

**SSTI - LEWIS SPACECRAFT  
NICKEL-HYDROGEN BATTERY**

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**THE 1996 NASA AEROSPACE BATTERY WORKSHOP  
THE HUNTSVILLE HILTON  
HUNTSVILLE, ALABAMA  
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517-44

# **PRESENTATION OVERVIEW**

- **NASA SSTI OBJECTIVES  
(SMALL SPACECRAFT TECHNOLOGY INITIATIVE)**
- **SSTI - LEWIS OVERVIEW**
- **BATTERY REQUIREMENT**
- **TWO CELL CPV DESIGN SUMMARY**
- **CPV ELECTRICAL PERFORMANCE**
- **BATTERY DESIGN SUMMARY**
- **BATTERY FUNCTIONAL DESCRIPTION**
- **BATTERY PERFORMANCE**

# **SSTI OBJECTIVES**

- **REDUCE COST AND SCHEDULE OF CIVIL SPACE MISSIONS**
- **PRODUCE MORE ACCESSIBLE RESULTS**
- **TRANSITION GOVERNMENT AND INDUSTRY TECHNOLOGY TO THE CIVIL SPACE SECTOR**

# **SSTI - LEWIS OVERVIEW**

- **MAXIMIZE TECHNOLOGY TRANSFER FROM MILITARY TO CIVIL SPACE APPLICATIONS**
- **MORE THAN 40 NEW TECHNOLOGIES**
  - **NIH2 CPV INCLUDED**
- **517 KM, 97.4 ° INCLINATION SUN SYNCHRONOUS ORBIT**
- **5 YEAR LIFETIME GOAL**
- **FULLY REDUNDANT SUBSYSTEM ELECTRONICS**
- **2 YEAR FAST-TRACK SCHEDULE SPAN**
  - **DESIGNED MAJOR MODULES SO THEY COULD BE INTEGRATED AND TESTED INDEPENDENTLY OF EACH OTHER**
  - **REDUCED CUSTOMER SURVEILLANCE**

- **THREE SCIENCE PAYLOADS WILL PROVIDE MEANINGFUL SCIENCE AND REMOTE-SENSING DATA TO A BROAD RANGE OF CIVIL AND COMMERCIAL USERS**
  - **EARTH OBSERVATION (TRW-HYPERSPECTRAL IMAGER)**
  - **COMMERCIAL REMOTE SENSING (NASA GODDARD-LINEAR ETALON IMAGING SPECTRAL ARRAY)**
  - **ASTROPHYSICS (UCB- ULTRAVIOLET COSMIC BACKGROUND)**

# **BATTERY REQUIREMENTS**

- **LEO ORBIT- 95 MINUTE ORBIT (35.3 MINUTE ECLIPSE)**
- **5 YEAR GOAL - 30,000 CYCLES**
- **MAXIMUM DEPTH OF DISCHARGE - 30%**
- **NORMAL OPERATING VOLTAGE RANGE - 24.0 TO 38.4 VOLTS**
- **ECLIPSE DISCHARGES AT APPROXIMATELY- 0.5 C**
- **BATTERY CLAMP TO THE BUS**

