CALORIMETRIC EVALUATION OF 250 AHR Li/SOCl2 CELLS

STEPHEN F. DAWSON

JET PROPULSION LABORATORY,
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

ERIC DARCY

NASA JOHSON SPACE CENTER

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OVERVIEW

CENTAUR 250 AHr $Li/SOCl_2$ BATTERIES ARE CURRENTLY BEING DEVELOPED

DESIGN EFFORTS

- PERFORMANCE
  - VOLTAGE AND CAPACITY, LAUNCH SHELF LIFE WITH NEGLIGIBLE VOLTAGE DELAY
- STRUCTURAL
  - ENVIRONMENTAL DYNAMICS, WEIGHT
- THERMAL
  - WIDE OPERATION RANGE AND SAFETY

ONE FRENCH AND TWO AMERICAN CONTRACTORS

- SAFT FRANCE
- ALLIANT TECHNICAL SYSTEMS
- YARDNEY TECHNICAL PRODUCTS

OBJECTIVE

SURVEY CELL DESIGN OPTIONS FOR EFFECTS ON HEAT GENERATION, AND DETERMINE CELL HEAT CAPACITY.

EXPERIMENTAL DESCRIPTION

HEAT GENERATION RATES FOR FULL SIZE 250 AHr CENTAUR CELLS WERE MEASURED IN A HART CONDUCTION CALORIMETER. HEAT CAPACITY MEASUREMENTS WERE CONDUCTED ON FRESH AND DISCHARGED CELLS.

HEAT CONDUCTION CALORIMETRY
42 AMP CONSTANT CURRENT DISCHARGES AT 40 C.

HEAT CAPACITY
DROP CALORIMETRY, 15 C DELTA, 25 C

DESIGN OPTIONS
CARBON: SAB AND HIGH SURFACE AREA CARBONS
SALT CONCENTRATION: 1.0 TO 1.8 M $LiAlCl_4/SOCl_2$
BINDER: BINDER PERCENTAGE (3.5 TO 6.5 %)
ELECTROLYTE ADDITIVE: PVC

