Breaking resistance

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Superconductors: Conquering Technology's New Frontier. By Randy Simon and Andrew Smith. *Plenum: 1988. Pp.326. $28.74, £16.*

To physicists and engineers, the lure of superconductivity lay perhaps in its resemblance to magic. They had been taught that the consequence of passing electrons through wires was heating. Although true in the everyday world, there was nevertheless a wonderland where the usual laws according to Ohm and Ampère did not operate. It was a winter wonderland, a little chamber covered with icicles. The magic effect only took place near absolute zero, requiring an expensive coolant, liquid helium. The first attempt to harness the magic failed; a generation of engineers who hoped to use superconductivity in computers had their dreams frustrated because of the price of cooling. Then, in 1986, materials scientists made the first high-temperature superconducting ceramic systems.

This breakthrough has caused an unusual flutter in the wider world. In part this is because some people believe that superconductor magic has broken out of fairyland and is about to transform our world. There is thus a place for a book which attempts to tell people how superconductivity works and how it might, indeed, change the world. Randy Simon and Andrew Smith tackle this task in straightforward fashion. Their writing is informal but makes no concessions when a difficult point is to be made. If readers have to stretch their imaginations a bit, the authors give them due warning and provide the tools of analogy to help them along. One reason for this confident style is that both authors are physicists who themselves work on high-temperature superconductors for an aerospace firm. They are in the forefront of their field, and have probably had to explain the same points to their managers a hundred times. At the same time, the writing is highly polished. This is no journalistic paste job.

Twelve chapters take the reader logically through the history, physics and engineering of superconductors, and describe both the old and new versions. The old, low-temperature (LT) superconductors are based on alloys of niobium, tin and lead, and are cooled by liquid helium or neon. The new, high-temperature (HT) varieties are based on cuprate ceramic compounds, and operate at temperatures near that of boiling nitrogen (high temperature in this context). These are dealt with in the final four chapters of the book, which discuss the excitement of the advances that have been made in the past three years. Chapter 13 gives a historical account of the initial discovery in 1986; and Chapter 14 describes the most popular research material, yttrium–barium–copper-oxide.

In the last two chapters the authors consider the future. Here, however, they have not done a real analysis of the uses and economics of the new materials, so their predictions are qualitative. But their views are logical — and agree with those of many reasonable people.

In the 1970s, the goal for the superconducting computer was to make a device, cooled by helium, that would fit inside a teacup and could reel off the names of every person in the world in one second. The efforts failed (the computer equipment looked like a kitchen stove), primarily because of the poor thermal properties of helium. Such computers had some highly specialized uses, including many military applications, but by the early 1980s research in the United States was faltering. The authors do not clearly explain why this was so, but they do spell out with enthusiasm the case that was being made for the continuance of LT research. This case was based on the advantages of the LT superconductor — speed of switching, absence of electrical noise and uniquely precise action in sensor devices.

The authors are confident that the discovery of HT effects will reverse the trend and revive research into LT superconductors. But they fail to mention a strong argument for continuing LT work, namely that the experience of workers in that technology might be harnessed to explore the possibilities of the HT effect. At the very least, LT research should continue while the basic physics and materials science of the new systems are studied.

We are by no means sure that the HT effect will do the things we want. Higher temperature is bound to erode one of the three advantages mentioned earlier, low-noise operation. Furthermore, the lattice structure of the new materials impairs electronic functions and may present insuperable barriers to widespread commercial success. We can only hope that the speed and precision of many classical superconducting effects are not affected too badly by this materials problem. Nevertheless, it will be surprising if the HT effects do not find some startling, novel uses.

Without trying to be prophetic, the authors set the scene for the growth of HT superconductors into a high-technology industry. Their well-balanced account of a complex technical challenge is likely to help laymen appreciate what is going on; many scientists who need a quick review of the subject will also want to read the book. If zero-resistance materials and new quantum-effect devices are going to come out of the winter wonderland and into the real world, then we all need to know about them. □

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Face of the past — a Colossal Head, in total 2.84m high, fashioned from basalt and typical of the Olmec culture of Mexico (c. 1200–900 BC). The picture is reproduced from the new paperback of Michael D. Coe's Mexico, *3rd edn, to be published by Thames & Hudson on 13 February, £6.95.*