Will budget-cutters prevent fusion?

The only constraints on achieving fusion by the end of the century are budgetary and political, not technical. Princeton's latest results prove it. Carol White reports.

The only obstacle to achieving a demonstration commercial fusion plant by the year 2000, appears to be one of political will. The recent results with the Princeton Tokamak Fusion Test Reactor (TFTR) merely emphasize that it is budgetary not technical constraints which are slowing down the fusion program.

Princeton's breakthrough

The Princeton Plasma Physics Laboratory captured headlines by its announcement that it had achieved a plasma temperature of 200 million degrees Celsius, the highest temperature ever recorded in a laboratory. But this is only typical of the exciting results from the fusion program in general—both the magnetic and the inertial confinement programs.

In the first wave of enthusiasm following upon the announcement of the Princeton results, Department of Energy spokesmen appeared so carried away that they temporarily forgot the restraints of the Gramm-Rudman amendment and its attendant mentality. Since then, Fusion Office Director John Clarke has scaled down his optimism to the size of his budget. The United States is now seeking international cooperation—either from the Europeans and Japanese, or the Soviets, for the development of an Engineering Test Reactor (ETR).

The Magnetic Fusion Energy Engineering Act of 1980, introduced by then Democratic Congressman Mike McCormack from Washington State, was voted up by an overwhelming majority in both the House and Senate, and was signed into law on Oct. 7, 1980 by President Jimmy Carter. It specified that the United States would build an ETR by the year 1990 and a commercial prototype fusion reactor by the year 2000.

It is a sad irony that this Act became the law of the land under the anti-nuclear Carter administration only to be consigned to oblivion—along with the fusion budget itself—by the pro-nuclear Reagan administration. Now, six years later, that law has died by default, and the fusion budget has been slashed by one-third in real dollars.

The McCormack Act

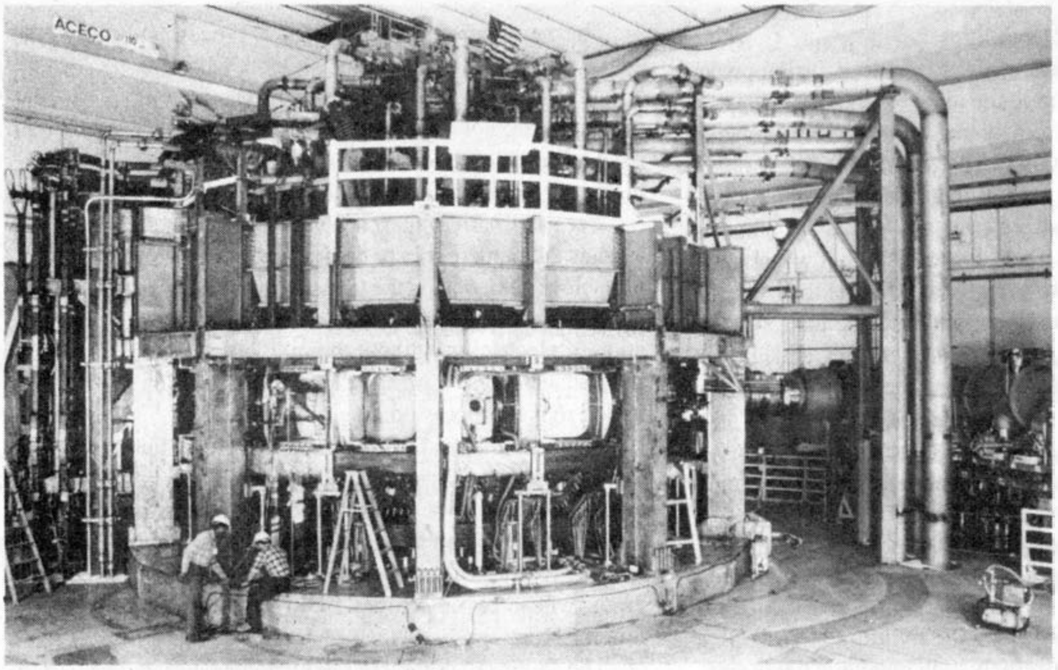
The McCormack Act must be revived. Even with minimal support, fusion has demonstrated its promise to provide virtually unlimited energy. And only as we have fusion energy will we achieve the goal of colonizing space. If we are to establish a base on Mars within 40 years, we will need to deploy energy at flux densities at least one order of magnitude greater than those which are presently available. Fusion power is the only way.

The McCormack Act mandated the maintenance of the United States as the world leader in magnetic fusion. Such a commitment of national pride in no way cuts across the obvious benefits of international cooperation. In the fusion program, as in the space program, it is precisely by having an active and aggressive program that we will stimulate other nations, including the Soviets, into cooperation and accelerated parallel development.

