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INFORMAL REPORT

INITIAL TESTING OF TWO DEMI MODEL 4E
ZINC-AIR RECHARGEABLE CELLS

J. E. Hardin
M. E. Martin

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EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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Purpose

The purpose of this document is to report the results of INEL laboratory testing of two DEMI 4E Aerobic Power Battery cells (collectively designated Pack 46 in INEL records).

Background

The 4E Aerobic Power Battery is a secondary battery developed privately by Driesbach Electromotive Inc. (DEMI). The battery employs zinc as the anode and a bifunctional air cathode. This testing was performed as the first phase of a cooperative agreement between INEL and DEMI leading to the construction and testing of electric vehicle-size cells, to be followed eventually by a battery pack.

Reference Information

INEL Battery Test Procedures
ETV-BAT-988
DEMI Technical Information dated June 29, 1989

Battery Description

The test batteries consisted of two Model 4E Aerobic Power zinc-air cells, as illustrated in Figure 1. These cells have a projected capacity of 20 ampere-hours at the 1-ampere rate and a projected (target) energy density of 200 Wh/kg.

Table 1
Physical Characteristics

Module Weight:	Cell A	145.0 g
	Cell B	149.5 g
	Average	147.25 g
Module Size:		
Width	6.35 cm	
Length	12.19 cm	
Thickness	1.27 cm	(non-uniform)

Test Equipment

All testing was performed using a Bitrode cycler-tester modified to handle the relatively low current from these small cells. (The tester's 500 ampere shunt was replaced with a 50 ampere shunt to give better resolution and control.) Voltage measurement leads were soldered to the cell output output leads as close to the case as possible to reduce any voltage loss during testing.

Battery Configuration and Other Test Conditions

The following configuration and special conditions (generally as specified by DEMI) were applied to the cells themselves:

1. The air management fan (shown in Figure 2) was allowed to run only during the discharge steps. A photo of the fan is seen in Figure 3. It drew 200 ma from a 12 volt dc supply. A signal was brought out of the Bitrode tester for this control function. The fan outlet was placed 8.9 centimeters (3.5 inches) from the cell inlets.
2. The cells were sealed away from oxygen when not in test.
3. The cells were periodically checked for weepage and drained if necessary.
4. The cells were operated on a level surface with the labels up. (Cell B was stacked on top of cell A.)
5. The charge current was set at 260 milliamperes.

The INEL battery laboratory altitude is 1484 meters (64 cm atmospheric pressure). The average relative humidity during the conduct of this testing was 40%.

Test Cycle

The test cycle used for all tests was a modified version of the Simplified Urban Driving Schedule (SFUDS). The SFUDS 79 W/kg step was limited to 50 W/kg, and the -10 W/kg (regeneration) steps were replaced with rest steps of the same duration.

The SFUDS discharge tests were performed between 75% and 50% state of charge (SOC). The cells were assembled fully charged. Therefore an initial 1.2 ampere constant current discharge of 5 ampere-hours was accomplished, putting the cells at 75% state of charge for the start of SFUDS testing. (This discharge lasted 4 hours 10 minutes.)

The end of life termination criterion was defined as the point when the voltage on the 10 W/kg step was less than 0.75 volts per cell. The SFUDS cycle termination was arbitrarily fixed at 5 ampere hours in order to operate the cells between 75 and 50% SOC. The recharge was 6 ampere-hours (260 milliamperes constant current charge for 23 hours.)

Test Results

Detailed tabulations of the results of each discharge test are included as Tables 2-5 following. These results are summarized and described in narrative fashion below. The format of the data listings is as follows:

For each table, each 6 lines is a summary of data for one (numbered) SFUDS cycle. Each line within a cycle describes one of

the 6 steps at the nominal (requested) power level (-10, 0, 10, 20, 50 and 79 W/Kg) for that step. The power, voltage, current and actual W/kg values are the averages for that step within that cycle. Each line also shows the time, A-h and kWh output, and the percent depth-of-discharge (%DOD) (relative to the 5 A-h planned) at the end of the cycle which includes this step. (Note: The -10 and 79 W/kg steps were actually 0 and 50 W/kg respectively for this testing.)

The first SFUDS test ran 4 hours 5 minutes (7 complete cycles plus 6 minutes 41 seconds), for an output of 5.05 A-h and 3.58 W-h. The average voltage for the 20 W/kg step was suppressed below 0.4 volts per cell and below 0.1 volts on the 50 W/kg steps. (See Table 2 for the detailed test results.) No minimum voltage limit was imposed, and the voltage was allowed to collapse under higher power current demands. After a discussion with Mike Cheike at DEMI, "air cathode stall" was determined to be the reason for this limiting behavior. It was decided that the voltage should be limited to 0.7 volts per cell on future discharges. The cells were then given a 6 A-h charge at 260 ma.

