programs around the world. He asserts that AID has supported coercion in the past, but he declines to take a stand with regard to AID support of international agencies.

In preparing for the conference, the White House has gotten itself in a position where it has to tread a fine line indeed if it wants to bestow a favor on its right-wing supporters while avoiding a storm of criticism.

The cause of unobtrusiveness will surely suffer if anything resembling the White House draft position paper is adopted for use in Mexico City. The White House analysis, seven pages long, explains that the postwar population boom "provoked an overreaction by some," because it coincided with two negative factors. The first was "governmental control of economies, a pathology which spread throughout the developing world with sufficient virulence to keep much of it from developing further." Agricultural price-fixing, taxes on industry, and "dependency on the state . . . disrupted the natural mechanism for slowing population growth." The pattern seen in the Western industrialized democracies, says the paper, "would already be well under way in many nations" if economies had been allowed free rein.

The second negative factor identified in the analysis is "an outbreak of anti-intellectualism" in the Western world, "which attacked science, technology, and the very concept of material progress." This "pseudoscientific pessimism" contributed to the "demographic overreaction" of the last two decades.

In short, population programs may be advisable in some cases, but they are no substitute for economic reforms and "the rapid and responsible development of natural resources." The paper also dismisses population growth as a cause of unemployment, illegal migration, and drought-induced famine.

The paper does not suggest how shortsighted foreign governments should be induced to change. The only specific policy declaration it contains is that this country is against coercion and that it will no longer contribute "directly or indirectly" to any family planning programs that advocate abortion.—CONSTANCE HOLDEN

Congress Turns Cold on Fusion

A 5-percent drop in research funds brings competition between basic science and machine building

The U.S. fusion program will be hit with a budget cut this summer that could delay the next big experiment and affect most laboratories in the field. Both houses of Congress picked fusion as an easy target, protecting river and dam projects in the same funding bill. The Administration is making no rescue effort. An actual reduction of 5 or 6 percent for fusion research is expected.

This presents the fusion community with a dilemma. It may trim or cancel a number of small research projects to keep the big machines running at speed or else postpone the most exciting and glamorous experiments until later. There is a possibility that the present schedule could be maintained by forming joint efforts with other nations, but U.S. and European scientists so far have shown little interest in genuine collaboration. It is more exciting to compete.

There is a tendency in government R&D for expensive hardware to take on a life of its own. This is happening now in fusion research, where new discoveries seem to come only by tinkering with large devices. The research is unavoidably dominated by machines because the goal is to package intense stellar conditions on earth. Fusion reactors will have to withstand extreme electromagnetic and radioactive stresses, not to mention the hottest and coldest temperatures man can create.

While intimately technological, fusion research at the same time has a fantastic quality that sets it apart from other hardware-bound efforts. The thing to be studied (a small, steady fusion "burn") has never been seen in nature. Thus, fusion scientists are engaged in a paradoxical venture—trying to analyze a phenomenon that has not been observed, by observing it in a machine that has not been invented.

The remoteness and the escalating costs of fusion research make officials uneasy. This Administration has tried to reduce the number of energy demonstration projects in the budget, concentrating instead on science, according to a White House aide: "The trouble is that fusion is very expensive for the good science you get out." George A. Keyworth, II, the President's science adviser, told an audience in February that he advocates a "balanced fusion program" that is attuned to "the economic forces of the marketplace" and linked in "close partnership" with industry. He also spoke of the need for restraint in building new devices.

As Congress prepared to take a slice out of the U.S. fusion program this June, many of the leaders in the field were meeting at the Princeton Plasma Physics Laboratory to go over plans for the next machine they plan to build. Called the Tokamak Fusion Core Experiment (TFCX), it would be the first to ignite a self-sustaining burn. Princeton now manages the largest U.S. machine, the Tokamak Fusion Test Reactor or TFTR, which is supposed to produce a nonsustained burst of fusion fire in 1986, at least 3 years ahead of the European competition. According to a preliminary estimate by J. R. Thompson of Princeton, the new TFCX would cost between $700 million and $1.3 billion. This is already a large price, and such estimates have a way of creeping up as construction gets under way.

The 1984 budget for magnetic fusion, the main category of research and the one likely to succeed in the near term, is $470 million. That is about half the cost of the TFCX being conjured up at Princeton. The Administration asked for $13 million more for fusion in 1985—barely enough to keep life signs flickering, the fusionists told Congress. The House was not moved; it voted to slash the request by $64 million. The Senate was gentler, cutting only $13 million. The compromise, due 4 July, will be painful, whatever the amount.

The Princeton conferees were keenly aware of the news from Washington, down to the last comma and adjective in the appropriations bill. But they seemed intent on keeping it at bay. Planning for the TFCX went forward without a hiccup. It is supposed to be operational in the early 1990's. No one cared to dwell on the message that came from both sides of Capitol Hill, that the ignition

machine may be postponed. The House Appropriations Committee report made it explicit. Noting that $14 million was requested for TFCX work, the report said: "The Committee believes it is premature to enter this stage at this time and recommends no funding for the TFCX." The Senate document said that "vital program elements" should not be sacrificed "in order to construct such projects as TFCX." Both committees urged U.S. researchers to collaborate with foreigners on the ignition experiment.