# CPV DESIGN

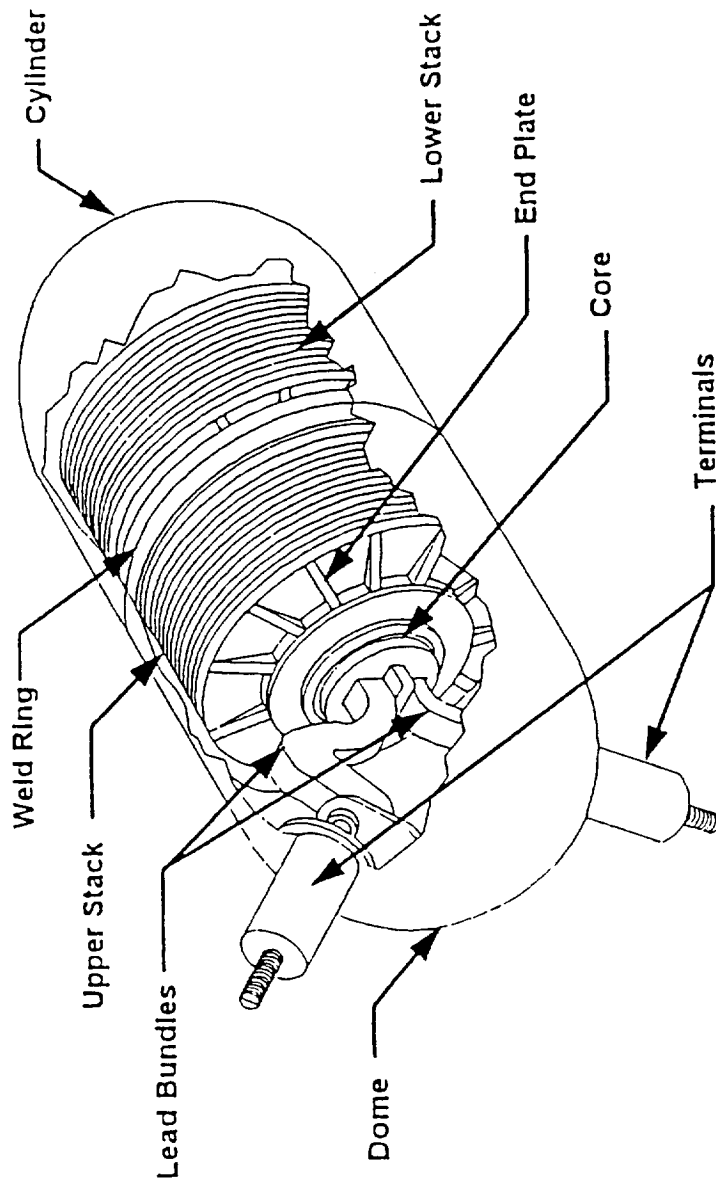
- EPI MANTECH DESIGN: RNHC-23-1
- DUAL-STACK: 2-23AH CELLS/VESSEL
- TERMINALS: RABBIT EARS
- POSITIVE ELECTRODE: 30-MIL, SLURRY SINTER  
36 ( 18 PER STACK)  
80% SINTER POROSITY  
1.65 GM/CC ACTIVE  
MATERIAL LOADING
- SEPARATOR: DOUBLE LAYER ZIRCAR

- **PRECHARGE:**  
**NICKEL**
- **PRESSURE VESSEL:**  
**23-MIL ,INCONEL 718**
- **INTERNAL COATING:**  
**ZIRCONIUM OXIDE WALL-  
WICK WITH Pt-CATALYST  
RECOMBINATION SITES**
- **DIMENSIONS:**  
**3.506 INCH DIAMETER  
7.60 INCH OVERALL LENGTH**
- **WEIGHT**  
**MAXIMUM VESSEL WEIGHT -  
1400 GM**  
**VESSEL LOT- AVERAGE  
1380 GM**



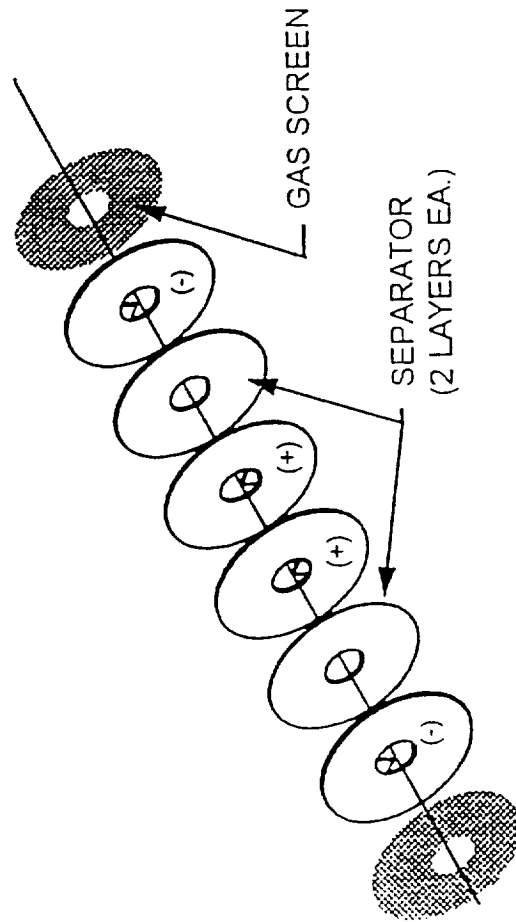
# CPV RABBIT EAR "DUAL STACK"