The second SFUDS ran 5 hours 11 minutes (9 complete cycles plus 5 minutes 10 seconds), producing 5.02 A-h and 8.19 W-h. (See Table 3 for detailed data.) This is equivalent to 27.86 Wh/kg. The cells were then given a 6 A-h charge at 260 ma. The cells were drained of what appeared to be an amber condensate and then bagged in preparation for a laboratory shutdown for maintenance. The amber liquid was subsequently determined to have a ph of 14.

The third SFUDS test was run after the cells had been idle for about 1 month. The cell voltages went to zero on the first 10 W/kg step in the cycle. After a discussion with DEMI, it was determined that the cells had apparently lost too much liquid (5 - 10 ml). [DID WE ADD LIQUID TO THEM AT THIS POINT??] It was then decided to give the cells one or two charge cycles (6 to 12 A-h) and cycle them again. After a 6 A-h charge the test was started again. The discharge ran 2 hours 30 minutes (4 cycles plus 13 minutes 35 seconds), for a total of 2.18 A-h and 3.43 W-h. (See Table 4 for detailed results.) The test was terminated per the end of life criterion (less than 0.75 volts per cell on the 10 W/Kg step). The cells were subsequently charged for 6 A-h at 260 ma.

The fourth SFUDS ran 3 hours 38 minutes (6 cycles plus 13 minutes 40 seconds), for 3.27 A-h and 5.17 W-h. (See Table 5.) The test again failed the end of life criterion (less than 0.75 volts on the 10 W/kg step).

At the end of the testing, the cells had experienced an overall loss of 18 ml of liquid. The liquid had a thick dark amber appearance. The final weights of the cells were: A 141.8 grams and B 151.5 grams. [LIQUID LOSS DOES NOT AGREE WITH INITIAL & FINAL WEIGHTS UNLESS WE ADDED LIQUID ABOVE??]

General Comments and Observations

The two cells performed similarly during this testing, as shown in the voltage-vs-time curve in Figure 3, although one cell lost weight and the other gained weight.

A 6 A-h recharge using the charge current of 260 ma requires over 23 hours. This is a longer charge time than any battery evaluated to date and does not seem practical for electric vehicles unless this time can be significantly reduced.

If the condensation of liquid observed represents typical behavior, some method needs to be developed to deal with it.

Operating a battery between 50 and 75% SOC is clearly inefficient, since it effectively derates the energy density by a factor of 4. It is not known whether this operating mode will be required in the future.

The first cycle (performed with no voltage limits during higher power steps of the discharge, as agreed to by DEMI) may have done permanent damage to the cells. By requiring a power that the cells could not deliver, the cathode may have been forced into oxygen transport reactions that caused it to lose its hydrophobic properties.

The cells were returned to DEMI for their teardown analysis in accordance with the cooperative agreement. Overall test results were approximately as expected for this first phase.

Table 2.
First SFUDS Cycle Discharge Data

From Bitrode SFUDS Data File: 'demi2.dat'

Number of cells: 2 Average cell weight: 0.147 kg.
Time started: Wed Jul 19 14:03:28 1989
Time updated: Wed Jul 19 18:12:42 1989
Programmed amp-hours: 5.00