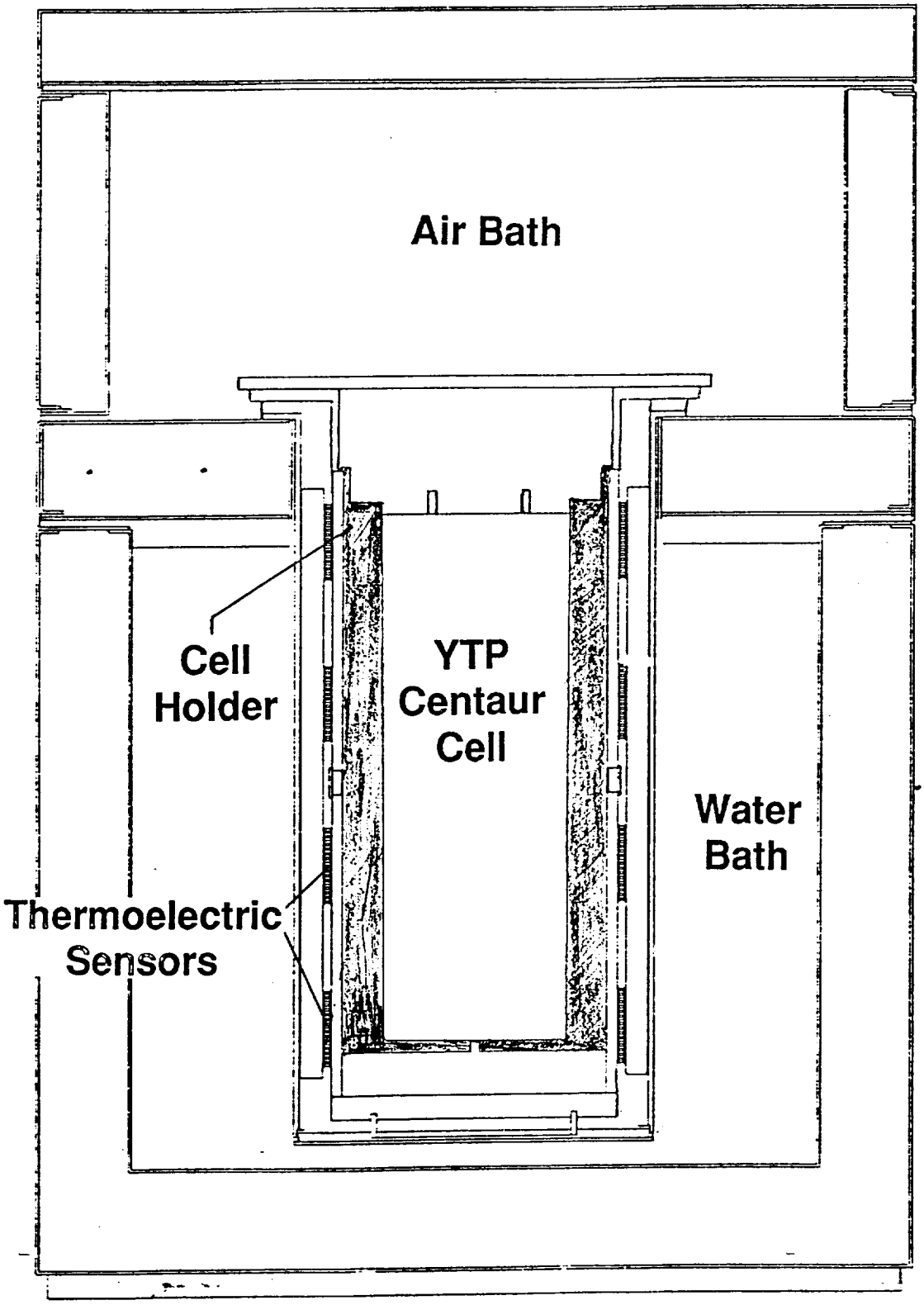
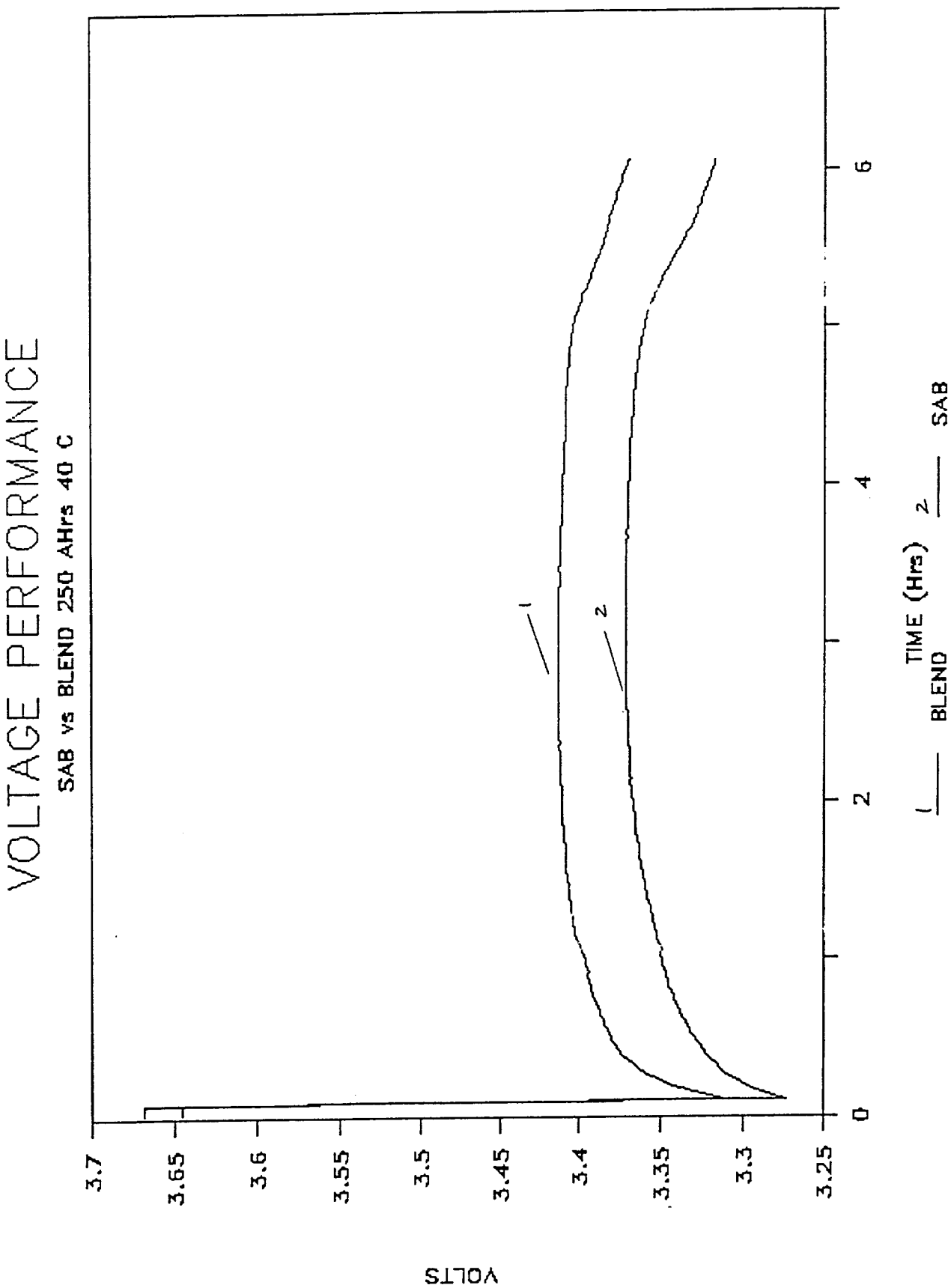


Fig. 1. Schematic of the cell in an aluminum cell holder in the calorimeter.

A battery calorimeter from Hart Scientific, Inc., was used. The heart of the system is the combination of water and air baths to provide heat conduction calorimetry in a temperature controlled range of 0 to 100 °C with heat sources up to 200 W. The battery chamber of the calorimeter (Fig. 1) is 5.5 inches in diameter and 11.5 inches tall. The system relies on the Seebeck or thermocouple effect in which a voltage is produced proportional to the temperature difference across a semiconductor thermoelectric sensor located in the heat flow between the battery and the water bath. Since the sensors have a stable thermal conductivity and are placed so as to be in the major heat flow path, the temperature difference, and hence, the voltage generated across the sensors is directly proportional to the heat flow from the calorimeter chamber to the temperature stabilized water bath heat sink. The system maintains the water bath stabilized to within ± 0.005 °C.


