genic temperatures; limited access (e.g., Frascati Tokamak at 10 T, or ALCATOR C designed for 14 T at MIT).

d) 14 T $<$ *B:* Compact one-turn toroidal solenoid; very poor access.

High magnetic fields allow (according to expression (2), Sect. 1) the operation of denser plasmas in more compact devices. In addition, so far the best results concerning $n\tau_E$ and Z_{eff} have been obtained in high field and high density operation. High field Tokamaks pose challenging technical problems, but represent today an interesting approach to fusion that is complementary to the low field and low density regimes contemplated up to now in larger devices (Table III). Since magnetic fusion reactors will, most probably, require superconducting magnets for economical reasons, the long range high field prospects concentrate on the magnetic field range b). On the other hand, devices operating in the range c) or d) may be very interesting in the intermediate phase, to demonstrate controlled ignition of a deuterium-tritium plasma, or as a material testing device.

Conclusions

Unless a substantial scientific breakthrough emerges in the next five years (which is not at all impossible) and unless the world-wide fusion technology effort is increased manyfold, it looks unlikely that a fusion demonstration reactor (at the level represented, for example, by the Phénix Reactor in the fast breeder programme) could be effectively working before the year 2000. In the next years it will be necessary to work out long-term programmes that are sufficiently flexible — and credible — that they can accommodate delays or fundamental reorientations in fusion research and development, even if that means shifting the target date of the demonstration reactor to the year 2010 or beyond. Medium-term programmes that give useful guidance on the choices open in fusion research, exist in the United States and are now particularly needed in Europe. In view of the future large prototypes and of the related costs and risks of the complex research and development programmes, medium-term planning on a broad international level is becoming ever more desirable, even necessary.

Discussions at the Erice meeting have shown that a majority of the scientific community is realistically aware of the many important implications of the future fusion research programmes. It was clear to all that magnetic fusion has now reached a level of political attention and funding (270 M$ in 1978 in the U.S. alone) that a strong, competent and imaginative management has become necessary. Only gradually is the community becoming aware of the fact that fusion research and development, if it is finally to be carried through to success, will probably surpass in impact and in technological and financial dimensions, for example, the NASA Apollo Programme.

At the same time, there is a second aspect, namely the scientific and intellectual motivation for this activity that will make it possible to survive inevitable pauses or drawbacks during its progress. In fusion-oriented plasma research and development there is a challenge of new frontiers in physics, of new numerical and theoretical working methods, of sophisticated diagnostic systems and of advanced technologies that in its totality is hardly matched by any other scientific field of human endeavour.

Table III: Build Larger Tokamaks now?
Yes, because :

1. Fusion reactors will necessarily be large (minor radius: 2-3 m, major radius: 5-8 m; the sooner one is confronted with the physics and technology of large systems, the better).
2. Alpha particles will be contained (the physics of thermonuclear heating can be studied).
3. General physical considerations and results from present Tokamak generation, suggest a favourable scaling with size.
4. Surface to volume ratio is reduced (the impurity influx, and thus heat losses, should be reduced).
5. Quality of magnetic topology may be improved.
6. Good access for injection heating and diagnostics is provided.
7. Solutions to important new technology problems (superconducting magnets?) will be sought.

No, because :

1. The outstanding physics questions (containment, heating, plasma beta, impurities) will barely be answered by 1985.
2. Within limited budgets, the priority must be given to basic physics problems.
3. The so-called scaling laws in support of larger devices are not based on sufficient scientific data (for example, temperature scalling in Tokamaks can be studied only with future injection heated devices).
4. No fusion concept can scientifically claim at present to be the most promising (a high field device, for example, may turn out to be more convenient).

Waiting for JET

Still no decision has been taken on the project to build the Joint European Torus, JET, although it had been hoped that some solution might have been found at the meeting of the heads of State of western European countries that took place in London in June. Now it is hoped that something positive may emerge from the meeting of the Council of Foreign Ministers of the countries of the European Communities on September 20.

Wide publicity has been given to the problem of selecting a site with, at various times, the centres at Cadarache, Culham, Garching and Ispra being quoted. The site is not, however, the only decision that has to be taken. The Committee of Permanent Representatives of the Communities has to recommend a management structure for the Project and this also has been the subject of controversy. Everyone seems to be in agreement that JET is a project of great importance for the development of fusion and is vital for the promotion of the technology in western Europe but this has only served to accentuate the divergences and regretably the politics of collaboration have seemed to dominate the scientific imperatives.

A certain parallel exists between the present JET situation and that encountered with the CERN SPS in the latter part of the 1960's, but at CERN it proved possible to appoint without too much argument a project leader who was able then to catalyse the subsequent accord. There was also, of course, an existing single international site whereas, although Euratom has been successfully coordinating western European research on fusion devices over many years, there is as yet no single European centre devoted to fusion research. JET has so far no project leader, but a design team leader in the person of Paul Redut. The remit of his team at Culham has been extended to cover the months of August and September but it seems unlikely that the members of this team will be prepared to continue on such a hand to mouth existence indefinitely.

In the meantime, the only large, new Tokamak presently being built in Europe is the ASDEX device in Garching near Munich shown in the photograph on the opposite page.

Ed.