Report Number: 02-97EE15687

Final Technical Report for Electric Utility Energy Storage Device for the Period of July 1999 to September 2000

SUBMITTED TO:

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DISCLAIMER

Technical Report for Electric Utility Energy Storage Device

This is the final project report, and the annual report for the period ended September 30, 2000 for ERIP project number 687, Electric Utility Energy Storage Device. Although this project was approved on September 30, 1997, and further extended on December 9, 1997, no official work other than some preliminary design concepts under Task 1 were undertaken prior to February 1999.

Although the project was delayed in its commencement, no extension to the project period was required. There were some delays in receiving prototype parts from contractors in the first half of 2000, particularly with rotational molded electrolyte tanks. A new design was finalized, a new contractor selected and parts became available in August and September 2000. These components enabled the module design to be completed and all prototype testing to be undertaken. The company has since proceeded to incorporate the results from this program into its larger energy storage systems. The project was effectively concluded on September 30, 2000.

Project Aim:

To build a reliable and cost effective energy storage module that will serve as a building block for a multi-megawatt energy storage device.

Variance from Project Goals:

The design of a new 50 kWh battery module was completed under Task 1 of the contract. Task 2 consisted of utilizing external vendors to build the mold and manufacture parts. The modified tanks were assembled into a battery module under Task 3, while the final revisions and testing of the module were accomplished under Task 4. At the date of this report, all of the project tasks have been satisfactorily accomplished.

Task 1: Module Design: (Finalized)

A design review was completed following in-house testing of various iterations of rotational molded electrolyte tanks. The production of molds and manufacturing of prototypes were outsourced to a local vendor.

Early iterations revealed a need to provide greater strength to tank walls and particularly to the pump platform for the electrolyte pump and motor fittings. The initial rectangular design of the electrolyte tanks (see Figure 1) has not proved to be entirely satisfactory in early modules assembled for cycle testing. Most notable has been a "bowing" effect in the tank walls and to the pump platform resulting in a possible mis-alignment of the pumps and motors.

Newer designs have been discussed with the rotational molders/tool makers as part of Task 2. The design changes focused on adding a slight angle to the pump platform, eliminating the uprights on either side of the pump platform, and manufacturing a thicker part. The improved design, seen in Figure 2, has significantly reduced the bowing of the tank walls.

An alternative plumbing configuration has been incorporated onto a three stack (50kWh) module. This improvement incorporates an electrolyte distribution manifold that is a single manufactured part and replaces the previous thirteen piece manually assembled manifold. (Figure 3).

Some issues remained with optimizing the system at either three stacks (50kWh) or four stacks (67kWh), and after early (Task 4) testing it was determined that a three stack module optimized the system performance.

A “battery rack” has also been incorporated for ease of assembly with the three battery stacks, and for installing and removing the battery stacks from the module housing while not disturbing the other components within the battery module. (Figure 4).

New electrolyte pump motors were evaluated during the final phase of this project. The motors ultimately selected for incorporation onto the battery module are a pulse width modulated, brushless d.c. type and are shown in Figure 5.

Task 2. Rotational Mold Module: (Finalized)

ZBB's engineers were involved in the full review of tank and plumbing designs, and the operational performance of the module as part of Task 1. Task 2. involved utilizing external contractors for the mold design and manufacturing of the parts. ZBB identified two independent Wisconsin based manufacturers and examined prototype components from both parties. Although initially selecting one contractor, subsequent delays with prototypes and early delivery of final components caused the Company to re-evaluate contractors. The vendor subsequently manufactured a new tank mold to ZBB's proprietary design and has successfully rotational molded new electrolyte tanks for incorporation into the final battery modules. A rotationally molded tank using the new design is shown if Figure 6.

The new tank design also incorporates a novel design for the tank lids, enabling the replacement of the two previous circular "cap type" lids per tank with a single flat polyethylene lid capable of being affixed to the tank by holding bolts. The tank lid incorporates level sensors, which penetrate into the electrolyte tank.

