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Thermal Control Surfaces Experiment (S0069)

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Background

The optical properties of thermal control surfaces in the solar region of the spectrum are of primary interest to spacecraft thermal designers since these properties govern the solar-heat input to exposed surfaces (such as the thermal radiators) and therefore influence the temperature of the spacecraft. These properties, however, have been shown to be altered considerably under the space environment, which includes solar irradiation, thermal vacuum, micrometeoroid bombardment, and contamination. One such mechanism of solar ultraviolet degradation is caused by photodesorption of oxygen, which is immediately and completely reversible upon exposure to a very small amount of oxygen (10^{-4} to 10^{-6} torr partial pressure). This type of bleaching mechanism shows the necessity of *in situ* measurements of the optical properties of environmentally damaged surfaces (i.e., in vacuum before repressurization).

Until now, no optical measurements of thermal control surfaces have been made in space. Temperature measurements of thermally isolated samples have been used to back-calculate solar absorptance and thermal emittance. This type of measurement is not as definitive as required and does not describe the spectral character of the sample surface. Spectral reflectance measurements of the samples are required to differentiate between different damage mechanisms of environmental effects and to separate contamination effects.

Additionally, because of the inability to simulate exactly the conditions of the coating surface temperature and the solar spectrum, there is a major difference between laboratory test data and in-flight experiment data. Although the current generation of laboratory test apparatus is extremely complex and well thought out, it provides only relative data on the degradation of coatings in actual space conditions. The only accepted test for flight qualification of new coatings is to have them evaluated in actual conditions of space flight in the space environment where they will be used.

Objectives

The objectives of this experiment are to determine the effects of the near-Earth orbital environment and the Shuttle-induced environment on spacecraft thermal control surfaces. Spectral reflectance measurements will be obtained and used to differentiate between different solid-state damage mechanisms of environmental damage, to separate the effects of contamination from those of natural-environmental damage, and for comparison and correlation with laboratory test data.

Approach

The experiment is designed to measure certain physical properties of 25 "active" spacecraft thermal surface samples in an environment that approximates their normal use. The parameters to be measured include the hemispherical reflectance as a function of wavelength (100 wavelength steps from 0.25 to 2.5 μm) and the temperature of these samples as a function of time in a calorimeter configuration. The latter measurements will be made in two different physical configurations that allow calculation of the emittance and the ratio of solar absorption to emittance for each sample. In addition, 24 passive samples will be exposed to approximately the same environment as the active samples.

Figure 26 shows a simplified block diagram of the experiment, figure 27 shows the experiment layout in a 12-in.-deep tray, and figure 28 is a photograph of the flight hardware. The active samples are contained in calorimeter assemblies and are mounted along with the passive samples on the carousel. In addition, three radiometers (solar and Earth albedo, Earth albedo, and earthshine) are also mounted on the carousel. The radiometers are used to measure the radiant energy incident upon the samples, which is required for calculating the ratio of absorption to emittance, and to provide a record of the total exposure of the samples to the solar ultraviolet.

The carousel has two fixed positions, referred to as in IN, or protected, and OUT, or exposed. The OUT position exposes the samples to the environment. The samples are in this position approximately 23½ hours for every Earth day, including the 1½-hour period each day when temperature and radiometer measurements are being recorded to determine the ratio of absorption to emittance. The carousel is rotated 180° from the OUT position to the IN position for the emittance measurements for approximately ½ hour each day. For these measurements, the samples view a massive heat sink (aluminum "emittance" plate) which maintains a relatively constant temperature, and temperature change as a function of time is recorded for each sample.

The IN, or stowed, position also places the samples and radiometers in a protected enclosure for launch and reentry. This position is also maintained for 10 days after launch to allow volatiles to outgas prior to starting experimental operations.

The reflectometer assembly includes an integrating sphere, which is located at the bottom of the carousel assembly. The carousel is rotated by a stepping motor through a geneva drive mechanism to position each of the 25 active samples in the integrating sphere aperture, where sample reflectance can be measured. Each sample will be measured 20 times during the LDEF mission, nominally once per month with measurements slightly more often near the beginning of the mission.

