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"PREPARED FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GODDARD SPACE FLIGHT CENTER, SPACE POWER TECHNOLOGY BRANCH, GREENBELT, MARYLAND, PURSUANT TO PURCHASE ORDER NUMBER W11,252B."

QUALITY - RELIABILITY - ANALYSIS
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QUALITY EVALUATION LABORATORY
UNITED STATES NAVAL AMMUNITION DEPOT
CRANE, INDIANA

EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

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

QE/C 65-124 16 February 1965

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Enclosure (1)

REPORT BRIEF

GULTON 12 AMPERE-HOUR 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 Gulton Industries, Inc. 12 ampere-hour 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. Thirty cells were purchased from Gulton Industries, Inc., Metuchen, New Jersey by National Aeronautics and Space Administration (NASA). These cells are rated at 12 ampere hours by the manufacturer and are similar to those used in the OGO satellite program.

II. CONCLUSIONS.

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

1. The ceramic seals of these cells manufactured by Gulton Industries, Inc., are satisfactory as evidenced by no leakers out of the 30 cells tested.

2. The capacity of the cells was in the acceptable range of 13.6 to 15.5 ampere-hours.

III. RECOMMENDATIONS.

A. It is recommended that these Gulton Industries, Inc. 12 ampere-hour cells be accepted on the basis of the acceptance test results.

D. These cells, rated by the manufacturer at 12.0 ampere-hours, were supplied in a discharged (with shorting wire) condition.

IV. TEST PROCEDURES AND RESULTS.

A. 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. Since one capacity check was submitted by the manufacturer, the second and third capacity checks were made at this activity. The cells were discharged individually but were recharged in series.

2. The cell capacities of the second and third capacity checks, made by this activity, generally were quite similar or slightly lower than those submitted by the manufacturer. The individual cell capacities ranged from 13.6 to 15.5 ampere-hours for an average of 14.3 ampere-hours. The cell capacities are tabulated in Table I. Characteristic 2-hour rate discharge curves are shown in Figure 2.

B. 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 a c 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 were 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 1.20 to 1.23 volts for an average of 1.22 volts..

4. Of the 31 cells subjected to the cell short test, one was rejected. The voltage values for the 30 accepted cells are shown in Table I.

C. 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 place 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 30 cells subjected to the immersion seal test.

D. <u>Overcharge Test.</u>

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. There was no need to remove any cells from the charging sequence.

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

E. <u>Internal Resistance Test.</u>

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

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 tape 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 0.87 milliohms to 2.02 milliohms.

TABLE I

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS FIRST BY MANUFACTURER	CAPACITY TESTS SECOND BY NAD CRANE	CAPACITY TESTS THIRD BY NAD CRANE	CELL SHORT TEST	IMMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	°F	OVERCHARGE c/10	°F	OVERCHARGE c/5	°F	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST LEAKAGE
1439	544.5	4.608	0.895	2.99	14.2	13.6	12.6	1.22	NONE	1.41	87	1.44	93	1.44	104	2.02	NONE
1443	541.0	4.600	0.899	2.89	14.2	13.6	12.6	1.22	NONE	1.41	88	1.44	93	1.43	103	0.87	NONE
1445	540.0	4.600	0.890	2.99	14.5	13.7	12.8	1.22	NONE	1.41	88	1.44	92	1.43	103	0.87	NONE
1447	541.0	4.615	0.890	2.99	15.1	14.2	13.4	1.22	NONE	1.41	86	1.44	94	1.43	104	0.87	NONE
1449	539.0	4.625	0.890	2.99	15.0	13.8	12.7	1.23	NONE	1.41	87	1.44	94	1.43	102	0.87	NONE
1450	543.0	4.604	0.896	2.89	15.0	13.9	13.0	1.21	NONE	1.41	86	1.44	93	1.43	104	1.75	NONE
1452	548.0	4.600	0.895	2.99	15.2	14.5	13.6	1.20	NONE	1.41	87	1.44	93	1.43	104	1.75	NONE
1454	541.0	4.591	0.895	2.89	15.0	14.2	13.3	1.21	NONE	1.41	87	1.44	92	1.42	104	1.75	NONE
1455	542.5	4.620	0.888	2.85	15.1	15.0	14.6	1.21	NONE	1.42	88	1.44	94	1.44	102	1.75	NONE
1456	548.5	4.608	0.900	2.89	14.8	13.7	12.8	1.23	NONE	1.41	88	1.44	93	1.43	103	1.75	NONE
1457	543.0	4.625	0.896	2.89	14.9	14.6	14.0	1.22	NONE	1.41	88	1.41	94	1.44	103	1.75	NONE
1458	552.0	4.612	0.892	2.99	15.4	15.5	13.7	1.22	NONE	1.41	87	1.41	92	1.42	103	1.75	NONE
1459	544.5	4.590	0.890	2.89	14.7	14.3	13.8	1.22	NONE	1.41	89	1.41	92	1.43	103	1.75	NONE
1460	546.0	4.612	0.891	2.99	14.6	14.0	13.6	1.22	NONE	1.40	87	1.41	94	1.48	104	1.75	NONE
1461	546.5	4.590	0.896	2.99	15.3	14.7	13.8	1.21	NONE	1.41	87	1.40	93	1.43	104	1.75	NONE

