MARS PATHFINDER BATTERY PERFORMANCE

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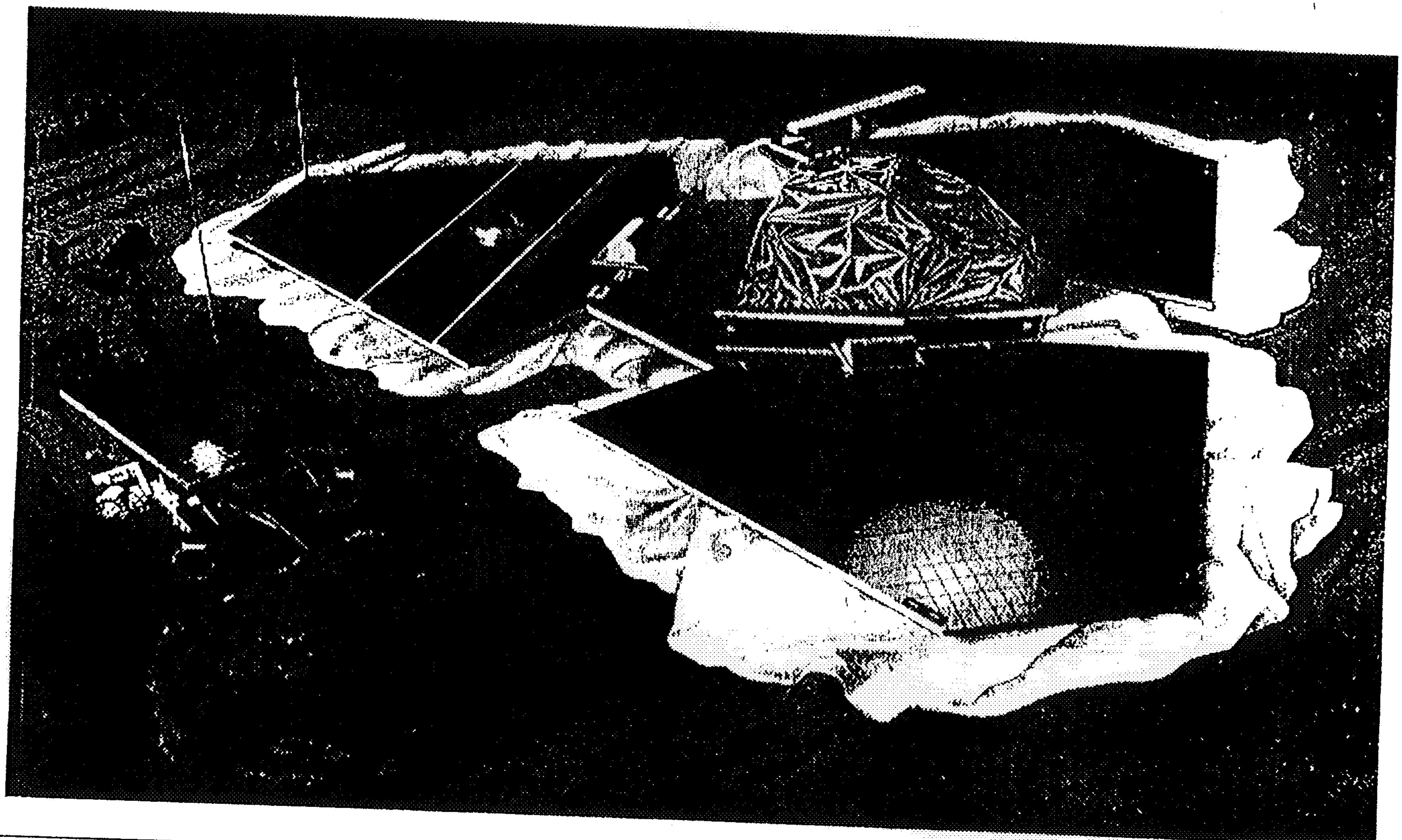
JPL

MARS PATHFINDER LANDER



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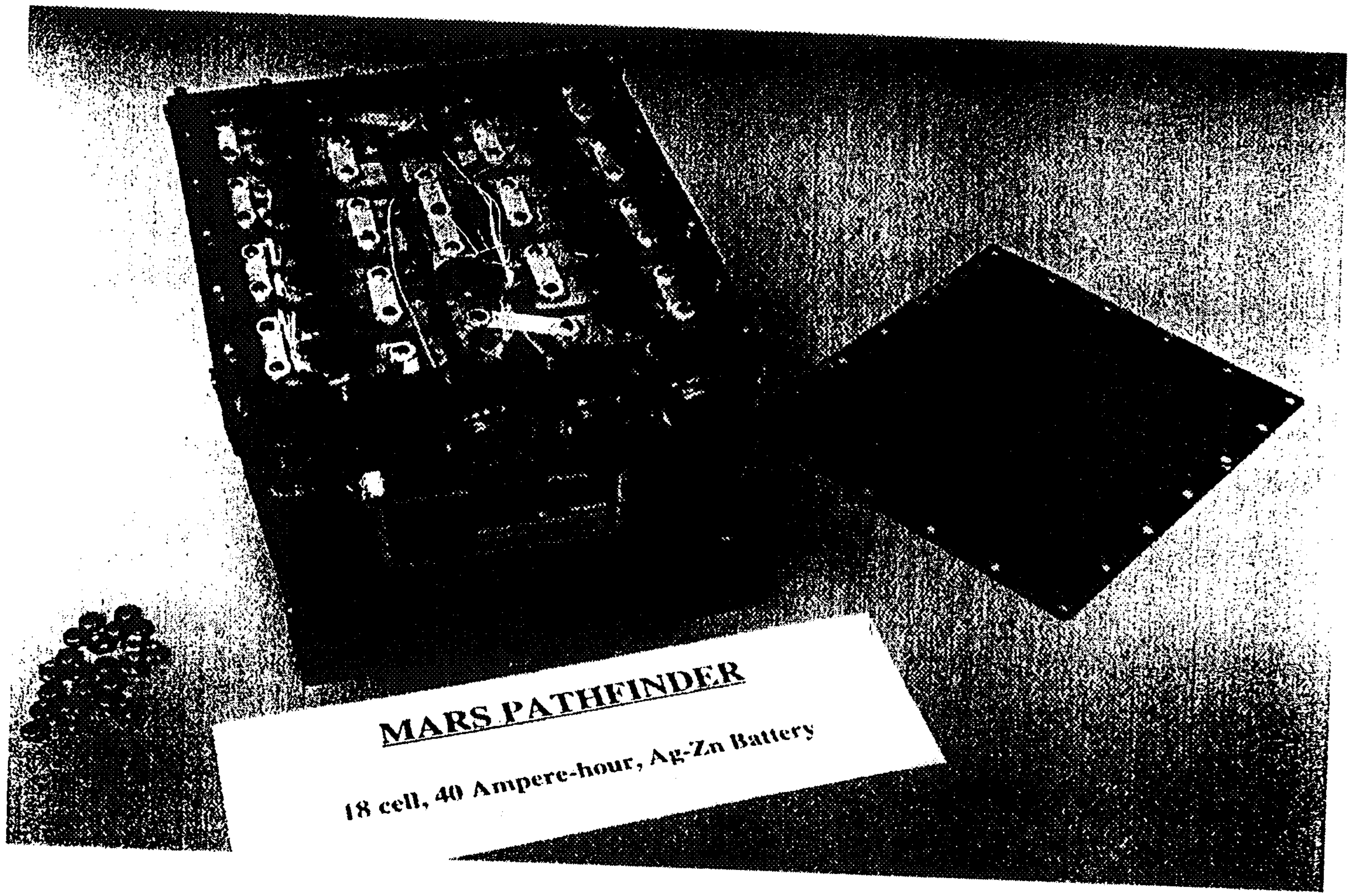
MISSION REQUIREMENTS

