MAGNETIC RESONANCE IMAGING IN 1987

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ABSTRACT

The superior performance of superconducting magnets for magnetic resonance imaging has led to the production of over 1000 magnets for this application. Further growth in this industry will depend on reducing system costs, extending medical applications, and easing the present siting problem. New magnet designs from Oxford address these issues. Compact magnets are economical to build and operate. A 4 Tesla whole body magnet for research in Magnetic Resonance Spectroscopy (MRS) has been successfully tested. Active-Shield magnets, by drastically reducing the fringing field, will allow MRI systems with superconducting magnets to be located in previously inaccessible sites.

MRI IN 1987

As of the spring of 1987, approximately 1100 one-meter bore superconducting magnets have been manufactured for whole body magnetic resonance imaging (MRI). These magnets comprise about 90% of the MRI magnets built, with the balance utilizing resistive and permanent magnet technology. Superconducting magnets have achieved preeminence in this application for several reasons:

1. They provide strong magnetic fields economically. Superconducting magnets in routine clinical use today range in field strength from 0.35 Tesla to 2 Tesla. Resistive and permanent magnets have only been practical up to the lower end of this range. Although the optimum field for imaging is the subject of much debate, fields below 0.35 Tesla clearly do not provide as high signal-to-noise data as higher fields. The MRI system design can
convert high signal-to-noise into improved spatial resolution, faster image acquisition, and/or reduced image "graininess".

2. Superconducting magnets in general provide a larger homogeneous volume, allowing imaging over a wider field of view. Weight and power consumption constraints lead to compromises in the useful imaging volume in permanent and resistive magnet designs.

3. Superconducting magnets provide magnetic fields of unsurpassed temporal stability. Operating in the persistent mode and isolated from thermal or electrical transients, stability of better than 0.1 ppm hour is routinely achieved. Good temporal stability is as important as good spatial uniformity in achieving the image quality the industry has come to expect.

4. Superconducting magnets for MRI are highly reliable and simple to operate. Because they operate in the persistent mode and use sealed off vacuum vessels, they are unaffected by power interruptions. The efficient cryogenic performance (specifications on helium consumption are now typically <0.4 ppm/hour) allows operation in most cases without on site refrigeration systems. The only maintenance requirement is periodic topping up of the cryogens.

REQUIREMENTS FOR FURTHER GROWTH OF MR

Impressive as the last five years' progress has been, the installed base of MRI remains nearly an order of magnitude below that of the competing technology of x-ray Computed Tomography (CT). Several advances are necessary in order for the installed base to approach that of CT.

The price of an MR system is currently about three times that of CT. It must be brought down if the industry is to grow to its full potential. Although the magnet price is only about 20% of the selling price of an MR system, the increasingly cost conscious industry demands magnets that are both economical to build and economical to operate.

Specific medical applications of MRI are to date less widespread than are applications of CT. This is partly due to the newness, and great flexibility of the technology. Different pulse sequences are required to highlight different pathologies, and protocols to establish the optimal approach to different clinical symptoms are still being worked out. In addition, there are technical issues in imaging the chest and abdomen, due to image artifacts induced by respiratory and cardiac motion. For this reason, images of the head and spine, which are easily immobilized and where MRI's soft tissue contrast makes it clearly superior to CT, account for about 70% of the scans performed today. New, faster imaging techniques which minimize motion artifacts promise to extend applications of MRI in the body.