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**ANNUAL REPORT FOR 1978 ON
RESEARCH, DEVELOPMENT AND DEMONSTRATION OF
NICKEL-ZINC BATTERIES FOR
ELECTRIC VEHICLE PROPULSION
Contract No. 31-109-38-4224**

by

**Yardney Electric Division
Yardney Electric Corporation**

U of C-AUA-USDOE

**ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS
Operated for the U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38**

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Printed in the United States of America

Available from
National Technical Information Service
Springfield, Virginia 22161

NTIS price codes
Printed copy: A04
Microfiche copy: A01

ANL/OEPM-78-12

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Prepared for
The Office for Electrochemical Project Management
Argonne National Laboratory
Under Contract No. 31-109-38-4224

By
Yardney Electric Division
Yardney Electric Corporation
Pawcatuck, Connecticut

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October 1979

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SECTION I

INTRODUCTION

This report is the first annual report on work conducted under the ANL Statement of Work for Research, Development and Demonstration of a Nickel/Zinc Battery for Electric Vehicle Propulsion, Appendix E to Contract No. 31-109-38-4224. The report includes not only the work accomplished during the last year but also the activity since contract effectivity, July 11, 1977, a total of 14 months.

The following sections present an executive summary followed by individual progress reports for each major task coded by WBS number. These reports present details of each of the three major activity areas, Research and Development (WBS 1.2, 1.3, 1.4,) Engineering Development (WBS 1.5, 1.6) and Process Development (WBS 1.7, 1.8).

The Program Management documentation including revised and updated Manpower and Cost Plans plus the Milestone Schedule and Status Report have previously been forwarded by letter dated August, 1978. The Milestone Schedule has been repeated here to add perspective to the timing of technical task accomplishment.

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SECTION 11

EXECUTIVE SUMMARY

The work carried out under the Yardney Contract with ANL for R, D & D on nickel zinc batteries over the past year was directed in three major areas. These are:

- (1) Elucidating the failure modes of the nickel-zinc battery system.
- (2) Improving performance of the system.
- (3) Effecting a cost reduction program.

Progress has been made in all areas.

(1) The failure modes analysis used a mixture of empiricism and fundamental science. It was established that the negative electrode was responsible for the capacity degradation of the system on repetitive deep-discharge cycling. The capacity degradation was an effect of several causes; no one of these causes appears to be of lesser importance. The active material of the negative electrode leaves the electrode compartment; some is deposited in the positives, some goes into solution, some is captured in the separator, and some just slumps into the electrolyte at the bottom of the cell. The loss is non-uniform. The zinc electrode also degrades in capacity because some of the material becomes passive. The zinc electrode material also redistributes itself within the compartment in a direction normal to the plane of the electrode. Loss of active material is accelerated by oxygen evolved during charge of the positive electrode. Amalgamation of the zinc also hastens capacity degradation.

The material that deposits in the positive electrode apparently is responsible for a decrease in the capacity of the positives, but this is not confirmed until such electrodes are removed from the cell environment. This loss is fully recoverable by several high rate charge and discharge cycles. The positive electrodes also can not be fully utilized unless there is sufficient zinc species on the negative electrodes.

(2) Performance has been improved by using the findings of the Failure Modes Analysis. Cells rated at 30 Ah have delivered about 70 Wh/Kg and have been cycled using an 80% DOD at the 3 hour rate with a 16 hour recharge. Thus far 70 cycles have been achieved. A detailed plot of these tests is given under WBS Task 1.5.0.1. The cells are clean both inside and outside. The outside cleanliness is indicative of no spewage. The cell does gas as evidenced by measurements, although the amount of gassing is less than expected on a theoretical basis; and this serves as additional evidence of some gas recombination. The end of discharge voltage was at 1.4 volts at the beginning of cycling and remains thus to date. The initial charge rate was 1.6 amps, which was later increased to 1.65 amps. This, too, appeared inadequate; and the cell was charged once at 2 amps and then subsequently at 1.7 amps. This charge appears to be adequate to maintain capacity. It results in a coulombic efficiency of 88% which translates to an energy efficiency of about 75%. Watering of the cells was infrequent, and consistent with the diminished gas evolution rate.

Efforts are being made to seal the nickel-zinc cell, and there is some degree of success. There is a special cell on test that has achieved 30 cycles thus far with pressure excursions from 30 inches of vacuum at the end of discharge to 18 inches of vacuum at the end of charge. Again, this is an 80% DOD at the 3 hour rate followed by a 16 hour charge.

(3) The cost reduction effort deals with each component of the battery cell, and therefore has many aspects. The positive electrode cost reduction is centered on an inexpensive sintered type as well as on a rolled/bonded type which is inherently less costly.

The cost reduction of the sintered electrode involves the use of thicker and more porous sinters. The greater porosity requires less nickel, and this affects both weight and cost. The thicker electrodes require fabrication by the loose powder metallurgical process which is inherently less costly, and also results in an improved ratio of sinter mass to grid mass. Since many steps involve procedures on an electrode basis, labor costs are decreased. Distex forms of Ni and Ni plated iron are being investigated as less expensive grids. This part of the investigation is continuing.

The impregnation bath is being altered to the use of inert anodes. Thus far it has been shown in the experimental tank that the new concept of bath use results in a great deal of cost and labor savings. However, it is more difficult to eliminate NO_3^- ions from the thicker plates. The NO_3^- are reduced to NH_3 at the Zn electrodes, by 8 Faradays per mole of NO_3^- . This effects the precharging of the zinc. This facet of the investigation continues.

Development of the alternate rolled/bonded Ni oxide electrode has been progressing. Hall Chemical Company has supplied electrochemically oxidized material that appears to be the best material yet tested. Conductive diluents selected are a graphite (SW 1615) at the 20% level admixed with Ni flake at the 10% level. Such electrodes are yielding test capacities of 145 mah/gm on a dry basis. These are also giving about 25% hard swelling. There remains the question of gassing of oxygen during charge as well as performance on a cell basis.

The separators have become a complex problem, even more so than originally conceived at the outset of the program. It appears that a complex separator system is required at this time. The first part of the system is the coating applied to the negatives to impede zinc migration; the second is the porous YIFL which serves to lower the effective density of the negative electrodes as well as serve as a reservoir. A main separator is also used to further impede zinc and prevent slumping. The fourth part is an interseparator that prevents the nickel oxide electrode from oxidizing the main separator.

