

AN ADVANCED NI-CD BATTERY CELL DESIGN

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Introduction

An advanced Ni-Cd space battery cell design is evolving as the result of the incorporation of Ni-H₂ battery cell design technology. High rate oxygen and hydrogen gas recombination capability with higher levels of electrolyte activation have been demonstrated. Increased performance and life are projected via extended operational range and the use of inorganic separator materials.

Electrode Stack Design

The advanced electrode stack configuration is shown in Figure 1. The first major design feature involves the use of two (2), half thickness negative electrodes in a "back-to-back" configuration. Enhanced oxygen gas recombination is achieved by the application of a hydrophobic (to prevent electrolyte flooding), gas permeable membrane to their inter surfaces which are separated by a gas accessibility spacer material (Ni-H₂ design technology).

Recombination performance dependency upon an intra electrode couple, specific porosity, organic separator material is eliminated. Various more stable materials of inorganic compositions should be accommodated extending system life. In addition, intra couple separator flooding concerns are eliminated allowing higher electrolyte activation levels also extending life.

The second major design feature involves the incorporation of a catalyzed gas electrode. The gas electrode interfaces the electrode stack edge surfaces and is connected electrically to the cell positive terminal. Design intent is to offer a mechanism for rapid hydrogen gas recombination.

If a cell is subjected to sufficient operational or environmental stress to promote hydrogen gas generation (either by design to increase system performance or inadvertently), the gas would be rapidly recombined by the Ni-H₂ reaction defined in Figure 2.

Testing

Testing of the above design concepts has been reported in a previous Battery Workshop (1).

The results of this effort may be summarized as follows.

A group of 6 AH rated cells were constructed in three (3) design versions.

- 1) Standard space cell design.
- 2) Same as 1) except incorporated gas electrode.
- 3) Same as 1) except incorporated "back-to-back" negative electrodes (split negative).

Figure 3 graphically presents the results of a test designed to evaluate electrolyte activation level sensitivity. Clearly the "back-to-back" negative electrode design version demonstrates a significantly improved tolerance to electrolyte activation level.

Figure 4 graphically presents the results of a test designed to measure hydrogen gas recombination ability. The test temperature and charge rate were chosen to assure the hydrogen overvoltage potential would be achieved. Again, clearly proper functioning of the gas electrode design version was demonstrated.

More recent testing was initiated with a small group (3 each) of current production 50 AH rated cells. All three (3) cells incorporated the same gas electrode design version configured as depicted in Figure 5. To assure hydrogen gas generation, discharged excess negative electrode capacity or overcharge protection was not incorporated in these cells.

Figure 6 graphically presents the results of a test designed to assess hydrogen gas recombination rate capabilities. Surprisingly doubling the charge rate (from C/10 to C/5) did not increase the maximum pressure achieved. It would appear a relatively small catalytic gas electrode area is capable of managing high gas generation rates.

Conclusion

The evolution of an advanced Ni-Cd space battery cell design continues to prove very promising. High oxygen/hydrogen gas recombination rates (currently up to a C/5 charge rate) and increased electrolyte activation level tolerance (currently up to 5.6 grams/AH of positive capacity) have been demonstrated by test.

A superior performance, extended life battery cell offering the advantages listed in Figure 7 should soon be available for mission applications.

References

1. Miller, L. (Eagle-Picher Industries): Advanced Sealed Nickel-Cadmium Design. Proc. 1976 Goddard Space Flight Center Battery Workshop, X-711-77-28, GSFC Greenbelt, Maryland, November 1976.

