

state & society

CTR in Europe: More cash for Culham and a joint tokamak

Hard times for the thermonuclear fusion program at Culham Laboratory are over. The United Kingdom Atomic Energy Authority has authorized a larger budget for the future. Furthermore, the laboratory is acting as host for an international design team drawing up plans for a Joint European Tokamak (JET) project that might operate by the end of 1978.

When we recently visited Culham, director R. S. (Bas) Pease told us that although the design group is working at Culham, "There is going to be a glorious international minuet to decide the site for JET." Funds for JET would come primarily from Euratom, with the remainder provided by the individual nations who are members of the European Economic Community fusion program, and presumably an especially large contribution would come from the country where JET would actually be located.

Culham was hit by a severe cutback in 1967, when it was ordered to reduce its staff and money by 50%, to be spread over the next five years. One unpleasant implication, Pease told us, was that at the end of five years Culham would be in a position to be closed down. In 1967, he went on, the prospects for fusion were not very good. The emphasis was on understanding high-temperature plasma physics so that eventually thermonuclear reactors would be practical. When Culham was established in 1959, the worldwide situation was poor in the sense that experimenters working on big machines like the British Zeta, the C Stellarator at Princeton and the Ogra at the Kurchatov Institute in Moscow, had almost no accurate, reliable method of measuring density and temperature as a function of time and position in the plasma. "When you have parameters like the temperature of your plasma wrong by a factor of two, what sort of physics can you do?" he queried. At the time of Culham's establishment as Britain's fusion laboratory, Pease believes people underestimated how long it would really take to improve the situation.

By 1966 it had become fashionable in Britain to question the value of research. Pease believes this concern occurred in Britain before the US because his country had far less pressing

defense research needs; he feels that US physical research in those days was often justified by its relationship to defense requirements. In Britain, on the other hand, the question was asked, "What are these guys doing to help Britain's export problem?" At the same time fusion appeared to be far in the future, an extensive oil and natural-gas supply had been found in the North Sea, and the breeder reactor appeared to be going rather well. All these things combined to cause the Culham cutback, which by 1972 had produced a budget of £3 million and a professional staff of 135, half the amounts that existed in 1967.

But now the tide has turned. In 1972 the whole fusion program was reviewed in depth by a UKAEA committee, headed by Sir Harrie Massey. Last spring the group recommended that Culham's budget be increased and that it should link up with the European Economic Community. The committee recommended that Culham continue exploring a variety of magnetic confinement systems, build a big experiment that would approach reactor conditions (at a cost of roughly £5 million) and also do work on the technology of fusion reactors. The Culham fusion budget for fiscal year 1973-74 is about £3.9 million and is expected to grow to somewhat over £5 million in fiscal year 1975-76, with the staff in-



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creasing to two hundred people.

In October the UKAEA and Euratom signed a contract to advance fusion collaboration, which provides that Euratom will pay about one-quarter of the cost of British research, which amounts to £17 million over the three years beginning 1 January 1973. Similar contracts have already been operating for several years in France, Italy, Germany, the Netherlands and Belgium. At the same time as the British contract was signed, Euratom also

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Daddario becomes director of OTA

The Office of Technology Assessment is ready to operate with a 2-million dollar appropriation for the remainder of FY 1974 and a new director—Emilio Q. Daddario, formerly chairman of the House Subcommittee on Science, Research and Development. He has championed the cause of OTA for seven years, during and after his tenure in Congress. He is leaving a position with the Gulf and Western Engineering Group.

The Technology Assessment Board, a part of OTA, includes 12 legislators, with the director being a nonvoting 13th member. This board is composed of six representatives, and six senators, half coming from each major party. The director, with the approval of the

entire TAB, is expected soon to appoint a deputy director and ten members of the Technology Assessment Advisory Council to be made up of people from outside government. In addition, two government members of the Technology Assessment Advisory Council are the Comptroller General of the United States and the Director of the Congressional Research Service of the Library of Congress.

The nature of technology assessment (TA) can be perceived in many ways. Walter A. Hahn, President of the International Society for Technology Assessment commented, "TA is a process that explicitly involves more than objective factual elements. Values, judgments, choices, experience and politi-



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cal, economic, social and environmental forces are an integral part of TA. Therefore, the power structure, the public and the practitioner [of TA] must all interact for viable assessment. What is important is not which of these views should prevail, but how to achieve an acceptable and workable balance between them in conducting real impact studies."

The future course of OTA is largely undetermined at this point. Once the job of staffing is well under way, TAB members will probably choose which areas initially should be the object of technology assessment.

Aiding OTA in its various tasks are the Congressional Research Service, the General Accounting Office and the National Science Foundation. —RAS

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signed a contract with the Danish Atomic Energy Commission.

