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OVONIC NICKEL METAL HYDRIDE BATTERIES FOR SPACE APPLICATIONS

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ABSTRACT

Ovonic nickel-metal hydride (NiMH) rechargeable batteries are easily adaptable to a variety of applications. Small consumer NiMH cells have been developed and are now being manufactured by licensees throughout the world. This technology has been successfully scaled up in larger prismatic cells aimed at electric vehicle applications. Sealed cells aimed at satellite power applications have also been built and cycle tested by OBC and other outside agencies. Prototype batteries with high specific energy (over 80 Wh/kg), high energy density (245 Wh/L), and excellent power capability (400 W/kg) have been produced. Ovonic NiMH batteries have demonstrated an excellent cycle life of over 10,000 cycles at 30% DOD. Presently, Ovonic Battery Company is working on an advanced version of this battery for space applications as part of an SBIR contract from NASA.

INTRODUCTION

Space power requirements include high gravimetric and volumetric energy densities, long cycle life, and high reliability. Nickel-cadmium and nickel-hydrogen batteries are currently used for most space applications. However, these systems do have several disadvantages. The environmental impact related to the manufacture of nickel-cadmium batteries is coming under increasing scrutiny. The high cost of nickel-hydrogen batteries makes it difficult to justify their use of many applications. Further, improvements in gravimetric and volumetric energy densities for each system would be desirable.

The Ovonic nickel-metal hydride battery offers a viable alternative to the existing batteries with an opportunity for significant gains in energy density [1-3]. They have roughly twice the gravimetric and volumetric energy density of nickel-cadmium batteries. They are made with nontoxic environmentally acceptable materials. The viability of this technology has been demonstrated in consumer cell applications with batteries now being manufactured and sold around the world through licensees. Licensees of Ovonic Battery Company include Varta (Germany), Hitachi Maxell (Japan), Gold Peak (Hong Kong), Samsung (Korea), Gates Energy Products and Harding Industries.

Considerable ongoing development is aimed at larger prismatic cells for electric vehicle applications [1-3]. Last year, Ovonic Battery Company was awarded the first development contract by the United States Advanced Battery Consortium, a consortium of the big three auto companies, DOE, and EPRI to develop electric vehicle batteries.

In this paper, we describe the performance characteristics of Ovonic nickel-metal hydride cells as they apply to space applications.

RESULTS AND DISCUSSION

Previously [4], the high energy density of Ovonic nickel-metal hydride technology was demonstrated in small wound consumer cells. Gravimetric and volumetric energy densities of 70 Wh/kg and 210 Wh/L, respectively, were attained. More recently, even higher energy density was demonstrated in larger prismatic cells. Results from a 50 Ah prismatic cell showing 80 Wh/kg and 245 Wh/L are shown in Fig. 1. Presently, several proprietary approaches are being pursued at Ovonic Battery Company aimed at a specific energy well in excess of 100 Wh/kg.

In collaboration with Eagle-Picher Industries [5], we have produced prismatic cells specifically designed for satellite applications. Figure 2 shows a diagram of the OBC aerospace cells. These cells delivered 5 Ah discharged at 5 A (C-rate), which corresponds to a specific energy of 55 Wh/kg. The energy density delivered represents a two-fold improvement over the NiCd version of the cell in Fig. 2 which is rated at 2.5 Ah. The next generation of cells being fabricated at OBC under the ongoing NASA contract work will have a specific energy of 70 Wh/kg due primarily to improvements in the positive electrode energy density.

Ovonic NiMH cells also exhibit excellent high rate capability. Previously, we have demonstrated up to 400 W/kg in large prismatic cells aimed at electric vehicle applications [1-3]. The high rate performance of OBC aerospace cells is shown in Fig. 3. The dependence of discharge capacity on the discharge current up to 20 A (4-C rate) is shown. These cells deliver 80% of their rated capacity at the 4-C discharge rate.

Ovonic NiMH have a wide operating temperature range as previously reported [1-3]. Figure 4 shows the discharge performance of OBC aerospace cells over a range of temperatures. The discharge performance is virtually identical between 10 and 30°C.