Time (sec.)	Cycle	Amp- Hours	Watt- Hours	Request W/kg	Actual W/kg	%DOD	Avg. Power	Avg. Voltage	Avg. Current
00	00	0.00	0.00	0	0.00	0.00	0.00	1.39	0.00
2040	01	0.36	0.28	-10	0.47	14.27	0.07	1.31	0.07
2040	01	0.36	0.28	0	0.45	14.27	0.07	1.34	0.07
2040	01	0.36	0.28	10	9.84	14.27	1.45	1.09	1.36
2040	01	0.36	0.28	20	8.70	14.27	1.28	0.37	4.72
2040	01	0.36	0.28	50	0.20	14.27	0.03	0.03	4.40
2040	01	0.36	0.28	79	0.64	14.27	0.09	0.07	7.41
4080	02	0.71	0.57	-10	0.47	28.32	0.07	1.32	0.07
4080	02	0.71	0.57	0	0.45	28.32	0.07	1.34	0.07
4080	02	0.71	0.57	10	9.84	28.32	1.45	1.10	1.36
4080	02	0.71	0.57	20	9.40	28.32	1.38	0.37	4.66
4080	02	0.71	0.57	50	0.20	28.32	0.03	0.03	4.26
4080	02	0.71	0.57	79	0.64	28.32	0.09	0.07	7.23
6120	03	1.09	0.84	-10	0.49	43.66	0.07	1.32	0.07
6120	03	1.09	0.84	0	0.47	43.66	0.07	1.34	0.07
6120	03	1.09	0.84	10	9.84	43.66	1.45	1.10	1.36
6120	03	1.09	0.84	20	8.50	43.66	1.25	0.34	4.69
6120	03	1.09	0.84	50	0.21	43.66	0.03	0.03	4.49
6120	03	1.09	0.84	79	0.78	43.66	0.11	0.09	7.16
8160	04	1.44	1.08	-10	0.47	57.78	0.07	1.31	0.07
8160	04	1.44	1.08	0	0.45	57.78	0.07	1.34	0.07
8160	04	1.44	1.08	10	9.84	57.78	1.45	1.08	1.37
8160	04	1.44	1.08	20	5.41	57.78	0.80	0.22	4.90
8160	04	1.44	1.08	50	0.20	57.78	0.03	0.03	3.88
8160	04	1.44	1.08	79	0.60	57.78	0.09	0.07	6.54
10200	05	1.79	1.30	-10	0.47	71.68	0.07	1.29	0.07
10200	05	1.79	1.30	0	0.45	71.68	0.07	1.33	0.07
10200	05	1.79	1.30	10	9.84	71.68	1.45	1.05	1.41
10200	05	1.79	1.30	20	2.57	71.68	0.38	0.10	4.84
10200	05	1.79	1.30	50	0.20	71.68	0.03	0.03	3.69
10200	05	1.79	1.30	79	0.58	71.68	0.09	0.07	5.80

Table 2 (cont.)

12240	06	2.12	1.51	-10	0.47	84.95	0.07	1.28	0.07
12240	06	2.12	1.51	0	0.45	84.95	0.07	1.33	0.07
12240	06	2.12	1.51	10	9.84	84.95	1.45	1.05	1.42
12240	06	2.12	1.51	20	2.51	84.95	0.37	0.10	4.51
12240	06	2.12	1.51	50	0.20	84.95	0.03	0.03	3.48
12240	06	2.12	1.51	79	0.58	84.95	0.09	0.07	5.68
14280	07	2.44	1.73	-10	0.47	97.72	0.07	1.27	0.07
14280	07	2.44	1.73	0	0.45	97.72	0.07	1.33	0.07
14280	07	2.44	1.73	10	9.84	97.72	1.45	1.06	1.41
14280	07	2.44	1.73	20	2.89	97.72	0.43	0.11	4.44
14280	07	2.44	1.73	50	0.20	97.72	0.03	0.03	2.98
14280	07	2.44	1.73	79	0.60	97.72	0.09	0.07	5.24
14665	08	2.52	1.79	-10	1.64	100.94	0.24	1.25	0.22
14665	08	2.52	1.79	0	1.64	100.94	0.24	1.30	0.22
14665	08	2.52	1.79	10	9.84	100.94	1.45	1.05	1.42
14665	08	2.52	1.79	20	4.07	100.94	0.60	0.17	4.14
14665	08	2.52	1.79	50	0.76	100.94	0.11	0.09	2.50
14665	08	2.52	1.79	79	1.97	100.94	0.29	0.24	4.01

Discharge time: 14681 seconds 4:04:41

7 cycles 6 minutes 41 seconds

Discharge time minus 10 minute rests: 2:54:41

Discharge Ampere-hours: 5.05 Watt-hours: 3.58

Minimum Temperature: 24.5 C Maximum Temperature: 35.5 C

Table 3.
Second SFUDS Cycle Discharge Data

From Bitrode SFUDS Data File: 'demi4.dat'

Number of cells: 2 Average cell weight: 0.147 kg.

