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RESULTS FROM THE IMP-J VIOLET SOLAR CELL EXPERIMENT AND VIOLET CELL BALLOON FLIGHTS

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ABSTRACT

The IMP-J violet solar cell experiment was flown in an orbit with mild thermal cycling and low hard particle radiation. The results of the experiment show that violet cells degrade at about the same rate as conventional cells in such an orbit. Balloon flight measurements show that violet solar cells produce approximately 20% more power than conventional cells.

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RESULTS FROM THE IMP-J VIOLET SOLAR CELL EXPERIMENT AND VIOLET CELL BALLOON FLIGHTS

INTRODUCTION

Lindmayer and Allison publicly introduced the COMSAT violet solar cell in 1972.[1] This cell represented a considerable improvement in solar cell technology, producing at least twenty percent more power than conventional or state of the art cells available at that time.[2] The violet cell achieved this performance through the use of a very shallow junction, an improved anti-reflection coating and a superior contact geometry.

This report compares the flight performance of violet cells to typical conventional cells available for space flight use in 1972. The conventional cells used for this purpose were those specified for the solar array for the Explorer 50 Spacecraft, otherwise known as Interplanetary Monitoring Platform-J (IMP-J). These cells had an efficiency of 11.0% after final assembly onto the array producing 31.7 milliampere/cm^2 at 0.470 volt at 25°C.

THE VIOLET CELL PANEL ON IMP-J

The violet cell panel is one of forty-eight solar panels making up the solar array for the IMP-J spacecraft, Figure 1. It is a technology experiment flown as part of the satellite's power system. As a result, it was made as similar as practicable to the other forty-seven solar panels on the satellite.

The violet cell panel used 204 - 2cm × 2cm × .028cm COMSAT violet cells with three in parallel by sixty-eight in series. Each cell is covered with .15mm thick ceria doped coverglasses. The other panels each have sixty-eight 2cm × 6cm × .036cm conventional solar cells in series with each cell covered by .15mm thick Dow Corning 7940 coverglasses with AR coating and 410 μm cutoff filters. All panels use Sylgard 186 as a cell adhesive and Sylgard 182 as a coverglass adhesive. The cells are mounted on substrates of aluminum honeycomb with aluminum face sheets.

SPACE FLIGHT RESULTS

During spaceflight operation, the panels are biased at 28V ± 0.5V. There is a .9V drop across the panel's harness and diodes. Therefore, each cell string operates at 28.9V ± .5V. Since there are sixty-eight series cells, each cell operates at .425V ± .007V. The current produced by the violet cell panel and the current of an adjacent conventional cell panel, chosen as being typical, are monitored by special circuitry. The results of these measurements, corrected for variation

