Superconductors: The Next Generation of Permanent Magnets

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Abstract—Magnets made from bulk YBCO are as small and as compact as the rare earth magnets but potentially have magnetic flux densities orders of magnitude greater than those of the rare earths. In this paper a simple technique is proposed for magnetising the superconductors. This technique involves repeatedly applying a small magnetic field which gets trapped in the superconductor and thus builds up and up. Thus, a very small magnetic field such as one available from a rare earth magnet can be used to create a very large magnetic field. This technique which is applied using no moving parts is implemented by generating a travelling magnetic wave which moves across the superconductor. As it travels across the superconductor it trails flux lines behind it which get caught inside the superconductor. With each successive wave more flux lines get caught and the field builds up and up. The wave could be generated in many different ways but the preferred way is simply to heat a material whose permeability changes with temperature at its edge. As the heat travels across the material so the permeability changes and a magnetic wave is generated. It is in effect the first novel heat pump in a very long time and one which will enable the enormous potential available from these unique and highly versatile superconducting magnets to be fully realised. Within this paper we present results showing the superconductor being progressively magnetised by sequentially applied "heat" pulses. We also demonstrate that the sign of the magnetisation is reversed if "cold" pulses are applied instead of heat pulses. These experimental results are supported by modelling.

Index Terms—Heat engine, Magnetization processes, Superconducting magnets.

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