TABLE I (Contd)

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS FIRST BY MANUFACTURER	SECOND BY NAD CRANE	THIRD BY NAD CRANE	CELL SHORT TEST	IMMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	°F	OVERCHARGE c/10	°F	OVERCHARGE c/5	°F	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST LEAKAGE
1462	540.5	4.600	0.894	2.99	15.2	14.5	13.4	1.22	NONE	1.40	89	1.40	93	1.42	102	1.75	NONE
1464	543.0	4.616	0.895	2.99	14.9	14.2	13.8	1.22	NONE	1.41	87	1.41	92	1.43	104	0.87	NONE
1465	544.5	4.603	0.896	2.99	15.4	14.8	14.4	1.21	NONE	1.40	87	1.41	94	1.43	103	1.75	NONE
1466	543.0	4.615	0.893	2.89	15.0	14.5	14.0	1.22	NONE	1.41	89	1.41	93	1.44	104	0.87	NONE
1467	543.5	4.625	0.896	2.99	14.6	13.6	13.3	1.21	NONE	1.41	88	1.42	93	1.42	104	0.87	NONE
1468	542.5	4.625	0.893	2.99	14.2	1.37	12.7	1.22	NONE	1.40	88	1.41	94	1.41	105	1.75	NONE
1469	547.0	4.625	0.893	2.89	15.0	14.2	13.4	1.22	NONE	1.40	87	1.41	94	1.40	106	1.75	NONE
1470	543.5	4.610	0.893	2.99	14.8	14.0	13.4	1.22	NONE	1.40	87	1.41	94	1.40	104	0.87	NONE
1471	543.5	4.590	0.899	2.89	13.9	14.8	14.4	1.21	NONE	1.44	86	1.46	94	1.44	106	1.75	NONE
1473	546.0	4.588	0.900	2.89	14.5	14.4	14.1	1.22	NONE	1.40	88	1.41	94	1.40	106	1.75	NONE
1474	547.0	4.600	0.900	2.89	15.3	14.5	13.3	1.22	NONE	1.42	87	1.44	94	1.42	104	0.87	NONE
1476	543.5	4.588	0.900	2.89	14.6	14.6	14.0	1.22	NONE	1.40	86	1.41	93	1.41	104	1.75	NONE
1477	547.5	4.610	0.896	2.99	14.2	14.3	14.1	1.22	NONE	1.40	86	1.42	92	1.41	103	0.87	NONE
1478	546.0	4.608	0.896	2.99	14.4	14.4	13.8	1.22	NONE	1.41	86	1.42	93	1.42	103	1.75	NONE
1480	542.3	4.610	0.893	2.89	14.3	14.1	13.5	1.22	NONE	1.41	86	1.41	93	1.42	103	1.75	NONE

