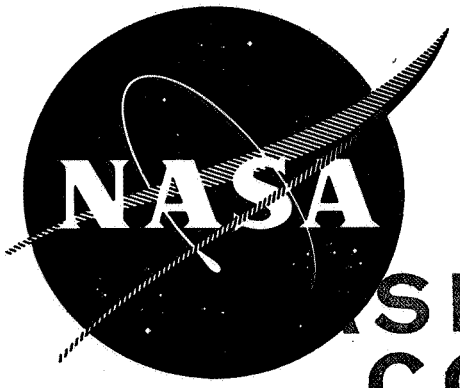

EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST
OF
GULTON INDUSTRIES, INC.
12 AMPERE–HOUR SILVER–CADMIUM CELLS

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT W12–397

QUALITY EVALUATION LABORATORY
NAD CRANE, INDIANA

DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
QUALITY EVALUATION DEPARTMENT
CRANE, INDIANA 47522

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ACCEPTANCE TEST
OF
GULTON INDUSTRIES, INC.
12 AMPERE-HOUR SILVER-CADMIUM CELLS

QE/C 69-660 22 SEPTEMBER 1969

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Enclosure (1)

REPORT BRIEF
GULTON INDUSTRIES
12.0 AMPERE-HOUR SILVER-CADMIUM
SECONDARY SPACECRAFT CELLS

Ref: (a) National Aeronautics and Space Administration Purchase Order W12,397
(b) NASA ltr BRA/VBK/pad of 25 September 1961 w/BUWEPS first end FQ-1:WSK of 2 October 1961 to CO NAD Crane
(c) Work Program for the Evaluation of Silver-Cadmium Cells of 14 January 1965

I. TEST ASSIGNMENT BRIEF

A. In compliance with references (a) and (b), evaluation of Gulton 12 ampere-hour silver-cadmium secondary spacecraft cells was begun according to the program outline of reference (c).

B. The purpose of this acceptance test program is to insure that all cells put into the life cycle program are of high quality by the removal of cells found to have electrolyte leakage, internal shorts, low capacity, or inability to recover open circuit voltage above 1.10 after the cell short test. During the pulse discharge, it is also essential to remove cells not capable of maintaining 0.9 volt. The cells were expected to maintain this voltage until at least 12 ampere-hours had been removed.

C. One hundred cells were purchased from Gulton Industries, Inc., Metuchen, New Jersey, by National Aeronautics and Space Administration (NASA). The cells are rated at 12.0 ampere-hours by the manufacturer.

II. RESULTS

A. All 100 cells leaked.

B. Twenty-three of the cells did not meet the required 12 ampere-hour capacity on third discharge. The capacity of the remaining cells ranged from 12.7 to 17.0 ampere-hours with an average of 15.7 ampere-hours.

C. Twenty-seven of the cells failed the cell short test.

D. Thirty-two of the cells failed to maintain 0.9 volt during pulse discharging at a time corresponding to the removal of the 12 ampere-hour rated capacity.

III. COMMENTS

A. Due to the poor performance of these cells as shown by the listed results, they were not placed on the life cycle program.

RESULTS OF ACCEPTANCE TEST OF 12 AMPERE-HOURS SILVER-CADMIUM SECONDARY SPACECRAFT CELLS MANUFACTURED BY GULTON INDUSTRIES, INC.

I. INTRODUCTION

A. On 18 October 1968 acceptance testing began on 100 cells in groups of 10 as described in paragraph III.A. Testing was completed on these cells on 5 March 1969.

II. TEST PROCEDURE

A. The acceptance test procedure of Goddard Space Flight Center is outlined in the following six steps:

1. Mechanical Leak Test:

a. All cells were washed with distilled water until no evidence of discoloration of pink litmus paper (to blue) was shown by the wash water.

b. The cell closure areas were wiped with wet litmus paper and discoloration (to blue) was noted.

c. The closure areas were sprayed with phenolphthalein solution (clear) and coloration, if any, to pink was noted.

2. Capacity Test: Capacities were determined at the c/4 rate. The cells were expected to deliver a minimum of 12 ampere-hours on the third discharge. The following sequence was performed three times.

a. The cells were charged in packs of 10 at the c/16 rate to 1.60 volts per cell, average--16.0 volts total.

b. The cells were placed on open circuit for 24 hours.

c. The cells were discharged at the c/4 rate to 1.00 volt per cell.

3. Cell Short Test:

a. The terminals of each cell were shorted with a 0.2 ohm resistor for 16 hours.

b. The resistors were removed and the cells were placed on open circuit for 1 week.

c. Individual cell voltages at the end of each 24-hour period were recorded.

NOTE: At the end of 1 week, open circuit voltages were expected to be greater than 1.10 volts.

4. Mechanical Leak Test:

a. The cell closure areas were wiped with wet litmus paper and discoloration (to blue) was noted.

b. The closure areas were sprayed with phenolphthalein solution (clear) and coloration, if any, to pink was noted.

c. All cells were washed with distilled water until no evidence of discoloration of pink litmus paper (to blue) was shown by the wash water.

5. Overcharge Test:

a. The cells were charged at the c/16 rate to 1.55 volts per cell, average.

b. The on-charge voltage was then lowered to 1.51 volts per cell, average.

c. The charging was maintained at 1.51 volts per cell, average, for 1 week.

d. During the last 10 minutes of the 1-week charge, the cell lengths were measured and recorded.

NOTE: These cells were unrestrained. The expansion of the individual cell was expected to be less than that caused by a pressure of 30 pounds per square inch absolute.

e. Following the 1-week overcharge, the cells were discharged at the c/4 rate to 1.00 volt per cell. During the discharge the cells were subjected to a 15 ampere pulse for 60 milliseconds. The pulses were applied at 1 minute and at each hour after the start of discharge.

NOTE: The voltage of each cell was expected to remain at 0.9 volt or above during the 15-ampere pulses as recorded on a high speed recorder until at least 12 ampere-hours had been removed.

6. Mechanical Leak Test:

a. Procedure described in paragraph II.A.4. was repeated.

B. All charging and discharging was done at constant current (+ 5 percent). Cells were charged in series, in packs of 10 cells, but discharged individually.

C. With few exceptions, all cells were subjected to the entire acceptance test as outlined even though many cells failed one or more portions of the test.

III. CELL IDENTIFICATION AND DESCRIPTION

A. The 100 cells were identified by the manufacturer's serial numbers from 111 through 210, and as packs of 10 cells each, numbered J-1-8 through J-10-8 at NAD Crane. The "J" and "8" of the 10 pack numbers signify that the acceptance tests started in October 1968.

B. These cells are rectangular with an average height (base to top of positive terminal), length, and width of 4.366, 1.057 and 2.322 inches respectively. The average weight is 402.1 grams. The individual cell dimensions and weight are given in Table I. One of these cells is shown in Figure 1.

C. The cell containers and covers are made of molded nylon, and serve as an insulator for the terminals. The terminals are set in molded seats which protrude approximately 1/16 inch above the top casing. The "screw-lock" filler plug, also of molded nylon, is located between the two terminals.

IV. RESULTS

A. Mechanical Leak Tests:

1. Mechanical leak tests were run upon receipt, following the cell short test and after the overcharge test.

2. All of the cells leaked during one or more of these tests. Ninety-three cells failed the initial and succeeding leak tests. All leaks were primarily around the terminals. However, a substantial number of leaks occurred around the filler cap and case-to-top seam following the cell short and overcharge tests.

3. The cases of two cells, one of which leaked initially, were ruptured during pressure testing. Therefore, only two cells were so tested because the cases could not withstand the specified (unrestrained) internal pressure of 65 pounds per square inch absolute. Paragraphs II.A.5.d. and IV.D.5 describe the attempted cell pressure tests. Six additional cells ruptured following the cell short and/or overcharge tests. The results of the three mechanical leak tests are summarized in Table II.

B. Capacity Tests:

1. The individual cells were expected to deliver at least 12.0 ampere-hours at the c/4 rate on the third capacity check. Of the 100 cells tested, 23 did not meet this requirement. Table III is a summary of the three capacity checks. Table IV presents a summary of the 23 capacity failures. With few exceptions, the capacity of the cells in Table IV dropped rapidly with each succeeding check.

2. Figure 2 presents capacity differences, ΔC, through the use of histograms. The differences (ΔC_1, ΔC_2 and ΔC_3) are respectively the differences between capacity checks 2 and 1, 3 and 2, and 3 and 1. The ΔC's are positive if increasing and negative if decreasing. The histograms "channel" the data into capacity intervals by frequency and show the following:

a. The capacity tends to increase in the second check over that of the first--ΔC_1.

b. The trend is toward decreasing capacity in ΔC_2.

c. Overall capacity, ΔC_3, tends to be more evenly distributed except for the low end. This latter point indicates that nine percent of the cells dropped 4.5 or more ampere-hours of capacity overall.

3. Figure 3 shows representative discharge characteristics for high, modal and low capacity cells. Of the higher performing cells, the first part of the curve extends out to the 1-hour time interval before leveling off. This is the area in which silver in the high oxidation state is discharged. Afterward the cell voltage levels off corresponding to silver in the low oxidation state.

C. Cell Short Test:

1. Internal shorts are indicated in cells that fail to recover their open circuit voltages, to a minimum of 1.10 volts following a 1-week stand after a complete discharge. Twenty-four cells failed this test. Table III includes a listing of all cell recovery voltages.

D. Overcharge Test:

1. The purpose of this test is basically threefold:

a. To determine the degree to which a pack of cells maintain a balanced voltage.

b. To determine the cells capability of reaching a point of chemical equilibrium--oxygen recombination with the negative (cadmium) plate.

c. To test the integrity of the seals as the pressure increases.

