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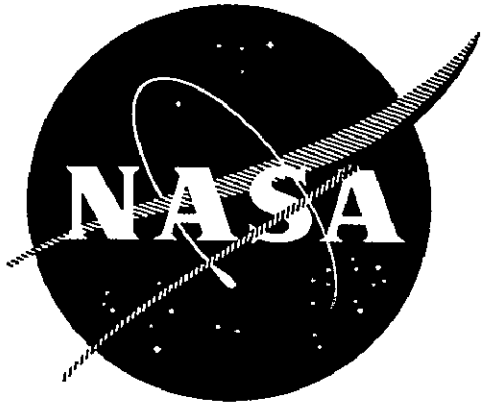

ACCELERATED TEST PROGRAM

prepared for

GODDARD SPACE FLIGHT CENTER

and

AIR FORCE WRIGHT AERONAUTICAL LABORATORIES

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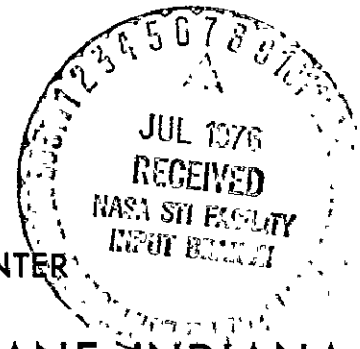

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ACCELERATED TEST PROGRAM FOR SEALED NICKEL-CADMIUM SPACECRAFT BATTERIES/CELLS

WQEC/C 76-8

13 FEBRUARY 1976

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Enclosure (1)

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Accelerated Test Program
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Ref: (a) NASA Purchase Order Number S-53742AG
(b) W-P AFB MIPR Number FY14557300406
(c) NASA/GSFC Document X-761-73-183, Accelerated Test Plan for Nickel-Cadmium Spacecraft Batteries of October 1973
(d) NASA/GSFC Document X-711-74-279, Procedure for Analysis of Nickel-Cadmium Cell Materials of October 1974

I. TEST ASSIGNMENT AND OBJECTIVES

A. In compliance with references (a) and (b), a program, references (c) and (d), was implemented to determine the feasibility of inducing an accelerated test on sealed Nickel-Cadmium batteries/cells as a tool for spacecraft projects and battery users to determine: (1) the prediction of life capability; (2) a method of evaluating the effect of design and component changes in cells; and (3) a means of reducing time and cost of cell testing.

B. The factors and levels, composite design and supplementary requirements for the program, are given in Tables I, II, and III.

II. TESTS

A. The program began in June 1974. This interim report for the program includes tests completed through 31 December 1975.

III. TEST STATUS

A. Precycling has been completed on cells of 44 packs for accelerated cycling. Table IV lists the packs under accelerated test or completed. Postcycling, chemical and physical analyses are being conducted as cells complete the accelerated cycling.

IV. COMMENTS

A. Specifics for precycling, postcycling, data analysis, and chemical and physical analysis are given in Sections I, II and III respectively. Cell design, proofing test, and test facilities are given in Appendices A, B, and C respectively.

V. CONCLUSIONS

A. To date, there is insufficient data to perform a complete analyis to determine the feasibility of predicting cycle life.

Interim Report
Accelerated Test Program
For
Sealed Nickel-Cadmium
Spacecraft Batteries/Cells

I. INTRODUCTION

A. In compliance with references (a) and (b), a program, references (c) and (d), was implemented in June 1974 to determine the feasibility of inducing an accelerated test on sealed Nickel-Cadmium batteries or cells as a tool for spacecraft projects and battery users to determine: (1) the prediction of life capability; (2) a method of evaluating the effect of design and component changes in cells; and (3) a means of reducing time and cost of cell testing.

II. BACKGROUND

A. Presently it is the practice to life test a sample lot of cells from prototypes and/or production lots to determine the life cycle capability of cells for flight missions. Because of the time required to determine the effects of changes in technology, the performance of batteries or cells is normally unknown at the beginning of a long term mission of several years. It would be impractical to have complete batteries or cells under simulated laboratory cycling to evaluate the effects of design and component changes for a period of time comparable to the actual mission.

III. COMMENTS

A. Although an accelerated program to meet the stated objectives is not a new concept and implementation of this program is controversial, conclusions from efforts initiated by NASA with Mauchly Associates, NAVWPNSUPPCEN Crane Statistical Branch and Battelle Memorial Institute to investigate the possibility of predicting cycle life to failure by statistical and cryptanalytic techniques using existing data from different suppliers, various test conditions, different ampere-hour capacities, developmental cells and known defects did indicate the feasibility of such a program even with the obstacles which had to be used in the work. Similarly, the U. S. Air Force (W-P AFB) has supported several programs, both in-house and at Battelle Memorial Institute to determine the feasibility of predicting the life of sealed, nickel-cadmium cells in simulated synchronous orbits. Although their tests had not been designed to be accelerated, data analysis from these tests shows some trends exist that may predict cycle life in this mode of operation.

IV. TEST PLAN

A. The accelerated test plan stated in reference (c) was developed by representatives of NASA--Messrs. E. Cohn, E. R. Stroup and T. Hennigan, W-P AFB--Drs. J. Lander, D. Pickett and Mr. G. Miller, NAVWPNSUPPCEN Crane--Messrs. D. Miley, D. Mains, D. Jerger, and Dr. V. L. Anderson of Purdue University's Mathematical Department. Excerpts from reference (c) have been included in this report for clarification.

B. While the plan, reference (c), discusses variations of a fractional composite design, the final composite design selected was $1/4 \times 2^8$ design that consisted of four parts--a factorial part, star points, center points, and normal--over all design with one qualitative factor at one level and eight quantitative factors at five levels. Table I lists the factors and levels.

C. The total number of cells required for the program is 547. General information on the cell is listed in Appendix A. The distribution for the cells is given in Tables II and III. The matrix listing of all factor combinations of the composite design with time values for charge and discharge and number of cells per pack is given in Table IV. Also listed in Table IV are the storage conditions for 24 cells. The test packs having eight cells include three cells designated for early/unfailed removal and chemical and physical analysis.

NOTE: At the time of writing reference (a), some changes were anticipated in numerical values of the design. General information on tests conducted and conclusions for the plan are listed in Appendix B with corrections made on Table IV and the conclusion noted under Table 2 of reference (c).

D. The cells for the program are General Electric 6 ah sealed nickel-cadmium cells. Each cell was identified as shown on Figure 1. Packs of five or eight cells were constructed with each cell of each pack having the same KOH concentration/KOH volume and negative precharge, ah. The respective pack and serial numbers are given in Table V; cells 1 and 2 of a 5-cell pack and cells 1, 2, and 3 of an 8-cell pack have pressure transducers. Comments on postcalibration of the transducers are stated in Section I.

V. TEST STATUS

A. Excluding the manufacturer's acceptance test and NAVWPNSUPPCEN base line tests, Table IV lists the packs which are on cycle or which have completed cycling in accordance with the established criterion for the test. The total cycles applied as indicated either applies to the

total pack, remaining cell(s) in a pack not completed, or the last cell removed with specific cycles given per cell and the reason for removal. Temperature, cycling, and monitoring are controlled by the test facilities given in Appendix C with general requirements for test items and facilities. Figure 2 shows precycling before accelerated cycling tests and postcycling after accelerated cycling. Comments for these tests are stated in Section I.

VI. DATA

A. All data, including manufacturer's data, is in a form that can be readily used in computer analysis. Working computer programs are available at GSFC, NAVWPNSUPPCEN, and the U. S. Air Force to perform data analysis. Requirements for data analyses and the completed analyses are contained in Section II.

B. Chemical and physical analysis have been completed on cells from various phases of the program. Details on the analyses are contained in Section III.

VII. CONCLUSIONS

A. As of 31 December 1975, there is insufficient data to perform a complete analysis to determine the feasiability of predicting cycle life.

TABLE I

Factors and Levels

		1*	2**	3***	4**	5*
A.	Temperature °C (T)	20	30	40	50	60
B.	Depth of Discharge (DOD)	20	40	60	80	100
C.	Charge Rate (CR)	C/4	C/2	C	2C	4C
D.	Discharge Rage (DR)	C/2	C	2C	4C	8C
E.	Percent Recharged (%RC)	110	110	140	200	200
F.	Concentration of KOH (%KOH)	22	26	30	34	38
G.	Amount of KOH (cc)	17.5	18.5	19.5	20.5	21.5
H.	Precharge (ah)	2.20	2.50	2.80	3.00	3.30

*Star Point Levels - The "star" points of the design take each extreme level of each quantitative factor in combination with the center level of every quantitative factor.

**Factorial Levels - The factorial levels are analyzed separately to determine which main effects and/or interactions have a significant effect on battery life.

***Center Point Levels - the center points of the design take the center point of each quantitative factor with each level of each qualitative factor. Repeats of these center points are made for estimate of error which is used in the statistical analysis.

TABLE II

Composite Design

A.	Factorial Part - 1/4 x 2^8	64 packs - 320 cells
B.	Star Points - 2 x 8	16 packs - 80 cells
C.	Center Point - 1 + 5 cells repeated for error	2 packs - 10 cells
*D.	Normal Conditions	4 packs - 20 cells
E.	Total Required	86 Packs - 430 cells

*Normal conditions for temperature (0°C) and percent recharge (105) are not included in the levels in Table I, therefore, to tie these conditions into the design, a 2^2 factorial using two levels of temperature (0°C and 20°C) and one level of percent recharge (105) is utilized.

TABLE III

Supplementary Requirements*

A.	Analysis of Uncycled cells - 2 x 15 conditions	30 cells
B.	Unfailed Removal - 3 x 21 conditions/points	63 cells
C.	Conditioned Storage - 3 x 8 conditions	24 cells
D.	Total Required	117 cells

*Supplementary requirements are additional tests and analyses that correlate with the basic composite design and benefits the overall program. These requirements consist of analyses of uncycled cells, scheduled removal of unfailed cycled cells, and a conditioned storage.

TABLE IV

MATRIX OF FACTOR COMBINATIONS

A. Fractional Factorial

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No Cells	Total Cycles Applied	Cells Removed From Test (Cycles) Cell Numbers and Mode* for Removal 1 *M	2 *M	3 *M	4 *M	5 *M
1N	30	40	C	0.4	1.12	C/2	140	26	18.5	2.50	5	1915					
2N	50	80	C	0.8	0.56	2C	140	34	20.5	3.00	5	5					
3N	30	80	4C	0.2	0.80	2C	200	26	18.5	3.00	5						
4N	50	40	4C	0.1	1.60	C/2	200	34	20.5	2.50	5						
5N	30	40	C	0.4	1.60	C/2	200	34	20.5	3.00	5	1209					
6N	50	80	C	0.8	0.80	2C	200	26	18.5	2.50	5						
7N	30	80	4C	0.2	0.56	2C	140	34	20.5	2.50	5						
8N	50	40	4C	0.1	1.12	C/2	140	26	18.5	3.00	5						
9N	30	40	4C	0.1	0.28	2C	140	26	20.5	3.00	5						
10N	50	80	4C	0.2	2.24	C/2	140	34	18.5	2.50	5						
11N	30	80	C	0.8	3.20	C/2	200	26	20.5	2.50	5	711					
12N	50	40	C	0.4	0.40	2C	200	34	18.5	3.00	5	4					
13N	30	40	4C	0.1	0.40	2C	200	34	18.5	2.50	5						
14N	50	80	4C	0.2	3.20	C/2	200	26	20.5	3.00	5						
15N	30	80	C	0.8	2.24	C/2	140	34	18.5	3.00	5	864					
16N	50	40	C	0.4	0.28	2C	140	26	20.5	2.50	5	4					

* Explanation for Mode for Removal

a. P - Pressure greater than 250 psia
b. L - Low cell voltage
c. A - Could not monitor pressure in cells without transducers as precaution for safety
d. S - Cell shorted - would not accept charge
e. R - Cells removed before failure as specified
f. PL - Pressure greater than 250 psia - Low cell voltage

TABLE IV (Continued)

MATRIX OF FACTOR COMBINATIONS

A. Fractional Factorial

Pack No.	Temp (°C)	Dod (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles Applied	Cells Removed From Test (Cycles) Cell Numbers and Mode* for Removal 1 *M	2 *M	3 *M	4 *M	5 *M
17N	50	80	C	0.8	0.56	2C	140	26	18.5	3.00	5	4					
18N	30	40	C	0.4	1.12	C/2	140	34	20.5	2.50	5	1404					
19N	50	40	4C	0.1	1.60	C/2	200	26	18.5	2.50	5						
20N	30	80	4C	0.2	0.80	2C	200	34	20.5	3.00	5						
21N	50	80	C	0.8	0.80	2C	200	34	20.5	2.50	5	4					
22N	30	40	C	0.4	1.60	C/2	200	26	18.5	3.00	5	923					
23N	50	40	4C	0.1	1.12	C/2	140	34	20.5	3.00	5						
24N	50	80	4C	0.2	0.56	2C	140	26	18.5	2.50	5						
25N	50	80	4C	0.2	2.24	C/2	140	26	20.5	2.50	5						
26N	30	40	4C	0.1	2.28	2C	140	34	18.5	3.00	5						
27N	50	40	C	0.4	0.40	2C	200	26	20.5	3.00	5						
28N	30	80	C	0.8	3.20	C/2	200	34	18.5	2.50	5	1296					
29N	50	80	4C	0.2	3.20	C/2	200	34	18.5	3.00	5						
30N	30	40	4C	0.1	0.40	2C	200	26	20.5	2.50	5						
31N	50	40	C	0.4	0.28	2C	140	34	18.5	2.50	5						
32N	30	80	C	0.8	2.24	C/2	140	26	20.5	3.00	5	578					

TABLE IV (Continued)

MATRIX OF FACTOR COMBINATIONS

A. Fractional Factorial

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles Applied	Cells Removed From Test (Cycles) Cell Numbers and Mode* for Removal 1 *M	2 *M	3 *M	4 *M	5 *M
33N	30	80	4C	0.2	3.20	C/2	200	34	20.5	2.50	5						
34N	50	40	4C	0.1	0.40	2C	200	26	18.5	3.00	5						
35N	30	40	C	0.4	0.28	2C	140	34	20.5	3.00	5						
36N	30	80	C	0.8	2.24	C/2	140	26	18.5	2.50	5	679					
37N	30	80	4C	0.2	2.24	C/2	140	26	18.5	3.00	5						
38N	50	40	4C	0.1	0.28	2C	140	34	20.5	2.50	5						
39N	30	40	C	0.4	0.40	2C	200	26	18.5	2.50	5						
40N	50	80	C	0.8	3.20	C/2	200	34	20.5	3.00	5	266					
41N	30	80	C	0.8	0.80	2C	200	34	18.5	3.00	5						
42N	50	40	C	0.4	1.60	C/2	200	26	20.5	2.50	5	518					
43N	30	40	4C	0.1	1.12	C/2	140	34	18.5	2.50	5						
44N	50	80	4C	0.2	0.56	2C	140	26	20.5	3.00	5						
45N	30	80	C	0.8	0.56	2C	140	26	20.5	2.50	5						
46N	50	40	C	0.4	1.12	C/2	140	34	18.5	3.00	5	1043					
47N	30	40	4C	0.1	1.60	C/2	200	26	20.5	3.00	5						
48N	50	80	4C	0.2	0.80	2C	200	34	18.5	2.50	5						

TABLE IV (Continued)

MATRIX OF FACTOR COMBINATIONS

A. Fractional Factorial

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles Applied	Cells Removed from Test (Cycles) Cell Numbers and Mode* for Removal 1 *M	2 *M	3 *M	4 *M	5 *M
49N	50	40	4C	0.1	0.40	2C	200	34	20.5	3.00	5						
50N	30	80	4C	0.2	3.20	C/2	200	26	18.5	2.50	5						
51N#	50	80	C	0.8	2.24	C/2	140	34	20.5	2.50	5	15					15
52N	30	40	C	0.4	0.28	2C	140	26	18.5	3.00	5						
53N	50	40	4C	0.1	0.28	2C	140	26	18.5	2.50	5						
54N	30	80	4C	0.2	2.24	C/2	140	34	20.5	3.00	5						
55N	50	80	C	0.8	3.20	C/2	200	26	18.5	3.00	5	248					
56N	30	40	C	0.4	0.40	2C	200	34	20.5	2.50	5						
57N	50	40	C	0.4	1.60	C/2	200	34	18.5	2.50	5	465					
58N	30	80	C	0.8	0.80	2C	200	26	20.5	3.00	5						
59N	50	80	4C	0.2	0.56	2C	140	34	18.5	3.00	5						
60N	30	40	4C	0.1	1.12	C/2	140	26	20.5	2.50	5						
61N	50	40	C	0.4	1.12	C/2	140	26	20.5	3.00	5	455					
62N	30	80	C	0.8	0.56	2C	140	34	18.5	2.50	5						
63N	50	80	4C	0.2	0.80	2C	200	26	20.5	2.50	5						
64N	30	40	4C	0.1	1.60	C/2	200	34	18.5	3.00	5						

Pack 51N would not cycle more than 15 cycles because of low charge rate and high temperature. Matrix requirement changed to be the same as Pack 83N, for additional information only. Cell number 5 was subjected to teardown analysis.