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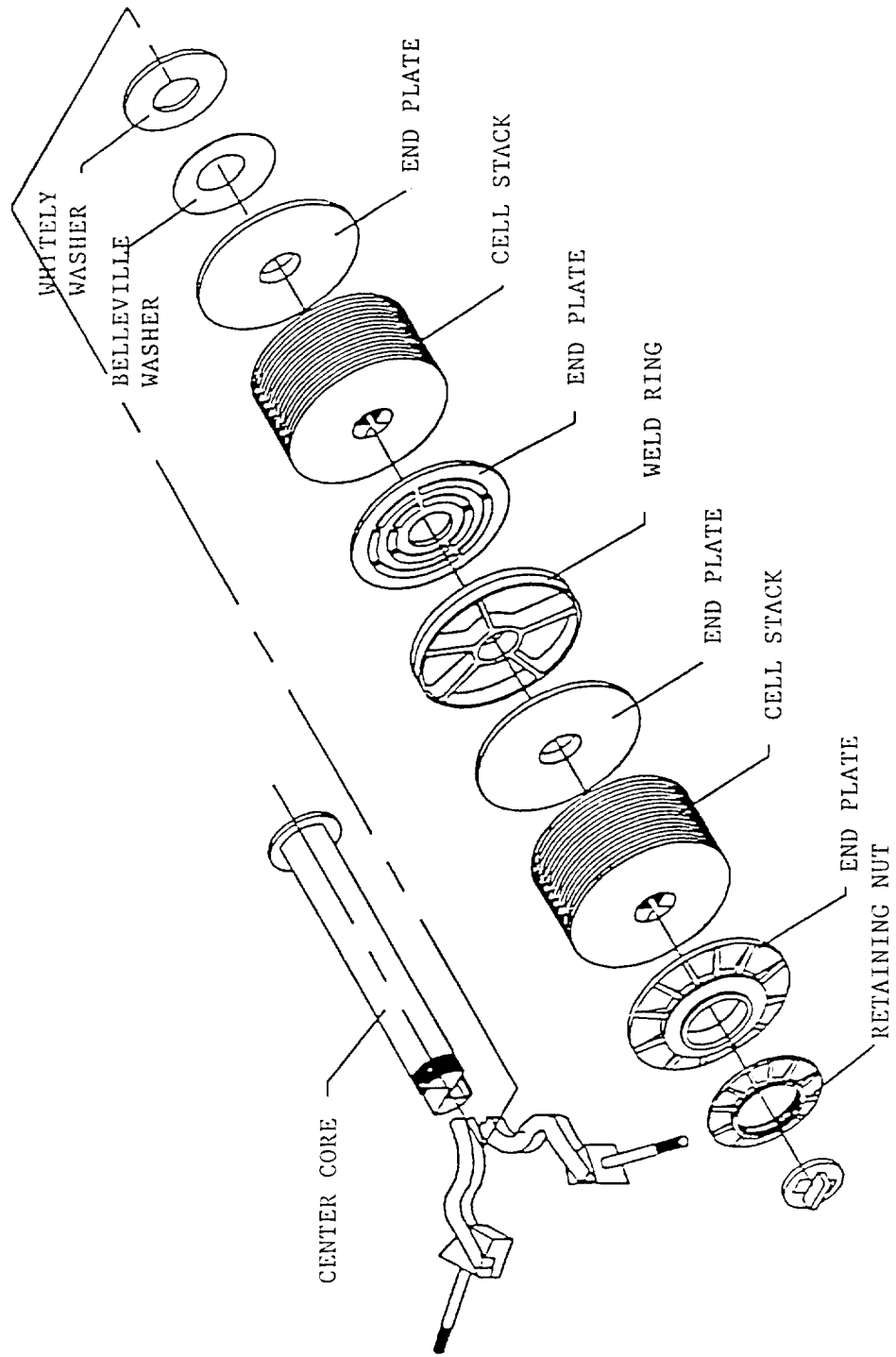


# ELECTRODE STACK ASSEMBLY

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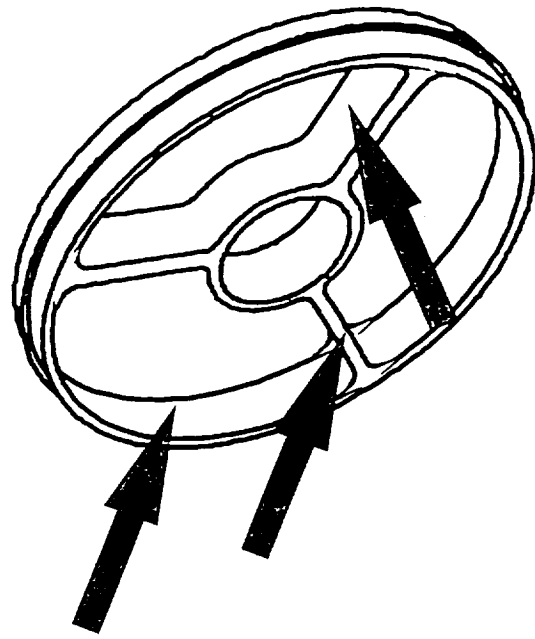