The McCormack Act contains the following provisions, all of which are as apt today as six years ago.

"Section (a)

"1. The United States must formulate an energy policy designed to meet an impending worldwide shortage of many exhaustible, conventional energy resources in the next few decades;



The Tokamak Fusion Test Reactor (TFTR) at Princeton, in January 1983. This year, it achieved a record 200-million-degree (Celsius) temperature.

"2. The energy policy of the United States must be designed to ensure that energy technologies using essentially inexhaustible resources are commercially available at a time prior to serious depletion of conventional resources;

"3. Fusion energy is one of the few known energy sources which are essentially inexhaustible, and thus constitutes a long-term energy option;

"4. Major progress in all aspects of magnetic fusion energy technology during the past decade instills confidence that power production from fusion energy systems is achievable;

"5. The United States must aggressively pursue research and development programs in magnetic fusion designed to foster advanced concepts and advanced technology and to develop efficient, reliable components and subsystems;

"6. To ensure the timely commercialization of magnetic fusion energy systems, the United States must demonstrate at an early date the engineering feasibility of magnetic fusion energy systems;

"7. Progress in magnetic fusion energy systems is currently limited by the funds made available rather than technical barriers;

"8. It is a proper role for the Federal Government to accelerate research, development, and demonstration programs in magnetic fusion energy technologies; and

"9. Acceleration of the current magnetic fusion program will require a doubling within seven years of the present funding level without consideration of inflation and a 25 per centum increase in funding each of fiscal years 1982 and 1983.

"Section (b)

"It is therefore declared to be the policy of the United States and the purpose of this Act to accelerate the national effort in research, development, and demonstration activities related to magnetic fusion energy systems. Further, it is declared to be the policy of the United States and the purpose of this Act that the objectives of such program shall be—

"1. To promote an orderly transition from the current research and development program through commercial development;

"2. To establish a national goal of demonstrating the engineering feasibility of magnetic fusion by the early 1990s;

"3. To achieve at the earliest practicable time, but not later than the year 1990, operation of a magnetic fusion engineering device based on the best available confinement concept;

"4. To establish as a national goal the operation of a magnetic fusion demonstration plant at the turn of the twenty-first century;

"5. To foster cooperation in magnetic fusion research and development among government, universities, industry, and the national laboratories;

"6. To promote the broad participation of domestic industry in the national magnetic fusion program;

"7. To continue international cooperation in magnetic fusion research for the benefit of all nations;

"8. To promote greater public understanding of magnetic fusion; and

"9. To maintain the United States as the world leader in magnetic fusion."

The Act also called for a doubling of magnetic fusion funding over a seven-year period (in constant dollars). Instead, the fusion budget has decreased since the Act became law. The fusion program needs a far more drastic infusion of funds now than six years ago, if it is to proceed at the pace indicated by its technical potentialities.

The current policy direction of the magnetic fusion program stems from capitulation to the idea that the only way to keep the fusion program from being destroyed by budget cuts, is to replace an aggressive U.S. program with international cooperation. But the kind of increases in productivity which are already being realized from the Strategy Defense Initiative, will accelerate in a non-linear fashion if we develop the technologies needed to successfully realize the Moon-Mars program. This will provide more than adequate funds to pursue vigorous national programs in each area, and allow international cooperation to proceed as it becomes appropriate.

There is no necessary trade-off between a vigorous national development of fusion power and the space program, and international cooperation. It would be a tragic blunder to base the next steps in development on the politics of summitry, waiting to build a next-generation ETR, for example, for a cooperative agreement with the Soviets.

This is in no way equivalent to the building of an ETR. The CID will be run with extremely high magnetic fields and will not actually replicate the conditions which must be met to tame fusion power for industrial purposes. For this, the critical next step is the ETR.

A better plan

An alternative approach to building the CID or TFCX would be to build an engineering test device which would incorporate both concepts in sequenced phases, beginning with a first, two-year phase in which short-pulse physics ignition experiments would be conducted. This would be followed by long-pulse experiments. The third phase would be the engineering work, materials testing, and a full ETR machine operating with superconducting magnets. Such a device could produce results over a 10-year period and could start operation in 5 to 8 years. This would push the program 10 to 20 years ahead of the present track, allowing a commercial demonstration plant by 2000-2005.

The cost of such a three-stage machine would be only $1.5-2 billion. The idea would be to update previous design work over a six-month period, during which the construction site would also be chosen. At the end of six months, hardware orders could be placed.