TABLE IV (Continued)

MATRIX OF FACTOR COMBINATIONS

B. Star Points

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles Applied Per Pack No.	Cells Removed From Test (Cycles) Cell Number and Mode* for Removal 1	*M	2	*M	3	*M	4	*M	5	*M	6	*M	7	*M	8	*M
65N	20	60	2C	0.3	1.02	C	140	30	19.5	2.80	8	4558	2564	P			2564	P	4086	L	4468	L	2861	R	1504	R	771	R
66N#	60	60	2C	0.3	1.02	C	140	30	19.5	2.80	8	1943	1892	L	1927	L	1943	L	1892	L	1869	L	1883	L	454	R	13#	L
67N	40	20	2C	0.1	0.28	C	140	30	19.5	2.80	8	12283	8242	P	9053	S	9053	S					6875	R	4500	R	2251	R
68N	40	100	2C	0.5	1.40	C	140	30	19.5	2.80	8	955	524	P	472	P	524	PL	955	A	955	A	300	R	201	R	100	R
69N	40	60	2C	0.3	3.36	C/4	140	30	19.5	2.80	8	592	592	L	592	L	172	L	148	L	148	L	148	L	592	R	502	R
70N	40	60	2C	0.3	0.21	4C	140	30	19.5	2.80	8	1512	684	P	1512	P	774	P	1512	A	1512	A	1200	R	867	R	400	R
71N	40	60	C/2	1.2	0.84	C	140	30	19.5	2.80	8	1652	1647	P			1192	P	1422	R	1415	S	1357	S	1540	S	752	R
72N	40	60	8C	0.075	0.84	C	140	30	19.5	2.80	8	1717	1351	P	177	P	1352	P	1717	A	1717	A	150	R	100	R	50	R
73N	40	60	2C	0.3	0.660	C	110	30	19.5	2.80	8	3373	2222	P	3373	P	3373	P	3373	A	3373	A	750	R	500	R	250	R
74N	40	60	2C	0.3	1.20	C	200	30	19.5	2.80	8	1811	1196	P	1196	P	1751	PL	1808	L	1811	L	375	R	250	R	141	R
75N	40	60	2C	0.3	0.84	C	140	22	19.5	2.80	8	2560	2505	P	1835	S	1535	P	2560	L	2486	S	2250	R	1505	R	750	R
76N	40	60	2C	0.3	0.84	C	140	38	19.5	2.80	8	1669	1202	P	1669	P	1669	P	1115	L	1669	A	752	R	500	R	250	R
77N	40	60	2C	0.3	0.84	C	140	30	19.5	2.20	8	1909	1909	S	1909	S	1909	S	1909	S	1909	S	1504	R	1111	R	615	R
78N	40	60	2C	0.3	0.84	C	140	30	19.5	3.30	8	2339	2232	P	2330	PL	2319	S	2319	S	2339	L	750	R	509	R	250	R
79N	40	60	2C	0.3	0.84	C	140	30	17.5	2.80	8	3680	2321	P	3260	PL	1481	P	3628	L	3680	L	1352	R	1000	R	468	R
80N	40	60	2C	0.3	0.84	C	140	30	21.5	2.80	8	3063	3063	P	2268	S	2899	L	2268	L	2416	L	1373	R	900	R	459	R

#Pack 66N would not cycle more than 13 cycles because of low charge rate and high temperature. Matrix requirement changed to be the same as Pack 83N, for additional information only. Total cycles for cells 1 through 4 include the first 13 cycles for 66N. Cell No. 5 was subjected to teardown analysis.

TABLE IV (Continued)

MATRIX OF FACTOR COMBINATIONS

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Total Cycles Applied Per Pack No.	Cells Removed From Test (Cycles) Cell Number and Mode* for Removal 1 *M	2 *M	3 *M	4 *M	5 *M	6 *M	7 *M	8 *M
C. Center Points																				
81N	40	60	2C	0.3	0.84	C	140	30	19.5	2.80	8	3055	3014 P	3055 P	3055 P	3055 A	3055 A	1500 R	1000 R	501 R
82N	40	60	2C	0.3	0.84	C	140	30	19.5	2.80	5	277						NA	NA	NA
D. Normal Conditions**																				
83N	20	40	C/1.20	5.0a	2.52a	C/4.76	105	34	18.5	2.50	8	5388								4250 R
84N	20	20	C/2.40	2.5a	1.26a	C/2.38	105	34	18.5	2.50	8	4497								
85N	0	20	C/2.40	2.5a	1.26a	C/2.38	105	34	18.5	2.50	8	5693								
86N	0	40	C/120	5.0a	2.52a	C/4.76	105	34	18.5	2.50	8	4553								3262 R

**Discharge time is 0.48 hour and charge time is 1.0 hour; therefore, the value in column DISCH (Hrs) is discharge current (in amperes) and CHG (Hrs) is charge current (in amperes).

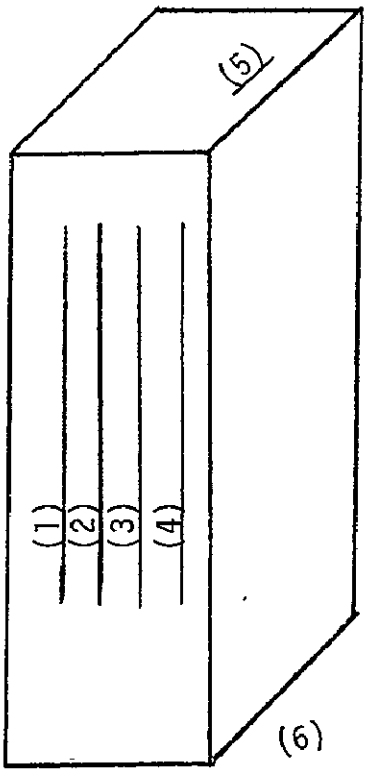
TABLE IV (Continued)

MATRIX OF FACTOR COMBINATIONS

*E. Storage

Pack No.	Temp (°C)	DOD (%)	Disch Rate	Disch (Hrs)	Charge (Hrs)	Chg Rate	Rechg (1%RC)	KOH (%)	KOH (cc)	Prechg (ah)	No. Cells	Date Cell Removed Cell No. 1	2	3	Compare With Test Cells From Pack Nos.
87N	20							30	19.5	2.80	3	11-26-74	11-4-74	12-4-74	**72N
88N	60							30	19.5	2.80	3	1-22-75	3-10-75	9-2-75	66N
89N	40							22	19.5	2.80	3	2-11-75	3-27-75	6-9-75	75N
90N	40							38	19.5	2.80	3	11-11-74	11-25-74	12-9-74	76N
91N	40							30	19.5	3.30	3	1-28-75	2-13-75	3-4-75	78N
92N	40							30	21.5	2.80	3	11-8-74	12-2-74	12-29-74	80N
93N	0							34	18.5	2.50	3	5-22-75			86N
94N	20							34	18.5	2.50	3	5-25-75			83N

* Placed in storage
** Should have been from Pack Number 65N



(1) General Electric
(2) Catalog No. 42B006AB62
(3) S/N: XXXXXXXX - XXX - LXX

- LXX — Lot No.
- XXX — Cell No.
- XXXXXXXX — Negative Plate Lot No.
- XXXXXXXX — Positive Plate Lot No.

(4) KOH CONC./VOLUME/PRECHARGE
(5) Etched Lot No. and Cell No.
(6) No. (4) repeated on bottom

Note: Numbers (1) through (4) each edge of cell.

GENERAL ELECTRIC CELL IDENTIFICATION

FIGURE 1

TABLE V

FRACTIONAL FACTORIAL

Pack No.	Cell Numbers 1	2	3	4	5	(1)	Group No.
1N	054-L04	055-L04	070-L04	138-L02	072-L04	26/18.5/2.50	9
2N	163-L02	164-L02	140-L02	141-L02	143-L02	34/20.5/3.00	16
3N	091-L04	092-L04	140-L04	141-L04	142-L04	26/18.5/3.00	11
4N	045-L02	046-L02	062-L02	063-L02	064-L02	34/20.5/2.50	14
5N	165-L02	166-L02	144-L02	145-L02	146-L02	34/20.5/3.00	16
6N	056-L04	057-L04	073-L04	074-L04	075-L04	26/18.5/2.50	9
7N	047-L02	048-L02	065-L02	066-L02	067-L02	34/20.5/2.50	14
8N	138-L04	139-L04	161-L04	162-L04	163-L04	26/18.5/3.00	11
9N	015-L04	019-L04	106-L04	107-L04	108-L04	26/20.5/3.00	12
10N	030-L02	034-L02	003-L02	004-L02	005-L02	34/18.5/2.50	13
11N	001-L04	002-L04	018-L04	019-L04	020-L04	26/20.5/2.50	10
12N	124-L02	125-L02	088-L02	089-L02	090-L02	34/18.5/3.00	15
13N	035-L02	036-L02	006-L02	007-L02	008-L02	34/18.5/2.50	13
14N	021-L04	026-L04	110-L04	111-L04	112-L04	26/20.5/3.00	12
15N	122-L02	123-L02	091-L02	092-L02	093-L02	34/18.5/3.00	15
16N	004-L04	065-L04	024-L04	027-L04	028-L04	26/20.5/2.50	10

(1) Concentration of KOH electrolyte percent by weight/volume of electrolyte, cc/negative precharge, ah

Notes: 1. Positive and negative lot number for lot 02 is 01460190.
2. Positive and negative lot number for lot 04 is 01560201.
3. Reference Figure 1 for complete cell identification format.

TABLE V (Continued)

FRACTIONAL FACTORIAL

Pack No.	Cell Numbers 1	2	3	4	5	(1)	Group No.
17N	095-L04	096-L04	143-L04	144-L04	145-L04	26/18.5/3.00	11
18N	049-L02	050-L02	068-L02	069-L02	070-L02	34/20.5/2.50	14
19N	060-L04	061-L04	076-L04	077-L04	078-L04	26/18.5/2.50	9
20N	167-L02	169-L02	147-L02	148-L02	149-L02	34/20.5/3.00	16
21N	051-L02	053-L02	071-L02	072-L02	073-L02	34/2015/2.50	14
22N	098-L04	100-L04	146-L04	147-L04	148-L04	26/18.5/3.00	11
23N	170-L02	171-L02	150-L02	151-L02	152-L02	34/20.5/3.00	16
24N	062-L04	063-L04	079-L04	080-L04	081-L04	26/18.5/2.50	9
25N	006-L04	007-L04	029-L04	030-L04	031-L04	26/20.5/2.50	10
26N	120-L02	121-L02	094-L02	095-L02	096-L02	34/18.5/3.00	15
27N	041-L04	045-L04	113-L04	114-L04	115-L04	26/20.5/3.00	12
28N	027-L02	028-L02	029-L02	001-L02	002-L02	34/18.5/2.50	13
29N	118-L02	119-L02	097-L02	098-L02	100-L02	34/18.5/3.00	15
30N	008-L04	009-L04	032-L04	033-L04	034-L04	26/20.5/2.50	10
31N	037-L02	038-L02	009-L02	010-L02	011-L02	34/18.5/2.50	13
32N	049-L04	089-L04	116-L04	117-L04	118-L04	26/20.5/3.00	12

TABLE V (Continued)

FRACTIONAL FACTORIAL

Pack No.	Cell Numbers 1	2	3	4	5	(1)	Group No.
33N	054-L02	055-L02	074-L02	075-L02	076-L02	34/20.5/2.50	14
34N	101-L04	131-L04	149-L04	150-L04	151-L04	26/18.5/3.00	11
35N	172-L02	173-L02	153-L02	154-L02	155-L02	34/20.5/3.00	16
36N	064-L04	065-L04	082-L04	083-L04	084-L04	26/18.5/2.50	9
37N	132-L04	133-L04	152-L04	153-L04	154-L04	26/18.5/3.00	11
38N	056-L02	057-L02	077-L02	078-L02	079-L02	34/20.5/2.50	14
39N	066-L04	067-L04	085-L04	086-L04	131-L04	26/18.5/2.50	9
40N	174-L02	175-L02	156-L02	157-L02	158-L02	34/20.5/3.00	16
41N	116-L02	177-L02	101-L02	102-L02	103-L02	34/18.5/3.00	15
42N	010-L04	011-L04	035-L04	036-L04	037-L04	26/20.5/2.50	10
43N	031-L02	039-L02	012-L02	013-L02	014-L02	34/18.5/2.50	13
44N	090-L04	093-L04	119-L04	120-L04	121-L04	26/20.5/3.00	12
45N	012-L04	013-L04	038-L04	039-L04	040-L04	26/20.5/2.50	10
46N	114-L02	115-L02	104-L02	105-L02	106-L02	34/18.5/3.00	15
47N	094-L04	097-L04	122-L04	123-L04	124-L04	26/20.5/3.00	12
48N	044-L02	053-L02	015-L02	016-L02	017-L02	34/18.5/2.50	13

TABLE V (Continued)

FRACTIONAL FACTORIAL

Pack No.	Cell Numbers 1	2	3	4	5	(1)	Group No.
49N	176-L02	177-L02	159-L02	160-L02	161-L02	34/20.5/3.00	16
50N	068-L04	069-L04	132-L04	133-L04	134-L04	26/18.5/2.50	9
51N	058-L02	059-L02	080-L02	081-L02	082-L02	34/20.5/2.50	14
52N	134-L04	135-L04	155-L04	156-L04	157-L04	26/18.5/3.00	11
53N	058-L04	059-L04	135-L04	136-L04	137-L04	26/18.5/2.50	9
54N	178-L02	179-L02	162-L02	168-L02	180-L02	34/20.5/3.00	16
55N	136-L04	137-L04	158-L04	159-L04	160-L04	26/18.5/3.00	11
56N	060-L02	061-L02	083-L02	084-L02	085-L02	34/20.5/2.50	14
57N	042-L02	043-L02	018-L02	019-L02	020-L02	34/18.5/2.50	13
58N	099-L04	102-L04	125-L04	126-L04	127-L04	26/20.5/3.00	12
59N	112-L02	113-L02	107-L02	108-L02	109-L02	34/18.5/3.00	15
60N	014-L04	015-L04	042-L04	043-L04	044-L04	26/20.5/2.50	10
61N	140-L04	105-L04	129-L04	130-L04	050-L04	26/20.5/3.00	12
62N	041-L02	021-L02	022-L02	023-L04	024-L02	34/18.5/2.50	13
63N	017-L04	023-L04	046-L04	047-L04	048-L04	26/20.5/2.50	10
64N	110-L02	111-L02	126-L02	127-L02	128-L02	34/18.5/3.00	15

