EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST
OF
SONOTONE CORPORATION
3.5 AMPERE-HOUR
SEALED NICKEL-CADMIUM CELLS

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT W11,252B

QUALITY EVALUATION LABORATORY

NAD CRANE, INDIANA

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UNITED STATES NAVAL AMMUNITION DEPOT
CRANE, INDIANA

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QE/C 66-340 6 June 1966

PREPARED UNDER THE DIRECTION OF

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Enclosure (1)

QE/C 66-340

REPORT BRIEF

SONOTONE 3.5 AMPERE-HOUR

SEALED NICKEL-CADMIUM SECONDARY SPACECRAFT CELLS

Ref: (a) National Aeronautics and Space Administration Purchase Order Number W11,252B
(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) Preliminary Work Statement for Battery Evaluation Program of 25 August 1961

I. TEST ASSIGNMENT BRIEF.

A. In compliance with references (a) and (b), evaluation of Sonotone Corporation 3.5 ampere-hour sealed secondary spacecraft cells was begun according to the program outline of reference (c).

B. The object of this evaluation program is to gather specific information concerning secondary spacecraft cells. Information concerning performance characteristics and limitations, including cycle life under various electrical and environmental conditions, will be of interest to power systems designers and users. Cell weaknesses, including causes of failure of present designs, will be of interest to suppliers as a guide to product improvement.

C. Twenty-five 3.5 ampere-hour cells (manufacturer's rating) were purchased from Sonotone Corporation, Elmsford, New York by National Aeronautics and Space Administration (NASA). The positive terminal protrudes through a ceramic seal.

D. These cells are approximately two years old from date of manufacture. They will be used on two extended test programs as follows:

1. Ten cells will be placed on continuous overcharge at the c/100 rate.

2. Ten cells will be placed on an open circuit stand test.

3. Both tests will be at 25 ± 2° C and each year a complete acceptance test sequence will be rerun in an attempt to determine any cell degradation under the two test programs.

II. CONCLUSIONS.

A. From the results of this test, it can be concluded that:

1. The ceramic seals of these cells, manufactured by Sonotone Corporation, are satisfactory as evidenced by no leakers out of the 25 cells tested.

2. The capacity of the cells was in the acceptable range of 2.98 to 4.41 ampere-hours after the 2-year storage.

III. RECOMMENDATIONS.

A. It is recommended that these Sonotone Corporation 3.5 ampere-hour cells be accepted on the basis of the acceptance test results.

QE/C 66-340

RESULTS OF ACCEPTANCE TESTS

OF

3.5 AMPERE-HOUR SEALED NICKEL-CADMIUM SECONDARY SPACECRAFT CELLS

MANUFACTURED BY

SONOTONE CORPORATION

I. INTRODUCTION.

A. On 27 February 1966, this activity began acceptance tests on 25 cells. These tests were completed on 15 April 1966.

II. TEST CONDITIONS.

A. All acceptance tests were performed at an ambient temperature between 23° C and 27° C at existing relative humidity and atmospheric pressure, and consisted of the following:

1. Phenolphthalein Leak Test.
2. Capacity Test.
3. Cell Short Test.
4. Immersion Seal Test.
5. Overcharge Test.
6. Internal Resistance Test.
7. Immersion Seal Test.

B. All charging and discharging was done at constant current (± 5 percent). Cells were charged in series but discharged individually.

III. CELL IDENTIFICATION AND DESCRIPTION.

A. The cells were identified by the manufacturer's serial numbers which were from A2482 to A2564 although not consecutively.

B. The 3.5 ampere-hour "D" cell is cylindrical with an average diameter of 1.306 inches and an average overall length of 2.387 inches including the positive terminal. The average weight was 158.8 grams. Figure 1 is a photograph of a Sonotone Corporation 3.5 ampere-hour "D" cell.

C. The cell container or can, and the cell cover are made of cold rolled steel. A stainless steel tab, welded to the cover, serves as contact for the negative terminal. The positive terminal is a solder type extension of the positive plate tab, through the center of the cover. The positive terminal is insulated from the "negative" cover by a ceramic seal. Two crimp rings, about 1/32 inch deep, located about 9/16 inch from each end of the cell, were crimped after assembly to hold the element snugly in the can to withstand vibration.