# CELL ASSEMBLY CONFIGURATION



- **TEFLON COATED WELD RING**
- **ELECTROLYTE IMBALANCE MITIGATION**

**TEFLON COATED SURFACES**



# CPV PERFORMANCE DATA

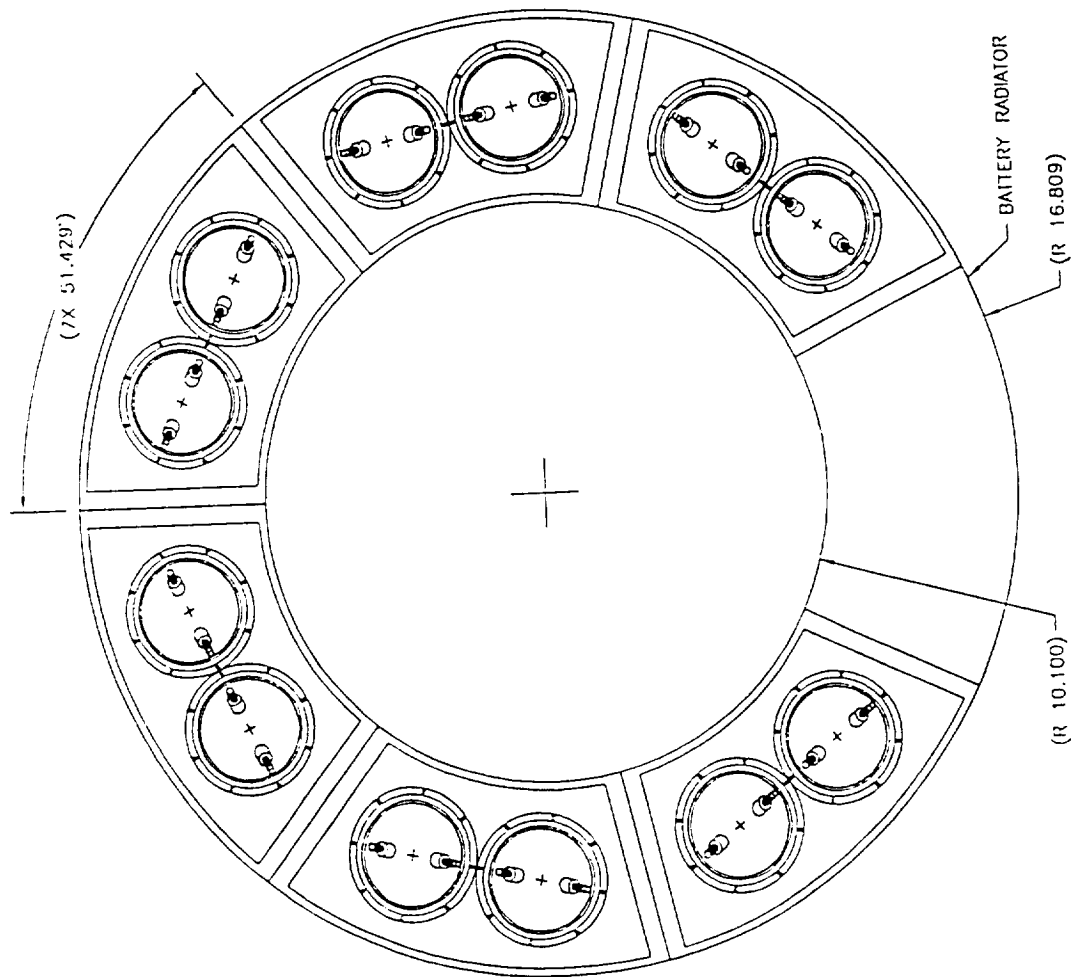
- ATP TESTING PERFORMED ON 19 VESSELS
- ALL CAPACITIES DETERMINED TO 2.0 VOLTS
- TEST RESULTS  

<u>TEMPERATURE</u>	<u>EOCV</u>	<u>CAPACITY</u>
20°C	2.996	24.2 AH
10°C	3.077	28.5
0°C	3.154	30.8
- CHARGE RETENTION CAPACITY AT 10°C = 25.7 AH (90.3%)
- OVERCHARGE AFTER 50 HOURS AT 1.5 AMPS AT 10°C = 3.075 VOLTS

