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PRESENTATION TO
1991 NASA AEROSPACE BATTERY WORKSHOP

OCTOBER 29-31, 1991
U.S. SPACE & ROCKET CENTER
HUNTSVILLE, AL

PULSED POWER MOLTEN SALT BATTERY

CONTRACT NO. F33615-88-C-2911
AERO PROPULSION LABORATORY
WRIGHT LABORATORY, WL/POOS-2
WRIGHT PATTERSON AIR FORCE BASE, OH 45433

S.D. ARGADE
TECHNOCHEM COMPANY
203-A CREEK RIDGE RD.
GREENSBORO, NC 27406

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INTRODUCTION

CHLORINE CATHODES

UNIT CELL DEVELOPMENT

CELL STACK DEVELOPMENT

SUMMARY

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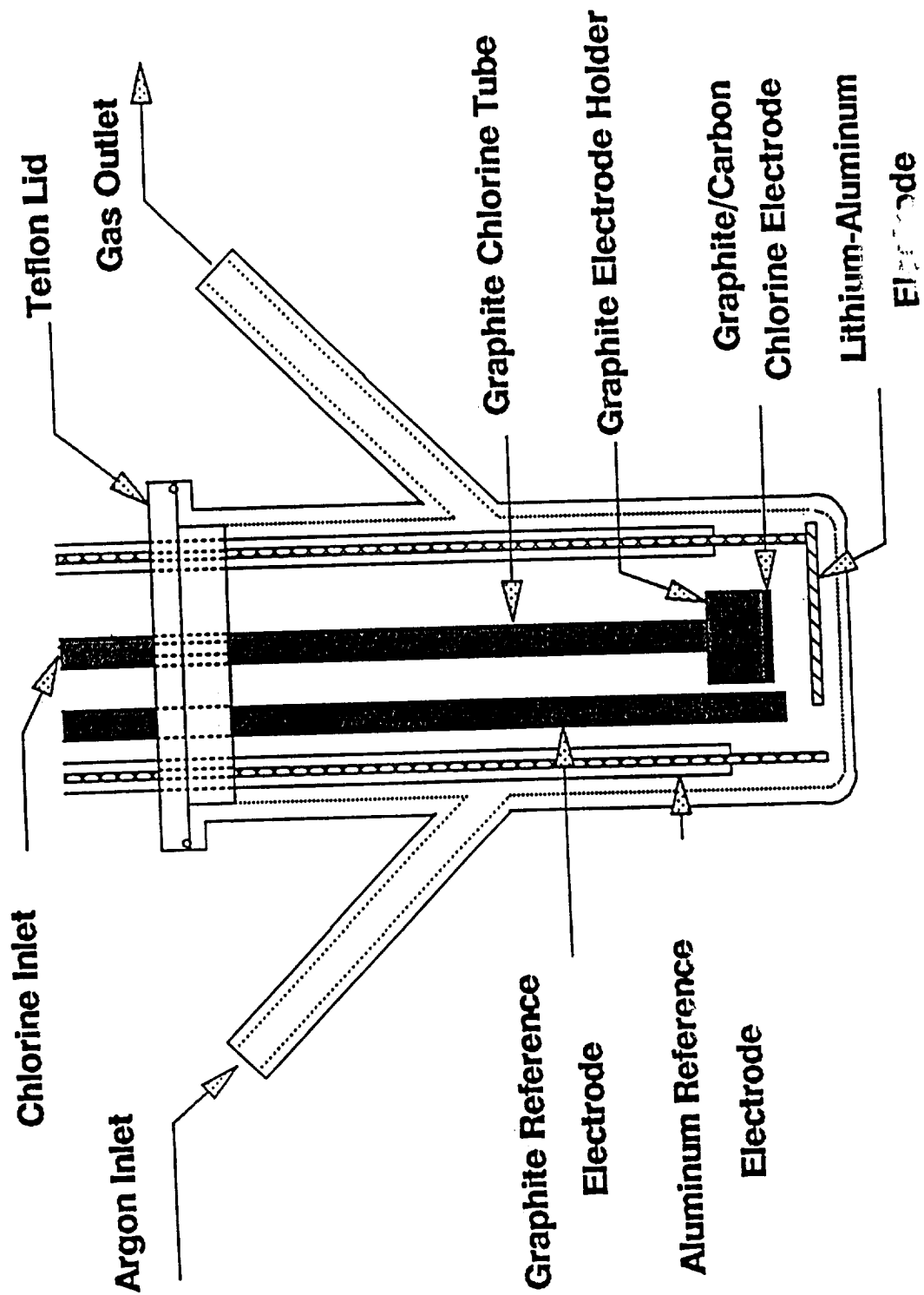
PHASE II PROGRAM GOALS

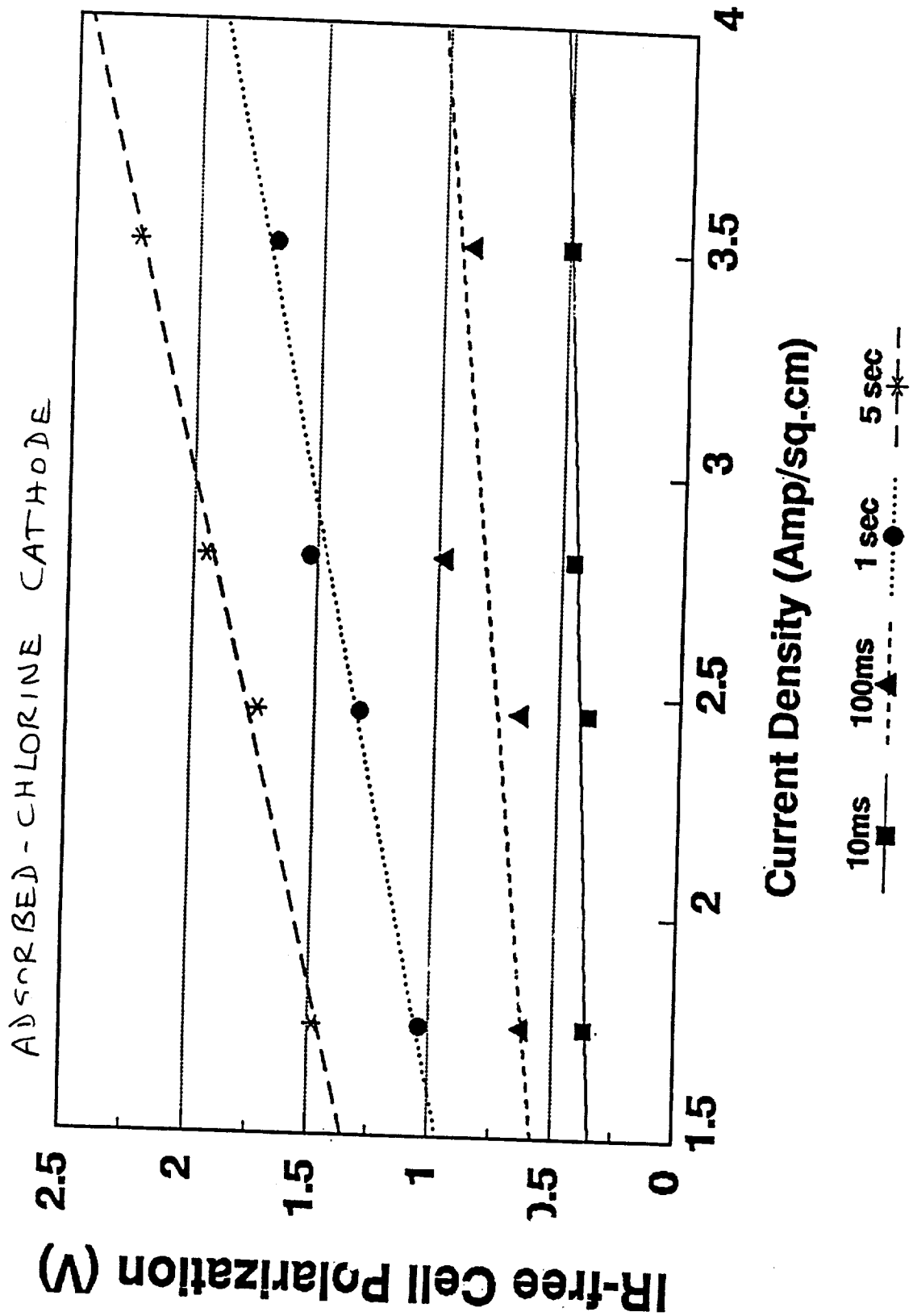
- **Develop and demonstrate a Li/Al/chlorine molten salt battery design**
- **Develop improved chlorine cathodes**
- **Develop unit cell design**
- **Demonstrate a stack/battery design**

