



HUBBLE SPACE TELESCOPE NICKEL HYDROGEN BATTERY SYSTEM BRIEFING

for the 1992 NASA Battery Workshop

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BETTY COLHOUN / CSC - GRAPHICS

N 9 2 - 2 0 5 1 3



HST MISSION

LOW EARTH ORBIT OPERATION

96 MINUTE ORBIT

15 ORBITS PER DAY

BETA ANGLES RANGE FROM 0° TO 52°

TRANSLATES TO 26 TO 35 MINUTE
DISCHARGE PERIODS

RECHARGE MUST BE ATTAINED IN 60 MINUTES*

STATE-OF-CHARGE

BASED ON ATP CAPACITY OF

88 AMPERE-HOURS AT 0°C

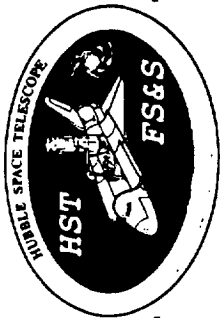
VEHICLE THRESHOLD (OLD)

68 AMPERE-HOURS -- OR 77%

NOMINAL OPERATION
(NEW THRESHOLD)

75 AMPERE-HOURS -- OR 85%

* EXCEPT FOLLOWING OFF NORMAL ROLLS



SYSTEM CONSTRAINTS

THERMAL: DISSIPATION OF HEAT GENERATED IN BATTERY CONDUCTED THROUGH TWO INCH HONEYCOMB PANEL PRIOR TO RADIATING TO SPACE

LOUVERS AND MLI ON BAY DOOR INSTALLED ON EXTERIOR BAY DOOR SURFACE TO REDUCE BATTERY HEATER DUTY CYCLES

BATTERIES IN INTIMATE PROXIMITY AND THERMALLY COUPLED

TEMPERATURE OPERATING RANGE: -5°C TO 20°C

ELECTRICAL: MAXIMUM CHARGE VOLTAGE 34.3 VOLTS DC (SYSTEM CONSTRAINT)
THIS TRANSLATES TO 1.56 VOLTS DC PER CELL
(THERMAL LIMITATION IS 1.53 VOLTS PER CELL)
MINIMUM DISCHARGE VOLTAGE 26.5 VOLTS DC (SYSTEM CONSTRAINT)
THIS TRANSLATES TO 1.20 VOLTS DC PER CELL AND WAS
SECONDARY REASON FOR ADJUSTING ELECTROLYTE CONC.

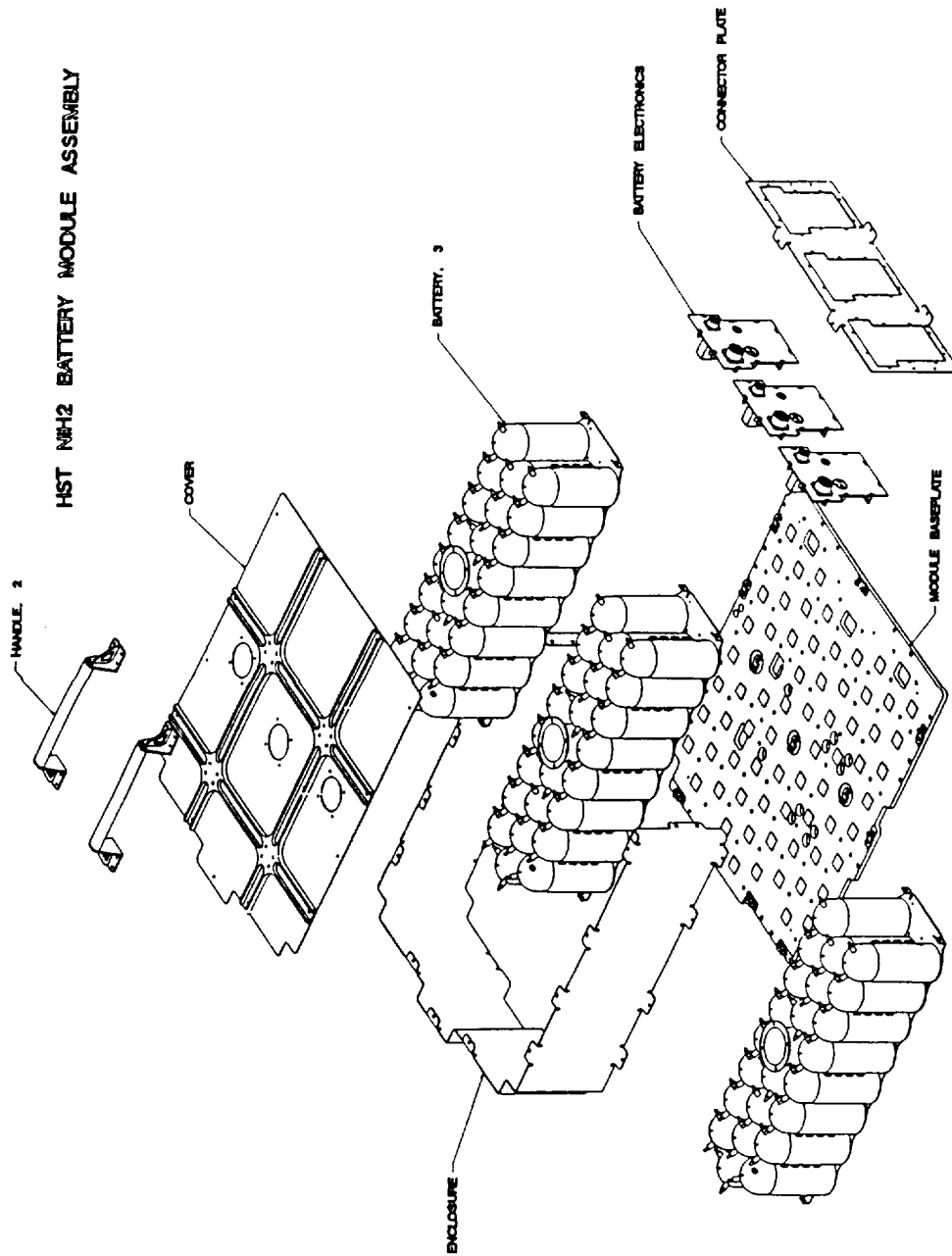


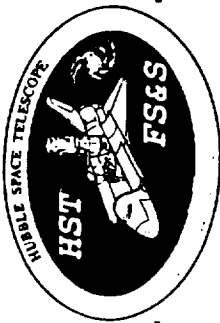
BATTERY SPECIFICATION

SIX BATTERY SYSTEM BATTERY CAPACITY AT 0°C	MAXIMUM DOD 14%	WITH ONE BATTERY FAILED
	88 AMP-HR	AT 15 AMP (C/6) DISCHARGE RATE
MAX. DISCHARGE CURRENT	20 AMPERES	TO 26.5 VOLTS DC AT BATTERY
PEAK DISCHARGE CURRENT	30 AMPERES	FOR 10 SECONDS MAXIMUM
CHARGING RANGES	5.0 TO 18.0 AMPERES	DURING ORBITAL OPERATIONS
ORBITAL LIFE	FIVE YEARS	27,375--14% DOD CYCLES