# BATTERY DESIGN

- TWELVE 23 AH NICKEL-HYDROGEN CPV's IN SERIES
- BATTERY CONFIGURATION CONSISTS OF SIX (6) MODULES OF TWO CPV's DISTRIBUTED AROUND INBOARD SIDE OF AFT FACING BATTERY RADIATOR
- BATTERY OCCUPIES 6 OF 7 BAYS IN BATTERY/ PROPULSION MODULE
- HEAT PIPE IS USED TO SPREAD HEAT EVENLY BETWEEN ALL 7 BPM BAYS

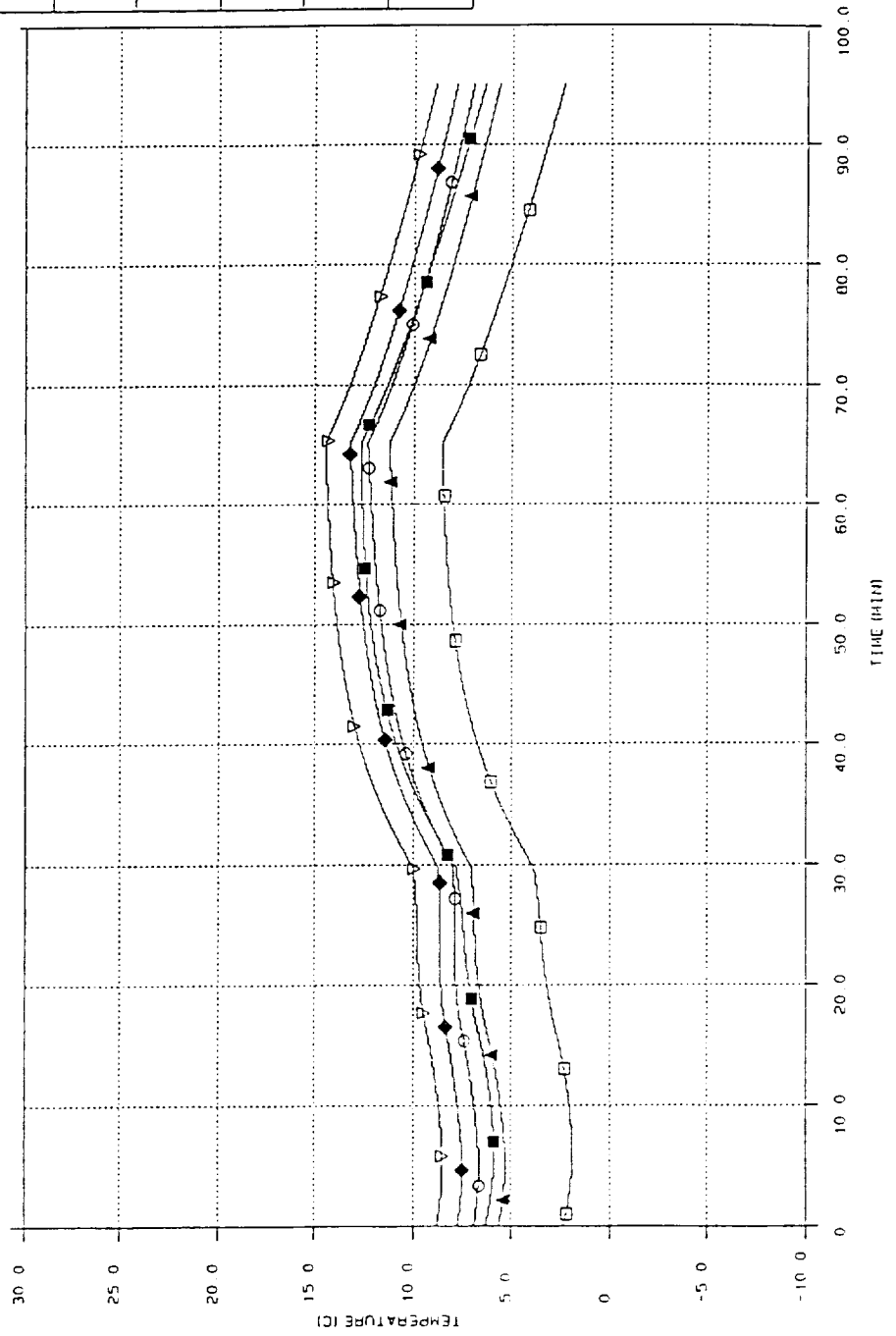
# BATTERY LAYOUT



# BATTERY TEMPERATURES WITHOUT HEATPIPE

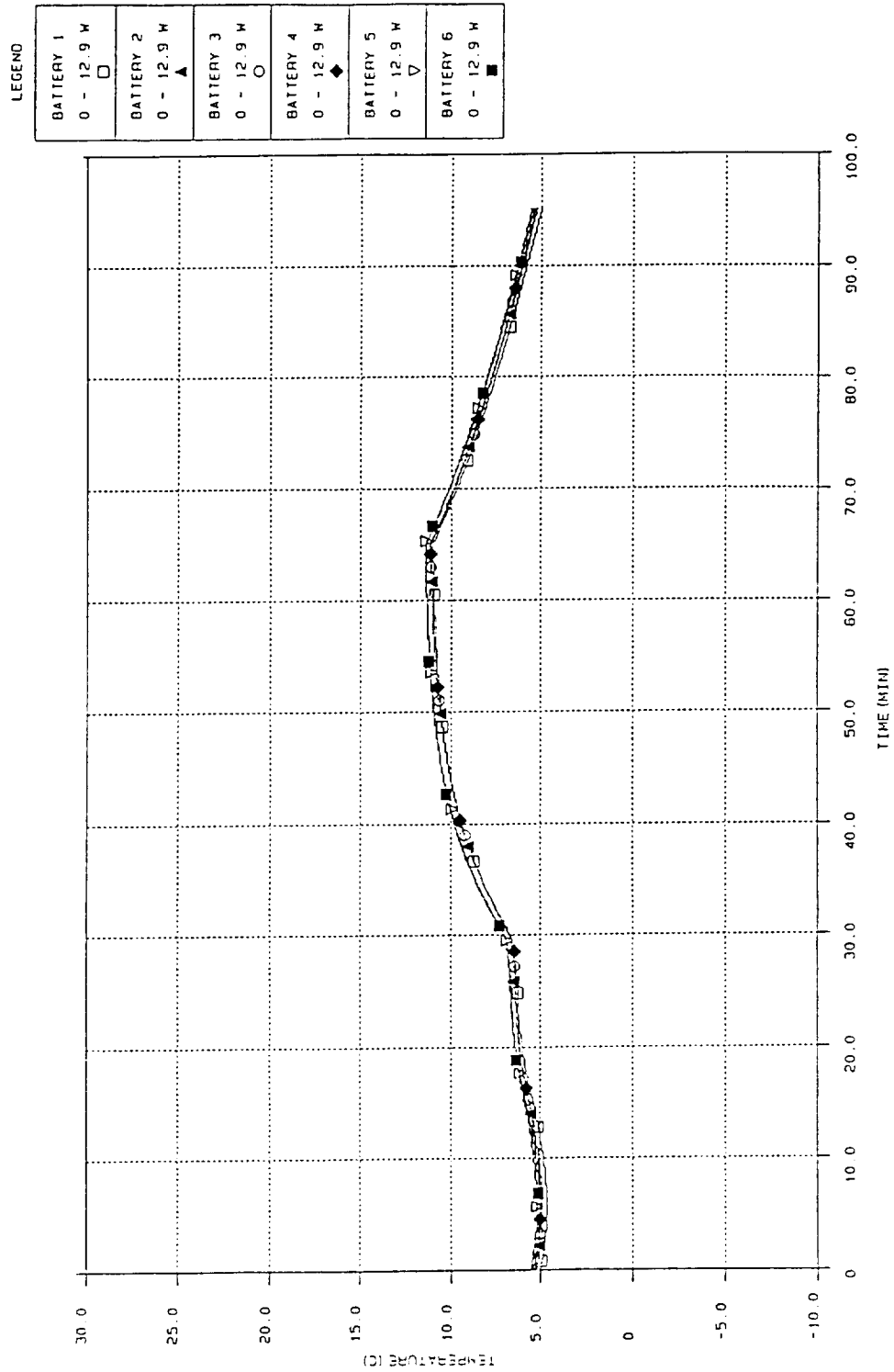
LEGEND

BATTERY 1 0 - 12.9 W	□
BATTERY 2 0 - 12.9 W	▲
BATTERY 3 0 - 12.9 W	○
BATTERY 4 0 - 12.9 W	◆
BATTERY 5 0 - 12.9 W	▽
BATTERY 6 0 - 12.9 W	■