• PRE LAUNCH	4 MONTH ACTIVE INVERTED STORAGE
• LAUNCH	INVERTED BATTERY LAUNCH
• CRUISE	7 MONTH ACTIVE STORAGE
• EDL	40 AH, 1080 WH
• MARS OPR. CYCLES	30 CYCLES(1CYCLE/DAY, 8 HOUR CHARGE 16 HOUR DISCHARGE) 50% DOD
• WEIGHT	15 KG
• DIMENSIONS	9.8" x 7.4" x 7.4"

MPF Ag-Zn BATTERY



MPF BATTERY SPECIFICATIONS

• VOLTAGE	27 V
• CAPACITY	40 Ah
• RATE CAPABILITY	1-5 A
• PULSE CAPABILITY	40 A FOR 40 MSEC
• CYCLE LIFE	40
• WET LIFE	14 MONTHS
• WEIGHT	15 KG
• DIMENSIONS	9.8" x 7.4" x 7.4"

KEY CELL DESIGN FEATURES

- Robust separator system - 5 layers of cellophane and 2 layers of polymer membrane.
  To achieve long calendar and cycle life
- Triple redundant case-to-cover seal including basic ultrasonic seal.
  To prevent electrolyte leakage
  To improve safety
- Large cell plate area - approximately 200 square inches.
  Low temperature operation
  For enhanced pyro-firing
- Unique leak-free cell vent valves.
  For inverted battery operation
  allow gas venting under off-limit operation
- Minimal free electrolyte
  For inverted battery operation

KEY BATTERY DESIGN & PROCESS FEATURES

- Titanium fabricated battery case with sealable cover and gasket.
  - Light weight construction
  - gas and electrolyte containment

- Battery vent valve and pressurization port.
  - Redundant valve to protect cells from electrolyte loss

- Battery heater and two temperature sensors.
  - Thermal management for charge control

- Over-pot of cells, surface conformal coating, connector back side potting and electrolyte absorption system.
  - Prevent ionic conductive paths
  - Improve safety

- Cell Matching and selection
  - Extend cycle life

KEY BATTERY OPERATING STRATEGIES

- Battery was mounted inverted and maintained at 12 C during pre-launch and launch Phases

- Battery was partially discharged to 80% SOC and on open circuit stand, at -5 to 0 degrees C, during 7 Month cruise period.

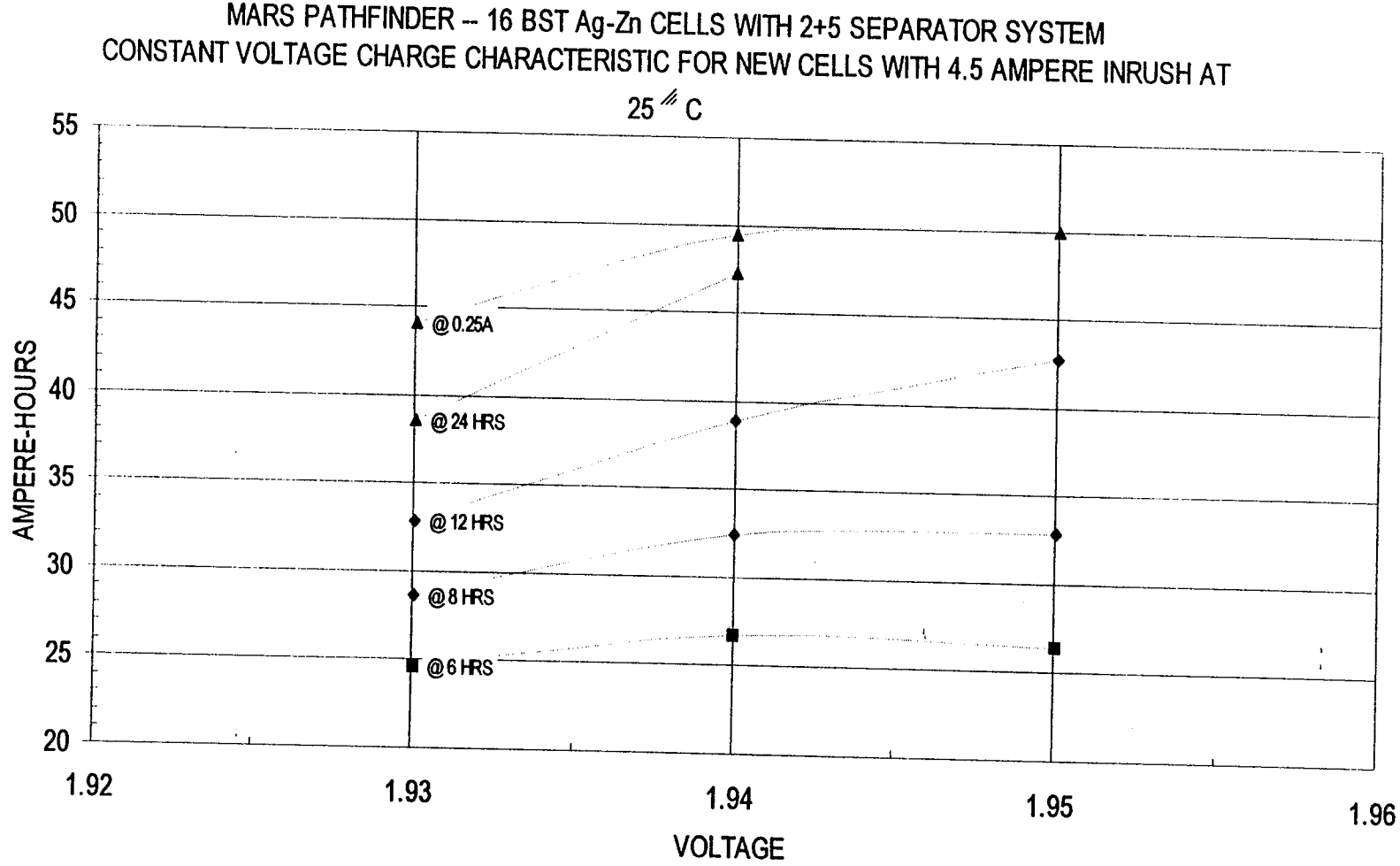
- Battery was charged at end of cruise through 1.2 Ohm resistor to 0.2 A cut-off and 1.95 V / cell Ave.