Work on Yardney Inorganic Fibrous Laminate (YIFL) has continued. This porous inorganic separator provides two functions as discussed above. There is a decrease of shape change in the negative electrode. One particular modification identified as S-20 has gone through preliminary testing very satisfactorily. Cells dismantled

with S-20 show the zinc compartment to be very wet. The cells exhibited lower end of charge voltages and high capacities.

The positive interseparator work tested asbestos which was found detrimental, and nylon and polypropylene material which are satisfactory. This aspect of the investigation is considered to be concluded.

An investigation was carried out early in the program on mean zinc density (MZD) and the importance of ratio of negative to positive capacity. Results indicated use of MZD no greater than 1.3 g/cm^3 , and negative to positive ratios no less than 1.8. However, with the more recent advances of the zinc electrode, such work bears repetition. Such information is necessary for the cell modeling program.

The cell modeling program was set up on the basis of the performance of the early electrodes. Using utilization versus thickness data for both sets of electrodes, a program was written. This program indicated that the EV5 cells (4 of which are equal to the GC-2 lead acid battery) would yield maximum energy density with 51 mil thick positive electrodes. The modeling program written shall be continually updated as component improvements are obtained.

The "Baseline" or Reference Design is on the EV5 size cell using components described in this report and the modeling program. The advanced monoblocks are anticipated to have loose powder metallurgy plaques, and other components sized in accordance with the modeling program. Any additional advances reduced to practice will also be included in the Advanced Monoblock. A summary of the projected manufacturing costs for the nickel zinc battery as it can be made now without capital expenditure and as it is planned for future production in a highly automated plant is as follows:

<u>Battery</u>	<u>Rated Capacity</u>	<u>KWH/Monoblock</u>	<u>Mfg. Cost,</u> <u>\$/KWH</u>
Present (EV5X6)	270 AH	1.73	496
Future	312 AH	2.0	58

A review of the status and projections of the Yardney Nickel Zinc Development Program as compared with the ANL Phase I Goals is presented in Table I-I. We continue to be optimistic on the attainment of Phase I goals at the conclusion of this phase of the contract.

TABLE I -1

PRELIMINARY PHASE 1 BATTERY DEVELOPMENT GOALS

PARAMETER	<u>ANL</u> Jan 1979 GOAL	<u>YED</u> Jan. 1979 PROJECTION	<u>NOTES</u>
Battery Capacity	20-30 KWH	20-30 KWH	8 hr. charge, C/3 discharge, Rated - 100% discharge
Volumetric Energy	120Wh/l	105Wh/l	8 hr. charge, C/3 discharge, Rated 100% discharge
Specific Energy	70 Wh/Kg	62Wh/kg	8 hr. charge, C/3 discharge, Rated - 100 % discharge
Specific Power:			
Peak	125 W/kg	110 W/kg	15 sec. avg. at 80%discharge state at C/1.5 rate for 20 min.following 50% DOD at C/3.
Sustained	45 W/kg	40 W/kg	
Duty Cycle:			
Charge	4 - 8 hr.	4 - 8 hr.	
Discharge	2 - 4 hr.	2 - 4 hr.	
Lifetime:			
Deep Discharge	400 cycles	300 cycles	80% depth from rated capacity
Wet Stand	2 years	2 years	
Price/Energy	75 \$/KWH	95 \$/KWH	Delivered price to EV Manufacturers Plant Production of Approx. 10,000/ yr.
Energy Efficiency	60%	75%	
Application			Compact passenger car

SECTION III

TASK PROGRESS REPORTS

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Nickel Electrode R & D - Sintered/EI

Progress As of 31 August 1978:

1.0 The impetus for a lower cost nickel oxide electrode is obvious to anyone who reviews current costing of the nickel zinc cell. Several routes, e.g., a roll bonded nickel electrode, are possible. This program seeks to lower that cost by (1) reducing the amount of nickel and by designing a highly porous plaque, (2) investigating alternatives to the nickel substrate, (3) developing thicker electrodes so that fewer electrodes need be handled, and (4) streamlining the EI process. The primary approach taken in this program to come up with a thick electrode was to develop a loose powder electrode whose performance would approach, if not equal, that of the slurry process electrode. Once this nickel sinter was developed, the impregnation process need be tweaked to handle differences relative to the aerospace electrode. To reduce the cost further, alternative substrates would be investigated; nickel plated iron being one prime candidate.

Concurrently, the pore former work described above could be applied to the slurry process, and thereby reduce the cost of the near-term nickel zinc cell.

2.0 Loose powder plaque were fabricated up to thickness of .200 inch and having either a central distex or a nickel foil backing for substrates. The plaque having the centered distex substrate were found to exhibit better sinter to grid adhesion. For this reason plus through-put rate considerations this approach was adopted.

Several iron distex grids were used to fabricate plaque. The adhesion was as good as experienced with nickel distex. Differences appear to rest solely in grid conductivity.

3.0 Slurry Plaque - Attempts to manufacture plaque having a sinter porosity of 82 percent (target) in the absence of the pore former, oxamide, in the YED pilot plant, have not been successful. A porosity of about 80 to 80.5 percent has been achieved at low sintering temperatures.

4.0 Electrochemical impregnation of thick plaque has yielded electrodes exhibiting a merit factor of 1.9 compared to 2.0 for the thinner aerospace electrode.

In order to weed out additional problems, a larger number of electrodes were fabricated for use in the WBS 1.6.0.3 program. This work indicated that the post-EI formation treatment of thinner aerospace electrodes is not sufficient to remove nitrates which have been picked up in the EI step. These nitrates manifest themselves by resulting in lower cell voltages and do not allow the zinc electrode to charge.

WBS NO. 1.2.1.0

Plaque having iron distex grids have been electrochemically impregnated. Merit factors of from about 1.5 to 1.7 were achieved. A series of Fe grids, ranging from 5 Fe 10 to 5 Fe 25, were used. No detectable difference in the various grids has emerged to date. Differences in the handleability of these electrodes relative to those having nickel substrates has become obvious. Rinsing of the Fe grid electrodes for extended times (e.g., overnight) results in the appearance of rust on exposed edges. This is easily controlled once recognized. The more serious problem to be answered is what is the degree of corrosion in the cell.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: R/B Electrode Optimization

Progress As of 31 August 1978:

1.0 This program to develop a rolled bonded positive electrode was built on the rolled bonded electrode program of Yardney. A proprietary chemically oxidized nickel with cobalt catalyst additive, and a proprietary position in binder technology allowed continuous rolling of a pre-tabbed grid-containing electrode strip. External experimental work was done with two nickel salt producing companies, McGean and Hall Chemical, to produce an equivalent or better active nickel. The McGean approach was a chemical oxidation, and Hall evolved an electrolytic approach. The latter approach consistently has made electrodes giving higher utilization of contained nickel and capacity per unit of weight, as well as approximately half the hard swelling of chemically-oxidized nickel hydrate plates. Optimization of bath temperature, pH, agitation, and buffering agent was done to produce a material which had reasonably high bulk density (and, therefore, gave electrode mix densities above 2.0 g/cc) and which filtered reasonably well (which differs from chemically-oxidized hydrates and impacts cost directly).