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CHLORINE CATHODES

- **Uniform Pore Size Distribution**
- **Good Permeability to Chlorine**
- **Activated Surface**
- **Electrochemical Activation**





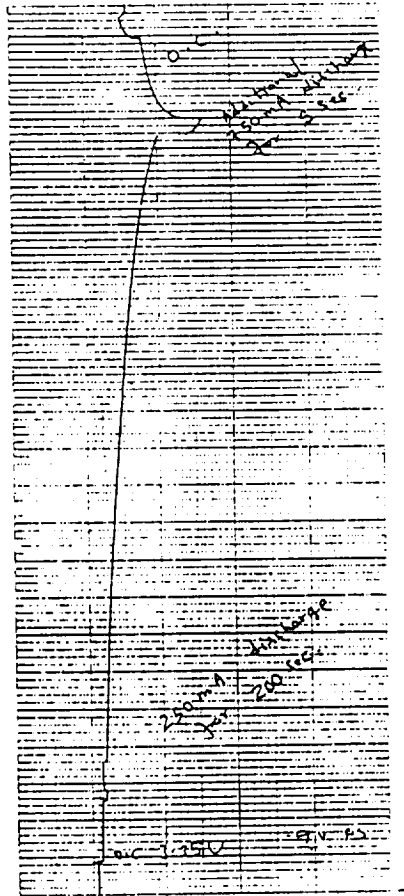
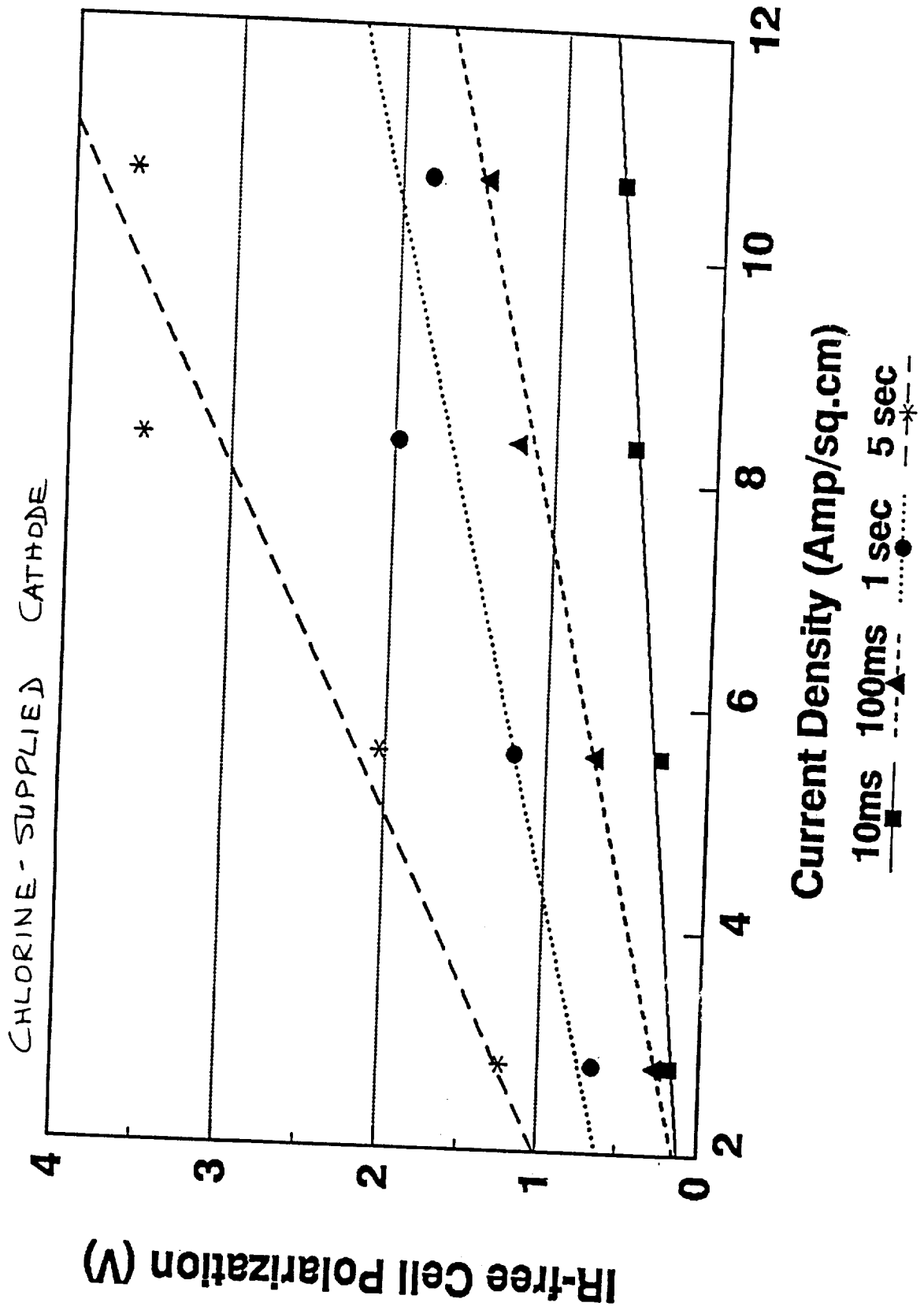
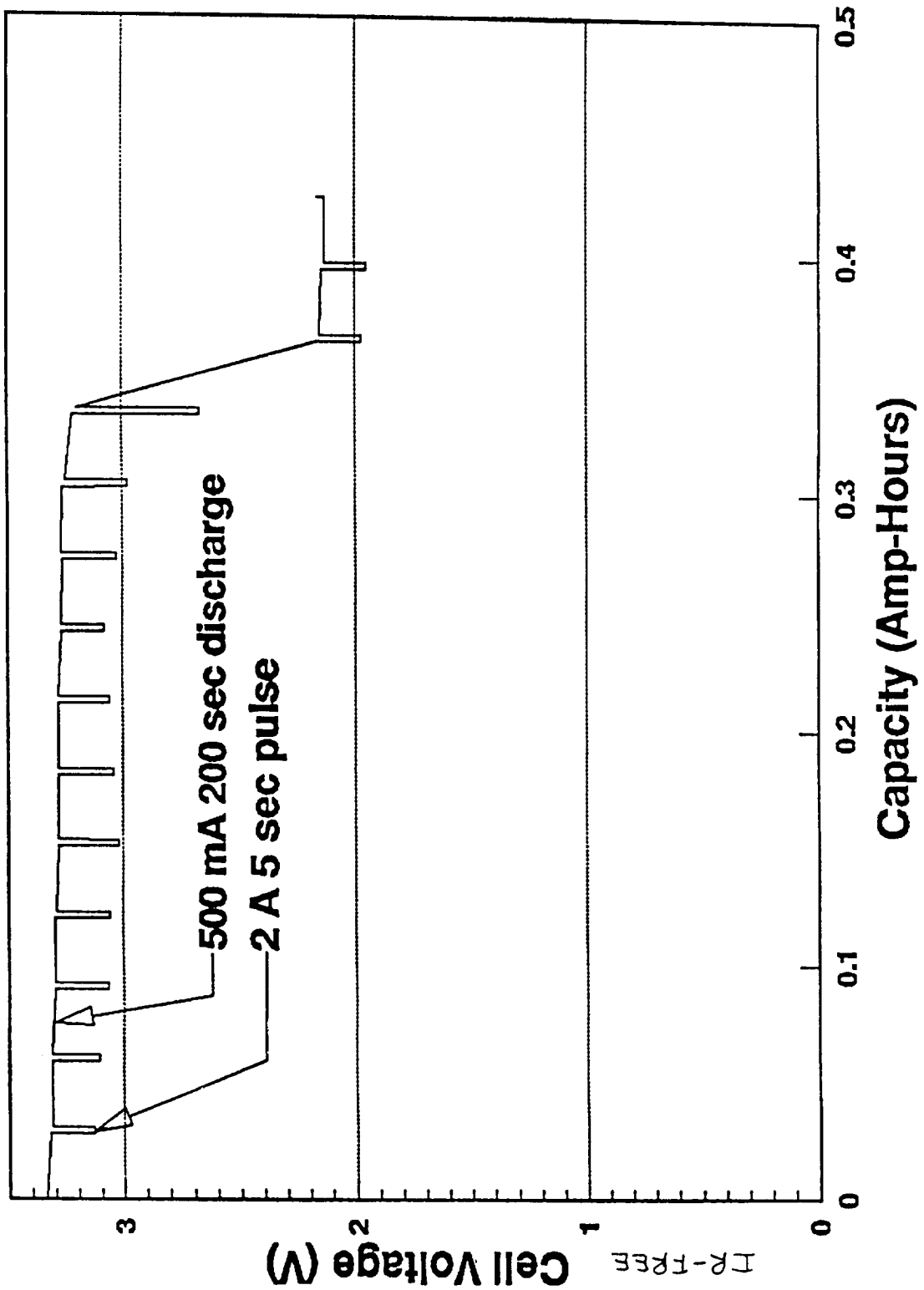