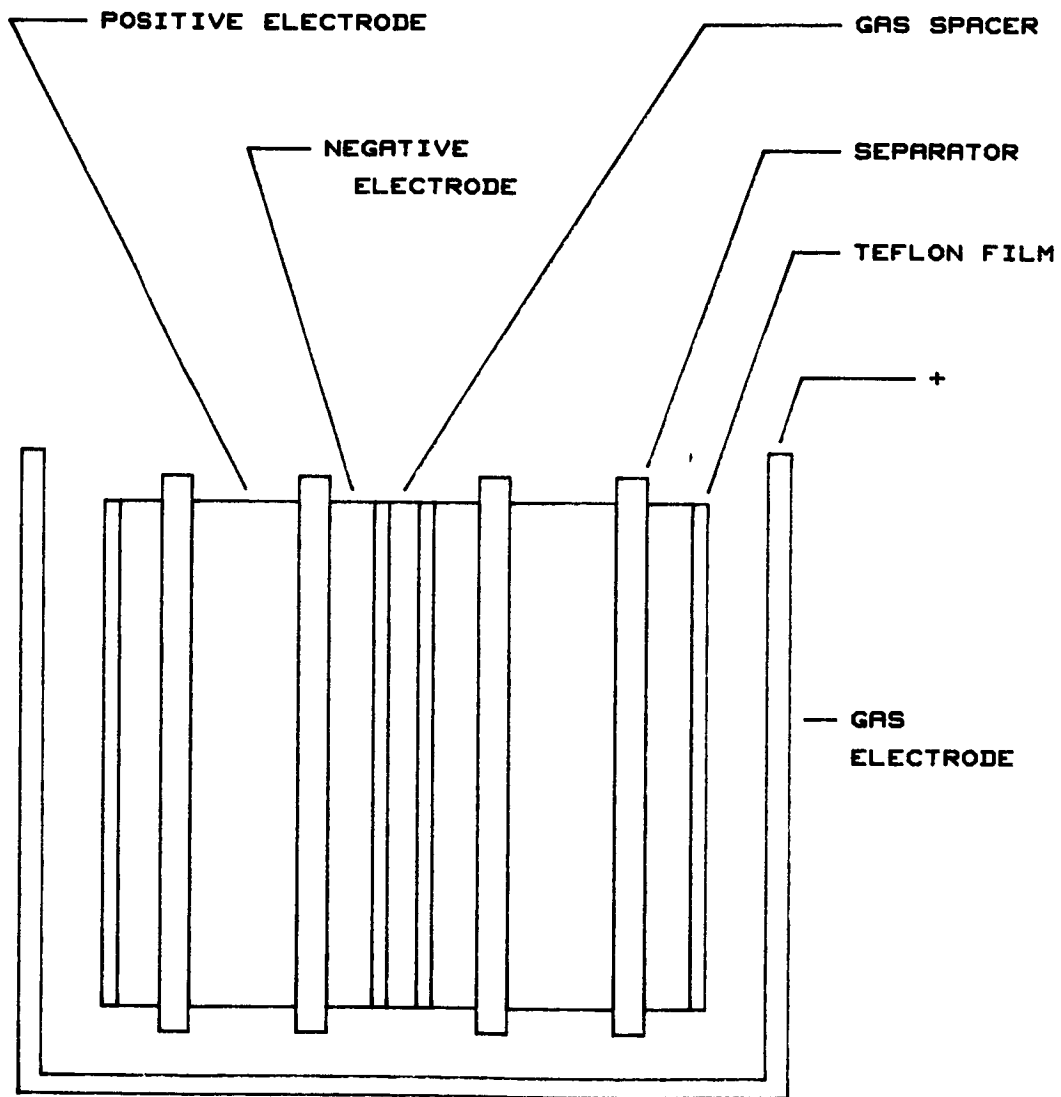
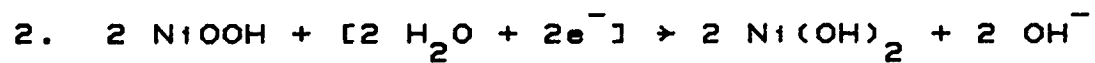
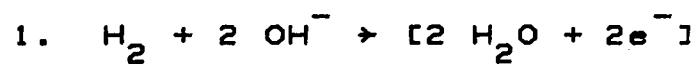