Ovonic NiMH cells have been tested by Eagle-Picher [5] and Rockwell International [6,7] to determine cycle life under simulated LEO conditions (35% DOD). Rockwell International reported having achieved over 10,000 cycles when the tests were terminated for other reasons [7]. From this test, they projected a cycle life well over 17,000 cycles for Ovonic NiMH cells. In tests of Ovonic aerospace cells, Eagle-Picher attained over 7,000 cycles to 37% DOD. Charge-discharge curves are compared for cycles 89, 4900, and 7900 in Fig. 5.

Resistance to abusive overcharge and overdischarge conditions is a unique feature of the Ovonic NiMH technology which should provide for improved reliability in actual operation in spacecraft applications. Intrinsic overcharge protection is provided via an oxygen recombination cycle where oxygen evolved at the positive electrode is recombined at the negative electrode. Intrinsic overdischarge protection is provided via a hydrogen recombination cycle where hydrogen evolved at the positive electrode is recombined at the negative electrode. Previous results [4] have shown Ovonic NiMH cells can be repeated overcharged and/or overdischarged by 15% or more for hundreds of cycles without damage.

Ovonic nickel-metal hydride system is a viable alternative to provide for improved energy densities beyond those currently provided by nickel-cadmium and nickel-hydrogen systems now in use. There should be no sacrifice in cycle life or reliability. However, disadvantages such as environmental concerns related to the NiCd system or high costs related to the nickel-hydrogen system can be overcome.

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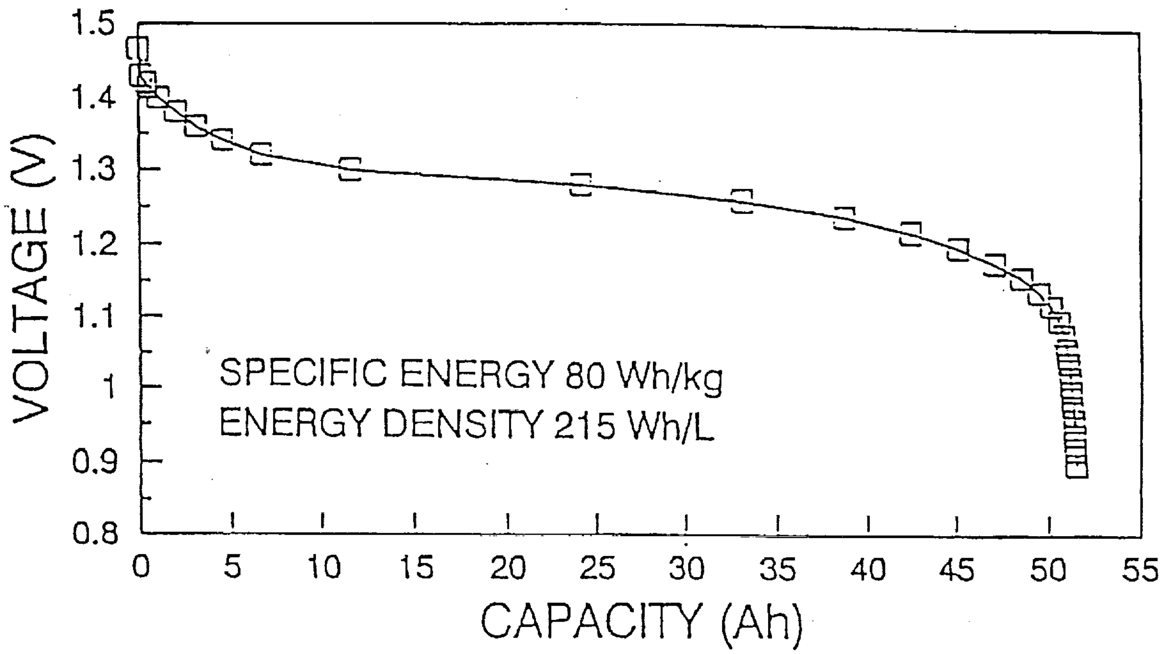

Figure 1. Discharge voltage versus time curve for advanced design 50 Ah EV prototype cell demonstrating 80 Wh/kg gravimetric energy density.