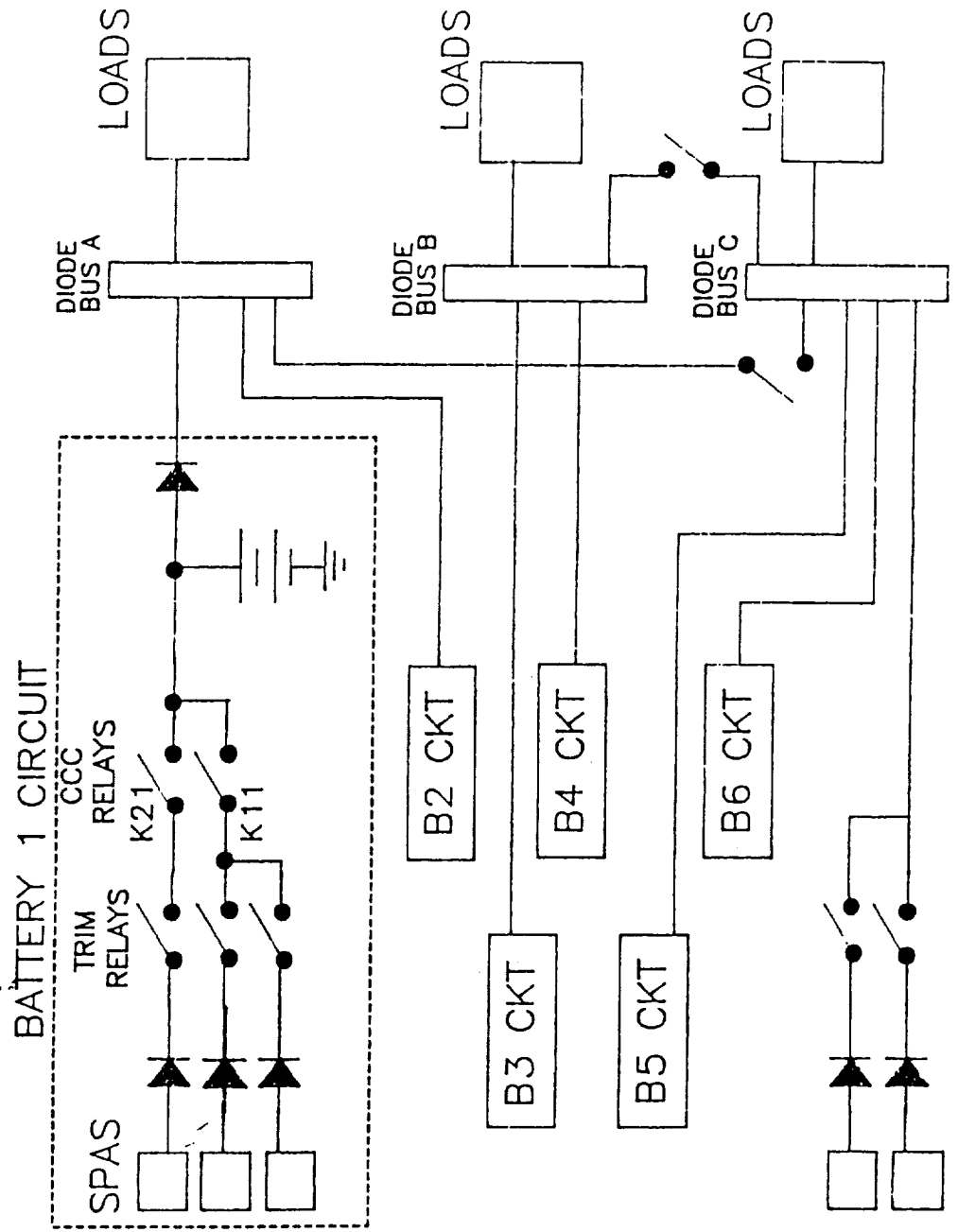


BATTERY MODULE





SIMPLIFIED BLOCK DIAGRAM





CELL DESIGN SUMMARY

AF "Pineapple Slice" Cell Design with the Following Components:

48 Dry Sintered Nickel Positive Electrodes (0.035 in. thick)

48 Platinum Negative Electrodes (0.006 in. thick)

Zirconium Oxide Cloth Separators and Gas Screens

Polysulfone End Plates, Core and Retaining Nut

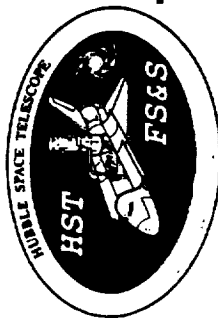
Belleville and Whiteley Washers

Inconel 718 Pressure Vessel (0.040 in. thick)

Zirconium Oxide Pressure Vessel Wall Wick

Inconel 718 Terminal Bosses and Weld Ring

Injection Molded Nylon Terminal Seals



PRESENT STATUS

LAUNCHED: 24 APRIL 1990

ABOUT 2.5 YEARS OF SERVICE // 15 YEAR SPACECRAFT SPEC LIFE

14,012 ORBITS DOY 323 @ 1800 EDT (18 NOV 92)

DOD AVERAGES BETWEEN 8 - 10 % BASED ON NAMEPLATE
HIGHEST DOD 27% FEATHERING TESTS
LOWEST DOD 5% HARDWARE SAFE MODE

TEMPERATURES: 0°C \pm 3°C NOMINAL

MAX TEMPERATURE: 5°C DURING HARDWARE SAFE MODE

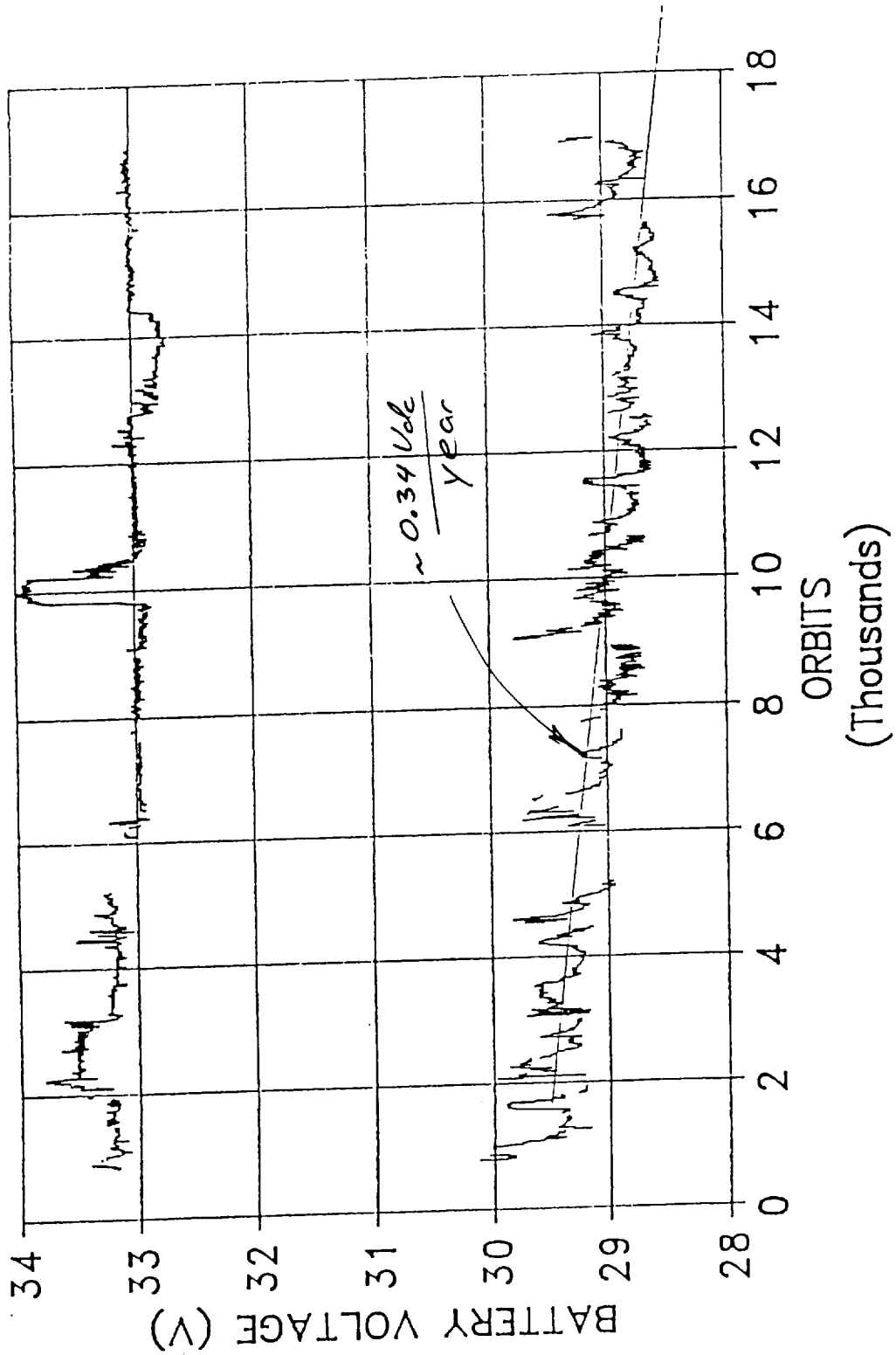
VOLTAGES: EOCV 33 - 33.2 VDC (CONTROLLED)

EODV: DECLINING (SEE NEXT PAGE)

