in 1951 to $114.7 million by 1958, wrote of Project Sherwood: "The importance of 'Sherwood' as the project was called, now conceded to be at least theoretically feasible, can hardly be overstated, and I hope to live long enough to see the same natural force which powers the hydrogen bomb tamed for peaceful purposes. A breakthrough could come tomorrow as well as a decade hence. Out of our laboratories may come a discovery as important as the Promethean taming of fire."

reactions, before instabilities disrupt the plasma.

6. Lewis Strauss, AEC Chairman (1953-58) in a Sept. 16, 1954 speech to the National Association of Science Writers.

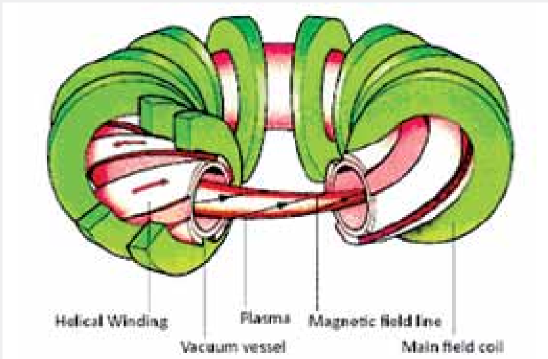
7. Reflecting the optimism of the period, the head of the Indian Atomic Energy Commission, Homi J. Bhabha, who presided over the 1955 conference in Geneva, said in his presidential address, "I venture to predict that a method will be found for liberating fusion energy in a controlled manner within the next two decades. When that happens the energy problems of the world will have been solved forever, for the fuel will be as plentiful as the heavy hydrogen in the oceans."

8. The Scylla designs were based on a "theta-pinch" concept, similar to the "z-pinch" of Tuck's Perhapsatron, but with a different orientation of the magnetic and electric fields.

9. All budget figures are given in 2013 dollars. Budget sources: Fusion Power Associates; the U.S. Energy Iniformation Agency; and Amasa S. Bishop, "Project Sherwood: The U.S. Program in Controlled Fusion," 1958.

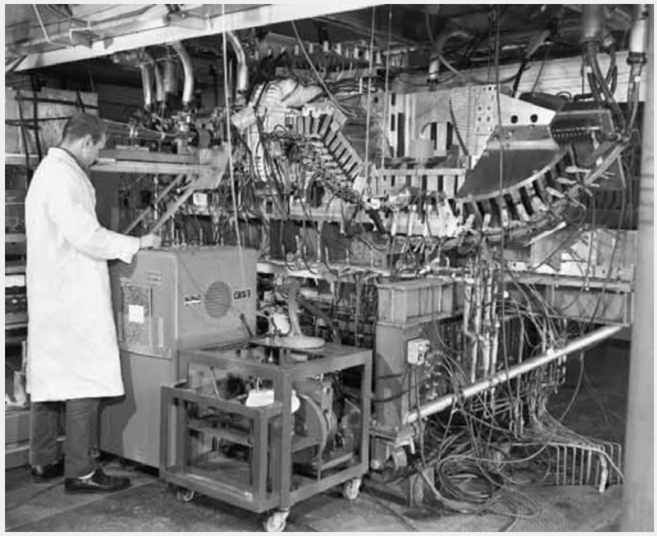
Fusion Designs

Stellarator



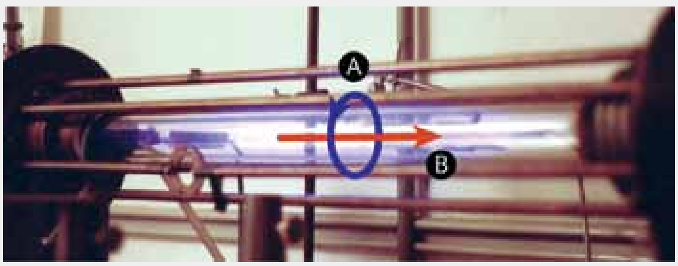
European Nuclear Society

Left: The stellarator uses an externally applied helical magnetic field to provide a twist in the path of the plasma particles, thereby counteracting net forces on the particles and keeping them on a "straight" path as they travel around the vessel. The earliest stellarators accomplished the same thing with a figure-8 geometry. Right: An early stellarator at Princeton.



