13A

Energy Research Advisory Board
to the
United States Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 586-5444

26 JUN 89 12:38 -R.L. GARWIN-

June 23, 1989

TO: Cold Fusion Panel

Enclosed is the Site Visit to Texas A&M from David Goodwin, Report on visit to Cold Fusion Research at ORNL, and Cold Fusion News No. 15, dated 17 June, 1989.

Bill
William Woodard

Enclosures

062389.WLW

DOE 1325.8

United States Government | Department of Energy

memorandum

DATE: JUN 21 1989

REPLY TO ATTN OF: ER-20.1

SUBJECT: June 19, 1989, Site Visit to Texas A&M

TO: W. Woodard, ER-6

In attendance were Huizenga (Co-Chairman from Rochester), Ramsey (Co-Chairman from Harvard), Bard (Texas), Bigeleisen (Stony Brook), Callis (ACS President), Happer (Princeton), Miller (AT&T), Schiffer (Argonne), Wrighton (MIT), Finn (ERAB) and myself (Technical Advisor).

Group #1

Appleby provided attachments #1 and #2 on the following experiments:

1. Three experiments with the following excess heat generation:
   (A). 3 runs: 16.3, 19.3 18.5 watts/cc
   (B). 4-7 watts/cc
   (C). 6-12 watts/cc
2. Two experiments where:
   (A). Excess heat generation was nearly eliminated by switching from LiOD to NaOH and
   (B) Excess heat generation returned by switching back to LiOD.
3. An experiment where excess heat generation was nearly eliminated by switching from an uncoated stainless steel cell to a teflon-coated Ni cell.
4. An experiment with LiOH, instead of LiOD, which generated no excess heat.
5. An experiment with Pt in LiOD, instead of Pd in LiOD, which generated no excess heat.
6. An experiment where:
   (A). Excess heat generation was nearly eliminated by switching from 6% Li-6 to Li-7 and
   (B). Excess heat was generated faster by switching to Li-6.

Analysis shows Li penetrates about 1 micron into the electrode. Surface analysis, at least some of which was done by Livermore, indicates Fe, Cr, Mg, Ca and Si. Bockris noted that Ni is also present.

Appleby also noted they have recently began measuring gas volumes in one experiment to confirm low levels of recombination.

Group #2

Wolf provided 3 positive results on neutrons from the Texas A&M, including 2.5 MeV neutrons up to 4 1/2 times background. The highest neutron level corresponded to an over 10^3 tritium increase. He also presented surface analysis which indicated (probably Fe based) dendrites and cracks. He also discussed the possibly of D + Li-6 fusion.

Group #3

Packham, from the Bockris group, provided attachment #3 and discussed 8 positive results for tritium, showing increases up to > 10^4 and that tritium analysis have been confirmed by sets of 5 samples which were sent to Argonne, Pacific Northwest, Los Alamos and General Motors.

Bockris provided attachment #4 and discussed:

(1) His 3 cells with excess heat: 4.5, 5.0 and 7 watts/cc,
(2) That he is installing recombiners in 1/2 of his cells,
(3) That his calculations from Henry's Law indicate about 100 times more tritium in the gas than in the electrolyte, which is approximately the level of tritium suggested by the excess heat, and
(4) That Fe/Cr and Ni dendrite tips may produce the KeV energies required for fusion.

Group #4

Martin reported on :

(1) Two cells, one with up to 50% excess heat,
(2) That measurements of gas flow indicated recombination does not exceed 1%, even for exposed electrodes
(3) Collaboration with Vancouver to use their flow-thru calorimeter with a recombiner, and
(4) Surface analysis shows high levels of Li and increased levels of C, Si and O.

Tours were then provided by each of the four groups.

ERAB Panel members have requested that copies of this summary of what was reported not be distributed beyond the ERAB Panel and the DOE distribution list.

David Goodwin
Special Assistant
Associate Director for
High Energy and Nuclear Physics

Attachment (4)

cc: W. Hess, ER-20
P. Stone, ER-1
T. Finn, ER-55
R. Gajewski, ER-16
L. Ianniello, ER-11
D. Barney, ER-16
R. Marianelli, ER-14
D. Crandall, ER-54
R. Marley, ER-1
W. Warnick, ER-32
D. Hendrie, ER-23
C. Richardson, ER-23

EVIDENCE FOR EXCESS HEAT GENERATION RATES DURING ELECTROLYSIS OF D_2O IN LiOD USING A PALLADIUM CATHODE - A MICROCALORIMETRIC STUDY

A. John Appleby, Supramaniam Srinivasan,
Young Jin Kim and Oliver J. Murphy

Center for Electrochemical Systems and Hydrogen Research
Texas Engineering Experiment Station
Texas A&M University
College Station, Texas 77843

Presentation to
U.S. Department of Energy "Cold Fusion" Task Force Review
Monday, June 19, 1989

PRINCIPLES OF MICROCALORIMETER TRONAC MODEL 350

* The design is based on the Seebeck effect in which a voltage is produced proportional to the temperature difference across the thermoelectric device (TED).

* The voltage generated across the TED is directly proportional to the heat flow from the microcalorimeter measuring cell.

* The rate of heat generation from 1μW to 8W can be measured.

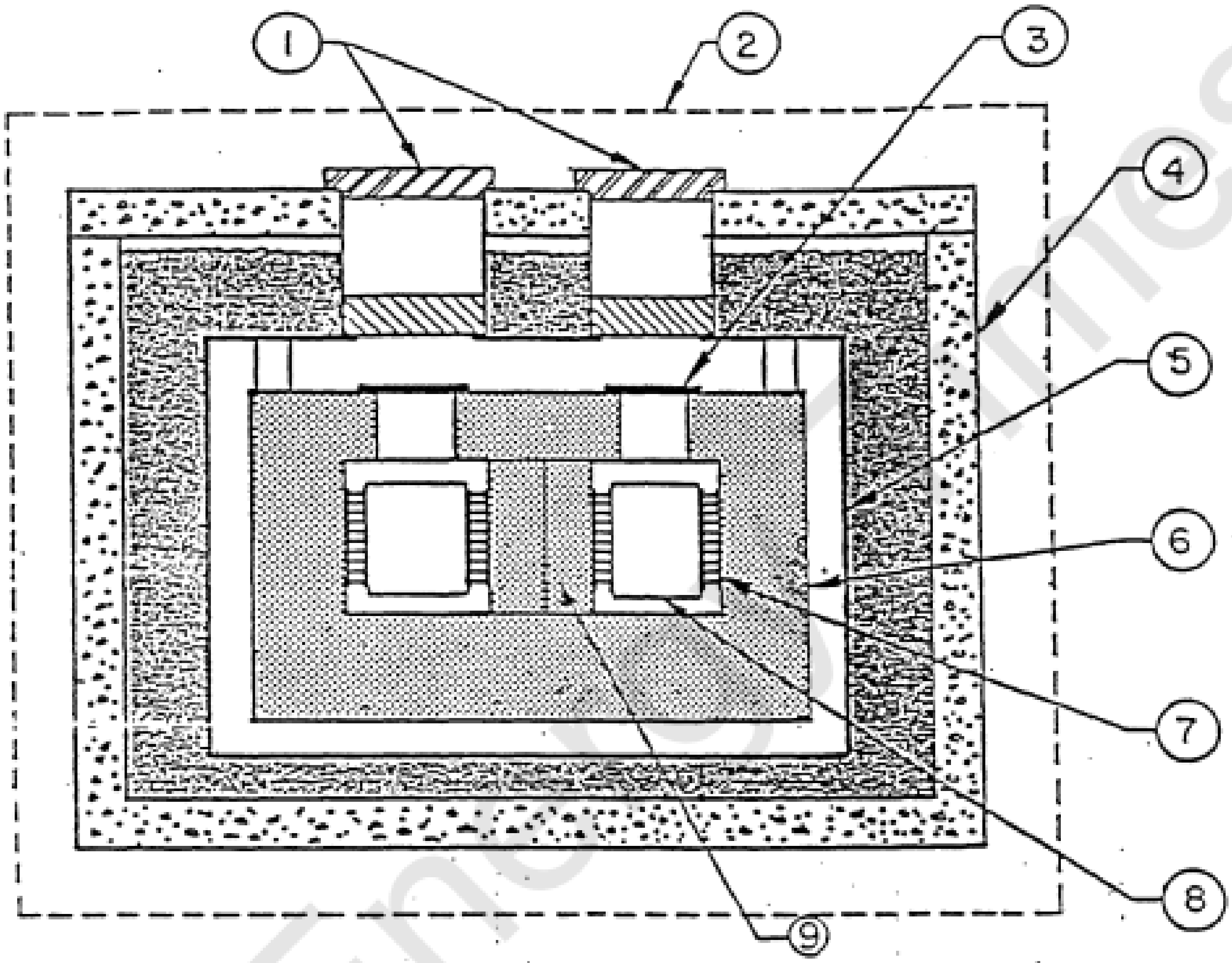


Figure 2: Schematic of Tronac Calorimeter System

(1) Access lid
(2) Temperature-controlled air bath.
(3) Cover on block compartment
(4) Temperature-controlled water bath
(5) Water-tight stainless steel box.
(6) Aluminum heat sink block.
(7) Thermoelectric sensors.
(8) Sample holder.
(9) One of four aluminum wedges placed in tapered channel.