PRESSURES: SEE GRAPH



VOLTAGE DECAY GROUND TEST (MSFC)



— END OF CHARGE - - - END OF DISCHARGE

⑨

HUBBLE SPACE TELESCOPE

On-Orbit Test System

Batt Volt

From 1990:110 to 1992:95

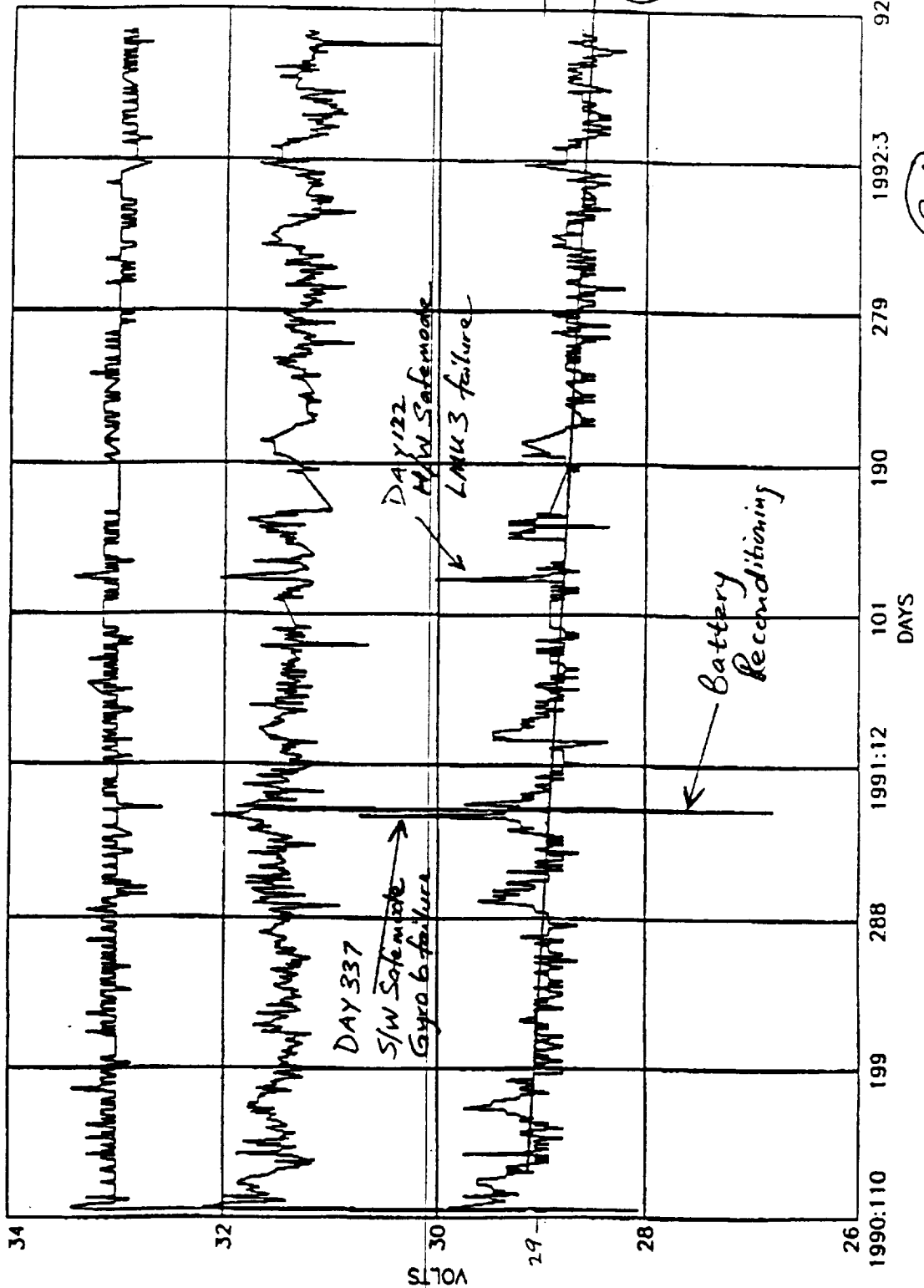
BAC01.PLT

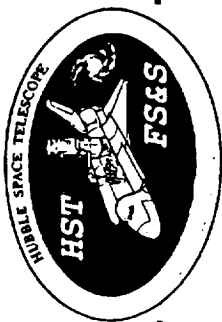
□ Max = 33.4

Δ Avg = 31.4

○ Min = 26.8

CBATTV

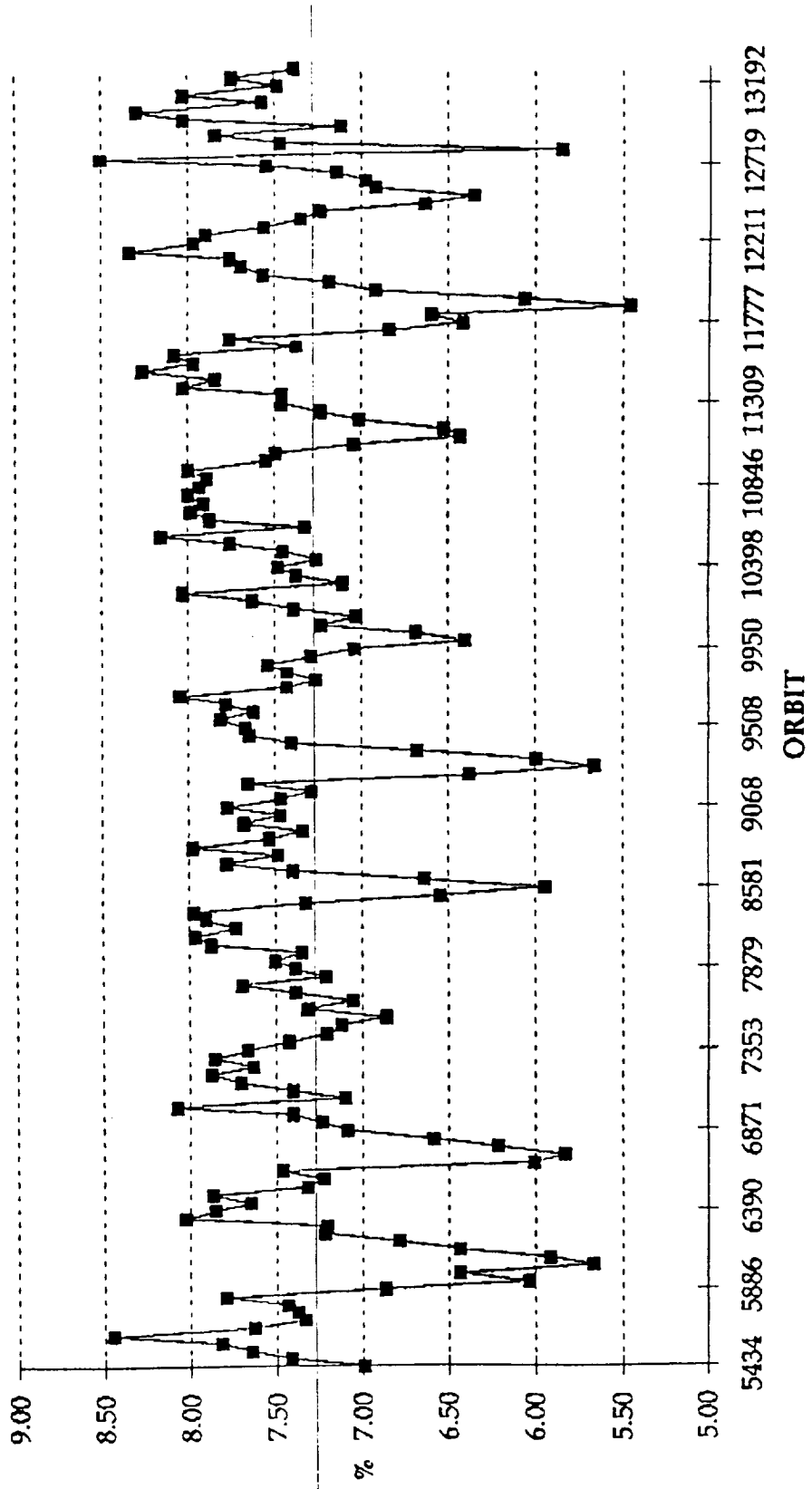




SYSTEM DOD

Total Battery Depth-of-Discharge (April 24, 1991 - September 30, 1992)