Figure 1. SEALED NICKEL-CADMIUM ADVANCED ELECTRODE STACK DESIGN



COMBINED REACTION

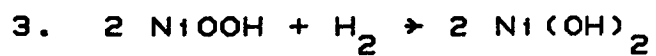


Figure 2. SEALED NICKEL-CADMIUM GAS ELECTRODE REACTION

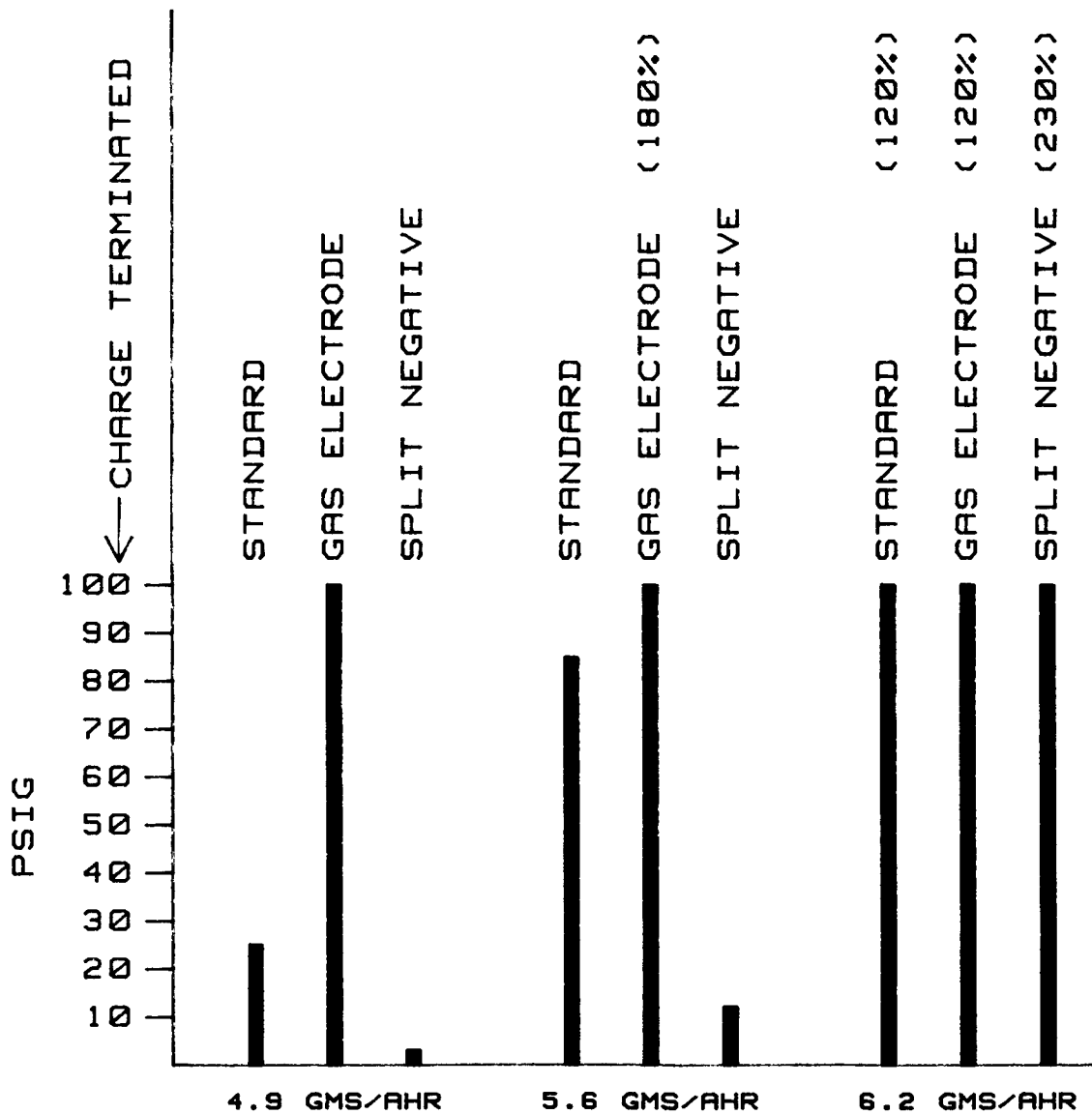


Figure 3. OVERCHARGE PRESSURE (O₂) VERSUS ELECTROLYTE QUANTITY