2. Table III includes, by 10-cell packs, the overcharge voltages of all cells at the end of the 7-day charge. It indicates poor cell balance in most packs. Secondly it does not indicate a definite equilibrium voltage. Thirdly Table II indicates that the integrity of the seals is nil before and after this overcharge.

3. Figure 4 is a graph of the characteristic overcharge performance for high, modal and low cells. This graph indicates a considerable lack of stability in the overcharge voltage.

4. Pulse Discharge--See Paragraph II.A.5.e.:

a. The histograms of figures 5, 6 and 7 show the distribution of cell voltages during the 60-millisecond pulse discharges after 1 minute, 1 hour, 2 hours...., and 7 hours of discharge. In all time invertals, even after 1 minute, at least 20 percent of the cells failed the test as indicated by the dotted bars. This number gradually increased until, after 4 hours of discharging at the c/4 rate (12 ampere-hours removed), 32 percent of the cells failed.

NOTE: The acceptable area above 0.9 volt has been divided from the rest of the histrograms by a heavy line.

b. Figure 8 is a graph of the discharge during the superimposed pulse discharge. The same cells were graphed as

those during the 1-week overcharge of Figure 4 except cell number 131 had failed after the first minute and cell 196 was graphed in its place for the low capacity representative.

5. Internal Pressure Test (See Paragraph II.A.5.d.):

a. These cells were not equipped with pressure gauges. Thus the distortion (bulging) of the nylon cell case was compared to the initial length of the cell as the criterion for pressure measurement.

b. Two cells (141 and 155) were pressurized on the absolute scale from 10 to 30 psia at intervals of 5 psia. Their lengths were measured and recorded at each pressure interval for standardization purposes. A portion of Figure 9 plots absolute pressure against case length for these cells. Both cell cases ruptured between 30 and 35 psia.

c. Figure 9 also gives the change in length (Δl) that both cells experienced at 30 psia--the upper pressure limit expected during testing even though the cases were expected to withstand 65 psia. The Δl for cell 141 was 0.314 inches and that of cell 155 was 0.321 inches.

d. The remaining data of Figure 9 is a histogram of change of length (Δl) for each cell. The implication from this data alone is that the 92 nonruptured cells remained within the pressure limits. However it has already been shown that these cells were poorly sealed and could therefore relieve themselves under pressure. Therefore the exact pressure these cells might have seen had the seals been good is not known.

TABLE I

Pack Number	Cell Number	Weight (Grams)	Height (Inches)	Length (Inches)	Width (Inches)	Pack Number	Cell Number	Weight (Grams)	Height (Inches)	Length (Inches)	Width (Inches)
J-1-8	111	393.4	4.375	1.057	2.335	J-2-8	121	397.7	4.372	1.056	2.312
	112	401.3	4.368	1.058	2.312		122	395.1	4.351	1.056	2.310
	113	398.5	4.357	1.072	2.344		123	395.1	4.355	1.063	2.321
	114	394.8	4.276	1.052	2.314		124	395.1	4.368	1.056	2.315
	115	394.0	4.395	1.056	2.309		125	394.2	4.335	1.056	2.324
	116	399.0	4.396	1.056	2.319		126	396.4	4.385	1.064	2.319
	117	395.3	4.380	1.069	2.313		127	396.0	4.364	1.065	2.307
	118	396.8	4.341	1.057	2.318		128	390.8	4.348	1.058	2.314
	119	397.3	4.370	1.056	2.323		129	395.1	4.372	1.059	2.318
	120	406.0	4.359	1.056	2.309		130	393.9	4.371	1.058	2.310
J-3-8	131	413.7	4.375	1.057	2.322	J-4-8	141	395.6	4.350	1.056	2.344
	132	398.5	4.357	1.057	2.314		142	397.6	4.356	1.055	2.350
	133	391.2	4.357	1.057	2.318		143	405.3	4.393	1.053	2.352
	134	394.1	4.368	1.055	2.313		144	391.0	4.367	1.054	2.316
	135	395.7	4.355	1.058	2.326		145	410.3	4.371	1.050	2.350
	136	405.2	4.369	1.057	2.308		146	396.7	4.385	1.058	2.311
	137	407.2	4.360	1.052	2.313		147	399.2	4.372	1.055	2.313
	138	391.6	4.364	1.060	2.316		148	396.5	4.330	1.048	2.343
	139	395.4	4.344	1.055	2.303		149	396.4	4.391	1.056	2.314
	140	393.7	4.400	1.050	2.319		150	409.4	4.382	1.054	2.322

TABLE I (Contd)

Pack Number	Cell Number	Weight (Grams)	Height (Inches)	Length (Inches)	Width (Inches)	Pack Number	Cell Number	Weight (Grams)	Height (Inches)	Length (Inches)	Width (Inches)
J-5-8	151	393.8	4.380	1.048	2.345	J-6-8	161	394.4	4.346	1.053	2.323
	152	395.7	4.370	1.058	2.319		162	392.0	4.347	1.050	2.318
	153	390.7	4.362	1.051	2.310		163	406.8	4.368	1.052	2.314
	154	391.3	4.355	1.054	2.314		164	395.3	4.350	1.052	2.300
	155	395.5	4.373	1.064	2.318		165	400.9	4.375	1.054	2.318
	156	395.0	4.358	1.056	2.320		166	396.0	4.410	1.047	2.313
	157	399.5	4.355	1.065	2.313		167	398.7	4.353	1.055	2.315
	158	393.9	4.372	1.058	2.315		168	393.4	4.358	1.061	2.310
	159	397.0	4.372	1.053	2.345		169	396.9	4.350	1.055	2.351
	160	394.3	4.367	1.052	2.313		170	397.5	4.375	1.058	2.330
J-7-8	171	403.3	4.372	1.051	2.322	J-8-8	181	396.9	4.384	1.055	2.335
	172	396.5	4.368	1.055	2.321		182	393.8	4.360	1.055	2.315
	173	397.8	4.357	1.048	2.350		183	398.4	4.358	1.050	2.315
	174	394.2	4.366	1.057	2.315		184	393.8	4.365	1.060	2.319
	175	406.8	4.397	1.056	2.314		185	395.6	4.350	1.050	2.350
	176	395.5	4.368	1.051	2.324		186	396.4	4.384	1.053	2.345
	177	398.2	4.371	1.052	2.320		187	407.5	4.369	1.081	2.330
	178	403.6	4.347	1.050	2.324		188	395.6	4.353	1.052	2.313
	179	389.4	4.372	1.056	2.313		189	395.5	4.344	1.050	2.312
	180	393.0	4.375	1.050	2.354		190	393.9	4.368	1.052	2.323

TABLE I (Contd)

Pack Number	Cell Number	Weight (Grams)	Height (Inches)	Length (Inches)	Width (Inches)	Pack Number	Cell Number	Weight (Grams)	Height (Inches)	Length (Inches)	Width (Inches)
J-9-8	191	404.5	4.346	1.051	2.318	J-10-8	201	394.0	4.367	1.057	2.314
	192	494.4	4.355	1.060	2.322		202	399.6	4.339	1.058	2.321
	193	396.0	4.361	1.056	2.310		203	387.1	4.381	1.054	2.332
	194	396.7	4.337	1.060	2.350		204	394.2	4.387	1.060	2.325
	195	398.4	4.357	1.053	2.311		205	396.7	4.353	1.054	2.337
	196	402.9	4.362	1.088	2.335		206	396.3	4.392	1.056	2.334
	197	400.8	4.347	1.069	2.327		207	397.0	4.375	1.055	2.318
	198	400.5	4.383	1.088	2.325		208	398.2	4.369	1.058	2.324
	199	399.3	4.370	1.075	2.322		209	399.0	4.365	1.055	2.318
	200	394.4	4.350	1.056	2.315		210	395.6	4.415	1.057	2.326

TABLE II

Leak Test Data

Pack Number	Cell Number	INITIAL Terminals Pos	INITIAL Terminals Neg	INITIAL Top Seal	INITIAL Cap	AFTER CELL SHORT TEST Terminals Pos	AFTER CELL SHORT TEST Terminals Neg	AFTER CELL SHORT TEST Top Seal	AFTER CELL SHORT TEST Cap	AFTER OVERCHARGE Terminals Pos	AFTER OVERCHARGE Terminals Neg	AFTER OVERCHARGE Top Seal	AFTER OVERCHARGE Cap
J-1-8	111	VS	L			L	VS				L		
	112	VS	L		VS	L	L			L	VS		
	113	L	L			L	L			VS	L		
	114	L	L		VS	L	L		L	VS	VS		
	115	VS	L			L	L				VS		
	116	VS	L			L	L				L		
	117	L	L		VS	L	L			VS	VS		
	118	L	L		VS	L	VS			L	L		
	119	VS	L			L	L			L	L		
	120	L	L		L	L	L		VS		L		
J-2-8	121	VS	L				L				L		
	122	L	L			VS	L			L	L		
	123	VS	VS			VS	L						*
	124	VS	L			VS	VS				L		L
	125	VS	VS			VS	VS			L			
	126	L	L			VS	VS						
	127	L	VS		L		L		L				L
	128	L	L			L	L			VS	VS	L	L
	129	L	L			L	L				L		
	130	L	L			VS	L				L		
J-3-8	131	VS	VS				L			VS	VS		
	132	VS	VS			L	L		L	VS	VS		L
	133	L	L			L	L		L	L	L	L	L
	134	L	L			L	L	L*		VS	L	L	
	135	L	L			L	L		L	L	L	L	
	136	VS	L			L	L		L	L	L		L
	137					VS	VS		VS				
	138		L			L	L		L	L	L	L	L
	139		L			VS	L		VS				
	140		L			L	L		L				VS

L - Definite Leak
VS - Very Slight
* - Ruptured case unless noted in a column pertaining to "Top Seal" or "Cap"-- also the rupture occurred during overcharge unless noted otherwise in the table.
** - Cell ruptured from initial pressure testing.