- Battery was heated to 15 to 20 degrees C prior to all charges.

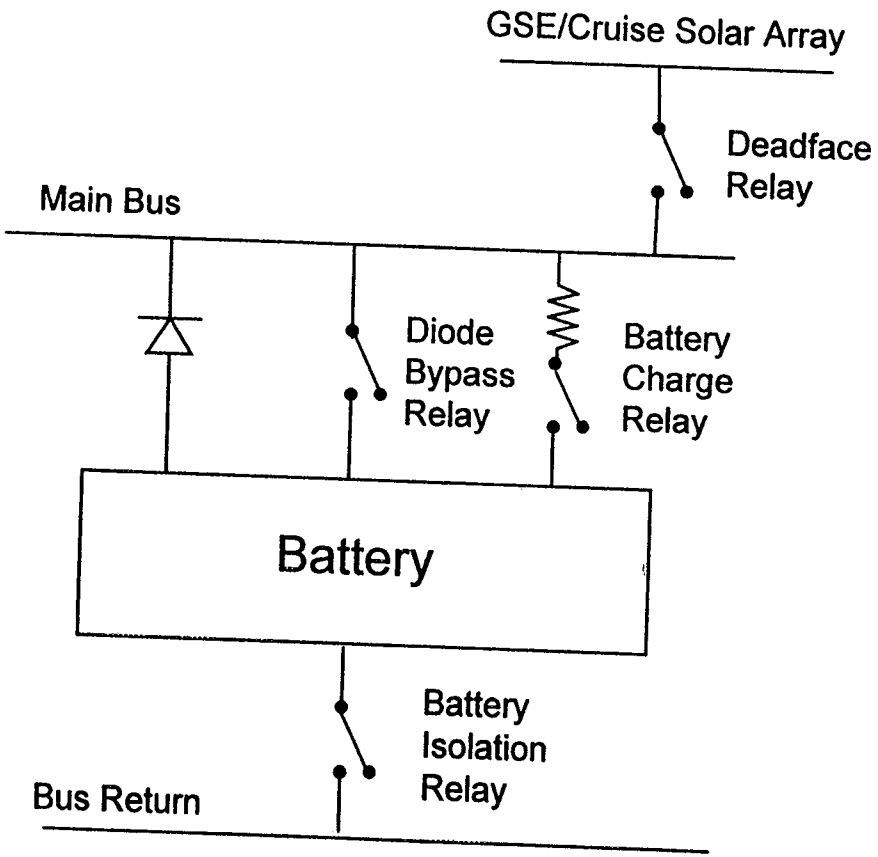
- Battery was charged during Mars operations without resistor to a selective shunt limiter controlled maximum voltage. Six voltage settings were available with 1.95 V / cell Ave.., the nominal full charge selection.

- Battery was taper charged to a constant shunt limiter voltage, 1.95 V / cell Ave.. well below the 2 V. limit employed in constant current charging with same full charge result.