EXPERIMENTAL APPROACH

* MATERIAL

Pd: (i) 0.5mm diameter x 10mm long
(ii) 1.0mm diameter x 10mm long
(iii) 2 mm diameter sphere

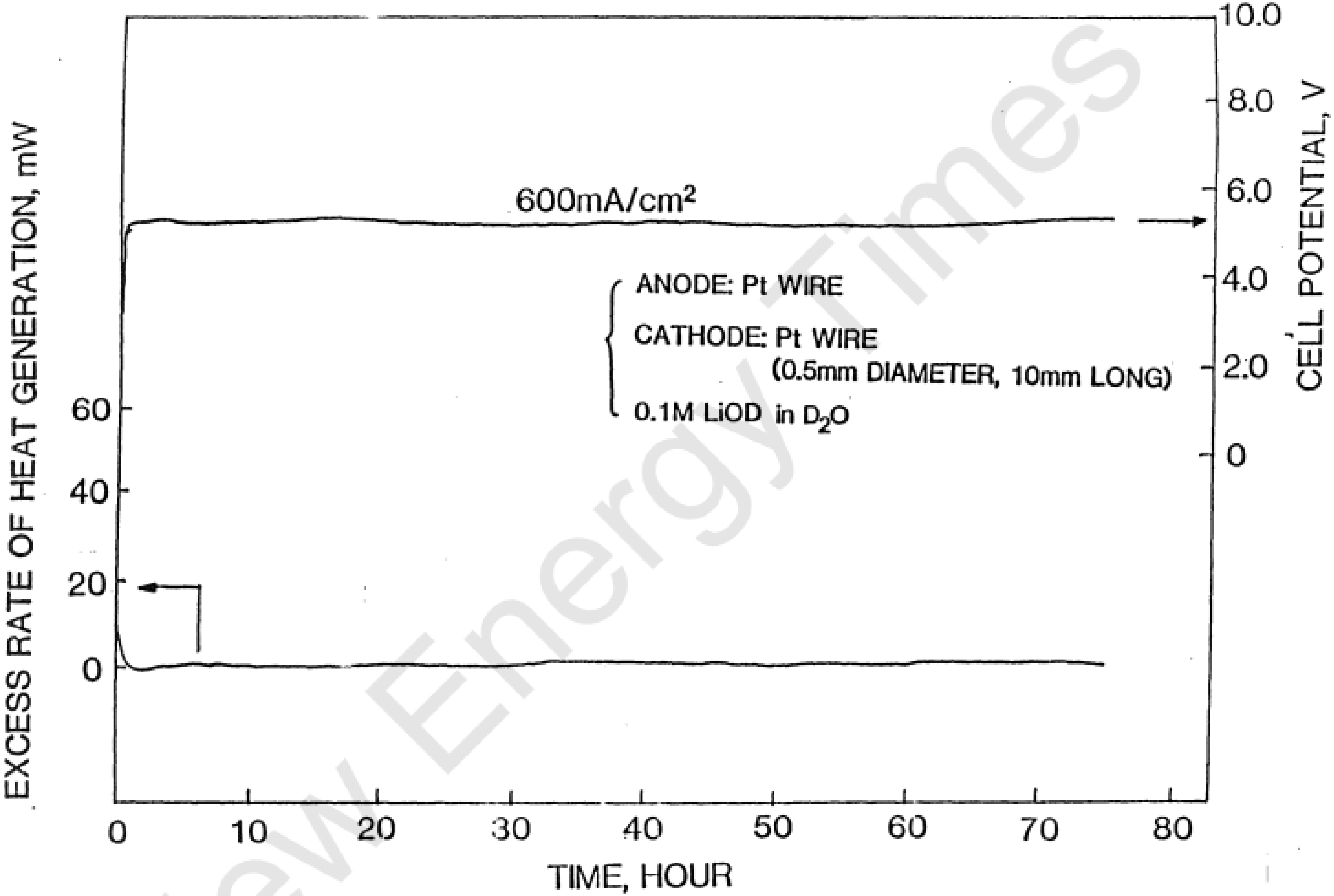
Pt: (i) 0.5mm diameter x 10mm long
(ii) 1.0mm diameter coil

*ELECTROLYTE

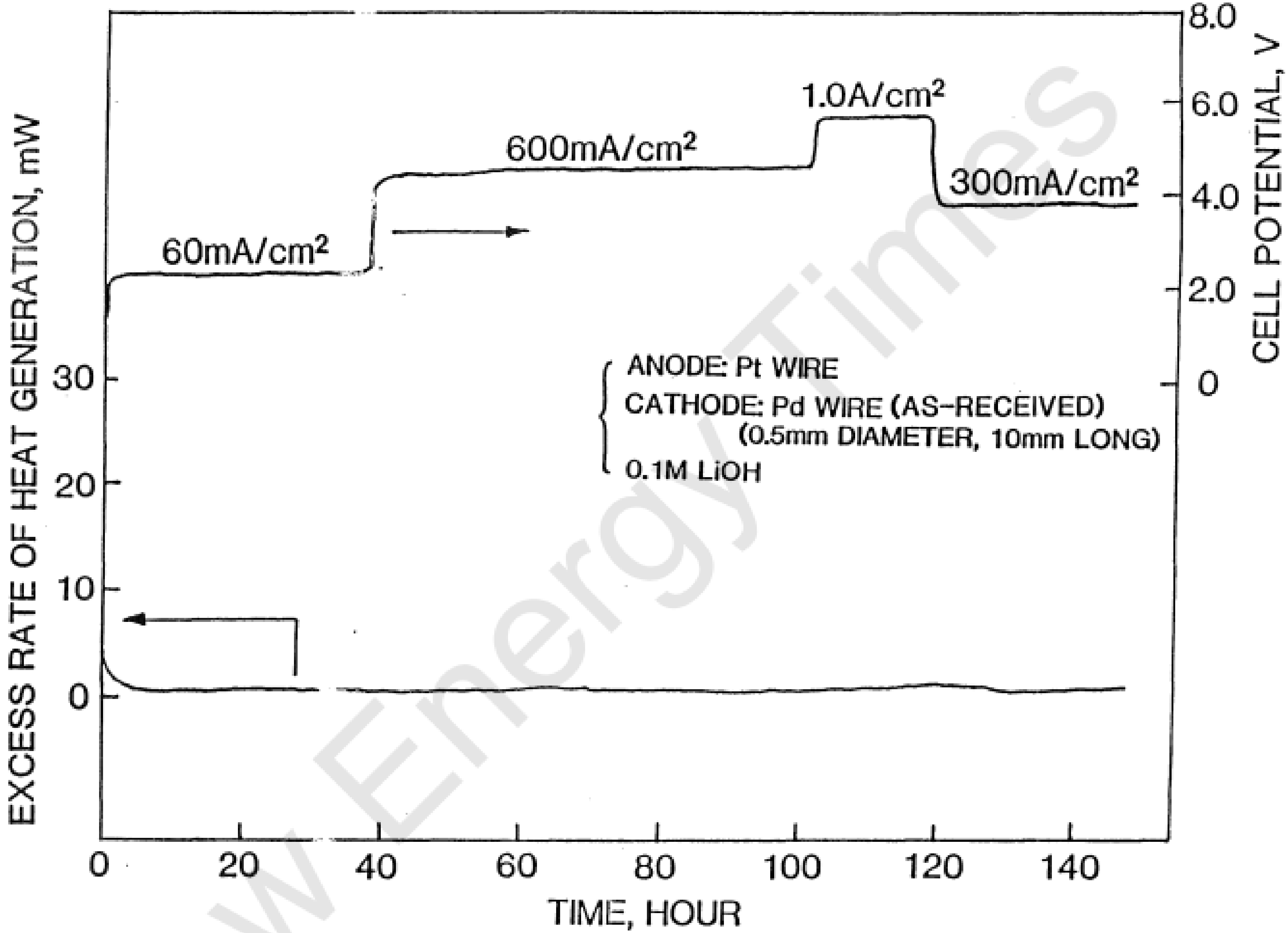
(i) 0.1M LiOD, 0.1M LiOH, 0.1M NaOD, 1.0M LiOD, 0.,1M ^{6}LiOD, and 0.1M ^{7}LiOD

(ii) Volume: 7.5 - 8.0 ml.