A new anolyte cooling loop was designed by the Company and has been incorporated into the electrolyte tanks. At present this part is assembled by the Company as no pre assembled or manufactured alternative is commercially available.

Task 3. Assemble and Inspect Module: (Finalized)

A final prototype module was assembled and inspected which incorporates all of the advanced features resulting from this project. Pictured in Figure 7 is an early version of the 50kWh battery module showing the layout of battery stacks and ancillary parts. The modified stack assembly incorporating the improved electrolyte tanks and electrolyte manifold system is shown in Figure 8.

Task 4. Final Revisions and Testing: (Finalized)

Dr. Phillip Symons, of Electrochemical Engineering Consultants, Inc. of Morgan Hills, California, conducted an independent test on a 50kWh zinc/bromine battery module in July 2000. The overall objective was to determine the probability that, within a two-year period, ZBB can develop the technology to the point it will be found acceptable by potential customers for the applications intended for it by ZBB.

The conclusions from Dr. Symons report were "that ZBB have a good handle on the manufacturing costs, and that, given sales to a sufficiently high volume of production, it should be possible to profitably make and sell ZBB systems to the applications for which it is intended".

Dr. Symons also concluded that, with its hazmat building approach for "distributed resources" energy storage products, ZBB have a design that should be safe and have little environmental impact.

The Company now intends to continue a program of life cycle testing and in-field site testing of various modules of the configuration resulting from this program, and to also build and test larger capacity energy storage systems consisting of numbers of these modules configured in series and parallel arrangements.

