High Magnetic Field Facilities
Planning Europe's Future

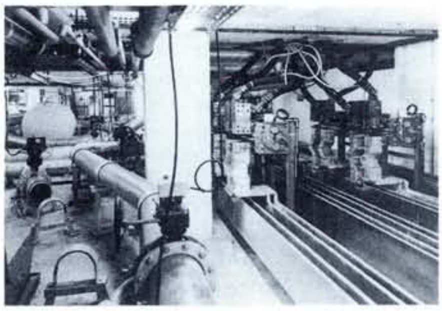
An European Community Study Panel recommended in its final report issued last December the creation, in the long term, of a state-of-the-art European high magnetic field **facility**. The Panel was set up by the Advisory Committee of the EC's Large Installations Plan and was charged with assessing future needs for facilities and how they could be satisfied, notably by developing national capabilities. It envisaged a 150-200 MECU centre equipped with a small number of units producing 100 tesla "semi-continuous" fields (where the peak field is held for times greater than 100 ms and approaching 1 s) together with several ≈ 10 ms "pulse" field stations in the 60-100 T range — an affordable facility with a large constituency.

For the immediate future, the Panel recommended **design studies** of these two types of magnets (100 T/1 s/ ≈ 60 MECU, and 70 T/10 ms / ≈ 1 MECU) along with a similar study of a 45 T "continuous" field hybrid magnet, comprising an outer superconducting coil and an inner resistive coil and costing an estimated 10 MECU over five years for a 30 mm bore. **Extension** until 1995 of the EC programme on high strength coil conductors (see page 154) essential for fields above 60 T was also recommended.

The recommendations stem from a growing interest in exploiting increasingly higher magnetic fields in several research areas including solid state physics, biology, chemistry and minerals technology (see page 160). Improved data acquisition systems has led to a resurgence of interest in pulsed fields and there is greater appreciation of the importance of large sample volumes capable of accommodating specialized measuring devices and imposing extreme conditions, notably ultra-low temperatures. However, semi-continuous (long pulse) systems were seen as the most important as they minimize eddy currents in conducting specimens at the highest attainable fields.

Pulsed and Semi-Continuous

Leaving aside its unique explosive field facility (see Table 1) which has been operational since July, the Los Alamos National Laboratory, USA, intends to extend today's limits with one or two 50-60+ T regulated semi-continuous units, to be constructed by 1995 under present budget planning. Meanwhile, Professsor J.J.M. Franse of Amsterdam University's High Field Installation has indicated that The Netherlands' Ministry of Education and Science announced at last month's 3rd International Symposium on Research in High Magnetic Fields in Amsterdam that it would fund a 10 MFLR upgrade of Amsterdam's regulated semi-continuous 40 T unit to 60 T initially proposed several years ago. This upgrade, for which Professor Franse is the Project Leader, represents a significant step up



Upgrading the power supply from 10 to 20 MW at the MPI/SNCI Grenoble facility. Completion planned for this year should relieve pressure on scheduling as most existing magnet stations will then be used for twice as long each day. Upgrades of the Laboratory's resistive, polyhelix and hybrid (upper, right) magnets can also be envisaged. The photo on the upper left shows the new water cooling lines and electric power buses serving the stations (courtesy of Serv'image).

The 40 T regulated semi-continuous pulse magnet at the Amsterdam University's High Field Installation. The Dutch government has recently approved an 10 MFLR upgrade to 60 T involving an extension to the existing building, an upgrade of the mains-supplied controlled rectifier power supply and implementation of a novel approach using two concentric, liquid nitrogen cooled, resistive coils. The field generated by energizing the outer coil for 10 s will rise to 30 T before it starts to decrease owing to an exponential increase in resistivity as the coil temperature increases: energizing the inner coil at peak field with the outer coil disconnected will then raise the field in the 25 mm diameter bore to 60 T for about 250 ms. The large, 1 m diameter, outer coil will be wound from copper band, the inner ≈ 0.25 m diameter coil from a high strength copper alloy or a microcomposite copper conductor. The centre plans to work more closely with the complementary continuous field facility at Nijmegen University.