TABLE II (Contd)

Pack Number	Cell Number	INITIAL Terminals Pos	INITIAL Terminals Neg	INITIAL Top Seal	INITIAL Top Cap	AFTER CELL SHORT TEST Terminals Pos	AFTER CELL SHORT TEST Terminals Neg	AFTER CELL SHORT TEST Top Seal	AFTER CELL SHORT TEST Top Cap	AFTER OVERCHARGE Terminals Pos	AFTER OVERCHARGE Terminals Neg	AFTER OVERCHARGE Top Seal	AFTER OVERCHARGE Top Cap	
J-4-8	141					VS	VS				L	L		**
	142		L				VS			VS		L	L	*
	143		L			L	L			L	L		L	
	144	VS	L			L	L			L	L	L	L	
	145	VS	VS			L				L	L		L	
	146					VS	L			VS	L		L	
	147	L				L	L			L	L		L	
	148	VS	L			L	L			L	L		L	
	149					VS	L			VS	L		VS	
	150	VS	Ruptured on stand following final capacity discharge											*
J-5-8	151	VS	VS		VS	L	L			L			L	
	152		L			VS	L			L	L			
	153	Ruptured during second capacity discharge												*
	154	VS	L			L	L			L	L			
	155	L	L	L		L	L	L		L	L	L		**
	156		VS			L	L			L	L		L	
	157		VS			VS	L				L		VS	
	158	VS	VS			L	VS	L		L	L	L	L	
	159	L	VS			L	VS			L	L		L	
	160	L	L			VS	L			L	L		L	
J-6-8	161	VS	L			L	L	L		L	L	L	L	
	162		L			VS	L			VS	L			
	163		L			L	L			L	L		L	
	164		L			L	L			L	L		L	
	165		VS			L	L			L	L		L	
	166	VS	L			L	L		L		L		L	
	167	L				L	L			VS	L			
	168	VS	VS			L	L		L	L	L		L	
	169	VS	VS			L	L			L	L		L	
	170	L				L	L		L	L	L		L	

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VS - Very slight
* - Ruptured case unless noted in a column pertaining to "Top Seal" or "Cap"-- also the rupture occurred during overcharge unless noted otherwise in the table.
** - Cell ruptured from initial pressure testing.

TABLE II (Contd)

Pack Number	Cell Number	INITIAL Terminals Pos	Terminals Neg	Top Seal	Cap	AFTER CELL SHORT TEST Terminals Pos	Terminals Neg	Top Seal	Cap	AFTER OVERCHARGE Terminals Pos	Terminals Neg	Top Seal	Cap
J-7-8	171	L	L			VS	L			VS	L		
	172	L					L				L		
	173	L	L		L	L	L	L	VS	L	L	L	L
	174	L	L		L	L	L	L		L	L	L	VS
	175	L	L		L	L	L		L	L	L		VS
	176	L	L			VS	L		VS	L	L		L
	177	VS	L			VS	L			L	L		
	178	L											
	179	L	L			L	L		L	L	L		
	180	L	L		L	VS	L			L	L	L	
J-8-8	181	L	L		VS	L	L	L	L	VS	L	L	L
	182	L	L		L	L	L	L	VS	L	L	L	L
	183	L	L		L	L	L		L	L	L		L
	184	L	L			VS	L		VS	VS	L		L
	185	L	L			L	VS						
	186	L	L		VS	L	L		VS	VS	VS		
	187	L	L		L	L	L			L	VS		
	188	L	L		L	L	L			VS	L		
	189	L	L			L	L			VS	L		
	190	L	VS		VS	L	L	L	L	L	L		L
J-9-8	191		VS		VS	L	L			L	L		L
	192		VS		VS	L	L	L	L	L	L		L
	193	VS	L		L	L	L			L	L	L	L
	194	VS	VS		VS	L	L		VS	L	L		L
	195		L			VS	L		L	L	L		L
	196	VS	VS		VS	L	VS			L	L		
	197						VS			L	L		L
	198	VS	VS		VS	L	L		L	L	L		L
	199				VS	VS				L	L		L
	200	VS	VS			L	VS			L	L		

L - Definite Leak
.. - Very slight
* - Ruptured case unless noted in a column pertaining to "Top Seal" or "Cap"-- also the rupture occurred during overcharge unless noted otherwise in the table.
** - Cell ruptured from initial pressure testing.

TABLE II (Contd)

Pack Number	Cell Number	INITIAL Terminals Pos	Terminals Neg	Top Seal	Cap	AFTER CELL SHORT TEST Terminals Pos	Terminals Neg	Top Seal	Cap	AFTER OVERCHARGE Terminals Pos	Terminals Neg	Top Seal	Cap
J-10-8	201	VS	L			L	L		L		L		L
	202	VS	VS		VS	VS	VS			L	L		
	203	VS	VS		VS	L	VS		L	L	L		L
	204	L	VS			L	L		L	L	L		L
	205	L	VS		L	L	L			L	L		L
	206	L	VS	Ruptured on open circuit following 3rd capacity discharge									
	207	L	L			L				L			VS
	208	VS	L			L	L		L	L	L		L
	209	L	L		VS	L	L	L	L	L	L	L	L
	210		VS		VS	L	L			L	L		VS

L - Definite leak
VS - Very slight
* - Ruptured case unless noted in a column pertaining to "Top Seal" or "Cap"--also the rupture occurred during overcharge unless noted otherwise in the table.
** - Cell ruptured from initial pressure testing.

TABLE III

Pack Number	Cell Number	Capacity #1 (ah)	Capacity #2 (ah)	Capacity #3 (ah)	After 1 Week Overcharge: Open Circuit Voltage	After 1 Week Overcharge: Overcharge Voltage	After 1 Week Overcharge: Hours to Discharge	Voltage After 60 Milliseconds at Indicated Ampere-Hour Intervals: 0.06 ah	3 ah	6 ah	9 ah	12 ah	15 ah	18 ah	21 ah
J-1-8	111	15.5	15.3	16.0	0.88	1.99	7	1.04	0.90	0.98	1.01	1.01	1.00	0.99	0.83
	112	13.9	15.4	15.8	1.14	1.44	7	1.10	0.97	1.02	1.02	1.02	1.01	0.99	0.76
	113	14.6	15.4	16.0	1.14	1.43	7	1.07	1.00	1.01	1.00	1.00	1.00	0.98	0.80
	114	14.8	15.7	16.0	1.14	2.03	7	1.11	0.89	0.94	0.95	0.95	0.94	0.93	0.74
	115	14.7	15.2	15.8	0.94	2.11	6	1.15	0.94	0.99	0.99	0.98	0.98	0.94	
	116	14.0	13.6	13.8	1.15	1.10	0	0.65							
	117	12.8	12.9	13.5	0.05	1.11	0	0.00							
	118	15.2	15.1	15.7	1.15	1.44	7	0.98	0.92	0.97	0.98	0.98	0.97	0.96	0.80
	119	14.1	13.8	14.3	1.15	1.74	7	1.07	1.02	1.03	1.03	1.03	1.02	1.01	0.80
	120	12.8	12.5	9.0	1.00	0.59	0	0.00							
J-2-8	121	15.5	15.6	16.0	1.14	1.58	7	1.05	0.94	1.02	1.02	1.01	1.01	0.98	0.80
	122	14.8	15.8	16.0	1.14	2.11	7	1.16	0.94	0.97	0.97	0.97	0.97	0.97	0.82
	123	14.3	15.7	15.6	1.15	1.55	7	1.06	0.94	0.95	0.97	0.97	0.96	0.94	0.67
	124	14.7	15.8	15.7	1.13	1.78	7	1.13	0.96	1.02	1.02	1.02	1.01	0.98	0.78
	125	14.3	14.8	13.8	1.14	1.56	7	1.17	0.97	1.02	1.02	1.01	1.02	1.01	0.83
	126	14.7	14.9	13.5	1.14	1.42	6	1.18	0.96	1.02	1.03	1.02	1.01	0.92	
	127	12.8	10.5	4.5	0.02	0.23	0	0.00							
	128	10.3	6.5	6.8	1.13	1.12	2	0.98	0.85						
	129	0.0	0.0	0.0	0.00	0.00	0	0.00							
	130	14.4	15.3	15.8	1.15	2.15	7	1.12	0.91	0.97	0.97	0.97	0.93	0.79	0.14
J-3-8	131	9.5	2.0	0.0	0.17	0.26	0	0.00							
	132	14.3	15.4	14.8	1.14	1.44	3	0.96	1.02	0.98	0.99				
	133	14.6	15.9	15.2	1.14	1.99	6	1.02	0.93	1.02	0.99	0.99	1.00	0.98	
	134	3.8	4.2	5.6	1.13	1.13	1	0.98	0.96						
	135	15.8	15.6	15.2	0.68	2.05	6	1.08	0.93	1.00	1.01	1.00	0.99	0.96	
	136	12.2	12.5	11.0	1.13	1.65	3	1.04	1.02	1.02	0.93				
	137	9.4	8.4	6.3	1.13	1.11	0	0.00							
	138	14.9	15.5	14.7	1.13	2.01	6	1.11	0.94	0.98	0.98	0.98	0.94	0.93	
	139	14.5	16.0	15.4	1.14	1.40	4	0.97	1.01	1.01	1.00	0.80			
	140	15.5	15.7	15.2	1.12	1.99	6	1.17	0.95	1.01	1.00	1.00	1.00	0.97	