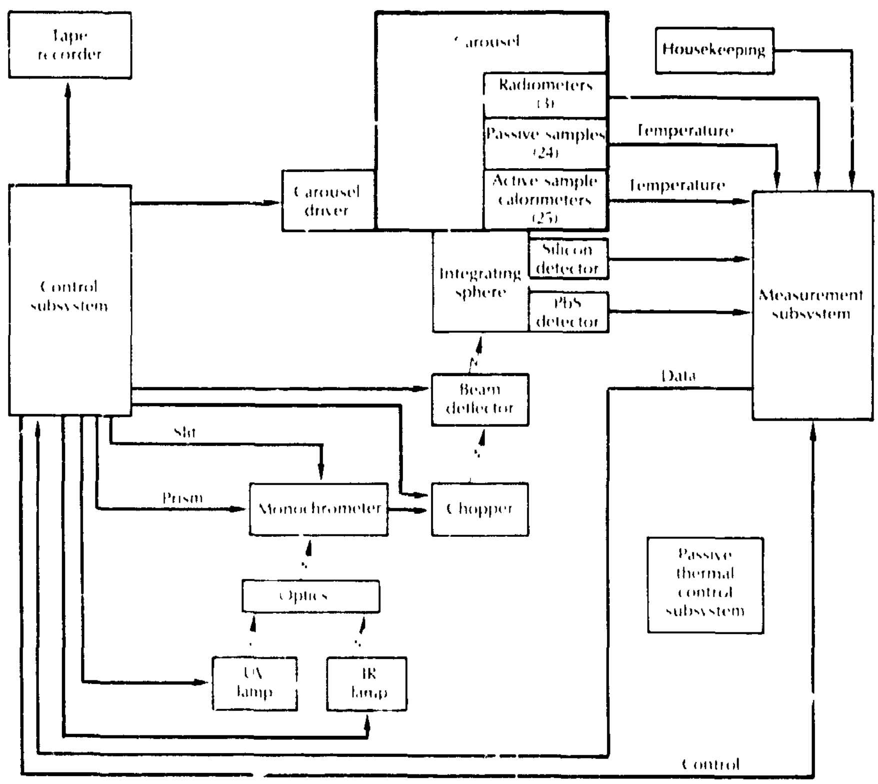

Figure 26.—Simplified block diagram of thermal control surfaces experiment.

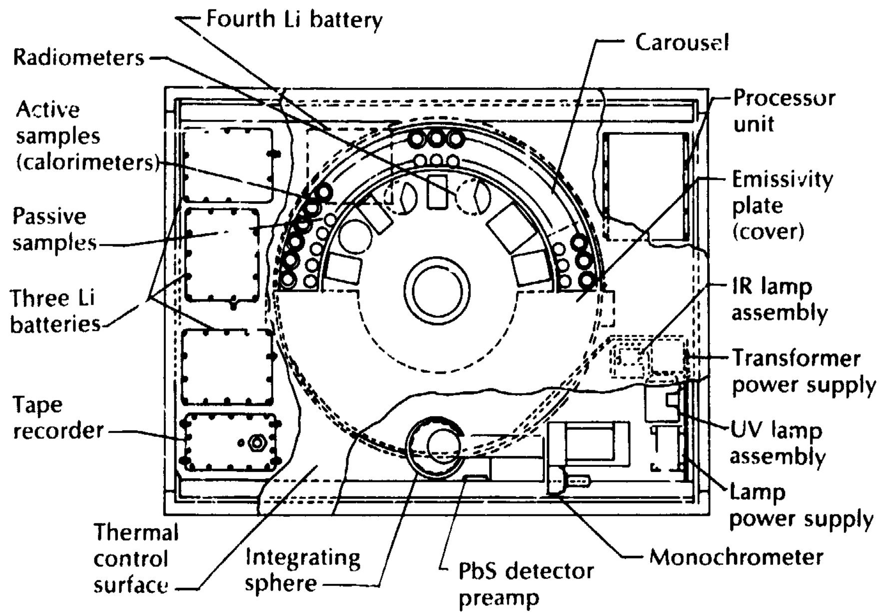

Figure 27.—Thermal control surfaces experiment layout showing location of components.

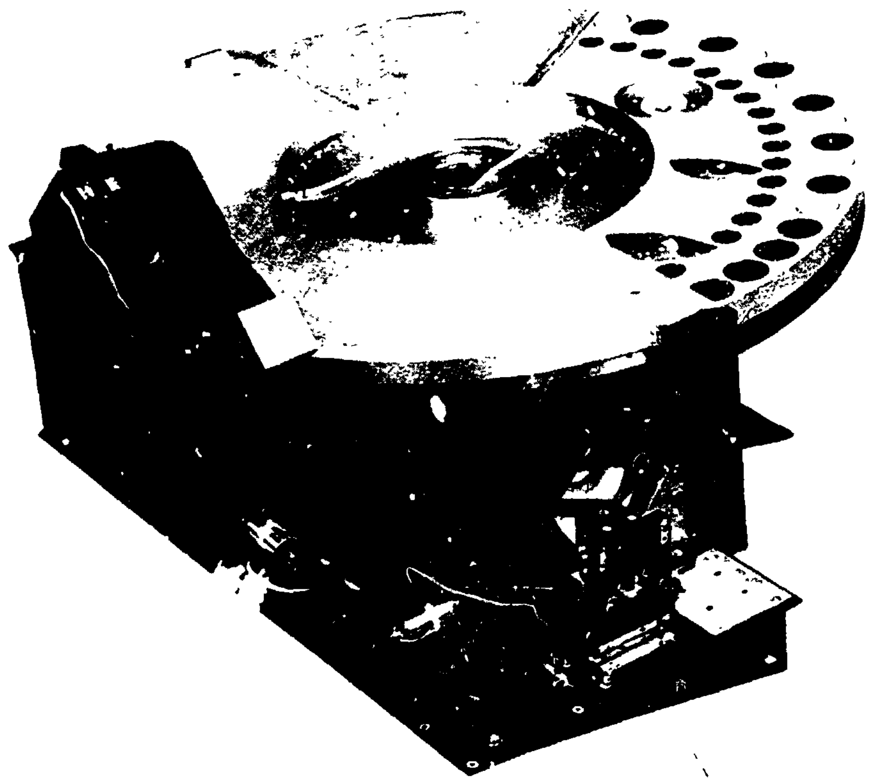

Figure 28.—Photograph of carousel showing samples.