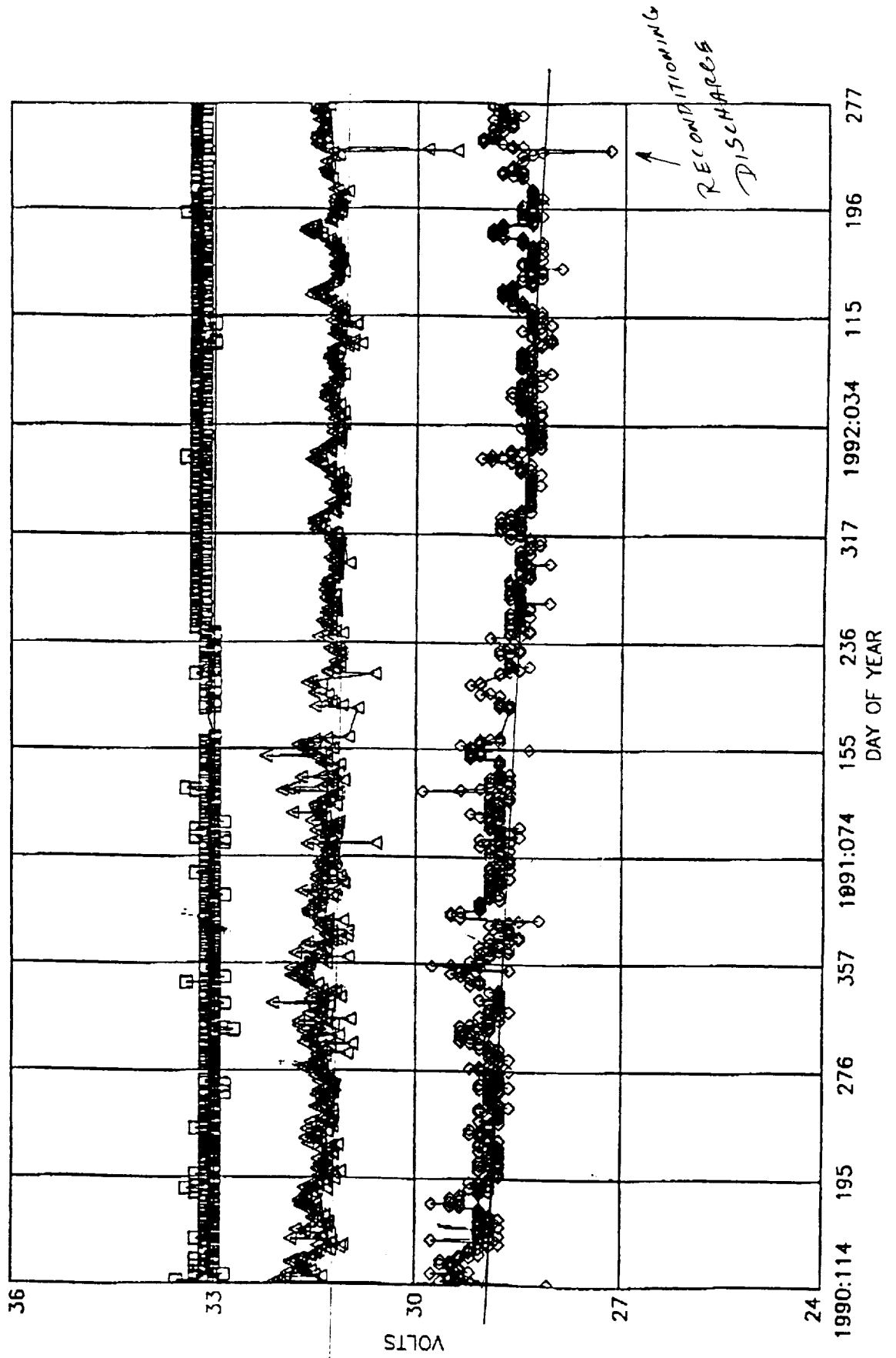
Based on nameplate capacity of 6 x 88 = 528 A-h

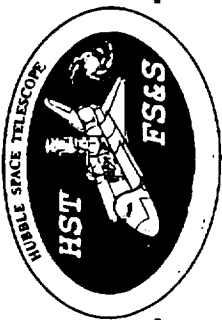




VOLTAGE DECAY (THRU 10/3/92)

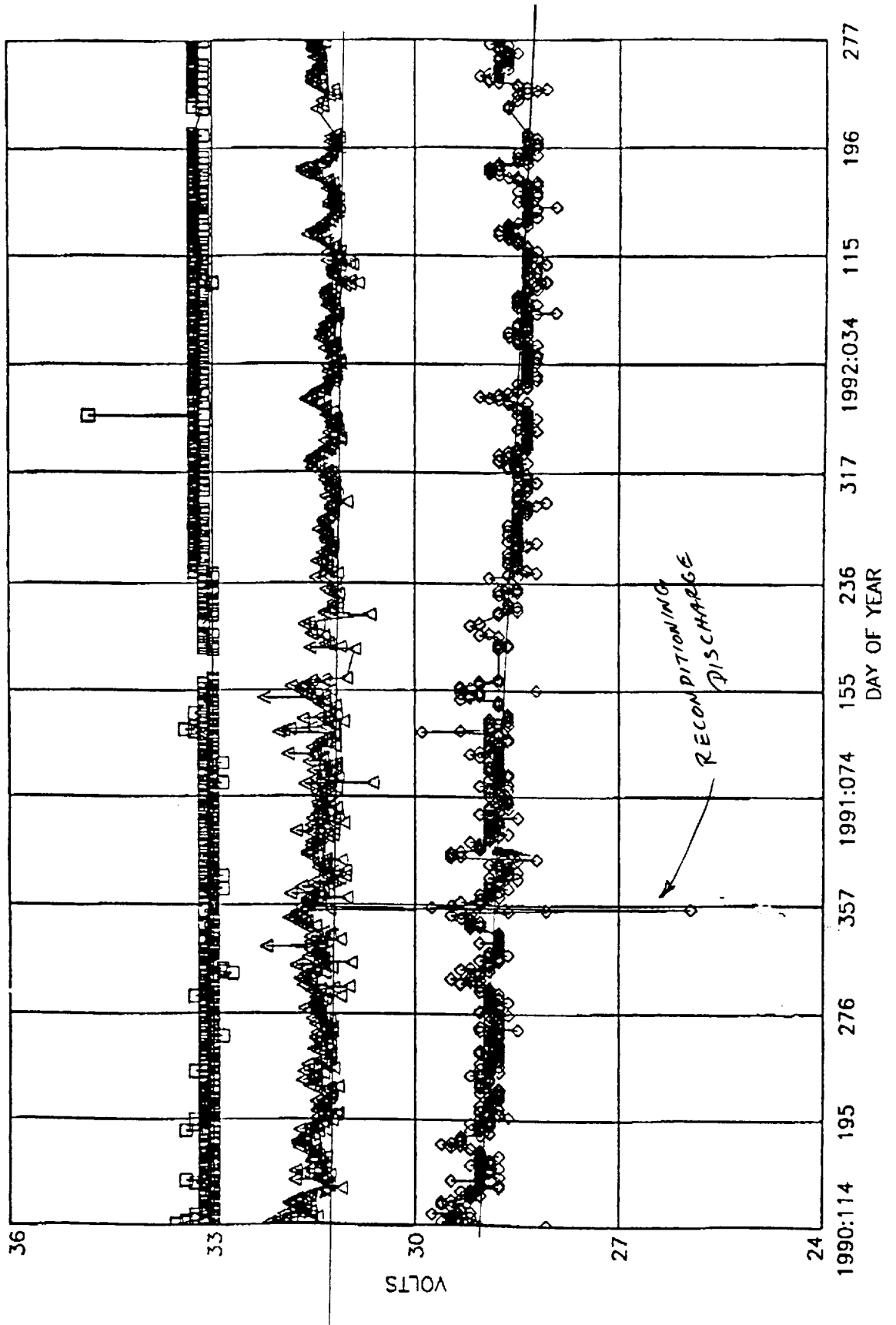
BATTERY #2





VOLTAGE DECAY (THRU 10/3/92)