2.0 A pilot size cell was built and installed in an Alabama plant to produce this material. Initial runs could not be duplicated because of heat exchange problems allowing a too high temperature bath. Current pilot production appears from screening tests to satisfactorily duplicate the laboratory-made optimum material.

3.0 Concurrently with the hydrate development was the development of the corresponding conductive diluent and grid. The best performing graphite is a Southwest 1651. The nickel flake needs to be less than 7 microns thick. Inco's Novamet Division has now developed a satisfactory material. C. P. Chemicals 1 micron flake is also satisfactory, but of much higher cost. A planar diameter of at least 0.015 inches is required. By screening the over 80 mesh Novamet flake, and by washing to remove process lubricants, resistivity decreases from over 100 ohms/cc to under 1 ohms/cc made a satisfactory diluent. The best proportions are 20% SW 1651 and 10% flake, along with 3% of the proprietary binder added in latex form.

4.0 The optimized high density hydrate made into a 10Ah cell showed over 145 mah/gm of electrode, 25% hard swelling, and ran over 85 deep cycles, with level performance at 80% after cycle 10. A 30 Ah cell from the same type material was constructed and cycling begun. Sufficient pilot material will be obtained to build a full size EV 5 cell.

WBS NO. 1.2.2.0

5.0 A conference is planned with Hall to expedite the transfer of technology to Yardney for possible future production of the hydrate material. Projected cost of the material is less than \$3.00/lb. of contained nickel. In pilot quantities it is quoted at \$5.00/lb contained nickel.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Separator R & D/Main Separator Evaluation

Progress As of 31 August 1978:

1.0 A silver impregnated cellulosic, C-19, has long been the main separator in Ag/Zn cells as manufactured by Yardney (U. S. Patent 2,785,106). The requirements of the nickel zinc, as different than Ag/Zn, mandate an improvement in performance of this material with respect to additional life if it is to find widespread use. The cellulosic is an inexpensive starting material whose performance as an alkaline separator is markedly improved by the impregnation of silver.

This program has resulted, to date, in several derivatives of the Yardney proprietary separator material, C-19, being fabricated, characterized, and tested in cells. Some of these materials are superior to C-19.

2.0 Screening tests were run to characterize the various separator materials. Additional data reflect the resistance of various materials to degradation in alkaline mediums of varying concentrations.

3.0 Cell tests were conducted to add to the evaluation of the various separators. Ag/Zn and NiZn cells were used as the vehicle for these tests. The results indicated that C-19T and CTC prepared in the laboratory did perform better in the cell environment relative to C-19 and in-situ C-19T obtained with the aid of various additives. The CTC was considerably weaker than the C-19T, evidence that considerable oxidative degradation had taken place.

4.0 The results of the NiZn cell tests, nominal 3.5 AH, and analysis of the cycles-to-failure in this accelerated test, confirmed the C-19T Brown and Black as the separators of choice.

Dissection of the cells revealed massive penetration of zinc through the separators (reverse wrap) at the bottom of the U resulting in bridging as the failure mode in every instance. In terms of physical strength, the separators were graded as follows:

ITEM	SEPARATOR					
	C-19T B	C-19T Br	C-19T (in-situ)	C-19	C-T	C
Phys. Strength*						
Cell #	16	14	12	5	10	7
Cycles Completed at Dissection	16	16	13	13	16	13

All the cells analyzed had exhibited significant capacity degradation prior to dissection.

*DEFINITION:

C = Cellophane

C-T = Titanated Cellophane

C-19 = Ag treated Cellophane

C-19T (in situ) = Ag treated cellophane converted to the titanated form within the cell

C-19T Br = Titanium and Ag impregnated cellophane

C-19T B = C-19T Br processed more extensively

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Separator R & D/I/O Evaluation

Progress As of 31 August 1978:

1.0 Derivatives of the Yardney proprietary separator C-19, used in Ag/Zn cells, are considered prime candidates as NiZn cell separators. However, the cellulosic starting material is subject to oxidative degradation. Further, improvements in resistance to zinc penetration coupled with a reduction in the volume of separator used would make the nickel zinc cell more marketable. Thus this program was initiated to seek an alternate separator material which could offer equal or better performance, measured as described above. The approach is to identify and screen potential separator candidates, and then to test the most promising materials in cells. The cellulosic derivative showing the greatest potential would be used as a benchmark upon which performance would be graded.

2.0 Several materials were acquired. Some, e.g., fluorocarbon material having pore diameters ranging from 2 to 20 microns and supplied by Fluoro-techniques Corporation, did not wet. Further testing was not pursued. Other materials evaluated are reported on in Table 1. One recently tested material, a CELGARD product, performed extremely well and is worthy of additional testing. This material is treated with a wetting agent whose performance in the NiZn cell environment is questionable, however.

SEPARATOR EVALUATION

SEPARATOR (Note 1)	Thickness (mils)		Dry Wt. (g)	Electrolyte per		Elect. Resist. mohms -in ² (Note 2)	Zn Penetration (cm/sec)X10 ⁶ (Note 2)
	Dry	Wet		Vol. sep. (g/in ³)	wt. sep. (g/g. sep.)		
MPS-A-10 (Note 3)	17.9	18.3	.700	13.50	1.412	52	7.06
MPS-A-30 (Note 4)	23.6	23.9	.818	14.30	1.670	55	5.09
LENZ 8-X-7	12.5	15.3	.920	16.30	1.083	111	2.46
LENZ 8-X-13	5.8	7.4	.419	8.66	.612	144	2.74
LENZ 8-X-19	7.7	11.7	.604	14.91	1.156	225	2.63
LENZ 8-X-21	10.1	10.6	.575	8.59	.634	135	2.31
LENZ 8-X-25	5.7	7.4	.433	11.48	.784	47	.94
LENZ 8-X-28	10.1	11.3	.529	12.33	1.052	39	2.51
CELGARD	.9	1.4	.042	22.04	2.94	4	.34
C-19	1.0	2.9	—	—	—	15	.66

NOTES:

- (1) in 35 percent KOH for all samples except C-19 and C-19-T Br which were 45%
- (2) sample size is 4 in²
- (3) MPS: Materials supplied by Microporous Products Division Amerace Corp.
- (4) LENZ: NASA LeRC separator materials

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Separator R & D/YIFL Variations

Progress As of 31 August 1978:

1.0 Yardney is presently using a negative interseparator designated YIFL. This material performs at least two functions, namely:

1. Serve as an electrolyte reservoir
2. Minimizes shape change of the Zn electrode

Items 1 and 2 could also be eliminated with the success of the Failure Modes Program (WBS 1.4.0.2) which has identified the negative electrode as the present life-limiting component and strives to improve that electrode.

