Mechanics/Machinery

Small, Lightweight, Collapsible Glove Box

The box is easily prepared for performing experiments in limited work space.

Ames Research Center, Moffett Field, California

A small, lightweight, collapsible glove box enables its user to perform small experiments and other tasks. Originally intended for use aboard a space shuttle or the International Space Station (ISS), this glove box could also be attractive for use on Earth in settings in which work space or storage space is severely limited and, possibly, in which it is desirable to minimize weight.

The development of this glove box was prompted by the findings that in the original space-shuttle or ISS setting, (1) it was necessary to perform small experiments in a large general-purpose work station, so that, in effect, they occupied excessive space; and it took excessive amounts of time to set up small experiments. The design of the glove box reflects the need to minimize the space occupied by experiments and the time needed to set up experiments, plus the requirement to limit the launch weight of the box and the space needed to store the box during transport into orbit.

To prepare the glove box for use, the astronaut or other user has merely to insert hands through the two fabric glove ports in the side walls of the box and move two hinges to a locking vertical position (see figure). The user could do this while seated with the glove box on the user's lap. When stowed, the glove box is flat and has approximately the thickness of two pieces of 8-in. (≈20 cm) polycarbonate.

This work was done by Jerry James of Lockheed Martin for Ames 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 the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-15179-1.

Only Simple Motions are needed to prepare the glove box for use.

Radial Halbach Magnetic Bearings

Complex active control systems are not necessary for stable levitation.

John H. Glenn Research Center, Cleveland, Ohio

Radial Halbach magnetic bearings have been investigated as part of an effort to develop increasingly reliable noncontact bearings for future high-speed rotary machines that may be used in such applications as aircraft, industrial, and land-vehicle power systems and in some medical and scientific instrumentation systems. Radial Halbach magnetic bearings are based on the same principle as that of axial Halbach magnetic bearings, differing in geometry as the names of these two types of bearings suggest. Both radial and axial Halbach magnetic bearings are passive in the sense that unlike most other magnetic bearings that have been developed in recent years, they effect stable magnetic levitation without need for complex active control.

Axial Halbach magnetic bearings were described in "Axial Halbach Magnetic Bearings" (LEW-18066-1), *NASA Tech Briefs*, Vol. 32, No. 7 (July 2008), page 85. In the remainder of this article, the description of the principle of operation from the cited prior article is recapitulated and updated to incorporate the present radial geometry.

In simplest terms, the basic principle of levitation in an axial or radial Halbach magnetic bearing is that of the repulsive electromagnetic force between (1) a moving permanent magnet and (2) an electric current induced in a stationary electrical conductor by the motion of the magnetic field. An axial or radial Halbach bearing includes multiple permanent magnets arranged in a Halbach array ("Halbach array" is defined below) in a rotor and multiple conductors in the form of wire coils in a stator, all arranged so the rotary motion produces an axial or radial repulsion that is sufficient to levitate the rotor.

A basic Halbach array (see Figure 1) consists of a row of permanent magnets, each oriented so that its magnetic field is

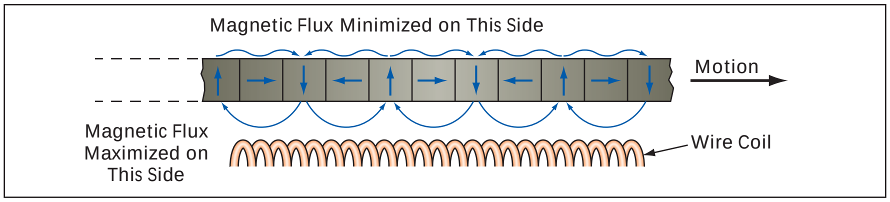

Figure 1. A **Basic Halbach Array** consists of permanent magnets oriented in a sequence of quarter turns chosen to concentrate the magnetic field on one side. The motion of the array along a wire coil gives rise to an electromagnetic repulsion that can be exploited for levitation.

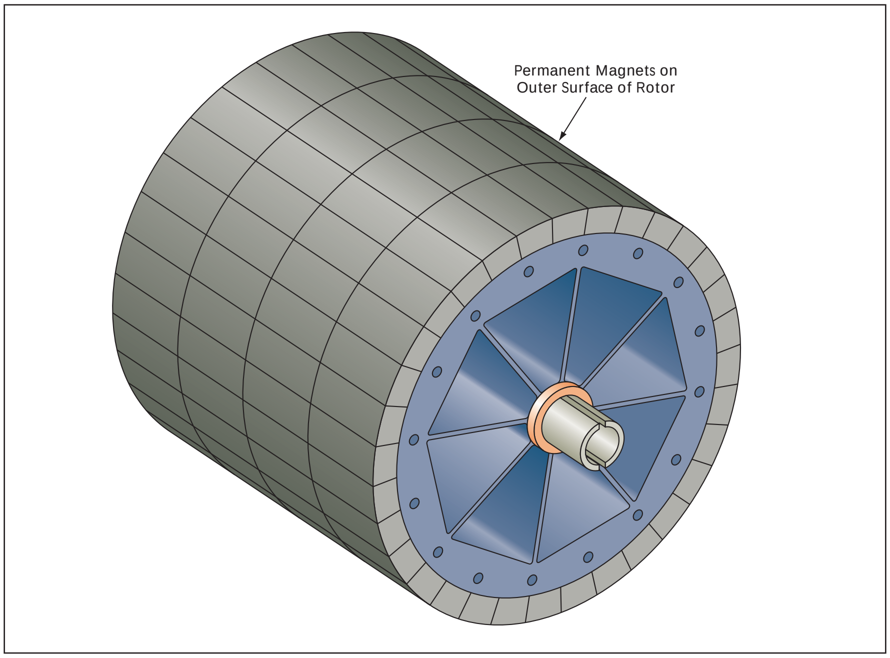

Figure 2. The **Rotor in a Radial Halbach Magnetic Bearing** has an outer layer consisting of a cylindrical version of the Halbach array of Figure 1. The bearing also includes multiple coils in a stator (omitted from this view) surrounding the rotor.

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 sys-