PPPL

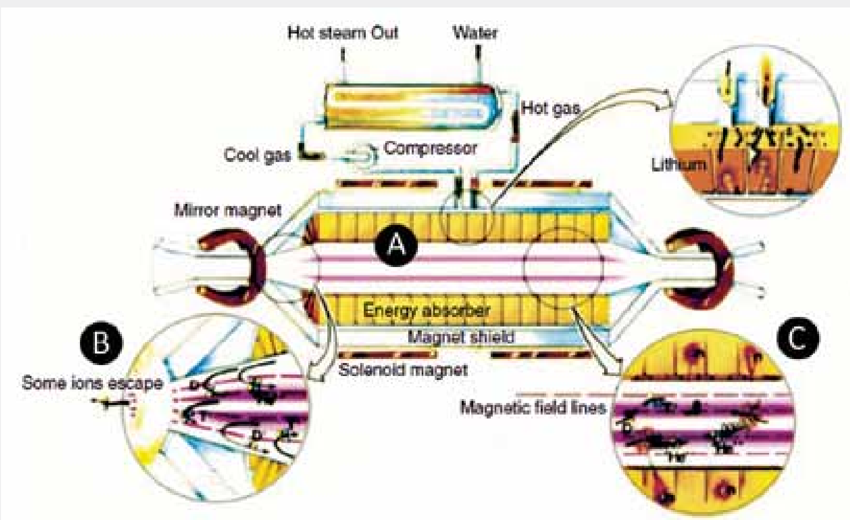
Pinch



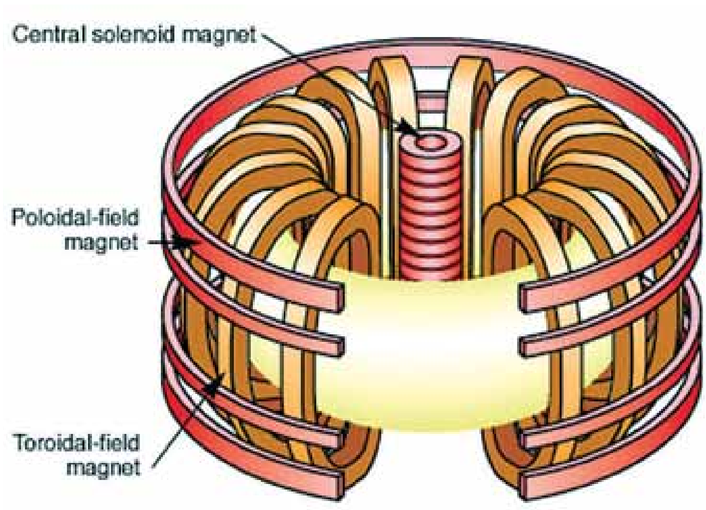
Left: The pinch design uses a magetic field (A) to induce an electric field (B) in the plasma along the direction of the plasma flow. The charged plasma flow is pinched inward under the Lorentz force, into a thin, dense filament. Right: The Perhapsatron at Los Alamos.

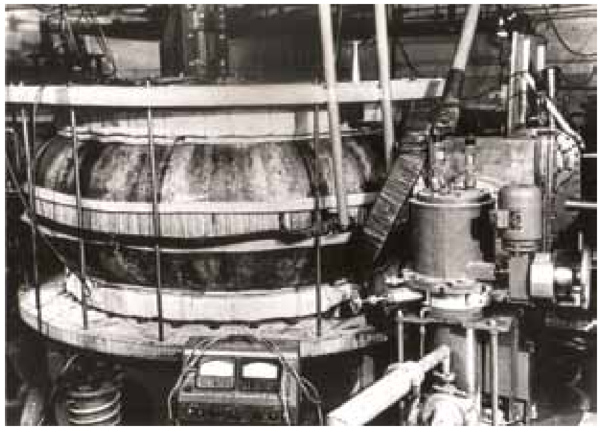
LANL

Mirror



This diagram of the Tandem Mirror design shows the basic principle of the mirror machine. Hot plasma in the center of the cylindical reactor vessel (A) is contained within the chamber by two mirror magnets, which "plug" the ends (B) and turn (or reflect) most of the plasma ions back into the center where they undergo fusion (C). The mirror design was considered potentially more favorable for a commercialized reactor, because its linear design was easier to engineer and led to less instabilities in the plasma.





LLNL *Left: Basic tokamak design. The tokamak features two external magnetic fields (toroidal and poloidal) designed to contain the plasma long enough for fusion reactions to occur. Above: The first tokamak, T-1, in the Soviet Union.*

The 1960s

Spearheaded by the U.S., U.S.S.R., and U.K., work proceeded into the 1960s, and substantial fusion research also began in Germany, France, and Japan. Work on the Scylla design at Los Alamos continued, and by 1964, temperatures in excess of 40 million degrees were achieved by the Scylla IV, though confinement time was still quite short: less than 10 millionths of a second. In 1968, an announcement came from the Soviet Union that record temperatures and confinement times had been achieved with the Soviet tokamak design in its T-3 machine.[10] When these breakthrough results were confirmed by a delegation from the U.K.'s Culham Laboratory in 1969, the world began converting their toroidal magnetic bottles to tokamaks, including the conversion of the Model-C stellarator at Princeton, which became the first U.S. machine to confirm the Soviet results.

Inertial fusion, in which fusion is triggered by a rapid application of energy to a pellet of fuel, also had its beginnings in the 1960s. With the invention of the laser in 1960, discussions began about the possibility of using a laser to set off a "micro-hydrogen bomb" which could be contained in a chamber and harnessed for energy, and the first patent applications for a laser fusion design were filed in 1969.

By the end of the 1960s, the fusion budget had risen from $114.7 million in 1958 to $140 million in 1968, allowing the groundwork to be laid for the breakthroughs to come in the 1970s.

The 1970s

By the early 1970s, the decision was made to elevate the fusion program to division status within the Atomic Energy Commission. By 1972, with a budget increase to $144.7 million, a plan was mapped out for future fusion facilities and experiments designed to prove the scientific feasibility of fusion.[11] A 1972 planning project within the AEC projected important results from the planned Princeton Large Torus (PLT) by 1978, and the follow-on operation of a physics test reactor, to produce 10 MW of fusion power, by 1984.[12] In 1971, a small tokamak, ORMAK, began operation at Oak Ridge National Lab, which would come to play an important role in the ability to raise the temperature of the plasma to thermonuclear levels. In 1973, approval was given for initial efforts at fusion power plant design by teams at the University of Wisconsin, General Atomics, Argonne National Lab, and Oak Ridge National Lab.