Eliminating the need for a reservoir and a mat to minimize shape change is, in this author's opinion, of low probability. The fact that YIFL consists of asbestos necessitates that a substitute material be found which is not environmentally objectional. This program seeks to formulate and test such a substitute.

2.0 Three negative interseparators were formulated. These interseparators were designed S-20, S-30, and S-40, respectively.

3.0 Three types of cells, nominal 4.5 Ah, each type defined by the negative interseparator, plus one YIFL control type, were assembled and tested in an accelerated manner. The data is shown in Figure 1. Capacity on cycling was comparable for all cells with the exception of the S-20 cells which were delivering higher capacities (about 2-10%) generally. Further, the end-of-charge voltages of the S-20 cells ran below the others while the discharge midpoint voltages were about the same. The discharge midpoint voltages of all the cells increased with cycling over approximately the first five cycles. Four cells were taken off test following 25 cycles and were dissected. The positives were found to be in good condition, visibly wet and without any zinc on the surface. The negatives and negative interseparator were examined and analyzed.

The negative in the control exhibited considerable zinc loss, confirmed by the analysis, but showed little shape change. The substitute cells had more material on the grid (verified by analysis) but each had some shape change (less than 10%). The S-20 cell was unique in the difficulty encountered when attempting to separate this material from the negative, and in the unusually large amount of electrolyte found in the negative electrode compartment. In dissecting the cells, it was observed that the layer of C-19 closest to the positive was weaker in the test cells than in the control.

WBS NO.1.3.0.3

Continued cycling of the remaining cells failed to result in any additional trends. The low end of charge voltage of cell No. 4 (S-20 type) was not in itself sufficient for longer life. It appears that a different type of failure mode, i.e., shorting, occurred at about cycle 28-29. Dissection of these cells yielded no new information other than that the C-19 in all types including the control, appeared comparable.

4.0 The materials developed in this program appear to be suitable replacements for YIFL. In fact, the S-20 would seem to be an improvement yielding lower end-of-charge voltages and higher capacity. This was correlated with its higher porosity. The use of this material is being further investigated to improve on negative electrode performance as evaluated in the Failure Modes Program (WBS 1.4.0.2).

NY-5 TEST CELLS

(AVERAGE OF 2 CELLS PER GROUP)

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Separator R & D/Positive Interseparator Evaluation

Progress As of 31 August 1978:

1.0 A positive interseparator was being sought to minimize the exposure of the main separator to the oxygen evolved from the nickel electrode. The material selected need retain the primary role of electrolyte reservoir. Asbestos was a prime candidate.

2.0 The PPO impregnated asbestos was screened and tested (WBS NO. 1.6.0.1). When compared with nylon (specifically Pellon 2506); the asbestos proved to be detrimental to overall performance with respect to capacity delivered and discharge midpoint voltage. Nylon and the more commonly used polypropylene have been found to be comparable. The use of asbestos without an additive is restricted to experimental use since the asbestos lacks the strength for handability and asbestos in general is to be avoided where possible because of health objections. The difficulty with the PPO impregnated asbestos appears to lie in its inability to function as a reservoir. The second substitute for the polypropylene or nylon type positive interseparator, a treated TiO_2 material, should function even worse in this capacity. For these reasons, the program is being concluded at this time, recognizing the adequacy of polypropylene and nylon to meet the near-term requirements of the nickel-zinc system.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: MZD Optimization, Neg./Pos. Ratio Evaluation

Progress As of 31 August 1978:

1.0 Two groups of experimental cells have been built and tested per the WBS 1.4.0.1 Task Description.

2.0 The first group consisted of 3 cells each of 6 designs (all 5 Ah nominal capacity). "Mean-zinc densities" ranged from 1.0 to 1.5 gm/cc zinc in the negative electrode/negative interseparator compartment. "Negative to positive" capacity ratios ranged from 1.3 to 1.8 (expected (-) capacity : expected (+) capacity) or from 1.6 to 2.2 (theoretical (-) capacity : expected (+) capacity) as we now define the ratios.

2.1 Sixty cycles were run on these cells. Results are presented in Figure 1 and Table 1.

2.2 As can be seen from the summary, we accelerated the failure of these cells by maintaining a high input capacity, thus lowering the "efficiency" and providing greater and greater overcharge as capacity dropped off. We wanted to accelerate the occurrence of any differences between the cells' performance. The lower "MZD" (<1.3) and the higher ratio (>1.7) cells performed the best under this regime. The low ratio cells (< 1.5) fell off in capacity the most quickly, as expected. Note that the 1.0 MZD, 1.8 ratio cells were still providing greater than 80% of initial capacity during cycles 51-55.

3.0 All of the cells in the second group were designed with a 1.2 gm/cc "mean zinc density" and 2.2 theoretical (-) : expected (+) ratio. Two cells each of eleven designs were constructed and tested. Design variations included varying initial negative electrode mix densities in the range of 2.9 gm/cc to 3.8 gm/cc (before expansion in the cell to the design value of 1.2 gm/cc "MZD") and negative electrode mix variations as shown in Table 11. Test results are presented in Figure 2. All of these cells dropped below 80% of initial capacity (when discharged to 1.0 v/cell) within 20-30 cycles. Analysis of these and later cells under our WBS 1.4.0.2 "failure modes" program indicates the probability that the cause of the early failure of these cells was likely the use of copper grids in their negative electrodes vs. the silver grids in the original cells.

4.0 The effect of (-) : (+) ratio is being further evaluated in the current WBS 1.5.0.1 30 Ah cell tests where cells containing 3.75 and 3.00 ratios are being tested concurrently.

WBS 1.4.0.1

5.0 We still intend to establish an optimum, or minimum, (-) : (+) ratio for meeting the ANL goals. However, it is clear that we must have our stable long-life negative electrode in the test cells for the results to be of value. We have, therefore, delayed building a third set of cells for this experiment until the results of the Failure Modes (WBS 1.4.0.2) and Baseline (WBS 1.5.0.1) tests are definitive.