TABLE III (Contd)

Pack Number	Cell Number	Capacity #1 (ah)	Capacity #2 (ah)	Capacity #3 (ah)	After 1 Week Overcharge: Open Circuit Voltage	After 1 Week Overcharge: Overcharge Voltage	After 1 Week Overcharge: Hours to Discharge	Voltage After 60 Milliseconds at Indicated Ampere-Hour Intervals: 0.06 ah	3 ah	6 ah	9 ah	12 ah	15 ah	18 ah	21 ah
J-4-8	141	14.0	16.0	16.7	1.14	1.93	7	1.15	0.97	1.01	1.01	1.01	1.00	0.98	0.78
	142	9.7	12.8	10.8	1.14	1.10	0	0.69							
	143	5.9	1.5	1.7	0.23	0.43	0	0.00							
	144	14.9	16.0	16.6	1.14	2.08	7	1.04	0.95	1.02	1.03	1.03	1.03	1.01	0.82
	145	14.3	15.9	16.4	1.13	1.42	6	0.95	0.96	1.02	1.02	1.02	1.01	0.97	
	146	14.3	14.5	14.0	0.02	0.02	0	0.00							
	147	14.6	15.9	16.8	1.14	1.87	7	1.02	0.98	1.02	1.03	1.03	1.02	1.00	0.86
	148	12.4	11.2	8.5	1.14	1.12	3	0.97	0.97	0.95	0.87				
	149	14.5	15.8	14.0	0.89	2.10	6	0.82	0.63	0.70	0.68	0.69	0.68	0.55	
	150	11.8	12.5	10.6	0.56	0.56	0								
J-5-8	151	16.2	16.5	15.2	1.10	1.92	7	1.12	0.94	0.98	0.99	1.00	1.00	0.98	DNR*
	152	15.0	17.0	16.6	1.15	1.40	6	1.15	1.00	1.02	1.02	1.02	1.01	0.97	
	153	15.3	17.3	0.0	1.03		0								
	154	13.3	11.4	5.9	1.04	1.09	0	0.00							
	155	8.7	0.0	0.0	0.00		0								
	156	15.9	11.3	13.5	1.15	1.39	4	0.98	1.03	1.03	1.02	1.02			
	157	15.3	16.9	16.5	1.14	1.47	7	1.15	1.02	1.03	1.03	1.03	1.02	1.00	DNR*
	158	15.8	16.9	16.5	1.14	1.45	6	1.08	1.02	1.03	1.03	1.03	1.02	0.98	
	159	14.9	17.0	17.0	0.46	1.89	6	1.11	0.95	0.98	0.98	0.99	0.99	0.95	DNR*
	160	Bad Position	17.3	16.6	1.13	1.41	6	1.11	0.97	1.02	1.03	1.03	1.03	0.98	
J-6-8	161	15.8	17.6	17.0	1.11	1.40	7	1.14	0.94	0.99	0.99	0.99	0.99	0.98	0.63
	162	14.8	16.9	16.2	1.12	1.42	7	1.13	1.00	1.02	1.02	1.02	1.02	1.01	0.84
	163	9.7	9.3	8.3	1.12	1.38	5	0.93	0.97	0.99	0.99	0.98	0.96		
	164	14.9	17.2	16.9	1.13	1.63	7	1.14	0.98	1.01	1.01	1.02	1.01	1.00	0.79
	165	14.6	17.0	16.2	1.13	1.42	7	1.12	0.98	1.01	1.01	1.01	1.00	0.99	0.80
	166	8.3	0.0				0								
	167	10.0	8.6	5.4	1.12		0								
	168	16.5	17.4	16.6	1.13	1.58	7	1.05	0.95	1.00	1.00	1.00	0.99	0.98	0.74
	169	15.7	17.6	16.9	1.13	1.68	7	1.12	0.95	1.00	0.99	0.99	0.99	0.98	0.82
	170	12.7	7.2	5.3	0.00		0								

* DNR: Did not read--pulse not taken.

Table III (Contd)

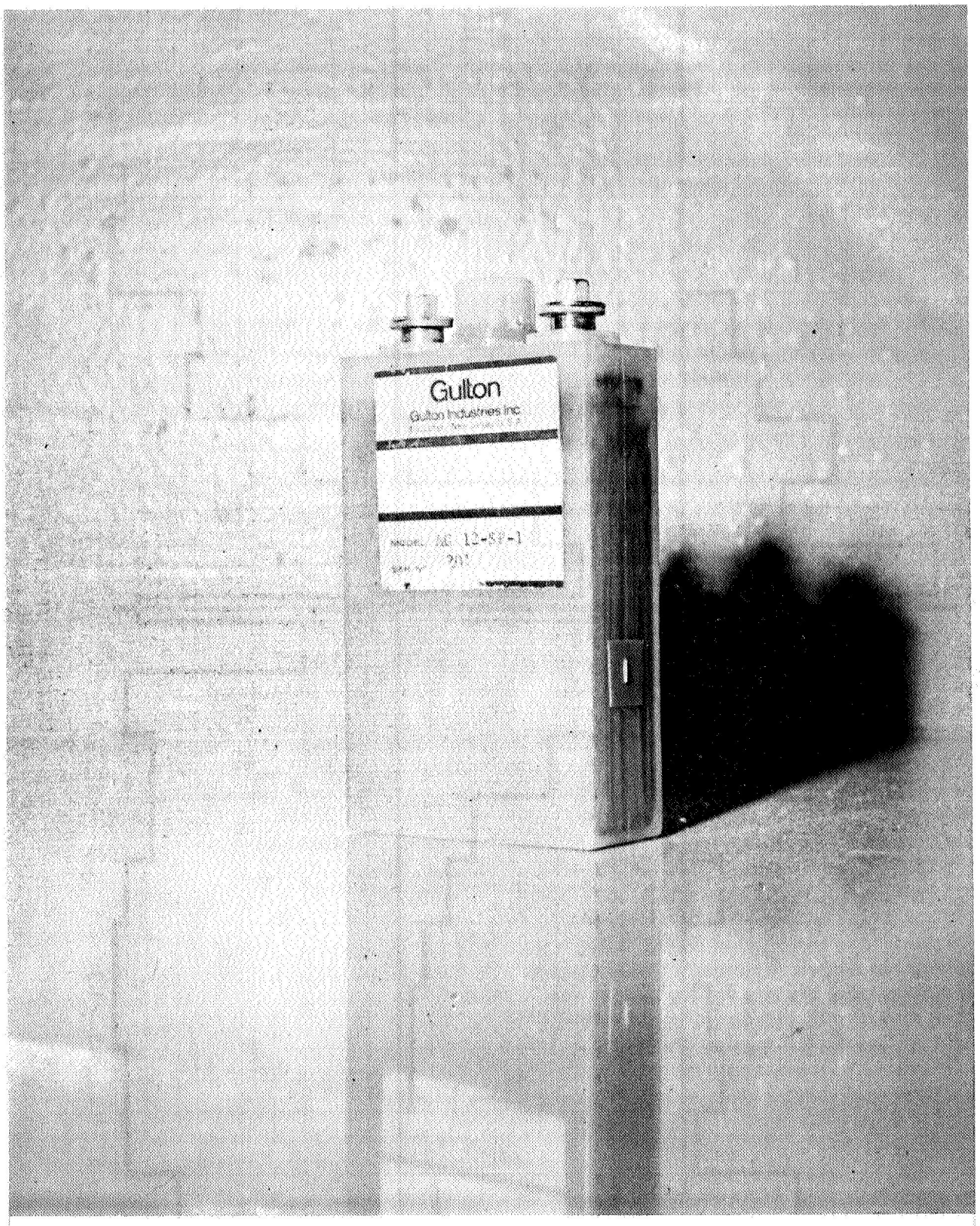
Pack Number	Cell Number	Capacity #1 (ah)	Capacity #2 (ah)	Capacity #3 (ah)	After 1 Week Overcharge: Open Circuit Voltage	Overcharge Voltage	Hours to Discharge	Voltage After 60 Milliseconds at Indicated Ampere-Hour Intervals: 0.06 ah	3 ah	6 ah	9 ah	12 ah	15 ah	18 ah	21 ah
J-7-8	171	14.4	14.3	13.2	1.13	1.39	6	1.12	1.01	1.02	1.02	1.01	1.00	0.79	
	172	16.8	17.3	16.3	1.14	1.73	7	1.15	1.00	1.03	1.03	1.03	1.02	1.01	0.69
	173	17.7	17.2	15.5	1.12	1.52	6	1.17	0.97	1.01	1.01	1.01	1.01	1.00	
	174	17.3	17.2	16.3	1.13	1.81	7	1.24	0.99	1.04	1.04	1.04	1.04	1.01	0.35
	175	16.5	16.8	15.5	1.14	1.39	6	1.10	0.96	1.01	1.02	1.02	1.01	0.93	
	176	16.7	17.3	15.1	1.02	1.38	4	0.95	1.03	1.03	1.03	1.01			
	177	16.8	17.0	15.7	1.14	1.11	4	0.96	1.00	1.00	0.99	0.84			
	178	0.0					0								
	179	17.0	17.2	16.4	1.14	1.75	6	1.10	0.94	0.98	0.99	0.99	0.99	0.93	
	180	17.0	16.9	16.0	1.14	1.44	6	1.22	0.98	1.01	1.01	1.01	1.00	0.98	
J-8-8	181	15.4	16.7	16.3	1.14	1.45	7	Missed	0.98	1.03	1.03	1.03	1.03	1.02	0.82
	182	16.4	17.2	15.8	1.12	1.42	6	1.21	0.98	1.04	1.04	1.03	1.02	0.99	
	183	15.8	16.9	15.6	1.14	1.43	7	1.07	0.96	0.98	0.99	0.99	0.98	0.97	0.88
	184	16.0	16.7	15.6	1.14	1.70	7	1.15	0.97	1.02	1.02	1.02	1.01	0.97	0.62
	185	15.8	17.2	15.9	1.14	1.46	7	1.20	1.00	1.04	1.04	1.04	1.03	1.03	0.85
	186	16.2	16.3	15.6	1.14	1.69	7	1.09	0.96	1.02	1.02	1.02	1.01	0.98	0.68
	187	10.0	9.7	6.8	0.04		0								
	188	13.8	15.2	13.9	1.12	1.43	7	1.10	0.92	0.98	0.99	0.99	0.99	0.96	0.60
	189	13.5	14.6	12.8	1.14	1.42	6	1.15	0.98	1.02	1.02	1.02	1.02	1.00	
	190	15.4	16.7	15.9	1.14	1.44	7	1.14	1.00	1.03	1.03	1.03	1.03	1.02	0.88
J-9-8	191	13.5	12.0	5.0	1.13		0								
	192	16.3	17.0	16.5	1.15	1.76	7	1.23	0.98	1.00	1.00	1.00	0.99	0.96	0.10
	193	17.3	17.3	17.1	1.14	1.63	7	1.16	0.95	1.00	1.00	1.00	1.00	0.97	0.68
	194	16.7	17.1	17.0	1.15	1.40	7	1.22	1.03	1.04	1.05	1.05	1.05	1.03	0.83
	195	16.6	17.0	17.0	1.16	1.83	7	1.24	0.97	1.01	1.00	1.00	1.00	0.98	0.78
	196	15.3	16.4	15.8	1.15	1.12	3	1.03	1.04	1.03	1.00				
	197	16.3	17.1	17.1	1.15	1.44	7	1.02	0.98	1.00	1.01	1.01	1.01	1.00	0.84
	198	16.5	17.2	17.0	1.15	1.38	6	0.98	1.02	1.02	1.02	1.02	1.01	0.85	
	199	16.8	17.0	16.9	1.15	1.71	7	1.17	1.00	1.02	1.03	1.03	1.03	1.01	0.85
	200	16.5	17.3	16.7	1.15	1.28	4	1.02	1.01	1.01	1.01	1.00			