D. These cells, rated by the manufacturer at 3.5 ampere-hours, were supplied in a discharged state.

IV. TEST PROCEDURE AND RESULTS.

A. Phenolphthalein Leak Test:

1. The phenolphthalein leak test is a determination of the condition of the welds and ceramic seals on receipt of the cells. This test was performed with a phenolphthalein spray indicator solution of one-half of one percent concentration.

2. There were no signs of leakage on any of the 25 cells subjected to the leak test.

B. Capacity Test:

1. The capacity test is a determination of the cell capacity at the c/2 discharge rate, where c is the manufacturer's rated capacity, to a cutoff voltage of 1.00 volt per cell. The discharge was made after a 1-hour open circuit period following the 16-hour charge at the c/10 rate. A total of three capacity checks were made at this activity. The cells were discharged individually, but were recharged in series.

2. Since no capacity data was submitted by the manufacturer, it was not possible to compare the manufacturer's capacity values with those of this activity. The individual cell capacities ranged from 2.98 to 4.41 ampere-hours for an average of 3.93 ampere-hours to 1.00 volt. The cell capacities are tabulated in Table I. Characteristic 2-hour rate discharge curves are shown in Figure 2.

C. Cell Short Test:

1. The cell short test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to element in handling or assembly.

2. Following completion of the third capacity discharge test, each individual cell was loaded with a resistor of value giving c/1 to c/5 discharge rate and allowed to stand 16 hours with the resistor acting as a shorting device. At the end of 16 hours, the resistors were removed and the cells placed on open circuit stand for 24 hours. Any cell whose voltage did not recover to 1.15 volts or higher was rejected.

3. The open circuit cell voltages, 24 hours after removal of the shorting resistors, ranged from 1.19 to 1.23 volts for an average of 1.22 volts.

4. There were no rejects of any of the cells subjected to the cell short test. The voltage values for the 25 accepted cells are shown in Table I.

D. Immersion Seal Test:

1. The immersion seal test is a means of detecting leakage of a seal or weld. The test was performed before and after the overcharge test sequence to determine the presence and cause of leaks.

2. The cells were placed under water in a bell jar container. A vacuum of 20 inches of mercury was held for 3 minutes. Cells discharging a steady stream of bubbles were considered rejects.

3. There were no rejects in the 25 cells subjected to the immersion seal test.

E. Overcharge Test:

1. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/20, c/10 and c/5 rates, for a minimum of 48 hours at each charge rate or until the increase of the "on-charge" voltage was less than 10 millivolts per day.

2. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.50 volts while on charge. Three cells were removed from the charging sequence because of high "on-charge" voltage.

3. The steady state voltage of each cell at the end of each 48-hour charge rate test is shown in Table I. Characteristic overcharge voltage curves are shown in Figure 3.

F. Internal Resistance Test:

1. This test was performed to determine the internal resistance of the cells.

2. At the completion of the overcharge test; the cells were returned to the c/20 charging rate and given a short pulse (5-10 seconds) at a rate of c in amperes. The cell voltages, V1, immediately prior to the pulse; and V2, 5 milliseconds after the pulse, were read on a suitable recording instrument. A CEC high speed oscillograph recorder (28.8 inches of tape per second) was used. The internal resistance of the cell in ohms was calculated according to the following formula:

$$R = \frac{V2 - V1}{Ic - Ic/20}$$

V1 and V2 are in volts, Ic and Ic/20 are in amperes.