TABLE I

MZD OPTIMIZATION, NEG/POS RATIO EVALUATION
NZIO (5) CELLS-TEST SUMMARY

GROUP	1	2	3	4	5	6
MZD	1.2	1.2	1.3	1.0	1.2	1.5
(-)/(+) Ratio Old (New)*	1.3(1.6)	1.5(1.84)	1.7(2.1)	1.8(2.2)	1.8(2.2)	1.8(2.2)
Avg. Capacity Cycles 1-5	4.62	4.70	4.70	4.69	4.69	4.68
Aho/Ahi Efficiency cycles 1-5	.91	.92	.92	.92	.92	.92
Avg. Capacity Cycles 21-25	4.62	4.94	5.05	5.04	4.99	4.98
Aho/Ahi Efficiency	.89	.95	.97	.97	.96	.96
Avg Capacity Cyc. 31-35	3.88	4.38	4.71	4.68	4.59	4.43
Aho/Ahi Efficiency	.76	.86	.92	.92	.90	.87
Avg. Capacity Cyc. 41-45	3.45	3.62	4.07	4.27	3.94	3.88
Aho/Ahi Efficiency	.72	.75	.85	.89	.82	.81
Avg. Capacity Cycles 51-55	2.49	2.85	3.12	3.81	3.71	3.20
Aho/Ahi Efficiency	.52	.59	.65	.79	.77	.67
%Cycle 1-5 Capacity	.54	.61	.66	.81	.79	.68

*Old = Expected (-) / Expected (+)

New = Theoretical (-)/ Expected (+)

WBS 1.4.0.1
Neg. Electrode Test Cells

TABLE II

<u>Cell Group</u>	<u>Negative Electrode Variation</u>
1	Initial electrode mix density: 2.9 gm/cc
2	" " " 3.2 gm/cc (Standard)
3	" " " 3.5 gm/cc
4	" " " 3.8 gm/cc
5	ZnO mix particles screened to < 150 mesh
6	" " " < 40 mesh
7	No HgO in electrode (vs. St'd 1%)
8	10% CdO/5% Ca(OH) ₂ HgO substitute
9	3% Kraton G - 1650 Binder (vs. 3% Neoprene)
10	3% TFE Binder (" ")
11	3% PPO Binder (" ")

All cells designed with 1.2 "MZD", 1.8(-)/(+) Ratio, Nominal Capacity: 4.7 Ah

CAPACITY VS CYCLE NO.
NZ 10 (5) EXPERIMENTAL CELLS

Figure 1

WBS NO. 1.4.0.1

NZN-5 Test Cells

Average of 2 Cells Per Group

Cycle No.
Figure 2

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Failure Modes Analysis

Progress As of 31 August 1978:

1.0 This program is designed to identify and offer solutions to present and potential failure modes which exist in the nickel zinc cell.

2.0 The results to date indicate that :

1. Lower charge rates C/15 relative to C/6 serve to increase cell performance (capacity out) at a fixed discharge rate.
2. Shape change has been judged to be less of a problem in nickel zinc cells relative to silver zinc cells. The combination of the YIFL negative interseparator plus low mean zinc density appear to be the mitigating influences.
3. Shape change is one manifestation of zinc migration.
4. The negative electrode has been identified as the cell's life limiting component.
5. Negative electrode capacity degradation has been related to (1) loss of zinc from the negative compartment; and (2) inactive (passivated) zinc.
6. Positive electrode capacity degradation has been related to non-uniform current distribution as mirrored by a zinc electrode having undergone extreme shape change.
7. For a given design, the amount of zinc material having left the negative compartment was found to be about 40 percent up to cycle 26. From cycle 26 to about 70 the quantity of zinc in the negative compartment remained constant although the distribution between what was determined to be at the electrode as opposed to that in the YIFL interseparator reversed. Electrodes analyzed in the discharged state revealed that considerable charged zinc was to be found at the electrode. Electrodes analyzed in the charged state revealed that considerable zinc oxide was to be found at the electrode. The material in the YIFL was highly utilized.
8. The binder being used in the roll bonded negative electrode has been found to result in a film which remains as the zinc migrates away from that electrode into the YIFL.

9. The negative interseparator, YIFL, has been found to shrink approximately 17-20%. About 70 percent of this occurs preferentially lengthwise.
10. Zinc mossing has been related to oxygen generation from the positive.
11. Oxygen evolution has been found to be detrimental to the negative electrode as measured by capacity loss.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: NiZn Cell R & D/ Sealed Cell

Progress As of 31 August 1978:

The goal of this program is to develop a sealed cell which would provide maintenance free operation plus increased cycle life.

During early cell testing, it was established that:

1. The nickel oxide and zinc electrodes interact during charge and discharge.
2. Gas was entrapped within the electrodes and the pressure relationships depend on the method by which the pressure develops.
3. Premature hydrogen evolution on charge, above that expected from corrosion, was observed and later verified. The hydrogen coming off the negatives was suppressed when oxygen began coming off the positives. Premature hydrogen evolution on charge was found to be dependent on the type and condition of the negative electrodes. Improved negative electrodes do not exhibit this phenomenon because charge acceptance is improved.
4. Hydrogen is being consumed at a low rate. This hydrogen is suspected of self-discharging the positive as has been postulated in nickel hydrogen cells.
5. Oxygen consumption was found to occur.

Hydrogen recombination was viewed as the problem which lent itself more readily to a solution. A difficulty in obtaining consistent long-term data lay in the changing character of the zinc electrodes. Tests have begun, incorporating more stable zinc electrodes, which should allow for the collection of sustained data.

Oxygen recombination has been a more difficult problem. That the zinc electrodes do recombine some oxygen has been established as indicated above. An attempt to use large silver tabs on the zinc electrodes proved unsuccessful, in that considerable H_2 was then evolved. The approach was then shifted to produce a highly active, highly porous silver structure which would serve as a third electrode. The electrode developed was found to lose response capability in the cell from that measured in a test chamber. This difficulty appears to involve the mechanics which were employed in fixturing this component within the cell, resulting in poor mass transport.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: NiZn Cell R&D/Cell System Modeling

Progress As of 31 August 1978:

1.0 To parallel the latter stages of the Phase I R&D effort, the nickel zinc cell will be modeled with the aid of a computer, so as to stimulate the dynamic behavior of the cell. In this way design of an optimized nickel zinc cell will be possible.