BATTERY #4

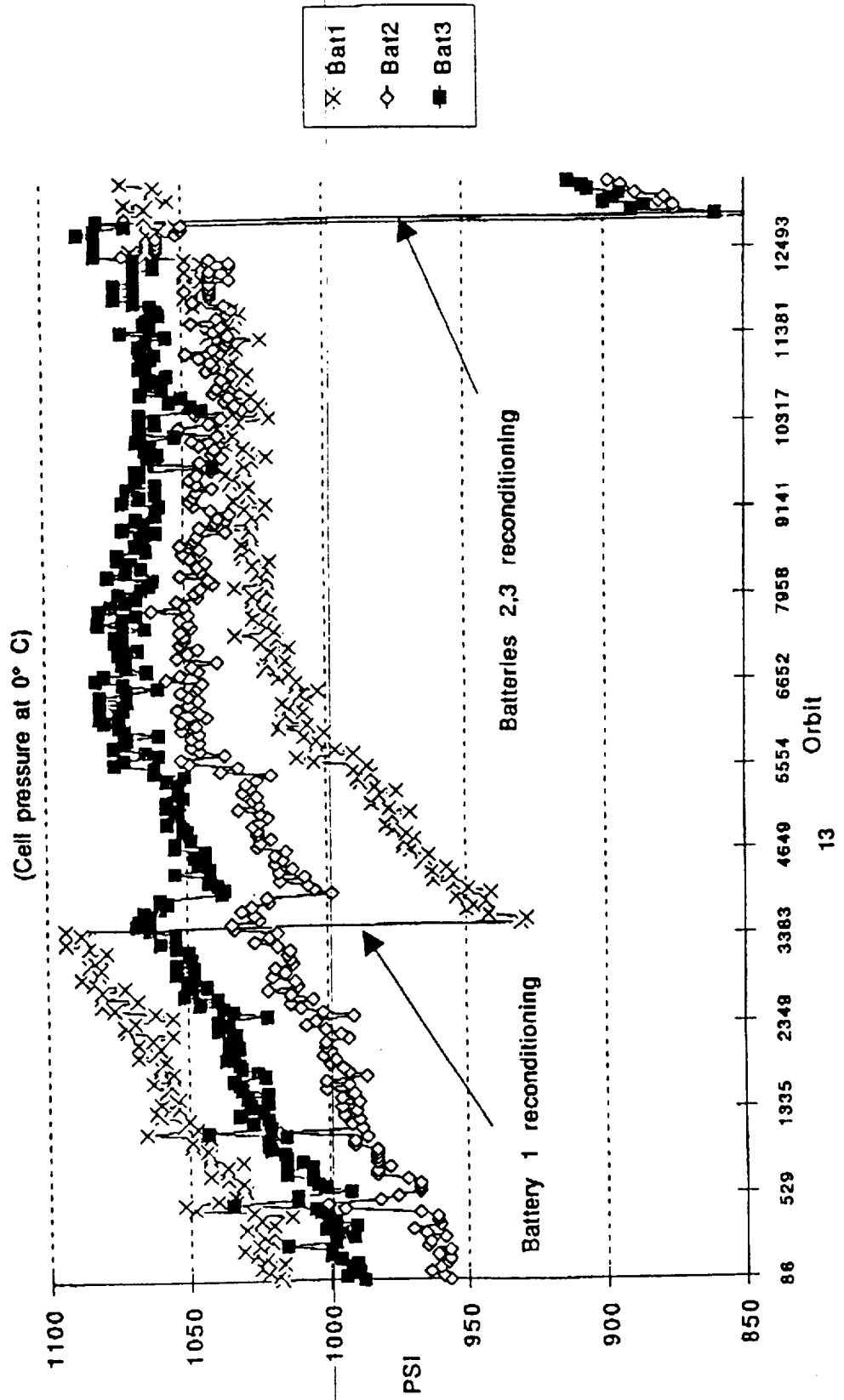




PRESSURE SINCE LAUNCH

BATTERIES 1, 2, & 3

Battery 1,2,3 pressures at the end of trickle charge. May, 1990 through September, 1992.



