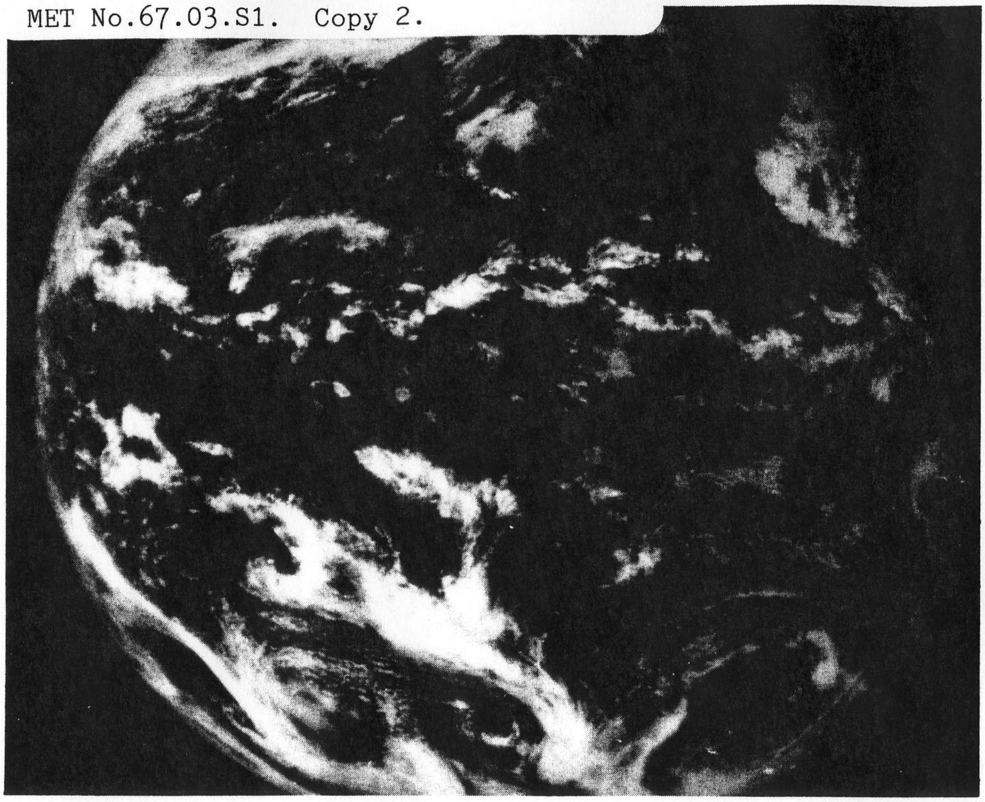

Studies in Atmospheric Energetics Based on Aerospace Probings

Annual Report-1966

Department of Meteorology,
The University of Wisconsin
MARCH, 1967

THE PROTOTYPE FLAT-PLATE RADIOMETERS
FOR THE ESSA III SATELLITE

by

David F. Nelson and Robert Parent

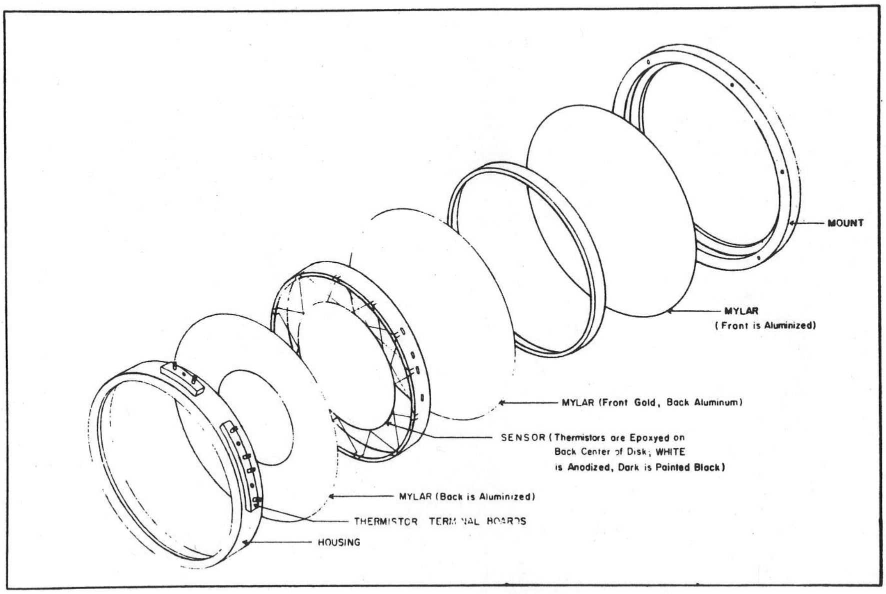