VOLTAGE PERFORMANCE
SAB vs BLEND 250 AHrs 40 C
VOLTS
3.7
3.65
3.6
3.55
3.5
3.45
3.4
3.35
3.3
3.25
0
2
4
6
TIME (Hrs)
1 BLEND
2 SAB
1
2

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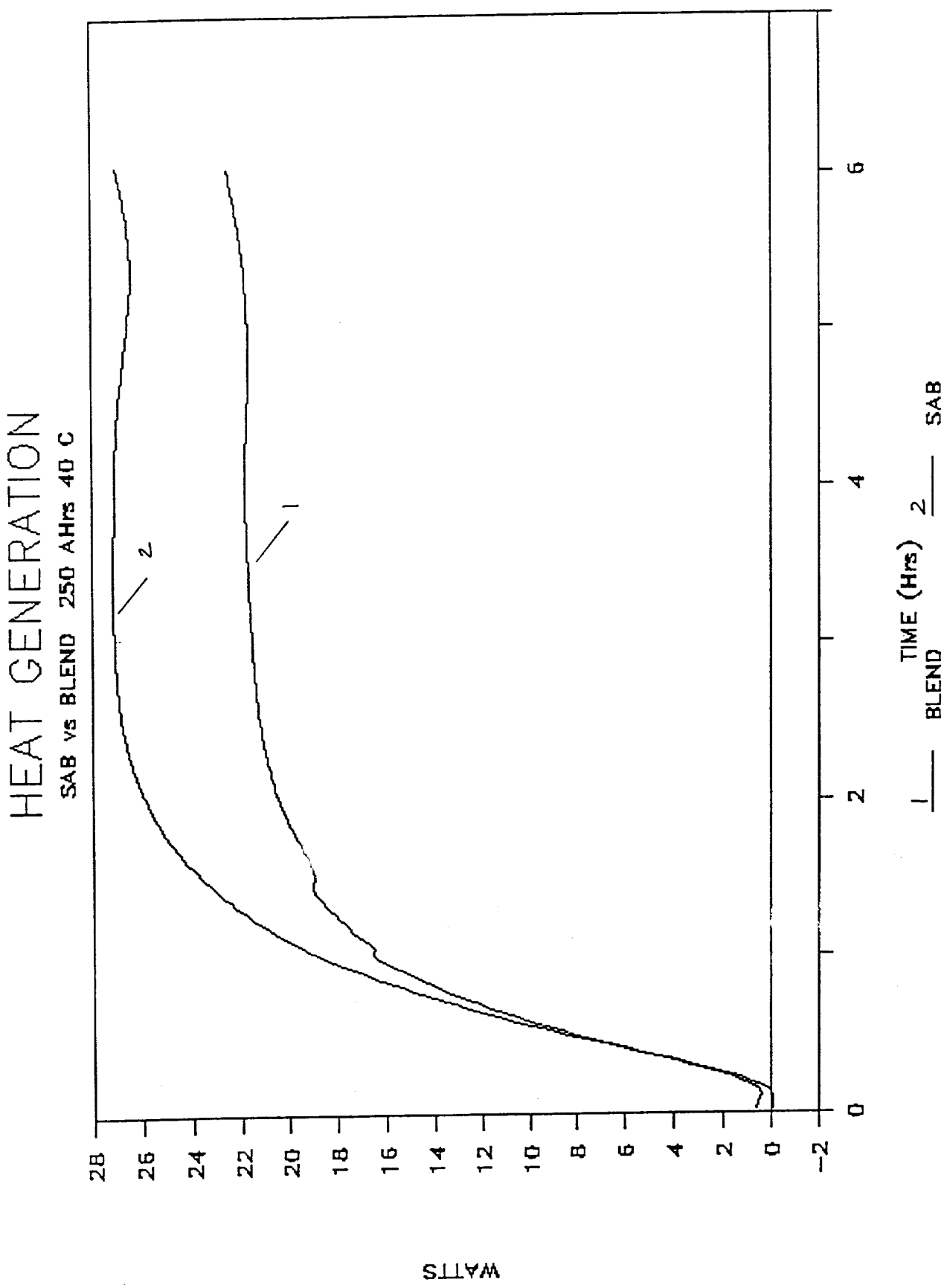
DISCHARGE PERFORMANCE OF STANDARD CARBON AND BLENDED CARBON ELECTRODES AT 40 C AND 42 AMP CONSTANT CURRENT TO 250 AHrs IS GIVEN. THE BLENDED CARBON ELECTRODE CELL SHOWS HIGHER VOLTAGE PERFORMANCE THROUGHOUT THE DISCHARGE.


HEAT GENERATION
SAB vs BLEND 250 AHrs 40 C
WATTS
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
0
2
4
6
TIME (Hrs)
1 BLEND
2 SAB
1
2