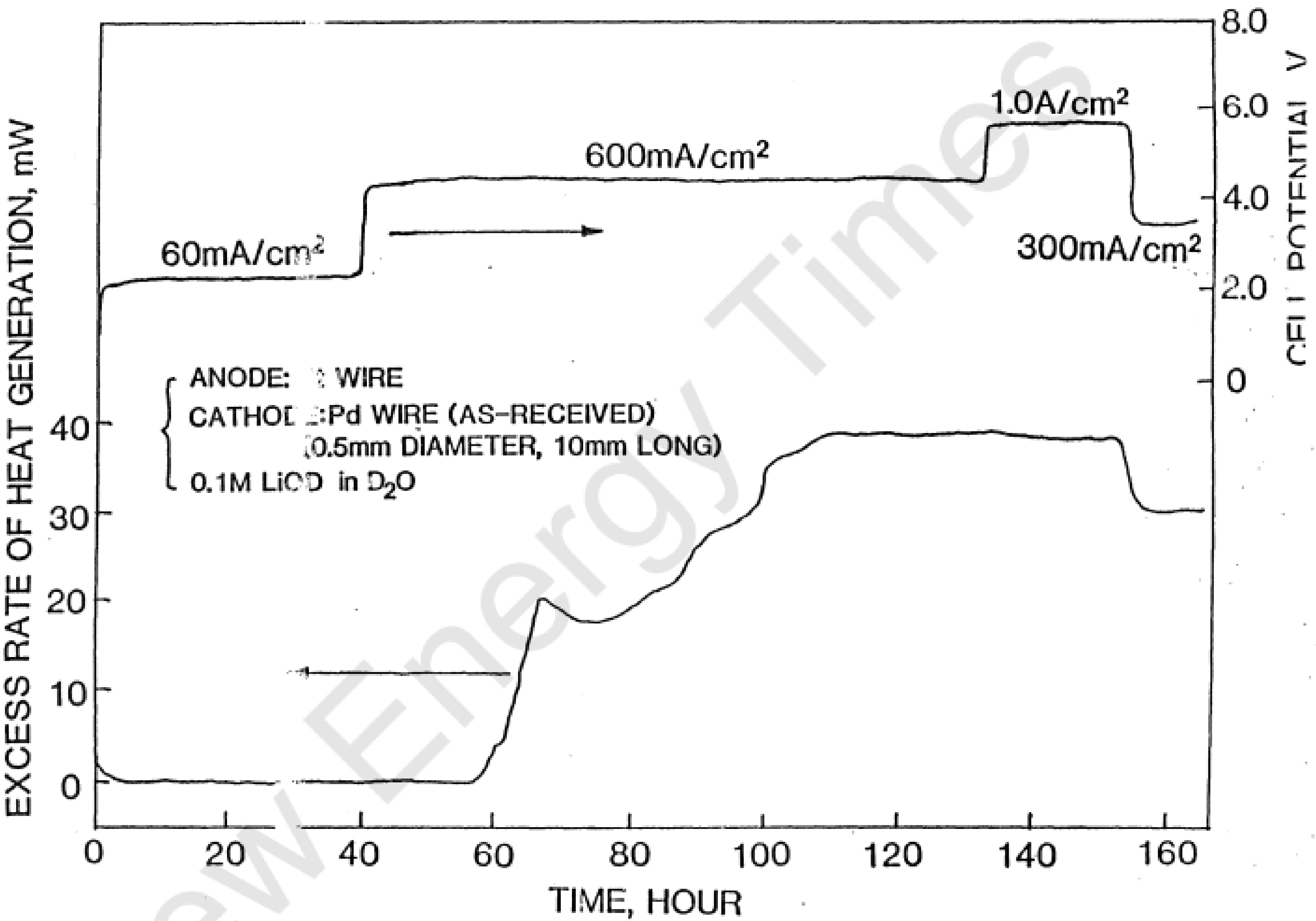
*The rate of heat generation was measured in a closed stainless steel (1cm x 3.9cm x 3.5m). The rate of heat generated by oxidation of the stainless steel in the electrolyte is negligible.

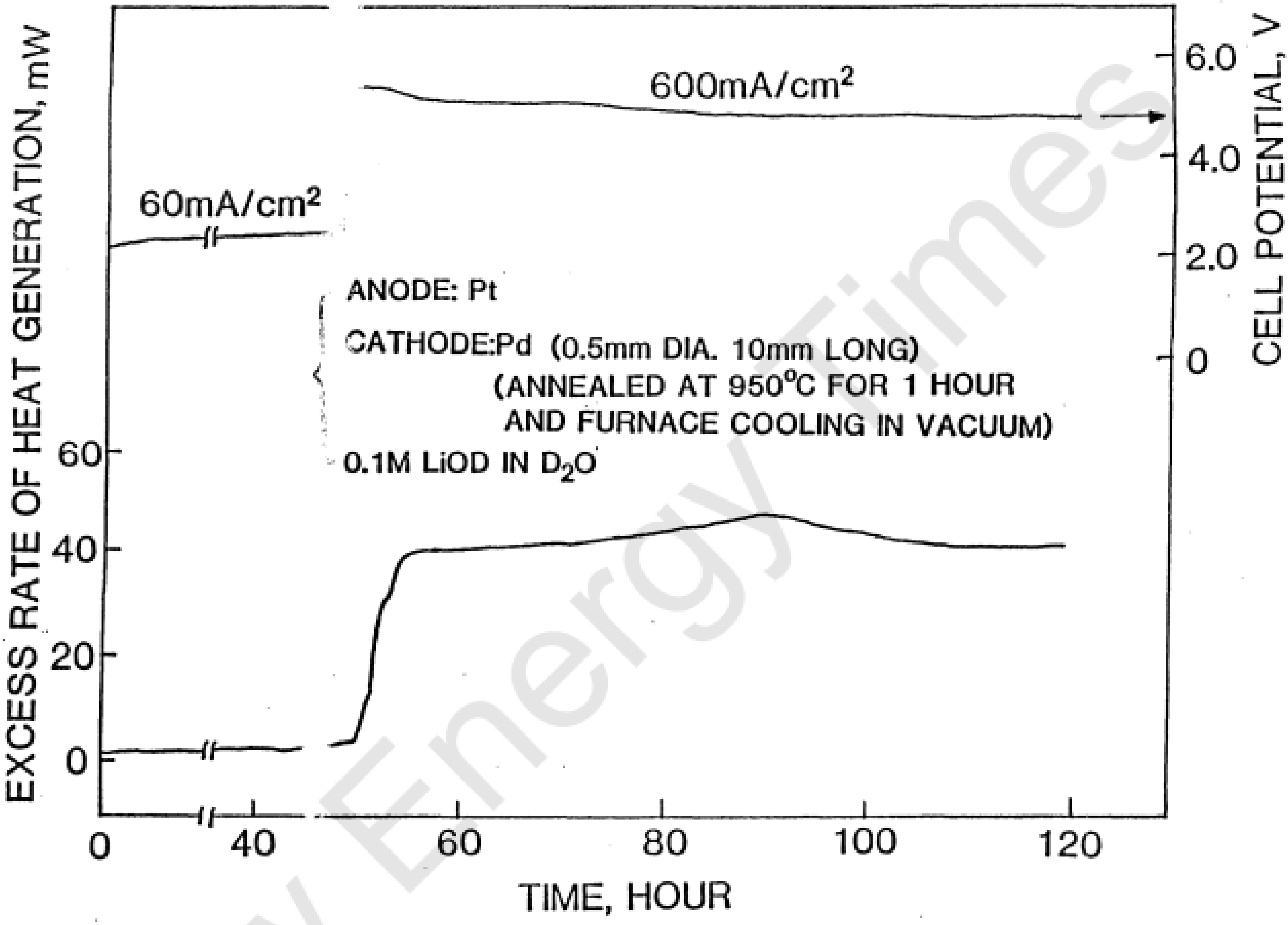


EXCESS RATE OF HEAT GENERATION, mW
CELL POTENTIAL, V
600mA/cm²
ANODE: Pt WIRE
CATHODE: Pt WIRE
(0.5mm DIAMETER, 10mm LONG)
0.1M LiOD in D₂O
TIME, HOUR
0
20
40
60
10
30
50
70
80
2.0
4.0
6.0
8.0
10.0



EXCESS RATE OF HEAT GENERATION, mW
CELL POTENTIAL, V
TIME, HOUR
60mA/cm2
600mA/cm2
1.0A/cm2
300mA/cm2
ANODE: Pt WIRE
CATHODE: Pd WIRE (AS-RECEIVED)
(0.5mm DIAMETER, 10mm LONG)
0.1M LiOH
0
10
20
30
0
20
40
60
80
100
120
140
2.0
4.0
6.0
8.0