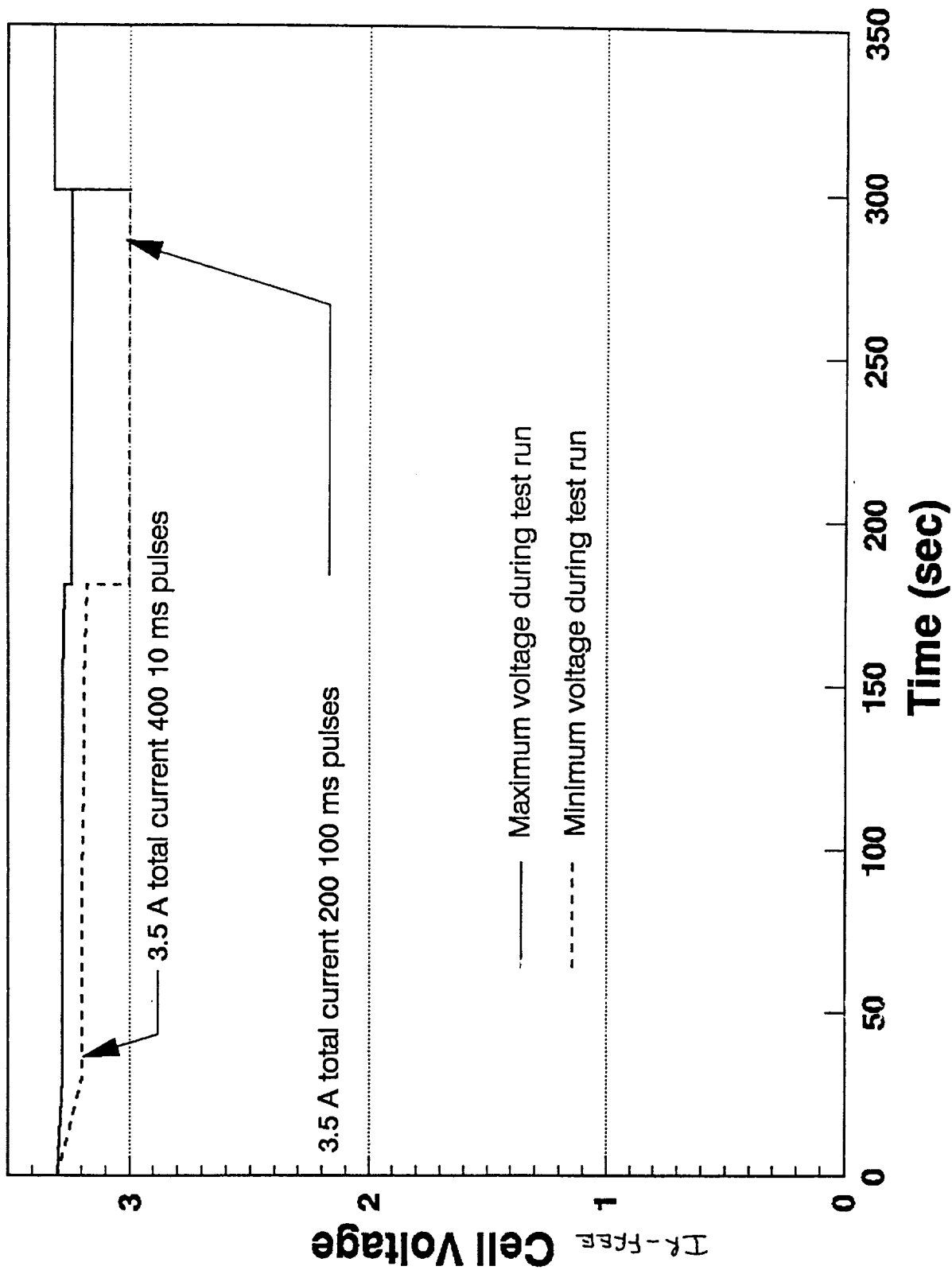
Fig. 5 Discharge characteristics for a Li-Al/carbon 8-9-2 absorbed chlorine cell under test cycle 1 regime, 250 mA for 200 sec followed by 1 A current