3. The internal resistance value for each cell is shown in Table I. The values range from 3.01 to 15.04 milliohms.

TABLE I

CELL NUMBER	DIAMETER (INCHES)	LENGTH (INCHES)	WEIGHT (GRAMS)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CELL SHORT TEST (VOLTS)	IMMERSION SEAL TEST	OVERCHARGE c/20 (VOLTS)	OVERCHARGE c/10 (VOLTS)	OVERCHARGE c/5 (VOLTS)	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST
A2482	1.312	2.404	155.5	3.82	3.62	3.38	1.22	O.K.	1.49	1.47	1.48	9.02	O.K.
A2488	1.315	2.379	161.3	3.41	3.36	3.20	1.21	O.K.	1.54	1.54	*1.55	12.03	O.K.
A2491	1.304	2.399	160.2	4.34	4.29	4.11	1.21	O.K.	1.47	1.46	1.46	6.02	O.K.
A2492	1.310	2.379	162.5	4.06	4.15	4.03	1.23	O.K.	1.52	1.52	1.53	9.02	O.K.
A2493	1.300	2.377	157.0	3.64	3.50	3.33	1.23	O.K.	1.48	1.45	1.44	15.04	O.K.
A2494	1.312	2.386	160.6	4.11	4.06	3.94	1.22	O.K.	1.48	1.49	1.49	6.02	O.K.
A2495	1.305	2.379	157.5	2.98	2.80	2.58	1.22	O.K.	1.47	1.45	1.45	6.02	O.K.
A2498	1.312	2.404	157.7	3.69	3.37	3.17	1.22	O.K.	1.42	1.42	1.39	6.02	O.K.
A2503	1.305	2.400	158.9	4.29	4.17	3.80	1.22	O.K.	1.50	1.52	1.54	9.02	O.K.
A2508	1.310	2.392	159.8	3.89	3.97	3.80	1.22	O.K.	1.50	1.54	*1.55	9.02	O.K.
A2526	1.300	2.392	158.8	4.15	4.06	3.97	1.22	O.K.	1.48	1.47	1.48	3.01	O.K.
A2530	1.305	2.382	155.1	3.99	3.76	3.45	1.20	O.K.	1.48	1.46	1.46	3.01	O.K.
A2536	1.300	2.377	157.2	3.82	3.64	3.36	1.23	O.K.	1.48	1.45	1.45	3.01	O.K.
A2538	1.300	2.377	159.0	4.15	4.03	3.85	1.19	O.K.	1.50	1.51	**1.59	3.01	O.K.
A2540	1.312	2.400	159.7	3.99	3.99	3.99	1.23	O.K.	1.43	1.43	1.39	6.02	O.K.
A2542	1.305	2.407	158.2	4.17	4.15	3.89	1.22	O.K.	1.47	1.46	1.46	3.01	O.K.
A2544	1.308	2.382	161.7	3.99	3.82	3.73	1.22	O.K.	1.48	1.46	1.46	6.02	O.K.

*After 10 hours
**After 1 hour

TABLE I (contd)

CELL NUMBER	DIAMETER (INCHES)	LENGTH (INCHES)	WEIGHT (GRAMS)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CELL SHORT TEST (VOLTS)	IMMERSION SEAL TEST	OVERCHARGE c/20 (VOLTS)	OVERCHARGE c/10 (VOLTS)	OVERCHARGE c/5 (VOLTS)	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST
A2545	1.308	2.383	160.2	3.78	3.50	3.25	1.22	O.K.	1.42	1.42	1.38	6.02	O.K.
A2546	1.298	2.396	159.2	4.41	4.20	3.80	1.23	O.K.	1.46	1.45	1.45	3.01	O.K.
A2547	1.308	2.382	159.5	3.50	3.20	2.92	1.22	O.K.	1.46	1.45	1.45	6.02	O.K.
A2548	1.305	2.392	157.8	3.81	3.75	3.47	1.24	O.K.	1.41	1.43	1.46	6.02	O.K.
A2552	1.310	2.380	159.0	3.55	2.73	2.46	1.21	O.K.	1.40	1.39	1.38	9.02	O.K.
A2557	1.308	2.379	157.4	3.76	3.80	3.54	1.22	O.K.	1.48	1.47	1.47	6.02	O.K.
A2559	1.305	2.392	161.9	3.76	3.90	3.76	1.21	O.K.	1.49	1.50	1.53	3.01	O.K.
A2564	1.308	2.379	154.2	4.03	3.82	3.59	1.23	O.K.	1.47	1.46	1.46	3.01	O.K.