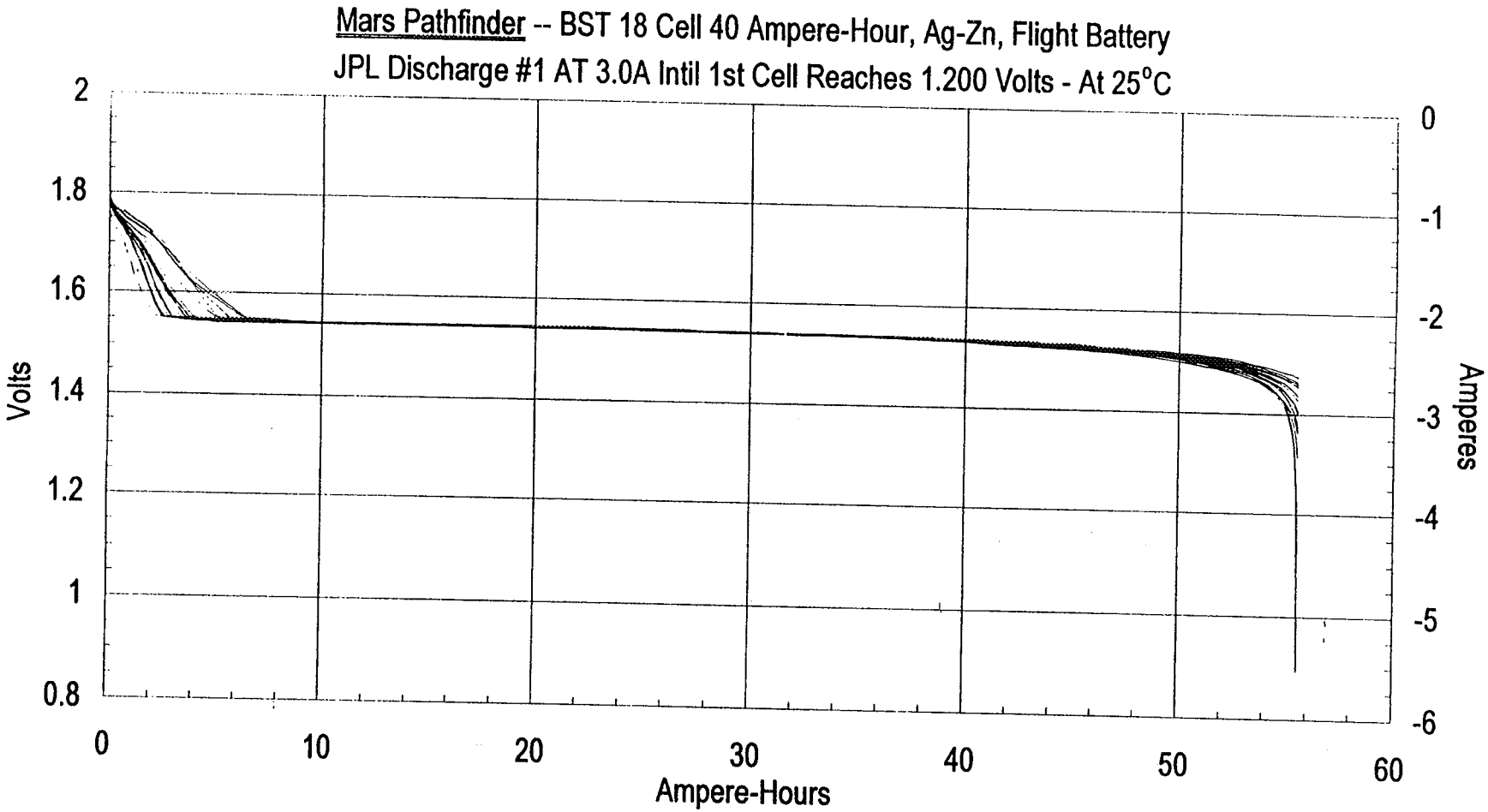
BATTERY CAPACITY VS CHARGE VOLTAGE



MARS Pathfinder Power System Configuration Relays



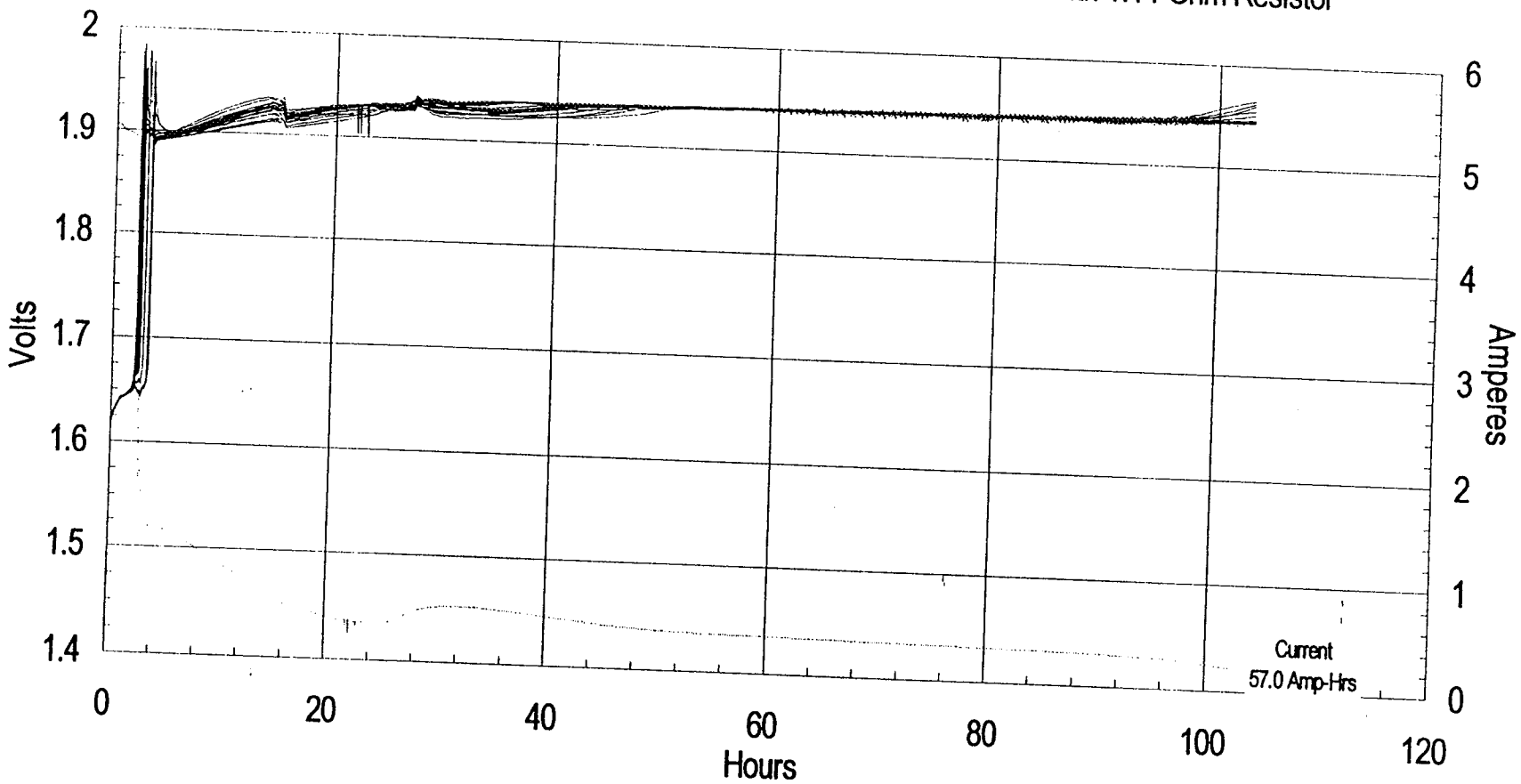
MPF BATTERY PRELAUNCH DISCHARGE



MPF BATTERY PRELAUNCH CHARGE

Mars Pathfinder -- BST 18 Cell, 40 Ampere-Hour, Ag-Zn, Flight Battery

JPL Charge #2 AT 1.960 Volts Per Cell To A 0.2A Cut Off At 25°C - With 1.14 Ohm Resistor