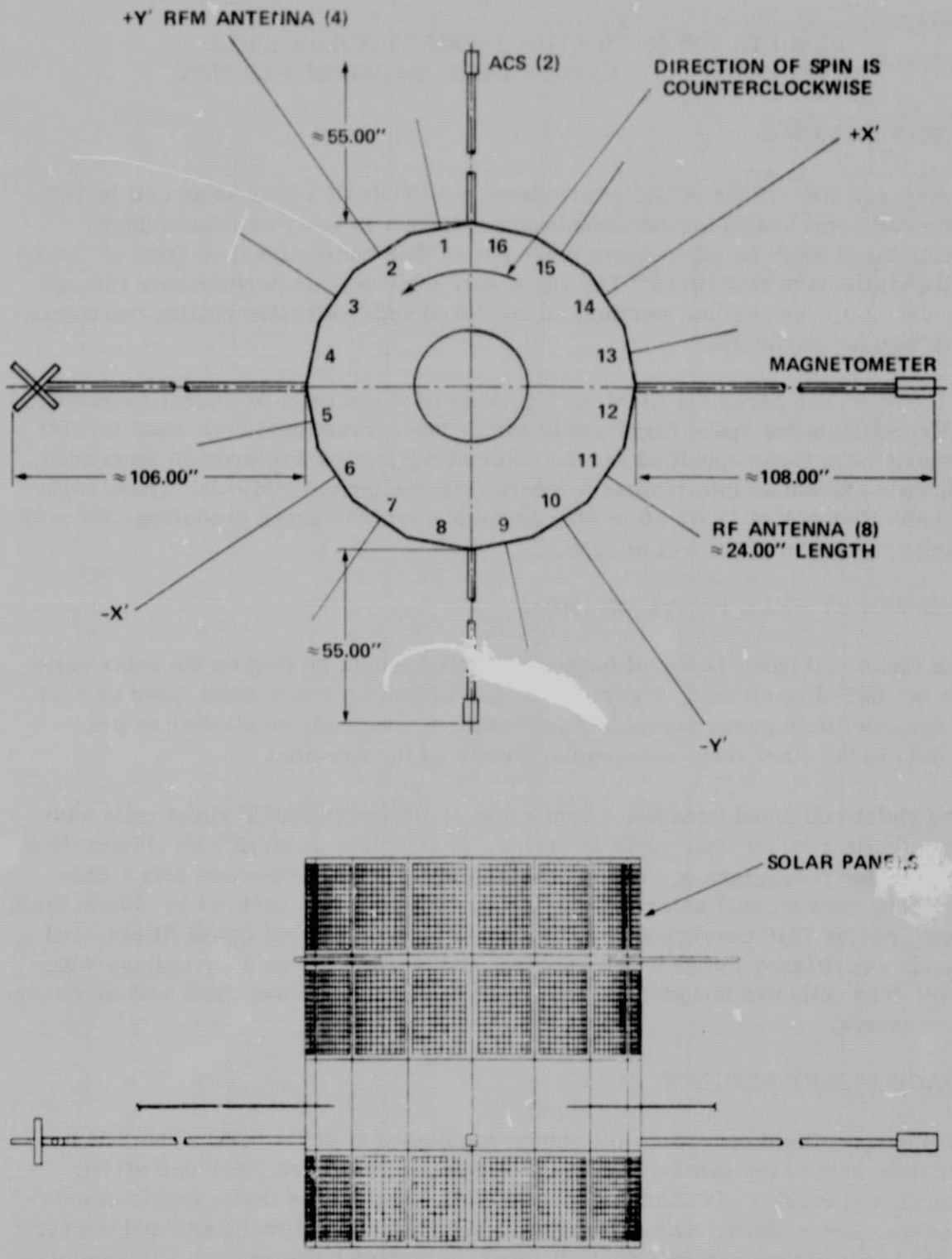

Figure 1. The IMP-J Spacecraft

in the earth sun distance are presented in Table I. All measurements were taken with the sunline normal to each panel at a temperature of 12°C ± 3°C.

Several comments should be made about the results in Table I. The degradation shown results primarily from solar flare protons and perhaps from ultraviolet light. Practically all other sources of degradation are absent by virtue of the IMP-J's orbit. Since the orbit does not traverse the Van Allen belts, there is no damage due to trapped protons or electrons. Additionally, the thermal cycling of the panels is very light and this source of degradation is also virtually eliminated.

Table I

Degradation of Violet Cell Current vs. Conventional Cell Current
All measurements at 12°C

Days After Launch*	Reference (Conventional) Panel		Violet Cell Panel	
	Current in Amperes	Percent Degradation	Current in Amperes	Percent Degradation
Pre-Launch Ground Measurement	0.392	+1.6%	0.459	+4.1%
4**	0.386	0.0%	0.441	0.0%
128	0.373	-3.4%	0.428	-2.9%
280	0.371	-3.9%	0.426	-3.4%
392	0.370	-4.1%	0.424	-3.9%

* Launch took place on October 25, 1973.
** Fourth day measurement taken as zero.

Another comment about the data in Table I concerns the ground predictions of the flight results. In the case of both panels an error was made in calibrating the telemetry to the current through the panel. Unfortunately, the exact magnitude of the error cannot be determined. It follows that the magnitude of the current produced by the panels is not known. Only the percent degradation figures are accurate. However, results from the balloon flight measurements, described below, show that the ground measurements actually underestimated rather than overestimated the current producing capability of the panels.

BALLOON FLIGHT RESULTS

In addition to the spacecraft flight results described above, three violet cells and two commercial cells were flown by J. P. L. on a balloon flight. The violet cells flown on the balloon were randomly selected from the same batch of cells used for the IMP-J panel. The conventional cells flown on the balloon were selected from cells typical of those used on the IMP-J commercial panels.

The balloon flight results are shown in table II. As can be seen there is good correlation between the ground measurements and the flight readings. However, in all cases the flight measurement is approximately 1.5% higher than the ground measurements.

DISCUSSION

The ground measurements and subsequent predictions for the balloon cells and the spacecraft panels were made using the same solar simulator. Since the balloon flight measurements were 1.5% higher than the ground predictions, we conclude that both panels should produce about 1.5% more short circuit current than predicted from ground measurements.

Using this conclusion and observing the current-voltage curves obtained under the simulator for both the violet cell panel and conventional cell panels, Figure 2, we make the extrapolation that violet cells produce approximately 20% more peak power than conventional cells at 25°C. The percentage is obtained from Figure 2 merely by noting that 14.4W is 20% greater than 12.0W. The estimate that both panels have flight short circuit currents some 1.5% higher than that shown by Figure 2 does not, of course, affect the comparison.

CONCLUSION

The IMP-J flight results demonstrate that violet cells degrade at just about the same rate as conventional cells in the space enviroment.

Violet cells generate approximately 20% more power than conventional cells available in 1972.