With a growing budget, three new tokamaks were

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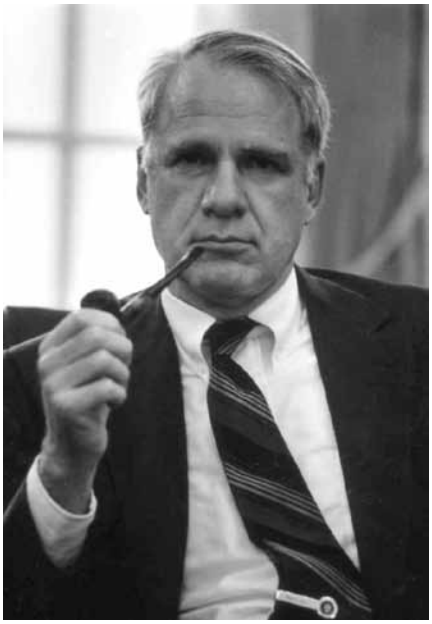
10. The tokamak design, begun in the Soviet Union in the 1950s, is a toroidal magnetic bottle with helically wrapped coils, with a strong toroidal (along the axis of the tube) magnetic field.

11. At the time this was understood to mean the achievement of the Lawson criterion in a deuterium plasma experiment, or to mean "equivalent scientific breakeven"—that is, an experiment using only deuterium fuel that would have produced more energy than it took to heat the plasma, if tritium had been included as a fuel. This has not yet been accomplished.

12. Both of which goals were achieved. The PLT achieved such results in 1978, and a physics test reactor, the Tokamak Fusion Test Reactor (TFTR), began operation at Princeton in 1982. TFTR did indeed produce 10 MW of fusion power, though not until 1994, ten years after originally projected.



EIRNS

Left: James R. Schlesinger, whose Malthusian views woudn't allow the realization of practicable fusion power. As Energy Secretary, 1977-79, he delayed and undermined fusion development. Right: Congressman Mike McCormack, sponsor of the 1980 Magnetic Fusion Energy Engineering Act, speaks to a meeting of the Fusion Energy Foundation in May 1981.

approved for construction: the Alcator-A at MIT, the Doublet-II at General Atomics, and the PLT at Princeton. In 1974, the Atomic Energy Commission was abolished, and fusion research was rehoused under the newly created Energy Research and Development Administration, the precursor to the Department of Energy (DOE). The same year, even before operation of the PLT began, the Tokamak Fusion Test Reactor (TFTR) was approved for construction at Princeton as the follow-on "physics test reactor" to the PLT, with the expectation of achieving breakeven.

At Livermore, the "mirror machine" was well advanced from its humble beginnings during the Sherwood days, and in 1975, the 2XIIB at Lawrence Livermore achieved plasma parameters comparable to those being achieved in the more widely worked-on tokamaks. In 1977, a new design, the Tandem Mirror Experiment (TMX), intended to solve the "end plug" problem,[13] was approved. The TMX began operation in October 1978, and its success led to the approval of the more advanced Mirror Fusion Test Facility (MFTF), to be completed in 1985.

As the 1970s progressed, and the great pace of advancements in all three mainline approaches (tokamak, pinch, and mirror machine) accelerated, steps were taken to accelerate fusion research through expanded international cooperation. In 1973, President Richard Nixon and Soviet leader Leonid Brezhnev signed an agreement on the Peaceful Uses of Atomic Energy. The first U.S. team to travel to the U.S.S.R. under the agreement was a fusion team, which was casually briefed on a technique being developed for inertial fusion which corresponded quite closely to very highly classified work being done in the U.S. at the Sandia Laboratory.

While the perspective for a robust fusion program seemed to characterize the early part of the decade, the end of the 1970s would prove to be a decisive collision point on issues of global policy.

The PLT and the Magnetic Fusion Energy Engineering Act

The Princeton Large Torus, which produced its first plasma in 1975, would soon take center stage in a policy fight that stretched far beyond the bounds of so-called "scientific research."

In late July 1978, reports surfaced that scientists at

13. The mirror design is an open-ended, straight magnetic bottle with two strong "mirroring" magnetic coils at the ends of the tube, which turn the plasma flow back toward the center of the machine. The linear design was seen as more appropriate than the tokamak because of its potential for commercialization, as all sides of the machine are accessible for maintenance and repair, and because its plasmas tended to be more stable than in the closed, toroidal designs. However, too many ions were leaking out the ends. Hence the "end plug" problem.

Princeton had succeeded in using auxiliary heating in the PLT, demonstrated first with Oak Ridge's ORMAK[14] tokamak, to raise the temperature of the plasma to a level never before achieved—over 60 million degrees—for the first time surpassing the minimum temperature required for ignition, 44 million degrees.[15] Achieving this temperature milestone was especially significant, since the Alcator tokamak at MIT had recently shown that it was possible to confine a plasma at the needed density for sufficient time to achieve ignition.[16] Breaking the temperature threshold for ignition broke a psychological threshold, too. As expressed by Steve Dean, director of magnetic confinement systems at the DOE, "The question of whether fusion is feasible from a scientific point of view has now been answered.... It is the first time we've produced the actual conditions of a fusion reactor in a scale-model device."