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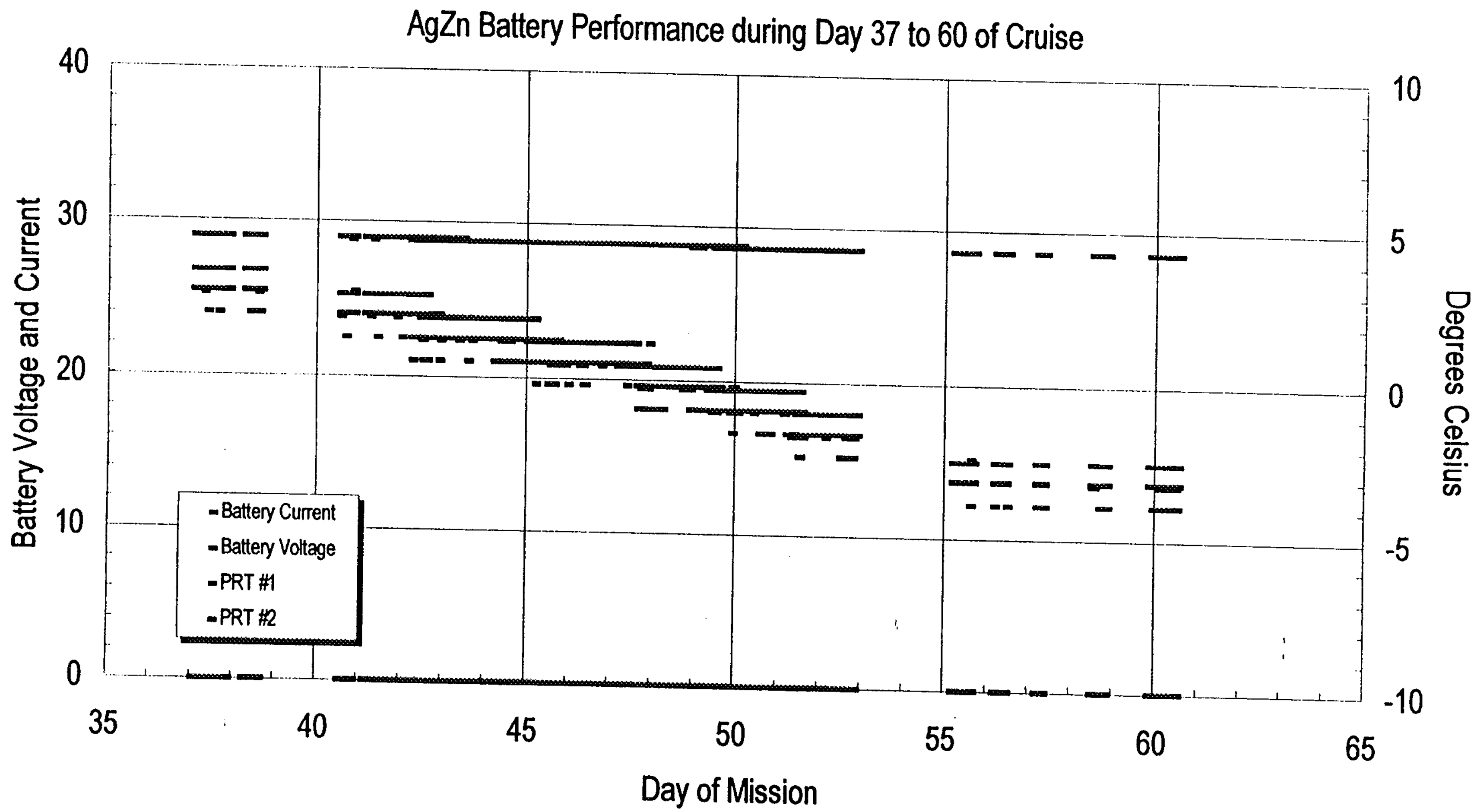