Table 1 — Summary of high magnetic field facilities (US, Europe, Japan)

Location			Peak field T	Peak time ms	Bore diam. mm	No. units	Status
Pulse & semi-continuous (energy >0.8 MJ)							
US	LANL	Los Alamos	100/1000	10	—	1	
			50-60+	100	30	1-2	planned
	FBNML	MIT	40	100	20	1	
EU	Univ.	Amsterdam	60	250	25	1	planned
			40	100	20	1	
	CNRS	Toulouse	61	250	14	1	
			43	920	28	1	
	Univ.	Leuven	55	50	20	1	
	CNR	Parma	60	20	27	1	under constn.
	Clarendon	Oxford	63	20	20	1	under constn.
JA	NRIM		50-80	≈100	—	1	under dev.
	Tohoku Univ.	Sendai	35	10	14	1	
Continuous/hybrid (>30 T)							
US	NHMFL	Tallahassee	45		≈40	2	under constn.
	FBNML	MIT	30-33		32	2	
EU	MPI/SNCI	Grenoble	31→40		50	1	poss. upgrade
	Univ.	Nijmegen	25-30		32	2	
JA	NRIM	Tsukuba	40		40	1	under constn.
	Tohoku Univ.	Sendai	31		32	1	

from the 61 T/250 ms and 43 T/920 ms unregulated semi-continuous pulse units at Toulouse and the 55 T/55 ms medium pulse unit at the Catholic University, Leuven. The Amsterdam upgrade is seen as a necessary step towards the regulated 100 T semi-continuous European facility.

Short pulse (10 ms) facilities include the construction of 60+ T units at the CNR, Parma and at the Clarendon Laboratory, Oxford. The National Research Institute for Metals (NRIM), Japan, is developing a 50-80 T/≈ 100 ms unit. The Panel recommended increased support for extending access to the European 60+ T pulsed field facilities by developing them into a **network** of regional training centres.

Continuous

Hybrids beyond 30 T

Continuous (steady state) magnetic fields with fields of around 30 T produced using hybrid magnets are today available at four laboratories. Dr. Bill Moulton, Associate Director of the new National High Magnetic Field Laboratory at Florida State University, Tallahassee, USA, confirms that two next generation 45 T hybrids constructed using a modified polyhelix design for the inner resistive magnet (pioneered by Grenoble's facility operated jointly by the Max Planck Institute for Solid State Physics, Stuttgart and the French CNRS's Service National des Champs Intenses) are planned for 1995. He also indicates that the hitherto preeminent US centre — MIT's Francis Bitter National Magnet Laboratory

An artist's sketch of the new US National High Magnetic Field Laboratory at Florida State University, Tallahassee with ground breaking scheduled for 1 October 1991. The ≈110 M$ centre for magnet-related research, due for completion in 1995, will house two 45 T hybrid magnets, 14 resistive magnets, two 21 T superconducting NMR magnets, and a small body 14 T NMR magnet. The NHMFL is to receive roughly 70% of a 60 M$ NSF grant awarded last year: the remainder goes to the Los Alamos National Laboratory for the construction of 60+ T regulated semi-continuous magnets. It has not yet been decided if a large motor-driven power supply developed for fusion experiments will be used. The hitherto preeminent US centre — MIT's Francis Bitter National Magnet Lab., reputedly holder of world records for continuous (31.8 T) and pulsed (68.4 T) fields — was unsuccessful in the original bid but has recently been awarded a 5 M$ NSF grant to participate in developing the hybrids.

— will participate in the development. This follows the recent award of an additional 5 M$ over and above the 60 M$ over five years already committed by the US National Science Foundation and a 56 M$ pledge from the State of Florida. Meanwhile, a 40 T hybrid is under construction at NRIM, Tsukuba.

Grenoble believes it will be able to consider upgrading its 30 T hybrid, presently the world's largest and most powerful, to maybe 40 T on completing the 30 MECU upgrade of the Laboratory's power supply from 10 to 20 MW this year. Dr. Jos Perenboom, Coordinator at Nijmegen University's High Field Magnet Laboratory — the other main European centre for continuous fields — has indicated that his centre will be collaborating more closely with Amsterdam University in offering complementary fields so as to encourage use by guest scientists. Access to both Grenoble and Nijmegen is being supported by the Large Installations Plan: the Panel recommended increased access by funding **new user groups** backed by 1-2 postdoc posts at the two laboratories.

Resistive to 30 T

According to Professor Peter Wyder, Director of the MPI/SNCI facility, 20 T resistive magnets cater for 70% of user time at Grenoble and are today's workhorses at most other centres serving many visitors. Tallahassee will have 14 resistive magnets (4 polyhelix, 10 modified Bitter) of 22-35 T with 33-55 mm bores: Grenoble hopes to upgrade its resistive 25 T polyhelix magnet to 30-31 T by 1992/3, and eventually its 20 T resistive units to 26 T.

Large bore superconducting to 20 T

Two 21 T/ 20-40 mm bore superconducting magnets are planned for Tallahassee, and the NRIM, Japan, is building a 20 T large bore magnet. With commercial manufacturers offering small bore 20 T superconducting magnets, Grenoble believes the next frontier for Europe is a 20 T large bore magnet with a homogeneous field. The EC Panel made no recommendations along this direction, arguing that specialist laboratories producing high fields at the limit of technology with pulse, hybrid and resistive magnets remain the priority.