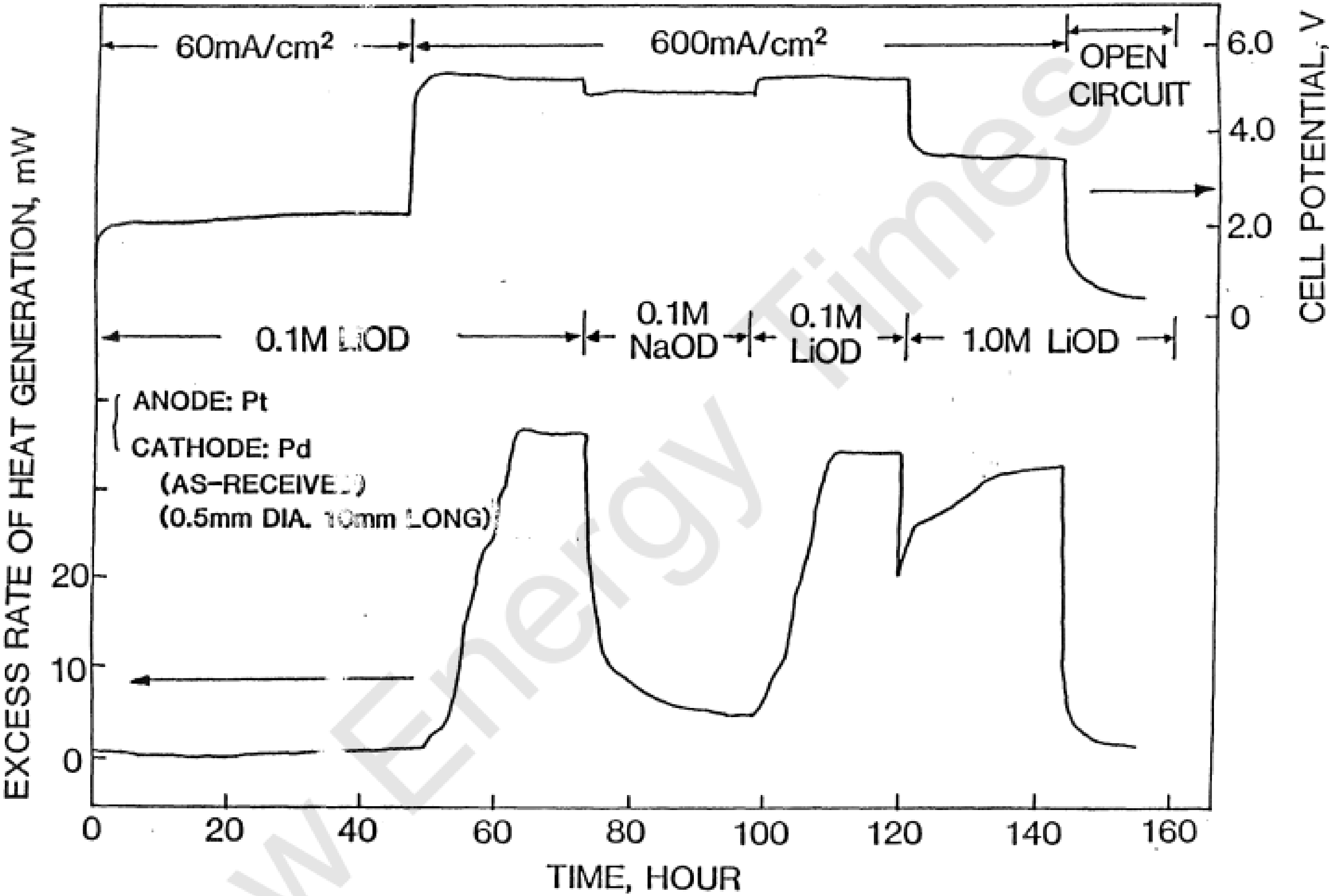

EXCESS RATE OF HEAT GENERATION, mW
CELL POTENTIAL, V
TIME, HOUR
60mA/cm²
600mA/cm²
1.0A/cm²
300mA/cm²
ANODE: WIRE
Pd WIRE (AS-RECEIVED)
(0.5mm DIAMETER, 10mm LONG)
0.1M LiOD in D₂O
0
10
20
30
40
0
2.0
4.0
6.0
8.0
0
20
40
60
80
100
120
140
160
New Energy Times



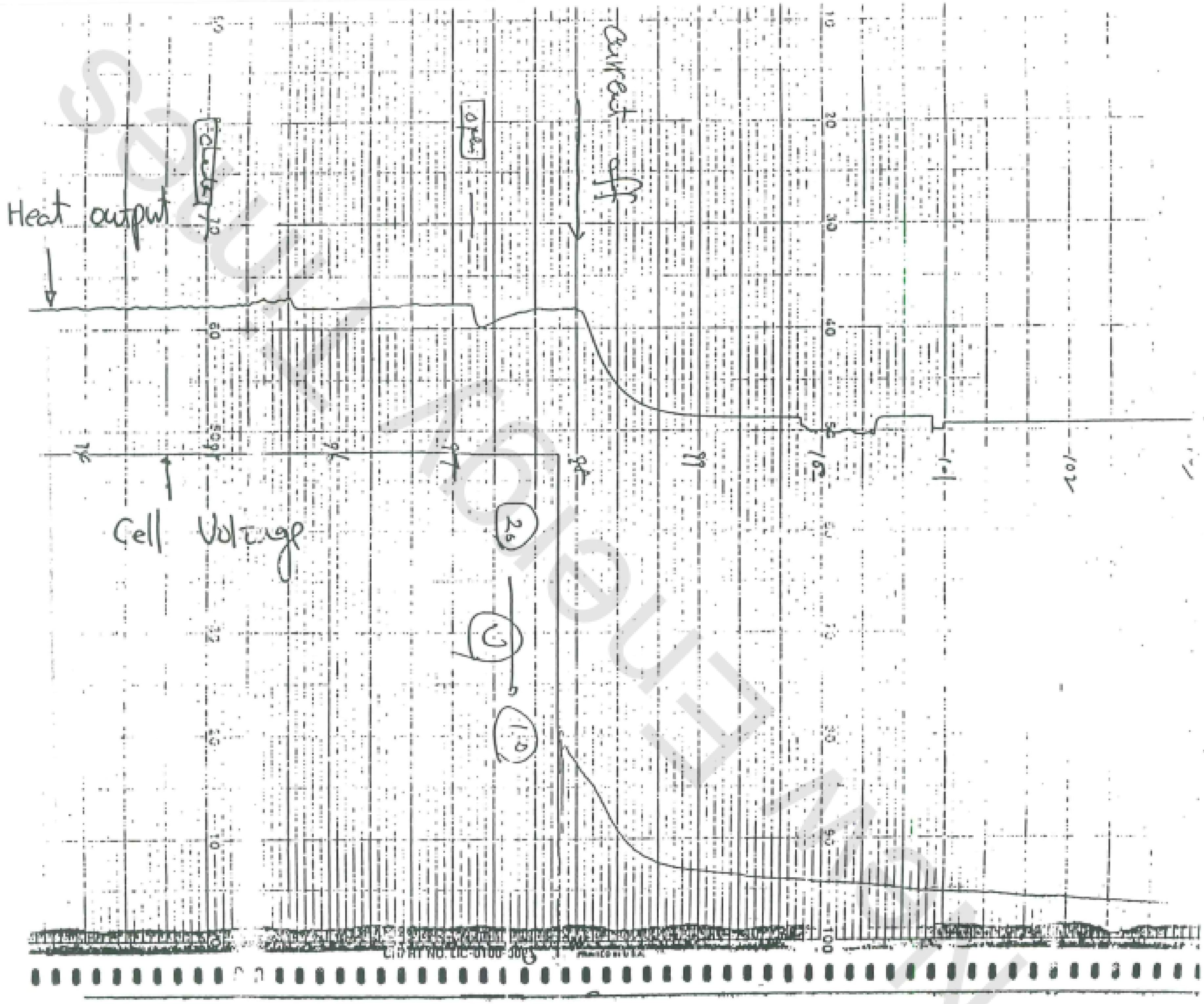
600mA/cm2
60mA/cm2
ANODE: Pt
CATHODE:Pd (0.5mm DIA. 10mm LONG)
(ANNEALED AT 950°C FOR 1 HOUR
AND FURNACE COOLING IN VACUUM)
0.1M LiOD IN D2O
EXCESS RATE OF HEAT GENERATION, mW
CELL POTENTIAL, V
TIME, HOUR
0
20
40
60
80
100
120
2.0
4.0
6.0

TABLE: Evidence for "Anamolous Heat Generation" During Electrolysis of D2O in LiOD on Palladium Cathode - Results of Test and Control Experiments

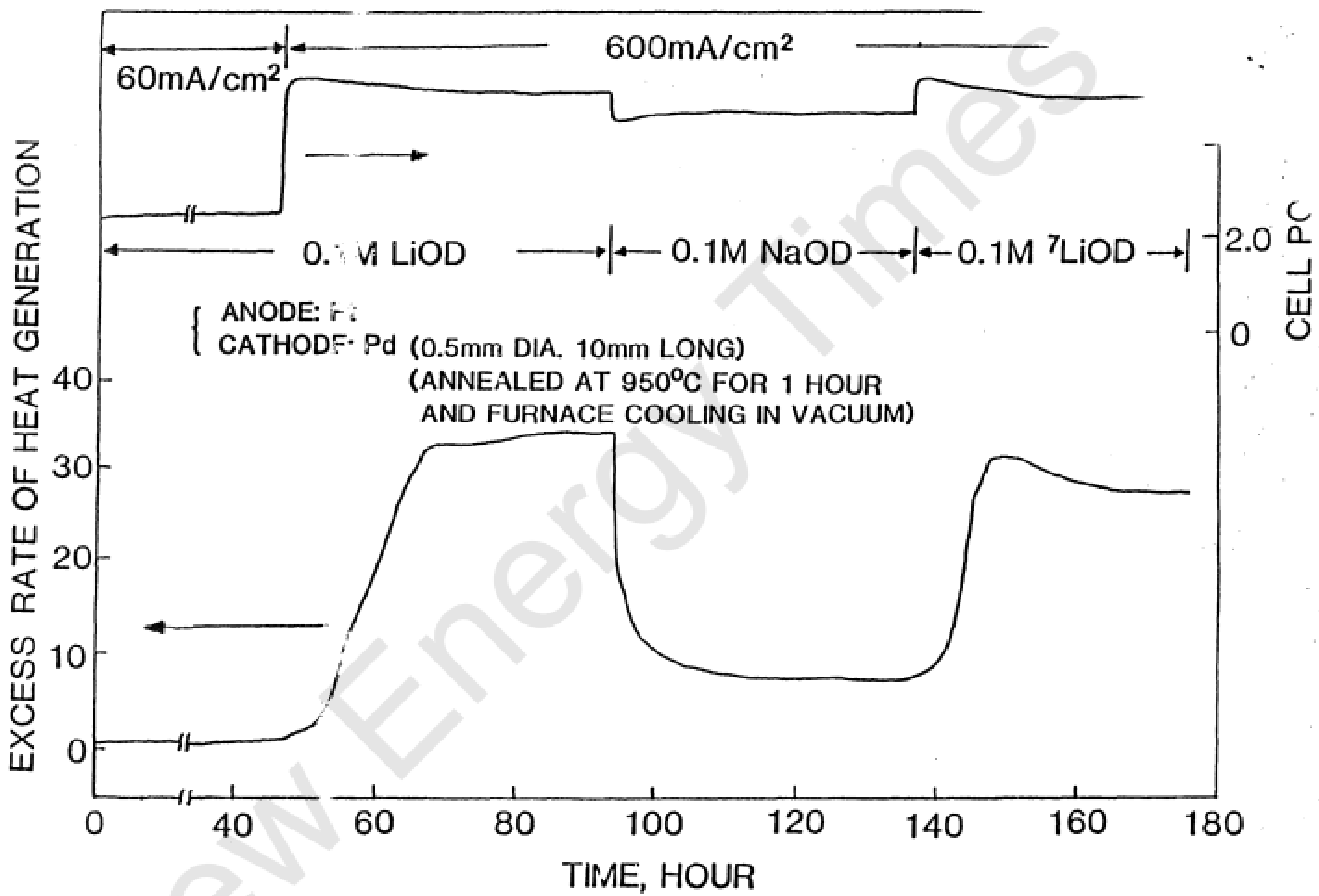
Exp. #	Electrode Material		Electrolyte	Current Density	Rate of Excess Heat Generation
	Cathode	Anode		mA/cm*2	W/cm*3 of Pd
1	Pd 0.5mm dia. 10mm long	Pt	0.1M LiOD	300	16.3
				600	19.3
				1000	18.5
2	Pd 0.5mm dia. 10mm long	Pt	0.1M LiOH	600	0
3	Pt 0.5mm dia. 10mm long	Pt	0.1M LiOD	600	0
4	Pd 1.0mm dia. 10mm long	Pt	0.1M LiOD	600	4 - 7
5	Pd 2.0mm dia. sphere	Pt	0.1M LiOD	600	6 - 12


