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The large communications satellites in geosynchronous orbit have around 20–50 TWTs that provide many essential services. Complete world coverage also requires satellites in polar orbits. Fortunately, Iridium Communications now maintains a constellation of 66 low-Earth-orbit communications satellites that are in polar orbits. The geosynchronous-orbit and low-Earth-orbit satellites, taken together, provide the world with access to space-based communications because of the discovery and development of SmCo_5 and $\text{Sm}_2\text{Co}_{17}$ magnets in the late 1960s.

In 1966 Karl Strnat and Gary Hoffer reported finding promising magnetic properties in the yttrium-cobalt compound YCo_5 . The following year, they and their colleagues reported the discovery of a new family of cobalt-based permanent magnet materials.¹ The researchers substituted other rare earths for Y and determined that SmCo_5 was the optimal choice for practical applications. Strnat and Alden Ray continued that line of study and ultimately discovered $\text{Sm}_2\text{Co}_{17}$, which has even more impressive magnetic properties. That research was possible only because a separation process developed by the Department of Energy's Ames Laboratory for the Manhattan Project made pure rare-earth elements available for the first time.

SmCo_5 and $\text{Sm}_2\text{Co}_{17}$ magnets are superior to the platinum-cobalt magnets they replaced in terms of magnetic properties, cost, size, and weight. At present, they remain the only choices for many applications, particularly those that require very low or very high operating temperatures. Uses include gyros for space launch vehicles, brushless high-torque motors for dental and medical power tools, aircraft radar, and computer disk drives.

SmCo magnets have an extremely large coercive force, a measure of their ability to resist demagnetization, and an extremely large energy product (the maximum product of the **B** and **H** fields during demagnetization), a measure of their ability to do work. The maximum energy products for SmCo_5 and $\text{Sm}_2\text{Co}_{17}$ are around 20 megagauss oersteds (160 kJ/m³) and 32 MGOe (250 kJ/m³), respectively. They are appropriate for operating at temperatures from absolute zero (−273 °C) to 300 °C for SmCo_5 and to 350 °C for $\text{Sm}_2\text{Co}_{17}$.

Importantly, the magnetic field SmCo magnets produce is parallel to the *c*-axis of their hexagonal unit cell and never flips to the easy basal plane at any temperature. The phenomenon, known as magnetocrystalline anisotropy, gives application designers great flexibility in magnet shape.

Neodymium-iron-boron magnets, discovered in 1984, have far better magnetic properties than SmCo_5 or $\text{Sm}_2\text{Co}_{17}$ at ordinary temperatures. Their maximum energy product is about 55 MGOe (440 kJ/m³), and their useful temperature range is between −138 °C and 150 °C. Therefore, NdFeB magnets are the only choice for moderate-temperature applications such as electric car motors or MRI devices. They have already replaced the superconducting magnets used in older MRIs, mitigating claustrophobia and size issues. SmCo_5 and $\text{Sm}_2\text{Co}_{17}$ magnets, however, have far better magnetic properties than neodymium-iron-boron magnets at low temperatures and are the only choice for most space applications, such as TWTs. Thus, SmCo and NdFeB magnet technologies will coexist peacefully because their application areas do not overlap.

Reference

1. K. Strnat et al., *J. Appl. Phys.* **38**, 1001 (1967).

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Ellipse, College Park, MD 20740-3842. Please include your name, work affiliation, mailing address, email address, and daytime phone number on your letter and attachments. You can also contact us online at <https://contact.physicstoday.org>. We reserve the right to edit submissions.

Correction

September 2021, page 23—The story erroneously referenced a nonexistent radionuclide of iridium. The correct radionuclide is iridium-192. **PT**