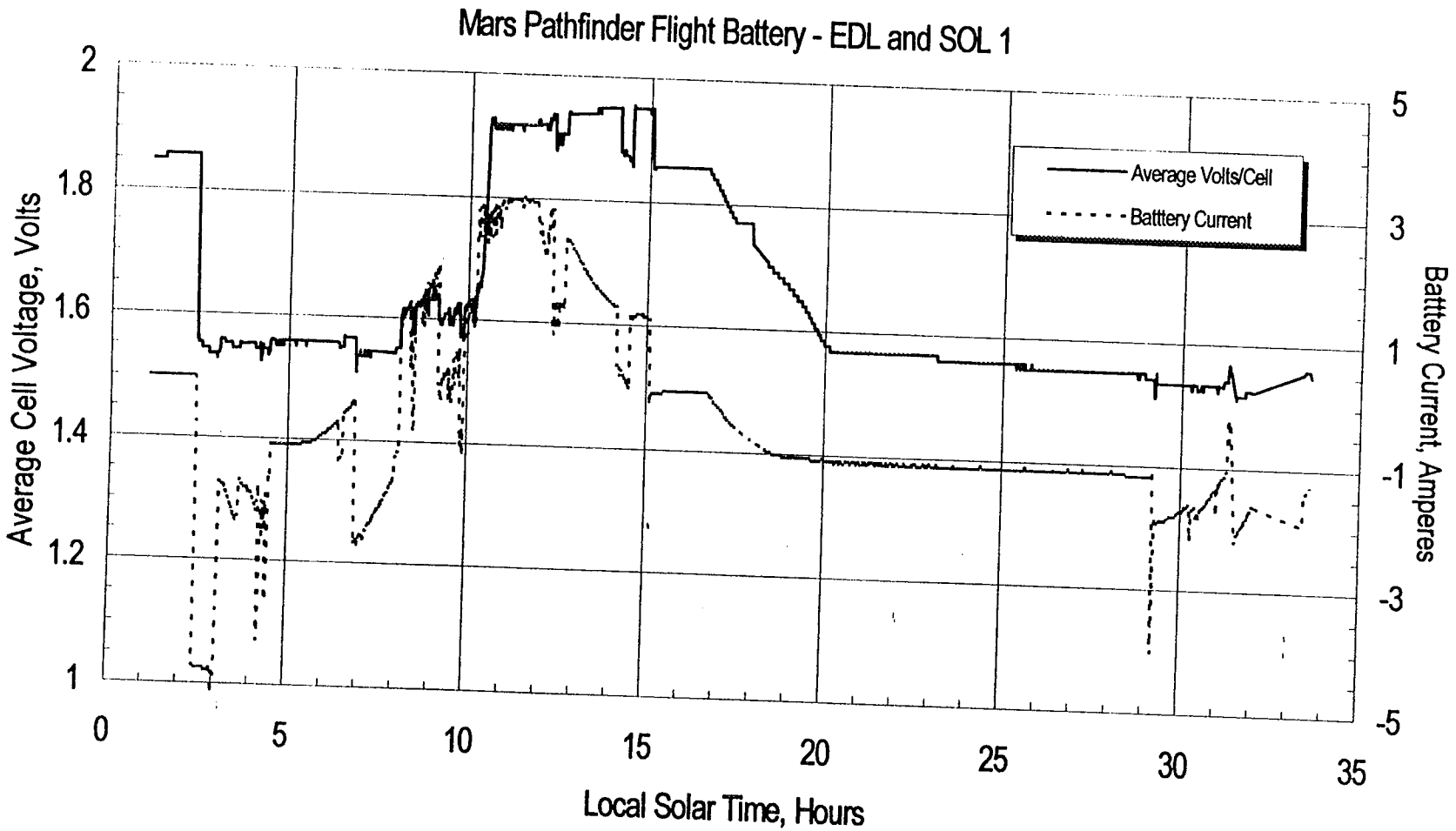
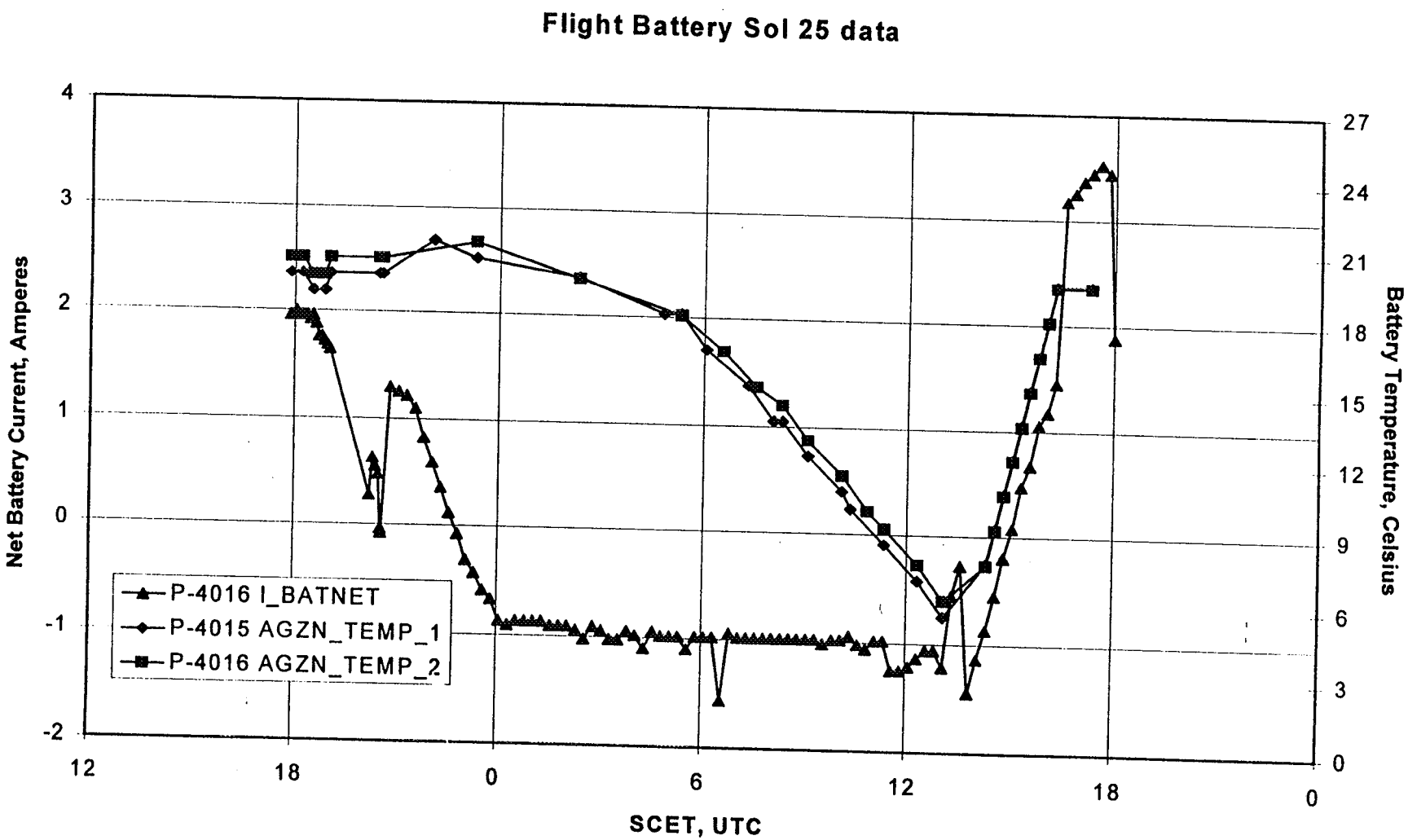
MPF BATTERY VOLTAGE AND TEMPERATURE DURING CRUISE