TABLE III (Contd)

Pack Number	Cell Number	Capacity #1 (ah)	Capacity #2 (ah)	Capacity #3 (ah)	After 1 Week Overcharge: Open Circuit Voltage	Overcharge Voltage	Hours to Discharge	Voltage After 60 Milliseconds at Indicated Ampere-Hour Intervals: 0.06 ah	3 ah	6 ah	9 ah	12 ah	15 ah	18 ah	21 ah
J-10-8	201	16.1	16.0	16.5	1.15	1.62	7	1.20	0.96	1.02	1.02	1.02	1.02	1.00	0.93
	202	16.4	16.0	16.5	1.15	1.64	7	1.23	0.95	1.02	1.01	1.01	1.01	0.98	0.82
	203	14.3	13.6	13.5	1.12	1.12	3	0.98	0.98	o.97	0.77				
	204	14.7	14.8	14.7	1.09	1.43	6	1.20	0.97	1.03	1.03	1.03	1.02	0.88	
	205	15.8	16.3	16.6	1.15	1.48	7	1.15	0.92	0.97	0.97	0.97	0.97	0.96	0.78
	206	14.9	13.0	12.7	0.59		0								
	207	15.7	15.9	16.0	1.14	1.41	7	1.07	0.84	0.90	0.80	0.90	0.89	0.85	0.63
	208	15.7	16.6	16.7	1.14	1.51	7	1.20	0.93	0.99	1.00	1.00	1.00	0.96	0.77
	209	16.4	15.9	16.7	1.13	1.85	7	1.20	0.95	1.03	1.03	1.03	1.03	0.99	0.54
	210	0.0					0								

TABLE IV
LOW CAPACITY CELLS

Cell Number	Capacity Check #1 Ampere-Hours	Capacity Check #2 Ampere-Hours	Capacity Check #3 Ampere-Hours
120	12.8	12.5	9.0
127	12.8	10.5	4.5
128	10.3	6.5	6.8
129	0.0	0.0	0.0
131	9.5	2.0	0.0
134	3.8	4.2	5.6
136	12.2	12.5	11.0
137	9.4	8.4	6.3
142	9.7	12.8	10.8
143	9.5	1.5	1.7
148	12.4	11.2	8.5
150	11.8	12.5	10.6
153	9.7	17.3	0.0
154	13.3	11.4	5.9
155	8.7	0.0	0.0
163	9.7	9.3	8.3
166	8.3	0.0	0.0
167	10.0	8.6	5.4
170	12.7	7.2	5.3
178	0.0	0.0	0.0
187	10.0	9.7	6.8
191	13.5	12.0	5.0
210	0.0	0.0	0.0
Range	17.7 - 0.0 ah	17.6 - 0.0 ah	17.1 - 0.0 ah
Average	13.8 ah	14.8 ah	13.1 ah



GULTON 12 AMPERE-HOUR SILVER-CADMIUM CELL

FIGURE 1

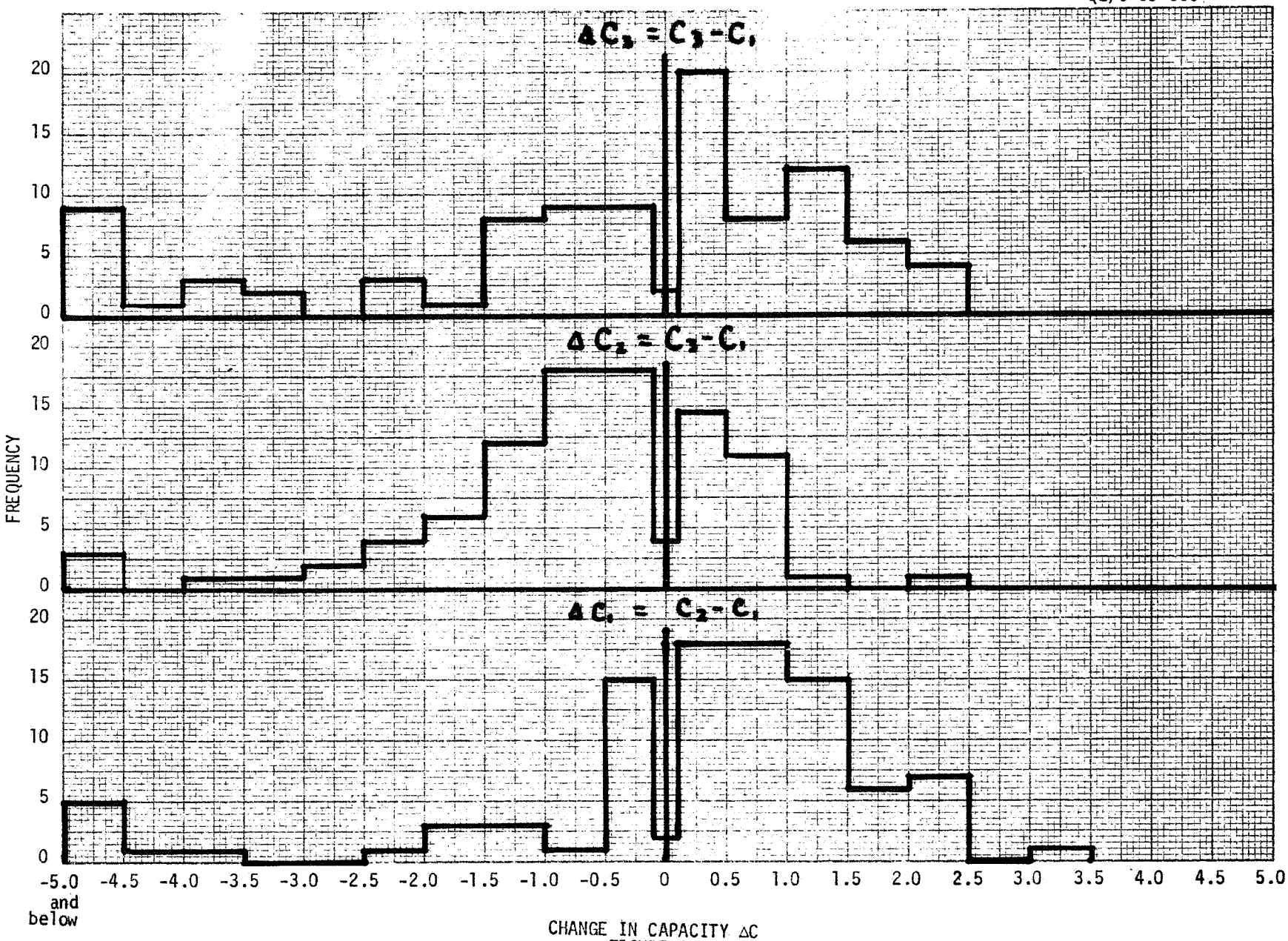
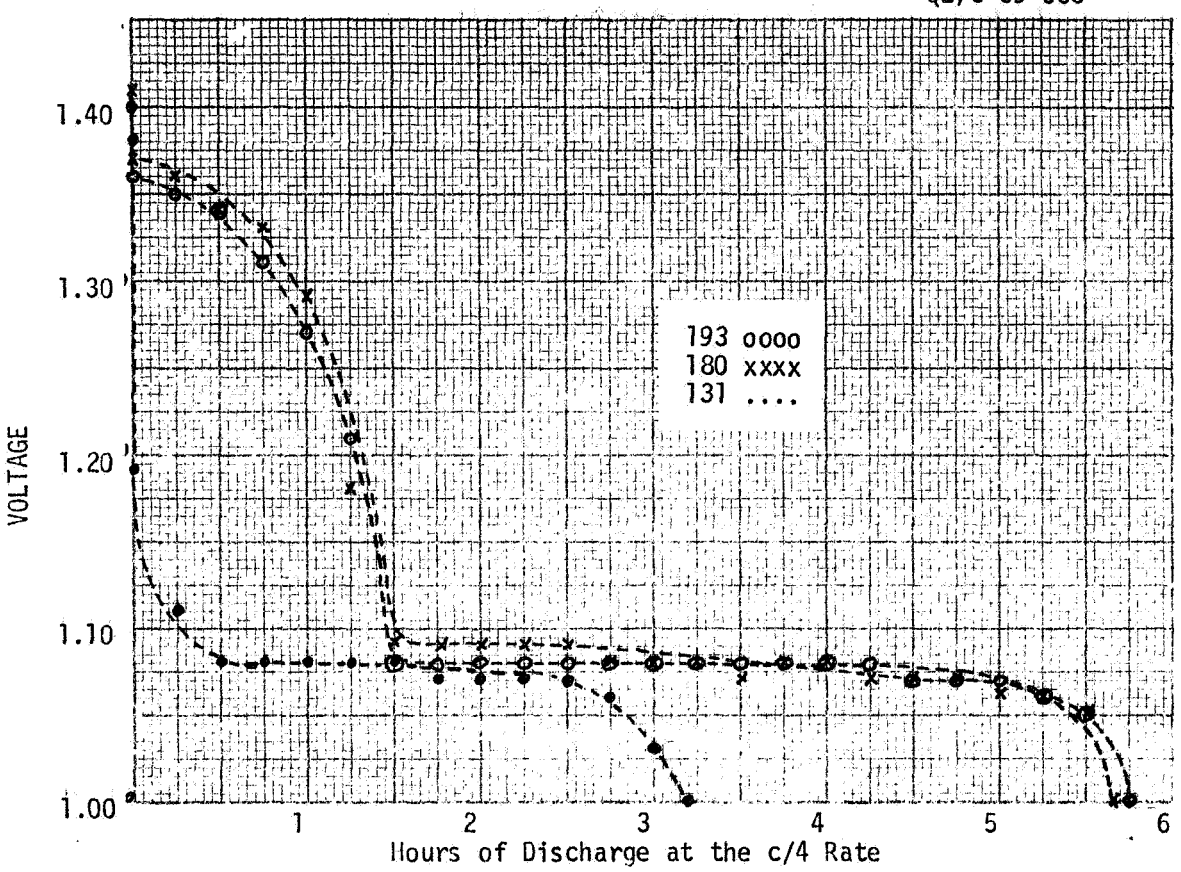