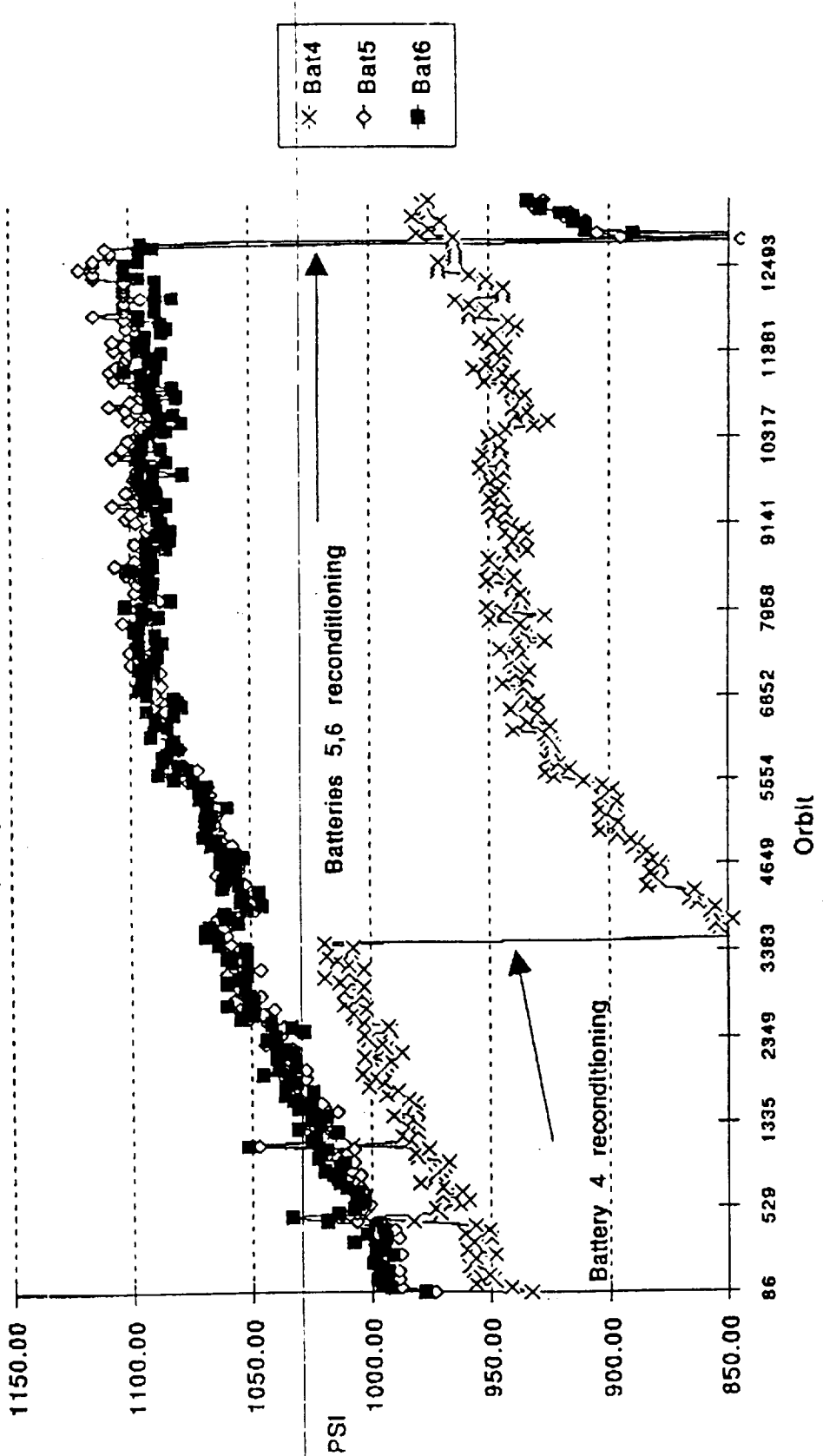


PRESSURE SINCE LAUNCH

BATTERIES 4, 5, & 6

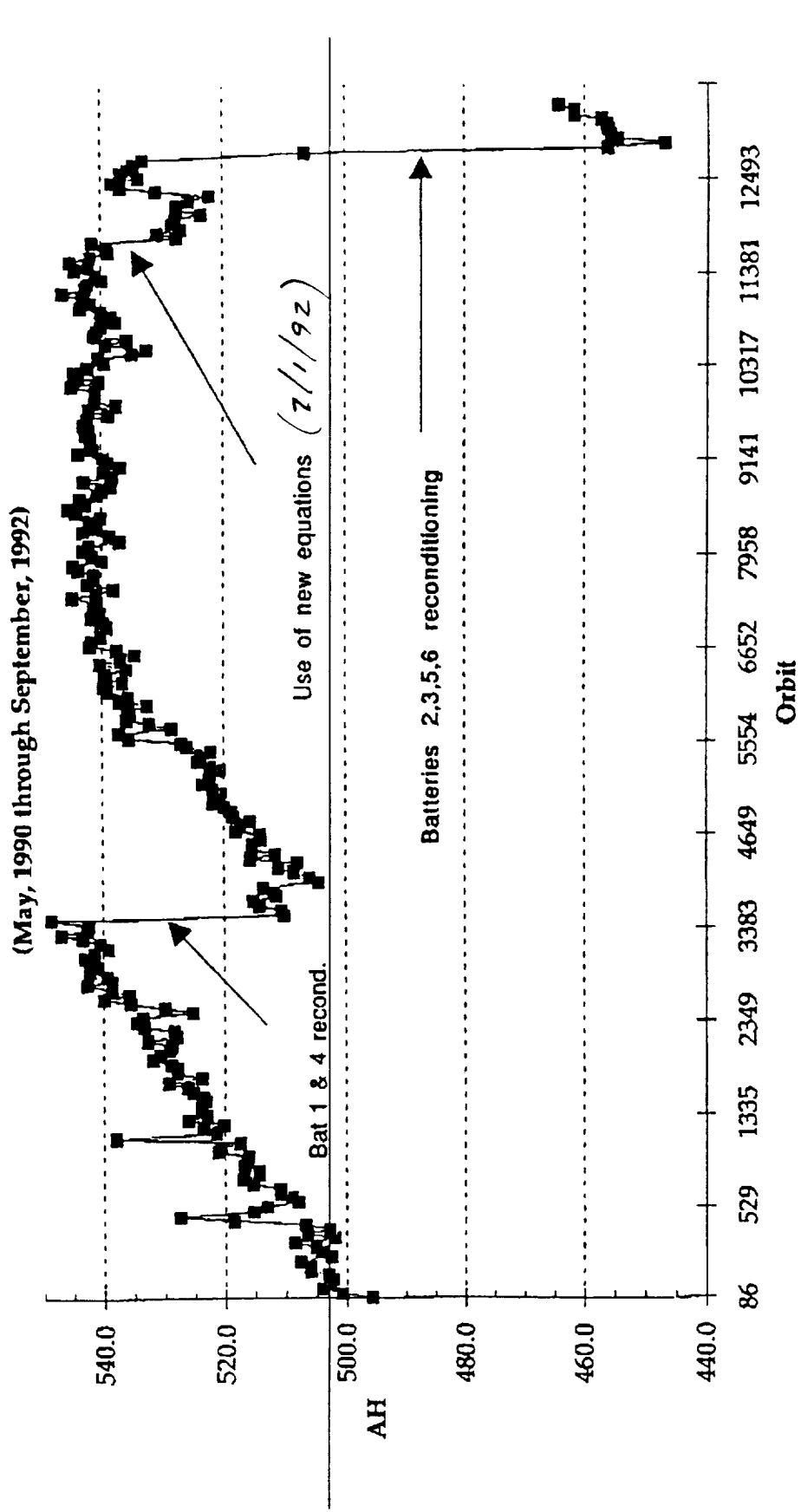
Battery 4,5,6 pressures at the end of trickle charge. May, 1990 through September, 1992.

(Cell pressure at 0° C)





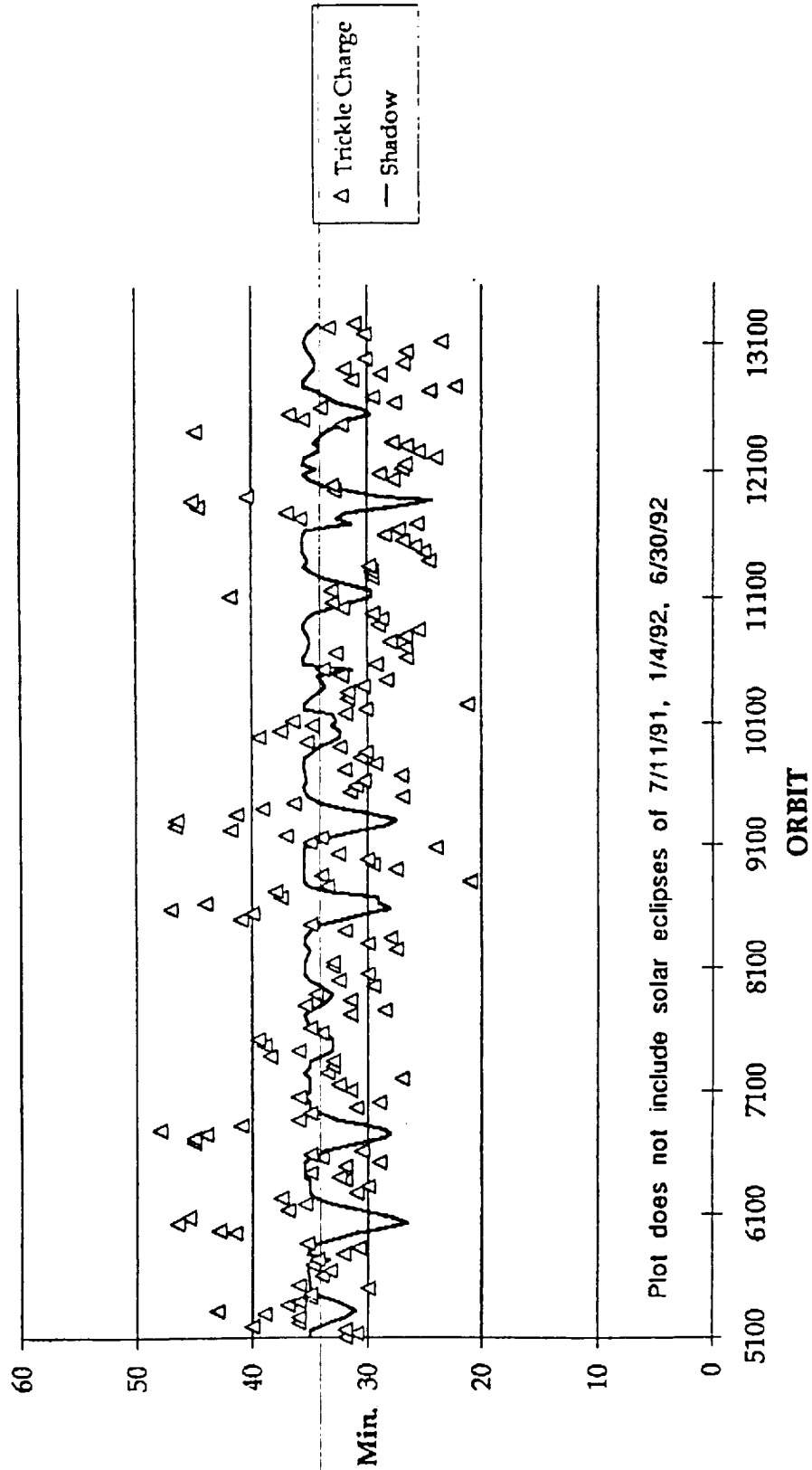
SYSTEM CAPACITY

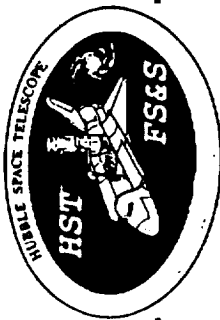




ECLIPSE TIME VS. TRICKLE CHARGE

Battery Trickle Charge & Shadow Duration (April, 1991- September, 1992)