Li-Al / CHLORINE CELL 450°C



Li-Al/CHLORINE CELL, 450°C



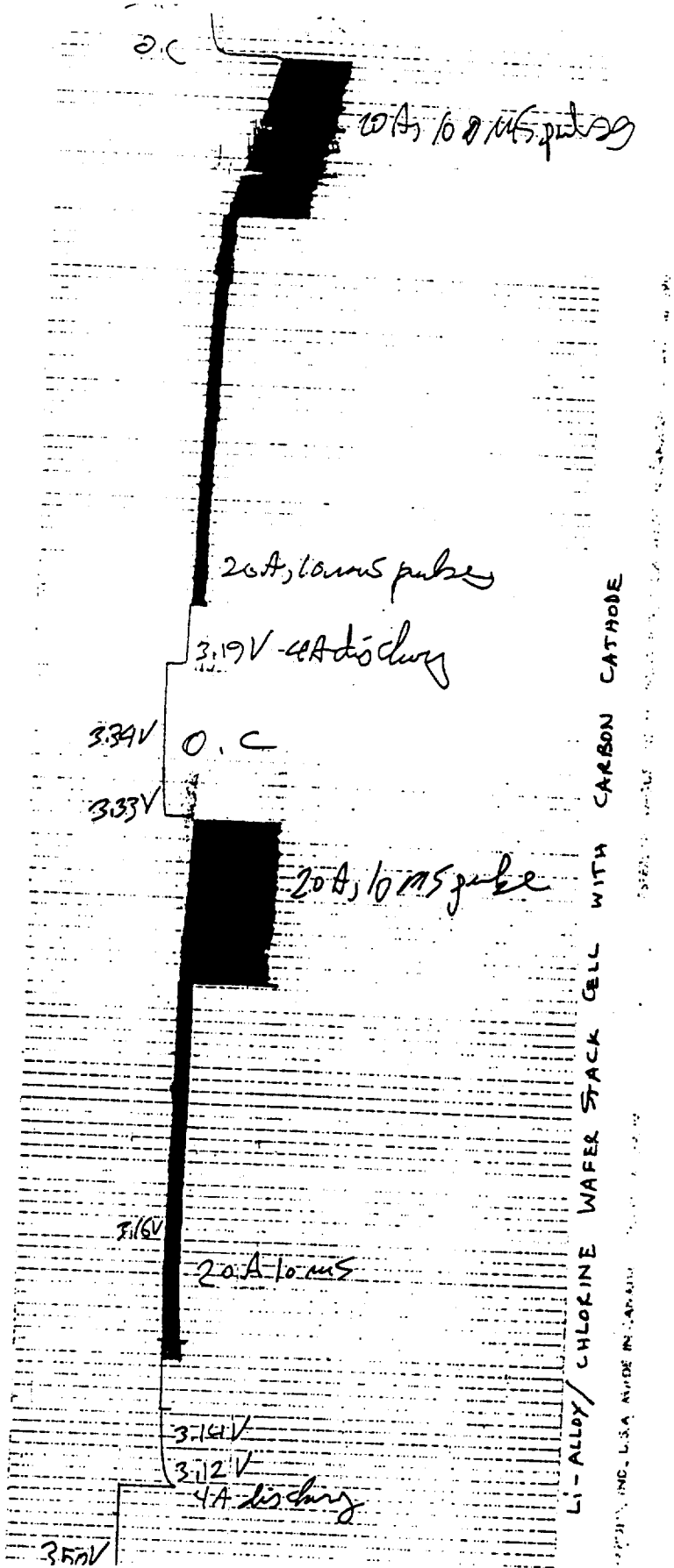
Cathode Performance Summary

- **Single Pulsing**
- **Repetitive Pulsing**
- **Steady State Discharge**
- **200 sec Steady State Load + 5 sec Pulse**
- **Steady State Load + 100, 10 ms pulses**

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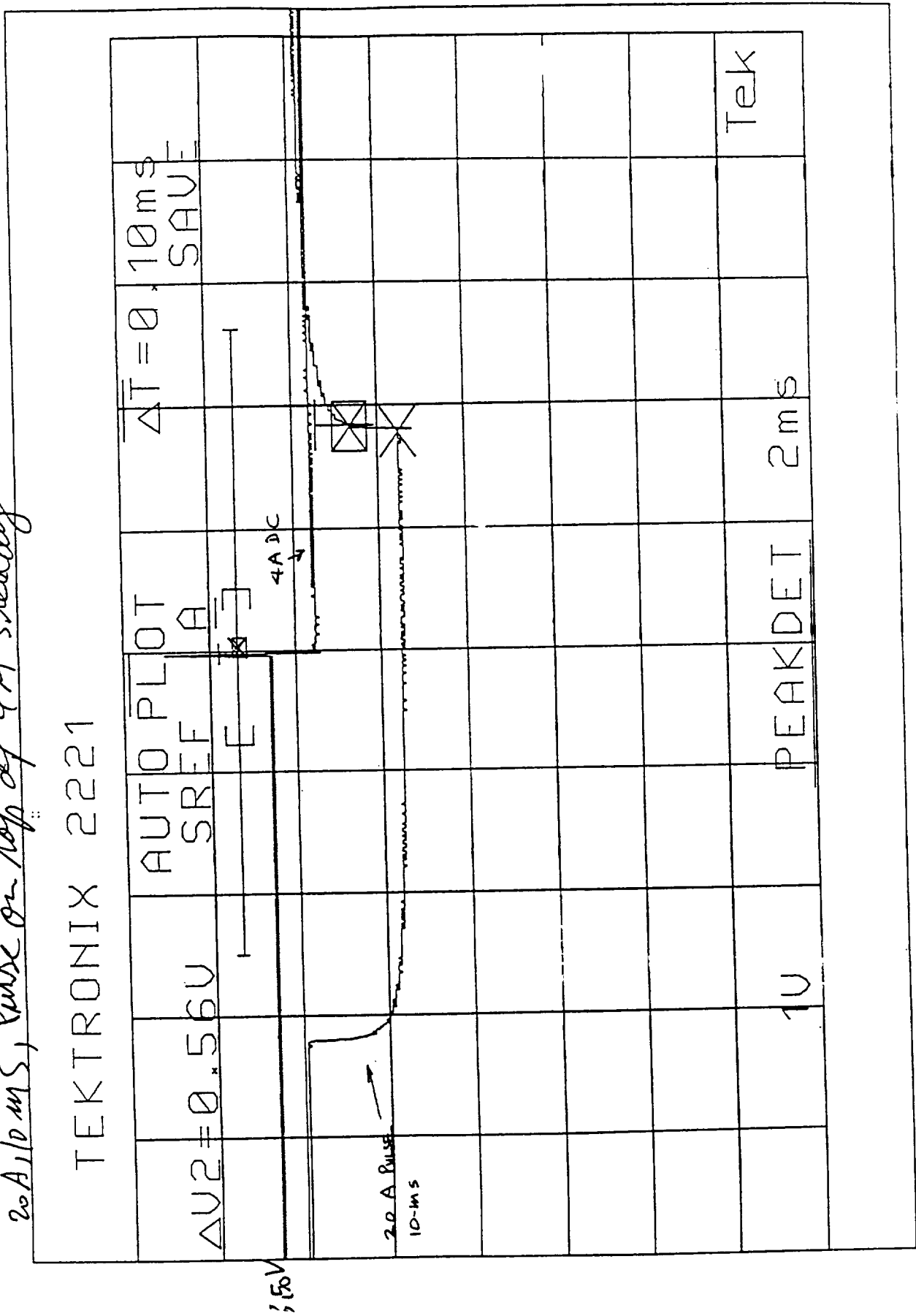
Cell Development