2.0 Elements of the NiZn cell design are being handled, initially, with the aid of a TI SR 52 programmable calculator. As the elements sum to a more complex program, a more powerful computer will be employed. The program written serves to answer four questions:

1. For some even number of positive electrodes, $2n$ (where n is an integer), with a thickness in mils f , will an acceptable stack thickness be achieved?
2. Then how thick will the negatives be?
3. Then how thick will the YIFL interseparator be?
4. Then what is the energy density of the cell?

3.0 Example: Design an EV5 cell having a negative to positive ratio of 2.4, a mean zinc density of 1.5 and 4 turns of C-19T. The internal dimension of the cell case is 2500 mils so that the stack thickness should lie between 2440 and 2480 mils. The case dimension is 2660. Set up the following matrix:

Responses

Stack Thickness	2443	2483	2453
Neg. Thickness	65	21	33
YIFL Thickness	26	8	13
Energy Density	2.9	3.0	3.2

Many values of thickness were chosen for each quantity of positive electrodes, but only those considered acceptable are shown.

Having a quadratic term for the thickness of the negatives gives rise to a maximum in the AH negative per unit volume term. The maximum occurs at a 74 mil thickness. This does not mean that the cell has a maximum capacity or energy density with 74 mil thick negatives. The interrelationships of the design terms are complex and interact so that one can not analytically determine extrema in the design configurations. Such extrema do exist and evidence is given in the program responses for energy density. The cell designs having 75 mil thick positives have the lowest energy density- 2.9 WH/in³. Essentially halving the positive plate thickness increases the energy density 3%. The plate with an intermediate thickness of 51 mils for positives yields a cell with a calculated energy density of 3.2 WH/in³. Such data indicate that an extremum exists between positive plate thicknesses of 35 and 75. The best design has not necessarily been selected. The best design will have more than 10 positive electrodes and less than 22 positive electrodes. Further, with each cell case selected, different thicknesses of positive electrodes may be required for energy density maximization. Each instance must be investigated. The tool for such an investigation is the program described.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Ni/Zn Baseline Cell and Monoblock Design, Development, Mfg. and Evaluation

Progress As of 31 August 1978:

1. Module Design

- 1.1 Our "baseline" four-cell module design is shown in Figure 1. Dimensionally, this is a direct replacement for the standard 6-volt lead-acid (BCI-GC2) battery.
- 1.2 This "baseline" module consists of four individual cells strapped together. The cell case and cover have been designed, the molds built, and cases and covers procured for this program.

2.0 Cell Construction & Testing

2.1 NZEV5X-5 Cells

Four cells (300 Ah nominal) were built early in the program and tested per the ANL regime: i.e. charge @ C/8, discharge @ C/3 for 2.4 hrs. (80% DOD) or to 1.2 volts, whichever comes first. These cells, which had a low (-) : (+) ratio (approximately 2.0 theoretical negative to expected positive) yielded 77 wh/kg initially, but fell off to below 80% of rated capacity within 20 cycles. The negatives contained copper grids and mercury, two factors which were also later determined to be detrimental to cycle life. Cycling was discontinued after 40 cycles.

2.2 NZM-2 Cells

Seven groups of 30 Ah test cells were later designed and built to evaluate the cycle-life performance of several of the negative electrode variations which appeared promising based on our WBS 1.4.0.2 screening tests. The design variations are detailed in Table I. Four-cell modules of each of the seven designs have now completed twenty 80% DOD cycles and are continuing on test. A single cell of the NZM-2X-2-0 design has now completed 74 cycles and is still providing more than 80% of rated capacity (> 1.2 volts at end of 24 Ah discharge @ C/3). Figure 2 shows the end of discharge voltage vs. cycle number for the cell and for the positive electrodes and negative electrodes relative to a nickel reference electrode. Of significance is the relative stability of the negative to reference values over the more than 70 cycles. Cycling of this cell is also continuing.

WBS NO. 1.5.0.1

2.3 NZEV5X-6 Cells

Two additional full-sized cells (250 Ah nominal based on 3.75 (-) : (+) ratio) have been designed per a "scaled-up" NZM-2X-2-0 design (see Table I). The cells have been assembled and cycling will begin shortly.

WBS NO. 1.5.0.1

TABLE 1
DESIGN OF 30AH TEST CELLS

Cell Type	(-) Grid	Type	Mix Density (gm/cc)	YIFL Thickness (inches)	MZD	Cap. (-)/(+) Ratio	Surface Treatment
NZM 2X-2-0	Ag	A	3.20	.015	1.4	3.75	Yes
-1	Ag	B	2.86	.017	1.1	3.0	No
-2	Ag	C	3.25	.015	1.1	3.0	No
-3	Cu	D	2.83	.015	1.1	3.0	Yes
-4	Cu	E	2.87	.015	1.1	3.0	Yes
-5	Cu	F	2.88	.017	1.1	3.0	No
-6	Ag	G	3.20	.015	1.1	3.0	Yes

Figure 1: Engineering Drawing - Four cell, 300 ampere-hour nickel-zinc battery.

NZM2X-2

END OF DISCHARGE VOLTAGE VS CYCLE NO.

Figure 2

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE:

Charger Design and Manufacture

Progress As of 31 August 1978:

1.0 The charger which will accompany the first deliverable monoblock has been designed and is nearing manufacturing completion. It consists, basically, of a solid-state power supply, SCR controlled, with a gas-transducer interfaced to the shut-down system. It will charge at a constant current (C/8, 40 A max.) to a voltage of up to 8.4 volts for the four cell monoblock. Shut-off occurs when the gas-flow from one of the cells reaches a preset level; additionally, the charger can be shut-off manually or can be interfaced with a timer. Input is 110 volts, 60 HZ, with a fuse rated at 16 A at 115 volts.

2.0 Work is continuing to determine the optimum charging method (modified constant potential, pulsed, etc.) and to develop an inexpensive cut-off device.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Advanced Cell/Monoblock Design, Manufacture, Test and
Evaluation

Progress As of 31 August 1978:

1.0 We have built and tested cells under this program to evaluate experimental positive electrode construction (i.e. by both loose powder and rolled-bonded methods) and to evaluate the effectiveness of NASA Lewis-type separators vs. standard Yardney materials in the ANL deep-discharge cycling regime.

2.0 Two cells were built early in the program using 0.070 inch thick "loose-powder" positive electrodes (vs. our back-to-back 0.035 thick standard slurry-type positive electrodes). Although the capacity expected from these cells was in the order of 300Ah, the highest capacity that we obtained was 275 Ah. The cells, which contained copper grids in the negatives and had a fairly low (-) : (+) ratio (approx. 2.0 theoretical negative: expected positive), were destroyed during our attempts to improve their capacity. The positive electrodes were subsequently removed, washed, and cycled to yield expected capacity; they were then cut-down and re-used in the 30 Ah cells described in paragraph 4.0 below.