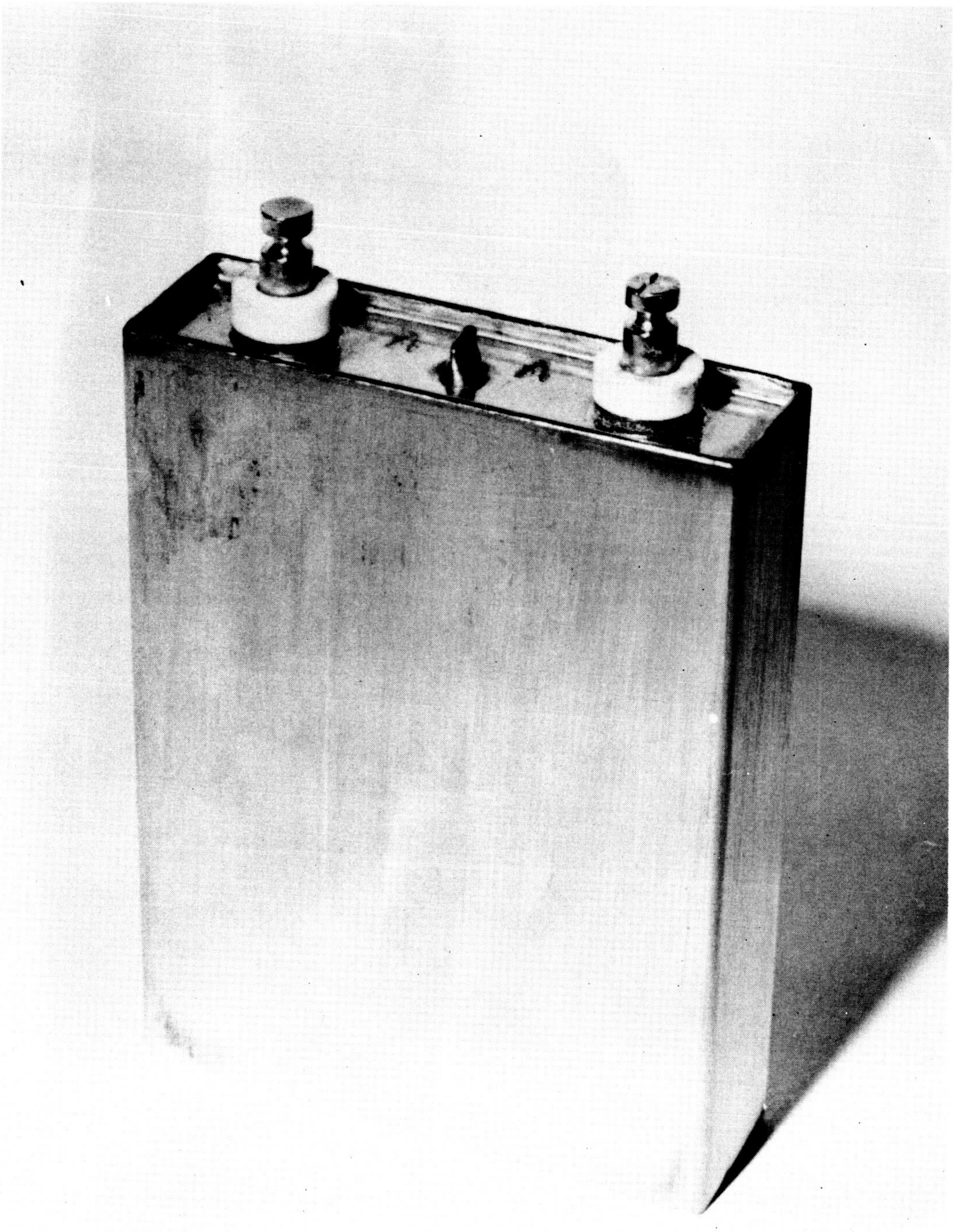
