Superconductivity's New Magnetic Strength

Superconductivity and magnetism are natural enemies. A superconducting current expels magnetic fields from the conductor in which it is established. Conversely a superconductor placed in a strong enough magnetic field will lose its superconductivity. Here lies a basic dilemma of superconducting magnets. If the field generated by the magnet reaches the critical strength for the material of which the magnet is made, it will destroy the superconductivity and then poof goes the magnet.

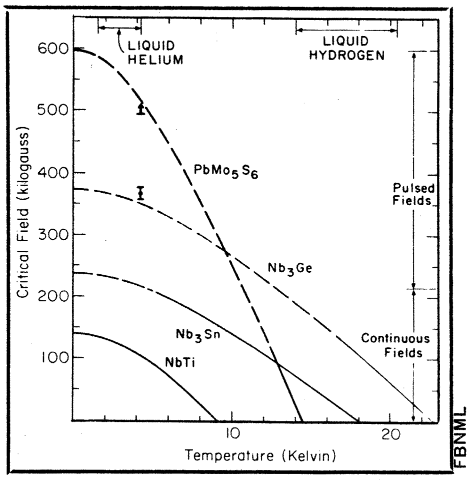
The critical magnetic field is different for every superconducting substance so there is a continuing search for substances with high critical fields, and superconductors are tested in high magnetic fields to see what their superconductivity will withstand. At the 1974 Applied Superconductivity Conference in Oak Brook, Ill., last week Simon Foner of the Francis Bitter National Magnet Laboratory reported a real winner, a substance with the truly fantastic critical field of half a million gauss. This is close to the strongest magnetic field that can be produced in the best equipped laboratories. It is a million times as strong as the earth's magnetic field (half a gauss). For comparison a toy magnet is about 100 gauss.

(First results appear in the Oct. 7 PHYSICS LETTERS. A more extensive report will be in the *Proceedings of the 1974 Applied Superconductivity Conference.*)

The material is a lead-molybdenum-sulfur compound ($PbMo_5S_6$). It is one of a class of ternary compounds discovered in France in 1971. In 1972 B. T. Matthias and colleagues of Bell Telephone Laboratories showed it to be superconducting. Now Foner, E. J. McNiff Jr., and E. J. Alexander have succeeded in measuring the critical field to 500,000 gauss. (Superconductivity as high as 350,000 gauss had been reported by a Swiss group.)

To do it strained the field-generating capacity of FBNML's best pulsed magnets. (Steady-field magnets do not go anywhere near that strong.) The critical field is not a constant but tends to rise as the temperature drops. Measurements were made at a series of temperatures from about 14 degrees K. to a maximum of 500,000 gauss at about 4.2 degrees K. This establishes a curve that can be extrapolated to hit 600,000 gauss at absolute zero.

The previous maximum critical field was 410,000 gauss for an alloy of niobium, aluminum and germanium reported in 1970 by Foner and McNiff and collaborators from the University of California, Stanford and Bell Labs. Better preparation techniques allow precise and minute variation in the



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Critical fields up to 600,000 gauss.

A superconducting magnet in your future

There's a superconducting magnet in your future. That's the message the U.S. Atomic Energy Commission is sending out to its particle-physics and controlled thermonuclear fusion (CTR) experimenters. The AEC is concerned with electric bills, which run into the millions of dollars a year for some of its laboratories. The word is "cut."

The problem is the huge amounts of power drawn by the high-field magnets used in the experiments in question. Superconducting magnets would draw far, far less power. Donald Stevens, assistant director for materials sciences of the AEC's division of physical research, told the 1974 Applied Superconductivity Conference: "The future of high-energy physics depends on superconductivity." None of the projected facilities can be built without it. He is equally blunt about CTR: It has a "critical dependence on superconductivity."

Controlled fusion is one of the places where Simon Foner foresees a use of the high-field superconductor mentioned in the accompanying story. This will be especially true if it turns out that CTR needs very high fields, a question that is not yet experimentally decided.

In particle physics superconductivity will mean savings in real estate too. Superconducting facilities will be smaller than those with conventional magnets. The 400-billion-electron-volt main ring at the Fermi National Accelerator Laboratory (FermiLab) in Batavia, Ill., is 2-kilometers in diameter. Someone once figured that a 1,000-billion-electron-volt installation could surround Greater Berlin, East and West together.

"What's new about all this?" say workers in the field. "We've seen it coming for years." What's new is that for years accelerator builders have talked about superconducting magnets but have built conventional ones. There have been periods of enthusiasm and unenthusiasm about superconducting technology; progress has been spotty and use limited. Now, say the managers of high-energy physics research, there is no alternative. Edwin L. Goldwasser, deputy director of FermiLab, estimates that the lab's proposed storage ring POPAE would run an electric bill of $240 million a year with conventional magnets.

FermiLab's immediate improvement project, intended to double its maximum energy (that is, ultimately reach 1,000 billion electron-volts), is beginning with superconducting magnets. There is no conventional option. The project is pushing the technology of superconductivity and the crucially allied technology of cryogenic refrigeration to their current outer limits, but the builders are confident that it will work and that it will work reliably.