TABLE V (Continued)

STAR POINTS

Pack No.	Cell Numbers 1	2	3	4	5	6	7	8	(1)	Group No.
65N	108-L01	109-L01	110-L01	133-L01	134-L01	135-L01	136-L01	137-L01	30/19.5/2.80	4
66N	111-L01	112-L01	113-L01	138-L01	139-L01	140-L01	141-L01	142-L01	30/19.5/2.80	4
67N	114-L01	115-L01	116-L01	151-L01	152-L01	153-L01	154-L01	155-L01	30/19.5/2.80	4
68N	117-L01	118-L01	119-L01	156-L01	157-L01	158-L01	159-L01	160-L01	30/19.5/2.80	4
69N	120-L01	121-L01	122-L01	161-L01	162-L01	163-L01	164-L01	165-L01	30/19.5/2.80	4
70N	123-L01	126-L01	127-L01	166-L01	167-L01	168-L01	169-L01	170-L01	30/19.5/2.80	4
71N	128-L01	129-L01	130-L01	171-L01	172-L01	173-L01	176-L01	177-L01	30/19.5/2.80	4
72N	131-L01	132-L01	179-L01	178-L01	191-L01	192-L01	193-L01	194-L01	30/19.5/2.80	4
73N	180-L01	181-L01	182-L01	195-L01	196-L01	197-L01	198-L01	202-L01	30/19.5/2.80	4
74N	183-L01	185-L01	187-L01	203-L01	204-L01	205-L01	206-L01	207-L01	30/19.5/2.80	4
75N	010-L01	011-L01	012-L01	002-L01	003-L01	004-L01	005-L01	006-L01	22/19.5/2.80	4
76N	228-L01	229-L01	231-L01	232-L01	233-L01	234-L01	235-L01	236-L01	38/19.5/2.80	4
77N	026-L01	022-L01	021-L01	014-L01	015-L01	016-L01	017-L01	018-L01	30/19.5/2.20	4
78N	064-L01	065-L01	066-L01	053-L01	054-L01	055-L01	057-L01	058-L01	30/19.5/3.30	4
79N	037-L01	036-L01	035-L01	027-L01	028-L01	030-L01	031-L01	032-L01	30/17.5/2.80	4
80N	049-L01	051-L01	052-L01	039-L01	040-L01	041-L01	042-L01	043-L01	30/21.5/2.80	4

Note: Positive and negative lot number for lot 01 is 00890147 except S/N's 291-297 - the lot number is 00810147. Reference Figure 1 for cell identification.

TABLE V (Continued)

CENTER POINTS

Pack No.	Cell Numbers 1	2	3	4	5	6	7	8	(1)	Group No.
81N	189-L01	190-L01	224-L01	208-L01	209-L01	210-L01	211-L01	212-L01	30/19.5/2.80	4
82N	291-L01	292-L01	293-L01	294-L01	295-L01	N/A	N/A	N/A	30/19.5/2.80	4
					NORMAL CONDITIONS					
83N	096-L01	099-L01	100-L01	068-L01	069-L01	071-L01	072-L01	073-L01	34/18.5/2.50	4
84N	103-L01	104-L01	105-L01	081-L01	082-L01	083-L01	084-L01	085-L01	34/18.5/2.50	4
85N	101-L01	102-L01	074-L01	076-L01	077-L01	078-L01	079-L01	080-L01	34/18.5/2.50	4
86N	106-L01	107-L01	086-L01	087-L01	088-L01	089-L01	090-L01	091-L01	34/18.5/2.50	4
					STORAGE					
87N	219-L01	220-L01	221-L02	N/A	N/A	N/A	N/A	N/A	30/19.5/2.80	4
88N	222-L01	226-L01	227-L01	N/A	N/A	N/A	N/A	N/A	30/19.5/2.80	4
89N	216-L01	217-L01	218-L01	N/A	N/A	N/A	N/A	N/A	22/19.5/2.80	4
90N	237-L01	238-L01	239-L01	N/A	N/A	N/A	N/A	N/A	38/19.5/2.80	4
91N	059-L01	060-L01	061-L01	N/A	N/A	N/A	N/A	N/A	30/19.5/3.30	4
92N	044-L01	045-L01	046-L01	N/A	N/A	N/A	N/A	N/A	30/21.5/2.80	4
93N	092-L01	093-L01	094-L01	N/A	N/A	N/A	N/A	N/A	34/18.5/2.50	4
94N	095-L01	245-L01	N/A	N/A	N/A	N/A	N/A	N/A	34/18.5/2.50	4
					SPECIAL TESTS					
95N*	241-L01	242-L01	244-L01	214-L01	215-L01	N/A	N/A	N/A	30/19.5/2.80	4

*Special testing having 40°C, 40% DOD, and normal charge and discharge.

TABLE V (Continued)

UNCYCLED CELLS

CELL ID	(1)	GROUP NO.
007-L01	22/19.5/2.80	4
019-L01	30/19.5/2.20	4
033-L01	30/17.5/2.80	4
047-L01	30/21.5/2.80	4
062-L01	30/19.5/3.30	4
038-L01	30/21.5/2.80	4
067-L01	34/18.5/2.50	4
001-L01	22/19.5/2.80	4
013-L01	30/19.5/2.20	4
029-L01	30/17.5/2.80	4
230-L01	38/19.5/2.80	4
056-L01	30/19.5/3.30	4
213-L01	30/19.5/2.80	4
297-L01	30/19.5/2.80	4
130-L02	34/18.5/3.00	15
129-L02	34/18.5/3.00	15
181-L02	34/20.5/3.00	16
182-L02	34/20.5/2.50	16
086-L02	34/20.5/2.50	14
087-L02	34/20.5/2.50	14
139-L02	26/18.5/2.50	9
025-L02	34/18.5/2.50	13
026-L02	34/18.5/2.50	13
103-L04	26/20.5/3.00	12
168-L04	26/20.5/3.00	12
052-L04	26/20.5/2.50	10
051-L04	26/20.5/2.50	10
071-L04	26/18.5/2.50	9
164-L04	26/18.5/3.00	11
165-L04	26/18.5/3.00	11

SECTION I

PRECYCLING TESTS

POSTCYCLING TESTS

POSTCALIBRATION OF PRESSURE TRANSDUCERS

I. PRECYCLING TESTS

A. The tests listed below are a summary of precycling tests specified in reference (c) and shown in Figure 2 which were conducted by General Electric Company prior to shipment and the tests conducted by NAVWPNSUPPCEN Crane prior to accelerated tests.

GE TESTS (1)	NAVWPNSUPPCEN TESTS (2)
Capacity Test at 24°C	Visual, Dimensional, Weight
Capacity Test at 38°C	Capacity Tests at 20° ± 2°C
Capacity and Overcharge at 0°C	Charge Efficiency Test at 20° ± 2°C
Charge Retention at 24°C	Internal Short Test at 20° ± 2°C
Internal Resistance at 24°C	0.5 ohm Cell Shorting
Leak Test	Baseline Capacity, Matrix Temperature (3)
	Baseline Capacity, Matrix Temperature and Rate (3)
	Leak Test

(1) All tests were performed with pressure gauges attached to each cell.

(2) All tests were performed on each cell as received i.e., with transducers or with Swagelok caps.

(3) Sample cells for storage at matrix temperature did not receive these tests.

B. The manufacturers' data will be analyzed and where applicable, compared with completed NAVWPNSUPPCEN Crane data.

1. Analyses consists of regression analysis to determine relationships between physical design parameters and the manufacturer's electrical tests and histograms of data.

II. POSTCYCLING TESTS

A. The tests listed below are a summary of postcycle tests specified in reference (c) and shown on Figure 2 conducted at NAVWPNSUPPCEN either when a cell was removed before failure as specified or after a cell was removed because of test failure cirterion.

1. Charge efficiency 20° ± 2°C.

2. Internal short test.

3. Capacity test 20° ± 2°C.

B. The results of the postcycle tests will be compared with the precycle tests, where applicable.

C. Regression analysis will be used to determine relationships between precycle and postcycle test data (both electrical and physical).

III. POSTCALIBRATION OF PRESSURE TRANSDUCERS.

A. All pressure transducers which have been subjected to postcalibration were found to be within tolerance.

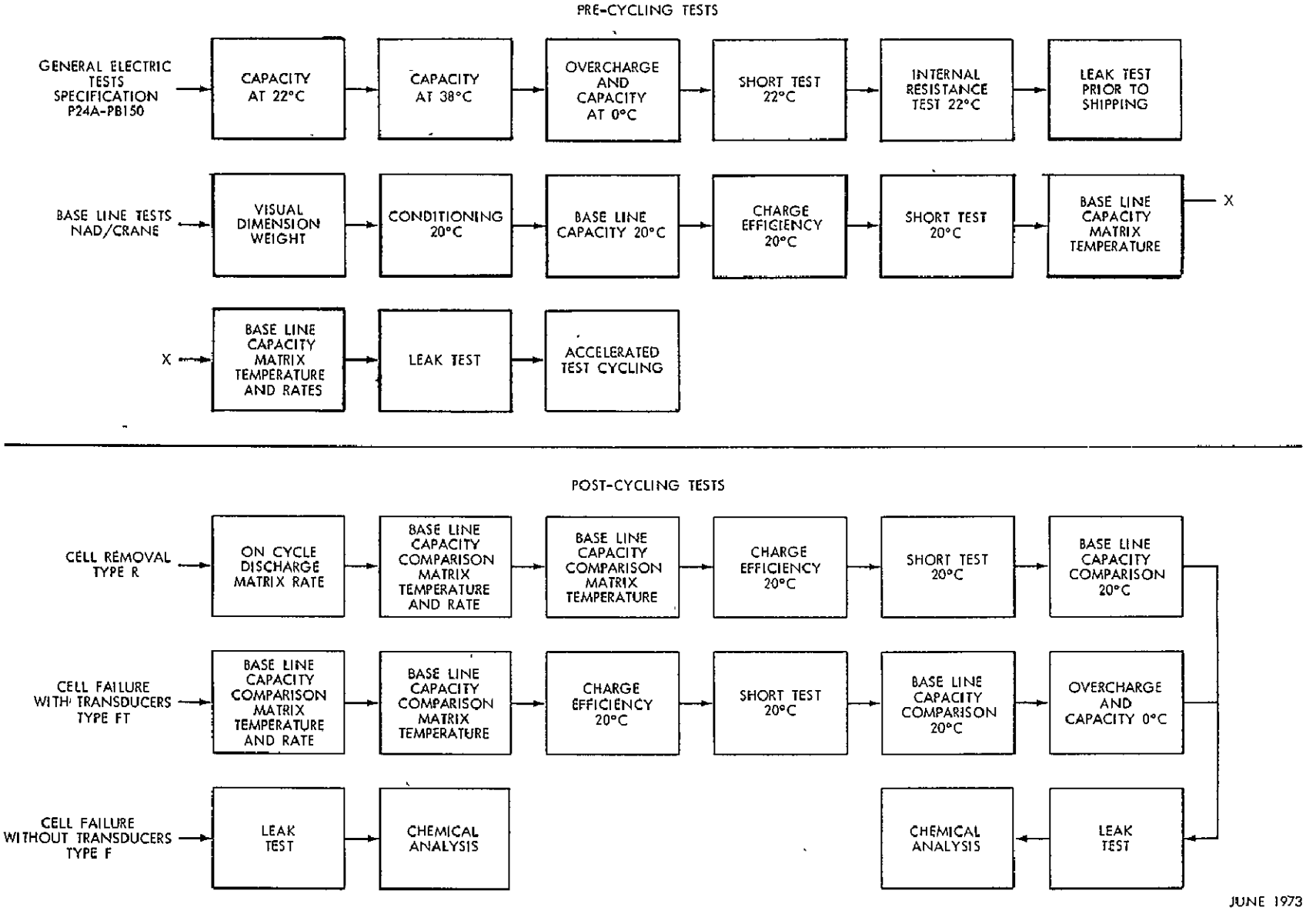


Figure 2. Flow Diagram 1

SECTION II

DATA ANALYSIS

DATA ANALYSIS

I. ACCELERATED TEST DATA ANALYSES (Reference Figure 3)

A. As data becomes available, the following analyses of the data is completed:

1. Initial Data Generated--Star and Center Points:

a. Predictions made using $\bar{t}_i$ method with t = time to discharge to 1.25 volts and failure times extrapolated from past data.

b. Investigate other times to discharge and various times to charge in $\bar{t}_i$ model.

B. At the completion of the fractional factorial tests, the following analyses of the data shall be completed:

1. Predictions made in similar manner as I.A.1.a.

2. Continue investigation in I.A.1.b. with factorial data.

3. Analyze data using analysis of various (ANOVA) techniques and various response elements--can be utilized in conjunction with output of cryptanalytic procedures, if any promising response elements have been found.

4. Find all main effect (e.g., Temp., DOD, CR, etc.) and two-way interactions (e.g., TxDOD, DODxCR, etc.) that show a statistical difference.

C. At the completion of star, center and fractional accelerated tests, the data shall then be analyzed as outlined below.

1. Combination of star, center, and factorial points:

a. Combine star and center points with all significant factors of the factorial points in multiple regression models.

b. With failure time as the dependent variable in the resulting regression model, use the model to relate accelerated failures back to normal failures.

c. Use various response elements in analysis of variance and regression model to find their accelerated relationship to normal life.

d. Incorporate failure analysis data into regression models using Battelle (Dr. Thomas) technique.

2. Prediction of battery life:

a. Use regression model estimated of failure times in $\bar{t}_i$ model with best indicator of life ($\bar{t}_i$ = x volts) from results of voltage study in I.A.1.a. and I.A.2.b.