MPF BATTERY PERFORMANCE-EDL/SOL1



MPF BATTERY PERFORMANCE- SOL25



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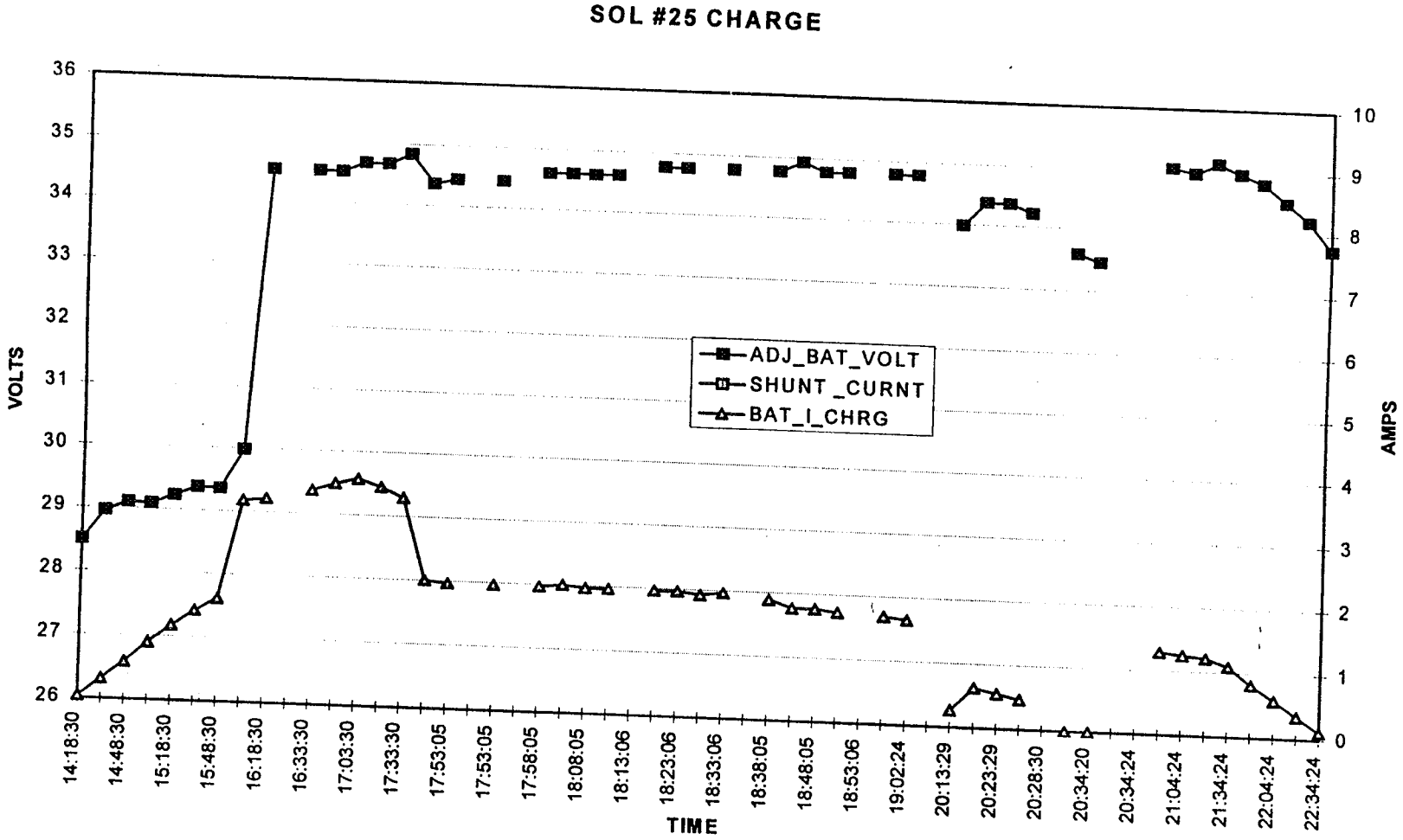

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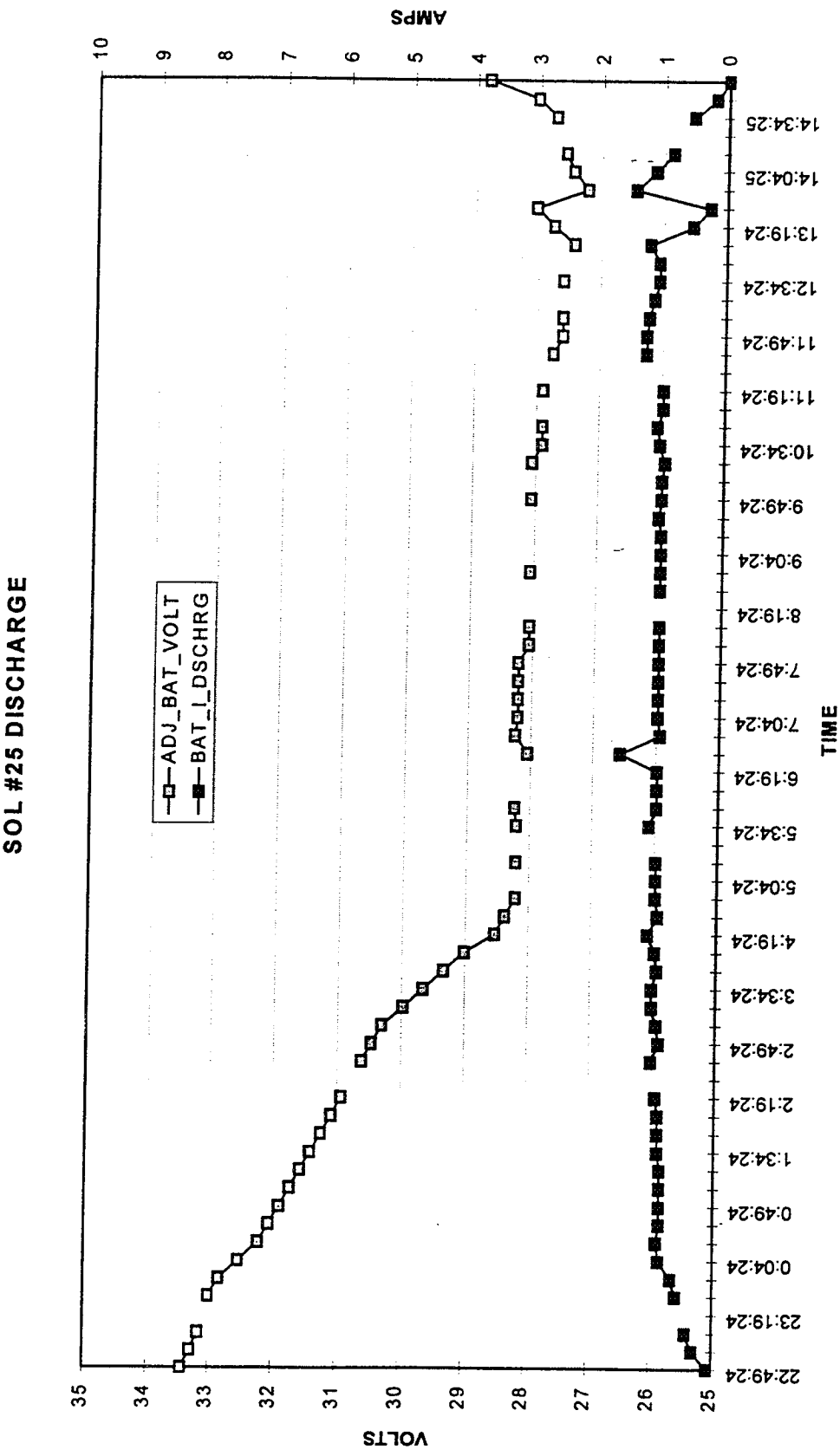