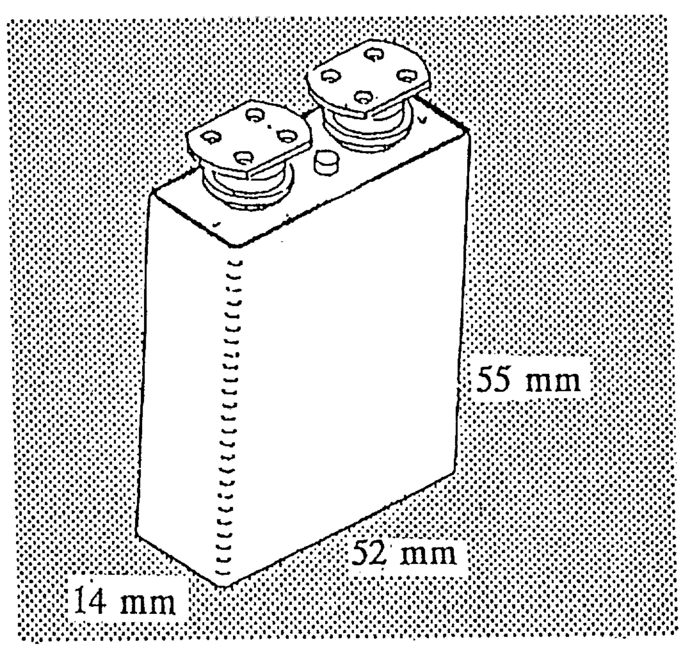

FIGURE 2

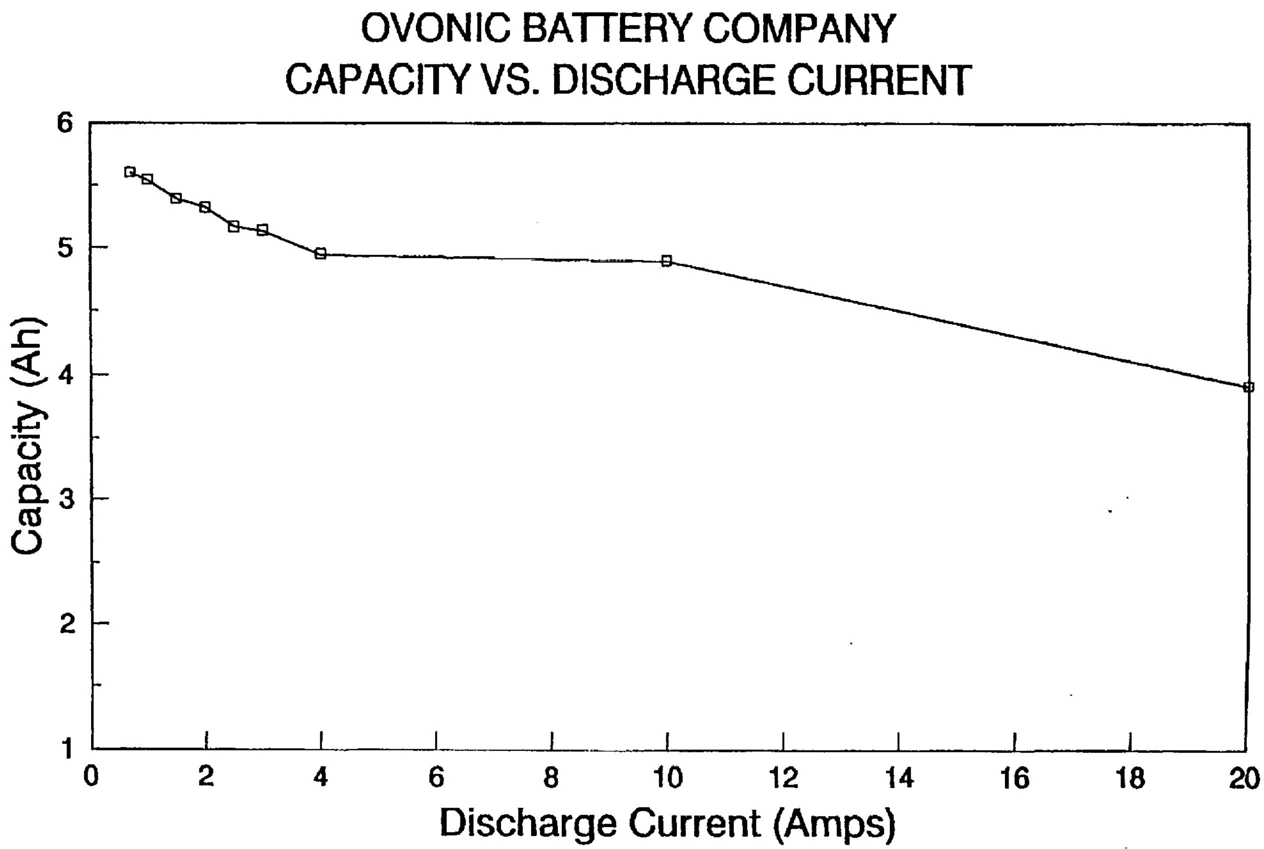

FIGURE 3

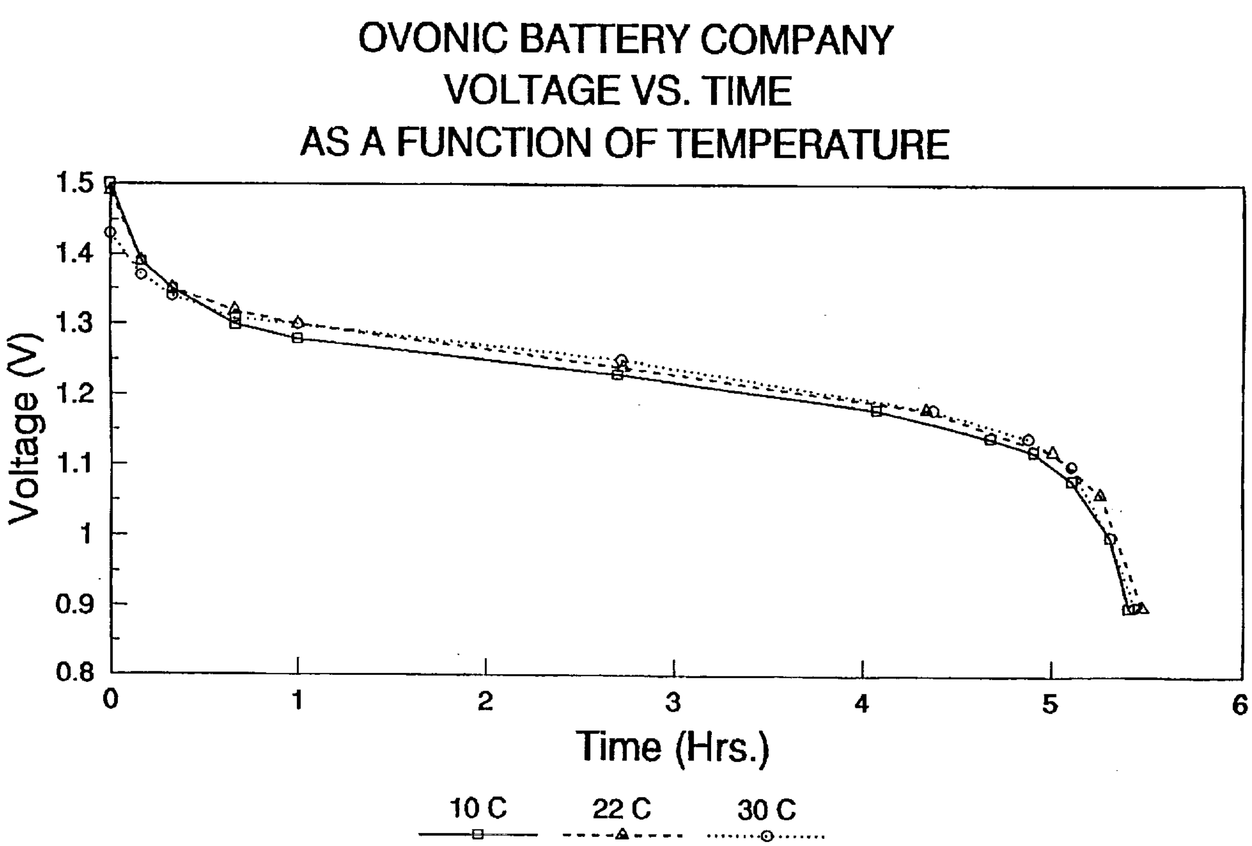

FIGURE 4