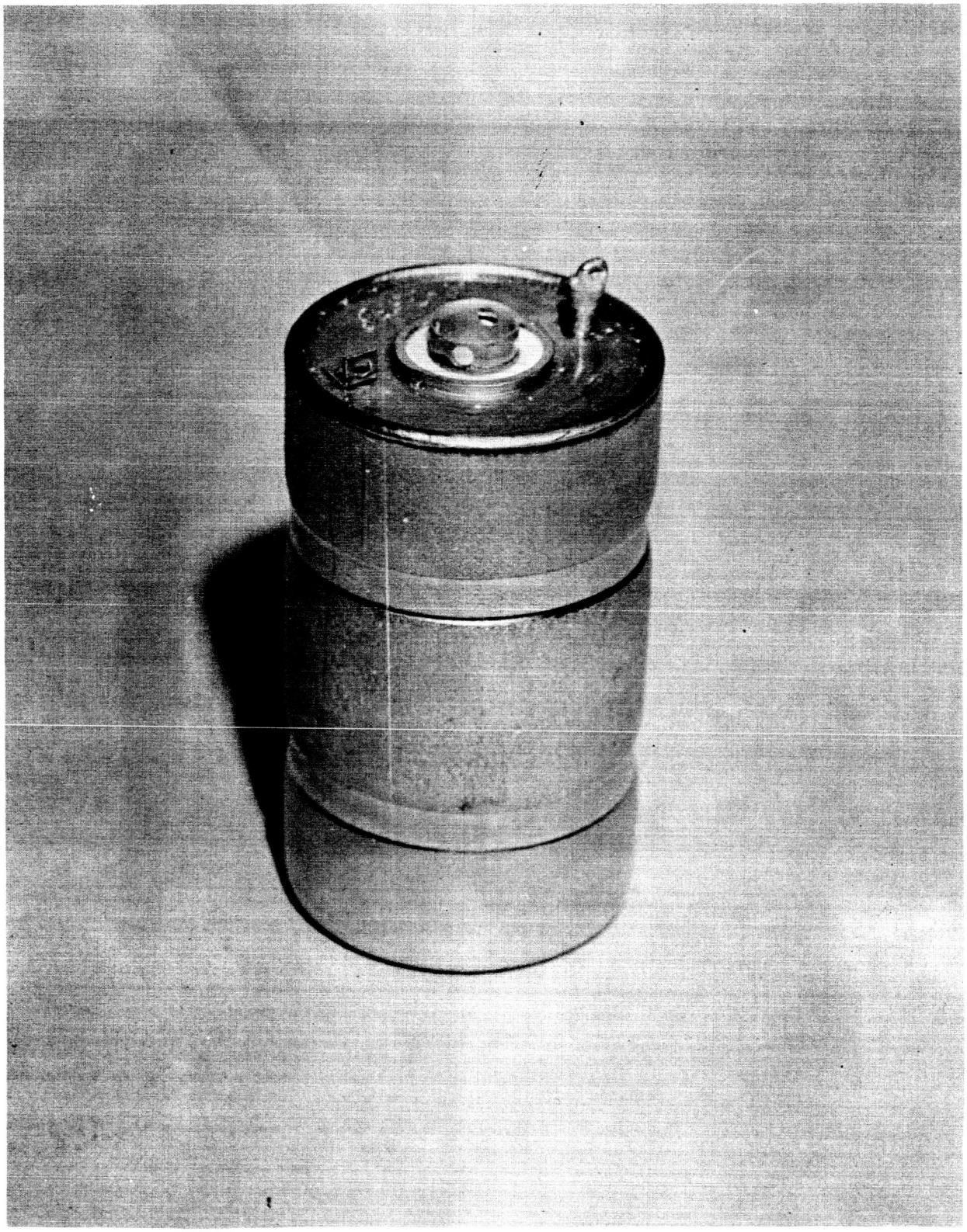