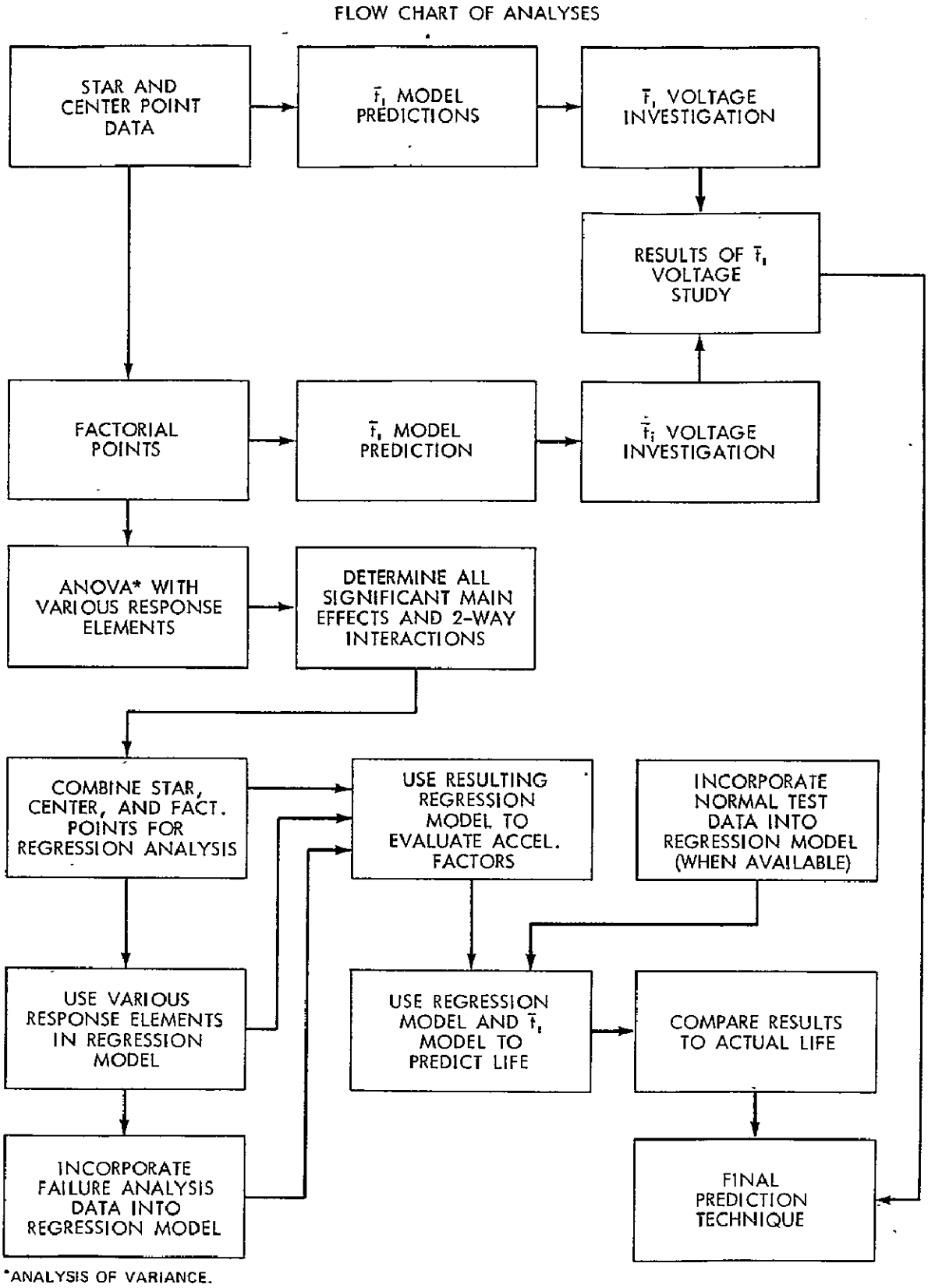
b. Compare and/or combine results with other life prediction methods (namely, cryptanalytic).

3. Air Force data analysis:

a. Determine correlation between prediction model and accelerated test data.

II. COMMENTS

A. As of 31 December 1975, all star and center point tests were not completed to conduct any data analysis.



Flow Diagram

DATA ANALYSES

FIGURE 3

SECTION III

Chemical and Physical Analyses

CHEMICAL AND PHYSICAL ANALYSES

I. Chemical and physical analyses are performed on cells from various phases of the test program. These analyses will be performed on the following:

A. One uncycled cell of each physical variable group, i.e., concentration of electrolyte, volume of electrolyte and amount of negative precharge.

B. Three cells from each star point of accelerated cycling removed before failure. (W-P Air Force degradation program.)

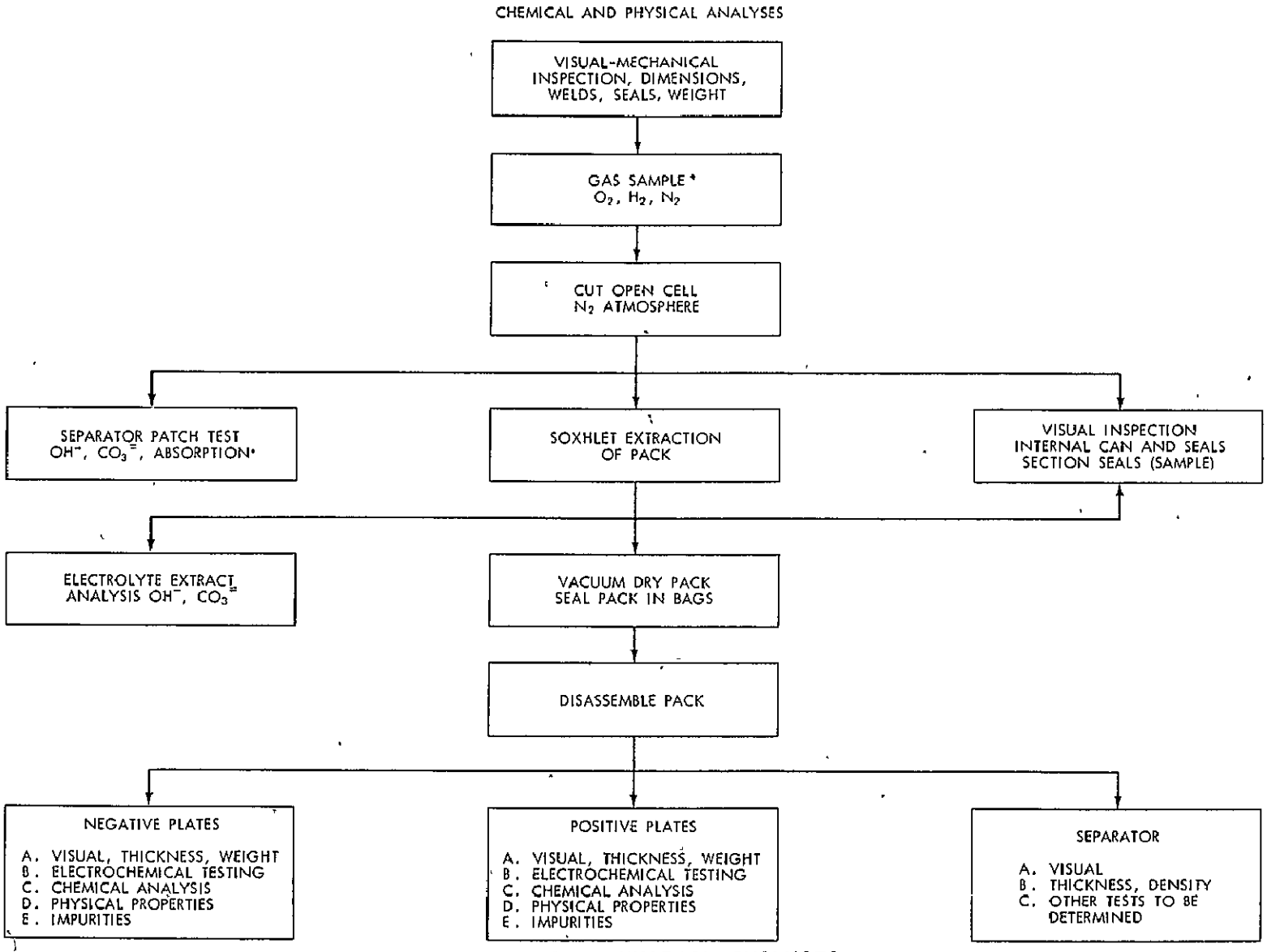
C. Three cells from a center point of accelerated cycling removed before failure. (W-P Air Force degradation program.)

D. Three cells from each normal test removed before failure. (W-P Air Force degradation program.)

E. Three cells from each matrix temperature storage condition for comparison with above.

F. Each cell that fails or cannot cycle under test conditions.

II. Figure 4 outlines the summary for failure analysis and reference (d) is the procedure for the analyses. The results for the analyses completed to date are submitted in Tables VI, VII, VIII, and IX.



CHEMICAL AND PHYSICAL ANALYSES

FIGURE 4

TABLE VI

ANALYSIS OF UNCYCLED CELLS

Cell ID.	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
029-L01	6.32	5.19	0.4687	0.2010	0.2677	.059	0.018	4.575	1.223
038-L01	6.47	5.28	0.6513	0.1982	0.4531	.105	0.029	5.690	1.437
067-L01	6.18	5.20	0.4984	0.1434	0.3550	.083	0.022	5.950	1.409
001-L01	6.22	5.24	0.5421	0.2012	0.3409	.045	0.027	2.720	1.459
013-L01	6.12	5.20	0.5546	0.1868	0.3678	.080	0.025	4.964	1.409
230-L01	6.13	5.23	0.5708	0.1840	0.3868	.119	0.019	8.013	1.109
056-L01	6.20	5.25	0.5733	0.1929	0.3804	.081	0.023	5.121	1.294
213-L01	6.13	5.20	0.5918	0.1866	0.4052	.089	0.022	5.226	1.209

TABLE VII

WQEC/C 76-8

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
64N	1	110										
	2	111										
	3	126										
	4	127										
	5	128										
65N	1	108	2564									
	2	109										
	3	110	2564									
	4	133	4086									
	5	134	4468									
	6	135	2861									
	7	136	1504									
	8	137	771									
66N	1	111	1892									
	2	112	1927									
	3	113	1943									
	4	138	1892									
	5	139	1869									
	6	140	1883									
	7	141	454									
	8	142	13	6.12	5.33	0.5500	0.1526	0.3974	0.066	0.031	4.510	1.786
67N	1	114	8242									
	2	115	9053									
	3	116	9053									
	4	151										
	5	152										
	6	153	6875									
	7	154	4500									
	8	155	2251									

Note: 1. Separator Data is the average of 3 samples from each cell.
2. "Separator" Data under Separator Calculations is an average of 3 samples for each cell.

TABLE VII (Continued)

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
68N	1	117	524	6.18	5.38	0.3980	0.1653	0.2327	0.036	0.041	4.411	3.776
	2	118	955	6.25	5.40	0.3538	0.1523	0.2015	0.026	0.036	4.296	3.686
	3	119	524	6.30	5.13	0.4172	0.1584	0.2588	0.031	0.053	1.345	5.060
	4	156	955	6.18	5.32	0.3473	0.1747	0.1726	0.033	0.026	5.777	3.048
	5	157	955	6.13	5.23	0.3488	0.1582	0.1906	0.030	0.037	4.349	4.029
	6	158	300	6.13	5.26	0.3477	0.1236	0.2241	0.020	0.048	4.515	3.686
	7	159	201	6.10	5.23	0.5211	0.1649	0.3562	0.047	0.060	4.246	3.904
	8	160	100	6.27	5.20	0.5951	0.1775	0.4176	0.058	0.070	4.204	3.814
69N	1	120	592									
	2	121	592									
	3	122	172									
	4	161	148	6.22	5.20	0.6490	0.2010	0.4480	0.090	0.054	6.999	4.237
	5	162	148	6.12	5.23	0.5860	0.1630	0.4230	0.086	0.052	7.217	3.694
	6	163	148	6.17	5.13	0.6520	0.1800	0.4720	0.095	0.058	5.348	3.051
	7	164	172	6.18	5.22	0.5535	0.1718	0.3817	0.078	0.045	5.322	3.260
	8	165	502									
70N	1	123	684									
	2	126	1512									
	3	127	774									
	4	166	1512	6.20	5.20	0.3380	0.1530	0.1850	0.018	0.031	4.873	3.772
	5	167	1512	6.20	5.20	0.3740	0.1140	0.1590	0.018	0.019	4.667	3.945
	6	168	1200	6.10	5.18	0.3600	0.1471	0.2129	0.023	0.036	4.203	3.354
	7	169	867	6.00	5.30	0.4300	0.1700	0.2600	0.037	0.050	4.935	3.525
	8	170	400	6.10	5.23	0.3820	0.1400	0.2420	0.035	0.040	4.274	2.917
71N	1	128	1647									
	2	129	1655									
	3	130	936									
	4	171	1422									
	5	172	1415									
	6	173	1357									
	7	176	1540									
	8	177	752									

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
72N	1	131	1351	6.13	5.16	0.4748	0.1543	0.3205	0.027	0.073	4.180	4.459
	2	132	1717	6.20	4.96	0.4244	0.1689	0.2555	0.027	0.056	4.216	4.336
	3	179	1352	6.23	5.16	0.4759	0.1471	0.2288	0.037	0.062	1.355	5.572
	4	178	1717	6.13	5.15	0.3583	0.1420	0.2162	0.025	0.039	3.650	4.721
	5	191	1717	6.27	5.10	0.387	0.149	0.238	0.024	0.051	4.022	4.051
	6	192	150	6.23	5.30	0.5910	0.2030	0.3880	0.071	0.049	4.908	3.365
	7	193	100	6.20	5.23	0.6240	0.2150	0.4090	0.070	0.053	5.623	2.444
	8	194	50	6.20	5.20	0.6460	0.2030	0.5100	0.080	0.061	5.056	3.129
73N	1	180	2222									
	2	181	3373									
	3	182	3373									
	4	195	3373									
	5	196	3373									
	6	197	750	5.67	5.27	0.3900	0.1295	0.2605	0.025	0.048	4.116	4.173
	7	198	500	6.20	5.27	0.5343	0.1838	0.3505	0.040	0.066	3.925	4.263
	8	202	262	62.0	5.23	0.5527	0.1606	0.3921	0.045	0.069	3.690	4.505
74N	1	183	1196									
	2	185	1196									
	3	187	1751									
	4	203	1808									
	5	204	1811									
	6	205	375									
	7	206	250									
	8	207	141									
75N	1	010	2505									
	2	011	1835									
	3	012	1535									
	4	002	2560									
	5	003	2486									
	6	004	2250									
	7	005	1505									
	8	006	750									

TABLE VII (Continued) WQEC/C 76-8

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
76N	1	228	1202									
	2	229	1669									
	3	231	1669									
	4	232	1115	6.16	5.23	0.4900	0.1882	0.3018	0.056	0.063	2.531	9.368
	5	233	1669									
	6	234	752									
	7	235	500									
	8	236	250									
77N	1	026	1909	6.07	5.17	0.3456	0.1526	0.1933	0.019	0.038	3.995	4.316
	2	022	1909									
	3	021	1909									
	4	014	1909	6.23	5.23	0.4734	0.1884	0.2850	0.021	0.025	4.147	2.160
	5	015	1909	6.15	5.27	0.3695	0.1855	0.1840	0.016	0.021	3.969	2.302
	6	016	1504									
	7	017	1111									
	8	018	615									
78N	1	064	2232									
	2	065	2330									
	3	066	2319									
	4	053	2319									
	5	054	2339									
	6	055	750									
	7	057	509									
	8	058	250									
79N	1	037	2321	6.27	5.33	0.4683	0.2004	0.2679	0.019	0.033	4.200	2.793
	2	036	3260									
	3	035	1481									
	4	027	3628									
	5	028	3680									
	6	030	1352									
	7	031	1000									
	8	032	468									

TABLE VII (Continued)

