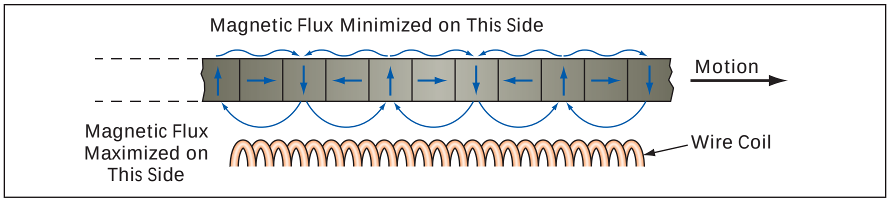

Figure 1. A **Basic Halbach Array** consists of permanent magnets oriented in a sequence of quarter turns chosen to concentrate the magnetic field on one side. The motion of the array along a wire coil gives rise to an electromagnetic repulsion that can be exploited for levitation.

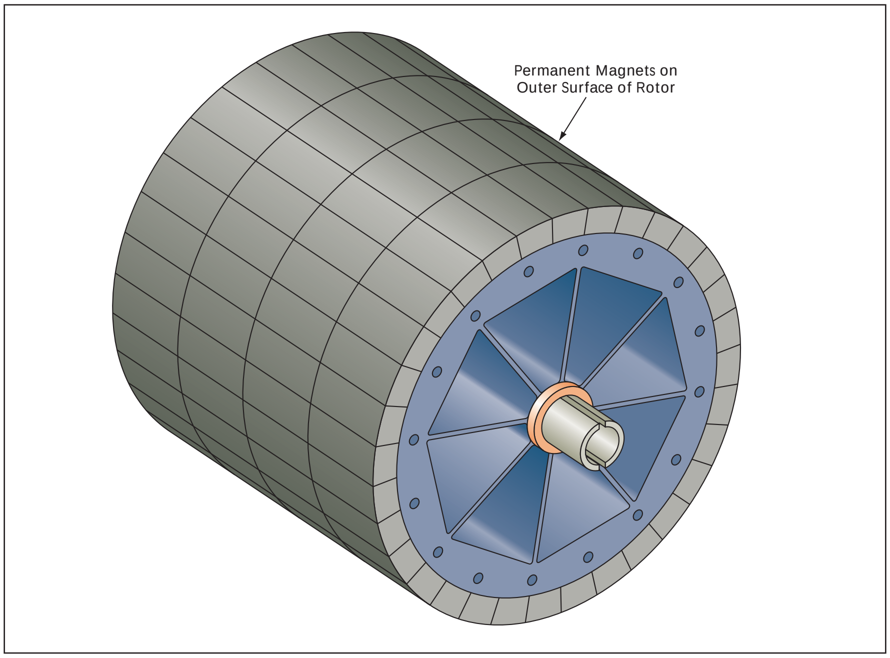

Figure 2. The **Rotor in a Radial Halbach Magnetic Bearing** has an outer layer consisting of a cylindrical version of the Halbach array of Figure 1. The bearing also includes multiple coils in a stator (omitted from this view) surrounding the rotor.

at a right angle to that of the adjacent magnet, and the right-angle turns are sequenced so as to maximize the magnitude of the magnetic flux density on one side of the row while minimizing it on the opposite side. The advantage of this configuration is that it makes it possible to approach the theoretical maximum force per unit area that could be exerted by a given amount of permanent-magnet material. The configuration is named after physicist Klaus Halbach, who conceived it for use in particle accelerators. Halbach arrays have also been studied for use in magnetic-levitation ("maglev") railroad trains.

In a radial Halbach magnetic bearing, the basic Halbach arrangement is modified into a symmetrical arrangement of sector-shaped permanent magnets mounted on the outer cylindrical surface of a drum rotor (see Figure 2). The magnets are oriented to concentrate the magnetic field on their radially outermost surface. The stator coils are mounted in a stator shell surrounding the rotor.

At a given radial position on the outer rotor magnet surface, the magnetic flux along any given direction varies approximately sinusoidally with the circumferential coordinate. When the disk rotates, the temporal variation of the magnetic field intercepted by the stator coils induces electric currents, thereby generating a repulsive electromagnetic force. The circuits of the stator coils are typically closed by inductors, the values of which are chosen to modify the phase shifts of voltage and currents so as to maximize the radial repulsion. Above a critical speed that depends on the specific design, the repulsive force is sufficient to levitate the rotor. During startup, shutdown, and other events in which the rate of rotation falls below the critical speed, the rotor comes to rest on an auxiliary mechanical bearing.

This work was done by Dennis J. Eichenberg, Christopher A. Gallo, and William K. Thompson of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18239-1.

Aerial Deployment and Inflation System for Mars Helium Balloons

Various factors are considered to ensure mission success.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method is examined for safely deploying and inflating helium balloons for missions at Mars. The key for making it possible to deploy balloons that are light enough to be buoyant in the thin, Martian atmosphere is to mitigate the transient forces on the balloon that might tear it.