Fig. 1. Expanded view of the basic radiometer components.

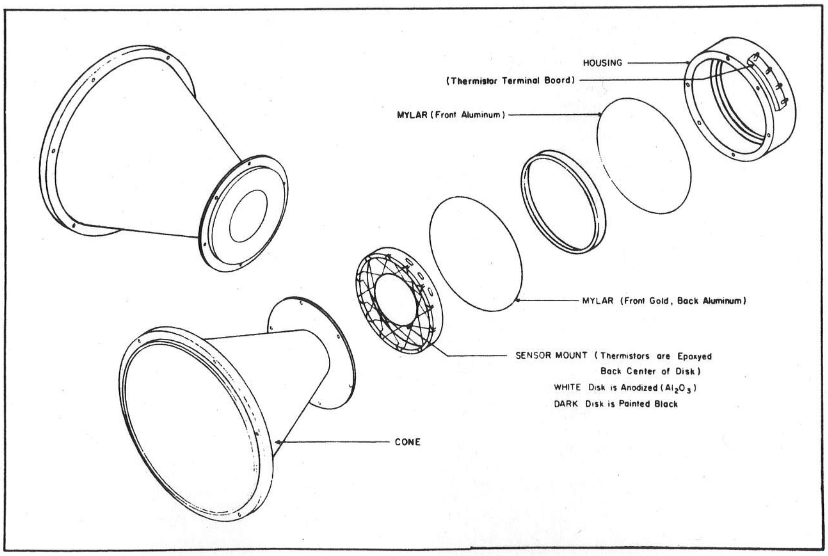

Fig. 2. Expanded view of the radiometer with cone optics.

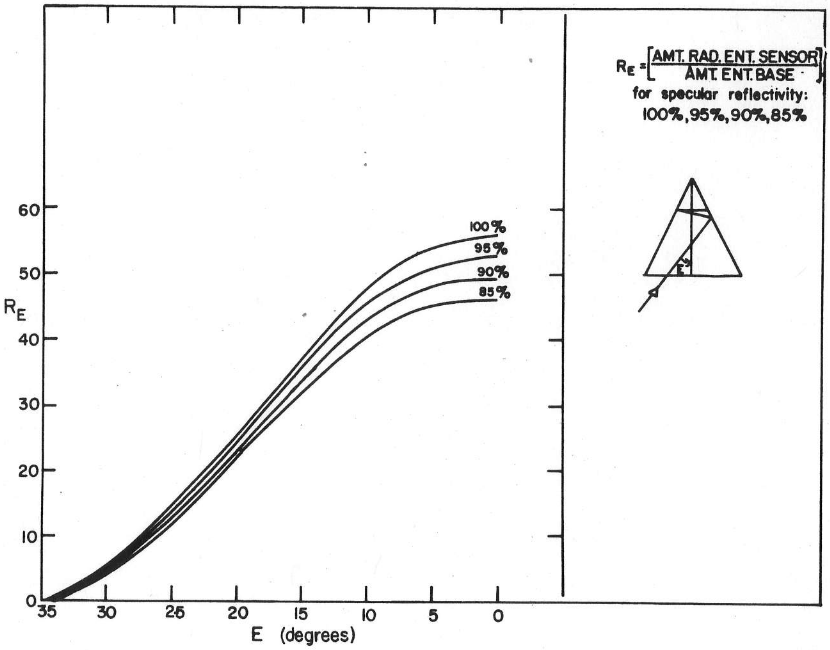

Fig. 3. Relative response (R_E) of the radiometer with cone optics as a function of angle (E) from the normal.