A key item in this agreement, Pease explained, is that Britain will now pool its resources with the Europeans on a big confinement experiment. Instead of talking about a £5-million experiment, they can now contemplate a £15-million experiment. This is the Joint European Tokamak.

JET. We chatted with some members of the JET design team, which now amounts to 15 people. The team is headed by Paul Rebut, who is from Fontenay-aux-Roses in France. Unfortunately, Rebut had had difficulty in mooring his boat on a trip back from France; so he was not present to join our conversation. But we did speak to Roy Bickerton (vice-chairman of the project supervisory board), Michel Huguet and Alan Gibson. By the

spring, the team will probably amount to 25 people.

JET is intended to be mid-way between the Princeton Large Tokamak (PLT) (PHYSICS TODAY, January 1973, page 17) and the deuterium-tritium burner proposed recently by the AEC (PHYSICS TODAY, October, page 77). Another large device now under construction is the T-10 tokamak at the Kurchatov Institute. JET is expected to produce a plasma current of 3 megamps, more than a tenfold extrapolation over present experiments. The highest current obtained in a tokamak so far has been in the Soviet T-4 and the French TFR—230 kA. The new Soviet machine, T-10, is expected to yield 0.8–1.0 megamps. It is scheduled for completion by the end of 1975. PLT, which is expected to produce 1.6 megamps, is scheduled for completion in the middle of 1975. Its estimated cost is \$13 million; a considerable saving is realized, the JET team noted, because Princeton already has an adequate power supply. The D-T burner now being considered by the AEC is expected to cost about \$100 million, and the target date for hydrogen operation is 1979–80.

Present thinking on JET design suggests a major radius of 2.8 meters and a minor radius of 1.3 meters. It may have neutral beam injection (injection power of 3–10 MW) to provide additional heating. The main toroidal (or configuration) field will be 30 kG; the poloidal field, which is produced by the current in the plasma, will be 5 kG.

The team members were cautious in predicting what plasma parameters might be achieved. If tokamaks scale so that the confinement time varies as the square of the current, 3 megamps would be between a factor of 10 and 40 from reactor conditions (generally expected to be in the 10–20-megamp range). The most optimistic possibility is that the temperature and density will be high enough to lead to self-heating effects. That would correspond to temperatures of 10 keV for the ions and electrons and a density-confinement time product, $N\tau$, of a few times 10^{14} . The significance of designing for 3 megamps is that this is the smallest current at which one can expect to confine the orbits of the alpha particles produced in thermonuclear reactions.

To produce self-heating, the JET experimenters would have to introduce deuterium and tritium, which would lead to radioactivity. In the design study, the team plans to examine the difficulties in using deuterium and tritium rather than hydrogen. The actual decision whether or not to use deuterium and tritium will hinge on whether the experiments with hydro-

gen show significant success. If 100 shots with deuterium and tritium were completely successful, the team pointed out, then without shielding the toroidal magnetic field coils and the vacuum vessel would become so radioactive that they could not safely be repaired.

The team hopes that a site will be selected by the end of this year. A committee made up of representatives from the Euratom fusion countries will begin discussions shortly. The design proposal is expected to be submitted to the Council of Ministers of Euratom by 1975.

One consideration in choosing the site, Pease points out, is that there be a strong plasma physics and fusion research program already there. Another is that the site have the capacity to handle such a large and difficult project. In particular, the design team members noted, no fusion laboratory in Europe has a large enough installed power supply, although the power could be extracted from one of the national networks. The JET site will need 250 MW (peak power) for a 20-sec period and a mean power of 180 MW; that is, 5 gigajoules would be required. One could use large flywheel generators, similar to those at the Princeton Plasma Physics Laboratory (which has 400 MJ) but use alternators instead of dc generators. If instead it is decided to take the power from a local network, the design team noted, there are only a few places in Europe that have a good transmission connection to many power stations. Likely sites, Pease feels, are Culham, Garching, Fontenay-aux-Roses, Grenoble, Jülich and in Italy.

—GBL

Two new groups gather at Bevatron Users Meeting

Two new organizations will come together at the annual Bevatron Users Meeting, 19 January, at the Lawrence Berkeley Laboratory. The Associated Users of Western High Energy Accelerators, formed in June, is designed to promote communications among users of the SLAC and LBL facilities. Richard L. Lander (University of California, Davis) is the chairman. Affiliated institutions include Cal Tech, MIT, Western Washington State College, Johns Hopkins, the University of California at Berkeley, Davis, Irvine, Los Angeles, Riverside, San Diego and Santa Barbara, and the Universities of Arizona, Colorado and Hawaii.

The second new group just being formed is the Bevalac Users Association, which will hold its organizational meeting during the 19 January conference. The Association was created for exchange of information among scien-

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