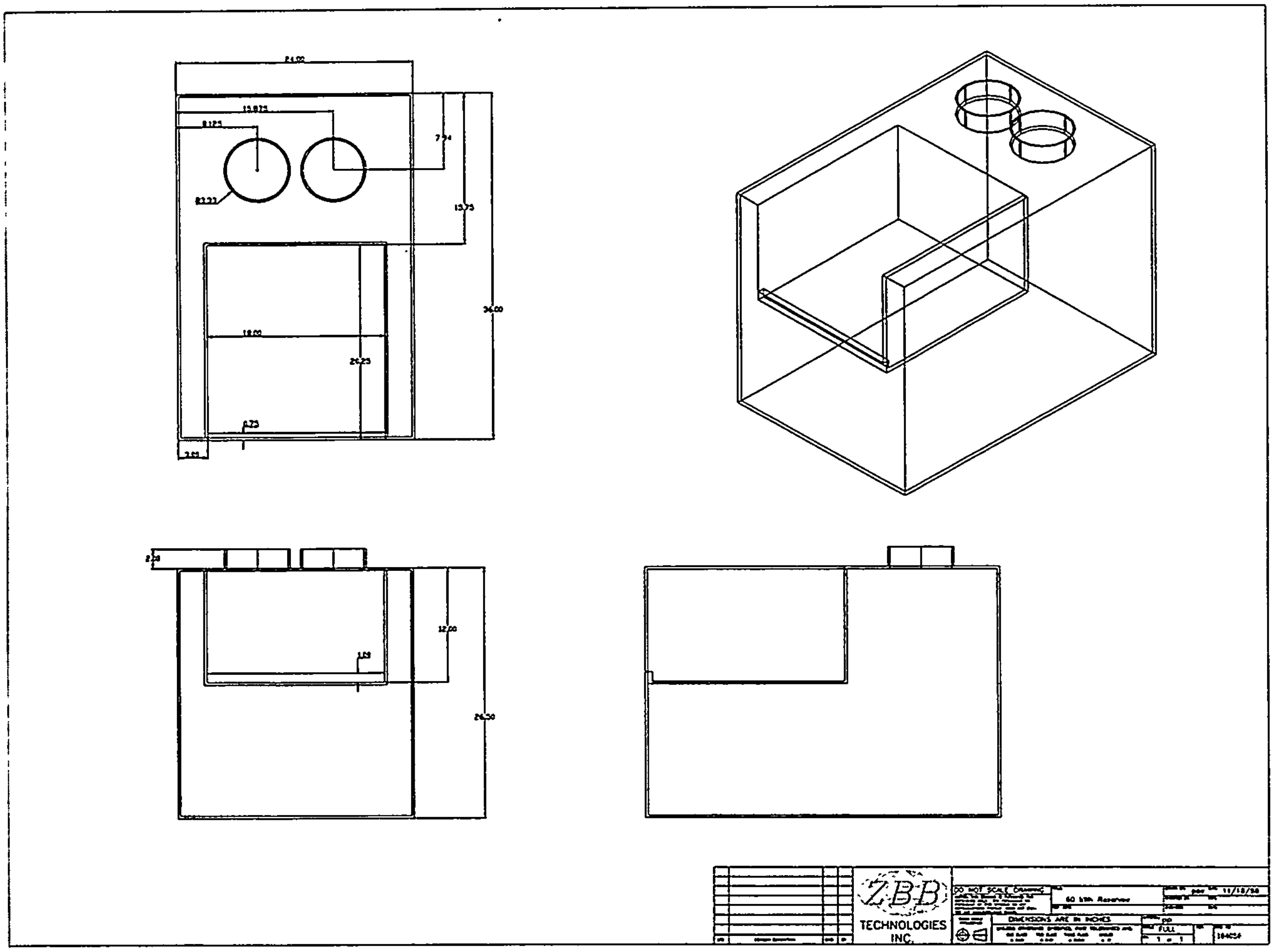

Figure 1. Early Electrolyte Tank Design

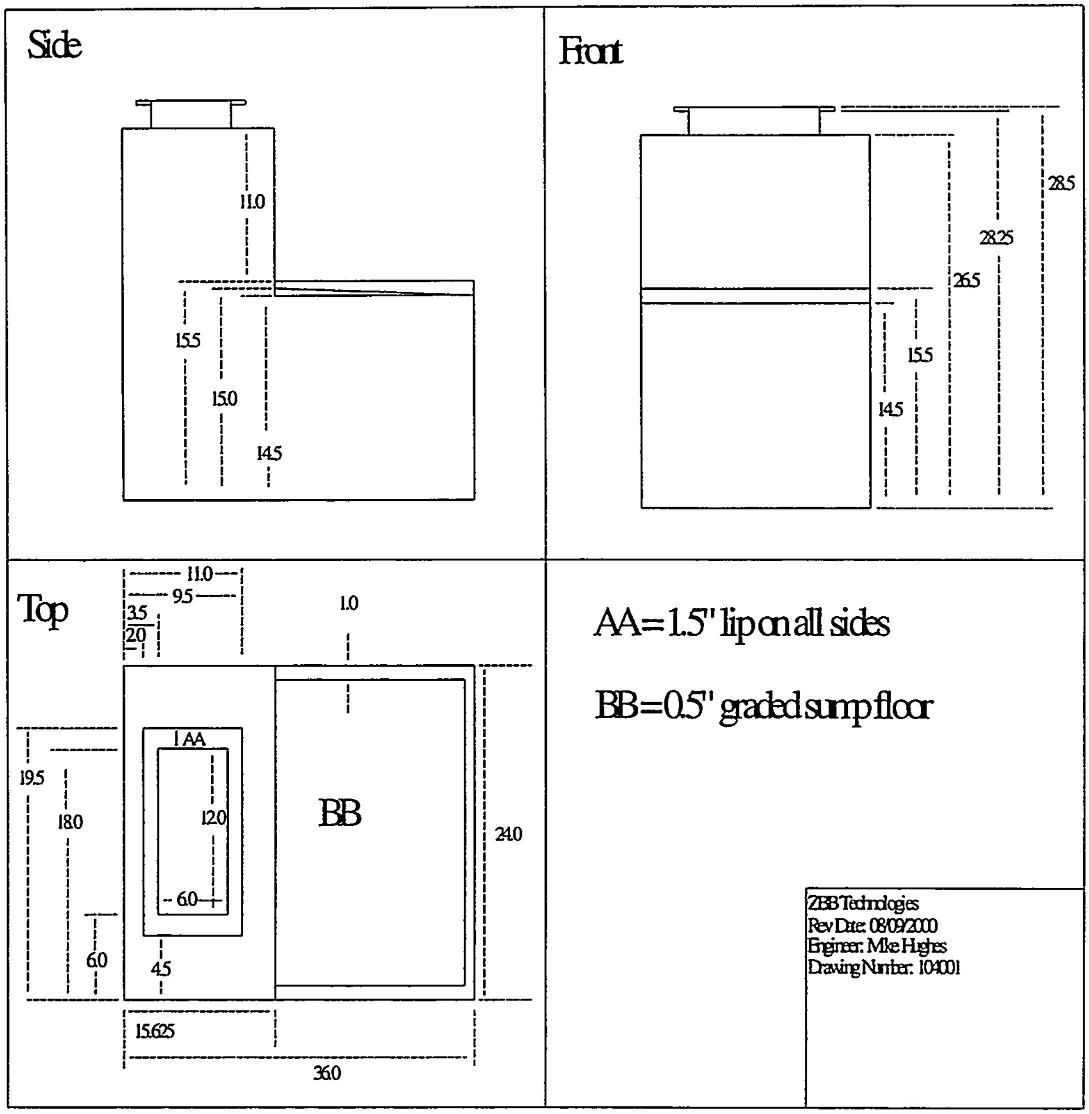

Figure 2. Current Electrolyte Tank Design

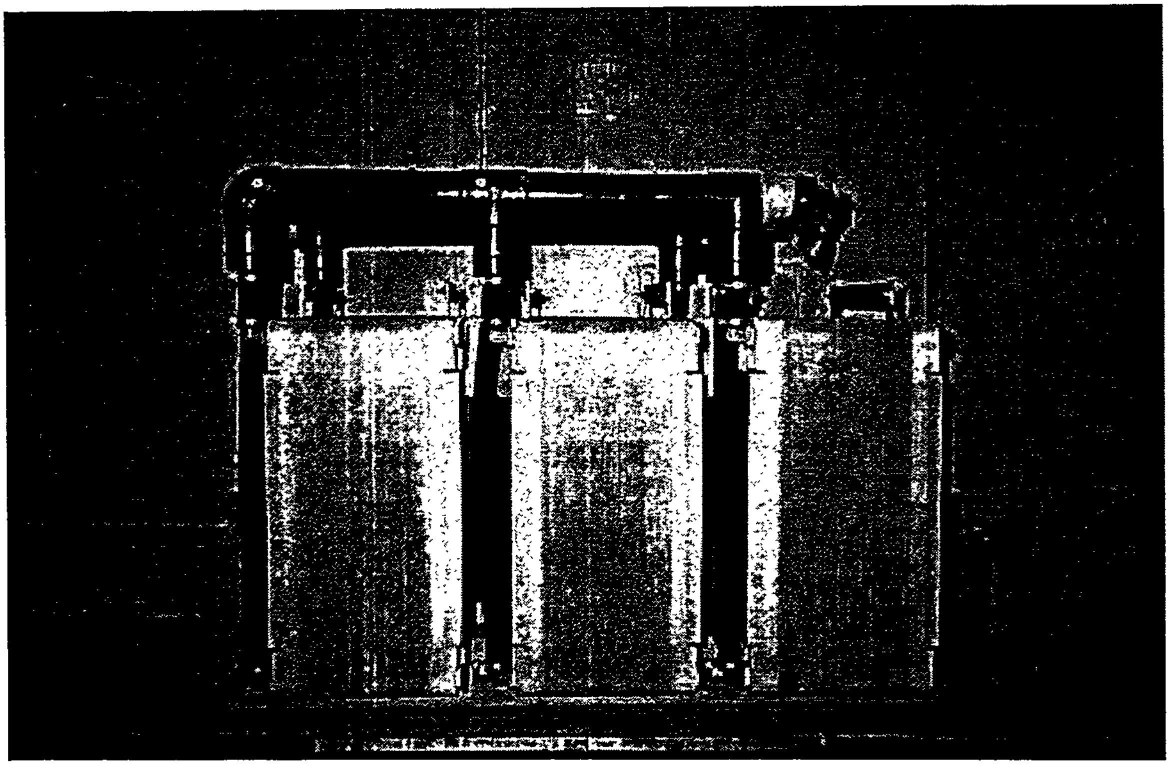

Figure 3 - Battery Stacks with New Manifold

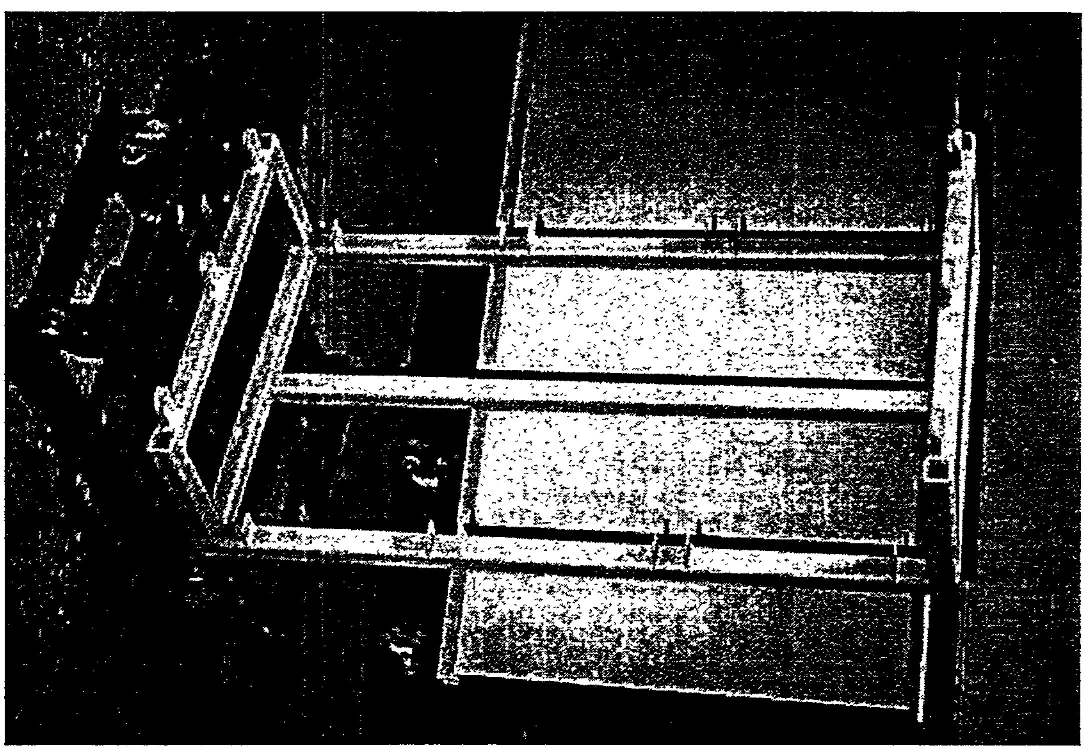

Figure 4 - Battery Rack

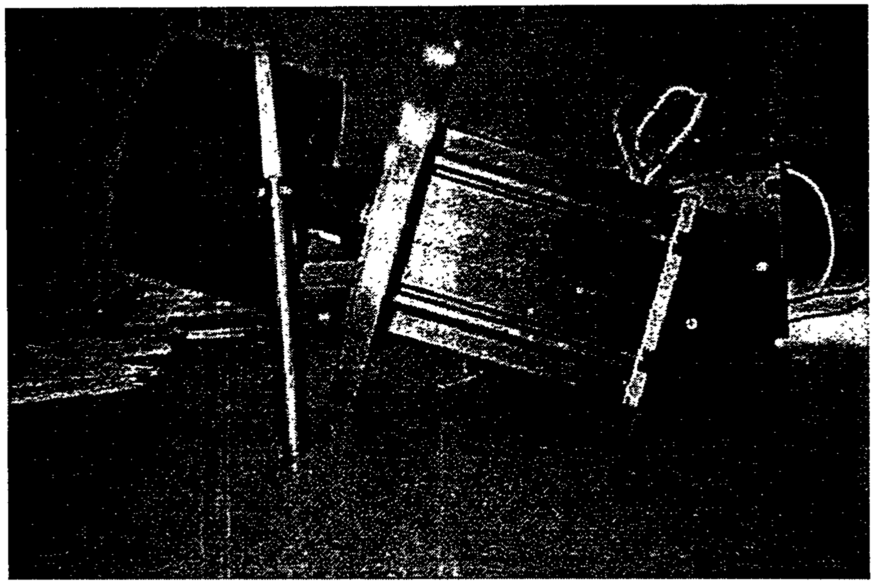

Figure 5 - New Pump Motor for Electrolyte Circulation

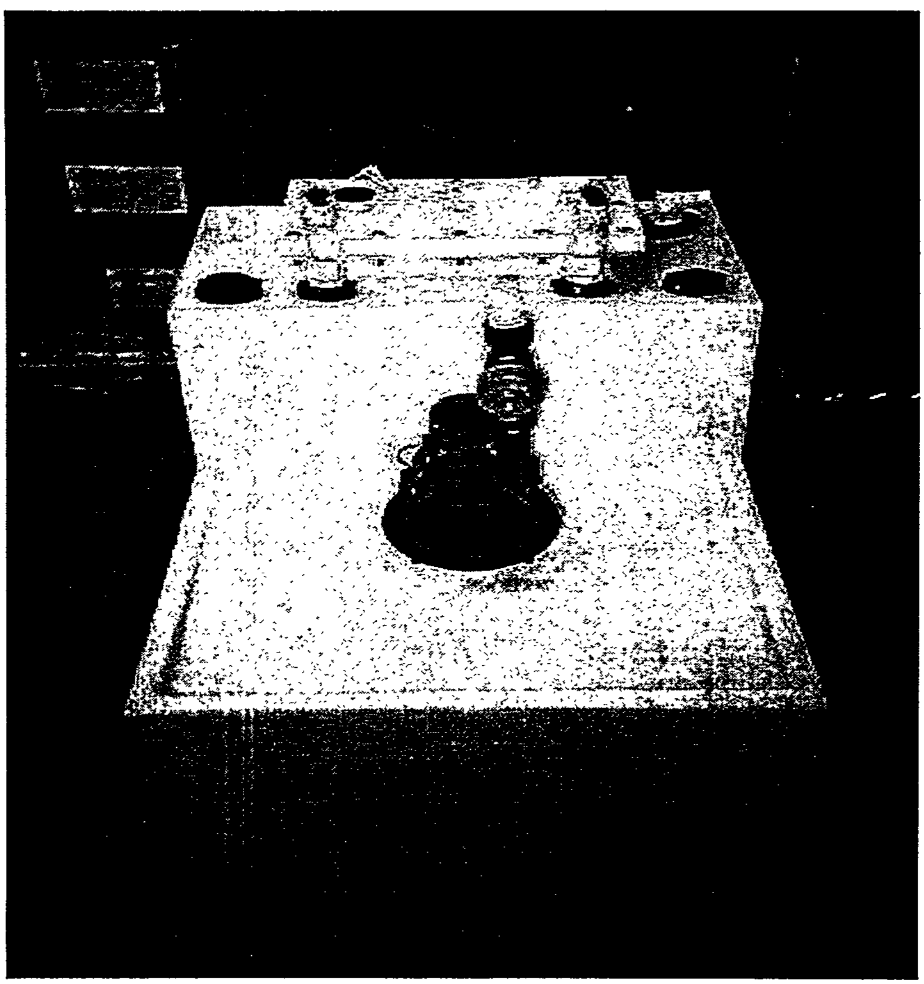

Figure 6 - Rotationally Molded Electrolyte Tank with Improved Design

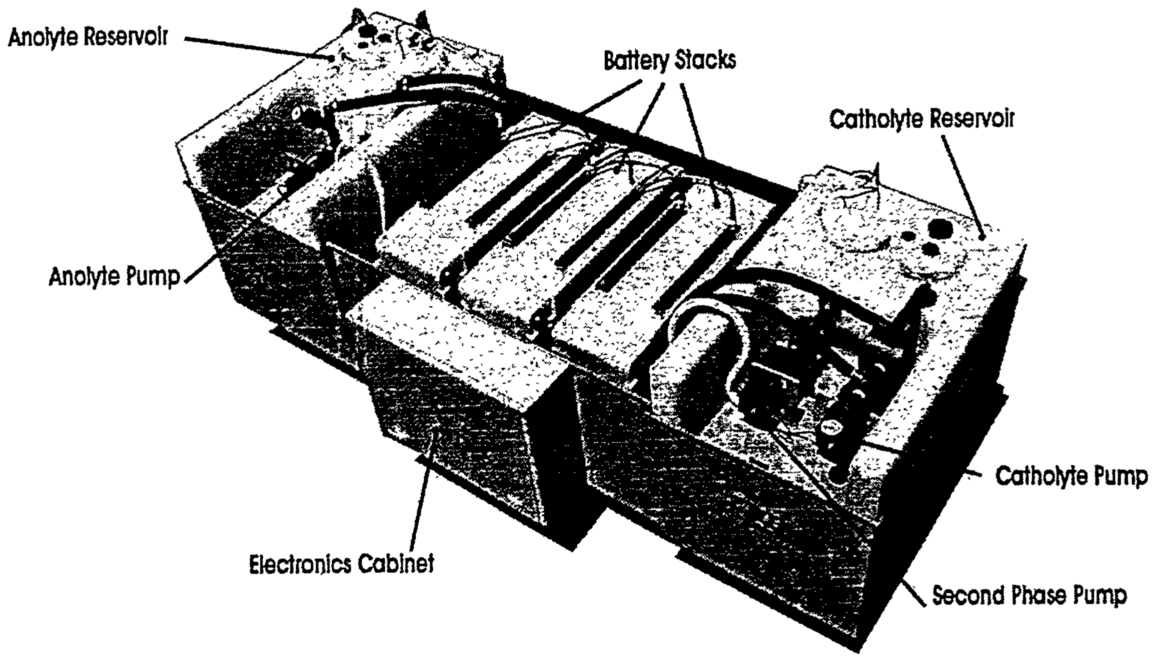

Figure 7. Early Module Design

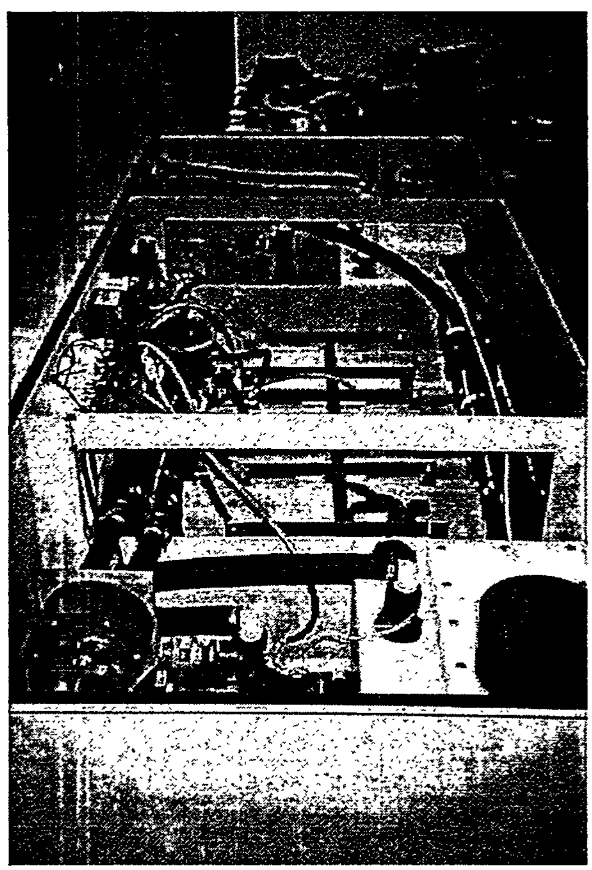

Figure 8 - First 50kWh module as part of a 400kWh system

Attachment A

Energy Savings

