Hybrid Inflatable Pressure Vessel

A bladder that holds pressure is reinforced with fabric straps.

Lyndon B. Johnson Space Center, Houston, Texas

Figure 1 shows a prototype of a large pressure vessel under development for eventual use as a habitable module for long spaceflight (e.g., for transporting humans to Mars). The vessel is a hybrid that comprises an inflatable shell attached to a rigid central structural core. The inflatable shell is, itself, a hybrid that comprises (1) a pressure bladder restrained against expansion by (2) a web of straps made from high-strength polymeric fabrics. On Earth, pressure vessels like this could be used, for example, as portable habitats that could be set up quickly in remote locations, portable hyperbaric chambers for treatment of decompression sickness, or flotation devices for offshore platforms. In addition, some aspects of the design of the fabric straps could be adapted to such other items as lifting straps, parachute straps, and automotive safety belts.

Figure 2 depicts selected aspects of the design of a vessel of this type with a toroidal configuration. The bladder serves as an impermeable layer to keep air within the pressure vessel and, for this purpose, is sealed to the central structural core. The web includes longitudinal and circumferential straps. To help maintain the proper shape upon inflation after storage, longitudinal and circumferential straps are indexed together at several of their intersections. Because the web is not required to provide a pressure seal and the bladder is not required to sustain structural loads, the bladder and the web can be optimized for their respective functions. Thus, the bladder can be sealed directly to the rigid core without having to include the web in the seal substructure, and the web can be designed for strength.

The ends of the longitudinal straps are attached to the ends of the rigid structural core by means of clevises. Each clevis pin is surrounded by a roller, around which a longitudinal strap is wrapped to form a lap seam with itself. The roller is of a large diameter chosen to reduce bending of the fibers in the strap. The roller also serves to equalize the load in the portions of the strap on both sides of the clevis pin. The lap seam is formed near the clevis by use of a tapered diamond stitch: This stitch is designed specifically to allow fibers in the stitch and strap to relax under load in such a manner that the load becomes more nearly evenly distributed among all fibers in the stitch region. Thus, the tapered diamond stitch prevents load concentrations that could cause premature failure of the strap and thereby increases the strength of the strap/structural-core joint. The lap seam can be rated at >90 percent of the strength of the strap material.

The rigid structural core serves partly as an interface for access to the interior of the pressure vessel. The core also serves as a rigid structure for mounting of, and integration with, other equipment to be used in conjunction with the pressure vessel. At each end of the core, there is a pressure bulkhead that can accommodate penetrations for utilities and a hatch for access by personnel. The bulkheads at opposite ends of the core are restrained in their required relative positions by longerons. The core can be completely outfitted with equipment prior to packaging with the inflatable shell. The inflatable shell can be compacted around the rigid structural core for storage and transport and inflated to full size and shape after delivery of the vessel to its destination.

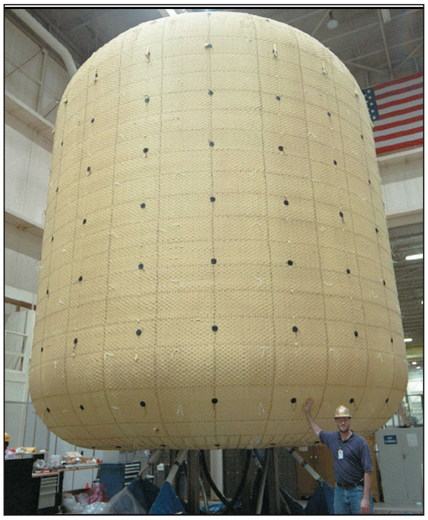

Figure 1. This **Hybrid Inflatable Pressure Vessel** is a lightweight unit that can be stored compactly during transport.

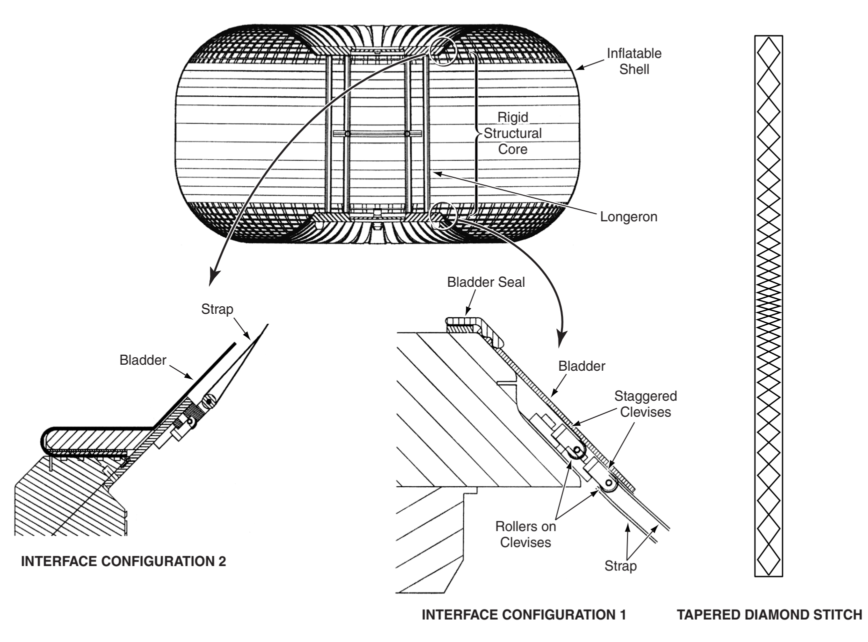

Figure 2. **Several Structural Features** contribute to the effectiveness of the hybrid inflatable pressure vessel.