Time started: Thu Jul 20 17:37:56 1989

Time updated: Fri Jul 21 18:28:34 1989

Programmed amp-hours: 5.00

Time (sec.)	Cycle	Amp- Hours	Watt- Hours	Request W/kg	Actual W/kg	%DOD	Avg. Power	Avg. Voltage	Avg. Current
00	00	0.00	0.00	0	0.00	0.00	0.00	1.26	0.00
2040	01	0.29	0.48	-10	0.47	11.55	0.07	1.28	0.08
2040	01	0.29	0.48	0	0.45	11.55	0.07	1.29	0.08
2040	01	0.29	0.48	10	9.84	11.55	1.45	1.08	1.38
2040	01	0.29	0.48	20	17.96	11.55	2.65	0.74	3.63
2040	01	0.29	0.48	50	16.63	11.55	2.45	0.71	3.53
2040	01	0.29	0.48	79	19.43	11.55	2.86	0.72	4.09
4080	02	0.57	0.95	-10	0.47	22.82	0.07	1.30	0.07
4080	02	0.57	0.95	0	0.45	22.82	0.07	1.33	0.07
4080	02	0.57	0.95	10	9.84	22.82	1.45	1.07	1.38
4080	02	0.57	0.95	20	17.64	22.82	2.60	0.73	3.60
4080	02	0.57	0.95	50	14.61	22.82	2.15	0.71	3.10
4080	02	0.57	0.95	79	19.11	22.82	2.81	0.72	4.02
6120	03	0.86	1.42	-10	0.47	34.31	0.07	1.30	0.07
6120	03	0.86	1.42	0	0.45	34.31	0.07	1.33	0.07
6120	03	0.86	1.42	10	9.84	34.31	1.45	1.07	1.39
6120	03	0.86	1.42	20	17.84	34.31	2.63	0.73	3.64
6120	03	0.86	1.42	50	15.86	34.31	2.34	0.71	3.37
6120	03	0.86	1.42	79	19.19	34.31	2.83	0.72	4.03
8160	04	1.14	1.89	-10	0.47	45.80	0.07	1.30	0.07
8160	04	1.14	1.89	0	0.45	45.80	0.07	1.33	0.07
8160	04	1.14	1.89	10	9.84	45.80	1.45	1.05	1.41
8160	04	1.14	1.89	20	17.45	45.80	2.57	0.71	3.66
8160	04	1.14	1.89	50	15.25	45.80	2.25	0.71	3.24
8160	04	1.14	1.89	79	18.63	45.80	2.74	0.72	3.91
10200	05	1.43	2.34	-10	0.47	57.06	0.07	1.30	0.07
10200	05	1.43	2.34	0	0.45	57.06	0.07	1.33	0.07
10200	05	1.43	2.34	10	9.84	57.06	1.45	1.04	1.42
10200	05	1.43	2.34	20	17.04	57.06	2.51	0.71	3.61
10200	05	1.43	2.34	50	14.14	57.06	2.08	0.71	3.00
10200	05	1.43	2.34	79	17.41	57.06	2.56	0.72	3.67

Table 3 (cont.)

12240	06	1.70	2.79	-10	0.47	68.20	0.07	1.30	0.07
12240	06	1.70	2.79	0	0.45	68.20	0.07	1.33	0.07
12240	06	1.70	2.79	10	9.84	68.20	1.45	1.03	1.44
12240	06	1.70	2.79	20	16.35	68.20	2.41	0.70	3.47
12240	06	1.70	2.79	50	14.71	68.20	2.17	0.71	3.13
12240	06	1.70	2.79	79	16.83	68.20	2.48	0.72	3.54
14280	07	1.95	3.19	-10	0.47	78.09	0.07	1.29	0.07
14280	07	1.95	3.19	0	0.45	78.09	0.07	1.32	0.07
14280	07	1.95	3.19	10	9.84	78.09	1.45	1.00	1.49
14280	07	1.95	3.19	20	13.57	78.09	2.00	0.70	2.89
14280	07	1.95	3.19	50	11.68	78.09	1.72	0.71	2.49
14280	07	1.95	3.19	79	13.90	78.09	2.05	0.72	2.92
16320	08	2.20	3.60	-10	0.47	88.04	0.07	1.29	0.07
16320	08	2.20	3.60	0	0.45	88.04	0.07	1.32	0.07
16320	08	2.20	3.60	10	9.84	88.04	1.45	1.00	1.49
16320	08	2.20	3.60	20	13.77	88.04	2.03	0.70	2.94
16320	08	2.20	3.60	50	11.48	88.04	1.69	0.71	2.45
16320	08	2.20	3.60	79	13.60	88.04	2.00	0.72	2.86
18360	09	2.45	4.00	-10	0.47	97.93	0.07	1.29	0.07
18360	09	2.45	4.00	0	0.45	97.93	0.07	1.32	0.07
18360	09	2.45	4.00	10	9.84	97.93	1.45	0.99	1.50
18360	09	2.45	4.00	20	13.53	97.93	1.99	0.70	2.88
18360	09	2.45	4.00	50	11.42	97.93	1.68	0.71	2.43
18360	09	2.45	4.00	79	14.04	97.93	2.07	0.72	2.95
18654	10	2.51	4.09	-10	1.97	100.35	0.29	1.25	0.28
18654	10	2.51	4.09	0	2.46	100.35	0.36	1.27	0.34
18654	10	2.51	4.09	10	9.84	100.35	1.45	0.97	1.53
18654	10	2.51	4.09	20	13.42	100.35	1.98	0.71	2.85
18654	10	2.51	4.09	50	11.25	100.35	1.66	0.73	2.35
18654	10	2.51	4.09	79	11.88	100.35	1.75	0.78	2.39