*unit definition to be used for all tables =*___kWh_________

Energy Type	(a) Conventional Technology (from your application) (input/yr/unit)	(b) Proposed Technology (from your application) (input/yr/unit)	(c) Your Demonstrated Technology (input/yr/unit)
Oil/gasoline (bbl)			
Natural Gas (mcf)			
Coal (tons)			
Electricity (kWh)		80	50
Other energy 1 (unit)			
Other energy 2 (unit)			
Total per unit			

Attachment B

Non-Combustion Related Emission Savings
(Combustion related emissions will be calculated from energy input values)

Waste Generated	**(a) Conventional Technology (from your application)** **tons/yr/unit**	**(b) Proposed Technology (from your application)** **tons/yr/unit**	**(c) Your Proposed Technology at the End of the Grant** **tons/yr/unit**
Waste 1 (define)			
Waste 2 (define)			
Waste 3 (define)			
Total	N/A	N/A	

Attachment C

Economic Competitiveness

Cost Per Unit (U.S. Dollars)	(a) Conventional Technology (from your application) (U.S. Dollars)	(b) Proposed Technology (from your application) (U.S. Dollars)	(c) Your Proposed Technology at the End of the Grant (U.S. Dollars)
Capital Cost of Unit - Ave.	$1620/kWh	N/A	$1256/kWh
Installation Cost of Unit	Included above		Included above
Annual Operation and Maintenance Costs (other than energy costs)	N/A		N/A
Life of Equipment (years)	3 years		10 years

Attachment D

Commercialization Table

Category	U. S. Market				
	Demonstration Year	**5 Years after Demo**	**10 Years after Demo**	**15 Years after Demo**	**20 Years after Demo**