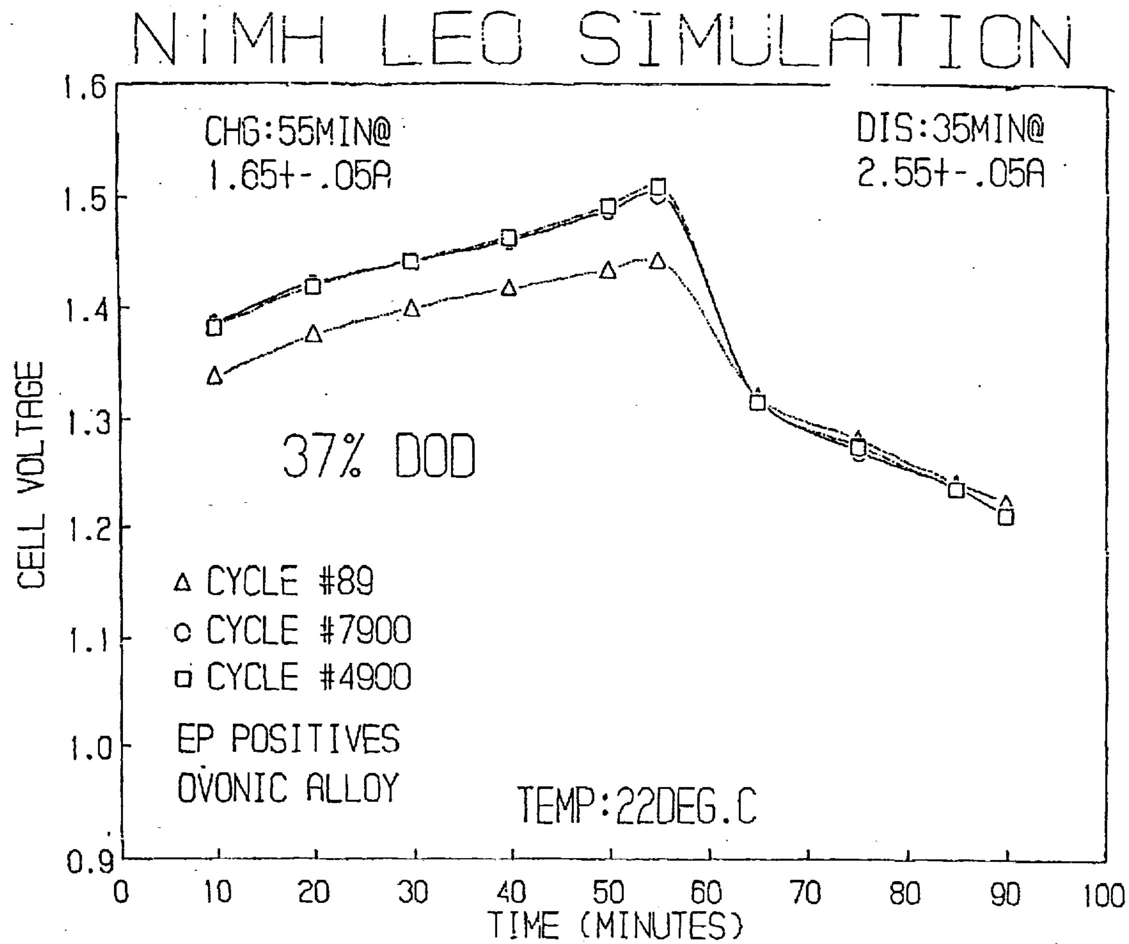
NiMH LEO SIMULATION
CHG:55MIN@
1.65+-.05A
DIS:35MIN@
2.55+-.05A
37% DOD
CELL VOLTAGE
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
CYCLE #89
CYCLE #7900
CYCLE #4900
EP POSITIVES
OVONIC ALLOY
TEMP:22DEG.C
0
10
20
30
40
50
60
70
80
90
100
TIME (MINUTES)

FIGURE 5