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
80N	1	049	3063									
	2	051	2268	6.23	5.20	0.5246	0.1770	0.3476	0.042	0.070	5.247	3.432
	3	052	2277	6.16	5.28	0.5167	0.1726	0.3441	0.043	0.065	4.352	4.279
	4	039	2268	6.06	5.10	0.4844	0.1837	0.2997	0.030	0.050	4.133	3.719
	5	040	2416	6.15	5.25	0.4972	0.1745	0.3227	0.044	0.045	5.574	2.393
	6	041	1373	6.16	5.20	0.4616	0.1523	0.3093	0.044	0.047	5.279	2.904
	7	042	900	6.10	5.32	0.5265	0.1623	0.3642	0.056	0.063	4.754	3.755
	8	043	459	6.30	5.20	0.5799	0.1665	0.4134	.067	0.039	4.311	2.125
81N	1	189	3014									
	2	190	1580	6.00	5.18	0.5048	0.1794	0.3254	0.030	0.068	3.203	5.105
	3	224	3055	6.13	5.21	0.6218	0.1886	0.4332	0.044	0.086	3.555	4.639
	4	208	2467									
	5	209	2467									
	6	210	1511									
	7	211	1000									
	8	212	501									
82N	1	291										
	2	292										
	3	293										
	4	294										
	5	295										
83N	1	096										
	2	099										
	3	100										
	4	068										
	5	069										
	6	071										
	7	072										
	8	073	4250									
84N	1	103										
	2	104										
	3	105										
	4	081										
	5	082										
	6	083										
	7	084										
	8	085										

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
85N	1	101										
	2	102										
	3	074										
	4	076										
	5	077										
	6	078										
	7	079										
	8	080										
86N	1	106										
	2	107										
	3	086										
	4	087										
	5	088										
	6	089										
	7	090										
	8	091	3262									
87N	1	219	N/A*	6.18	5.18	0.6230	0.1910	0.4320	0.096	0.047	5.735	2.312
	2	220	N/A*	6.20	5.30	0.6320	0.1940	0.4370	0.096	0.045	6.126	1.318
	3	221	N/A*	6.23	5.23	0.6280	0.2310	0.3980	0.098	0.046	5.639	2.677
88N	1	222	N/A*									
	2	226	N/A*									
	3	227	N/A*									
89N	1	216	N/A*									
	2	217	N/A*									
	3	218	N/A*									
90N	1	237	N/A*									
	2	238	N/A*									
	3	239	N/A*									
91N	1	059	N/A*									
	2	060	N/A*									
	3	061	N/A*									
92N	1	044	N/A*	6.18	5.22	0.7154	0.1914	0.5240	0.112	0.064	5.809	2.549
	2	045	N/A*	6.16	5.16	0.6889	0.1953	0.4935	0.106	0.057	6.533	2.022
	3	046	N/A*	6.23	5.28	0.7233	0.1860	0.5473	0.107	0.067	5.790	2.581

*Storage Cells

TABLE VII (Continued)

SEPARATOR ANALYSIS

Pack No.	Cell No.	Cell ID.	Completed Cycles	Separator Data: Sample Size (cm) Length	Width	Separator Wet Wt. (g)	Separator Dry Wt. (g)	Electrolyte Wt. (g)	Separator Calculations: Separator Grams KOH	Separator Grams K_2CO_3	Extract Grams KOH	Extract Grams K_2CO_3
93N	1	092	N/A*									
	2	093	N/A*									
	3	094	N/A*									
94N	1	095	N/A*									
	2	245	N/A*									
	3		N/A*									
95N		242										
		244										

*Storage Cells

TABLE VIII
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
65N	6	135	2861													
	7	136	1504													
	8	137	771													
66N	1	111	1892													
	2	112	1927													
	3	113	1943													
	4	138	1892													
	5	139	1869													
	6	140	1883													
	7	141	454													
	8	142	13	0.00	20.5	78.0	6.846	8.152	.0317	.0300	.0306	.0307	.0319	.0318	.0314	.0314
67N	1	114	8242													
	2	115	9053													
	3	116	9053													
	4	151														
	5	152														
	6	153	6875													
	7	154	4500													
	8	155	2251													
68N	1	117	524	73.0	6.5	17.5	7.220	7.916	.0341	.0355	.0364	.0353	.0328	.0333	.0331	.0331
	2	118	955	48.5	4.5	44.5	7.327	7.914	.0342	.0352	.0345	.0346	.0353	.0352	.0421	.0375
	3	119	524	14.5	5.5	80.0	7.301	7.857	.0354	.0351	.0356	.0353	.0336	.0345	.0330	.0337
	4	156	955	15.5	14.5	70.5	7.257	7.850	.0386	.0397	.0405	.0396	.0333	.0334	.0340	.0336
	5	157	955	65.0	9.5	25.0	7.310	7.843	.0376	.0381	.0376	.0377	.0324	.0328	.0330	.0327
	6	158	300	9.0	6.5	81.5	7.212	7.819	.0338	.0341	.0340	.0340	.0347	.0351	.0340	.0346

Note: Weight and thickness are an average of 10 positive plates and 11 negative plates in the cell without separator.

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
68N	7	159	201	19.0	11.0	65.0	7.151	7.952	.0325	.0322	.0328	.0324	.0329	.0325	.0324	.0325
	8	160	100	18.5	10.5	69.5	7.084	8.108	.0313	.0312	.0315	.0313	.0323	.0326	.0324	.0324
69N	1	120	592													
	2	121	592													
	3	122	172													
	4	161	148	65.5	11.0	23.0	6.975	8.130	.0301	.0303	.0300	.0301	.0329	.0328	.0321	.0326
	5	162	148	62.0	12.0	25.0	6.985	8.155	.0296	.0299	.0302	.0299	.0322	.0321	.0320	.0321
	6	163	148	51.0	10.0	45.0	6.929	8.163	.0298	.0298	.0299	.0298	.0325	.0322	.0321	.0323
	7	164	172	50.5	9.5	46.0	7.022	7.973	.0308	.0299	.0308	.0305	.0322	.0324	.0322	.0323
	8	165	502													
70N	1	123	684													
	2	126	1512													
	3	127	774													
	4	166	1512	71.0	2.5	26.0	7.246	7.807	.0357	.0363	.0366	.0362	.0378	.0375	.0365	.0373
	5	167	1512	75.5	2.0	22.0	7.118	7.730	.0365	.0364	.0370	.0366	.0376	.0374	.0370	.0373
	6	168	1200	76.5	3.5	19.0	7.170	7.894	.0337	.0380	.0346	.0354	.0375	.0368	.0351	.0365
	7	169	867	10.5	10.5	77.5	6.961	8.004	.0311	.0325	.0326	.0321	.0359	.0373	.0364	.0365
	8	170	400	9.5	5.0	81.5	7.072	8.091	.0335	.0324	.0322	.0327	.0382	.0416	.0397	.0398
71N	1	128	1647													
	2	129	1655													
	3	130	936													
	4	171	1422													
	5	172	1415													
	6	173	1357													
	7	176	1540													
	8	177	752													

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
72N	1	131	1351	82.0	2.0	15.5	7.155	7.825	.0361	.0364	.0353	.0359	.0349	.0357	.0357	.0350
	2	132	1717	73.5	5.0	20.5	7.200	7.903	.0392	.0387	.0386	.0388	.0342	.0337	.0333	.0337
	3	179	1352	21.0	11.5	67.0	7.201	7.813	.0362	.0353	.0338	.0351	.0325	.0329	.0345	.0333
	4	178	1717	62.0	15.0	22.0	7.217	7.826	.0445	.0428	.0420	.0431	.0333	.0335	.0323	.0330
	5	191	1717	71.5	0.0	23.0	7.285	7.886	.0418	.0415	.0407	.0413	.0333	.0323	.0325	.0327
	6	192	150	69.0	2.0	28.0	6.976	8.099	.0309	.0302	.0312	.0308	.0334	.0338	.0336	.0336
	7	193	100	81.0	3.0	15.6	7.024	8.204	.0315	.0311	.0316	.0311	.0334	.0325	.0322	.0327
	8	194	50	54.0	3.0	43.0	6.927	8.164	.0303	.0362	.0305	.0323	.0328	.0330	.0333	.0330
73N	1	180	2222													
	2	181	3373													
	3	182	3373													
	4	195	3373													
	5	196	3373				7.369	7.506	.0390	.0386	.0385	.0387	.0344	.0342	.0340	.0342
	6	197	750				7.876	7.163	.0332	.0340	.0340	.0337	.0346	.0355	.0347	.0349
	7	198	500				7.139	8.096	.0324	.0327	.0327	.0326	.0332	.0329	.0326	.0329
	8	202	262	25.0	5.0	70.0	7.058	7.855	.0327	.0325	.0331	.0327	.0347	.0343	.0341	.0344
74N	1	183	1196													
	2	185	1196													
	3	187	1751													
	4	203	1808													
	5	204	1811													
	6	205	375													
	7	206	250													
	8	207	141													

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
75N	1	010	2505													
	2	011	1835													
	3	012	1535													
	4	002	2560													
	5	003	2486													
	6	004	2250													
	7	005	1505													
	8	006	750													
76N	1	228	1202													
	2	229	1669													
	3	231	1669													
	4	232	1115	54.0	6.5	38.5	7.285	7.540	.0346	.0366	.0384	.0365	.0327	.0326	.0331	.0328
	5	233	1669													
	6	234	752													
	7	235	500													
	8	236	250													
77N	1	026	1909	12.0	0.0	82.0	7.076	7.930	.0417	.0431	.0424	.0424	.0367	.0354	.0332	.0351
	2	022	1909	3.5	12.0	79.5	7.211	7.917	.0363	.0382	.0388	.0378	.0335	.0331	.0335	.0333
	3	021	1909	5.0	10.0	83.5	7.134	7.901	.0435	.0446	.0426	.0436	.0343	.0354	.0345	.0347
	4	014	1909	2.0	18.0	80.0	7.161	7.942	.0383	.0397	.0400	.0393	.0334	.0333	.0324	.0330
	5	015	1909	0.0	17.0	81.5	7.114	7.998	.0403	.0408	.0405	.0405	.0338	.0347	.0335	.0340
	6	016	1504													
	7	017	1111													
	8	018	615													

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
78N	1	064	2232													
	2	065	2068													
	3	066	2319													
	4	053	2319													
	5	054	2339													
	6	055	750													
	7	057	509													
	8	058	250													
79N	1	037	2321	59.0	3.0	35.0	7.283	7.732	.0351	.0354	.0385	.0363	.0318	.0317	.0319	.0318
	2	036	3260	62.5	11.5	25.0	7.278	7.922	.0380	.0390	.0387	.0385	.0330	.0338	.0331	.0333
	3	035	1481	72.5	5.0	21.5	7.190	7.848	.0362	.0374	.0377	.0371	.0322	.0325	.0322	.0324
	4	027	3628													
	5	028	3680													
	6	038	1352													
	7	031	1000													
	8	032	468													
80N	1	049	3063													
	2	051	2268	59.5	4.0	35.0	7.151	7.890	.0360	.0383	.0375	.0373	.0346	.0330	.0331	.0336
	3	052	2277	81.5	6.0	22.0	7.296	7.774	.0372	.0355	.0347	.0358	.0332	.0355	.0347	.0345
	4	039	2268	7.0	10.0	83.0	7.810	7.144	.0361	.0378	.0375	.0371	.0319	.0336	.0308	.0321
	5	040	2416	48.5	2.0	49.5	7.173	7.849	.0366	.0353	.0363	.0361	.0334	.0334	.0314	.0327
	6	041	1373	35.5	3.5	59.5	7.077	7.966	.0339	.0361	.0361	.0354	.0348	.0353	.0347	.0349
	7	042	900	67.0	10.5	22.0	7.093	7.950	.0324	.0320	.0334	.0326	.0356	.0365	.0349	.0357
	8	043	459	9.0	12.5	78.5										

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
81N	1	189	3014													
	2	190	1580	69.5	5.5	23.5	7.108	7.935	.0354	.0381	.0380	.0372	.0361	.0350	.0338	.0350
	3	224	3055	69.5	0.0	29.0	7.291	7.792	.0316	.0324	.0312	.0317	.0324	.0319	.0317	.0320
	4	208	2467													
	5	209	2467													
	6	210	1511	7.5	15.0	73.0	7.283	7.838	.0348	.0350	.0348	.0349	.0337	.0336	.0331	.0335
	7	211	1000	6.5	11.5	80.0	7.041	8.024	.0326	.0343	.0342	.0337	.0339	.0336	.0336	.0337
	8	212	501													
82N	1	291														
	2	292														
	3	293														
	4	294														
	5	295														
83N	1	096														
	2	099														
	3	100														
	4	068														
	5	069														
	6	071														
	7	072														
	8	073	4250													
84N	1	103														
	2	104														
	3	105														
	4	081														
	5	082														

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight (g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
84N	6	083														
	7	084														
	8	085														
85N	1	101														
	2	102														
	3	074														
	4	076														
	5	077														
	6	078														
	7	079														
	8	080														
86N	1	106														
	2	107														
	3	086														
	4	087														
	5	088														
	6	089														
	7	090														
	8	091	3262													
87N	1	219	N/A*	0.0	20.0	79.0	7.506	7.867	.0294	.0294	.0295	.0294	.0325	.0325	.0319	.0323
	2	220	N/A*	0.0	20.0	75.5	7.332	8.214	.0301	.0298	.0306	.0301	.0325	.0315	.0311	.0317
	3	221	N/A*	0.0	18.0	81.0	6.908	8.314	.0293	.0291	.0289	.0291	.0326	.0324	.0318	.0323
88N	1	222	N/A*													
	2	226	N/A*													
	3	227	N/A*													

*Storage Cells

TABLE VIII (Continued)
GAS SAMPLING AND PLATE MEASUREMENTS

Pack No.	Cell No.	Cell ID	Completed Cycles	GAS SAMPLING Gas Concentrations (%) H_2	O_2	N_2	PLATE WEIGHT AND THICKNESS Weight-(g) Pos	Neg	Thickness (in) Positive Top	Mid	Bot	Avg	Thickness (in) Negative Top	Mid	Bot	Avg
89N	1	216	N/A*				6.898	8.357	.0289	.0287	.0286	.0287	.0324	.0322	.0322	.0323
	2	217	N/A*													
	3	218	N/A*													
90N	1	237	N/A*													
	2	238	N/A*													
	3	239	N/A*													
91N	1	059	N/A*													
	2	060	N/A*													
	3	061	N/A*													
92N	1	044	N/A*				6.898	8.357	.0289	.0287	.0286	.0287	.0324	.0322	.0322	.0323
	2	045	N/A*				6.845	8.314	.0295	.0289	.0297	.0294	.0326	.0322	.0317	.0322
	3	046	N/A*				6.918	8.303	.0288	.0291	.0293	.0291	.0329	.0326	.0327	.0327
93N	1	092	N/A*													
	2	093	N/A*													
	3	094	N/A*													
94N	1	095	N/A*													
	2	245	N/A*													
	3		N/A*													

*Storage Cells

TABLE IX
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS In Plate (g)	$Cd(OH)_2$ In Plate (ah)	In Cell (ah)	Cd In Plate (g)	Cd In Plate (ah)	In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	NICKEL PLATE ANALYSIS In Plate (g)	$Ni(OH)_2$ In Plate (ah)	In Cell (ah)	Ni In Plate (g)
66N	6	140	1883												
	7	141	454												
	8	142	13	4.066	1.489	16.375	0.280	0.102	1.106	17.501					
67N	1	114	8242												
	2	115	9053												
	3	116	9053												
	4	151													
	5	152													
	6	153	6875												
	7	154	4500												
	8	155	2251												
68N	1	117	524	3.120	1.142	12.564	0.915	0.335	3.685	16.249	5.757	3.583	1.035	10.35	1.717
	2	118	955	2.922	1.070	11.770	1.105	0.405	4.451	16.218	5.838	3.636	1.051	10.51	1.740
	3	119	524	3.524	1.290	14.190	0.570	0.209	2.296	16.487	5.835	3.575	1.033	10.33	1.782
	4	156	955	3.042	1.114	12.249	1.070	0.392	4.310	16.559	5.504	3.537	1.022	10.22	1.544
	5	157	955	3.229	1.182	13.004	0.739	0.271	2.977	15.981					
	6	158	300	2.787	1.020	11.225	1.077	0.394	4.337	15.562					
	7	159	201	3.595	1.316	14.478	0.440	0.161	1.772	16.250					
	8	160	100	3.386	1.240	13.638	0.811	0.297	3.266	16.904					
69N	1	120	592												
	2	121	592												
	3	122	172												

Note: 1. Cadmium plate analysis (g) of $Cd(OH)_2$ and Cd is the average of 2 samples from each of 3 plates.
2. Nickel plate analysis (g) of sintered and active material in plate, (g) of $Ni(OH)_2$ and (g) of metallic Ni in plate) is the average of 2 samples from each of 3 plates.