Discharge time: 18670 seconds 5:11:10

9 cycles 5 minutes 10 seconds

Discharge time minus 10 minute rests: 3:41:10

Discharge ampere-hours: 5.02 Watt-hours: 8.19

Minimum Temperature: 24.5 C Maximum Temperature: 28.5 C

Table 4
Third SFUDS Cycle Discharge Data

From Bitrode SFUDS Data File: 'demi8.dat'

Number of cells: 2 Average cell weight: 0.147 kg.
Time started: Tue Aug 29 10:42:52 1989
Time updated: Tue Aug 29 15:46:06 1989
Programmed amp-hours: 5.00

Time (sec.)	Cycle	Amp- Hours	Watt- Hours	Request W/kg	Actual W/kg	%DOD	Avg. Power	Avg. Voltage	Avg. Current
00	00	0.00	0.00	0	0.00	0.00	0.00	1.36	0.00
2040	01	0.24	0.38	-10	0.47	9.78	0.07	1.27	0.09
2040	01	0.24	0.38	0	0.45	9.78	0.07	1.29	0.09
2040	01	0.24	0.38	10	9.84	9.78	1.45	0.89	1.67
2040	01	0.24	0.38	20	11.70	9.78	1.72	0.70	2.50
2040	01	0.24	0.38	50	12.28	9.78	1.81	0.70	2.62
2040	01	0.24	0.38	79	12.86	9.78	1.89	0.71	2.73
4080	02	0.49	0.77	-10	0.47	19.71	0.07	1.27	0.08
4080	02	0.49	0.77	0	0.45	19.71	0.07	1.30	0.08
4080	02	0.49	0.77	10	9.84	19.71	1.45	0.92	1.62
4080	02	0.49	0.77	20	12.63	19.71	1.86	0.70	2.70
4080	02	0.49	0.77	50	12.01	19.71	1.77	0.71	2.56
4080	02	0.49	0.77	79	12.70	19.71	1.87	0.72	2.68
6120	03	0.73	1.15	-10	0.47	29.30	0.07	1.28	0.08
6120	03	0.73	1.15	0	0.45	29.30	0.07	1.31	0.08
6120	03	0.73	1.15	10	9.84	29.30	1.45	0.92	1.63
6120	03	0.73	1.15	20	11.94	29.30	1.76	0.70	2.55
6120	03	0.73	1.15	50	11.37	29.30	1.68	0.71	2.43
6120	03	0.73	1.15	79	11.96	29.30	1.76	0.72	2.52
8160	04	0.96	1.52	-10	0.49	38.59	0.07	1.28	0.08
8160	04	0.96	1.52	0	0.45	38.59	0.07	1.31	0.08
8160	04	0.96	1.52	10	9.84	38.59	1.45	0.89	1.68
8160	04	0.96	1.52	20	10.99	38.59	1.62	0.70	2.35
8160	04	0.96	1.52	50	10.74	38.59	1.58	0.71	2.28
8160	04	0.96	1.52	79	11.18	38.59	1.65	0.72	2.34
8959	05	1.09	1.72	-10	0.82	43.70	0.12	1.26	0.13
8959	05	1.09	1.72	0	0.82	43.70	0.12	1.29	0.13
8959	05	1.09	1.72	10	9.83	43.70	1.45	0.84	1.77
8959	05	1.09	1.72	20	10.13	43.70	1.49	0.70	2.17
8959	05	1.09	1.72	50	9.68	43.70	1.43	0.71	2.06
8959	05	1.09	1.72	79	10.11	43.70	1.49	0.74	2.09

Discharge time: 8975 seconds 2:29:35

4 cycles 13 minutes 35 seconds

Discharge time minus 10 minute rests: 1:49:35

Discharge ampere-hours: 2.18 Watt-hours: 3.43

Minimum Temperature: 21.5 C Maximum Temperature: 28.0 C

Table 5
Fourth SFUDS Cycle Discharge Data

From Bitrode SFUDS Data File: 'demil0.dat'

Number of cells: 2 Average cell weight: 0.147 kg.
Time started: Wed Aug 30 17:12:49 1989
Time updated: Thu Aug 31 10:41:30 1989
Programmed amp-hours: 5.00