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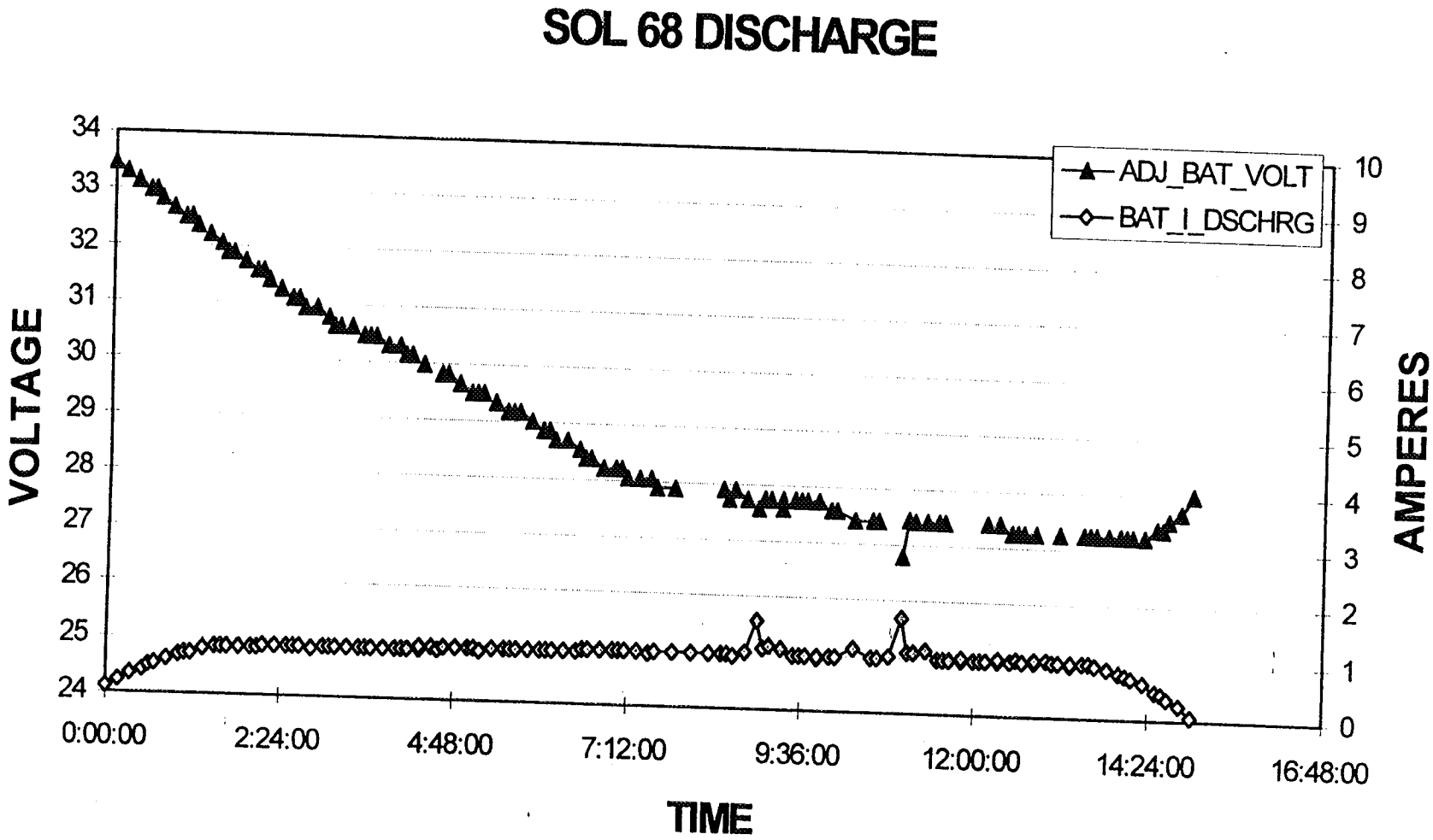
MPF BATTERY PERFORMANCE-SOL 68



SUMMARY AND CONCLUSIONS

- **The first use of a silver-zinc battery in a spacecraft application that called for extensive rechargeable operation after 12 months of active stand hasproven to be very successful.**

- **BST has developed a silver-zinc battery with unique design features for the Mars Pathfinder mission.**

- **JPL has developed battery management strategies to meet the Mars Pathfinder mission requirements.**
  - Partial SOC at low temperature and open circuit stand was found to be the most effective method for insuring extensive cycle life following a long period of active storage
  - Silver-zinc battery charging at a reduced constant voltage was shown to provide full charge and a capability of supporting a large number of cycles.
  - Launch of an inverted silver-zinc battery was shown to be possible when a leak free cell vent valve is employed.
  - The use of a silver-zinc battery and shunt limiter in a direct energy transfer power system resulted in a very energy efficient design approach.

ACKNOWLEDGMENT

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