60mA/cm²
600mA/cm²
OPEN CIRCUIT
6.0
4.0
2.0
0
CELL POTENTIAL, V
0.1M LiOD
0.1M NaOD
0.1M LiOD
1.0M LiOD
ANODE: Pt
CATHODE: Pd
(AS-RECEIVED)
(0.5mm DIA. 10mm LONG)
20
10
0
EXCESS RATE OF HEAT GENERATION, mW
0
20
40
60
80
100
120
140
160
TIME, HOUR

V6. In

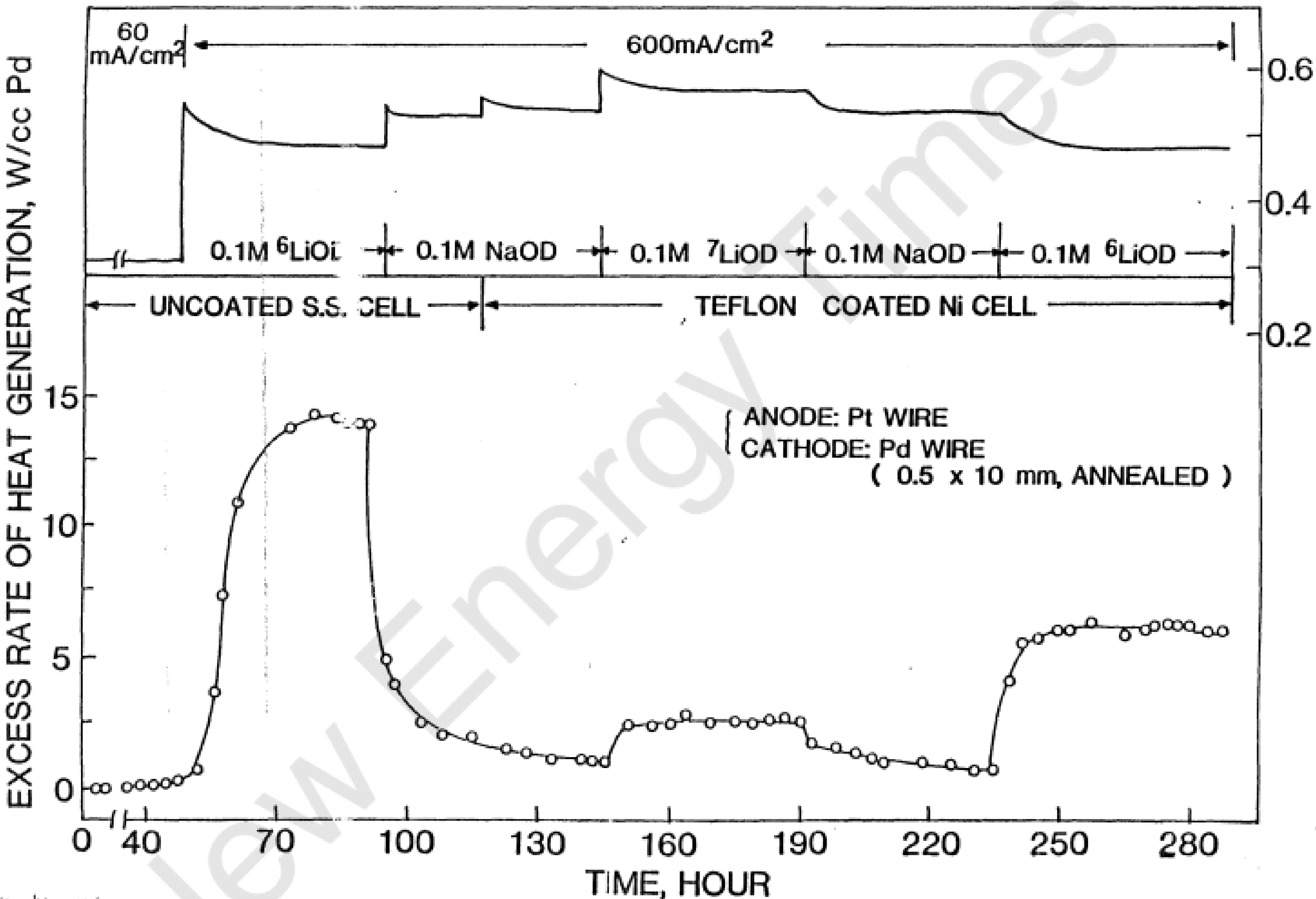


VG 11



60mA/cm²
600mA/cm²
0.1M LiOD
0.1M NaOD
0.1M ⁷LiOD
ANODE: Pt
CATHODE: Pd (0.5mm DIA. 10mm LONG)
(ANNEALED AT 950°C FOR 1 HOUR
AND FURNACE COOLING IN VACUUM)
EXCESS RATE OF HEAT GENERATION
CELL PC
2.0
0
40
30
20
10
0
0
40
60
80
100
120
140
160
180
TIME, HOUR
New Energy Times

V4 12



60 mA/cm2
600mA/cm2
0.6
0.4
0.2
0.1M 6LiOD
0.1M NaOD
0.1M 7LiOD
0.1M NaOD
0.1M 6LiOD
UNCOATED S.S. CELL
TEFLON COATED Ni CELL
ANODE: Pt WIRE
CATHODE: Pd WIRE
(0.5 x 10 mm, ANNEALED)
EXCESS RATE OF HEAT GENERATION, W/cc Pd
15
10
5
0
0
40
70
100
130
160
190
220
250
280
TIME, HOUR

HELIUM CONCENTRATIONS IN COLD FUSION PALLADIUM

Sample	A&M Group	Description	Sample Mass[a] (mg)	Measured Helium (atoms released)	
				^{3}He	^{4}He
JOMB-Pd1-A	Bockris	1 mm ø wire	11.72	$<1.2 \times 10^{9}$	$<0.3 \times 10^{9}$
-B		test sample	13.56	$<0.7 \times 10^{9}$	$<0.2 \times 10^{9}$
JOMB-Pd2-A	Bockris	1 mm ø wire	14.19	$<1.2 \times 10^{9}$	$<0.3 \times 10^{9}$
-B		control	14.49	$<0.7 \times 10^{9}$	$<0.2 \times 10^{9}$
JAAM-Pd1-A	Appleby	1 mm ø wire	9.14	$<1.2 \times 10^{9}$	$<0.3 \times 10^{9}$
-B		control	10.74	$<0.7 \times 10^{9}$	$<0.2 \times 10^{9}$
JAAM-Pd2-A	Appleby	2 mm ø sphere	9.18	$<1.2 \times 10^{9}$	$<0.3 \times 10^{9}$
-B		test sample	8.79	$<0.7 \times 10^{9}$	$<0.2 \times 10^{9}$

[a]Mass uncertainty is ±0.01 mg.

```
[illegible]
[illegible]
TIME:    60        WINDOW WIDTH:    10        STEP:    10

  WINDOW        CPM   0.0        2.0        4.0        6.0        8.0       10.0  E 0
                      +----------+----------+----------+----------+----------+------
   5 -   14     .00 *
  15 -   24     .00 *
  25 -   34     .00 *
  35 -   44     .00 *
  45 -   54     .00 *
  55 -   64    1.00 I====*
  65 -   74    6.00 I=============================*
  75 -   84    2.00 I=========*
  85 -   94    7.00 I==================================*
  95 -  104    6.00 I=============================*
 105 -  114   10.00 I=================================================*
 115 -  124    7.00 I==================================*
 125 -  134    5.00 I========================*
 135 -  144    9.00 I============================================*
 145 -  154    5.00 I========================*
 155 -  164    4.00 I===================*
 165 -  174    1.00 I====*
 175 -  184    1.00 I====*
 185 -  194    2.00 I=========*
 195 -  204    1.00 I====*
 205 -  214     .00 *
 215 -  224     .00 *
 225 -  234     .00 *
 235 -  244     .00 *
 245 -  254    1.00 I====*
 255 -  264    1.00 I====*
 265 -  274     .00 *
 275 -  284    4.00 I===================*
 285 -  294     .00 *
-------------------------
   5 -  294   73.00
```