the disc temperature is measured. Constantan wire, 0.002 inch in diameter, connects the thermistors with the terminals on the side of the housing. Constantan wire is used because of its low thermal conductivity. An aluminized mylar baffle is used in front of the disc to prevent radiation from entering the housing where it would be reflected off the inside of the housing and strike the back side of the disc. This baffle is spaced 1/32 inch in front of the disc and has a hole slightly smaller than the disc. A thermistor is attached to the outer surface of the housing to provide an indication of its temperature.

2.3 Flat Plate with Cone Optics

A cone has been added to the basic flat plate radiometer to restrict its field of view. The construction of the sensor is shown in Figure 2. The radiometer disc in this sensor is one inch in diameter and the cone half angle is 20°. The cone surface is a highly reflecting aluminum coating evaporated onto glyptal varnish.

The relative response (R_E) of this sensor vs angle (E) from the normal appears in Figure 3.

Reference to Figures 4 and 5 shows that for N = 0° the sun will be excluded from the sensor or for the entire year if the spacecraft is launched into an orbit with its ascending node at 1500 hours or later. If the spacecraft is in an earlier orbit the direct solar illumination will vary with the time of the year.

2.4 Spectral Response

Two spectral response characteristics are employed in each sensor. They are classified by the appearance of the disc, specifically "black" and "white."

2.4.1 Black Sensors—The black sensor disc is 0.5 mil. aluminum treated on one side with irradite and painted with a Mautz 9300S black paint to give a black matte surface. The total thickness after painting is approximately 5 mils.

The paint produces a surface with reasonably high absorptivity from the visible wavelengths to beyond 25 microns. The absorptivity of this paint is given in Table 1, based on data obtained in a Hohlraum. The accuracy is ± 2 percent. The black sensor thus responds to the sum of the direct solar, reflected solar, and long wave radiation from earth.

2.4.2 White Sensors—The white discs are made from 99.99% pure aluminum which is electro-polished to produce a highly reflecting surface. It is then anodized on one side to produce a .5 mil. coating of aluminum oxide, (Al_2O_3).

This oxide has an absorptivity of about 20 percent in the visible, but becomes similar to black paint in its infrared absorbing properties beyond 7 microns. Therefore, the white sensor absorbs most of the long wave radiation from the earth, but reflects much of the solar radiation incident on it.

2.5 Sensor/Spacecraft Interface

The TOS Spacecraft is spin stabilized in the wheel mode. A single sensor mounted with its axis perpendicular to the spin axis will scan the earth once per revolution. The temperature of a single sensor would be modulated at the spin frequency; however, to reduce the effect of this modulation, two sensors of each type are used. The two sensors of a pair are mounted 180° apart on the spacecraft base plate and combined electrically in series to act as one sensor. This reduces modulation due to spin. In addition, the time constant of the sensors (which is about one minute) an order of magnitude greater than the period of satellite revolution. This also reduces modulation of the sensors due to spin.

Four sensors (one of each type) are mounted to a common panel and two such panels are mounted 180° apart, facing outwards, along the spacecraft base plate. The axis of each sensor is perpendicular to the spacecraft spin axis. The panels are thermally isolated from the spacecraft by Kel-F-blocks and an