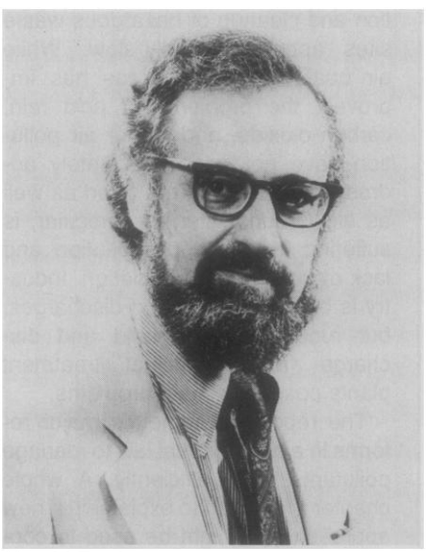
Harold Furth, director of the Princeton Plasma Physics Laboratory and an acute wit, sees the future dispassionately. Fusion laboratories will not be the ones to decide where to cut and trim, he told *Science*. "There are two modes in which that could happen. One in which we get together, pass the hat and volunteer to cancel our own projects. I can't see that happening. And there's the second, in which we get together and volunteer one another's projects for cancellation." The trauma of the second approach outweighs any possible benefit. So the cuts will have to be drawn up by the government.

As the manager of the Department of Energy's (DOE) biggest and most recent investment—the TFTR—Princeton probably will avoid injury in the coming budget scuffle. Other big institutions may be protected as well. For example, the Massachusetts Institute of Technology (MIT) last year took an important step, achieving "non-thermalized breakeven" in a device called Alcator C (*Science*, 2 December 1983, p. 1002). It demonstrated that a deuterium plasma could be contained long enough (50 milliseconds in this case) and at a density high enough for fusion to occur.

In the next few years, researchers hope to use the Princeton TFTR to show that deuterium and tritium nuclei actually can be fused in a short, controlled event. Finally, in the 1990's the TFCX is meant to create a self-sustaining fusion fire lasting perhaps as long as 5 minutes. After that, the grand plan calls for an engineering test reactor using the scientific data collected at TFCX to scale up to a precommercial prototype. Princeton, MIT, the reactor design lab at Oak Ridge, and other national laboratories involved in this central effort will be sustained. The same applies to a second effort based at the Lawrence Livermore National Laboratory aiming to confine plasmas in a magnetic mirror system and a third (Doublet-III) developed by GA Technologies in San Diego, California.

The University of Wisconsin at Madison is the kind of center more likely to be hurt. The director of fusion research there, Gerald Kulcinski, asks, "Should we go on with the TFCX?" Kulcinski has been teaching fusion engineering from the earliest days of the DOE program and is a member of the DOE's advisory panel on TFCX. "Even if we don't go ahead with TFCX," Kulcinski says, "there are so many large mortgages out with the national labs that we think the universities will catch more than their share of the cuts." Payments for hardware "come off the top" and "education comes off the bottom." He points out that while procurement contracts can be enforced, "we can't sue the government" for turning its back on students.

Wisconsin now produces 12 fusion Ph.D.'s each year, at least three in reactor design. "You can't just turn students on and off," Kulcinski says. If there are big cuts now, "it might really cause us to reassess our educational program." Once stopped, it would be difficult to restart.



Harold Furth

The march toward a fusion ignition "has been steady and presumably will continue."

One MIT physicist, Lawrence Lidsky, wrote a controversial article in MIT's journal *Technology Review* last November, arguing that the fusion program had come prematurely under the sway of machine-builders. Science was suffering as a consequence, he argued. Lidsky was then associate director of the Plasma Fusion Center at MIT. Ronald Davidson, director of the center, chairman of DOE's fusion advisory panel and an advocate of building TFCX, asked for and got Lidsky's resignation. This illustrates the problem, according to Lidsky: "That response [demanding a resignation] was proper for a national laboratory, but not for an academic institution." The plasma physics centers at MIT and Princeton, he says, have become little national labs.

As Lidsky sees it, problems arise from the fact that all fusion research is expensive. To justify it, scientists too early linked their work to the promise of delivering a usable reactor. This led to specific goals and deadlines, a tendency for braggadocio, and an intense focus on technology. The cut in funds, he says, "may be for the best, in a way. It may turn things back to the scientific mode." On the other hand, he concedes that the leaders of fusion research might "dig the trench they're in a little deeper."

Furth, who would like to have the TFCX built at Princeton, argues that it would be "sterile" to engage in a lot of "low-level experiments" without attacking the main issue. He wants to know as soon as possible what will happen when a plasma is ignited in a fusion reactor. "From a scientific point of view, it won't be simple at all. In fact, it will be about as unsimple as firing a rocket engine." Furth engaged in an intense exchange of letters with Lidsky over the merits of the fusion program as attacked in the *Technology Review* article. He believes Lidsky retreated on several points. Nevertheless, Lidsky's public dissent may have affected the budget vote.

Furth is baffled by Congress's faintheartedness. "The advance on the parameters [required for a fusion reactor] has been steady and presumably will continue," he says. Most attention focuses on the doughnut-shaped tokamak machines like those at Princeton because they work best, he argues. That does not mean other ideas should be ignored, just given lesser rank. Princeton does some theoretical work on alternate concepts, for example.

As for international collaboration, Furth is strongly in favor of it, provided the United States gets to run the ignition experiment. European and Japanese researchers also may want to light the first fire themselves. After that, they will be quite enthusiastic about collaborating on an engineering reactor.

It is clear from the votes in Congress that the fusion program is headed into a difficult time. DOE will be under considerable pressure to justify spending half a billion dollars a year on a program that offers no likelihood of going commercial, according to DOE's estimate, for 40 to 50 years. Thus fusion has come down a bit in the world since the golden year of 1980 when Congress passed the Magnetic Fusion Energy Engineering Act calling for an electricity-producing reactor by 2000.—ELIOT MARSHALL