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS							NICKEL PLATE ANALYSIS				
				In Plate (g)	$Cd(OH)_2$ In Plate (ah)	In Cell (ah)	In Plate (g)	Cd In Plate (ah)	In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	In Plate (g)	$Ni(OH)_2$ In Plate (ah)	In Cell (ah)	Ni In Plate (g)
69N	4	161	148	3.569	1.303	14.333	0.589	0.190	2.091	16.428	5.451	3.235	0.935	9.35	1.882
	5	162	148	3.668	1.343	14.773	0.566	0.207	2.279	17.052	5.446	3.233	0.934	9.34	1.870
	6	163	148	3.659	1.340	14.740	0.474	0.162	1.779	16.516	5.367	3.192	0.922	9.22	1.794
	7	164	172	3.821	1.399	15.386	0.453	0.166	1.823	17.209	5.546	3.636	1.051	10.51	1.969
	8	165	502												
70N	1	123	684												
	2	126	1512												
	3	127	774												
	4	166	1512	3.005	1.100	12.100	0.784	0.287	3.161	15.263	5.642	3.537	1.022	10.22	1.734
	5	167	1512	2.952	1.081	11.891	0.680	0.249	2.740	14.627	5.604	3.404	0.984	9.84	1.754
	6	168	1200	2.943	1.077	11.847	1.020	0.373	4.106	15.956	5.593	3.577	1.034	10.34	1.822
	7	169	867	3.259	1.193	13.123	1.120	0.410	4.510	17.636	5.520	3.301	0.954	9.54	1.754
	8	170	400	3.649	1.336	14.696	0.753	0.276	3.032	17.729	5.486	3.216	0.929	9.29	1.814
71N	1	128	1647												
	2	129	1655												
	3	130	936												
	4	171	1422												
	5	172	1415												
	6	173	1357												
	7	176	1540												
	8	177	752												

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS In Plate (g)	$Cd(OH)_2$ In Plate (ah)	In Cell (ah)	Cd In Plate (g)	Cd In Plate (ah)	In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	NICKEL PLATE ANALYSIS In Plate (g)	$Ni(OH)_2$ In Plate (ah)	In Cell (ah)	Ni In Plate (g)
72N	1	131	1351	2.582	0.945	10.395	0.942	0.345	3.792	14.189	5.636	3.502	1.012	10.12	1.769
	2	132	1717	2.650	0.970	10.670	1.491	0.546	6.010	16.680	5.678	3.807	1.100	11.00	1.538
	3	179	1352	2.914	1.067	11.737	1.096	0.401	4.413	16.150	5.790	3.458	0.999	9.999	1.845
	4	178	1717	2.392	0.876	9.632	1.338	0.490	5.386	15.018					
	5	191	1717	2.872	1.051	11.564	1.089	0.399	4.386	15.950					
	6	192	150	4.026	1.474	16.214	0.387	0.142	1.559	17.774	5.503	3.167	0.915	9.15	1.886
	7	193	100	4.073	1.491	16.401	0.127	0.046	0.509	16.913	5.474	3.129	0.904	9.04	1.723
	8	194	50	3.915	1.433	15.763	0.245	0.090	0.987	16.753	5.278	3.198	0.924	9.24	1.747
73N	1	180	2222												
	2	181	3373												
	3	182	3373												
	4	195	3373												
	5	196	3373	2.589	0.948	10.427	1.269	0.465	5.110	15.537					
	6	197	750	2.986	1.093	12.023	1.023	0.375	4.121	16.145					
	7	198	500	3.853	1.411	15.517	0.430	0.158	1.733	17.250					
	8	202	250	2.828	1.035	11.387	1.367	0.500	5.504	16.891					
74N	1	183	1196												
	2	185	1196												
	3	187	1751												
	4	203	1808												
	5	204	1811												
	6	205	375												
	7	206	250												
	8	207	141												
75N	1	010	2505												

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS								NICKEL PLATE ANALYSIS			
				In Plate (g)	$Cd(OH)_2$ In Plate (ah)	In Cell (ah)	In Plate (g)	Cd In Plate (ah)	In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	In Plate (g)	$Ni(OH)_2$ In Plate (ah)	In Cell (ah)	Ni In Plate (g)
75N	2	011	1835												
	3	012	1535												
	4	002	2560												
	5	003	2486												
	6	004	2250												
	7	005	1505												
	8	006	750												
76N	1	228	1202												
	2	229	1669												
	3	231	1669												
	4	232	1115	2.395	0.877	9.647	1.449	0.531	5.840	15.484	5.625	3.466	1.001	10.01	1.717
	5	233	1669												
	6	234	752												
	7	235	500												
	8	236	250												
77N	1	026	1909	3.705	1.356	14.921	0.511	0.187	2.057	16.978					
	2	022	1909	3.701	1.355	14.903	0.477	0.175	1.922	16.824					
	3	021	1909	3.359	1.230	13.525	0.749	0.274	3.017	16.542					
	4	014	1909	3.707	1.357	14.927	0.422	0.154	1.698	16.624					
	5	015	1909	3.855	1.411	15.526	0.284	0.104	1.144	16.670					
	6	016	1504												
	7	017	1111												
	8	018	615												
78N	1	064	2232												
	2	065	2330												

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS In Plate (g)	$Cd(OH)_2$ In Plate (ah)	$Cd(OH)_2$ In Cell (ah)	Cd In Plate (g)	Cd In Plate (ah)	Cd In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	NICKEL PLATE ANALYSIS In Plate (g)	$Ni(OH)_2$ In Plate (ah)	$Ni(OH)_2$ In Cell (ah)	Ni In Plate (g)
78N	3	066	2319												
	4	053	2319												
	5	054	2339												
	6	055	750												
	7	057	509												
	8	058	250												
79N	1	037	2321	2.595	0.950	10.452	1.439	0.527	5.796	16.249					
	2	036	3260	3.145	1.151	12.664	0.984	0.360	3.963	16.627					
	3	035	1481	3.308	1.211	13.322	0.800	0.293	3.220	16.542					
	4	027	3628												
	5	028	3680												
	6	038	1352												
	7	031	1000												
	8	032	468												
80N	1	049	3063												
	2	051	2268	3.371	1.234	13.574	1.477	0.541	5.948	19.525	5.563	3.327	0.961	9.61	1.670
	3	052	2277	3.181	1.165	12.815	0.885	0.324	3.564	16.380	5.608	3.460	1.000	10.00	1.802
	4	039	2268	2.892	1.059	11.649	1.068	0.391	4.300	15.946					
	5	040	2416	3.108	1.138	12.515	0.805	0.295	3.243	15.758					
	6	041	1373	3.651	1.337	14.703	0.443	0.162	1.756	16.489					
	7	042	900	3.591	1.315	14.465	0.689	0.252	2.776	17.236	5.513	3.352	0.969	9.69	1.856
	8	043	459	3.805	1.393	15.323	0.359	0.132	1.448	16.770					
81N	1	189	3014												
	2	190	1580	3.707	1.357	14.928	0.256	0.145	1.152	16.079					

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS: In Plate (g)	$Cd(OH)_2$ In Plate (ah)	$Cd(OH)_2$ In Cell (ah)	Cd In Plate (g)	Cd In Plate (ah)	Cd In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	NICKEL PLATE ANALYSIS: In Plate (g)	$Ni(OH)_2$ In Plate (ah)	$Ni(OH)_2$ In Cell (ah)	Ni In Plate (g)
81N	3	224	3055	2.843	1.040	11.440	1.464	0.536	5.894	17.340	5.722	3.421	0.989	9.89	1.928
	4	208	2467												
	5	209	2467												
	6	210	1511	3.230	1.182	13.006	0.893	0.327	3.598	16.604					
	7	211	1000	3.529	1.292	14.215	0.593	0.217	2.388	16.602					
	8	212	501												
82N	1	291													
	2	292													
	3	293													
	4	294													
	5	295													
83N	1	096													
	2	099													
	3	100													
	4	068													
	5	069													
	6	071													
	7	072													
	8	073	4250												
84N	1	103													
	2	104													
	3	105													
	4	081													
	5	082													

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS								NICKEL PLATE ANALYSIS			
				In Plate (g)	$Cd(OH)_2$ In Plate (ah)	In Cell (ah)	In Plate (g)	Cd In Plate (ah)	In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	In Plate (g)	$Ni(OH)_2$ In Plate (ah)	In Cell (ah)	Ni In Plate (g)
84N	6	083													
	7	084													
	8	085													
85N	1	101													
	2	102													
	3	074													
	4	076													
	5	077													
	6	078													
	7	079													
	8	080													
86N	1	106													
	2	107													
	3	086													
	4	087													
	5	088													
	6	089													
	7	090													
	8	091	3262												
87N	1	219	N/A*	3.507	1.284	14.284	0.083	0.026	0.256	14.409	5.434	3.230	0.933	9.33	1.865
	2	220	N/A*	4.198	1.537	16.907	0.059	0.019	0.205	17.112	5.431	3.097	0.895	8.95	1.910
	3	221	N/A*	3.693	1.352	14.872	0.150	0.055	0.605	15.478	5.502	3.232	0.934	9.34	1.889
88N	1	222	N/A*												
	2	226	N/A*												

*Storage Cells

TABLE IX (Continued)
PLATE ANALYSIS

Pack No.	Cell No.	Cell ID	Completed Cycles	CADMIUM PLATE ANALYSIS In Plate (g)	$Cd(OH)_2$ In Plate (ah)	In Cell (ah)	Cd In Plate (g)	Cd In Plate (ah)	In Cell (ah)	Total Neg In Cell (ah)	Sinter/Active Plate Material (g)	NICKEL PLATE ANALYSIS In Plate (g)	$Ni(OH)_2$ In Plate (ah)	In Cell (ah)	Ni In Plate (g)
88N	3	227	N/A*												
89N	1	216	N/A*												
	2	217	N/A*												
	3	218	N/A*												
90N	1	237	N/A*												
	2	238	N/A*												
	3	239	N/A*												
91N	1	059	N/A*												
	2	060	N/A*												
	3	061	N/A*												
92N	1	044	N/A*	4.446	1.628	17.908	0.148	0.054	0.595	18.500	5.493	3.428	0.991	9.91	2.043
	2	045	N/A*	4.049	1.482	16.304	0.218	0.080	0.878	17.181	5.585	3.285	0.949	9.49	2.036
	3	046	N/A*	4.352	1.593	17.523	0.090	0.033	0.362	17.890	5.375	3.192	0.923	9.23	1.927
93N	1	092	N/A*												
	2	093	N/A*												
	3	094	N/A*												
94N	1	095	N/A*												
	2	245	N/A*												
	3		N/A*												
95N		242		4.275	1.565	17.216	0.072	0.026	0.291	17.507					
		244		4.168	1.526	16.784	0.096	0.035	0.388	17.172					

*Storage Cells

APPENDIX A

Cell Design

CELL DESIGN

I. The cells used as test samples in the Accelerated Test Program are sealed 6 ah cells, manufactured by the General Electric Company per GSFC Specification S-716-P-6 and General Electric Manufacturing Document 232A2222AA-36. The catalogue number assigned to the cell is 42B006AB62. General information on the various cell components is as follows:

A. Cell Case. The cell case is drawn from 304 stainless steel with a wall thickness of 0.016 in. (0.040 cm) to 0.022 in. (0.056 cm). The wall thickness at the bend radii is 0.011 in. (0.028 cm) minimum.

B. Cell Header. The cell cover is fabricated from 304 stainless steel and contains two alumina ceramic seals with nickel iron (alloy 42) stress relief collars and nickel terminal posts. The braze used in the ceramic to metal seals is a nickel titanium alloy whereas the braze used to join the collar to the cover is a silver palladium alloy. Each terminal is tinned with solder. The header assembly has a 0.187 in. (0.475 cm) O.D. stainless steel fill tube welded to the cover.

C. Positive Plates. Each cell contains 10 sintered positive plates. The nominal dimensions of the plate, not including the tab, are 2.170 in. (5.51 cm) high, 1.968 in. (5.00 cm) wide and 0.027 in (0.069 cm) thick. All edges of the positive plates are coined 0.08 in. (0.20 cm). The tab is an integral part of the nickel-plated steel grid. The nominal flooded capacity, at the 2-hour discharge rate, is 0.75 ampere-hours per plate.

D. Negative Plate. Each cell contains 11 sintered negative plates. The nominal dimensions of the plate, excluding the tab, are 2.170 in. (5.51 cm) high, 1.968 in. (5.00 cm) wide and 0.0315 in. (0.08 cm) thick. All edges of the negative are coined 0.08 in. (0.20 cm). The tab is an integral part of the nickel-plated steel grid. The nominal flooded capacity, at the 2-hour rate, is 1.3 ampere-hours per plate.

E. Separator. The separator used in the cells is a PELLON, Nylon 6, nonwoven material, style number 2505. Each positive plate has a separate, single thickness bag which is heat sealed on two edges with the fold along the height of the positive plate. The as received material is double water washed by the material manufacturer. No surfactants were added to the material by General Electric.

F. Insulation Wrapper. The electrode/separator assembly is insulated from the case walls by a film of polypropylene of 0.0050 in. (0.013 cm) nominal thickness.