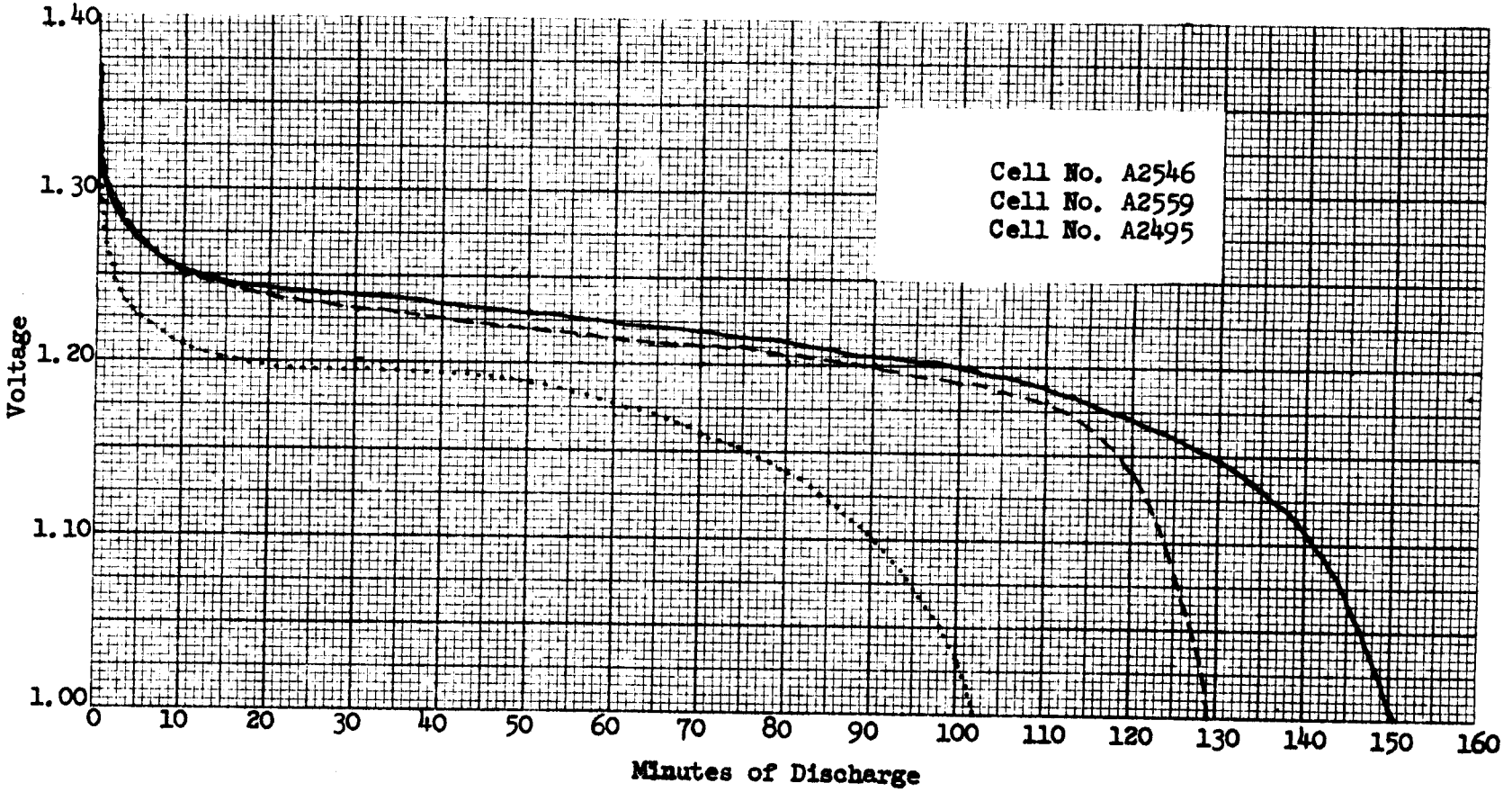