After Test

```
SAMPLE SPECTRUM
POSITION: 002
TIME:    60        WINDOW WIDTH:    10        STEP:    10

  WINDOW        CPM   0.0        2.0        4.0        6.0        8.0       10.0  E 0
                      +----------+----------+----------+----------+----------+------
   5 -   14     .00 *
  15 -   24     .00 *
  25 -   34     .00 *
  35 -   44     .00 *
  45 -   54     .00 *
  55 -   64    2.00 I=========*
  65 -   74    1.00 I====*
  75 -   84    3.00 I==============*
  85 -   94    9.01 I============================================*
  95 -  104    5.01 I========================*
 105 -  114    8.01 I=======================================*
 115 -  124    4.00 I===================*
 125 -  134    7.01 I==================================*
 135 -  144    7.01 I==================================*
 145 -  154    2.00 I=========*
 155 -  164    5.01 I========================*
 165 -  174    2.00 I=========*
 175 -  184    3.01 I==============*
 185 -  194    3.00 I==============*
 195 -  204     .00 *
 205 -  214    1.00 I====*
 215 -  224    1.00 I====*
 225 -  234    1.00 I====*
 235 -  244    1.00 I====*
 245 -  254     .00 *
 255 -  264    2.00 I=========*
 265 -  274    1.00 I====*
 275 -  284    1.00 I====*
 285 -  294    1.00 I====*
-------------------------
   5 -  294   70.08
```

As Received

CHEMICAL EXPLANATIONS

Recombination of D_2 and O_2 : No

Pd lattice yield stress 2600 atm (higher after hardening)
Pd $L_s \approx 4$ eV. Bond strength 0.67 eV.
20 W/ml for 100 k = 0.75 keV/Pd atom

Formation of Pd-D alloy : 9 kcal/mole
= 0.4 eV
1.05 Wh/ml
≈ 170 seconds of anomalous heat (at 20W/ml)
Formation of Pd-Li alloy : Similar

CONCLUSIONS

- MICROCALORIMETRY

  - Excess Heat Generation Only With Pd/LiOD and Not With Pd/LiOH and Pt/LiOD

  - Substitution of LiOD With NaOD Reduces Heat Generation to Negligible Values

  - Changing Electrolytes From Natural 0.1M LiOD (94% Li, 6% ^{6}Li) to ^{7}LiOD Results in Reduced Excess Heat Generation Rates

  - With ^{6}LiOD Electrolyte, Response Time For Excess Heat Generation Rate Is Reduced

- NUCLEAR REACTION PRODUCTS

  - No ^{3}He or ^{4}He in Pd Samples (as Received and After Excess Heat Generation) - Mass Spectrometry

  - Tritium in Electrolyte After Excess Heat Generation Same Level as Background - Liquid Scintillation

- SURFACE ANALYSIS

  - Lithium on Electrode (Penetration ≈ 1μm) - SIMS

  - Fe, Cr, Mg, Ca,Si - SIMS, EDX

  - DendriteSEM

ACKNOWLEDGEMENTS

- ^{3}He and ^{4}He Analysis
  Atomics International Division
  of Rocketdyne Corp. and
  Lawrence Livermore Laboratory

- SIMS - Lawrence Livermore Laboratory

- ^{6}Li Supply - Oak Ridge National Laboratory

- EPRI Sponsorship is Gratefully Acknowledged

Run 10 $P_i = (E - 1.48) \cdot I$

5/26 { 0.5 mm dia. Pd. [annealed 950C, 1hr, 10^{-6} torr, furnace cool.. in vacuum.]

{ 0.1 M LiOH . charged at bench for 2 days.
(7.8 ml)

day	time	i (mA)	V	in (mW)	out (mW)	gain	W/cc
5/26	12:15 PM	9.585	2.50	9.2	—		
	3:30 PM	9.600	2.60	10.19	18.12		
	5:00 PM	9.627	2.60	10.70	18.00		
5/27	~~[illegible]~~ 9:30 AM	9.746	2.73	11.89	18.00		
	9:40 AM	96.345	~~[illegible]~~				
	11:30 AM	96.400	4.325	274.76	271.8	~~[illegible]~~	
	1:00 PM	96.35	4.335	275.08	271.8		
	6:00 PM	96.40	4.330	274.74	271.8		
5/28	10:00 AM	96.55	4.295	271.99	271.8		
	11:30 AM	96.60	4.295	271.93	271.80		
	8:00 PM	96.61	4.280	270.51	268.18		
5/29	8:00 AM	96.60	4.272	265.84	264.55		
	8:15 AM	{ open calorimeter and measure solution amount electrolyte was : 6.1 ml ∴ 1.7 ml / 2 days. loss					
	12:00 AM	96.58	4.572	294.47	293.54		
	3:00 PM	96.56	4.525	293.83	291.73		
	5:00 PM	96.45	4.520	293.20	291.73		
	10:00 PM	96.60	4.50	291.73	289.92		

< Continued from page 28 >

day	time	i(mA)	V	in	out	gain
5/30	8:10	96.61	4.45	286.90	286.30	
	11:00 AM	96.58	4.43	284.91	284.48	
	3:30 PM	96.55	4.41	282.87	282.67	
5/31	8:00 AM	96.60	4.33	273.38	273.62	
	3:30 PM	96.58	4.32	274.29	273.62	

* take out cell and stop { pH { before : 13.10
after : 13.25

analysis of electrolyte by nuclear engineering

no tritium {
(A) regular 0.1 M LiOD
(B) used for charging at 60 mA/cm² for 31 days with 2 mm diameter sphere Pd.
(C) used for (B) + 20 hour at 600 mA/cm²

Run 11

5/31 { 0.5 mm diameter, 1 cm, annealed and furnace cooling in vacuum (annealing: 950°C 1 hr, 10^{-5} torr) | used sample: See page 21.

Volume of Pd: 1.9642×10^{-3} cc

day	time	i (mA)	V	IL (mW)	out	gain
5/31	4:00 PM	9.847	2.56	* 0.1 M ^6LiOD (7.8 ml).		
	5:00 PM	9.79K	2.611	10.49	10.87	
	8:30 PM	9.816	2.400	8.67	7.07	
6/1	8:30 AM	9.899	2.425	8.74	7.07	
	12:40 PM	9.782	2.421	8.62	6.52	
	2:45 PM	9.789	2.422	8.63	6.91	
6/2	8:10 AM	9.86	2.43	8.77	7.25	
	* change solution to new 0.1 M ^6LiOD (7.9 ml).					
	11:00 AM	9.819	3.07	15.02	12.0	
	12:00 PM	9.89	3.04	14.71	12.14	
	2:00 PM	9.840	3.00	14.30	12.14	
	4:30 PM	9.800	2.95	13.82	12.16	
	1:30 PM	9.817	3.262	16.90	16.85	
	7:00 PM	9.795	3.265	16.89	16.85	
	10:15 PM	9.832	3.2682	16.93	16.85	
6/4	8:30 AM	9.849	3.2734	17.14	17.21	

9:40 AM increase current to 600 mA/cm²

[Continued from page 30]

day	time	i(mA)	V	IL (mW)	out (mW)	gain (mW)	W/G
6/4	9:40 AM	96.90	5.36				
	4:30 PM	97.00	5.07	342.41	349.716	7.30	3.92
	7:5 PM	96.90	5.04	339.15	360.58	21.44	10.92
6/5	7:35 AM	96.90	4.98	333.33	357.87	24.54	12.50
	9:00 AM	96.90	4.97	332.37	"		"
	12:10 PM	96.91	4.94	329.49	358.77	29.29	14.92
	1:50 PM	96.92	4.94	"	"	"	"
	5:00 PM	96.75	4.92	327.01	355.15	28.14	14.39
	9:15 PM	96.90	4.89	324.61	353.34	28.73	14.64
6/6	7:45 AM	96.95	4.83	318.96	344.28	25.32	12.66

8:40 AM { change solution to 0.1M NaOD (7.8 ml)
collect used solution (0.1M ^{6}LiOD) ⇒ see page 26. (#2)
⇒ solution level ≑ 6.6 ml   ΔV = 1.3 ml loss/2day

day	time	i(mA)	V	IL (mW)	out (mW)	gain (mW)	W/G
	9:00 AM	96.92	5.39				
	10:15 AM	96.92	5.34	368.29			
	1:00 PM	96.92	5.29	363.45	371.46	8.01	4.00
	3:00 PM	96.90	5.27	361.43	369.65	8.22	4.11
	5:20 PM	96.80	5.26	360.01	366.02	6.01	3.00
	7:15 PM	96.74	5.26	359.87	364.21	4.34	2.17
6/7	7:30 AM	96.45	5.22	356.78	362.40	5.62	2.81

10:30 AM remove cell (electrolyte ~7.0 ml ∴ ΔL = 0.8 ml loss/day)

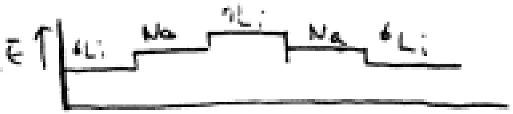
purity: { ^6Li : 98.68 % from ONR.
{ ^7Li : 99.9+ % from Eagle/Pıcher.