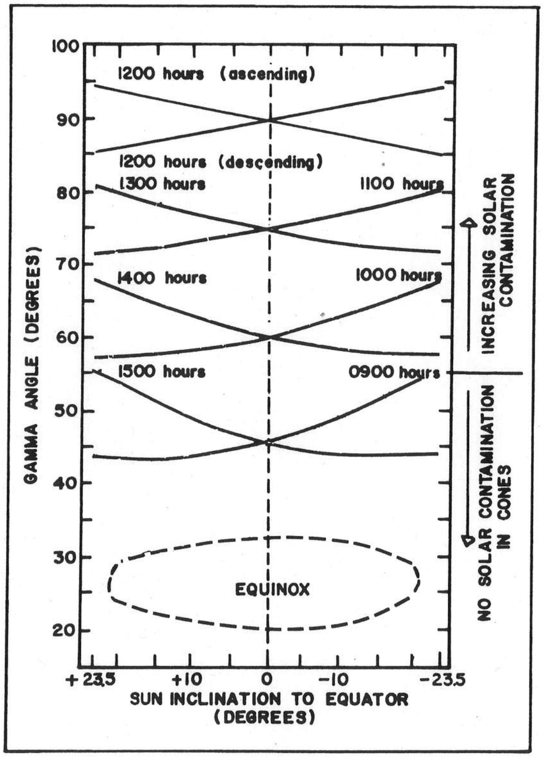

Fig. 4. Seasonal variations of gamma angle (sun angle) for different nodal crossings.

aluminized mylar radiation blanket. The panel is coated with mylar aluminized on the back side to make black surface in the infrared but reflecting in the visible. These techniques are used to radiation cool the sensor mounts to as low temperature as possible to reduce heat transfer to the sensor discs. The temperature of the mounts is monitored at three points on the back of the panel. Photographs of the sensor array appears in Figures 6, 7 and 8.

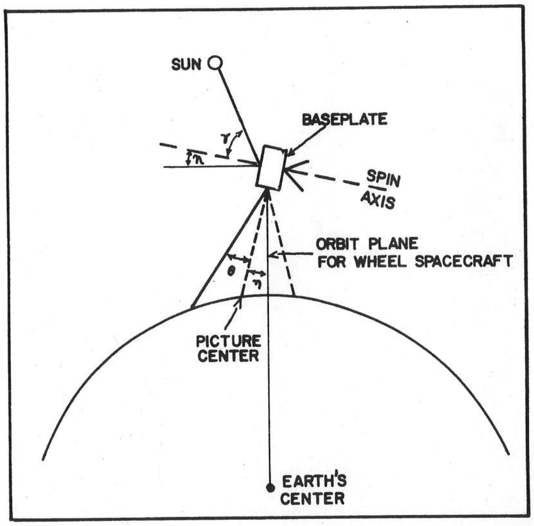

Fig. 5. Definitions of gamma angle and angles used to describe camera coverage.

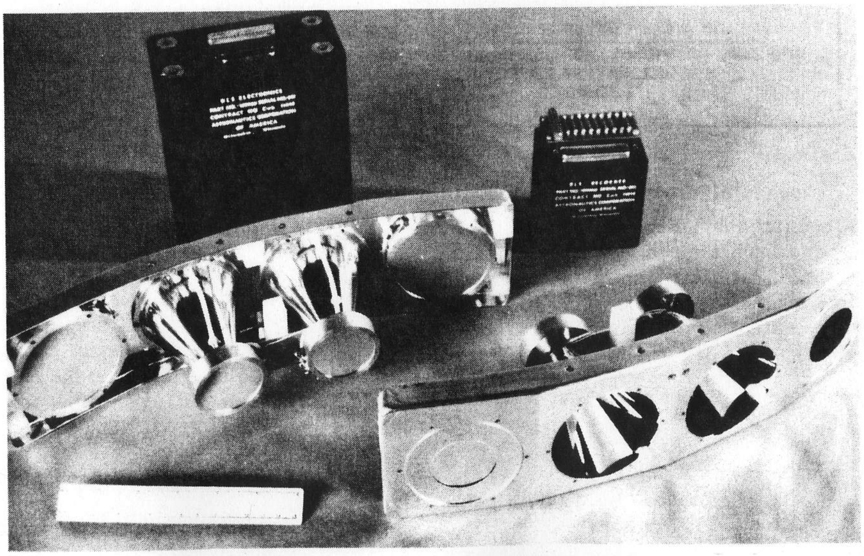

Fig. 6. Radiometers with recorder and electronics packages.