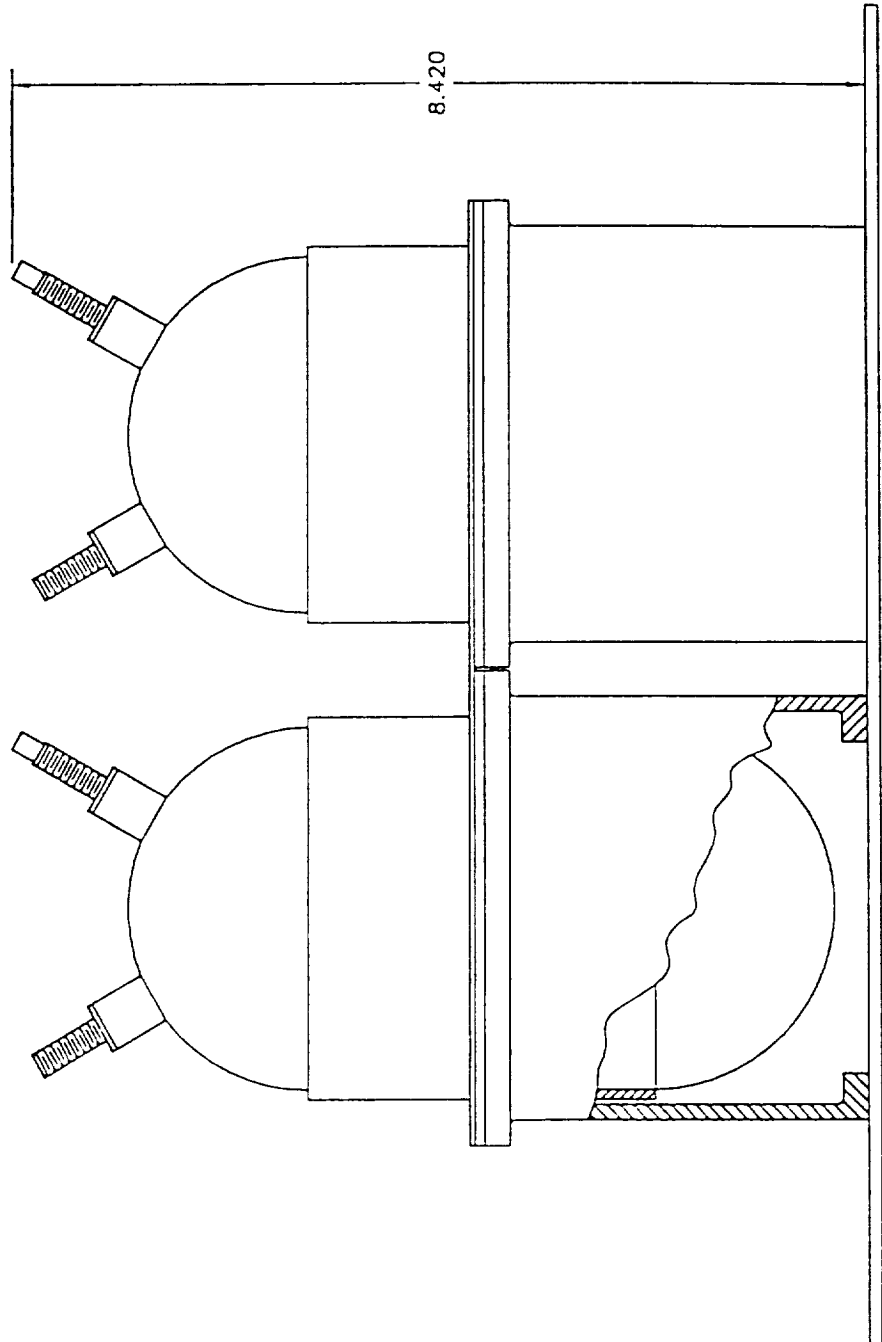


# BATTERY TEMPERATURES WITH HEATPIPE



# MODULE ASSEMBLY

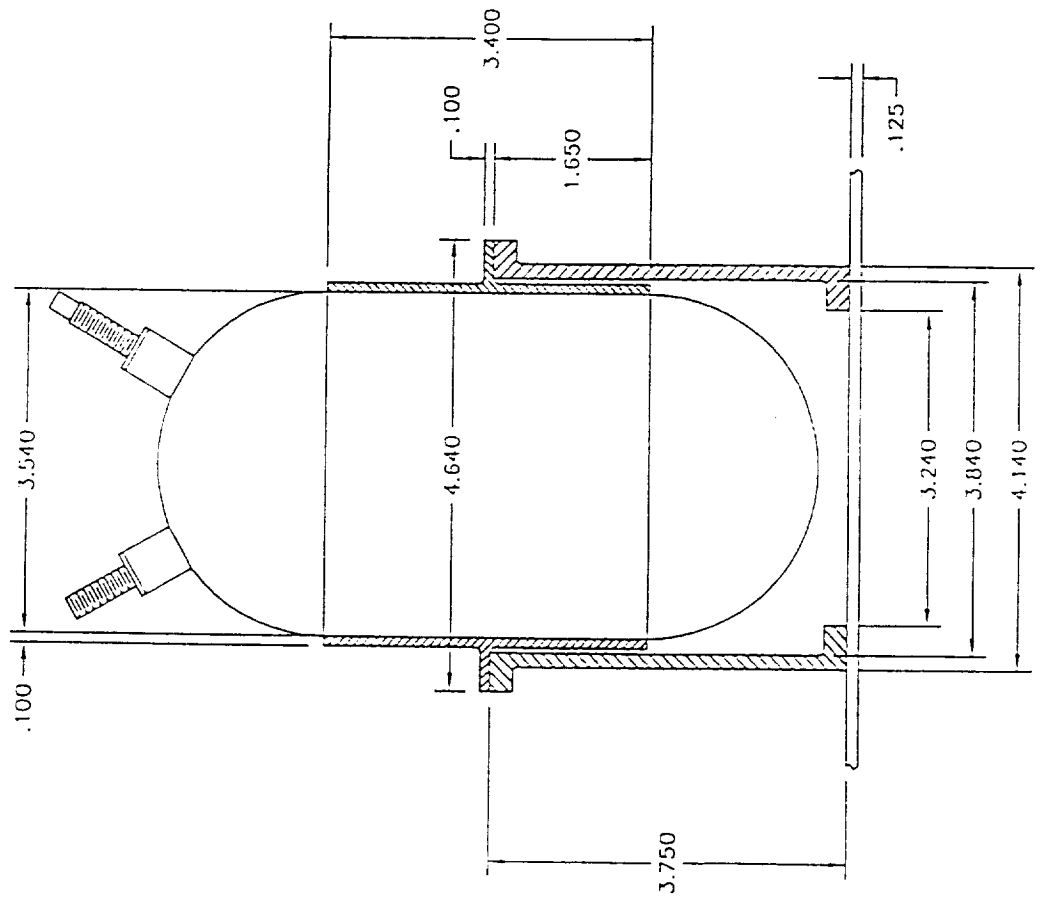
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- **CELL HEAT IS PASSIVELY CONDUCTED FROM THE CELL TO THE BASEPLATE WHICH RADIATES DIRECTLY TO SPACE**
- **EACH VESSEL IS CONTAINED WITH A THERMAL SLEEVE AND MOUNTING FLANGE WHICH IN TURN ARE MOUNTED TO ALUMINUM SLEEVES PERPENDICULAR TO THE BASE-PLATE**
- **BATTERY WEIGHT: 55.5 LB.**

# BATTERY VESSEL MOUNTING

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# BATTERY FUNCTIONAL DESCRIPTION

- CHARGE
  - PRIMARY CHARGE CONTROL IS PROVIDED BY AH INTEGRATION PERFORMED BY THE OBC
  - CHARGE RATE IS THREE STEP PROCESS WITH RECHARGE RATIOS NOT EXCEEDING 1.10
    1. INITIAL CURRENT OF 0.4 C
    2. TAPER CURRENT
    3. FINISH CHARGE AND OVERCHARGE AT 0.2 C