CAPACITY TEST OBJECTIVES

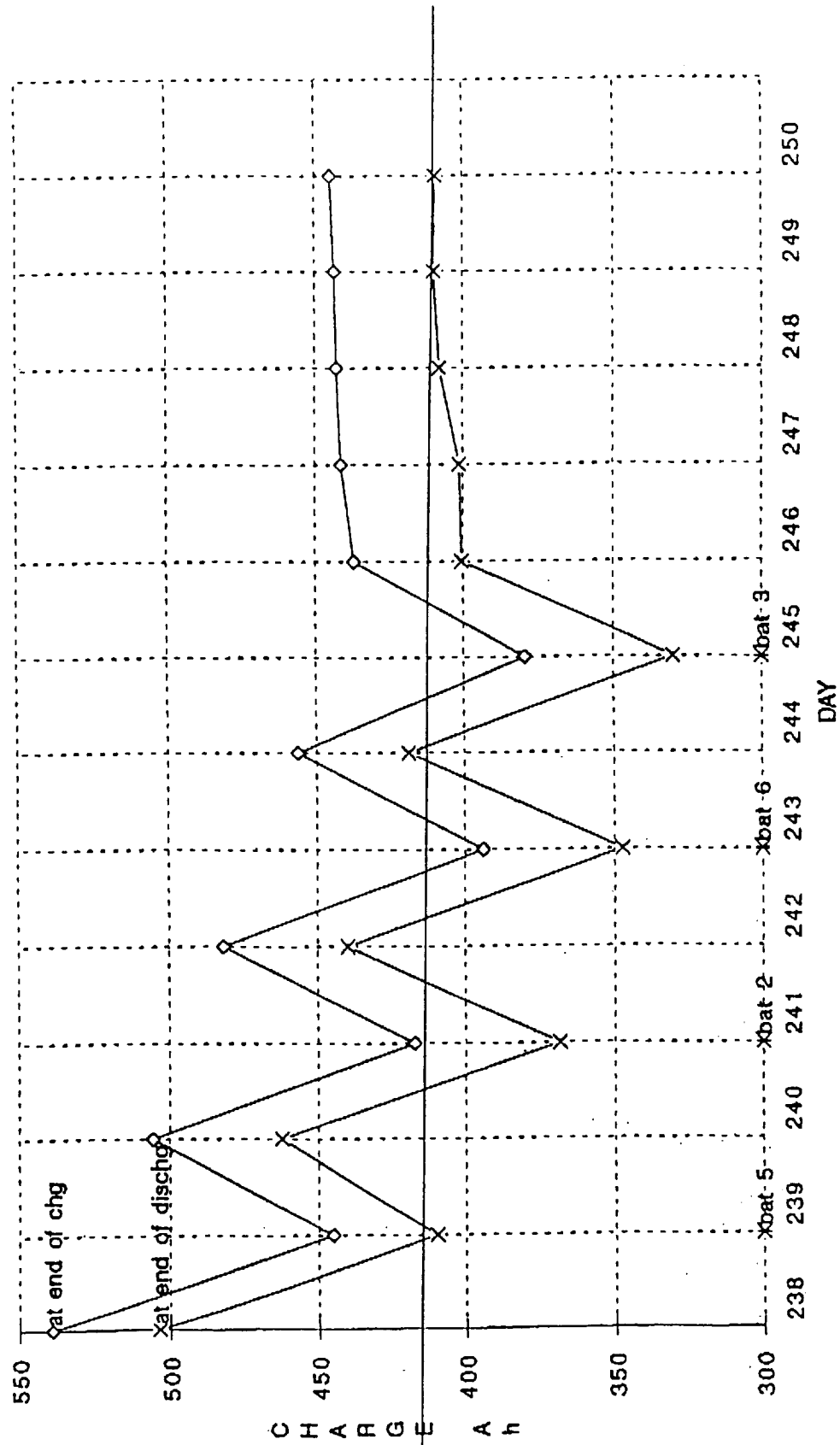
Determine the actual capacity of each battery. This is essential for:

- a. Establishing trend-analysis baseline for future SM replacement
- b. Are the batteries healthy at greater than 7% depth of discharge (the average to which the batteries are normally discharged)?
 - Determine if we are starting any soft shorts in cells
 - Need to trend end of discharge pressures
- c. Defining capacity versus pressure correlation, on a yearly basis.
- d. Evaluate the Safe Mode power margins.
 - New Safe Modes^{*} depend on having plenty of battery capacity
 - Safemode trip points must be lowered as known battery capacity declines, thus reducing margins above minimum requirement
- e. *Desire to have battery system "balanced"*