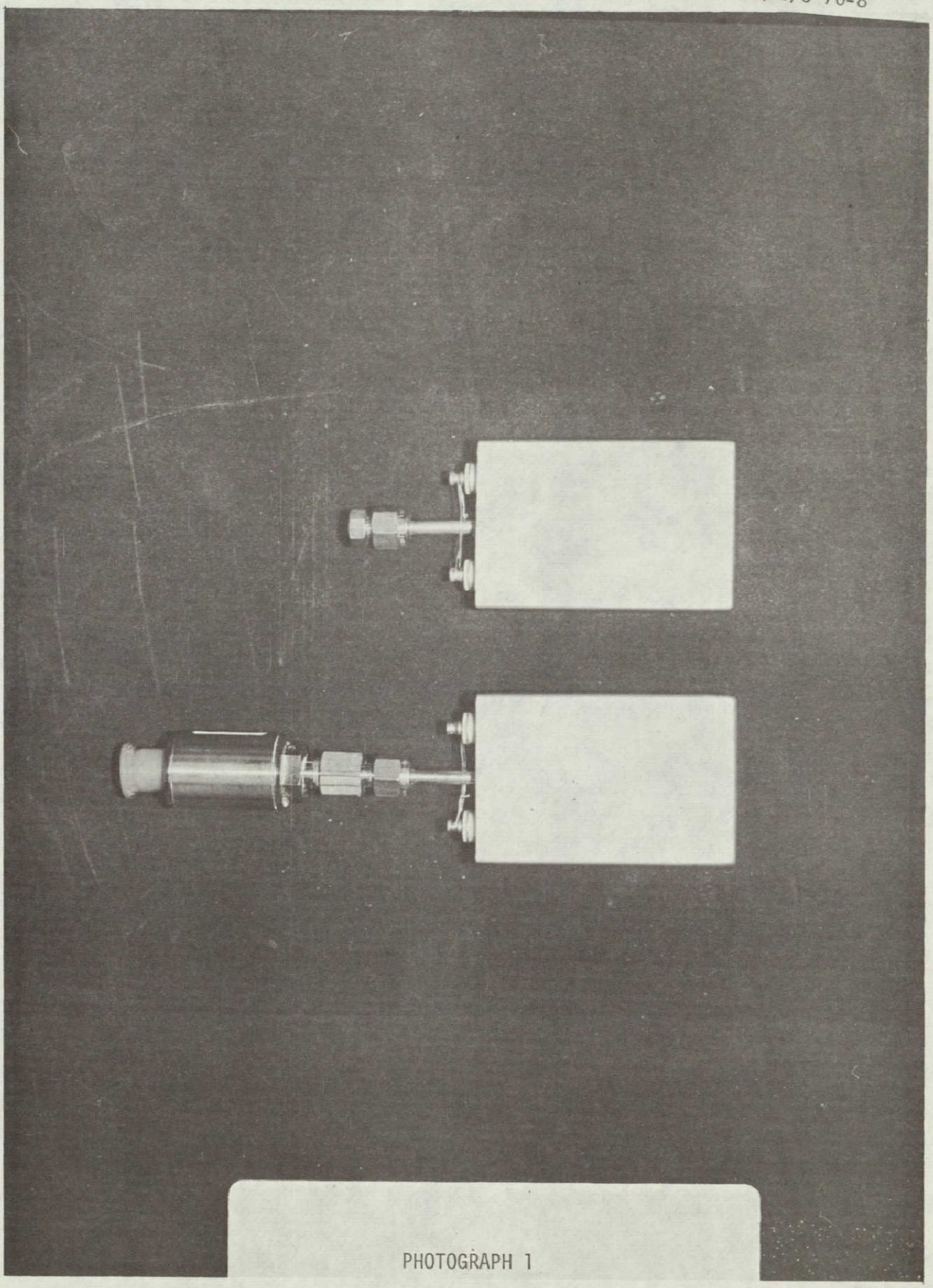
G. Cell Variables. In order to determine the effects of cell physical variables on the accelerated testing, three cell design parameters were varied, namely, concentration of electrolyte, volume of electrolyte and amount of negative precharge obtained by oxygen venting. No additives are added to the electrolyte. The 6 ah cell normally supplied by General Electric would have a 34 percent concentration of electrolyte, an 18.5 cc volume of electrolyte and a 2.50 ampere-hour negative precharge. These variables are shown in the following matrix.

	Physical Design Parameters				
Concentration of KOH electrolyte Percent by weight	22.0	26.0	30.0	34.0	38.0
Volume of electrolyte, cc.	17.5	18.5	19.5	20.5	21.5
Negative precharge, ah	2.20	2.50	2.80	3.00	3.30

H. Negative to Positive Ratio. The ratio of the full negative to the full positive is 1.7. The value is based on a measurement, per GSFC Specification S-716-P-6 made on five production cells of the standard design, i.e., 34 percent concentration of electrolyte, 18.5 cc of electrolyte and 2.50 ampere-hours of negative precharge.

I. Pressure Transducers. Approximately one-third of the cells are equipped with 5000 ohm potentiometric pressure transducers with a range of 0 to 300 PSIA. These transducers, Model 2-400, are manufactured by the Edcliff Instrument Company. They are attached to the cell fill tube by means of a Swagelok fitting. All other cells are capped off with a Swagelok fitting. The transducers and fitting are made from 304 or 316 stainless steel. All fitting assemblies were Helium leak checked before installation on the cells and a final leak check was performed after assembly on the cells. Maximum leak rates were 10^{-7} Std. cc/sec.

II. Photograph 1 shows cells with and without a transducer.



PHOTOGRAPH 1

APPENDIX B

Proofing Test

PROOFING TEST

I. Specific parameters of the accelerated test were chosen arbitrarily. The purpose for the proofing test was to validate these parameters or determine required changes and determine the best method to stabilize the temperature of the cells in pack configuration.

A. Two cells were taken from lot number one and configured as two separate cells in pack formation. Each cell was placed between two aluminum plates having an opening in each plate for temperature monitoring at the center of each cell can on each side and openings on each of the four corners to insert 1/4 inch bolts for cell restraining. The plate dimensions were 5-3/4 inches long by 3-1/2 inches wide by 1/4 inch thick. One side of each cell was metal to metal contact and the other side of each cell had a 0.032 inch thick polyvinylchloride (PVC) sheet (same length and width of cell) between the cell and the metal plate. Thermistors were inserted and held in contact with each cell can by RTV. The restrained cells were then positioned with a minimum of 1/2 inch spacing between the extremity of the adjacent plates and the plates secured by a 5/8 inch plastic base and top. Spacing between bottom of the cells to base was a minimum of 1/2 inch.

B. Conclusions based on tests in paragraph II are listed below.

1. Values stated in Table 2 of reference (c) for star and center point levels for percent recharged (%RC) should be changed from 170 and 230 to 140 and 200 respectively and the charge time (Hrs) in Table 5 of reference (c) adjusted accordingly.

2. The aluminum restraining plates for the cells were increased to 7.0 inches long by 4.5 inches wide by 1/4 inch thick with 1/2 inch between the outer extremity of each plate and approximately 1/2 inch between base plate and cell.

3. Each cell has silicon grease between cell can and restraining plates.

II. TESTS AND RESULTS

A. Tests to establish normal operating performance:

1. Capacity test at room ambient (22° to 28°C):

a. The cells were charged at the C/20 rate for 40 hours, then discharged at the C/2 rate to 0.75 volts, first cell. The capacity for the first cycle was 7.41 ah. The cells were then charged at the C/10 rate for 16 hours, and discharged at the C/2 rate to 0.75 volts first cell. Cycle 2 capacity was 7.12 ah.

2. Internal resistance and capacity test at 20°C:

a. The cells were charged at the C/10 rate for 16 hours. The internal impedance was taken at the end of charge. Cell 1 was 8 milliohms and cell 2 was 4 milliohms. The cells were discharged at the C/2 rate. Capacity for cycle 3 was 6.82 ah.

B. Proofing test:

1. Capacity test at 20°C; matrix rate for 65N:

a. The cells were charged at the C rate to 10.2 ah. Then; the cells were discharged at the 2C rate to 0.5 volts first cell. The internal impedance at the end of charge and discharge was 8 milliohms for cell 1 and 4 milliohms for cell 2. The capacity of each cell was 3.63 ah.

2. Cycled as pack 65N:

a. The parameters were 20°C, 60 percent depth of discharge, 2C rate discharge, C rate charge, 170 percent recharge.

b. The cells cycled for 19 cycles with the following results: The temperature on the side of the cell without the polyvinyl-chloride (PVC) was 4° to 6°C above the ambient. The temperature on the side of the cell with PVC was 6° to 8°C above ambient. The temperature on the side of the cell with the PVC was 2°C greater than the side without the PVC. The pressure of cell number 2 was 200 psia, worst case. The internal impedance of cell number 1 was 8 milliohms and cell number 2 was 4 milliohms.

3. Cycled as pack 70N except at 20°C:

a. The parameters were, temperature 20°C, 60 percent depth of discharge, 2C discharge rate, 4 C charge rate and 170 percent recharge.

b. The test ran two cycles before being terminated because of high pressure on cell number 2 which was 250 psia and 175 psia on cell number 1. The time the cells were on charge was 0.2 hour which equated to a recharge of 133 percent. Because of high pressure, the test was terminated so the cells would not be damaged and could be used for additional tests. Because of the pressure failure at the 20°C ambient it was decided to run the test at the matrix temperature.

4. Cycled as pack 70N at 40°C:

a. The parameters were, temperature 40°C, 60 percent depth of discharge, 2C discharge rate, 4C charge rate and 170 percent recharge.

b. After charging the cells at the 4C rate to 170 percent of 3.6 ah out, the cells ran two cycles. During the third cycle, cell 2 had a pressure of 250 psia and the cells were taken off charge with 160 percent recharge. Following the charge, the cells were discharged at the 2C rate to 60 percent depth of discharge; at the end of discharge the cells were put in open circuit for approximtely 0.33 hour. Then the cells were charged at the 4C rate. The cells completed one more cycle and during the next charge, the pressure on cell 2 was 250 psia and at the time of cutoff, the cells received 160 percent recharge. The cells were returned to cycling, but could not be cycled. The cells were then discharged to 0.0 volts and shorted with 0.5 ohm resistors. This was on cycle 32.

5. Cycled as pack 70N but with 140 percent recharge:

a. The parameters were, temperature 40°C, 60 percent depth of discharge, 2C discharge rate, 4C charge rate, and 140 percent recharge.

b. After 21 cycles the results were as follows: The pressures were 150 to 180 psia, worst case, the temperatures on the side of the cells without PVC were 6° to 7°C above ambient, the temperatures on the side of the cells with PVC were 9° to 10°C above ambient.

c. The results show that the pressures and temperatures were stabilized and that the temperatures on the side of the cell with PVC were 3°C greater than the side of the cells without PVC.

6. Cycled as pack 72N:

a. The percent of recharge was changed to 140 percent. The other parameters were 60 percent depth of discharge, 40°C, 8C discharge rate, and C charge rate.

b. After 28 continuous cycles, the cells were then discharged to 0.5 volts each and shorted with 0.5 ohm resistors.

c. The following are the results of this test. The maximum pressure was 104 psia. The temperatures of the cells were 4°C above the ambient. After the shorting of the cells with a 0.5 ohm resistor, the pressure decayed from 104 psia to 30 psia in 3 hours.

7. Before any additional tests were conducted on cell 1, the size of the restraining plate was increased to 7.0 inches long by 4.5 inches wide by 1/4 inch thick.

8. Cycled as pack 65N with the percent of recharge changed to 140:

a. The other parameters were 60 percent depth of discharge, 2C discharge rate, C charge rate, and 20°C.

b. After 123 cycles, the pressures and temperatures were stabilized. The maximum pressure was 135 psia at cycle 25 and at cycle 123 had stabilized at 115 psia. The temperatures at the side of each cell with PVC between the plates were 4°C above ambient and the sides of the cells without PVC were 3°C above ambient.

9. Cycled as pack 66N:

a. The parameters were 60 percent depth of discharge, 60°C, 2C discharge rate, C charge rate, 140 percent recharge.

b. After 25 cycles, cell 2 was at the cutoff voltage of 0.75 VDC at the end of discharge. The voltages at the end of charge were 1.42, pressures at the end of charge were 95 psia and the temperatures of the side of the cells with PVC were 4°C above ambient.

10. Cycled as pack 78N:

a. Parameters are 60 percent depth of discharge, 2C discharge rate, C charge rate, 40°C and 170 percent recharge.

b. After 45 cycles, the pressures and temperatures had stabilized. The sides of the cells with the PVC were 7 to 9°C above the ambient temperature and the sides of the cells without the PVC temperatures were 2 to 3°C above the ambient. The pressures were 150 psia at the end of charge and had decayed to 92 psia at the end of discharge.

11. Cycled as pack 74N:

a. The parameters are 60 percent depth of discharge, 40°C, 2C discharge rate, C charge rate, 200 percent recharge.

b. The cells cycled for 32 cycles and the temperatures and pressures had stabilized. The temperatures at the side of the cells with PVC were 10°C above the ambient, sides of the cells without PVC were 5°C above the ambient temperatures. The pressure at the end of charge was 200 psia and had decayed to 120 psia at the end of discharge.

12. Cycled as pack 78N:

a. The parameters were 60 percent depth of discharge, 40°C, 2C discharge rate, C charge rate, 140 percent recharge.

b. After 44 cycles, the cells were discharged at 2C rate to 0.75 volts and shorted with 0.5 ohm resistors for 16 hours. The results were the same as paragraph II.B.10.b.

13. Cycled as pack 73N:

a. The parameters were 60 percent depth of discharge, 40°C, 2C discharge rate, C charge rate, 110 percent recharge.

b. After 57 cycles, the pressures and temperatures had stabilized. The pressures were 57 psia during the cycling and the temperatures at the sides of the cells with the PVC were 2°C above ambient.

c. The preceding test was the last proofing test. The cells were then cycled as 65N. The parameters were 60 percent depth of discharge, 20°C, 2C discharge rate, C charge rate, 140 percent recharge. The cells went 1058 cycles before cell 2 failed because of low voltage.

APPENDIX C

Test Facilities

TEST FACILITIES

I. TEST FACILITIES

A. The ambient test temperatures of 0°C, +20°C, +30°C, +40°C, +50°C, and +60°C, are maintained by environmental chambers with temperature controls accurate to within ± 1.5°C, whereas test items cycling at +25°C are located in an air conditioned room with other temperature critical equipment and the temperature is maintained at 25°C ±2°C. Several chambers, with a temperature range of -75°C to +175°C, are available for additional tests which require special temperatures.

B. AUTOMATIC DATA ACQUISITION AND CONTROL SYSTEM (ADACS)

1. Brief Summary:

a. The system is capable of testing 200 battery packs with 3000 channels available for data input from these packs.

(1) Each battery pack has its own power supply and system interface, remotely programmed by the system, to provide its test requirements. During test, the system routinely scans each pack's data every 2.4 minutes and compares each data point, whether voltage, temperature, or pressure, with programmed limits to insure that the test items meet their test specifications. If the parameter is out of limits the system will initiate an alarm and also type out a message identifying which pack's parameter was out of limits.

(2) As data is being scanned, it is recorded on magnetic tape and also on a teletype, in report form, if requested.

(3) The system was designed to provide an accuracy of 1.0 millivolt on directly read data such as auxiliary electrode and cell voltages. The accuracy of temperature (thermistor) and pressure (transducer) measurements are 0.05°C and 0.05 psia respectively.

b. The system is organized in three functional hardware groupings as follows:

(1) Computer and computer peripherals:

(a) Honeywell 316 computer and options;

(b) two ASR35 heavy duty teletypes;

(c) Honeywell 316-50 high speed paper tape reader and spooler;

(d) Datum, Inc., Model 5091-H316 magnetic tape I/O system with two tape transports; and

(e) Datum, Inc., Model 6078-H316 mass memory system with 131,000 word drum memory.

(2) Auxiliary digital functions include:

(a) the real time clock, the system shut-down timer and alarm circuits, and medium speed analog input subsystem;

(b) two John Fluke, Model 8300-A digitizers;

(c) 3000-channel reed relay scanner; and

(d) computer interface.

(3) Control subsystem:

(a) 200 control channels providing the digital to resistance conversion and control-relay outputs to the interface between the system and the test items.

2. Measurements:

a. Cell voltages are presented directly to the system. Throughput measurement is 1.0 millivolt maximum.

b. Currents are measured by means of sampling the voltage drop across a low-resistance shunt of 100 MV full current value. Throughput measurement error of the shunt voltage is 1 millivolt maximum.

c. Temperatures; cell and ambient, are measured by means of sampling the output of a thermistor bridge which is driven by an excitation voltage. The temperature range is -30°C to +70°C and is resolved in increments of 0.1°C, with an error of less than 0.05°C resulting from linearity.

d. Cell pressures are measured by means of sampling the output of a pressure transducer which is driven by an excitation voltage. The pressure range is 0 to 300 psia, and is resolved in increments of 0.1 psia with an error of less than 0.05 psia resulting from linearity.

e. Battery pack voltages, which exceed 10 volts, are attenuated by resistors to the extent that the scanner system measures a maximum of 10 volts.