While news of the breakthrough was excitedly disseminated around the fusion community, it was determined that the official announcement could not be made public until the Aug. 23 IAEA fusion meeting in Innsbruck, Austria. News, however, did get out to the press, after which, the DOE leadership under Secretary of Energy James Schlesinger did everything possible to downplay the importance of the results, including an attempt to stop a DOE press conference scheduled for Aug. 14 (which did, after all, go forward, though with the conspicuous exclusion of the head of the DOE Fusion Office, Ed Kintner). Schlesinger's DOE insisted that the results obtained at Princeton were not, in fact, a breakthrough, and that fusion was just as far away as ever. John Deutch, DOE Director of Energy Research, echoed his boss by saying that these results were good for Princeton, but were not a breakthrough.

This suppression is not surprising from one such as Schlesinger, who wrote in his 1960 *The Political Economy of National Security*: "Economics is the science of choice in a world of limited resources.... We have gone around the world spreading the 'gospel of plenty' raising the level of expectations ... [but] in the nature of things, these rising expectations can never be satisfied.... We must in our strategic policy return to the days before the Industrial Revolution ... [and] prepare to fight limited wars."

Not everyone in positions of policymaking agreed with the Malthusian Schlesinger, however. Congressman Mike McCormack of Washington State seized the momentum created by the PLT results to convene a scientific advisory panel in the Congress, which met over the course of 1979, and concluded that the biggest barrier to fusion was a lack of political commitment, and an inadequate level of funding.

Meanwhile, the public interest in fusion boomed, with subscriptions to *Fusion* magazine, published by the Fusion Energy Foundation (FEF)[17] soaring to 100,000—making it the second most widely circulated science magazine in the nation.

The FEF played a critical role throughout the 1970s and into the 1980s, in educating the public and policymakers alike on fusion, with dozens of seminars held around the world, in addition to *Fusion* magazine, face-to-face organizing, and in publicly taking on the political fights against the attempts to sabotage fusion. In October of 1978, in response to the optimistic breakthrough at Princeton, the FEF released a memorandum to Congress outlining an acceleration in the fusion program, and a proposed budget comparable to that of the 1960s Apollo Program.

In January 1980, McCormack announced at a conference on nuclear safety in Washington, D.C., that he would be introducing legislation to "make it the policy of the U.S. government to bring the first electric-generating fusion power plant on line before the year 2000." He said, "We must move into the engineering phase with fusion. We must not wait for somebody else to do it.... Once we develop fusion, we will be in a position to produce enough energy for all time, for all mankind. This is not hyperbole, but fact." In a subsequent interview, in contrast to the outlook of Schlesinger, McCormack said that fusion "could be the most important deterrent to war in all of history."

The bill, which became the Magnetic Fusion Energy

14. ORMAK had succeeded in producing a temperature of 20 million degrees with neutral beam heating—triple what had been achieved less than a decade earlier in the T-3 tokamak.

15. Of a deuterium-tritium (or D-T) plasma. Mel Gottlieb, head of the Princeton Lab, told an Aug. 14, 1978 press conference, "It took us seven years to go from several million degrees to 26 million in December 1977, and then just six months to go another 35 million."

16. These were the three parameters outlined by Lawson in order to have a net power-producing fusion reactor: plasma density, confinement time, and temperature.

17. The FEF, founded in 1974 by Lyndon LaRouche and his collaborators, had been crucial in making sure that news of the PLT breakthrough got out to the public, and to the White House, helping to ensure that the planned press conference was able to go ahead. See: "Schlesinger vs. Fusion: A Dossier," *EIR,* Aug. 29, 1978; and "The Coming Breakthroughs in Fusion," *Fusion*, October 1978.

Engineering Act of 1980, authorized the construction of an Engineering Test Facility by 1987, and for the first experimental power reactor to put net power on the grid by 2000. Funding authorization also included the expansion and upgrading of the nation's science education programs. It had an estimated cost of $20 billion (in 1980 dollars) over two decades. Quickly gaining 140 co-sponsors, the bill passed the House overwhelmingly on Aug. 27 by a vote of 365 to 7. The Senate passed a companion bill by voice vote soon after, and the Magnetic Fusion Energy Engineering Act of 1980 was signed into law by President Carter on Oct. 7.

However, losing his bid for re-election the following month,[18] McCormack would not be in the Congress to oversee the implementation of the 1980 law. A report issued in December by McCormack's Subcommittee on Energy Research and Production warned the incoming administration and the nation, quite prophetically, that "the hardest battles are yet to come. There must be continual annual authorizations and subsequent appropriations of funds.... It will take tremendous vigilance and determination on the part of the nation to carry through the 20-year development plan which is necessary to make fusion a reality."

A Commitment Reversed

Mere months after the Magnetic Fusion Energy Engineering Act was signed, the incoming Reagan Administration submitted its first budget for FY1982, with a request for fusion funding which would make the implementation of the fusion law impossible. The 1980 law mandated that "The Secretary of Energy shall develop a plan for the creation of a national magnetic fusion engineering center for the purpose of accelerating fusion technology development via the concentration and coordination of major magnetic fusion engineering devices and associated activities at such a center." However, in July of that year, by which time the Secretary of Energy was to have submitted a plan for establishment of the engineering center, the DOE replied via acting Director of Energy Research, Doug Pewitt, "We have determined that it is premature to establish fully the national magnetic fusion engineering center at this time," and instead proposed that an "Engineering Feasibility Preparations Project" be established at an existing fusion research site.