3.0 A total of seven 100 Ah cells have been constructed to evaluate the use of NASA-Lewis type separators in this program. Table I summarizes their construction and the test results to date. It is obvious from these that the use of a low-resistance separator such as cellophane, in conjunction with an adequate negative electrode reservoir will provide both better voltage and capacity characteristics and greater cycle life during a deep cycling regime. All four cells built with NASA "K19W2" as their main (negative electrode) separator shorted via zinc penetration in less than 20 cycles; cell #7 with 4 turns of cellophane and Pellon on both the positive and negative electrodes, is still cycling at past 50 cycles.

4.0 Two 30 Ah cells containing the cut-down loose-powder positives described above and one 30 Ah cell containing rolled-bonded positives are now on test. These are of the same design as the NZM-2X-2-0 module cell being tested under WBS 1.5.0.1 with the exception of the replacement of the 0.034 thick back-to-back double positive with the thick experimental positives. These cells will be cycled under the same regime as the "reference" cell and a direct comparison of performance will be made.

WBS NO. 1.6.0.1
TABLE I

POSITIVE INTERSEPARATOR CELL TEST DATA

CELL NO.	POSITIVE ELECTRODE TYPE	POSITIVE ELECTRODE INTERSEPAFATOR	NEGATIVE (MAIN) SEPARATOR (I)	MIDPOINT VOLTAGE/ CAPACITY - CYCLE 5		# CYCLE TO SHORT (2)
1	Standard YED	2% PPO Treated FCA, 10 Mil	KI9W2 Bag w/Foam Tape	1.53V	90AH	13 - 14
2	Standard YED	Pellon #2505 (P-12)	"	1.58V	102AH	19
3	Cycled/Formed	2% PPO Treated F.C.A. 10 Mil	"	1.53V	87AH	13 - 14
4	Cycled/Formed	Pellon #2506 (P-12)	"	1.59V	101AH	19
5	Standard YED	Pellon #2506 (P-12)	4 Turns C-19	1.57V	95AH	23
6	Standard	Pellon #2506 (P-12 + 1 Turn Cellophane	3 Turns Cellophane	1.50V	98AH	23
7	Standard YED	Pellon #2506 (P-12) + 1 Turn Cellophane	Pellon #2506 (P-12 + 3 Turns Cellophane	1.51V	96AH	> 50

Notes: 1) All negatives "NASA-Lewis Type"-67 mils thick, pressed powder construction using 5Ag 27-1/0 Distex, 98% ZnO, 2% HgO, with YIFL II mat pressed into electrode.

2) Cycle # where slow short was first indicated during charge.

3) Cells #6 & 7 have no HgO in their negative electrodes.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Baseline Sintered Positive Cost Reduction System Upgrade

Progress As of 31 August 1978:

- 1.0 A quality temperature control along with a pH meter, a higher capacity circulating pump and a resistivity meter for the deionized water have been added to permit closer control of important impregnation parameters.
- 2.0 Additional exhaust fan capacity has been added in the sintering and impregnation areas to improve air quality and comfort.
- 3.0 A heated housing has been provided to insure ammonia flow at winter temperatures; and while not part of the project, a leased 300 gallon liquid nitrogen tank has been provided by Yardney to provide continuity of nitrogen availability.
- 4.0 Modifications to the impregnation conversion system have been drawn and parts ordered to permit making the electrical connections to the racks external to the tanks and to provide for using the same racks in the impregnation and conversion tanks.
- 5.0 Closer control of the bath conditions permit a more uniform precipitation of $\text{Ni}(\text{OH})_2 / \text{Co}(\text{OH})_2$ thereby reducing the total amount needed to meet the minimum requirement of the EV plate.

The basic modification to the impregnation and conversion tanks now underway will significantly reduce the labor to manufacture the positive plates.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Reference System Process Development / R/B Negative
Process Support

Progress As of 31 August 1978:

1.0 The testing and run-in of a rolling machine invented and built by Yardney, was conducted to prove the process that a bonded negative electrode can be made continuously with various percentages of zinc and zinc oxide to produce a desired state of charge. The starting mix powder can contain various binders added in latex form, followed by high speed mixing, drying, chopping, and screening. Proper humidity storage and proper humidity rolling conditions must be met. Teflon latexes do not give a free flowing powder for use in this rolling process because of agglomeration tendencies. The machine was also shown to be capable of satisfactorily handling a variety of additives compounded into the mix in powder form, which additives are included for purpose of decreasing zinc solubility and consequent increases of cycle life, and to replace the need for mercury in the electrode. Certain additives such as asbestos are not able to give a flowable powder in any significant content, but others are runnable on this machine.

2.0 The testing and initial run-in of a continuous tab welder, conceived and built by Yardney, was also conducted to prove a welding process which could make a satisfactory pre-tabbed roll of grid material with an interleaf to keep the tabs from tangling. This, in turn, was used as one of the starting materials for the continuous negative rolling machine, along with the mix powders. The run-in of this machine was limited to foil-type copper. It did not include expanded metal forms of current carriers.

3.0 The present limitations of the Yardney equipment on which these processes have been proved are as follows: maximum grid width (length of electrode) is 6 inches; maximum stickout of tab above grid is 3 inches; tab widths from 1/8" to 1"; maximum roll width on rolling machine is 8" (including tab of continuous grid), maximum cut-off width is 2 7/8", approximate maximum thickness of producible electrode is about 0.120", and minimum thickness is about 0.020". Mix densities can be run from 2.6 g/cc to 5.0 g/cc, depending on the mix composition (more binder and no zinc metal at minimum end, and no zinc oxide at the maximum end).

The rolling machine is currently being used to support research efforts in the zinc electrode/failure mode analysis, and has shown flexibility for a wide range of uses, including making electrodes for full size cells and batteries on a non-continuous basis.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE:

Reference System Process Development/Pilot Process
Analysis

Progress As of 31 August 1978:

1.0 The work under reference 21911-8-01-0 has indicated that a loose powder sintered plaque can be made satisfactorily, and thus this process was costed (under 21911-7-06-0) in the analysis of projected operations for comparison with the rolled/bonded positive previously presented in Phase A report, and for comparison with the ANL cost goals. This, taken together with the desirability of energy conservation and critical raw material conservation, and with the known ability of other types of sintered positive electrodes to be reused following cleaning, gave rise to the costing analysis of a single recycle of the loose powder electrode. The recycled sintered positive can be made into a battery for less manufacturing cost than the rolled/bonded positive, and thus more than meets the long term goal at high production of \$50/KWH selling price.