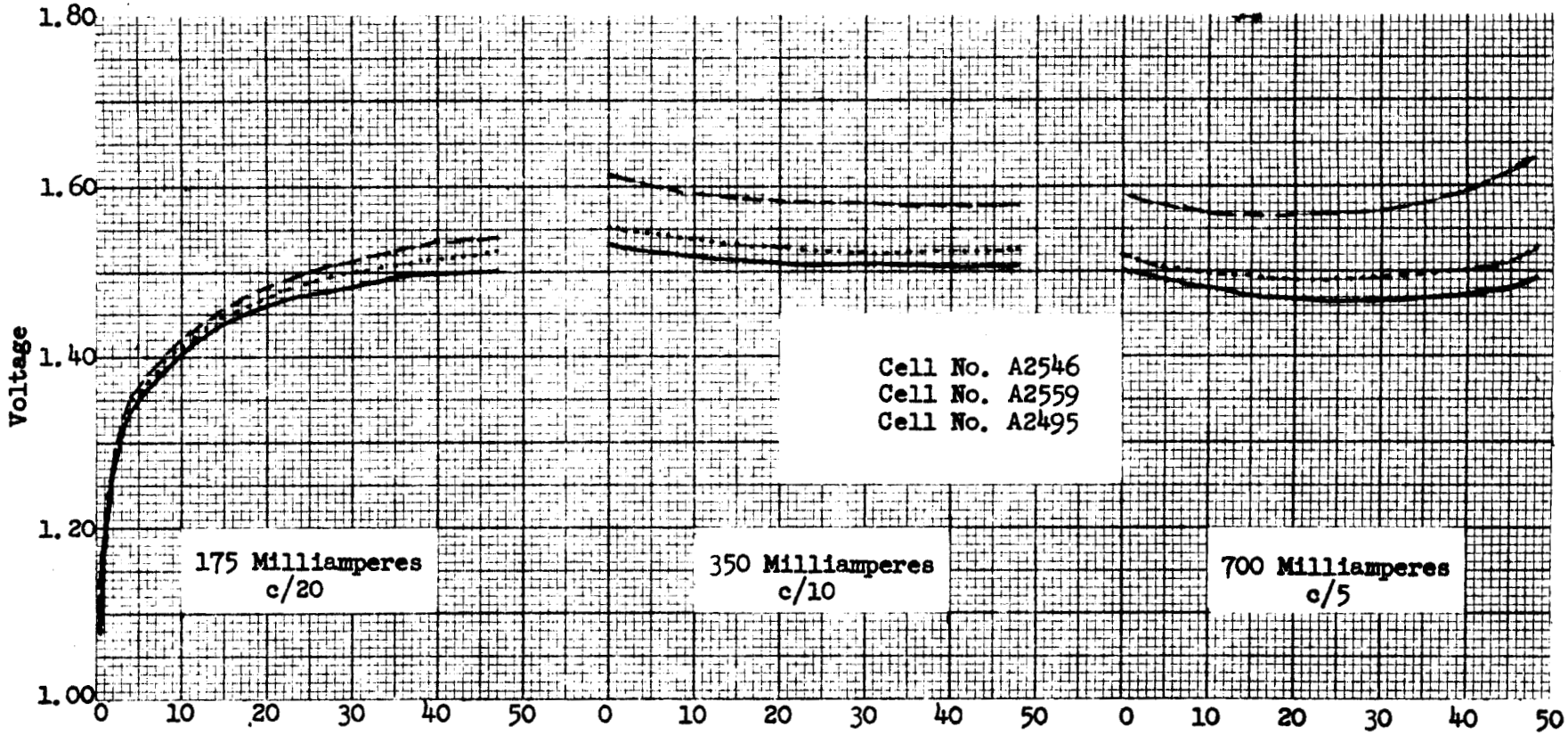
FIGURE 1



CHARACTERISTIC 2-HOUR RATE DISCHARGE CURVES

SONOTONE 3.5 AMPERE-HOUR NICKEL-CADMIUM SEALED CELLS

FIGURE 2



CHARACTERISTIC 48-HOUR OVERCHARGE CURVES

SONOTONE 3.5 AMPERE-HOUR NICKEL-CADMIUM SEALED CELLS

FIGURE 3

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