ΔC₃ = C₃-C₁
ΔC₂ = C₂-C₁
ΔC₁ = C₂-C₁
FREQUENCY
20
15
10
5
0
-5.0 and below
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
CHANGE IN CAPACITY ΔC

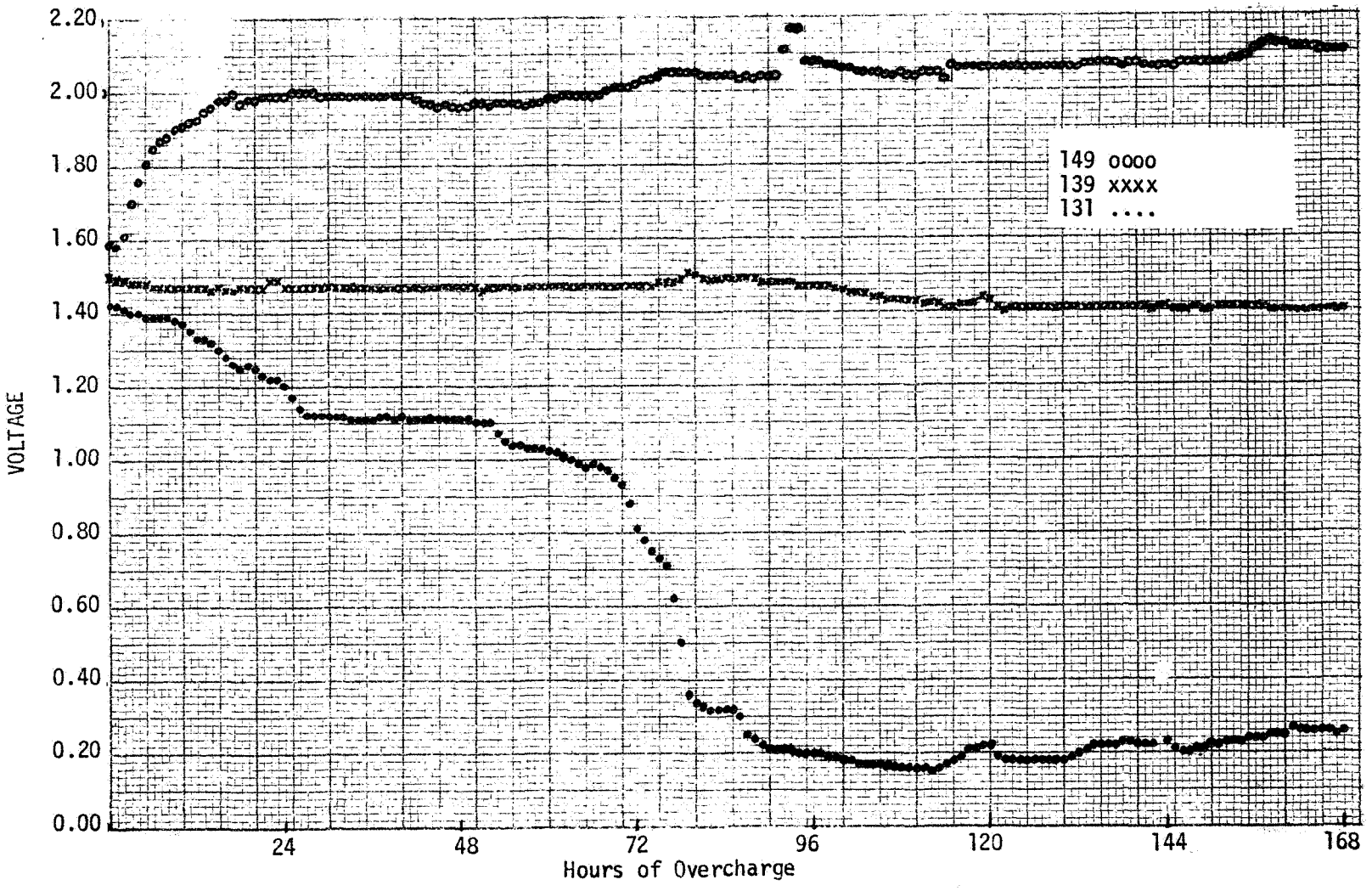
FIGURE 2



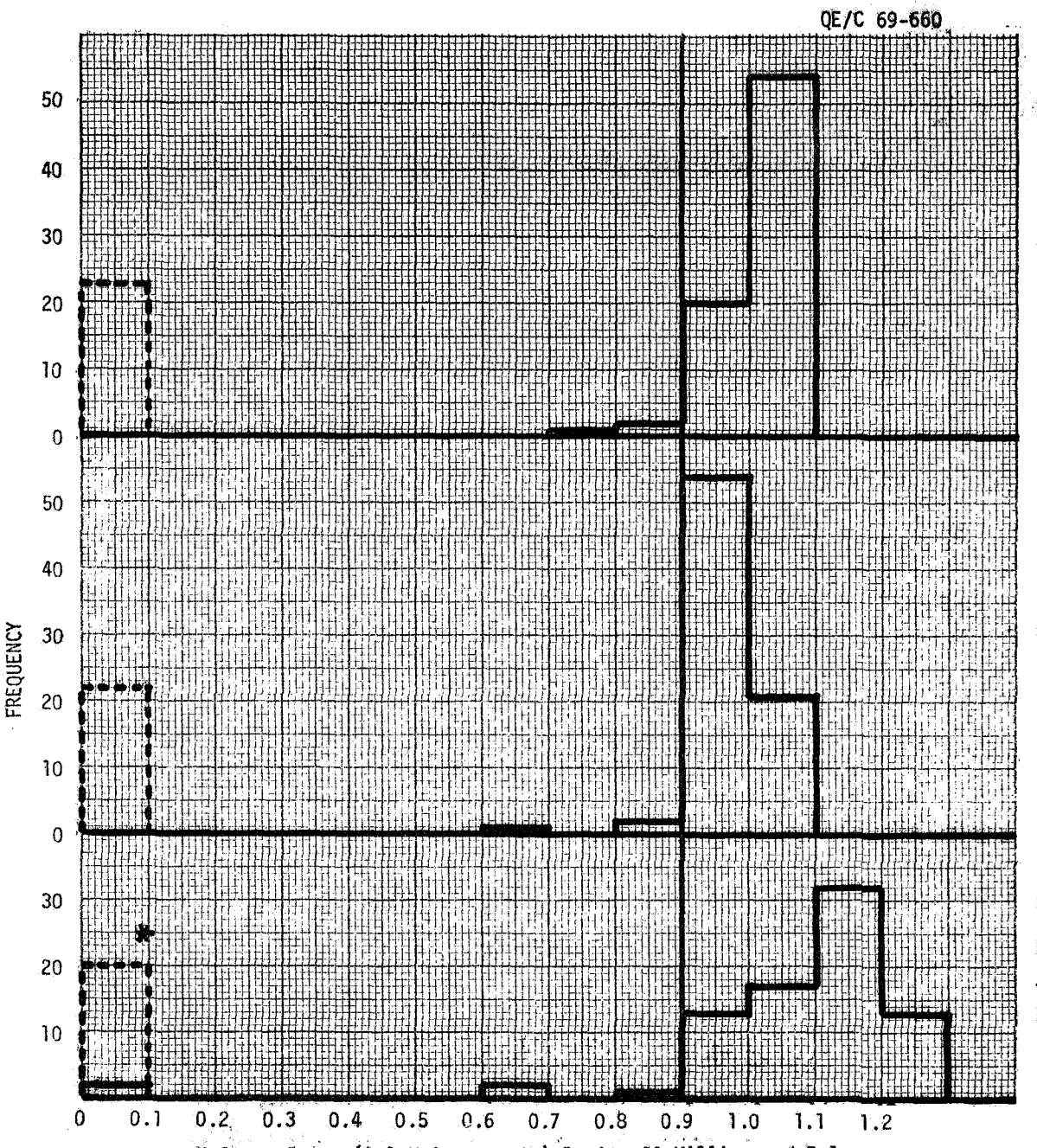
NOTE: The cells chosen for this graph were selected on the basis of their third capacity check. However cell 131 had no capacity at this point. Thus the first capacity check is graphed in each case.