- **Test Hardware**
- Glass Enclosure Cell
- Anode Wafer in Stainless Steel or Ni Cup, Nickel leads
- Cathode rests on EB salt wafer backed by graphite current collector
- Chlorine fed to the wafer-ambient pressure
- **Test Regime**
- Steady discharge load + 400 10 ms pulses + 200 100 ms pulses



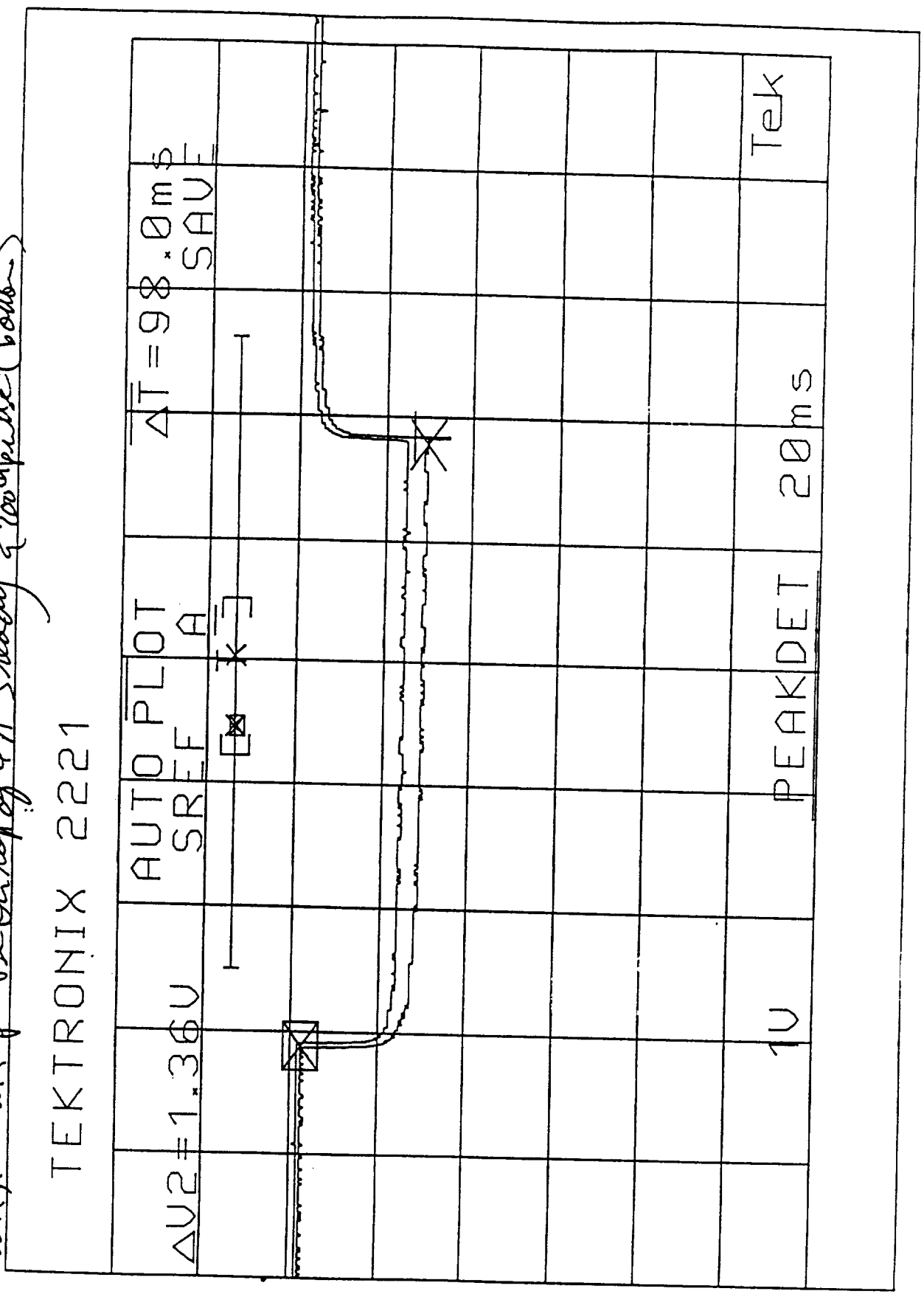
Cell # 12-92 (Max 1) Oct 19/90

