



### Recirculating 1-K-Pot for Pulse-Tube Cryostats

A paper describes a 1-K-pot that works with a commercial pulse tube cooler for astrophysics instrumentation testbeds that require temperatures <1.7 K. Pumped liquid helium-4 cryostats were commonly used to achieve this temperature. However, liquid helium-4 cryostats are being replaced with cryostats using pulse tube coolers.

The closed-cycle 1K-pot system for the pulse tube cooler requires a heat exchanger on the pulse tube, a flow restriction, pump-out line, and pump system that recirculates helium-4. The heat exchanger pre-cools and liquefies helium-4 gas at the 2.5 to 3.5 K pulse tube cold head.

This closed-cycle 1-K-pot system was designed to work with commercially available laboratory pulse tube coolers. It was built using common laboratory equipment such as stainless steel tubing and a mechanical pump. The system is self-contained and requires only common wall power to operate. The lift of 15 mW at 1.1 K and base temperature of 0.97 K are provided continuously. The system can be scaled to higher heat lifts of  $\approx 30$  to 50 mW if desired.

Ground-based telescopes could use this innovation to improve the efficiency of existing cryogenic systems or as a basis of new systems.

*This work was done by Christopher G. Paine, Bret J. Naylor, and Thomas Prouve of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48355*

### Method for Processing Lunar Regolith Using Microwaves

A paper describes a method of using microwave heating experiments on lunar simulants to determine the mechanism that causes lunar regolith to be such an excellent microwave absorber. The experiments initially compared the effects of sharp particle edges to round particle edges on the heating curves. For most compositions, sharp particle edged sam-

ples were more effective in being heated by microwaves than round particle edged materials. However, the experiments also showed an unexpected effect for both types of particles. Upon heating the sample surface above 400 °C, the sample experienced some sort of internal structure change that caused it to heat much more efficiently. This enhancement may be associated with the unique microwave volumetric heating that can produce a large temperature gradient within the sample leading to melting of some components at the center of the sample. This new effect that may also be happening in lunar regolith samples is probably the cause of the previously observed enhanced heating of a sample of lunar regolith. Properly designed microwave applicators could heat and solidify the lunar regolith to form roads and building blocks for structures needed on the Moon.

*This work was done by Martin B. Barmatz and David E. Steinfeld of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48895.*

### Wells for *In Situ* Extraction of Volatiles from Regolith (WIEVR)

A document discusses WIEVRs, a means to extract water ice more efficiently than previous approaches. This water may exist in subsurface deposits on the Moon, in many NEOs (Near-Earth Objects), and on Mars. The WIEVR approach utilizes heat from the Sun to vaporize subsurface ice; the water (or other volatile) vapor is transported to a surface collection vessel where it is condensed (and collected). The method does not involve mining and extracting regolith before removing the frozen volatiles, so it uses less energy and is less costly than approaches that require mining of regolith.

The only drilling required for establishing the WIEVR collection/recovery system is a well-bore drill hole. In its simplest form, the WIEVRs will function without pumps, compressors, or other gas-moving equipment, relying instead on diffusive transport and thermally induced convec-

tion of the vaporized volatiles for transport to the collection location(s). These volatile extraction wells could represent a significant advance in extraction efficiency for recovery of frozen volatiles in subsurface deposits on the Moon, Mars, or other extraterrestrial bodies.

*This work was done by Otis R. Walton of Grainflow Dynamics Inc. for 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: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-19017-1.*

### Estimating the Backup Reaction Wheel Orientation Using Reaction Wheel Spin Rates Flight Telemetry from a Spacecraft

A report describes a model that estimates the orientation of the backup reaction wheel using the reaction wheel spin rates telemetry from a spacecraft. Attitude control via the reaction wheel assembly (RWA) onboard a spacecraft uses three reaction wheels (one wheel per axis) and a backup to accommodate any wheel degradation throughout the course of the mission. The spacecraft dynamics prediction depends upon the correct knowledge of the reaction wheel orientations. Thus, it is vital to determine the actual orientation of the reaction wheels such that the correct spacecraft dynamics can be predicted.

The conservation of angular momentum is used to estimate the orientation of the backup reaction wheel from the prime and backup reaction wheel spin rates data. The method is applied in estimating the orientation of the backup wheel onboard the Cassini spacecraft. The flight telemetry from the March 2011 prime and backup RWA swap activity on Cassini is used to obtain the best estimate for the backup reaction wheel orientation.

*This work was done by Farheen Rizvi of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48350*