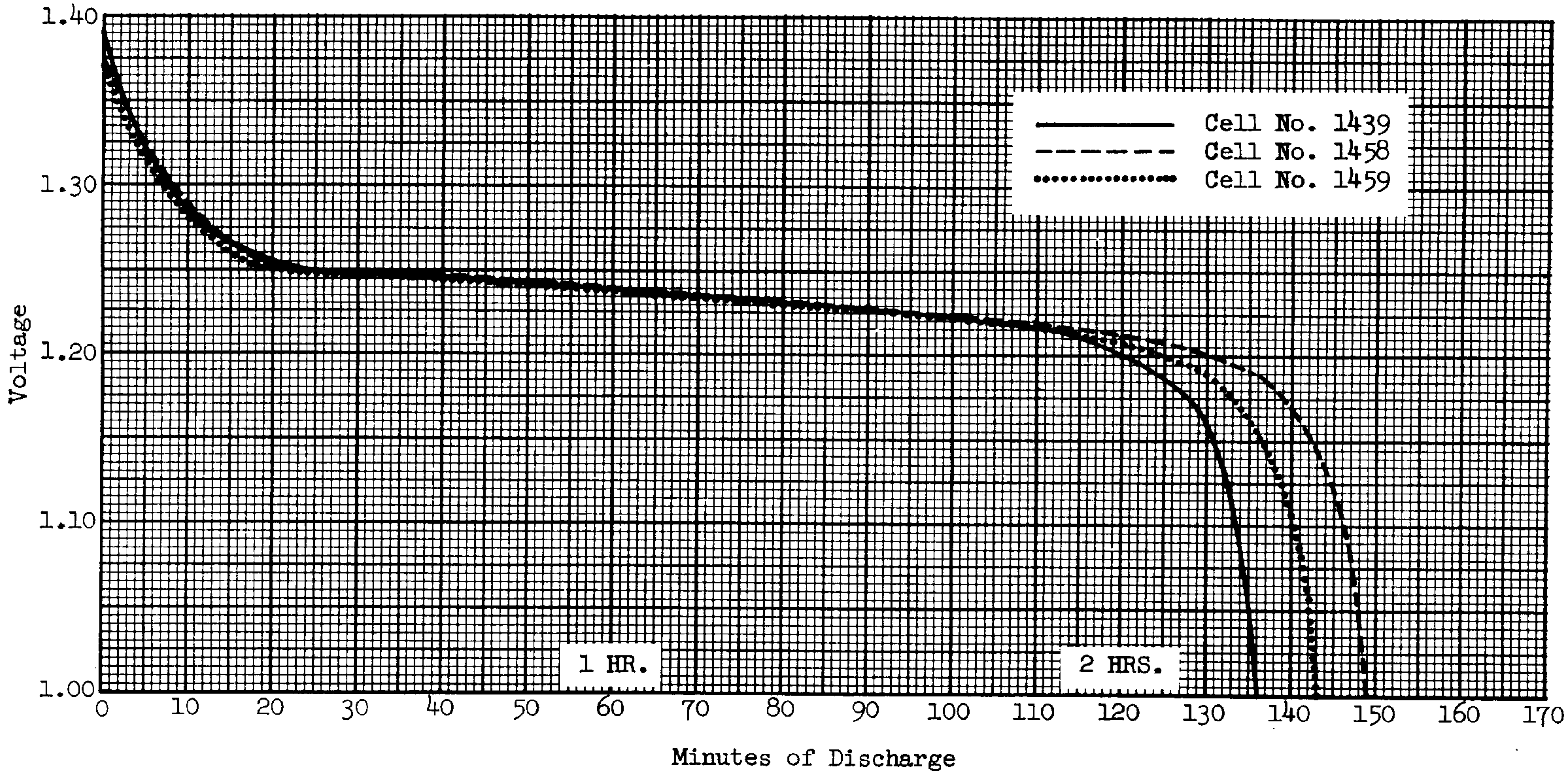