20 A/10 ms, Pulse on top of 4A steady

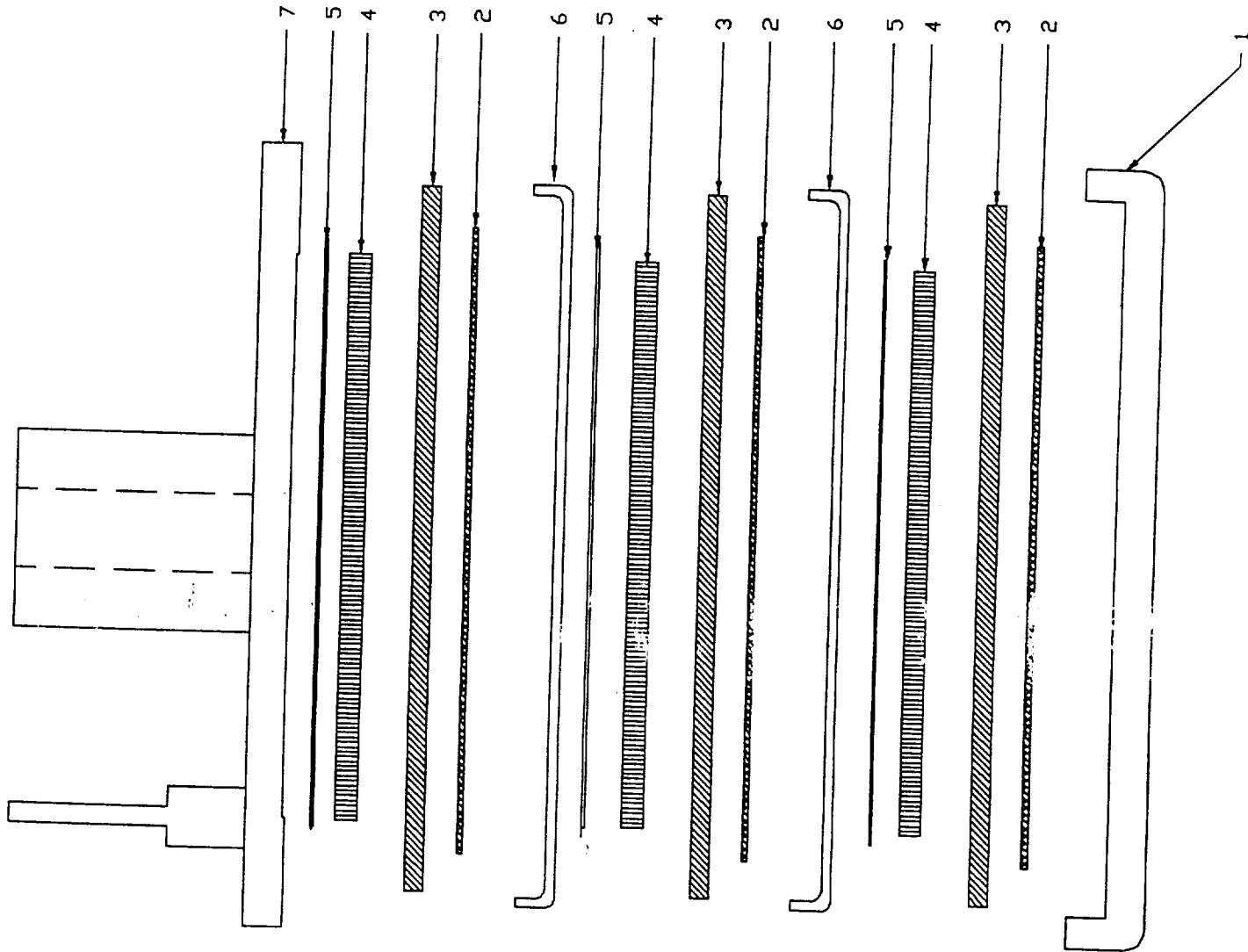


800 CELL # 16-1-C (unobs'd) 1st pulses (top) & 200th pulse (bottom) use 17/7C

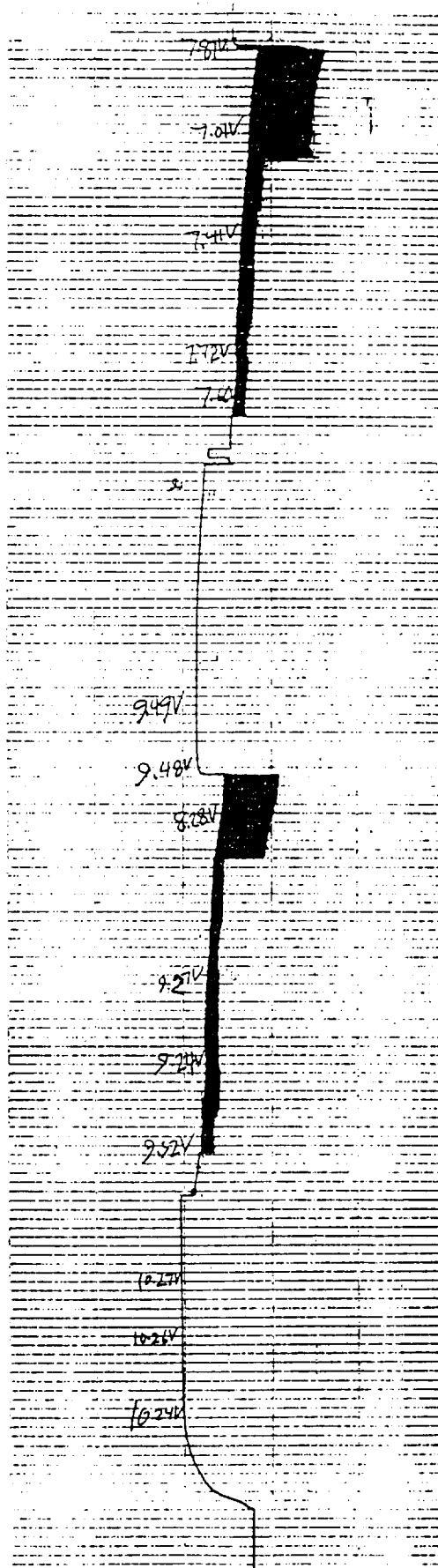
20 A, 100 ms pulse on top of 4 A steady



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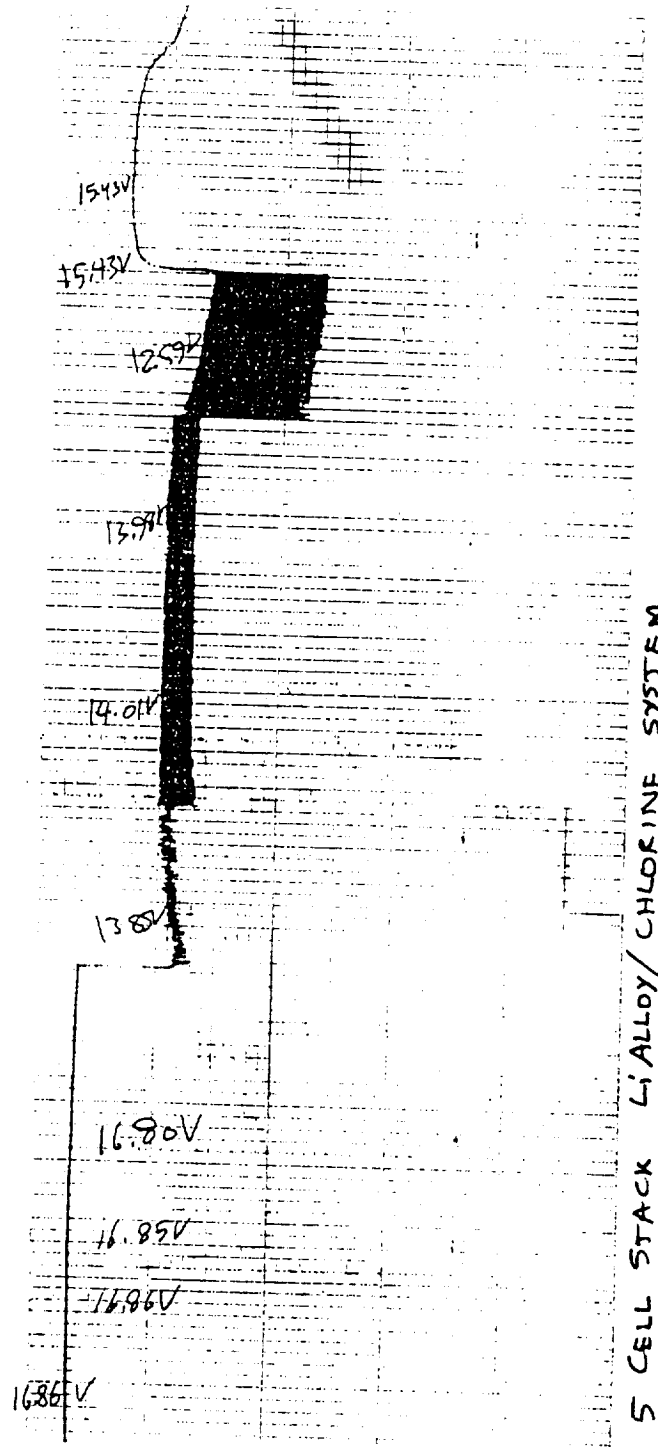