** - Spin Stabilized
- Zero Gyro*

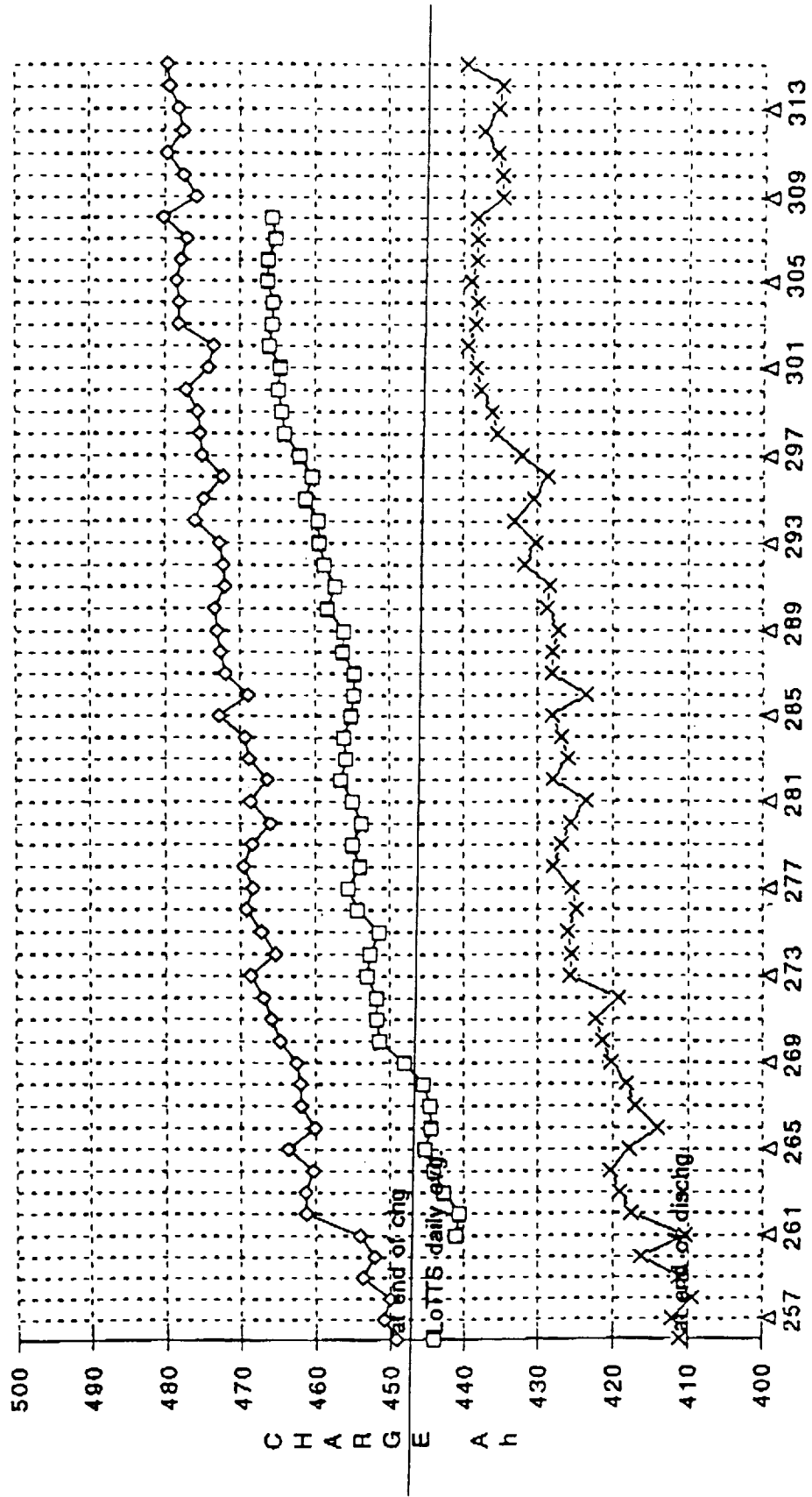


CAPACITY DURING TESTS

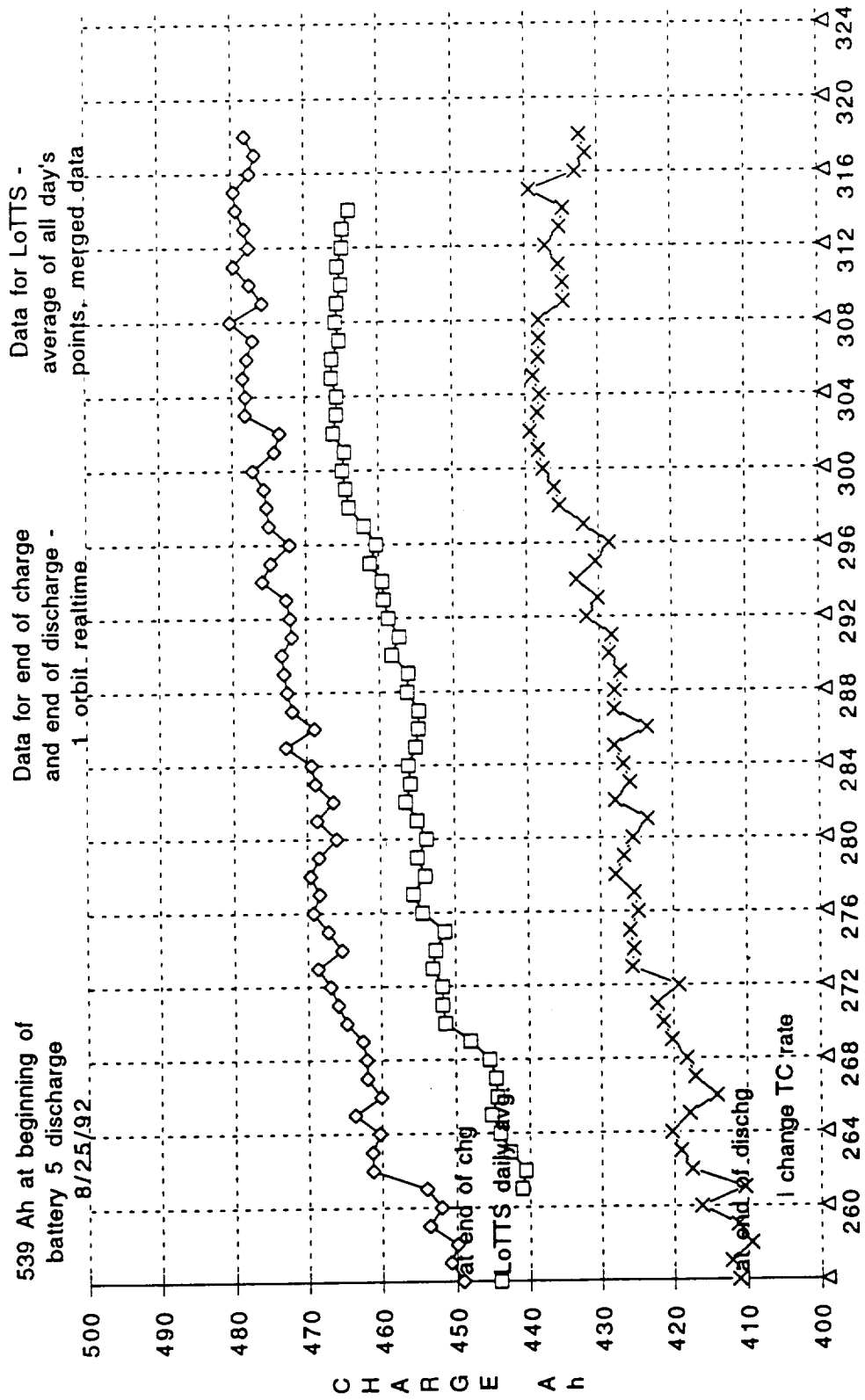




PRESENT CAPACITY RECOVERY TREND



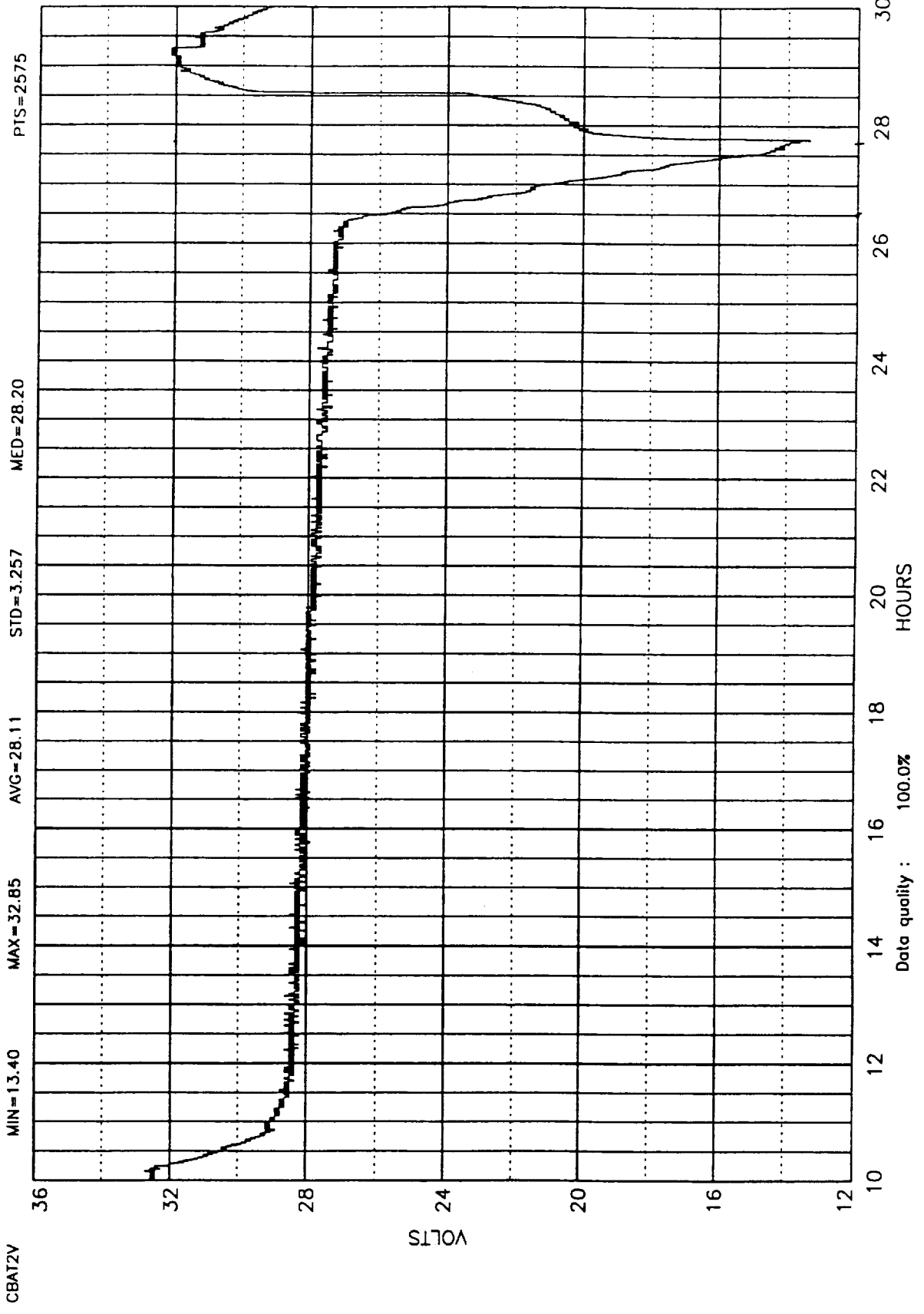
BATTERY CAPACITY CHECK - NORMALIZED TO TEMPERATURES - 9/12/92 THRU 11/13/92



HST LOTTIS - ESS
 Electrical Power Subsystem
 Battery 2 DISCHARGE

Data Processed : FRI AUG 28 17:02:00 1992 *Aleryccl*
 Frame quality : 0.00%

Last Data: 92:241:



Merged

Date Processed : FRI AUG 28 17:02:00 1992
Frame quality : 0.00%

HST LOTTIS - ESS Electrical Power Subsystem Battery 2 DISCHARGE

First Data: 92:240: Last Data: 92:241:
MIN = -22.00 MAX = 16.20 AVG = 1.688

CBATZCUR MED = 5.400 STD = 9.200 PTS = 6155 EPS00002.PLT