In protest over this betrayal, Ed Kintner resigned his post as Director of the Office of Fusion Energy at DOE in November 1981. Writing the following year about the budgetary attacks on fusion, Kintner said that the fusion budget offered by the administration for FY1983 was not only lower than what was needed to carry out the 1980 Act, but was 25% less than the budget for 1977! He said that this "leave[s] the fusion program without a strategic backbone—it is a collection of individual projects and activities without a defined mission or timetable.... The plan to increase industry involvement in fusion development is postponed indefinitely, and the industrial and economic benefits of high-technology spin-offs, surely an increasingly important by-product of an accelerated fusion technology program, will be lost."[19]

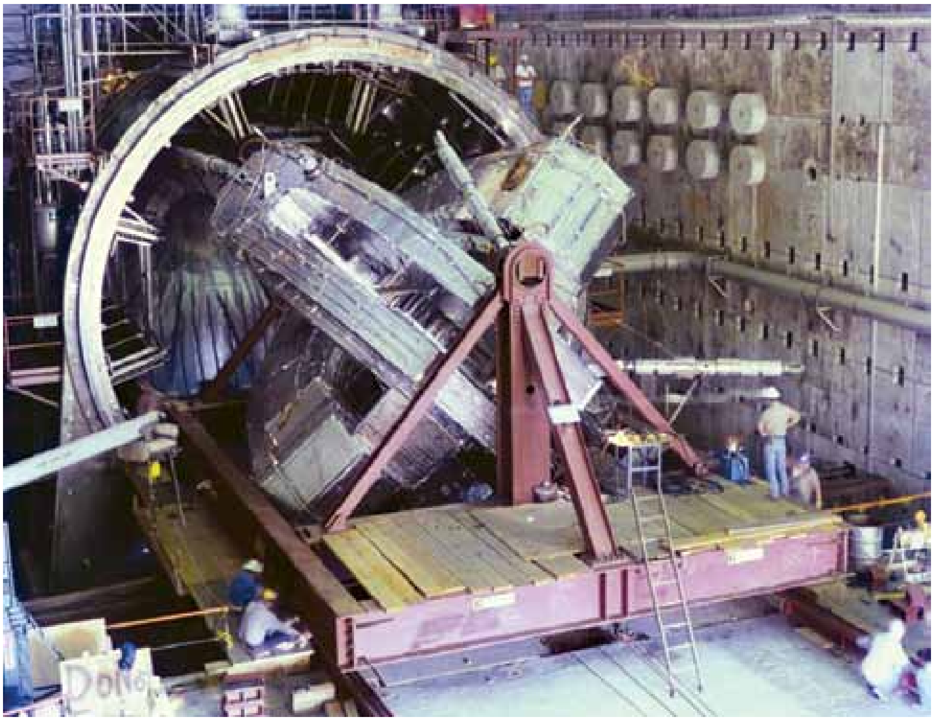
One month after Kintner's resignation, George Keyworth, science advisor to President Reagan, announced to a hearing in Congress: "The U.S. cannot expect to be pre-eminent in all scientific fields, nor is it desirable." The official position of the U.S. government became, from Keyworth's mouth: "It is not the government's responsibility to conduct energy R&D and pursue energy independence. It is the responsibility of private industry." Keyworth added, sophistically, that abundant funding "can even promote mediocrity, rather than stimulate excellence." How far the U.S. government had come from the vision of Kennedy's Apollo Program![20]

In December 1982, almost as if in defiance of the growing attacks on the fusion program, Princeton's workhorse, the TFTR, produced its first plasma, and would go on, in 1986, to set the record plasma temperature of 200 million degrees. Also in 1986, however, a great casualty was suffered at Lawrence Livermore, where the "mirror" approach had been progressing with encouraging results: Funding for the operation of the Mirror Fusion Test Facility (MFTF) was cut from the budget, and the MFTF was mothballed on the same day that it was officially completed, without ever being allowed to run a single experiment. The mirror program

18. Due to the early concession of Jimmy Carter to Ronald Reagan before polls had closed on the West Coast, many Democrats didn't bother to vote, meaning that many Democratic candidates for both state and federal positions lost their elections.

19. E.E. Kintner, "Casting Fusion Adrift," *MIT Technology Review,* May/June 1982.

20. "Those who came before us made certain that this country rode the first waves of the industrial revolutions, the first waves of modern invention, and the first wave of nuclear power, and this generation does not intend to founder in the backwash of the coming age of space. We mean to be a part of it—we mean to lead it." President John F. Kennedy, Sept. 12, 1963, Rice University, Houston, Texas.



LLNL

The MFTF under construction in 1981. The reactor was fully completed, but then mothballed, before it could ever run an experiment. The reactor vessel and structures weigh 8 million pounds, including 3 million pounds of superconducting magnets, designed to confine a plasma at more than 100 million degrees.

had been successfully killed, squeezed out of a rapidly constricting budget.

By the end of the 1980s, there was absolutely no scientific reason not to capitalize on the success of projects such as the TFTR, and the great knowledge of the teams assembled at Princeton and elsewhere, to move to the next stage in the tokamak program: the creation of sustained fusion power. The cause of the failure to do so, even to this day, has been purely political. In 1988, the team at Princeton submitted a completed design for the follow-on to TFTR, the Compact Ignition Tokamak (CIT), which would demonstrate a sustained "burning" plasma by the year 2000.[21] However, in October 1989 it was announced by President George H.W. Bush's DOE representative, Robert Hunter, that such an advancement simply wasn't in the budget, and that an additional $50 million cut to the fusion budget would be coming down the pike. Hunter told a Congressional hearing that the CIT was too risky, and probably would not succeed. Dr. Stephen Dean (former head of the AEC Fusion Division's Magnetic Fusion Office) responded that, "We've got to take some risks if we intend to develop a machine that makes electricity. If Columbus had waited for radar to be discovered before he set out, we wouldn't be here today."