TABLE 1.

Absorptivity of Flat Black Paint, Mautz 9300S

Wavelength (microns)	Absorptivity (%)	Wavelength (microns)	Absorptivity (%)
.5	.915	8.2	.94
.75	.91	8.6	.94
1.0	.92	8.9	.93
1.9	.94	9.3	.92
2.4	.95	9.8	.94
2.8	.94	10.3	.94
3.4	.96	10.8	.95
3.8	.95	11.5	.95
4.0	.95	12.2	.94
4.5	.94	12.9	.94
4.8	.96	13.9	.88
5.1	.95	15.0	.92
5.4	.95	16.0	.91
5.7	.95	17.0	.91
5.9	.95	18.0	.90
6.2	.96	19.0	.90
6.5	.95	20.0	.91
6.7	.95	21.0	.86
7.0	.94	22.0	.87
7.3	.94	23.0	.89
7.6	.94	24.0	.89
7.9	.94	25.0	.85

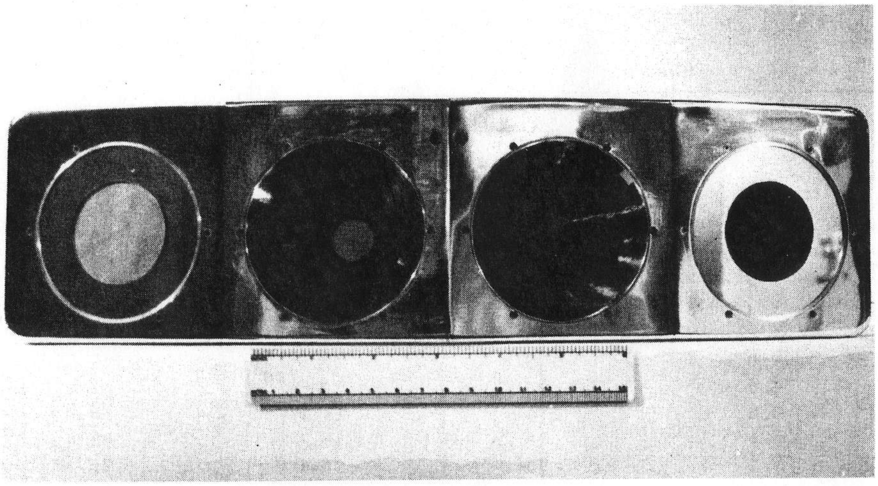

Fig. 7. Front view of the radiometer array.

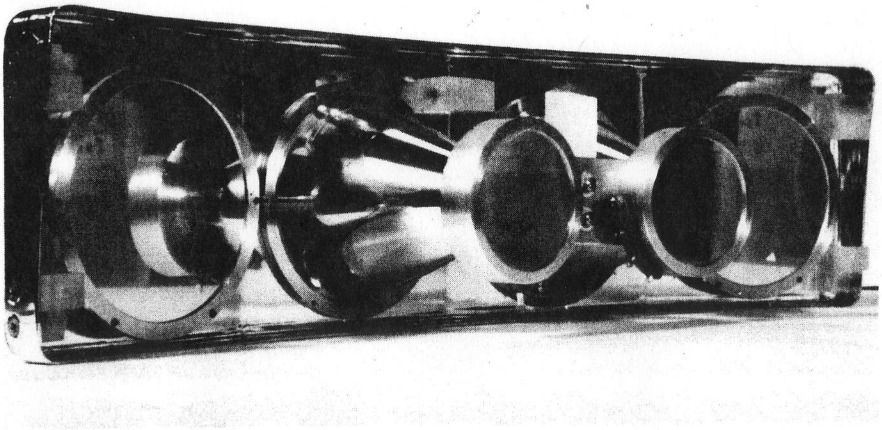

Fig. 8. Back view of the radiometer array.