It is precisely such an aggressive approach which will guarantee international cooperation. Indeed, the Soviets and Europeans will be knocking at our doors, as opposed to the present situation in which we are standing hat in hand at their doors, trying to save the U.S. program from being slaughtered by the budget cutters.

Alternative concepts

The Tokamak is a major contender for the first model of a commercial fusion power reactor, but it is a brute-force approach to the control of plasmas.

The new fusion age will deploy power as a combined energy and refining resource, which will also be able to "mold" the refined material as it is produced. For such a total transformation of industrial processes to take place, we will need a variety of machines enabling us to control and deploy high-energy plamas with precision.

Yet, alternative approaches to achieving fusion power such as the tandem mirror device are on the budgetary chopping block. Not only is the tandem mirror an attractive potential power source—because it would allow the direct generation of electricity, without the inefficent step of converting it to steam—but it offers a possible approach for fusion-fueled rocket propulsion.

A recent decision of DOE and the Magnetic Fusion Advisory Committee, in order to keep the tandem program alive at all, is to cut $3-4 million from the alternative concepts section of the fusion budget. This does not include the $350 million required for the Lawrence Livermore mirror program, whose two machines faced shutdown due to lack of funding.

The failure to complete the Fusion Materials Irradiation Test facility at Hanford, Washington, represents a similar error which must be rectified. Fusion must prove that it does not accumulate long-lived radioactive waste. Particularly when tritium is used as a fuel, there is radioactivation, which contaminates and corrodes the materials in contact with the plasma. New alloys and other materials, that are not now conventional building materials, have to be developed, along with technologies for manufacturing, handling, and construction of fusion reactors. A first step is to take small samples of new materials first, which can be subjected to fusion-comparable radiation environments for at least five years. This can be partially accomplished with the ETR.

With the Princeton program feeding a justified optimism that mankind is on the verge of controlling the energy of the Sun in his laboratory, now is the time to reaffirm the McCormack Act. Now is the time to drive the budget cutters out of the halls of Congress and set this nation back on the road to scientific preeminence.

It has been U.S. practice to leap-frog, planning two generations ahead, so that as a new device comes on line, the next is already in the planning phase. Such an approach implies a flexibility of design which allows for unanticipated advances. The Europeans and Japanese have traditionally taken a more cautious approach. Results from the European JET tokamak and the Japanese JT-60 are not expected before the mid-1990s, so that there is little likelihood of their moving ahead with a next-generation reactor before 1992.

The Soviets have offered cooperation; however, the device which they propose, INTOR (international tokamak reactor) would be about five times as expensive as the one considered here—$5 billion. There is talk now of joint development of such a large-scale program as a follow through from the Reagan-Gorbachov summit. Such a plan might involve as many as 15,000 skilled scientists, engineers, and technical workers. Should the Soviets agree to President Reagan's proposal for joint development of SDI technologies, similar cooperative efforts in space and fusion would no doubt follow.

The TFTR

In August 1978, the Princeton Large Torus (PLT) made worldwide headlines by reaching a then-record temperature of upwards of 60 million degrees Celsius. At that time, the director of the DOE's division of magnetic confinement said: "The question of whether fusion is feasible from a scientific point of view has now been answered. It's the first time we've produced the actual condition of a fusion reactor in a scale-model device." The TFTR is twice the size of the PLT.

The idea of building the TFTR took shape in 1973, long before the PLT had broken any records. The initial fusion advances by the Soviets in the late 1960s had been confirmed on several U.S. experimental devices, and there were significant advances in heating and controlling fusion plasmas. At the time, Dr. Robert Hirsch, then director of the U.S. fusion program, proposed building the TFTR. It was to be the first tokamak capable of using tritium as a fuel.

It is this kind of philosophy—the conviction that the technology was possible and necessary and therefore that the next stages had to be started even before the current stage had proved successful—that made possible the recent achievements on the TFTR. It also meant that the TFTR from the beginning was designed to be modified to take advantage of new discoveries as they were developed on other working tokamaks. Two years ago, various designs were proposed for a next generation Tokamak Fusion Core Experiment (TFCX), an ETR-type device which would cost $1.5 billion, as compared to $300 million for a smaller Compact Ignition Device (CID) which would test the plasma's ability to continue burning. The TFCX would have tested ignition, but would also have had reactor features such as a test configuration of a blanket module used to extract energy from the tokamak. In one design, it would have had a five-minute burn time, as compared to the projected two-second scale-up on the smaller device.

While it is confidently expected that scientific break even will be achieved next year (when more energy is released by fusion than is expended in operating the machine), the next significant goal is to test the capability of the machine to continue burning. The current idea is to build only the CID.