1. Anode Current Collector
2. Li-Al Anode
3. Salt Wafer
4. Carbon Cathode
5. Graphite
6. Nickel Cup
7. Cathode Current Collector with Chlorine Feed Tube



3 - CELL STACK Li/CHLORINE SYSTEM

INDIANAPOLIS, IND. U.S.A. MADE IN CANADA CHART NO. 2237
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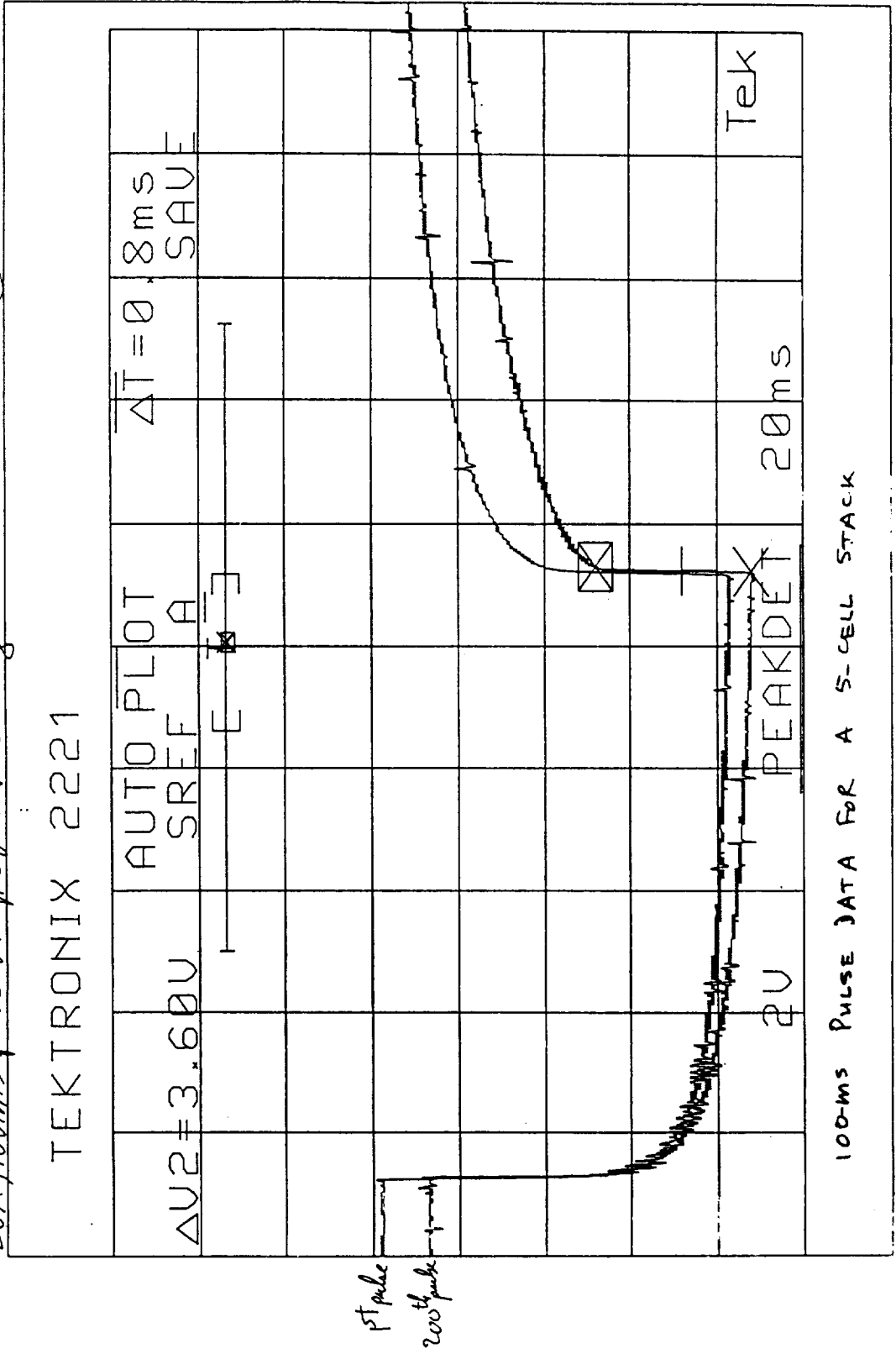
SYSTEMS INCORPORATED, BURLINGTON, VT, U.S.A. MADE IN CANADA