A fully inflated Mars balloon has a diameter of 10 m, so it must be folded up for the trip to Mars, unfolded upon arrival, and then inflated with helium gas in the atmosphere. Safe entry into the Martian atmosphere requires the use of an aeroshell vehicle, which protects against severe heating and pressure loads associated with the hypersonic entry flight. Drag decelerates the aeroshell to supersonic speeds, then two parachutes deploy to slow the vehicle down to the needed safe speed of 25 to 35 m/s for balloon deployment. The parachute system descent dynamic pressure must be approximately 5 Pa or lower at an altitude of 4 km or more above the surface.

At this point, a pyrotechnic device will break the retaining mechanism and open the balloon container. The parachute force will pull the balloon upwards out of the container while simultaneously the payload module (containing the helium tanks and flow control system) freefalls and pulls the bottom of the balloon down. This causes the balloon to stretch out to its maximum length. Transient shock loads are generated in the balloon when its maximum length is reached. These shock loads are held to safe values by ripstitch elements in the flight train that break at a prescribed force and dissipate energy. After a short delay, a valve opens to start the helium flow into the bottom of the balloon through a flexible hose connector. Pyrotechnic cutting devices fire at the end of inflation to stop the helium flow and to separate the parachute and payload module from the balloon. By design, the balloon ends inflation below its nominal float altitude to avoid over-pressurization. It will then rise to its nominal float altitude, typically 2 km or more above the surface, before leveling off. This may require some venting of excess helium through a pressure relief valve.

At the time of this reporting, this technology is at the prototype testing stage. Further development is needed, particularly with end-to-end flight tests showing the balloon surviving deployment and floating afterward, as well as increasing the size of the balloon from its current 10-m diameter to an ultimate size of 20 m in order to support equatorial Mars missions.

This work was done by Tim Lachenmeier of Near Space Corp.; Debora Fairbrother and Chris Shreves of NASA-Wallops; and Jeffery L. Hall, Viktor V. Kerzhanovich, Michael T. Pauken, Gerald J. Walsh, and Christopher V. White of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-44688

Steel Primer Chamber Assemblies for Dual Initiated Pyrovalves

NASA's Jet Propulsion Laboratory, Pasadena, California

A solution was developed to mitigate the potential risk of ignition failures and burn-through in aluminum primer chamber assemblies on pyrovalves. This was accomplished by changing the assembly material from aluminum to steel, and reconfiguration of flame channels to provide more direct paths from initiators to boosters. With the geometric configuration of the channels changed, energy is more efficiently transferred from the initiators to the boosters. With the alloy change to steel, the initiator flame channels do not erode upon firing, eliminating the possibility of burn-through. Flight qualification tests have been successfully passed.

This work was done by Carl S. Guernsey and Masashi Mizukami of Caltech, Zac Zenz of Conax Florida Corp., and Adam A. Pender of Lockheed Martin Corp. for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46302

Voice Coil Percussive Mechanism Concept for Hammer Drill

NASA's Jet Propulsion Laboratory, Pasadena, California

A hammer drill design of a voice coil linear actuator, spring, linear bearings, and a hammer head was proposed. The voice coil actuator moves the hammer head to produce impact to the end of the drill bit. The spring is used to store energy on the retraction and to capture the rebound energy after each impact for use in the next impact. The maximum actuator stroke is 20 mm with the hammer mass being 200 grams. This unit can create impact energy of 0.4 J with 0.8 J being the maximum.

This mechanism is less complex than previous devices meant for the same task, so it has less mass and less volume. Its impact rate and energy are easily tunable without changing major hardware components. The drill can be driven by two half-bridges. Heat is removed from the voice coil via CO_2 conduction.

This work was done Avi Okon of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45712

Inherently Ducted Propfans and Bi-Props

Noise would be reduced without the weight and other disadvantages of shrouds.

Langley Research Center, Hampton, Virginia

The terms "inherently ducted propfan" (IDP) and "inherently ducted biprop" (IDBP) denote members of a proposed class of propfan engines that would be quieter and would weigh less than do other propfan engines that generate equal amounts of thrust. The designs of these engines would be based on novel combinations of previously established aerodynamic-design concepts, including those of counter-rotating propfans, swept-back and swept-forward fixed wings, and ducted propfans.

Heretofore, noise-reducing propfan designs have provided for installation of shrouds around the blades. A single propeller surrounded by such a shroud is denoted an advanced ducted propeller (ADP); a pair of counter-rotating propellers surrounded by such a shroud is denoted a counter-rotating integrated shrouded propeller (CRISP). In addition to adding weight, the shrouds engender additional undesired rotor/stator interactions and cascade effects, and contribute to susceptibility to choking.

An IDP or IDBP would offer some shielding against outward propagation of noise, similar to shielding by a shroud, but without the weight and other undesired effects associated with shrouds. An IDP would include a pair of counter-rotating propellers. The