 CHARGE 250%, RATE C/10, TEMPERATURE 20°C

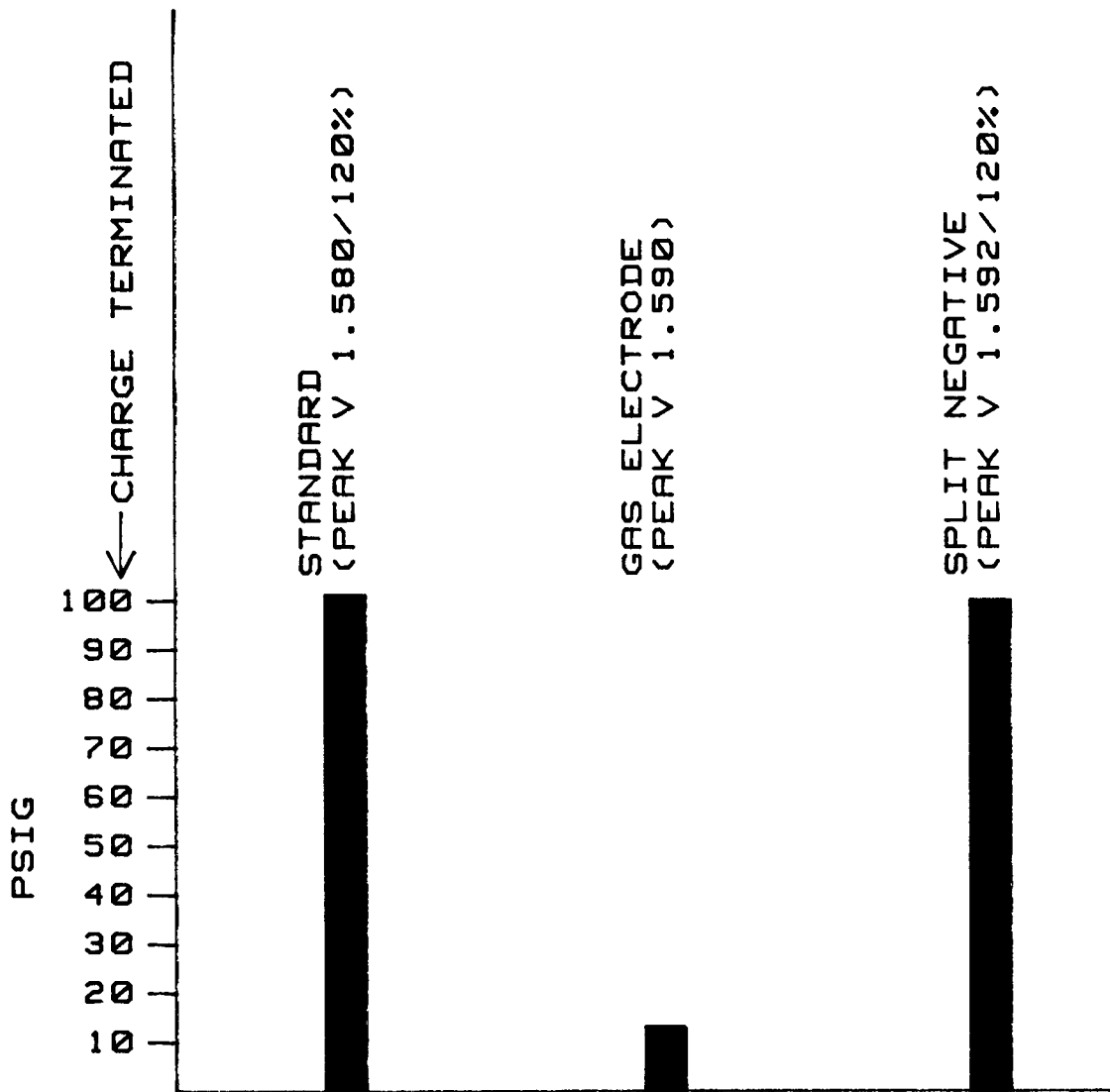


Figure 4. OVERCHARGE PRESSURE (H₂) VERSUS STACK DESIGN
CHARGE 200%, RATE C/10, TEMPERATURE 0°C

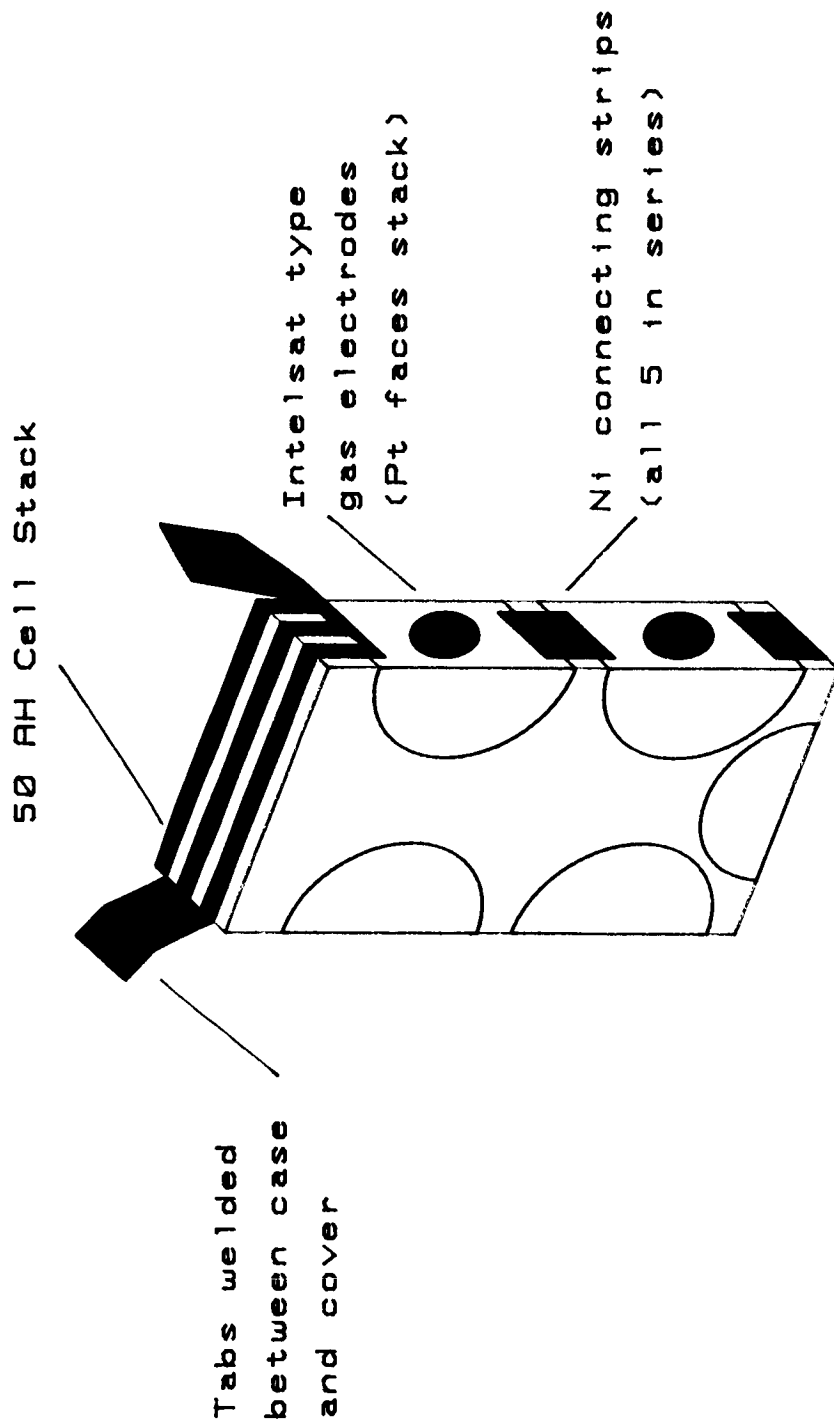
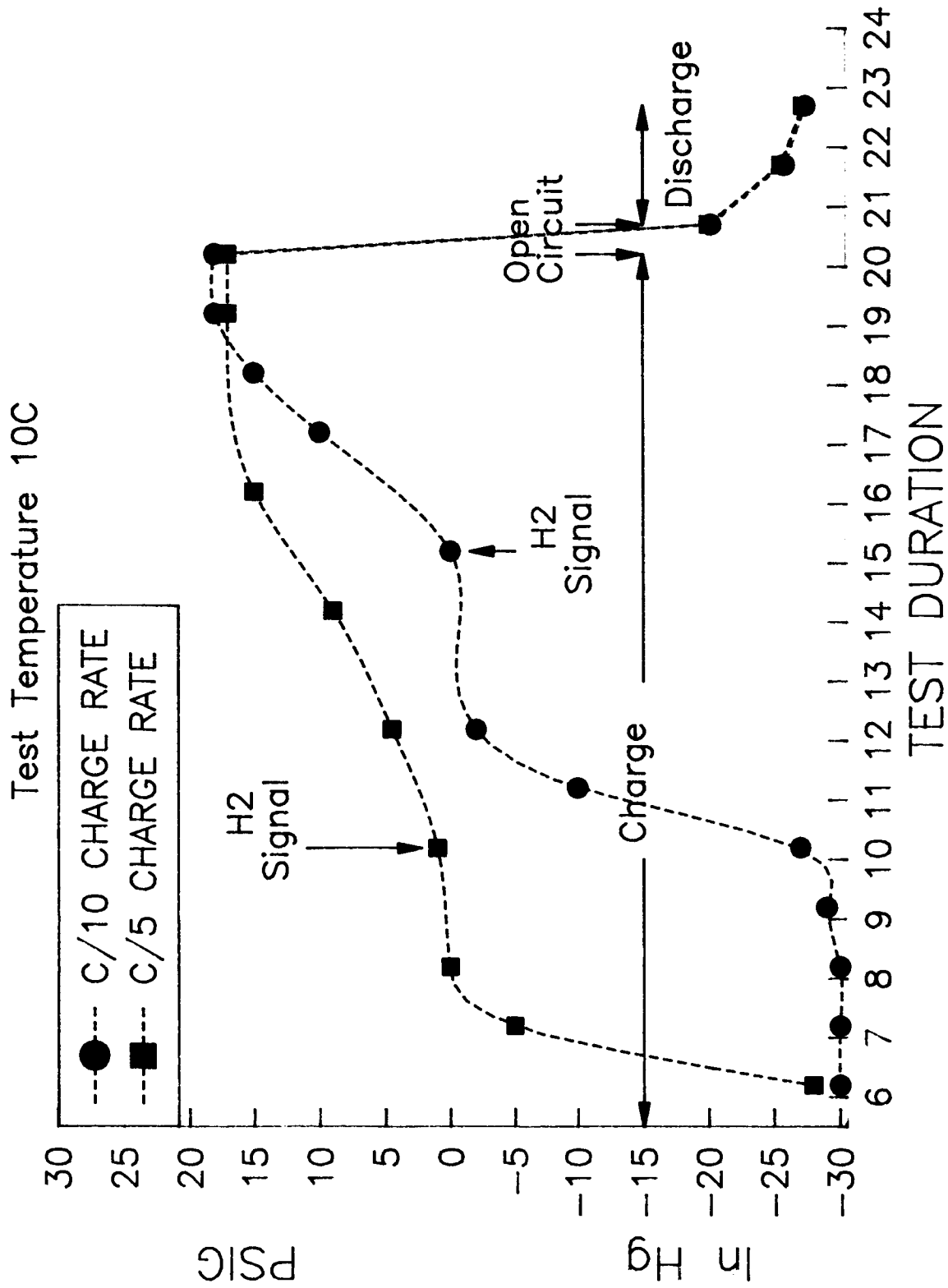


Figure 5. ADVANCED Ni-Cd TEST CELL ASSEMBLY SKETCH



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Figure 6. 50 Ah RATED Ni-Cd CELLS

1. GREATER OVERCHARGE TOLERANCE RELATIVE TO BOTH O₂ AND H₂ GAS EVOLUTION.
2. SIGNIFICANTLY DECREASED MAXIMUM ELECTROLYTE QUANTITY SENSITIVITY PROMOTING LONGER CYCLE LIFE.
3. IMPROVED CELL PERFORMANCE VIA EXTENDED OPERATIONAL RANGE.
4. ALLOWS CONSIDERATION OF MORE STABLE, LONGER LIFE INORGANIC SEPARATOR MATERIALS.
5. ENHANCED CELL REVERSAL TOLERANCE.

Figure 7. SEALED NICKEL-CADMIUM ADVANCED ELECTRODE STACK DESIGN ADVANTAGES