That $50 million cut, $12 million of which came from the Princeton facility, virtually ensured the cancellation of the CIT project, and the facility was forced to lay off 120 personnel, scattering the knowledge base assembled there, and delivering a severe blow to morale well beyond the bounds of Princeton. As outlined below, these cuts were not merely the folly of a gaggle of fiscally minded bureaucrats; they were the key mechanism for an intentional policy to kill fusion.

As the 1990s approached, the fate of fusion research in the United States was very much in jeopardy. The earliest of the 1976-predicted dates that a demonstration reactor could have been put on the grid had come, and the intentional sabotage of both the planned experiments and the creative optimism of the community of fusion scientists, growing both in numbers and in competence, was having its effect (See table, p.74).

The 1990s and ITER

With the U.S. fusion program being slowly choked off by year-after-year budget cuts, to the effect of an increasing loss of smaller and "alternative" (i.e., neither tokamak nor inertial fusion design) fusion experiments at the national labs and universities, attention shifted to an "outside" hope: U.S. involvement in international collaboration on the large tokamak, ITER.[22] Initiated in

21. A burning, or ignited plasma means that the fusion reactions occurring in the fuel are able to maintain the necessary temperature for a sustained reaction without the additional input of auxiliary heating (just as a fire requires initial input, but will burn as long as there is fuel available). The term "burning" does not indicate a literal flame in the plasma, but that the "fire" of fusion is a descendent of the original gift of Prometheus to man.

22. The International Thermonuclear Experimental Reactor, now under construction in Cadarache, France.

November 1985 from the "Reagan-Gorbachev Agreements," ITER was to be a very large tokamak, designed and built jointly by the U.S., the U.S.S.R., European nations, Japan, and Canada,[23] with the hopes of producing 500 MW of fusion power, sustained over 480 seconds, and would be the precursor to a DEMO (Demonstration Power Plant) tokamak reactor, designed to put power on the grid.

PPPL

The Tokamak Fusion Test Reactor at Princeton. The TFTR operated from 1982 to 1997, setting many significant records both in plasma temperature and in peak fusion power produced, before it was prematurely shut down.

Meanwhile, the TFTR at Princeton, despite the increasingly hostile and crippling budget cuts and delays, set a series of record plasma temperatures and would go on in 1994 to achieve the major milestone which had been mapped out in 1972: the production of a peak fusion power of 10.7 MW—*90 million times* what was possible in the early '70s, when the experiment was first proposed.[24] Just one year later, TFTR set another record plasma temperature of 510 million degrees.

Just two years after TFTR had set this record, however, it was decommissioned in an astoundingly irresponsible act of budget cutting, in the midst of Newt Gingrich's "Conservative Revolution," and was finally dismantled in 2002. Its sister tokamaks, the Joint European Torus (JET) and the JT-60 in Japan, are operational (with significant upgrades) to this day, and have gone on to surpass the records set by the prematurely retired TFTR.

In 1999, two years after TFTR was decommissioned, the United States shocked the world when the Congress refused to allocate a mere $12 million for continued participation in ITER, forcing the U.S. to withdraw from the program. The reason given by House Science Committee Chairman James Sensenbrenner was that, "It defies common sense that the United States should agree to continue to participate in a dead-end project that continues to waste the American taxpayer's dollars." Had this cut to ITER been paired with a restoration of funding to re-open the shuttered domestic program, perhaps Sensenbrenner's ignorant comment would have been made more palatable. However, this was not the case.

Funding for domestic research has continued to fall year after year, since its peak funding year in 1982,[25] culminating in the astoundingly low budget allocations of the Obama Administration, which are threatening shutdown of the MIT Alcator C-Mod, among other incredibly valuable programs.[26]

23. This group today includes: the U.S., E.U., Russia, Japan, India, China, and South Korea. For more on the history of U.S. involvement in ITER, see: "Fusion Energy Moves One Step Closer," *EIR*, Dec. 12, 2003.

24. This was superseded three years later by the Joint European Torus (JET), which produced 16 MW, still the current world record.

25. The exception to this has been a rise in the domestic program for inertial fusion, with the building of the National Ignition Facility at Lawrence Livermore National Lab. However, peak fuding of inertial fusion came in 2006.

26. And what is being offered in place of fusion? Take the statement of President Obama on how to solve the world's energy needs: "We wouldn't need new technologies. We wouldn't need to invent some

Whence the reversal of the success and optimism which drove the great progress made in fusion research in the 1970s? Why was the 1980 Magnetic Fusion Energy Engineering Act never allowed to be implemented? As outlined below, fusion was not the happenstance victim of the fiscally conservative environment created following the "days of plenty" of the 1970s. The fact that billions of people are not now already benefiting from the beginnings of a fusion economy was entirely intentional.

Library of Congress

Secretary of State Henry Kissinger, seen here with President Gerald Ford, presided over the implementation of the Malthusian NSSM 200, and worked to ensure that the British Empire's policy of population reduction supplanted the pro-growth and pro-progress policies of John F. Kennedy.