Time (sec.)	Cycle	Amp- Hours	Watt- Hours	Request W/kg	Actual W/kg	%DOD	Avg. Power	Avg. Voltage	Avg. Current
00	00	0.00	0.00	0	0.00	0.00	0.00	1.26	0.00
2040	01	0.28	0.45	-10	0.47	11.16	0.07	1.28	0.08
2040	01	0.28	0.45	0	0.45	11.16	0.07	1.29	0.08
2040	01	0.28	0.45	10	9.84	11.16	1.45	1.05	1.41
2040	01	0.28	0.45	20	16.80	11.16	2.47	0.71	3.54
2040	01	0.28	0.45	50	14.49	11.16	2.13	0.71	3.08
2040	01	0.28	0.45	79	17.03	11.16	2.51	0.72	3.59
4080	02	0.55	0.88	-10	0.47	21.92	0.07	1.28	0.08
4080	02	0.55	0.88	0	0.45	21.92	0.07	1.30	0.07
4080	02	0.55	0.88	10	9.84	21.92	1.45	0.98	1.52
4080	02	0.55	0.88	20	14.83	21.92	2.18	0.70	3.16
4080	02	0.55	0.88	50	14.61	21.92	2.15	0.71	3.11
4080	02	0.55	0.88	79	15.24	21.92	2.24	0.72	3.20
6120	03	0.81	1.29	-10	0.47	32.21	0.07	1.28	0.08
6120	03	0.81	1.29	0	0.45	32.21	0.07	1.30	0.08
6120	03	0.81	1.29	10	9.84	32.21	1.45	0.94	1.59
6120	03	0.81	1.29	20	13.44	32.21	1.98	0.70	2.87
6120	03	0.81	1.29	50	13.42	32.21	1.98	0.71	2.86
6120	03	0.81	1.29	79	13.64	32.21	2.01	0.72	2.89
8160	04	1.04	1.67	-10	0.47	41.78	0.07	1.28	0.08
8160	04	1.04	1.67	0	0.45	41.78	0.07	1.30	0.08
8160	04	1.04	1.67	10	9.84	41.78	1.45	0.90	1.66
8160	04	1.04	1.67	20	11.68	41.78	1.72	0.70	2.50
8160	04	1.04	1.67	50	11.11	41.78	1.64	0.71	2.37
8160	04	1.04	1.67	79	11.84	41.78	1.74	0.72	2.49
10200	05	1.28	2.03	-10	0.47	51.18	0.07	1.28	0.08
10200	05	1.28	2.03	0	0.45	51.18	0.07	1.31	0.08
10200	05	1.28	2.03	10	9.84	51.18	1.45	0.87	1.72
10200	05	1.28	2.03	20	11.03	51.18	1.63	0.70	2.36
10200	05	1.28	2.03	50	10.72	51.18	1.58	0.71	2.28
10200	05	1.28	2.03	79	10.64	51.18	1.57	0.72	2.25

