Books & Reports

Spool Valve for Switching Air Flows Between Two Beds

U.S. Patent 6,142,151 describes a dual-bed ventilation system for a space suit, with emphasis on a multiport spool valve that switches air flows between two chemical beds that adsorb carbon dioxide and water vapor. The valve is used to alternately make the air flow through one bed while exposing the other bed to the outer-space environment to regenerate that bed through vacuum desorption of CO_2 and H_2O. Oxygen flowing from a supply tank is routed through a pair of periodically switched solenoid valves to drive the spool valve in a reciprocating motion. The spool valve equalizes the pressures of air in the beds and the volumes of air flowing into and out of the beds during the alternations between the adsorption and desorption phases, in such a manner that the volume of air that must be vented to outer space is half of what it would be in the absence of pressure equalization. Oxygen that has been used to actuate the spool valve in its reciprocating motion is released into the ventilation loop to replenish air lost to vacuum during the previous desorption phase of the operating cycle.

This work was done by W. Clark Dean of United Technologies Corp. for **Johnson Space Center**.

Title to this invention, covered by U.S. Patent No. 6,142,151 has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457 (f)}. Inquiries concerning licenses for its commercial development should be addressed to:

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Refer to MSC-23667, volume and number of this NASA Tech Briefs *issue, and the page number.*

Partial Model of Insulator/Insulator Contact Charging

Two papers present a two-phase equilibrium model that partly explains insulator/insulator contact charging. In this model, a vapor of ions within a gas is in equilibrium with a submonolayer of ions of the same species that have been adsorbed on the surface of an insulator. The surface is modeled as having localized states, each with a certain energy of adsorption for an ion. In an earlier version of the model described in the first paper, the ions do not interact with each other. Using the grand canonical ensemble, the chemical potentials of both vapor and absorbed phases are derived and equated to determine the vapor pressure. If a charge is assigned to the vapor particles (in particular, if single ionization is assumed), then the surface charge density associated with adsorbed ions can be calculated as a function of pressure. In a later version of the model presented in the second paper, the submodel of the vapor phase is extended to include electrostatic interactions between vapor ions and adsorbed ones as well as the screening effect, at a given distance from the surface, of ions closer to the surface. Theoretical values of this model closely match preliminary experimental data on the discharge of insulators as a function of pressure.

This work was done by Michael Hogue, C. I. Calle, and C. R. Buhler of **Kennedy Space Center** *and E. R. Mucciolo of the University of Central Florida. Further information is contained in a TSP (see page 1).*
KSC-12722

Asymmetric Electrostatic Radiation Shielding for Spacecraft

A paper describes the types, sources, and adverse effects of energetic-particle radiation in interplanetary space, and explores a concept of using asymmetric electrostatic shielding to reduce the amount of such radiation impinging on spacecraft. Typically, such shielding would include a system of multiple inflatable, electrically conductive spheres deployed in clusters in the vicinity of a spacecraft on lightweight structures that would maintain the spheres in a predetermined multipole geometry. High-voltage generators would maintain the spheres at potential differences chosen in conjunction with the multipole geometry so that the resulting multipole field would gradually divert approaching energetic atomic nuclei from a central region occupied by the spacecraft. The spheres nearest the center would be the most positive, so as to repel the positively charged impinging nuclei from the center. At the same time, the monopole potential of the overall spacecraft-and-shielding system would be made negative so as to repel thermal electrons. The paper presents results of computational simulations of energetic-particle trajectories and shield efficiency for a trial system of 21 spheres arranged in three clusters in an overall linear quadrupole configuration. Further development would be necessary to make this shielding concept practical.

This work was done by Philip T. Metzger and Robert C. Youngquist of **Kennedy Space Center** *and John E. Lane of ASRC Aerospace. Further information is contained in a TSP (see page 1).*

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 Kennedy Innovative Partnerships Office at (321) 867-8130. Refer to KSC-12624.

Reusable Hybrid Propellant Modules for Outer-Space Transport

A report summarizes the concept of reusable hybrid propellant modules (HPMs), which would be used in outer space for long-term cryogenic storage of liquefied spacecraft-propellant gases, including for example, oxygen and hydrogen for combustion-based chemical rocket engines and xenon for electric thrusters. The HPM concept would provide the fundamental building block for an efficient, reusable in-space transportation system for both crewed and uncrewed missions. Each HPM would be equipped to implement an advanced zero-boil-off method of managing cryogenic fluids, and would include a fluid-transfer interface comprising standardized fittings that would be compatible with fittings on all supply facilities and on spacecraft to be supplied. The HPM, combined with a chemical or electric orbital transfer spacecraft, would provide an integrated propulsion system. HPMs would supply chemical propellant for time-critical transfers such as crewed missions, and utilize the more efficient electric-propulsion transfer vehicles to trans-