Evil Policies, Evil People

> *The U.S. economy will require large and increasing amounts of minerals from abroad, especially from less developed countries. That fact gives the U.S. enhanced interest in the political, economic, and social stability of the supplying countries. Wherever a lessening of population pressures through reduced birth rates can increase the prospects for such stability, population policy becomes relevant to resource supplies and to the economic interests of the United States. . . .*
>
> *Although population pressure is obviously not the only factor involved, these types of frustrations are much less likely under conditions of slow or zero population growth.*
>
> *—NSSM 200 (1974)*

This frankly evil statement by the deranged Henry Kissinger, contained in National Security Study Memorandum 200 (NSSM 200), written in 1974 under his direction at the U.S. State Department, was not an idle threat to peoples of the Third World; it was signed into law as official U.S. policy by President Ford in December 1975. Three years earlier, the Club of Rome, founded in 1968, had released its genocidal tract, *Limits to Growth*, laying the "scientific" (though actually inept and quite fraudulent) basis for policy measures that would reduce the world's population, based on the myth of limited resources and the denial of revolutionary scientific progress, such as that promised by fusion. While one form this policy took was CIA-run coups d'état to depose world leaders who were too tenacious in their national development policies, NSSM 200 was to be implemented domestically as well, as the earlier assassination of President John F. Kennedy had so vividly forewarned.

A major manifestation of this was the deployment of the "slush fund" of Wall Street moguls, the Nuclear Club of Wall Street,[27] to pour money into halting the shift from a fossil fuel-based economy to a fission economy, and to castrate fusion before it could truly get off the ground. After all, the prognosis that fusion could set mankind free from poverty with virtually unlimited energy, the end of famine, and greatly extended average lifespans, was simply unacceptable to those who be-

fancy new fusion energy or anything. If we just took our existing building stock in homes and insulated them, had new windows—schools, hospitals, a lot of big institutions—we could squeeze huge efficiencies out of that." Speech in Fairfax, Va. Sept. 13, 2010. A continuation of the shift to "green" technologies will lead to mass death.

27. For more on the Nuclear Club of Wall Street, founded to counter the influence of the Fusion Energy Foundation, see: "Hit Men vs. LaRouche's Fusion Energy Foundation."

lieved, as did the ancient Zeus, that those who ruled had a duty to control, and sometimes cull, the multitude.

In order to have a large-scale effect on national economies, energy-intensive industry, which drives economic growth, was put in the crosshairs. Following the orchestrated energy crisis of 1975 (and Carter's plea to Americans to turn down their thermostats and put on sweaters), cutbacks in energy usage were imposed on the industrial sector as well, initiated by the reduction of energy usage in Pittsburgh steel manufacturing with Schlesinger's "Project Pacesetter" in April 1977. That policy was successful. Since that time, average per capita energy consumption for the total population has leveled off, and is now beginning to fall, rather than growing to the levels projected by the Kennedy Administration, which were nearly double those of today.[28]

NFRI

South Korea's KSTAR tokamak in 2009. KSTAR is one of two superconducting tokamaks in the world, with a goal of training a generation of young fusion scientists and engineers to contribute both to the international ITER project, and to South Korea's own expanding fusion program. Pictured are Dr. Myeun Kwon (left), current president of the National Fusion Research Institute, and Marsha Freeman and Bill Jones of EIR.

It's no wonder, then, that in August of 1978, Schlesinger, on behalf of the policy of zero growth, had done everything possible to suppress news of the PLT breakthrough: If fusion were indeed on the horizon, the myth that population growth is inherently unsustainable would be shattered—along with the primary justification for the ongoing implementation of policies to shut down global development.

What Must Be Done

With the postponement of fusion, the world now sits on the edge of a precipitous collapse in global population. The average age of the fusion scientist in the U.S. is rising. Elder scientists who made the breakthroughs of the past decades are retiring. Teams which are built one year at research institutions are often scattered the next, and machines once mothballed are dismantled. We are rapidly losing the capabilities which have been built up over the past six decades! More fundamental, however, is the damage done to the process of creative hypothesis itself. The pessimism of an environment where one's experiment has a good chance of being shut down in the next 12-month budget cycle, regardless of its successes or potential contributions to the future, can stultify the creative process itself, which is driven by passion and optimism for the future.

Mankind survives as a species because he progresses. The great leaps in the energy density of each successive fuel source of man's "Promethean fire" (wood, charcoal, coal, coke, fossil fuels, etc.) have each corresponded to a revolution in man's power over nature, and a non-linear increase in, simultaneously, the potential population density and the power applied per capita.[29] Only fusion can ensure the continued survival of the human species in the immediate decades ahead,

28. "Civilian Nuclear Power: A Report to the President—1962," U.S. Atomic Energy Commission, Glenn Seaborg, Chairman.

29. See "Measuring Fire: Energy-Flux Density," in *Physical Chemistry: The Continuing Gifts of Prometheus*.

and that man will be capable of making the discoveries which lead to the next great leap forward.

This must be a global effort. Although over the past 30 years, the U.S. program has been under significant attack, and is currently struggling to keep its doors open, nations of Asia have been making significant progress, and have become partners in a global effort. China and South Korea, for example, have both made incredible strides in their fusion programs over the past 15 years, and have the only two advanced superconducting tokamaks in the world, EAST in China, and KSTAR in South Korea.[30] Both nations have built impressive domestic fusion programs with very serious goals, budgets, and timetables, geared toward post-ITER DEMO engineering reactors.