(A) Total Number of Units in U.S. Market (Addressable Market) MWh	**228,000**	**638,000**			
(B) Total Number Installed Units Using Your Technology (Capturable Market)	**28**	**12,000**			
(C) Market Penetration = B/A x 100%	**0 %**	**1.9 %**			

- **Your technology** - Total number of units employing the technology developed with the grant. This number includes, but is not limited by the number of units that the primary industrial partner will sell or operate.

- **Addressable Market** is that fraction of the entire market to which your technology is truly applicable. Remember to project the number of installed units by first considering limiting factors related to technology and market fit. For instance, the proposed technology may only fit a certain size range of equipment, i.e., a proposed glass furnace burner technology can only be constructed is sizes smaller than 5 MMBtu/hr, or the proposed burner can only be applied to recuperated furnaces, not regenerative furnaces.

- **Capturable Market** is that fraction of the Addressable Market willing to accept your new technology. Remember that the rate at which industrial technologies capture the market depends on technology characteristics (new vs. retrofit), industry characteristics (industry growth, competition), and external factors (government regulations and trade restrictions). Consider these limiting factors related to rates of market acceptance before projecting the number of installed units in the Capturable Market.

Attachment E

Final Cost Sharing
(If Applicable) N/A

#	**Company Name**	**Company Type***	**In-Kind Contribution**	**Cash Contribution**	**Total**
1					
2					
3					
4					
5					
	DOE				
	Total				

Only Include Cost-sharing Partners

* small business, business, non-profit, university, state agency, or utility

Attachment F

Partners and Contractors
(If Applicable) N/A

#	Company Contact	Address	City	ST	Zip	Phone / Fax / e:mail
1						
2						
3						
4						
5						

List all companies involved in the project (equipment vendors, consultants, subcontractors, customers etc. and provide a brief narrative discussing the role of each partner.)