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High-Field Magnets for NMR and MRI: A Review of the Past 30 Years and a Vision for the Future Perspectives

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Although my talk here is on high-field NMR and MRI superconducting magnets, I will begin by briefly describing early NMR studies on biological samples and even tumor detection that were performed with *Bitter magnets* in the late 1960s at the National Magnet Laboratory, now FBML. The full-fledged results achieved in the early 1970s with *low-field* NMR spectrometers lead directly to MRI for medical science and health care. Of many high-field NMR and MRI magnets covered in this talk, I will highlight a 600- MHz NMR magnet manufactured by IGC (IGC600) that in 1979 began operation at the Carnegie-Mellon University. Because the IGC600 was constructed from a stack of double-pancake coils wound with Nb3Sn *tape*, issues encountered during its development remain highly relevant to today's HTS inserts, particularly those wound with REBCO tape. I will discuss challenges, and possible solutions, for NMR and MRI magnets that incorporate HTS. As for the future perspectives, the sky's the limit, technically, but in reality, development will not come easily or quickly.

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Nuclear Fusion and Particle Accelerators: Past and Future Perspectives

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Particle accelerators and fusion plasma reactors have had what can be described as a demand pulled effect on the technology and development of applied superconductivity. Within months of the announcement of Nb3Sn by Bell Laboratories in 1961 there were papers reporting small superconducting magnets for bubble chamber particle detectors. Seven years later in 1968 at the Brookhaven National Laboratory Summer Study members of the international high energy physics community as well as commercial technologists had resolved and understood the stability and ac loss issues for composite conductors. That year also saw the completion of two very large bubble chamber magnets that were cryogenically stable. The next forty years witnessed the construction of a number of high energy particle accelerators including the Tevatron at Fermilab and the LHC at CERN. These and other projects nucleated major industrial production of NbTi based superconductors and magnets. Fusion applications have been a major source of development of Nb3Sn technology and its history will be discussed. Early in the new millennium HEP took a handoff of Nb3Sn technology from fusion with improvements to the performance of that conductor. Advanced Nb3Sn and HTS materials will be the enabling technology for the next generations of particle accelerators and fusion reactors. The daunting engineering challenges of these devices will be examined.

AP2-3-INV

Rotating Machine: A review of the past 30 years and future perspectives

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Research and development on superconducting rotating machines has history of more than 30 years. In the history, superconducting homopolar DC machines might be of the first practical use in superconducting rotating machines, which are not sure because of their war ship uses. Superconducting synchronous generators cooled by liquid helium are well developed, especially by SuperGM project in Japan. Fundamental subjects on design, manufacture, operate, control, power system performance and so on are definite, which will be presented in this paper. After developing oxide superconducting wires and bulks, superconducting electric motors by use of them, (mainly synchronous ones) are under developing, the structures of which are very similar to the generators above mentioned. They mucst be of speed change, differently from generators.
Increasing interest of hydrogen, synchronous generators by use of MgB_2 wires cooled by liquid hydrogen are under development. Generators of lower cost, smaller size and so on are expected. Superconducting equipment to solve several problems on power systems with large number of renewal energy power plants must be examined. It is very important to find subjects on superconductivity for meeting above mentioned problems.

Keywords: Superconducting electric machine, Liquid helium, Oxide superconductor, Liquid hydorogen

AP2-4-INV

Power applications: review of the past 30 years and future perspective

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Applied superconductivity will soon celebrate its 60 years. It was linked to the emergence of conductors (Nb_3Sn then NbTi) able to carry large currents under high fields. NbTi and Nb_3Sn still are the basic superconductors for applied superconductivity with well-established markets such as MRI. 30 years ago the first superconductor whose critical temperature breaks the liquid nitrogen barrier was discovered. The « Superconductivity revolution » was announced, but it did not really take place. On the other hand considerable works have been carried out about the strongly complex high Tc superconductors, which have so reached now a pre-industrial stage. In parallel the indispensable sustainable development among other things required new technologies and the high Tc superconductors are outstanding enablers. These loss free conductors are natural companions for sustainability. Renewable energies face several challenges such as very large wind turbines or the transport of huge energies over long distances. Superconducting wind generators, superconducting cables and superconducting fault current limiters offer for example new functions or possibilities in terms of footprint and weight performances breaking the conventional limits. The "Superconductivity revolution" is on track. The review of some works will be a basis for exploring the future of superconducting power applications.

Keywords: Superconducting Power Applications, Fault Current Limiter, Wind turbine, HVDC supergrids