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MRI from 400 gauss to 1.5 tesla and beyond

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Magnetic Resonance Imaging (MRI) is arguably the most novel and important medical imaging modality since the advent of the X-ray. MRI grew out of the long development of atomic spectroscopy, atomic and molecular beam resonance and, finally, nuclear magnetic resonance (NMR) in condensed matter. The operation and economics of MRI systems depend on the performance of magnets, pulsed magnetic field gradient windings and rf (radiofrequency) coils. Physics and physicists have made critical contributions to these technologies. Superconducting magnets have come to be the magnet of choice. Magnetic gradient windings present theoretical electromagnetic and practical challenges. The need for rf antennas that resonate at high frequencies while surrounding sizable spatial regions inspired large coils producing uniform rf magnetic fields while minimizing electric field interactions with the imaging subject. This development enabled MRI at high magnetic fields. Additionally it is possible to use arrays of small rf coils to obtain MRI images with the high signal-to-noise ratio of a small surface coil and the field of view of a large coil. We recently investigated the intense acoustic noise (110 dB or more) produced in MRI scanners. Surprisingly, eddy currents induced in the magnet cryostat inner bore make a major contribution to this noise. Calculations indicate that a thin layer of Cu on the outside of the gradient assembly could substantially decrease eddy currents and help reduce noise. GE R&D work was focused on the science underlying MRI, MRI technology and the MRI product. Corporate management sometimes discourages technical publication related to evolving products because it might help rivals. Our practice of extensive publication and participation in open scientific exchange—after filing appropriate patent applications—served as quality control for company science and technology. GE conference presentations and journal publications helped establish technical leadership and determine which ideas were most important. GE scientists built reputations leading to leadership prominent within the MRI technical community. Openness underpinned a highly effective development process that enabled GE to pull ahead of competitors.