Table II

Results of Balloon Flight Measurements

Cell Number	Cell Type	Flight Date	GSFC Pulsed Xenon Measurements			Flight Results	
			Reading* (mV)	Temp.† (°C)	% Dev. From Flight Reading	Reading* (mV)	Temp. (°C)
73-011A	Violet	February 2, 1974	78.3	51	-1.16	79.22	45.90
73-012A	Violet	April 23, 1974	79.0	51	-1.89	80.52	49.87
73-013	Violet	April 23, 1974	82.0	52	-1.32	83.10	54.25
73-014	Conventional N/P	May 8, 1974	65.6	53	-1.90	66.87	54.25
73-015	Conventional N/P	May 8, 1974	67.1	51	-1.47	68.10	49.87

* Reading taken across a 0.500 ohm resistance across cell. Current produced by each cell may be obtained by multiplying this reading by 2 ma/mV.

† The readings were taken at temperatures as close as practicable, with available equipment, to flight temperatures. A +5°C difference from the flight temperature would result in a reading approximately 0.2 mV high.

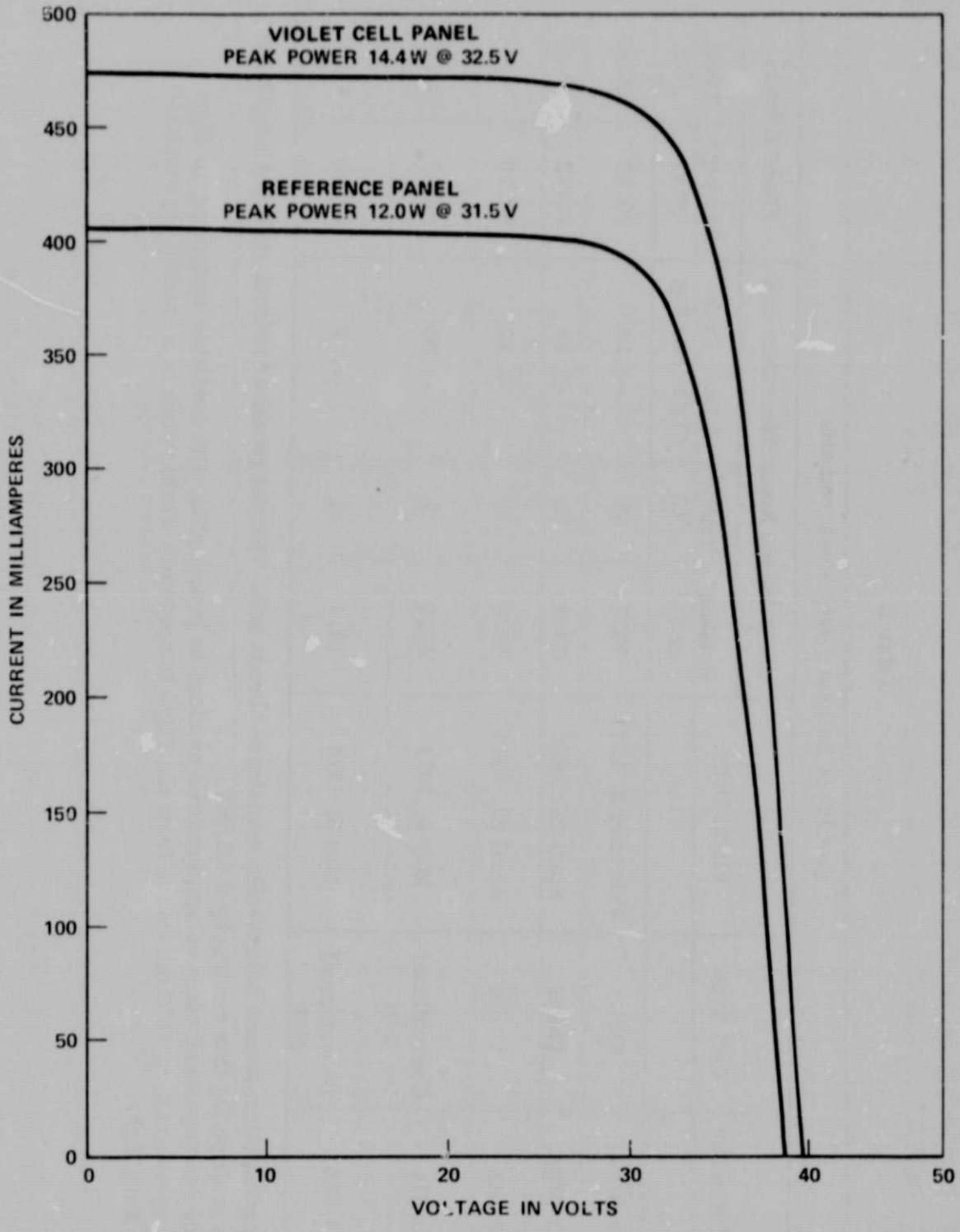

Figure 2. Voltage vs. Current for the IMP-J Violet Cell Panel and the IMP-J Reference Cell Panels, Temperature: 25°C

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