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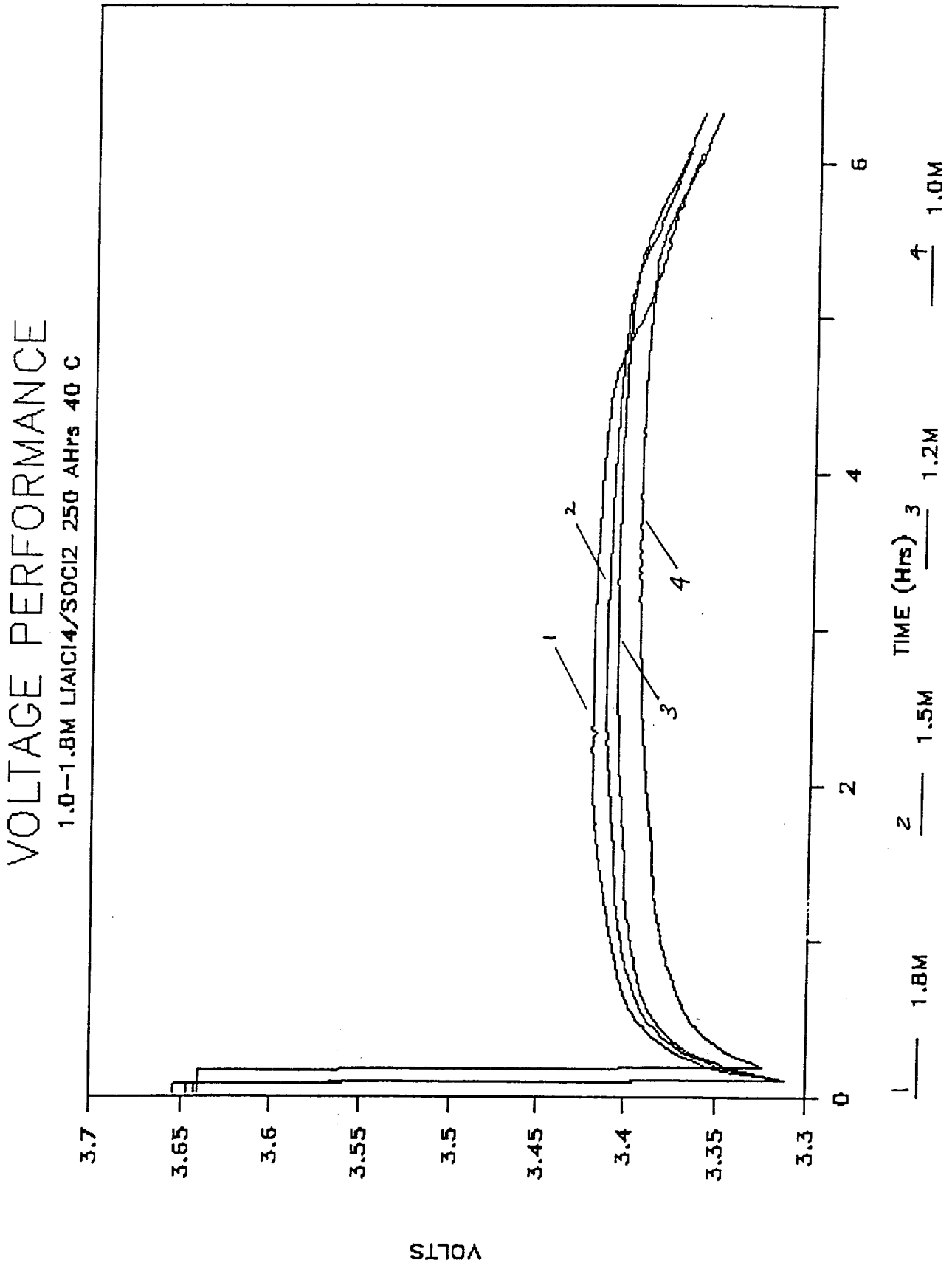
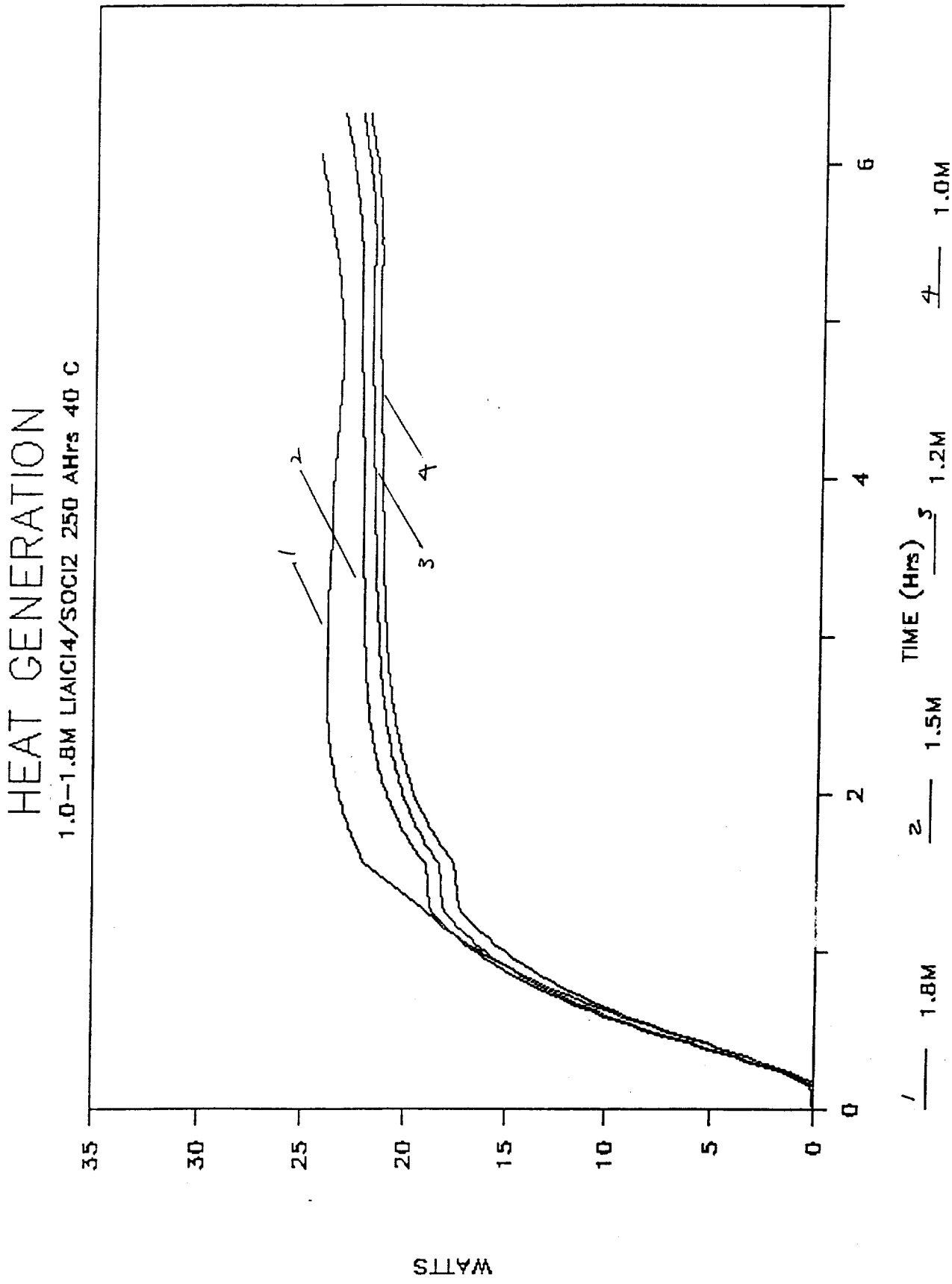
HEAT GENERATION RATES ARE DISPLAYED FOR STANDARD AND BLENDED CARBON ELECTRODE CELLS. HIGHER HEAT GENERATION IS OBSERVED FOR THE STANDARD SAB CELLS.