While important international cooperation is currently occurring under the auspices of the ITER project, and work on the project will make significant contributions to many aspects of fusion engineering design, ITER and its follow-on DEMO are not designed to yield a power-producing reactor for several decades.[31] Therefore, a crash program in the spirit of Project Sherwood, and on the scale of the Apollo Program, must be launched immediately in the United States, closely coordinated with an acceleration of efforts around the globe, with the goal of bringing fusion online within 10-15 years. This will take a full, long-term (not year-to-year) commitment from all nations involved. In the U.S., this will mean immediately reassembling the best minds of the fusion program, many of whom are retired, semi-retired, or have been forced to find work in other industries, to come together on the effort.

We must reverse this paradigm! The time has come for mankind to free itself from the dominance of the imperial system, and its genocidal policy of zero growth. We can no longer tolerate the fact that two-thirds of humanity lives in conditions of crushing poverty! Scientific discovery and its implementation expresses that which distinguishes man from beast, and allows an immortal contribution of the present generation to the future. The suppression of fusion must end!

30. For more on China's EAST tokamak, see: *EIR*, March 11, 2011. and for South Korea's KSTAR tokamak, see: *EIR*, Dec. 4, 2009.

31. Due to foot-dragging and budget cuts, largely on the part of the U.S. government, the date of the first plasma of ITER has been delayed numerous times, and is currently not expected until 2023, or possibly 2025. Operation of its successor, DEMO, is not scheduled to begin until at least 2033.

Devices and Capabilities Lost Since the 1990s

Date of Shutdown	Experiment	Location	Description
1990	LSX FRC	Math Sciences Northwest	A brand new facility and experiment at a commercial company under contract to DOE.
1990	Tandem Mirror Machine (TARA)	MIT	A mirror machine experiment at one of the nation's premiere university fusion programs.
1990	Compact Torus Spheromak Experiment (CTX)	LANL	Leading facility in the world looking at the spheromak, a potentially simpler magnetic geometry than the tokamak.
1990	Advanced Toroidal Facility (ATF)	ORNL	The first major stellarator in the U.S. built to study steady-state sustainment of fusion plasmas.
1995	Princeton Beam Experiment-Modified (PBX-M)	PPPL	An experiment using strong plasma shaping to increase the plasma pressure, was developing new methods to control plasma stability.
1995	Microwave Tokamak Experiment (MTX)	LLNL	An experiment to use a free electron laser to generate mocrowaves as an innovative way of heating and controlling the plasma.
1996	Texas Experimental Tokamak (TEXT)	University of Texas at Austin	Dedicated to turbulent transport (maintaining the energy of the plasma).
1997	Tokamak Fusion Test Reactor (TFTR)	PPPL	Largest U.S. fusion experiment, and one of two in the world capable of using D-T fuel to produce >10MW of fusion energy.
Late 1990s	Staged Z-Pinch	UC Irvine	High density pulsed approach to achieving fusion.
2003	Electric Tokamak	UCLA	Very large low field tokamak for innovative confinement and heating ideas
2007	POPS Electrostatic Confinement Penning Trap	LANL	Innovative approach to electrostatic confinement, suppported by theory, with a very compact point neutron source.
2007	Spheromak (SSPX)	LLNL	Innovative fusion confiuration design to achieve a fusion plasma with less engineering and materials.
2010	Field Reversed Configuration (TCS-U)	University of Washington	The only experiment of its kind in the field reversed configuration, using rotating magnetic fields for a simpler engineering approach to a high-pressure plasma
2010	Levitated Dipole Experiment (LDX)	MIT	Explored high-pressure steady-state plasma configurations.
2010	Maryland Centrifugal Experiment	University of Maryland	Examined the effects on plasma confinement of the supersonic spinning of the plasma.
2014	Magnetized Target Fusion (MTF)	Air Force Research Lab and LANL	High Energy Density Plasma (HEDP) experiment combining features of magnetic and inertial fusion

Lost U.S. Fusion Opportunities Since 1990

Fusion experiments into which significant planning efforts were invested, which were never constructed because of lack of funding.

Date Canceled	Experiment	Location	Description
1989	Compact Ignition Tokamak (CIT)	PPL and other institutions	Would have been the world's first burning plasma experiment designed to produce self-heated fusion plasmas and fusion powers exceeding 300MW of fusion power.
1990	ZTH Reversed Field Pinch	LANL	Was to be the world's leading facility looking at the RFP configuration. It was about 80% complete at time of shutdown.
1991	Burning Plasma Experiment (BPX)	multiple institutions	Design for a burning plasma tokamak to study high fusion power gain with fusion power producttion up to 500MW.
1996	Tokamak Physics Experiment (TPX)	multiple institutions	Would have been a premier U.S. fusion device: a large seady-state superconducting tokamak. The design was picked up by China and Korea.
2004	Fusion Ignition Research Experiment	multiple institutions	Design for an aggressive compact, high-gain tokamak burning plasma, using "advanced tokamak" developments to reach very high pressure and sustain the plasma.
2008	NCSX	PPPL	Innovative stellarator approach combining stellarator high-pressure stability with tokamak confinement properties.
2113	NDCX II	UC Berkeley	Heavy ion beam accelerator (alternative to lasers) for inertial fusion energy. It was built but shut down without sinificant testing.