[continued from page 31]

day	time	i (mA)	V	IL (mW)	out (mW)	gain	Power/Vol W/cc
6/7	{ change cell (Teflon coated nickel cell)						
	{ electrolyte : 0.1 M NaOD (7.9 ml)						
	11:00 AM	96.72	5.91	403.28			
	12:40 PM	96.83	5.70	402.81	407.7	4.89	2.49
	2:45 PM	96.81	5.69	401.76	405.89	4.13	2.11
	4:10 PM	96.83	5.68	400.87	405.89	5.02	2.56
	5:35 PM	96.87	5.67	400.07	405.89	5.82	2.97
	9:00 PM	96.90	5.65	398.26	404.07	5.81	2.96
6/8	8:15 AM	96.95	5.60	393.62	398.64	5.02	2.56
	10:35 AM	96.98	5.58	391.80	396.83	5.03	2.57
	[• change solution to <u>0.1 M ^7LiOD</u> (7.9 ml)						
	[• { collect used solution (0.1 M NaOD (see page 26 #3)						
	{ loss of solution = 0.8 ml/day.						
	11:10 AM	97.00	5.84	—	—	—	<u><0.1 M ^7LiOD></u>
	1:45 PM	96.92	5.79	411.91	407.70		
	2:00 PM	rearrange cell.					
	3:10 PM	96.91	5.85	417.68	422.19	4.51	2.30
	5:00 PM	96.84	5.82	414.30	418.57	4.27	2.18
	9:30 PM	96.93	5.76	409.13	413.14	4.01	2.05
6/9	8:10 AM	97.00	5.70	403.52	407.70	4.18	2.13
	10:00 AM	97.00	5.70	403.52	407.70	4.18	2.13

[continued from page 32]

day	time	i (mA)	V	IL (mW)	out (mW)	gain mW	Pd Power/Vol W/cc
6/9	11:15 AM	97.00	5.69	402.55	407.70	5.15	2.63
	2:00 PM	96.90	5.68	401.16	405.88	4.72	2.41
	4:25 PM	96.85	5.65	398.05	402.26	4.21	2.15
	6:00 PM	96.72	5.64	396.55	400.45	3.90	1.99
	10:50 PM	96.95	5.62	395.55	400.45	4.90	2.50
	11:00 PM	change cell to uncoated stainless steel cell containing the same amount of 0.1 M ^7LiOD used until 10:50 PM, 6/9 in Teflon coated Ni cell. amount of 0.1 M ^7LiOD = 6.6 ml ∴ 1.3 ml loss / 36 hours ⇒ 1.7 ml/2 day.						
	11:05 PM	96.98	5.70				
6/10	8:45 AM	97.00	5.57	390.91	398.64	7.73	3.94
	11:10 AM	97.00	5.55	388.97	393.20	4.23	2.13
	1:30 PM	97.00	5.54	388.0	393.20	5.20	2.65
	3:05 PM	97.00	5.53	387.03	391.39	4.36	2.22
	3:15 PM	• change solution to <u>0.1 M NaOD</u> (7.9 ml) • collect used solution 0.1 M ^7LiOD (#4, see page 26) • using Teflon coated Ni cell.						
	3:20 PM	97.00	5.73				
	8:00 PM	96.92	5.53	386.71	389.58	2.87	1.46



Continue from page 33

Pd sol Vol ol cc	day	time	i(mA)	V	IN(mW)	out(mW)	(mW) gain	W/cc
63	6/11	10:00 AM	96.95	5.42	376.16	380.52	4.36	2.22
u1		12:10 AM	97.00	5.41	375.39	380.52	5.13	2.61
.15		5:45 PM	96.99	5.37	371.39	371.46	0.07	–
99		9:00 PM	96.95	5.35	369.38	371.46	2.08	1.06
.50	6/12	8:10 AM	97.00	5.30	364.72	362.80		

9:35 AM
- Change solution to <u>0.1M ^{6}LiOD</u> (7.9 ml)
- collect used solution, 0.1M NaOD (see page 26, #5)
  solution loss 1.7 ml/2 day
- using Teflon coated cell (Ni)

Pd sol Vol ol cc	day	time	i(mA)	V	IN(mW)	out(mW)	(mW) gain	W/cc
		9:45 AM	97.00	5.09	344.35			
		10:45 AM	97.00	5.10	345.32	353.34	8.02	4.09
94		12:00 PM	97.00	5.13	348.23	355.15	6.92	3.53
13		2:10 PM	96.80	5.11	345.57	353.34	7.77	3.96
55		4:40 PM	96.85	5.10	344.78	353.34	8.56	4.36
.2		7:30 PM	96.80	5.08	342.67	351.53	8.86	4.51
		10:00 PM	97.00	5.07	342.41	351.53	9.12	4.65
26)	6/13	8:00 AM	97.00	5.03	338.53	347.90	9.37	4.77
		10:15 AM	97.00	5.03	338.53	347.90	9.37	4.77
		12:30 PM	96.90	5.01	336.24	346.09	9.85	5.02

↓

~~6/13 3:30pM 96.86 (mA) 4.9(V) 325.45 (mW)~~

day	time	i (mA)	V	in (mW)	out (mW)	gain (mW)	W/cc
6/13	3:30pM	96.86	5.00	335.13	346.09	10.96	5.58
	5:30pM	96.80	4.99	333.96	344.28	10.32	5.26
	9:20pM	96.80	4.96	331.05	342.47	11.42	5.82
6/14	8:10 AM	96.95	4.94	329.63	340.65	11.02	5.62
	11:05 AM	97.00	4.92	327.86	338.84	10.98	5.60
	12:30 PM	97.00	4.91	326.89	337.03	10.14	5.17

12:45PM
- current off.
- Cell voltage immediately drops to 0.55V and
- steady-state value at ~0.46V
- no heat generation.
- collect used solution (#6. 0.1M ^6LiOD, see page 26)
- solution level 6.1 ml after 52 hours (1.7 ml/2 days)

- water vapor pressure at 25°C = 23.756 torr (CRC Handbook D-190)

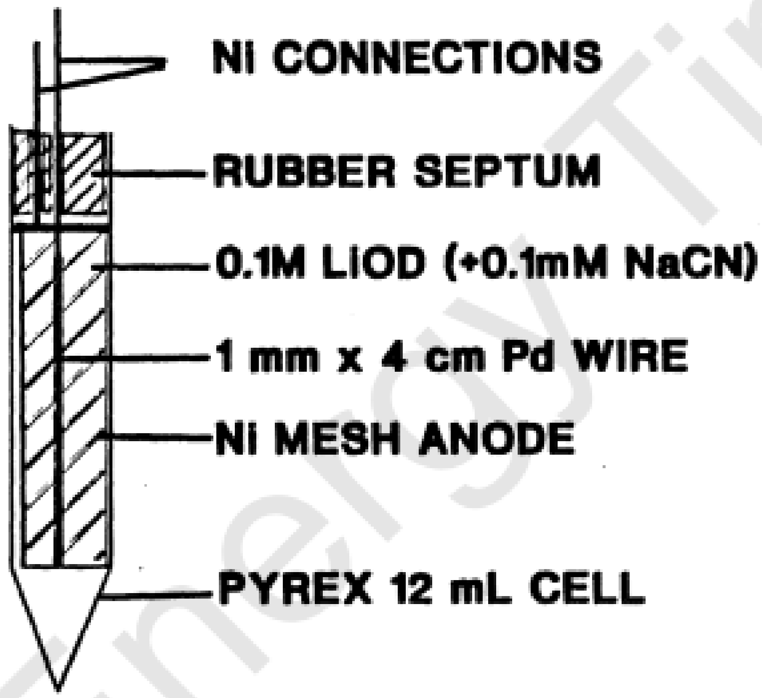
(if P_{atm} = 750 mm Hg, P_{vapor} = 24 torr ; P_{gas} = (750 − 24) = 726 torr
if V = 30 ml) $= \frac{726}{760} = 0.955$ atm.

$$n = \frac{PV}{RT} = \frac{0.955 \text{ atm} \times 0.030 \ell}{0.082 \frac{\text{atm}\cdot\ell}{°K\cdot \text{mol}} \times 298 (°K)}$$

$= 1.1728 \times 10^{-3}$ mole $= 1.17$ mM. : (for $D_2 + O_2$)

if V = 8 ml ; n = 0.0003126 M ($D_2 + O_2$)

CELL DESIGN AND TREATMENT



ALL CELLS RUN AT 50 $mAcm^{-2}$ FOR 14 TO 16 DAYS

THEN AT 500 $mAcm^{-2}$ FOR UP TO 12 HOURS

2 ml/DAY D_2O ADDED AT LOW i, 5 ml/HOUR AT HIGH i

TRITIUM ACTIVITY ANALYSIS

ANALYSIS PERFORMED BY LIQUID SCINTILLATION (LSC)