VOLTAGE PERFORMANCE
1.0–1.8M LiAlCl4/SOCl2 250 AHrs 40 C
VOLTS
3.7
3.65
3.6
3.55
3.5
3.45
3.4
3.35
3.3
0
2
4
6
TIME (Hrs)
1
1.8M
2
1.5M
3
1.2M
4
1.0M
1
2
3
4

VOLTAGE PERFORMANCE THROUGH 250 AHrs FOR CELLS WITH ELECTROLYTE SALT CONCENTRATION FROM 1.0 TO 1.8 M $LiAlCl_4/SOCl_2$ SHOW INCREASING VOLTAGE PERFORMANCE WITH INCREASING SALT CONCENTRATION.


HEAT GENERATION
1.0-1.8M LiAlCl4/SOCl2 250 AHrs 40 C
WATTS
35
30
25
20
15
10
5
0
0
2
4
6
TIME (Hrs)
1
1.8M
2
1.5M
3
1.2M
4
1.0M
1
2
3
4

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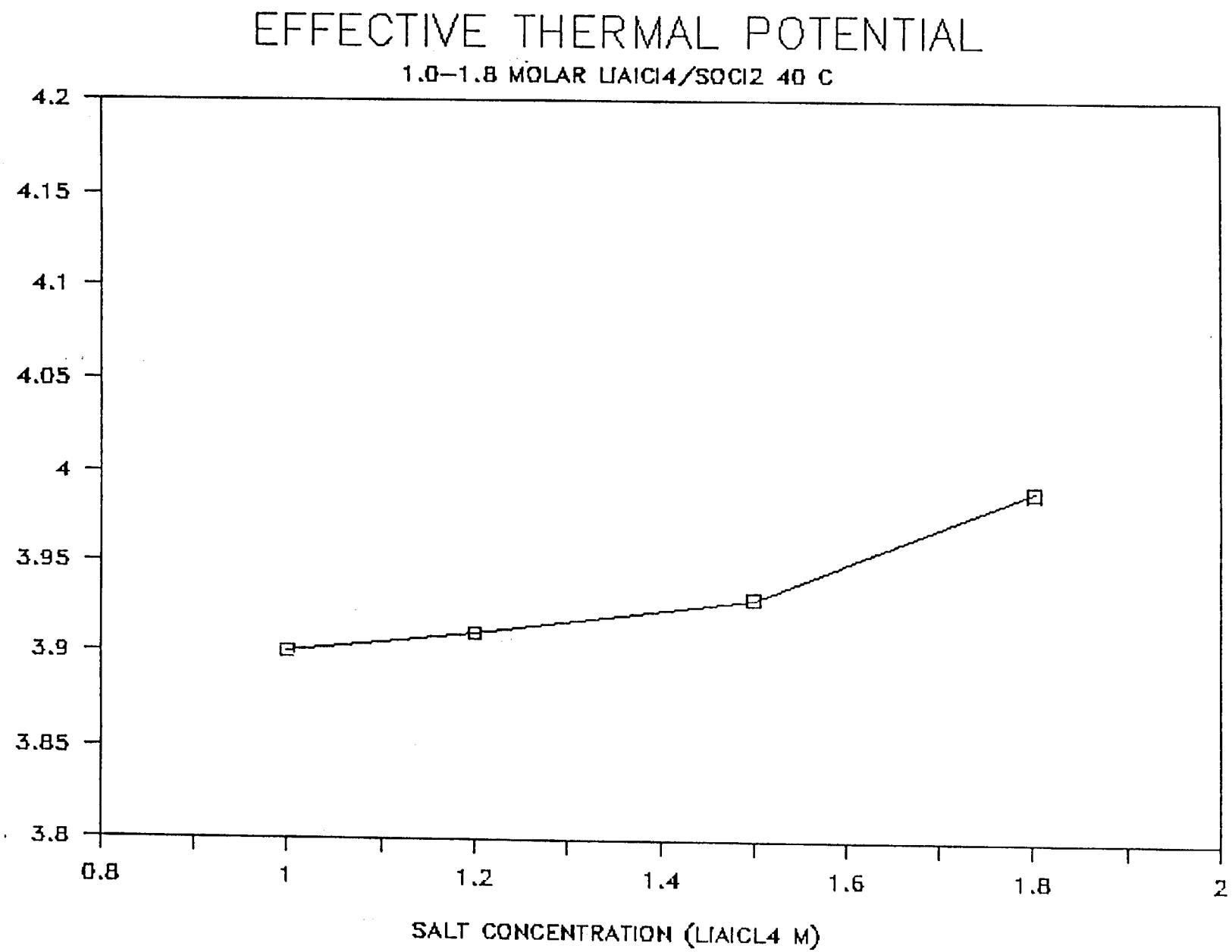
HEAT GENERATION RATES INCREASE WITH HIGHER SALT CONCENTRATION.