CHARACTERISTIC DISCHARGE CURVES--HIGH, MODAL AND LOW
FIRST CAPACITY CHECK

FIGURE 3



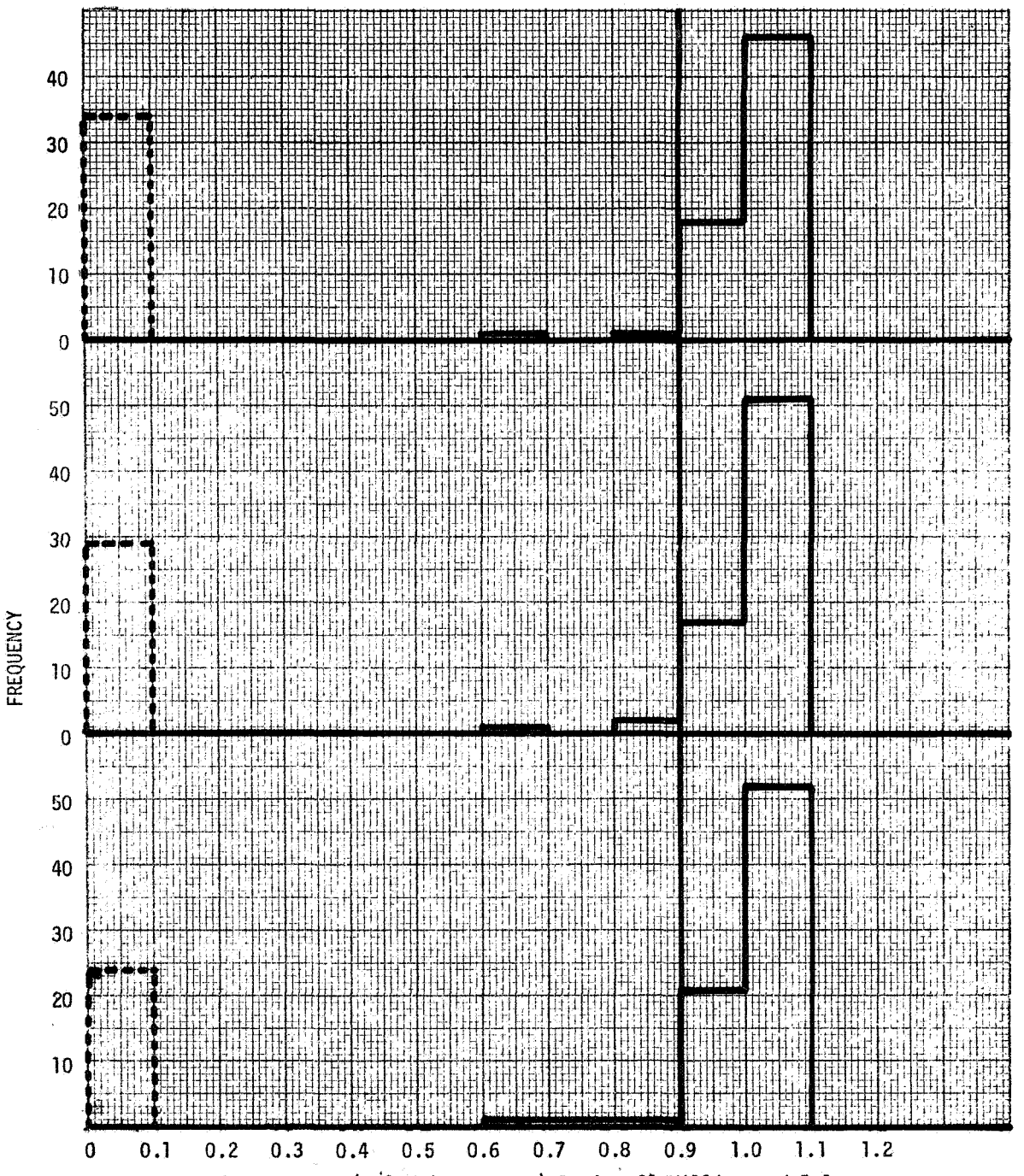
CHARACTERISTIC OVERCHARGE CURVES--HIGH, MODAL AND LOW
GULTON 12 AMPERE-HOUR SILVER-CADMIUM
FIGURE 4



--- Dotted rectangles pertain to cell removals at corresponding time intervals.
* Dotted line represents number of cells removed--20.
Solid line represents number of cells within 0 to 0.1 voltage range--2.

DISTRIBUTION OF CELLS BY VOLTAGE DURING PULSE DISCHARGE AT INDICATED TIME INVERVALS

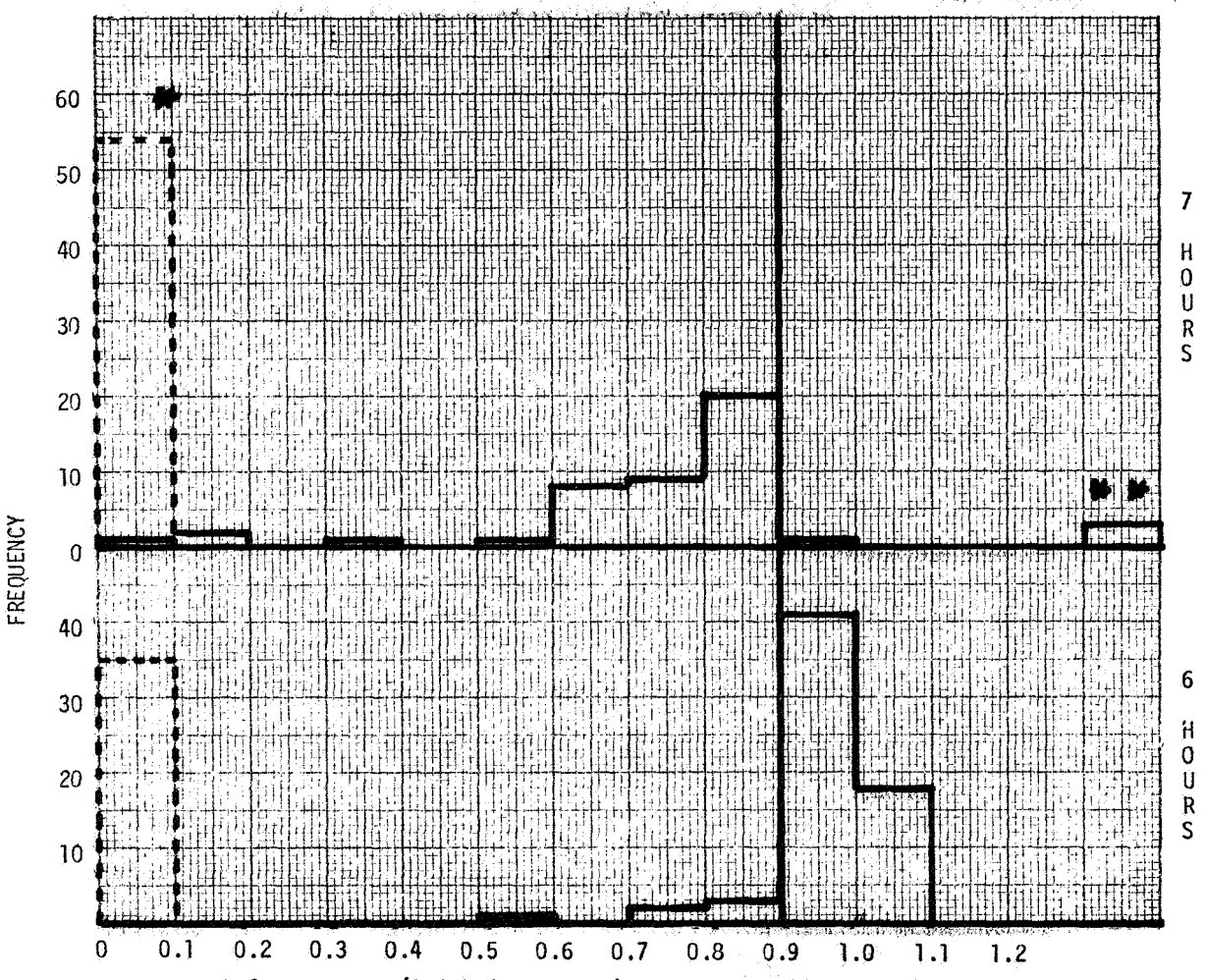
FIGURE 5



--- Dotted rectangles pertain to cell removals at corresponding time intervals.