2.0 There are other recycling processes which can significantly impact the reaching of the long term pricing goals. One which is being looked at is the multiple recycling of loose powder sintered positive electrodes. Since it is known that slurry plaque sintered electrodes can give cycle life in multiple reuse beyond three equivalent nickel zinc battery life projections, it is to be determined whether the further recycle of loose powder plaque sintered electrodes is best done by the battery manufacturer or by a rebuilder.

WBS NO. 1.7.0.5

TASK TITLE/SUBTITLE: Reference System Process Development/ Materials Requirements Definition

1.0 The Materials Requirements definition for batteries utilizing a rolled bonded positive, presented in the Phase A report, was updated to include the loose powder sintered plaque which is currently the design choice for the producing battery. The report utilizing that design in terms of materials requirements, was submitted on schedule in May 1978. That report also included the rationale for market development and market share, but did not take into account certain other requirements which had to do with battery manufacturer/ vehicle manufacturer interface. It is anticipated that these inputs will be derived from the meeting scheduled for September 11 at ANL and the final draft of the report will be delayed until the input from this interface is available. The work of this project was responsible for an early recognition of certain materials availability problems, which resulted in a timely start of research efforts on such items as cobalt reduction and substitution.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Reference System Process Development/ Manufacturing
Cost Analysis

Progress As of 31 August 1978:

1.0 Analysis have been made of manufacturing cost for sintered plaque positive construction of both slurry and loose powder types, along with rolled bonded negatives. Present conditions involving manual assembly and manufacturing quantities and future automated operations resulting from an assumed level of capital investment to produce ANL defined market quantities have been studied and the results are included in the supplement to this report. For both present reference design and advanced battery design the C-19T separator is used, since this is now a reasonably assured process for production.

2.0 These costing analysis also provide direction for priorities in cost reduction efforts in both raw materials production and processing into batteries. A specific example of such is substitution for nickel in the inactive componentry where materials such as steel in the positive grid are cost effective in an electrode design assuring post treatments such as shearing which would expose iron surfaces are not necessary. Other examples of cost reduction areas such as pore former substitution and/or elimination, innovative design work in combs and terminals, and separator process development to reduce treating time, are evident and programs are now being written to investigate them.

3.0 A summary of the manufacturing cost analysis for present and advanced batteries is as follows:

<u>Battery</u>	<u>Rated Capacity</u>	<u>KWH/Monoblock</u>	<u>Mfg. Cost,</u> <u>\$/KWH</u>
Present (EV5X6)	270 AH	1.73	496
Future	312 AH	2.0	58

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Sintered Positive Cost Reduction

Progress As of 31 August 1978:

1.0 An initial concept based on doctoring of dry powder for rolled bonded electrodes was attempted for loose powder plaque making to increase the process speeds for cost reduction. Although good positives and sufficiently low resistance was attained, the loading levels upon impregnation were low. This apparently resulting from increased density on the vibrating doctor side, since it did not occur with manual screening.

2.0 The process is capable of being automated at the upstream end of the existing sintering furnace. Current work in upgrading the fixturing of the machined carbon mold to get repeatable results is underway.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE: Advanced System Process Development/ R/B Positive
Process Development

Progress As of 31 August 1978:

1.0 A process similar to that successful in making rolled bonded negative electrodes was put together on Yardney equipment. The run-in of the equipment using mixes suggested by the bonded positive electrode development program proved that the process was feasible on a continuous basis. A length of material was run, producing satisfactory density, although the base hydrate used (to obtain sufficient quantity for run-in) was an inferior chemically-oxidized material. The grid was also not pre-tabbed since the continuous tab welder was not then in operation. This equipment was then used for research versions of electrode fabrication (non-continuous) for the electrode development program, as well as for initial concept trials in the loose powder, thick plaque sintered electrode process development program reported under WBS Task 1.8.0.1.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE:

Separator Process Development

Progress As of 31 August 1978:

1.0 A run was made to process C-19 (Yardney's proprietary silver impregnated cellophane) into C-19T duplicating the conditions determined by research efforts to give sufficient pickup for decreased zinc penetration and longer cycle life in nickel zinc cells. Results indicated that a material can be attained by such a two-pass process on existing equipment, at relatively high cost. Current testing is directed toward a true pickup level analysis, and more rapid in-process quality checks for future runs. As well, zinc penetration tests are scheduled and cycle life comparisons with other separators will be made to confirm the advantages of C-19T. Process parameters will be analyzed to optimize bath temperature and KOH concentration. From these data a process to make C-19T from cellophane can be designed and costed for pilot plant operation, as well as definition of final capital requirements and pricing information.

ANNUAL ENGINEERING PROJECT PROGRESS REPORT

TASK TITLE/SUBTITLE:

Pilot Process Analysis

Progress As of 31 August 1978:

1.0 Two subtask currently under investigation in the pilot process analysis are: (1) the development of mechanical handling equipment for grid plating, and (2) the sourcing of equipment for nickel salts for bonded positives. In the first subtask, the equipment has been ordered and is currently being assembled at Universal Industrial Equipment at Pitman, N. J.

2.0 The second subtask has progressed to the point of running in a pilot cell capability at the Hall Chemical Plant at Aram, Alabama. The first runs did not duplicate the material reported on under 21911-2-20-0. The second run completed in the last week of August appears to be similar to laboratory-produced material in bulk density, filterability, and appearance. It is en route for our testing now. This pilot electrolytic cell for production of nickel hydrate is a 20 times enlargement of the laboratory apparatus with capability for over a pound (dry basis) an hour.

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SECTION 1V

MILESTONE SCHEDULE

ANL NZ PHASE I PROGRAM SCHEDULE - RESEARCH & DEVELOPMENT

TARGET DATE/MONTHS AFTER GO AHEAD

I	= "Experimental" Reference Design
IA	* "Experimental" Advanced Design
II, IIA	= Second Series of Reference & Advanced Designs
III, IIIA	= Third Series of Reference & Advanced Designs
IV, IVA	= Fourth Series of Reference & Advanced Designs
V	= Fifth Series of Advanced Designs

ANL NZ PHASE I PROGRAM SCHEDULE - MANUFACTURING PROCESS DEVELOPMENT

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TARGET DATE / MONTHS AFTER GO AHEAD

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