  - BACKUP CHARGE CONTROL IS PROVIDED BY SENSING BATTERY TEMPERATURE TURNAROUND AT THE ONSET OF OVERVOLTAGE
  - CHARGE VOLTAGE SHALL NOT EXCEED 38.4 VOLTS

- **DISCHARGE**
  - **BATTERY IS CAPABLE OF PROVIDING AT LEAST 325 WATTS DURING A 35.3 MINUTE ECLIPSE AT A DOD NOT EXCEEDING 30%**
- **RECONDITIONING**
  - **NOT INCLUDED IN THE BASELINE DESIGN**
- **THERMAL CONTROL FEATURES PERMIT OPERATION WITHIN THE FOLLOWING CONSTRAINTS**
  - **BATTERY ORBITAL AVERAGE TEMPERATURE SHALL BE NO GREATER THAN 10°C**
  - **TEMPERATURE GRADIENT BETWEEN HOTTEST AND COLDEST VESSELS SHALL NOT EXCEED 3°C**
  - **TEMPERATURE GRADIENT BETWEEN CELLS WITHIN A VESSEL SHALL NOT EXCEED 1°C**

# BATTERY PERFORMANCE

- 12 VESSELS
- VESSEL SELECTION
  - CAPACITY VARIATION AT 10°C : LESS THAN  $\pm 1\%$
  - EOCV SPREAD AT 20°C: WITHIN 5 MV
- CAPACITY AT 10°C : 28.43 AH
- CHARGE RETENTION AT 10°C : 24.84 AH (87.4%)

