# Physical Sciences

## Passive Vaporizing Heat Sink

*Lyndon B. Johnson Space Center, Houston, Texas*

A passive vaporizing heat sink has been developed as a relatively lightweight, compact alternative to related prior heat sinks based, variously, on evaporation of sprayed liquids or on sublimation of solids. This heat sink is designed for short-term dissipation of a large amount of heat and was originally intended for use in regulating the temperature of spacecraft equipment during launch or re-entry. It could also be useful in a terrestrial setting in which there is a requirement for a lightweight, compact means of short-term cooling. This heat sink includes a hermetic package closed with a pressure-relief valve and containing an expendable and rechargeable coolant liquid (e.g., water) and a conductive carbon-fiber wick. The vapor of the liquid escapes when the temperature exceeds the boiling point corresponding to the vapor pressure determined by the setting of the pressure-relief valve. The great advantage of this heat sink over a melting-paraffin or similar phase-change heat sink of equal capacity is that by virtue of the ≈10× greater latent heat of vaporization, a coolant-liquid volume equal to ≈1/10 of the paraffin volume can suffice.

*This work was done by Timothy R. Knowles, Victor A. Ashford, Michael G. Carpenter, and Thomas M. Bier of Energy Science Laboratories, Inc., for Johnson Space Center. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-23414-1*

## Remote Sensing and Quantization of Analog Sensors

**This technique has applications in automotive ride and steering sensors, and in industrial vibration and process monitors.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

This method enables sensing and quantization of analog strain gauges. By manufacturing a piezoelectric sensor stack in parallel (physical) with a piezoelectric actuator stack, the capacitance of the sensor stack varies in exact proportion to the exertion applied by the actuator stack. This, in turn, varies the output frequency of the local sensor oscillator. The output, $F_{out}$, is fed to a phase detector, which is driven by a stable reference, $F_{ref}$.

The output of the phase detector is a square waveform, $D_{out}$, whose duty cycle, $t_W$, varies in exact proportion according to whether $F_{out}$ is higher or lower than $F_{ref}$. In this design, should $F_{out}$ be precisely equal to $F_{ref}$, then the waveform has an exact 50/50 duty cycle.

The waveform, $D_{out}$, is of generally very low frequency suitable for safe transmission over long distances without corruption. The active portion of the waveform, $t_W$, gates a remotely located counter, which is driven by a stable oscillator (source) of such frequency as to give sufficient digitization of $t_W$ to the resolution required by the application.

The advantage to this scheme is that it negates the most-common, present method of sending either very low level signals (viz. direct output from the sensors) across great distances (anything over one-half meter) or the need to transmit widely varying higher frequencies over significant distances thereby eliminating interference [both in terms of beat frequency generation and *in-situ* EMI (electromagnetic interference)] caused by ineffective shielding. It also results in a significant reduction in shielding mass.

*This work was done by Karl F. Strauss of Caltech for NASA's Jet Propulsion Laboratory.*

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## Phase Retrieval for Radio Telescope and Antenna Control

*Goddard Space Flight Center, Greenbelt, Maryland*

Phase-retrieval is a general term used in optics to describe the estimation of optical imperfections or "aberrations." The purpose of this innovation is to develop the application of phase retrieval to radio telescope and antenna control in the millimeter wave band.

Earlier techniques do not approximate the incoherent subtraction process as a coherent propagation. This approximation reduces the noise in the data and allows a straightforward application of conventional phase retrieval techniques for radio telescope and antenna control.

The application of iterative-transform phase retrieval to radio telescope and antenna control is made by approximating the incoherent subtraction process as a coherent propagation. Thus, for systems utilizing both positive and negative polarity feeds, this approximation allows both surface and alignment errors to be assessed without the use of additional hardware or laser metrology. Knowledge of the antenna surface profile allows errors to be corrected at a given surface temperature and observing angle. In addition to imperfections of the antenna surface figure, the misalignment of multiple antennas operating in unison can reduce or degrade the signal-to-noise ratio of the received or broadcast signals. This technique also has application to the alignment of antenna array configurations.

*This work was done by Bruce Dean of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15977-1*

# Helium-Cooled Black Shroud for Subscale Cryogenic Testing

## A sheet metal and honeycomb design allows a space-like thermal environment to be maintained around a test item.

*Goddard Space Flight Center, Greenbelt, Maryland*

This shroud provides a deep-space simulating environment for testing scaled-down models of passively cooling systems for spaceflight optics and instruments. It is used inside a liquid-nitrogen-cooled vacuum chamber, and it is cooled by liquid helium to 5 K. It has an inside geometry of approximately 1.6 m diameter by 0.45 m tall. The inside surfaces of its top and sidewalls have a thermal absorptivity greater than 0.96. The bottom wall has a large central opening that is easily customized to allow a specific test item to extend through it. This enables testing of scale models of realistic passive cooling configurations that feature a very large temperature drop between the deep-space-facing cooled side and the Sun/Earth-facing warm side.

This shroud has an innovative thermal closeout of the bottom wall, so that a test sample can have a hot (room temperature) side outside of the shroud, and a cold side inside the shroud. The combination of this closeout and the very black walls keeps radiated heat from the sample's warm end from entering the shroud, reflecting off the walls and heating the sample's cold end.

The shroud includes 12 vertical rectangular sheet-copper side panels that are oriented in a circular pattern. Using tabs bent off from their edges, these side panels are bolted to each other and to a steel support ring on which they rest. The removable shroud top is a large copper sheet that rests on, and is bolted to, the support ring when the shroud is closed. The support ring stands on four fiberglass tube legs, which isolate it thermally from the vacuum chamber bottom. The insides of the cooper top and side panels are completely covered with 25-mm-thick aluminum honeycomb panels. This honeycomb is painted black before it is epoxied to the copper surfaces. A spiral-shaped copper tube, clamped at many different locations to the outside of the top copper plate, serves as part of the liquid helium cooling loop.

Another copper tube, plumbed in a series to the top plate's tube, is clamped to the sidewall tabs where they are bolted to the support ring. Flowing liquid helium through these tubes cools the entire shroud to 5 K. The entire shroud is wrapped loosely in a layer of double-aluminized Kapton. The support ring's inner diameter is the largest possible hole through which the test item can extend into the shroud.

Twelve custom-sized trapezoidal copper sheets extend inward from the support ring to within a few millimeters of the test item. Attached to the inner edge of each of these sheets is a custom-shaped strip of Kapton, which is aluminum-coated on the warm-facing (outer) side, and has thin Dacron netting attached to its cold-facing side. This Kapton rests against the test item, but the Dacron keeps it from making significant thermal contact. The result is a non-contact, radiatively reflective thermal closeout with essentially no gap through which radiation can pass. In this way, the part of the test item outside the shroud can be heated to relatively high temperatures without any radiative heat leaking to the inside.

*This work was done by James Tuttle, Michael Jackson, Michael DiPirro, and John Francis for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15968-1*