DISTRIBUTION OF CELLS BY VOLTAGE DURING PULSE DISCHARGE AT INDICATED TIME INTERVALS

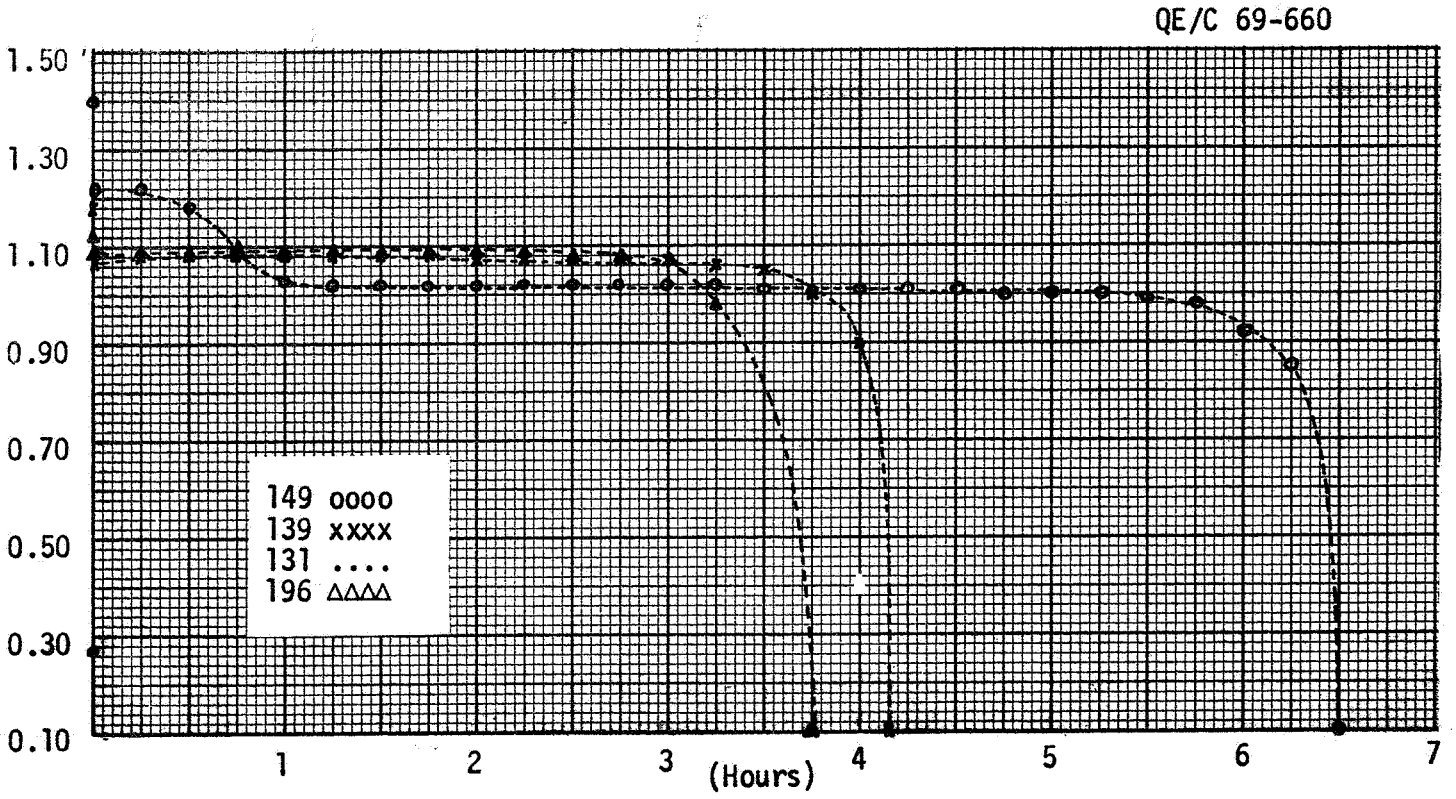
FIGURE 6



--- Dotted rectangles pertain to cell removals at corresponding time intervals.
* Dotted line represents number of cells removed--54.
Solid line represents number of cells within 0 to 0.1 voltage range--1.
** Equipment failure--pulse not recorded.

DISTRIBUTION OF CELLS BY VOLTAGE DURING PULSE DISCHARGE AT INDICATED TIME INTERVALS

FIGURE 7



DISCHARGE FOLLOWING 1-WEEK OVERCHARGE--c/4 RATE

FIGURE 8

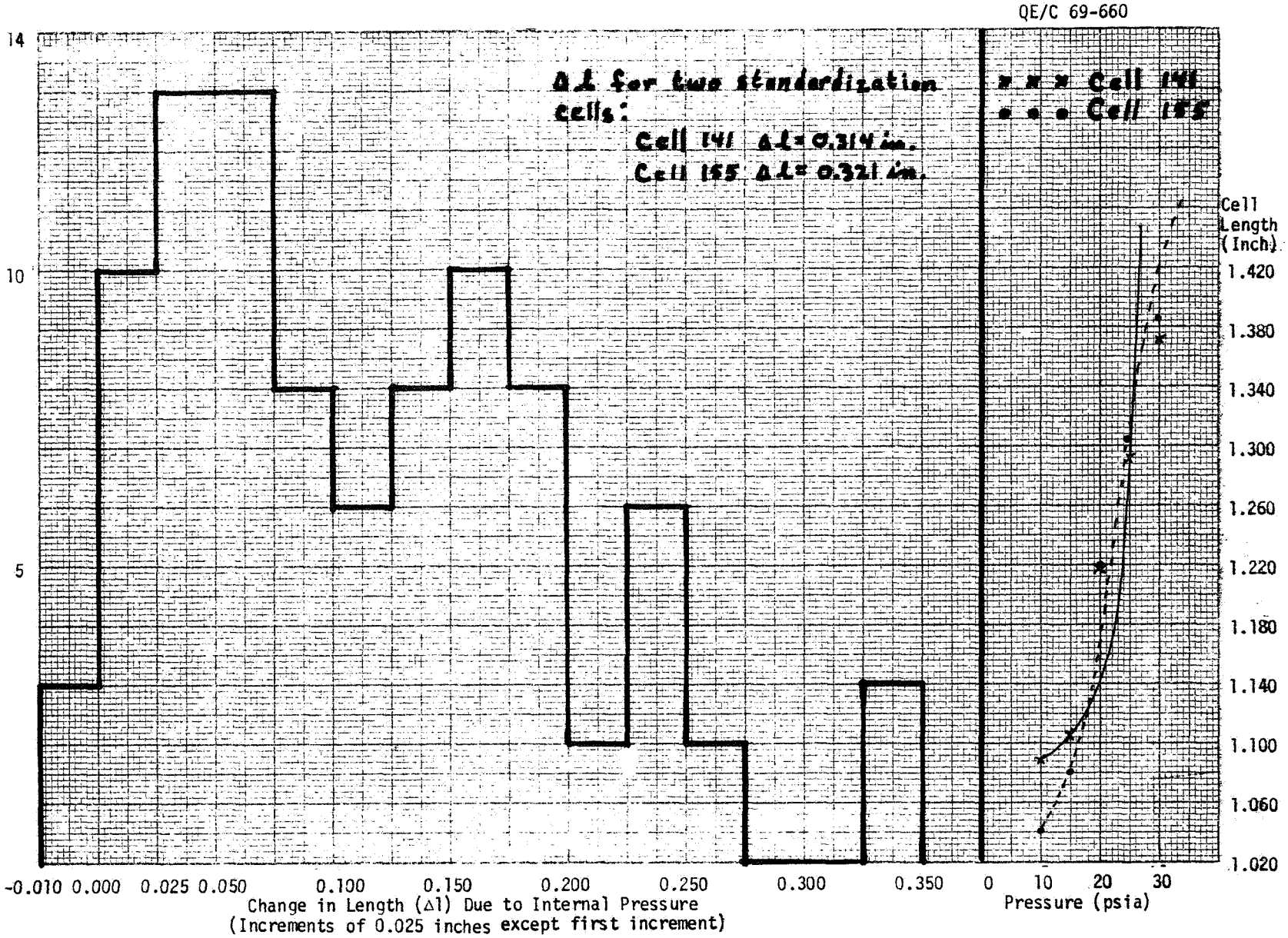

QE/C 69-660
Δ L for two standardization cells:
Cell 141 ΔL= 0.314 in.
Cell 155 ΔL= 0.321 in.
x x x Cell 141
• • • Cell 155
Cell Length (Inch)
1.420
1.380
1.340
1.300
1.260
1.220
1.180
1.140
1.100
1.060
1.020
14
10
5
-0.010 0.000 0.025 0.050 0.100 0.150 0.200 0.250 0.300 0.350
Change in Length (Δl) Due to Internal Pressure
(Increments of 0.025 inches except first increment)
0 10 20 30
Pressure (psia)

FIGURE 9

DISTRIBUTION LIST

COPY NO.

1-6	National Aeronautics and Space Administration, Goddard Space Flight Center (Mr. Thomas Hennigan, Code 716.2), Greenbelt, Maryland 20771
7	National Aeronautics and Space Administration (Mr. Ernst M. Cohn, Code RNW), Washington, D. C. 20546
8	National Aeronautics and Space Administration (Mr. A. M. Greg Andrus, Code SAC), Washington, D. C. 20546
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