This work was done by Jasen L. Raboin, Gerard D. Valle, Gregg Edeen, Horacio M. De La Fuente, William C. Schneider, Gary R. Spexarth, and Christopher J. Johnson of **Johnson Space Center** *and Shalini Pandya of Lockheed Martin. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23024/92.

Double-Acting, Locking Carabiners

Lyndon B. Johnson Space Center, Houston, Texas

A proposed design for carabiners (tether hooks used in mountaineering, rock climbing, and rescue) is intended to make it possible to operate these devices even while wearing thick gloves. According to the proposal, the gate of a carabiner would be capable of swinging either toward or away from the hook body, relative to the closed position. The gate would be spring-biased to return to the closed position. An external locking collar would be pinned to an internal locking rod that would be spring-loaded to slide the collar longitudinally over the gate to lock the gate in the closed position. The gate would be unlocked by sliding the collar axially against the spring load. To reduce the probability of inadvertent unlocking, the rod-and-collar mechanism would include two locking buttons. Optionally, the rod-and-collar mechanism could be replaced with an external locking mechanism based on a longer collar.

This work was done by Chi Min Chang and Dominic Li Del Rosso of **Johnson Space Center** *and Gary D. Krch of ILC Dover. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*
MSC-23163

Position Sensor Integral With a Linear Actuator

This sensor adds little to the bulk and weight of the actuator.

Marshall Space Flight Center, Alabama

A noncontact position sensor has been designed for use with a specific two-dimensional linear electromagnetic actuator. To minimize the bulk and weight added by the sensor, the sensor has been made an integral part of the actuator: that is to say, parts of the actuator structure and circuitry are used for sensing as well as for varying position.

The actuator (see Figure 1) includes a C-shaped permanent magnet and an armature that is approximately centered in the magnet gap. The intended function of the actuator is to cause the permanent magnet to translate to, and/or remain at, commanded x and y coordinates, relative to the armature. In addition, some incidental relative motion along the z axis is tolerated but not controlled. The sensor is required to measure the x and y displacements from a nominal central position and to be relatively insensitive to z displacement.

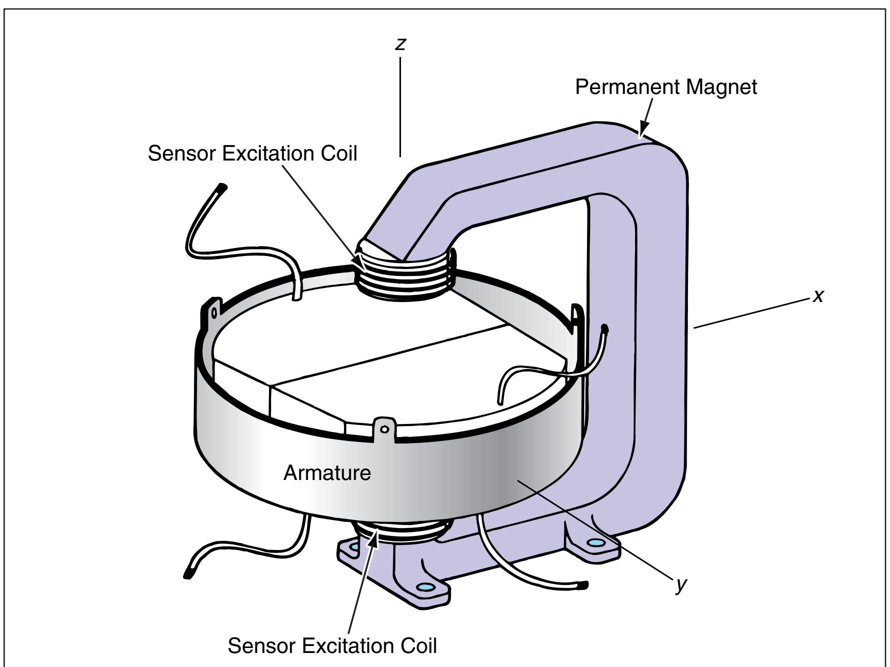

Figure 1. **Sensor Excitation Coils** are the only parts added to the actuator. The electromagnet windings of the actuator are utilized as sensor pickup coils.

The armature contains two sets of electromagnet windings oriented perpendicularly to each other and electrically excited in such a manner as to generate forces in the x,y plane to produce the required motion. Small sensor excitation coils are mounted on the pole tips of the permanent magnet. These coils are excited with a sine wave at a frequency of 20 kHz. This excitation is transformer-coupled to the armature windings. The geometric arrangement of the excitation coils and armature windings is such that the amplitudes of the 20-kHz voltages induced in the armature windings vary nearly linearly with x and y displacements and do not vary significantly with small z displacements. Because the frequency of