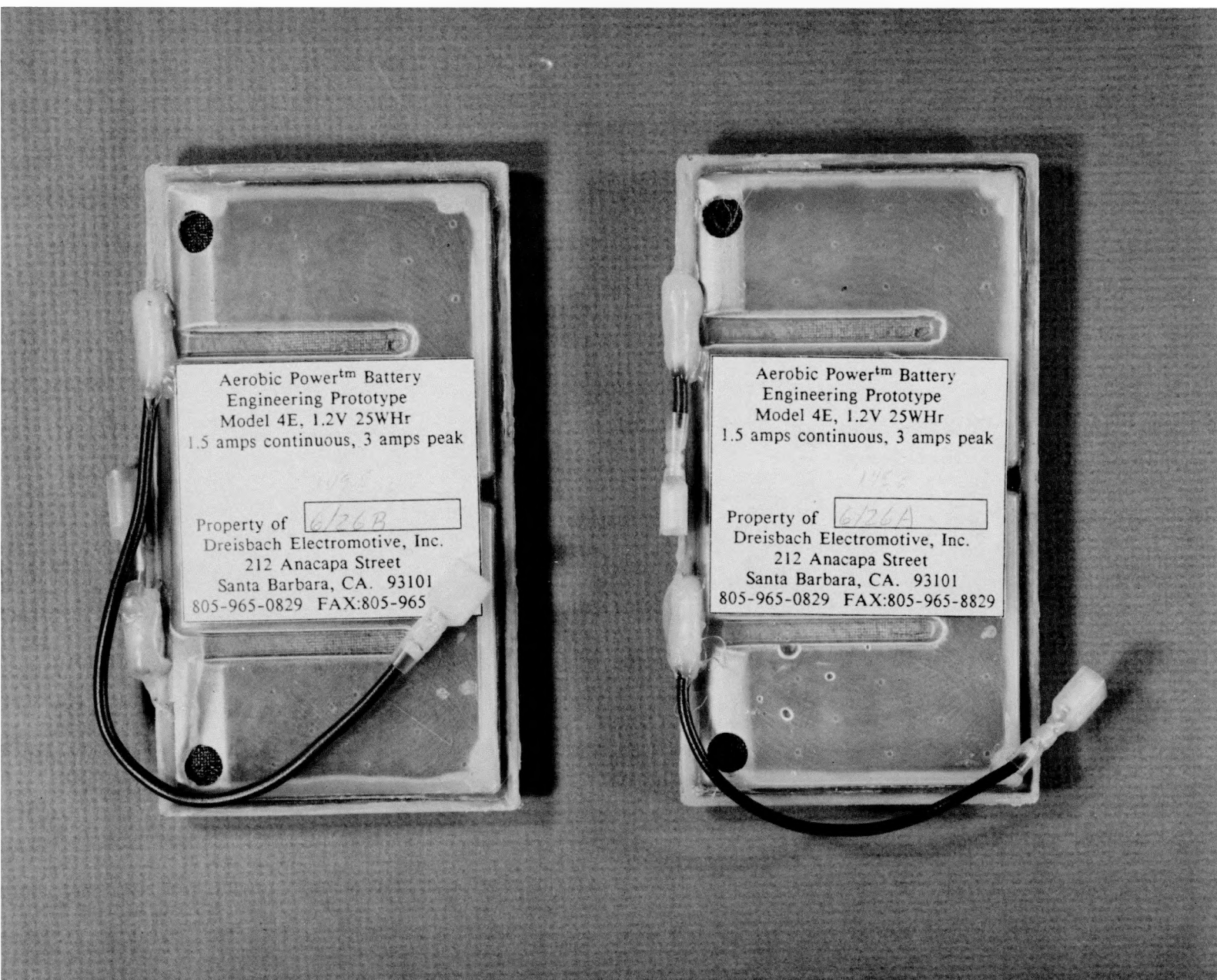


Figure 1. Photo of DEMI 4E Aerobic Power Cells

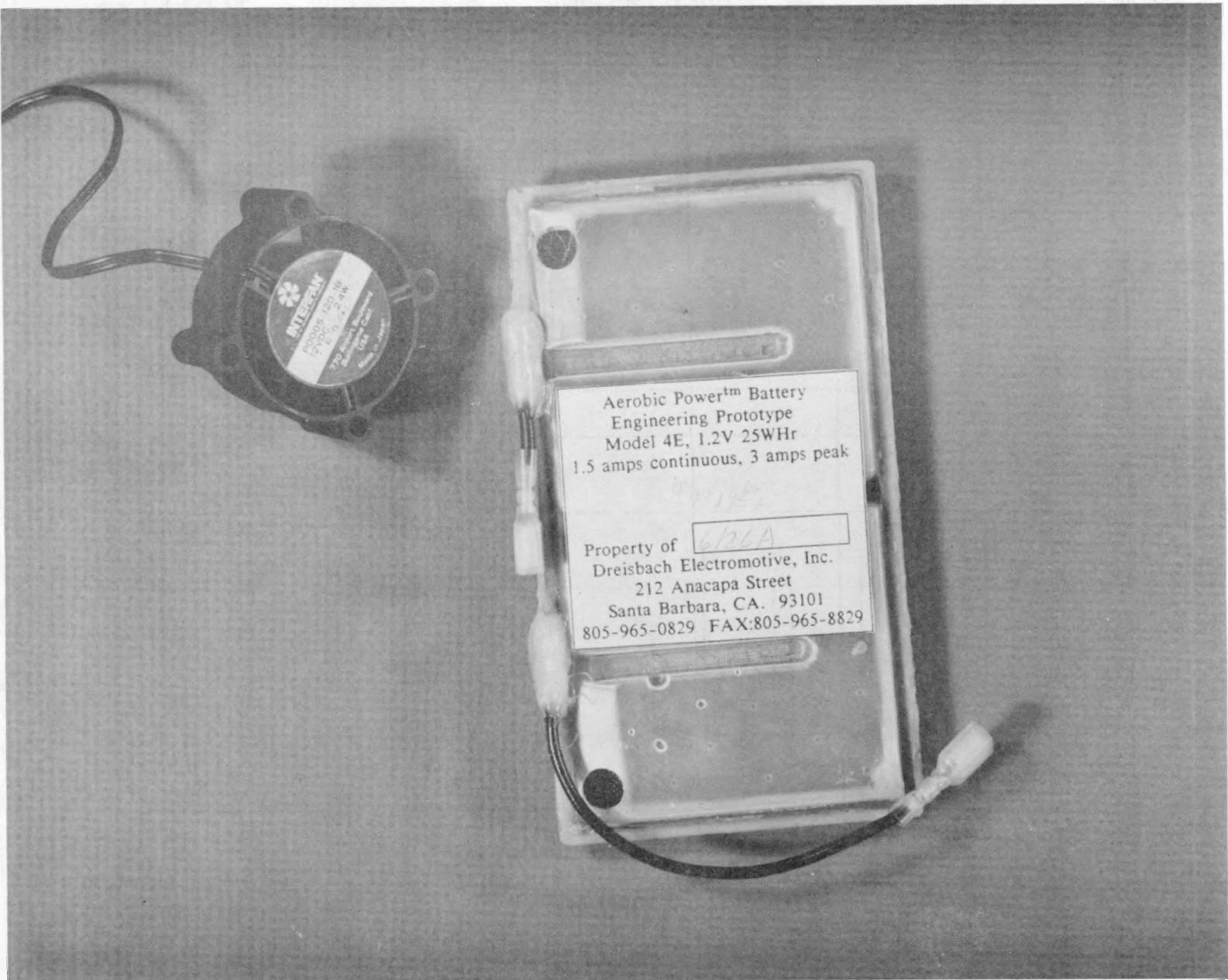