INSTRUMENT USED, LKB WALLAC MODEL 1219 LSC

BIOSAFE II SCINTILLATION COCKTAIL

1 ml SAMPLE + 15 ml COCKTAIL

30 MINUTES UNDER COVER BEFORE ANALYSIS

RECOUNTS 24 HRS LATER SHOW NO CHANGE

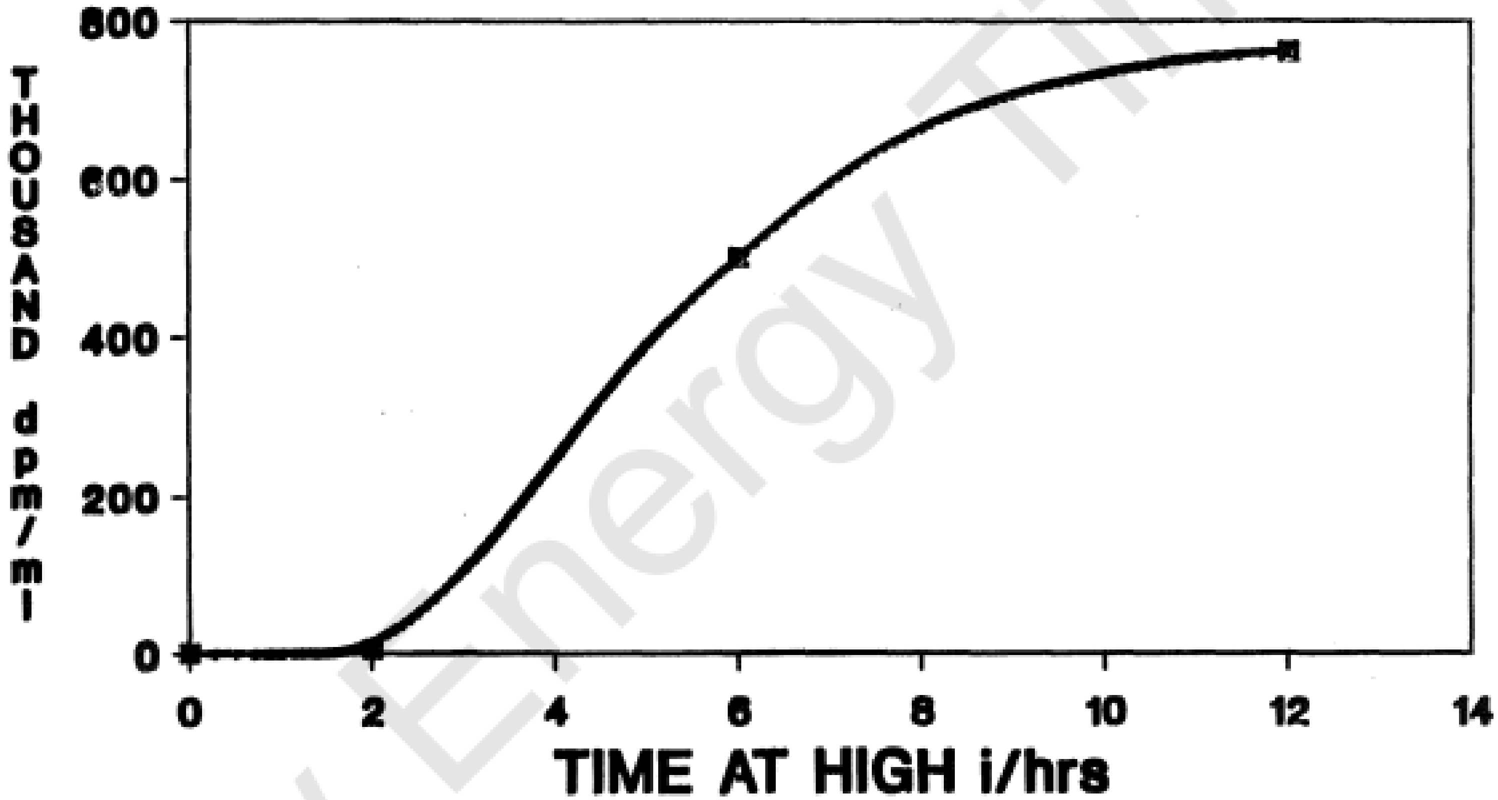
SAMPLES RUN IN BLIND FASHION

COUNTS CONFIRMED BY K. WOLF AND OTHERS

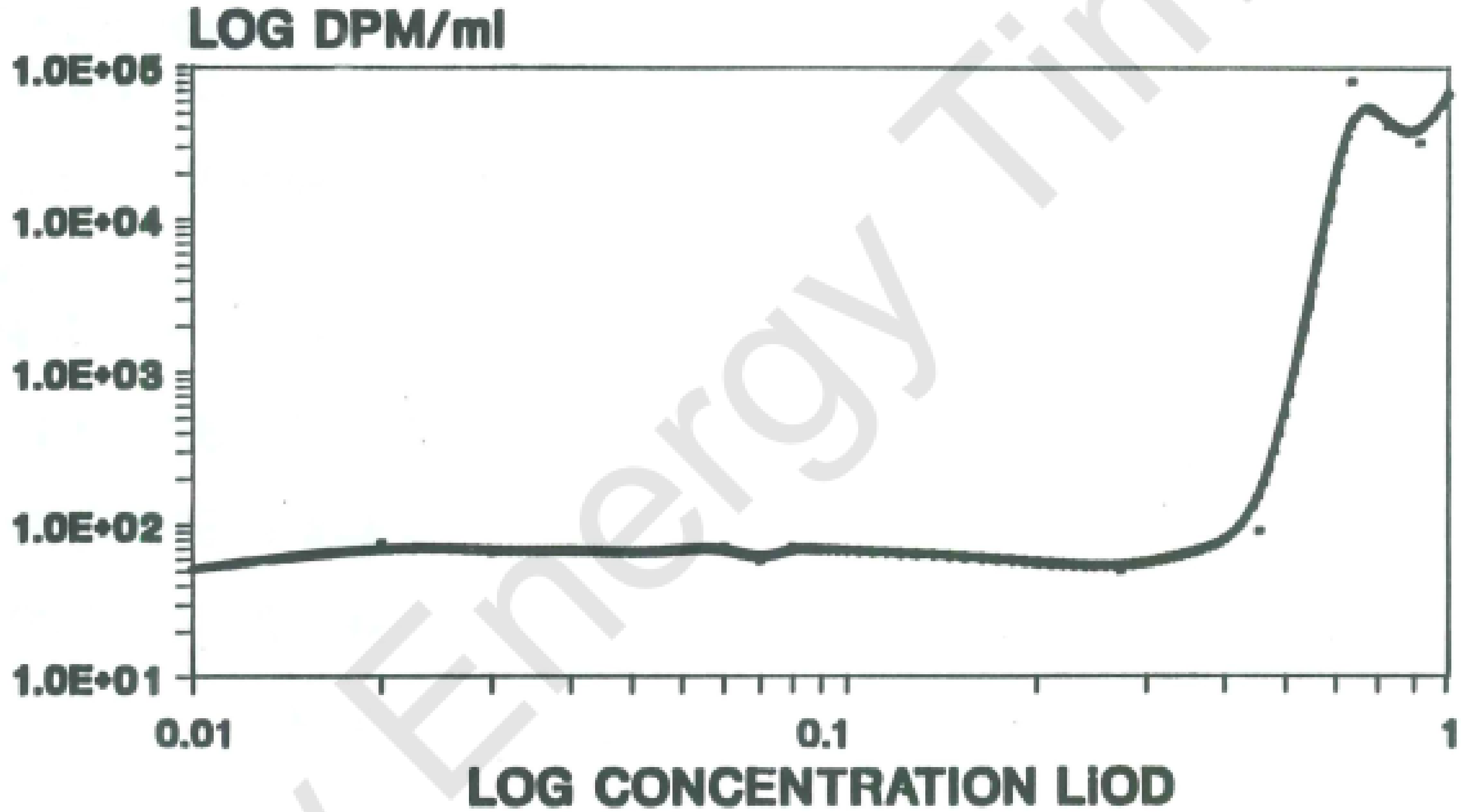
ELECTRODE PREPARATION, SOLUTION CONTENT AND ^3H ACTIVITY

CELL	ELECTRODE	SOLUTION	ACTIVITY (d/min/ml)
A1	NONE	0.1M LIOD	3.8E+4
A2	NONE	+0.1mM NaCN	315
A3	ANNEAL	0.1M LIOD	4.9E+6
A4*	ANNEAL	+0.1mM NaCN	1.2E+5
A5	ETCH	0.1M LIOD	3.7E+6
A6	ETCH	+0.1mM NaCN	3.3E+4
A7	E-CHEM	0.1M LIOD	249
A7	AT 2 hrs HIGH i		5370
A7	AT 6 hrs HIGH i		5.0E+5
A7	AT 12 hrs HIGH i		7.6E+5
A8	E-CHEM	+0.1mM NaCN	339
B3 (3mm)	ANNEAL	0.1M LIOD	6.3E+4
B5 (3mm)	ETCH	0.1M LIOD	195
CELL 1 (6mm)	NONE	0.1M LIOD	264
D_2O			195
0.1M LIOD			225
NEUTRALIZED 0.1M LIOD			220
NEUTRALIZED 0.1M LIOD + 0.1mM NaCN			230

TIME PROFILE OF TRITIUM PRODUCTION FROM CELL A7



ELECTROLYTE CONCENTRATION EFFECTS ON CHEMILUMINESENCE OF COCKTAIL



TRITIUM CONFIRMATION

	CELL A5	CELL A1	STANDARD	LiOD	D_2O
TAMU	2.13E6	1304	7.23E5	240	153
ARGONNE	1.96E6	1020	7.59E5	90	114
BATTELLE	1.96E6	1170	8.08E5	127	140
GENERAL MOTORS	1.80E6	1108	-------	---	---
LOS ALAMOS		VERBAL			
LAWRENCE LIVERMORE		UNAVAILABLE			