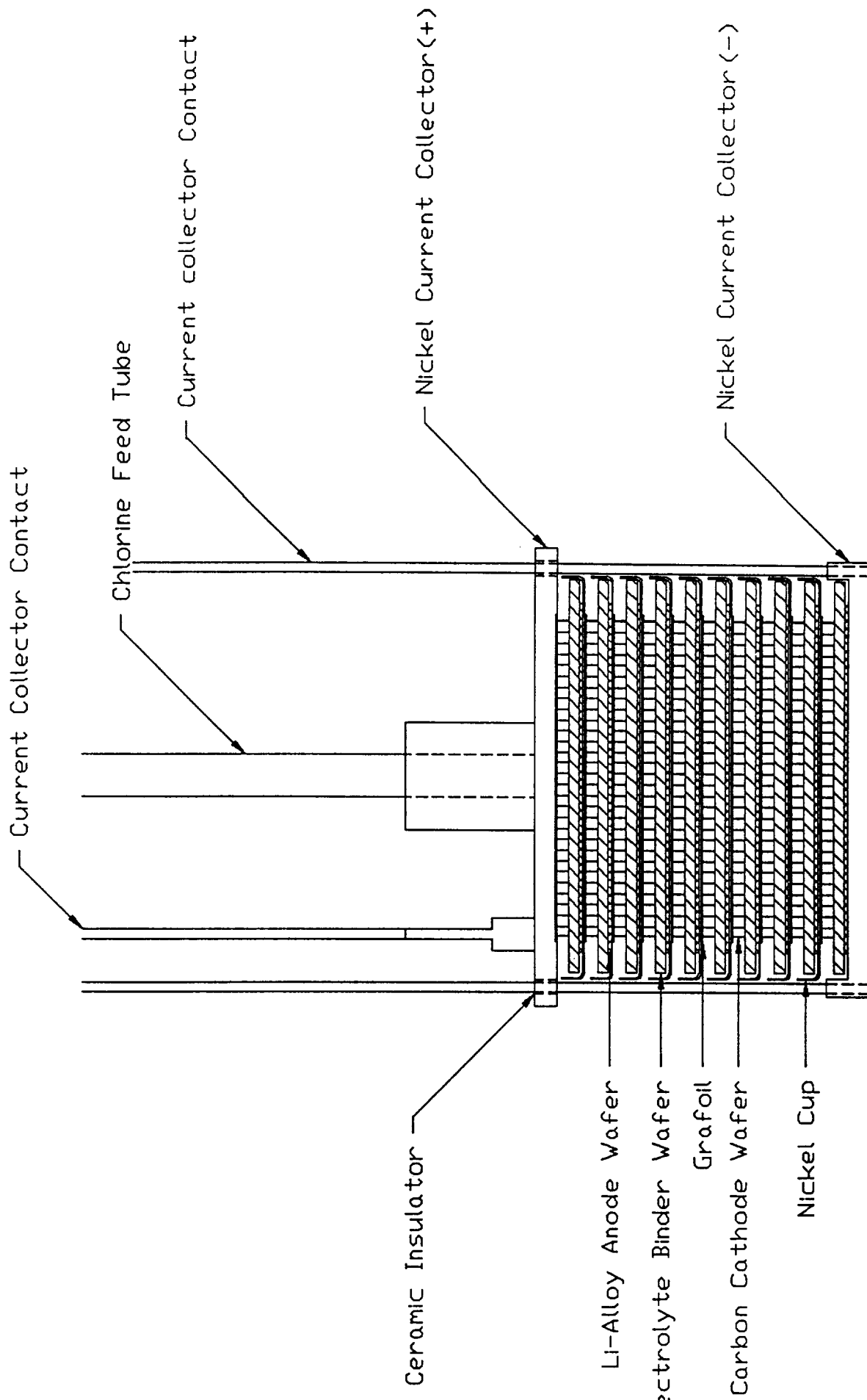
cell #12-146

(trial 1) ②

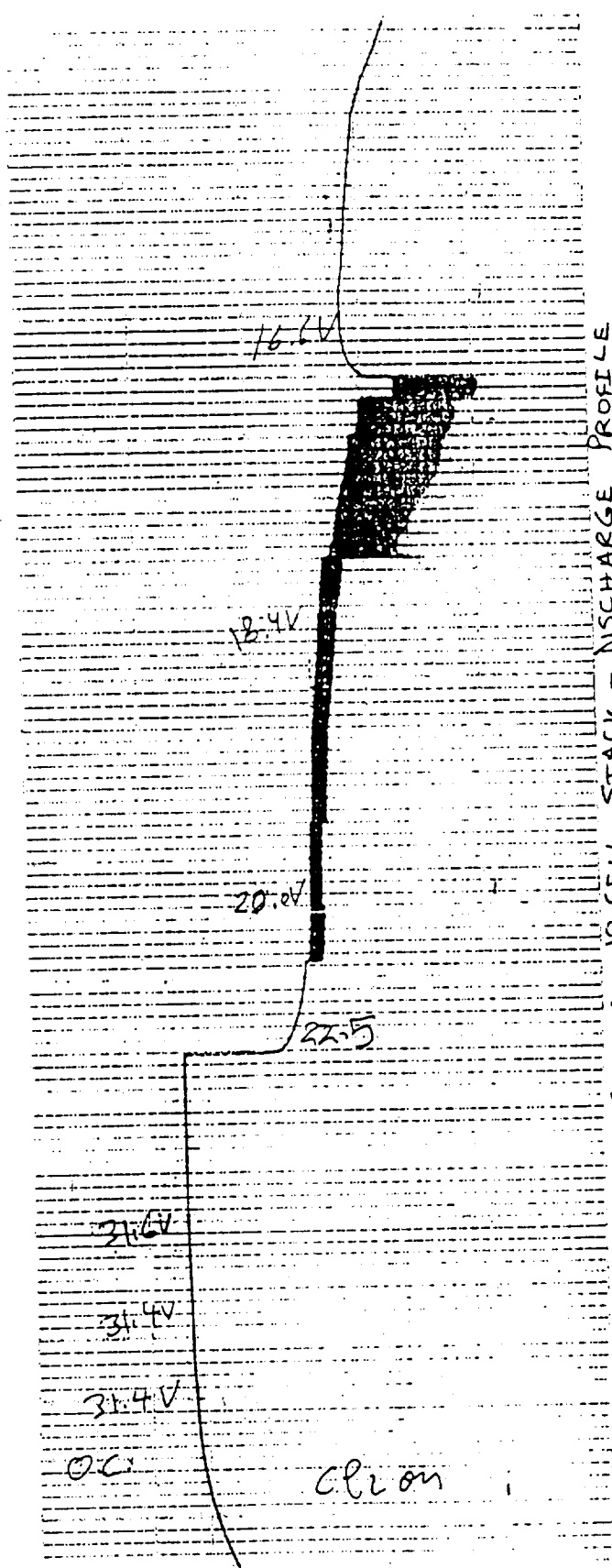
JA 11-19

20A, 100ms pulses on top of 4A discharge





10 CELL STACK - DISCHARGE PROFILE



Li-Al / CHLORINE SYSTEM 10 CELL STACK - DISCHARGE PROFILE

MADE IN CANADA 6-4827 704-1989
STERLING ARISTO INDIANAPOLIS, IND., U.S.A. MADE IN CANADA CHART No. 59015
ELECTRONIC ANAL.

BATTERY DESIGN PARAMETERS

Delivered Energy	56 Wh
Output Voltage	96 V
No. of Cells	40
Open Circuit Voltage	134 V
Capacity	0.56 Ah
Weight	1.34 kg
Volume	1.32 L
Current Density	0.25 A/sq. cm
Pulsing	1.00 A/sq.cm

POWER DENSITY
4A DC, 24A PULSE REGIME

	kW/kg 10 ms	kW/kg 100 ms	kW/L 10 ms	kW/L 100 ms
Cell	3.9	3.2	4.3	3.5
Stack (5-cell)	3.9	3.1	4.3	3.4
Battery	1.7	1.4	1.7	1.4

ENERGY DENSITY
4A DC, 24 A PULSE REGIME

	Wh/kg	Wh/L
CELL		
1 cycle	102	112
2 cycle	183	201
STACK	95	104
BATTERY	42	43

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- **Carbon Cathodes with chlorine work well**
- **Li-Alloy/chlorine at 450 deg. C, 1atm**
- **High Power capability**
- **High energy density**
- **DC + pulsing - 600 pulses**
- **No initial peak**
- **Can go to red heat without burn-up**

SUMMARY

- **Electrochemical performance at the cell and cell stack level under demanding test regime**
- **Engineering and full prototype development for advancing this technology is warranted**

Nickel-Hydrogen Technologies Session

*Organizers: Joe Stockel
Office of Research & Development*

*Michelle Marzo
NASA Lewis Research Center*

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