Figure 2. Photo of fan

DEMI 4E AEROBIC ZINC AIR CELLS

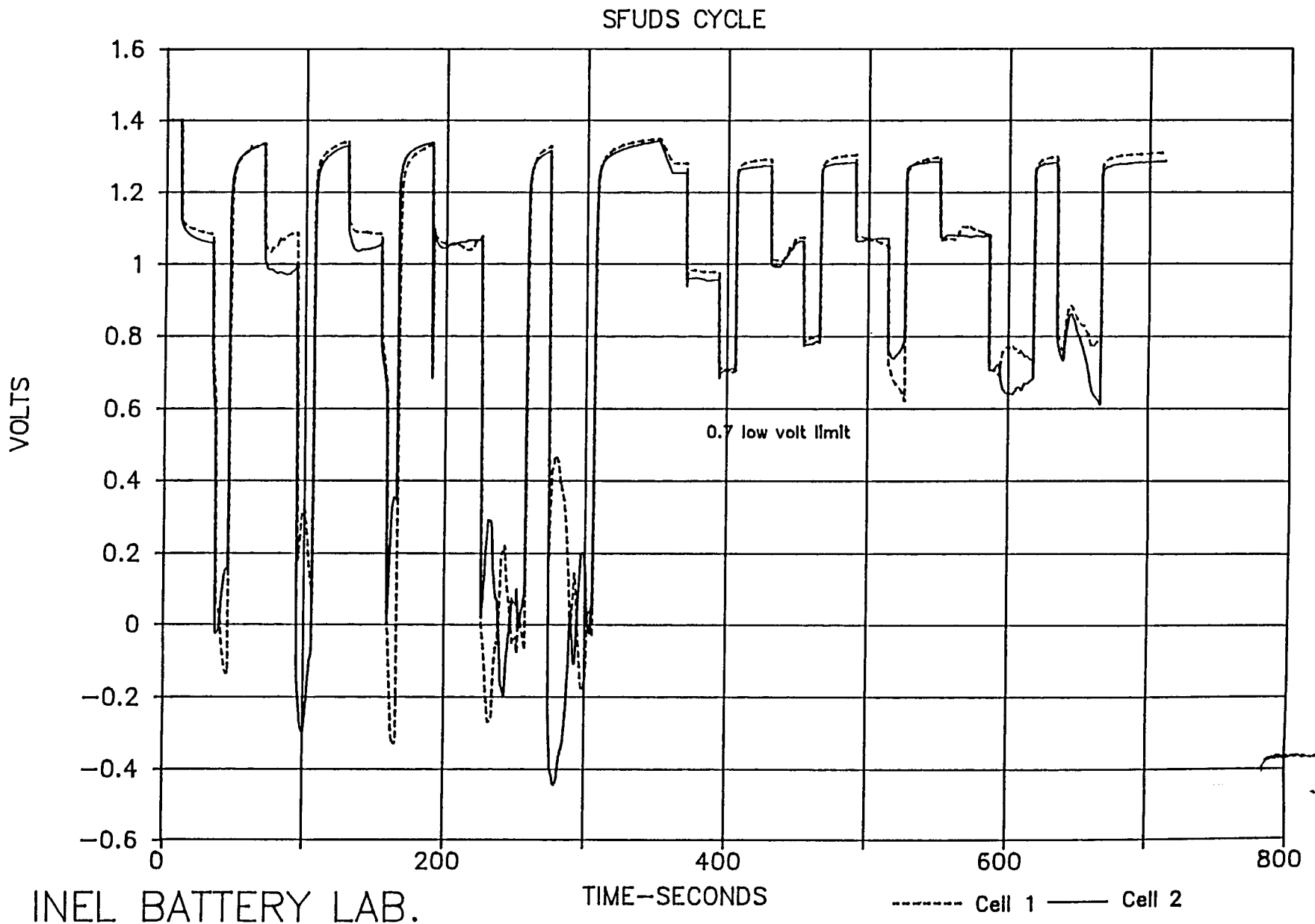


Figure 3. Cell Voltages on SFUDS Cycle