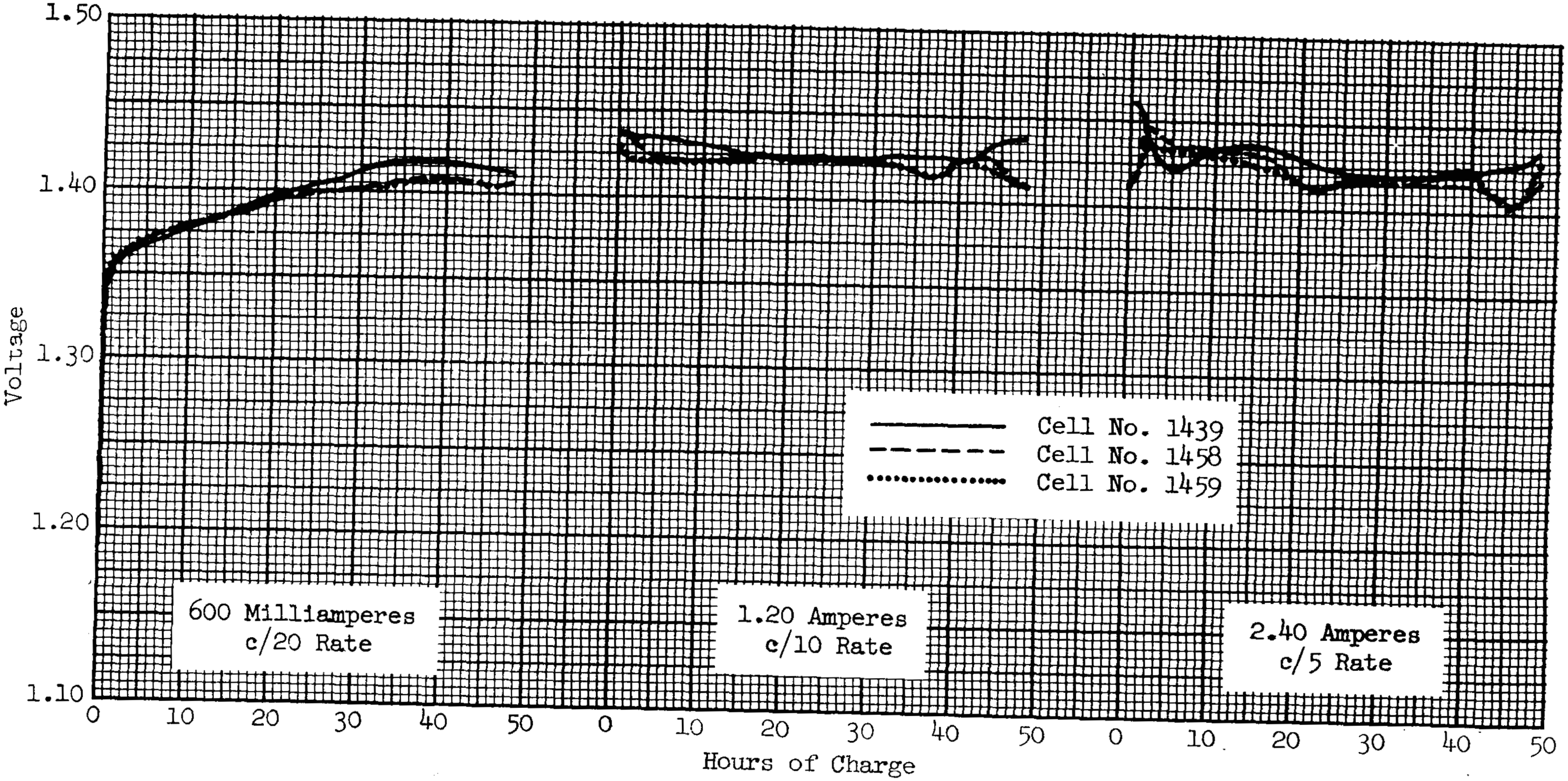
FIGURE 1



CHARACTERISTIC 2-HOUR RATE DISCHARGE CURVES

GULTON 12 AMPERE-HOUR NICKEL CADMIUM SEALED CELLS

FIGURE 2



CHARACTERISTIC 48-HOUR OVERCHARGE CURVES

GULTON 12 AMPERE-HOUR NICKEL CADMIUM SEALED CELLS

FIGURE 3

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