EFFECTIVE THERMAL POTENTIAL
1.0–1.8 MOLAR LIAICI4/SOCI2 40 C
ETP (40 C)
4.2
4.15
4.1
4.05
4
3.95
3.9
3.85
3.8
0.8
1
1.2
1.4
1.6
1.8
2
SALT CONCENTRATION (LIAICL4 M)

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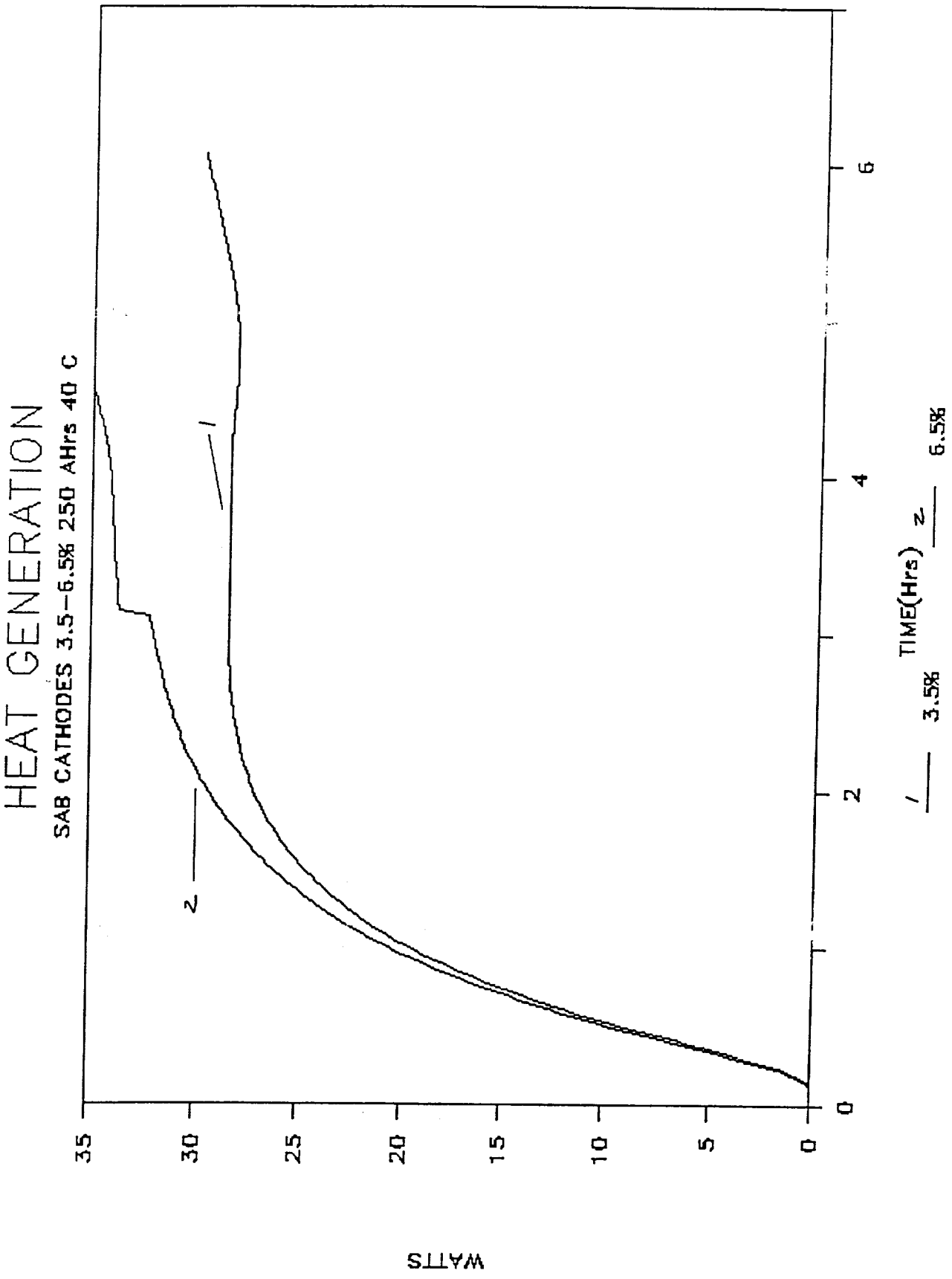
EFFECTIVE THERMAL POTENTIALS (ETP) ARE SHOWN AS A FUNCTION OF CELL SALT CONCENTRATION. ETP VALUES ARE GENERATED FROM INSTANTANEOUS HEATS, LOAD CURRENT, AND LOAD VOLTAGE BY THE FOLLOWING EQUATION:

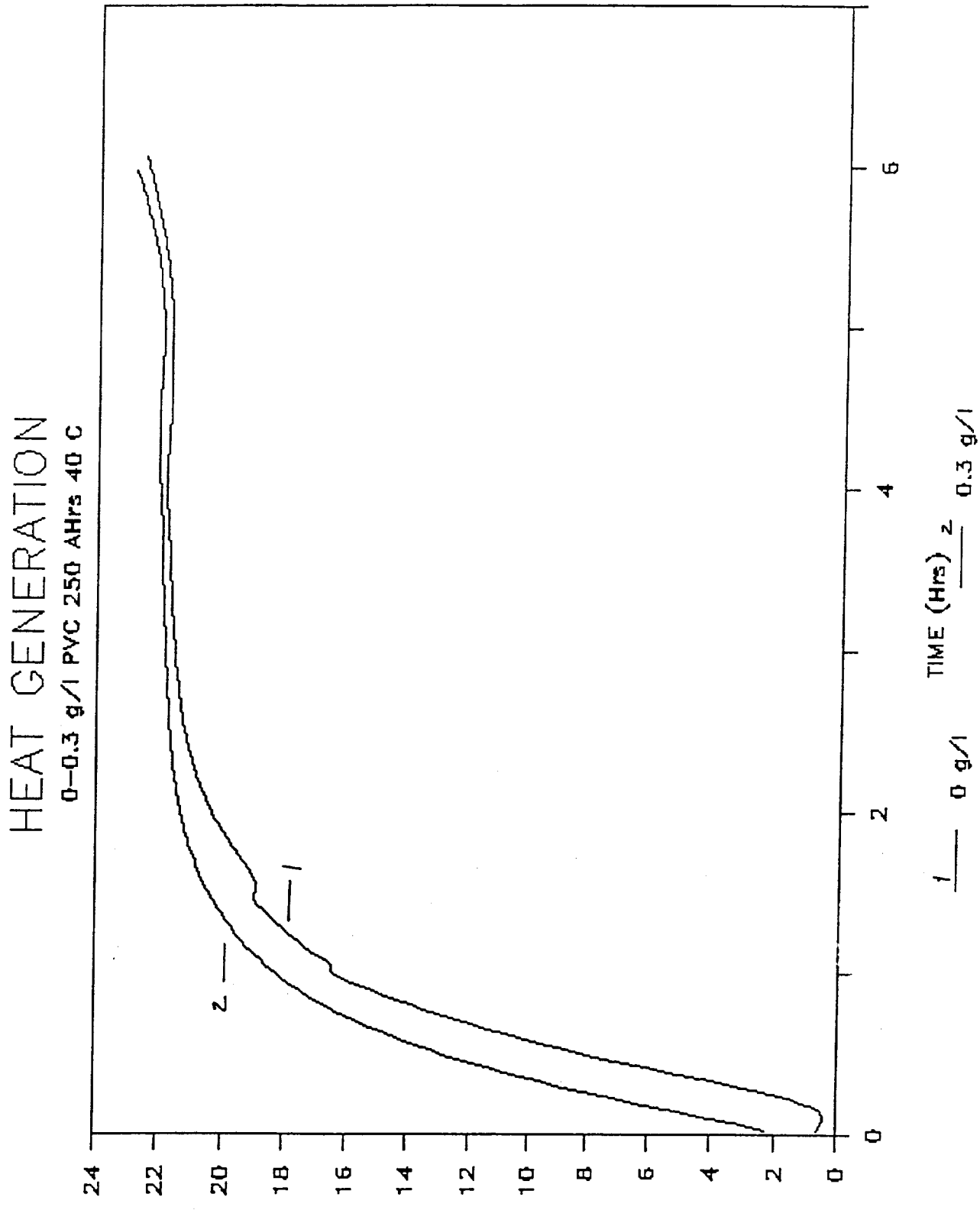
$$ETP=q/I+V_L$$

WHERE: q= HEAT GENERATION (WATTS)
I= DISCHARGE CURRENT
V_L= LOAD VOLTAGE

ETP IS A RELATIVE MEASURE OF THE HEAT GENERATION OF THE CELL AND MAY BE USED FOR ENGINEERING COMPARISON.


HEAT GENERATION
SAB CATHODES 3.5-6.5% 250 AHrs 40 C
WATTS
TIME(Hrs)
1 3.5%
2 6.5%
0
5
10
15
20
25
30
35
2
4
6

THE EFFECT OF BINDER PERCENTAGE ON CELL HEAT GENERATION IS GIVEN. CELL HEAT GENERATION IS OBSERVED TO INCREASE WITH INCREASING BINDER CONTENT OVER THE RANGE TESTED.