3. Expandability:

a. The system is expandable on a modular plug-in cabled-together basis up to a maximum of 5000 analog input channels, and 256 control output channels.

b. The computer memory may be expanded to 32,000 words and an additional drum mass memory may be added.

4. Calibration:

a. The system was designed for a maximum throughput measurement error of 1.0 millivolt.

b. The digitizers are routinely calibrated off-line, and when on-line, measures the temperature and pressure bridge excitation voltages along with a secondary standard reference voltage each scan (2.4 minutes) to insure maximum system accuracy.

C. INTERFACE CONTROLS

1. The control units for charge and discharge of the cells are controlled by the relays that are on the D/R cards of the ADACS. The D/R cards can control the voltage and current on a power supply up to 1/256 of current or voltage required. Figure 5 is the wiring diagram for the control unit for the power supplies of a multi-pack and Figure 6 is the wiring diagram for the control unit for a single pack testing. Photograph 2 shows a typical 5-cell pack. The control unit shown was used only during the base line tests so that single cells could be removed. This unit was not controlled by ADACS cards but by manual control.

II. GENERAL REQUIREMENTS FOR TEST ITEMS AND FACILITIES

A. TRANSDUCERS

1. When handling cells with transducers, care is taken to support the transducer during handling so that the fill tube/cell header joint is not stressed.

2. When removing pressure transducers from a cell, open end wrenches are used on Swagelok fittings only.

3. After removing the pressure transducer from a cell, it is stored in a sealed polyethylene bag except for postcalibration.

4. In the calibration of pressure transducers, only water pumped nitrogen is used.

B. TEMPERATURE CHAMBER BREAKDOWN

1. When temperature chamber breakdown occurs, the following procedures apply:

a. continue packs to end of discharge at the cycle rate; and

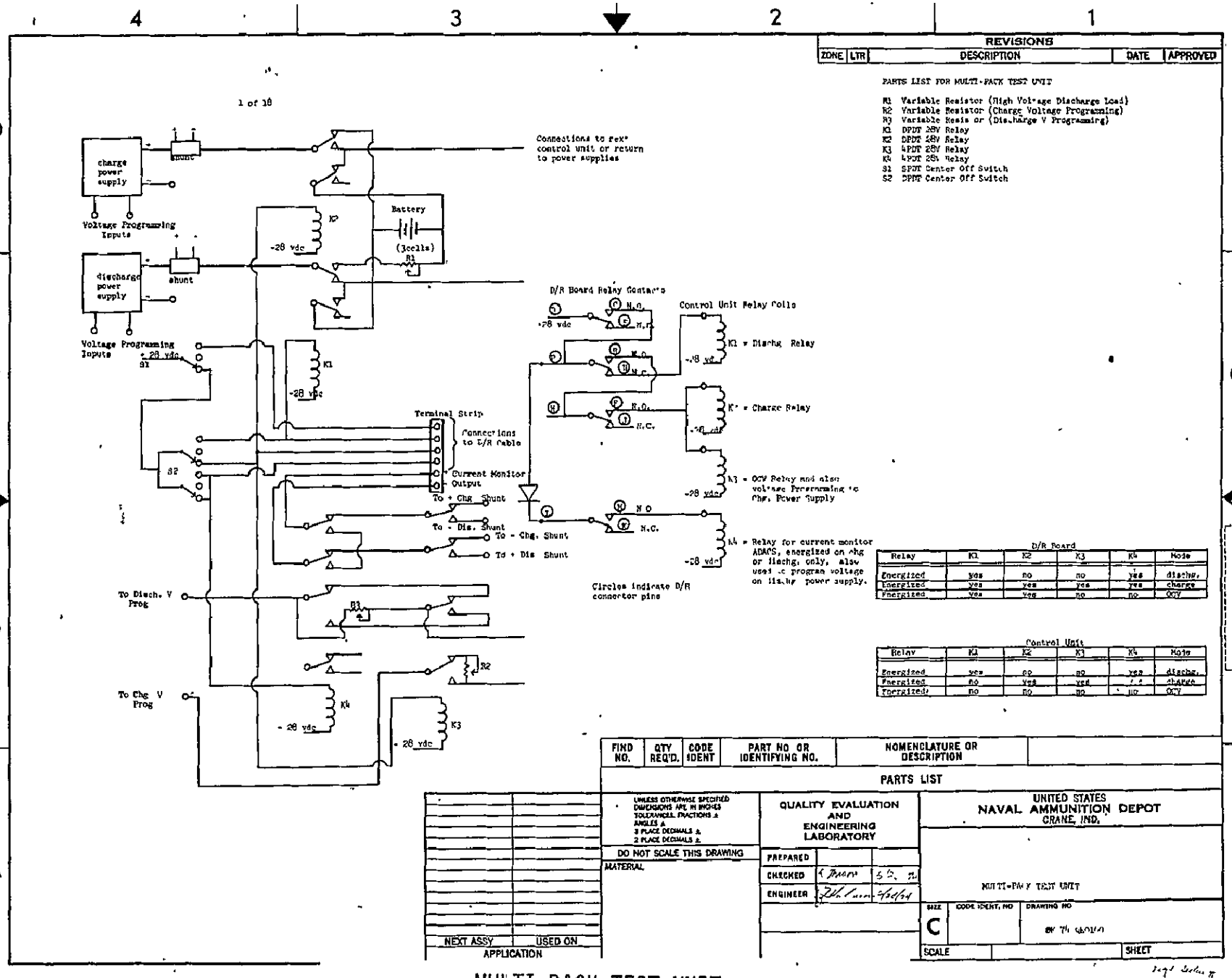
b. Put packs on open circuit and monitor once every hour.

c. Following chamber repair, bring chamber up to test temperature and condition packs for 8 hours. Monitor thermisters on packs to assure pack temperatures are constant ($\pm$2°C) for 1 hour.

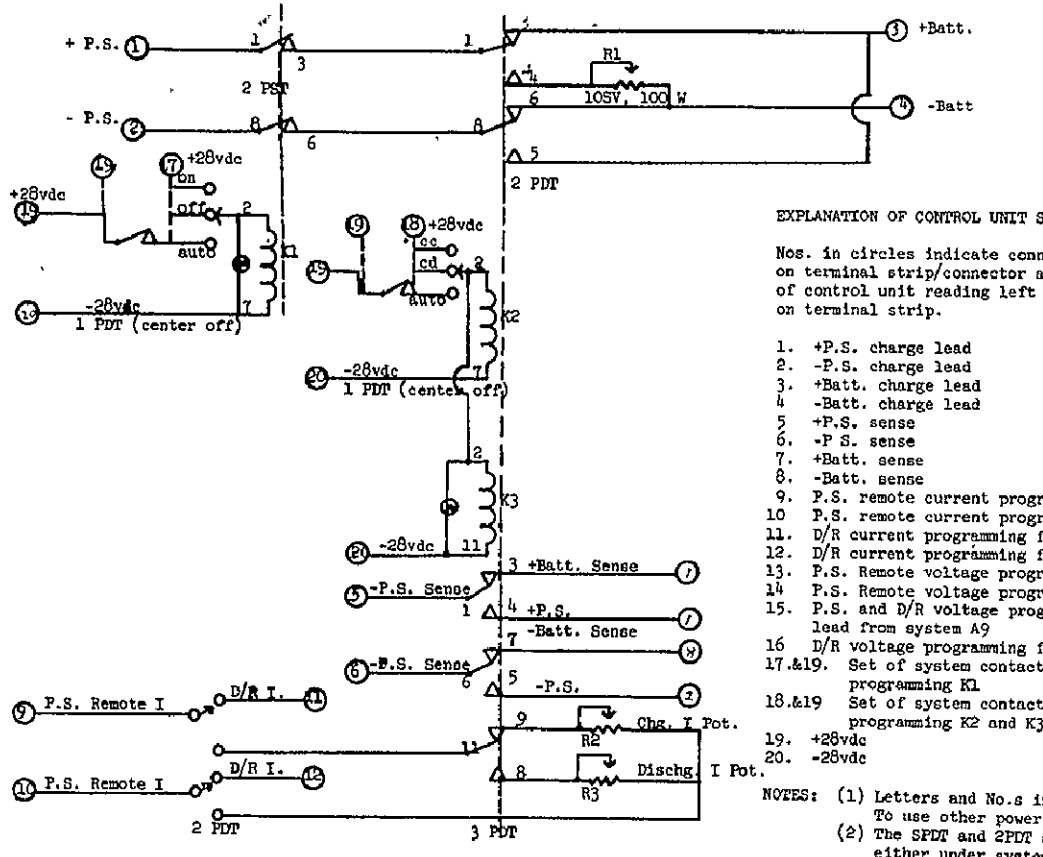
NOTE: A log book is maintained on each chamber to record temperature chamber anomalies and breakdowns and procedure used to return packs to cycling.

2. Cycling is resumed on cyclic charge.

3. A log book is maintained on each pack for any downtime of the ADACS.



MULTI-PACK TEST UNIT
FIGURE 5



EXPLANATION OF CONTROL UNIT SCHEMATIC

Nos. in circles indicate connections on terminal strip/connector at rear of control unit reading left to right on terminal strip.

1. +P.S. charge lead
2. -P.S. charge lead
3. +Batt. charge lead
4. -Batt. charge lead
5. +P.S. sense
6. -P S. sense
7. +Batt. sense
8. -Batt. sense
9. P.S. remote current programming A5
10. P.S. remote current programming A1
11. D/R current programming from system
12. D/R current programming from system
13. P.S. Remote voltage programming A6
14. P.S. Remote voltage programming A8
15. P.S. and D/R voltage programming lead from system A9
16. D/R voltage programming from system
17.&19. Set of system contacts for programming K1
18.&19. Set of system contacts for programming K2 and K3
19. +28vdc
20. -28vdc

NOTES: (1) Letters and No.s in circles correspond to terminal strip connections on A 6284A Power Supply. To use other power supplies --check power supply manuals.
(2) The SPDT and 2PDT switches are used to place the control of the pack (current and voltage) either under system control or local control.
(3) Numbers that are indicated at relay connections refer to pin socket numbers used for that relay.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST FOR WIRING DIAGRAM OF CONTROL UNIT

2ea Lamp holders
2ea. Lamps, #327
2ea SPDT, Center-off switches
1ea. SPDT switch
1ea. DPDT switch
1ea. Terminal strip, 20 position
1ea. Relay, K1, DPST, 10A 24 vdc
1ea. Relay, K2, DPDT, 10A 24 vdc
1ea. Relay, K3, 3PDT, 5A 24 vdc
1ea. Resistor, variable, R1
2ea. Resistor, variable, R2 and R3

NEXT ASSY	USED ON	
APPLICATION		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES FRACTIONS ± ANGLES ± 3 PLACE DECIMALS ± 2 PLACE DECIMALS ±
DO NOT SCALE THIS DRAWING
MATERIAL

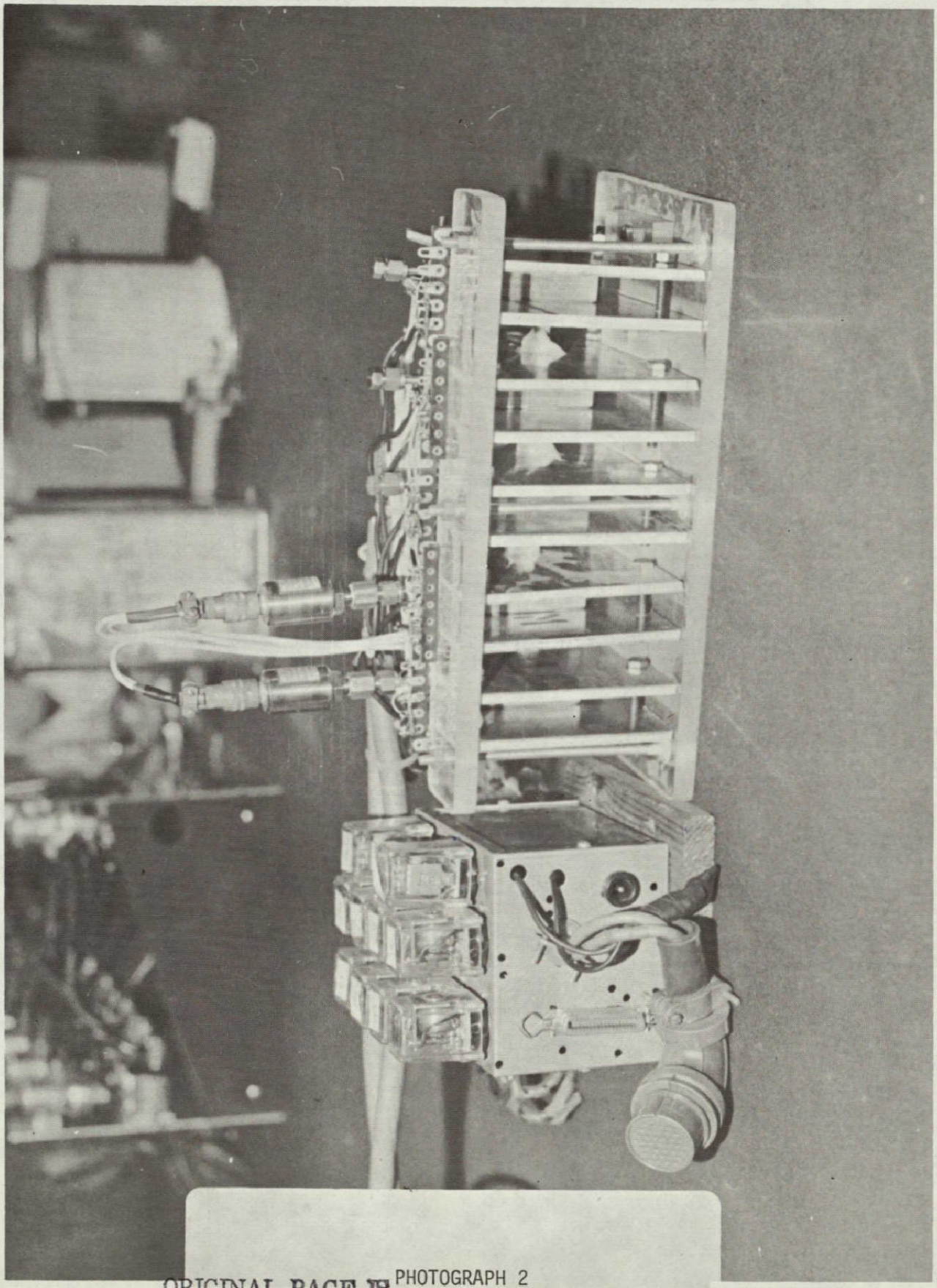
QUALITY EVALUATION AND ENGINEERING LABORATORY
PREPARED
CHECKED
ENGINEER

UNITED STATES
NAVAL AMMUNITION DEPOT
CRANE, IND

WIRING DIAGRAM OF CONTROL UNIT

SIZE B | CODE IDENT. NO. | DRAWING NO. SK 74 QE0035
SCALE | SHEET

SINGLE PACK CONTROL UNIT
FIGURE 6



PHOTOGRAPH 2

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