HEAT GENERATION
0-0.3 g/l PVC 250 AHrs 40 C
WATTS
TIME (Hrs)
1 — 0 g/l
2 — 0.3 g/l
1
2
0
2
4
6
0
2
4
6
8
10
12
14
16
18
20
22
24

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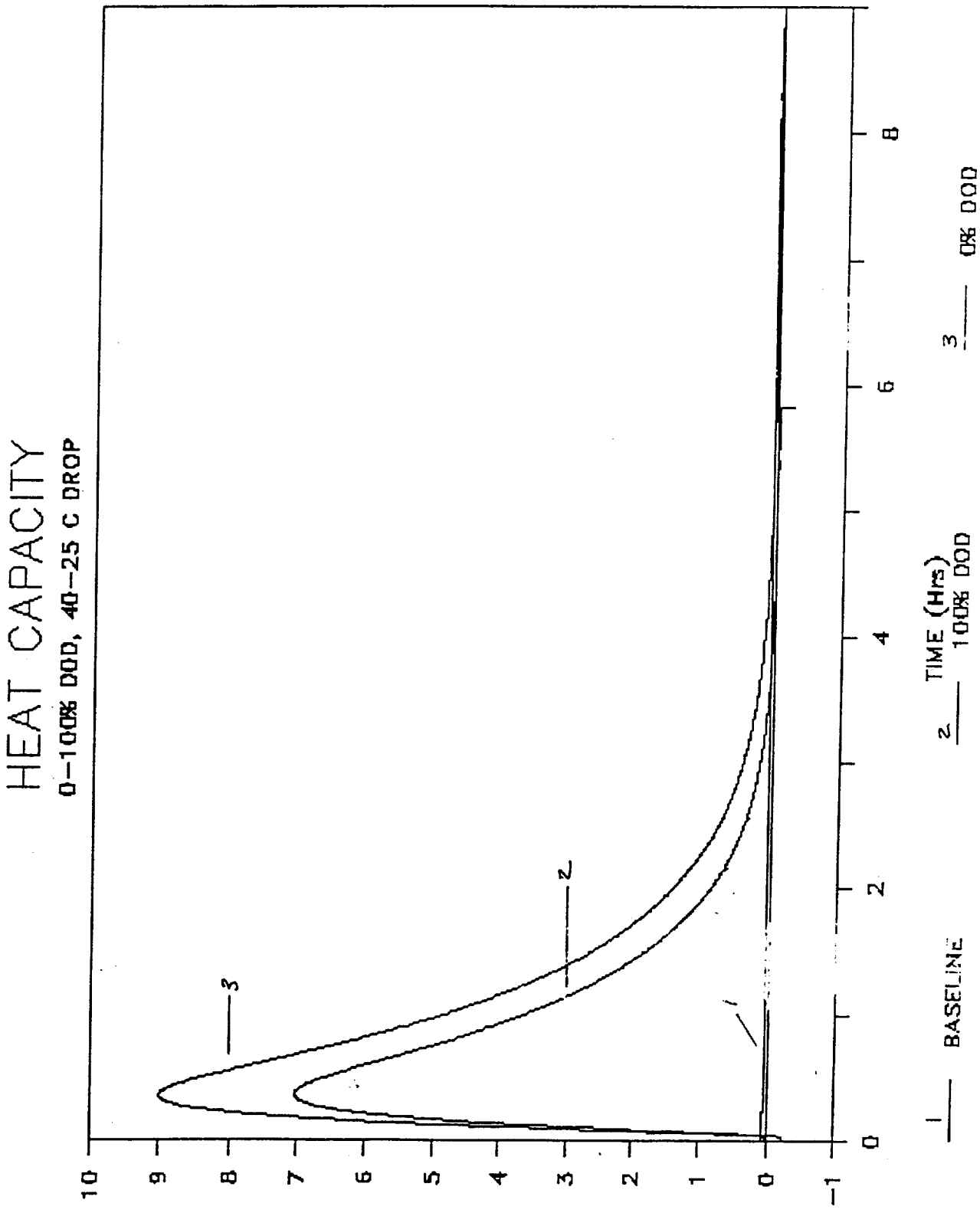
INCREASED HEAT GENERATION IS OBSERVED FOR CELL CONTAINING 0.3 g/l PVC OVER CELL WITHOUT PVC WHEN DISCHARGED WITH LITTLE OR NO STORAGE.


HEAT CAPACITY
0-100% DOD, 40-25 C DROP
WATTS
TIME (Hrs)
1 BASELINE
2 100% DOD
3 0% DOD

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HEAT CAPACITY FOR FRESH AND COMPLETELY DISCHARGED CELLS (315+ AHr) SHOW A 10% DROP IN THE C_p OF THE DISCHARGE CELL.

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CONCLUSION

BLENDED CARBON CELLS SHOW INCREASED DISCHARGE VOLTAGE AND DECREASED HEAT EVOLUTION OVER CELLS WITH STANDARD SAB ELECTRODES.

DECREASING $LiAlCl_4$ IN $SOCl_2$ ELECTROLYTES SHOW DECREASING CELL LOAD VOLTAGES AND LOWER HEAT EVOLUTION.

INCREASED PTFE BINDER CONTENT SHOWS INCREASED HEAT GENERATION OVER THE RANGE TESTED (3.5-6.5%).

ADDITION OF PVC TO THE CELL ELECTROLYTE PRODUCES HIGHER HEAT OUTPUTS IN FRESH CELLS.

CELL HEAT CAPACITY DECREASES WITH CELL DISCHARGE ON THE ORDER OF 10% AT FULL DISCHARGE.