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# IMPROVEMENT OF NICKEL-CADMIUM BATTERIES

MONTHLY TECHNICAL PROGRESS REPORT NO. 30

COVERING THE PERIOD

20 September 1963 to 20 October 1963

OTS PRICE

XEROX $ 2.60 ph

MICROFILM $ _____

Contract No. NAS 5-1045

INLAND TESTING LABORATORIES
Cook Technological Center
Dayton, Ohio

RQ4-14427

# PROGRESS REPORT NO. 30

## I. INTRODUCTION

This progress report is submitted in accordance with Article 1 and Item 2 of Article II, of Contract NAS 5-1048.

## II. CONTRACT OBJECTIVE

The objective of this contract is to improve nickel-cadmium batteries through testing and analysis of failures. Specifically, a number of batteries developed by manufacturers under NASA Contracts are being subjected to operational and environmental testing to determine failure rates and modes of failure. From these results specific suggestions for the proper application and possible improvement of this battery type may be made.

## III. PROGRAM FOR THE REPORT PERIOD

Cycle-life tests were continued and data recorded on the following groups of cells:

| Number of Cells in Original Group | Mfr. | Depth of Discharge | Temp. °C | Cycles Completed |
|---|---|---|---|---|
| 10 | Sonotone | 10% | 25 | 5000+ |
| 10 | Gulton | 10% | 25 | 5000+ |
| 10 | Gould | 10% | 25 | 5000+ |
| 10 | Sonotone | 10% | 50 | 4800+ |
| 10 | Gulton | 10% | 50 | 4800+ |
| 10 | Gould | 10% | 50 | 4800+ |

| Number of Cells in Original Group | Mfr. | Depth of Discharge | Temp. °C | Cycles Completed |
|---|---|---|---|---|
| 10 | Sonotone | 25% | 25 | 4700+ |
| 10 | Gould | 25% | 25 | 1900+ |
| 10 | Gulton | 25% | 25 | 4700+ |
| 10 | Sonotone | 10% | -10 | 4500+ |
| 5 | Gould | 10% | -10 | 3400+ |
| 10 | Gulton | 10% | -10 | 4500+ |
| 4 | Sonotone | 40% | 25 | 4200+ |

During this reporting period no failures were experienced by the cells of the three manufacturers in any of the five environmental and discharge depth conditions, and discharge voltages for representative cycles accumulated during the report period are shown on the attached sheets.

Post failure tests were conducted on the group of Gould National cells, which was removed from cycling at 25°C and 40% discharge as reported last month. A separate report on the procedure and results of these tests is appended.

During the report period, special tests were conducted on the group of three Sonotone cells cycling at 40% depth of discharge, to investigate methods which may be used (while in orbit) to eliminate 'memory effects' or to re-establish rated capacity without first 'shorting' individual cells. The data for these tests are shown on attached sheets. The data show that the capacity of the cells during cycling was less

than rated capacity and that the capacity was essentially restored on each of the cells after these special capacity cycles. The capacities of these cells to 1.0 volt following these tests were 3.21, 3.21 and 3.4 A-H compared to initial capacities to 1.0 volt of 3.38, 3.44 and 3.21 A-H, respectively, when the cells were received. These cells were again placed on continuous cycling. After a period of cycling or evidence of loss of capacity, it is intended to re-check the capacities of these cells by the same three methods used, except the charge periods will be extended to replace 125% of the rated capacity in the first step instead of basing the re-charge upon the capacity removed.

In order to make these checks for restoring capacity on cells of another manufacturer, the three Gulton cells (Nos. 654, 815 and 826) previously bulged in initial tests, were placed on the 100-minute continuous cycling during the report period. Prior to placing the cells on cycling, they were charged at C/20 for 16 hrs. followed by constant potential charge at 1.45V/cell for 4 hours. Resulting capacities to 1.0 volt at the C/2 discharge rate were 5.75, 6.3 and 6.5 ampere-hours. The cells were then re-charged at C/10 for 16 hours and allowed to stand on open-circuit for 64 hours

to check for any shorts which might prevent cycling. Open-circuit voltages at 64 hours were 1.29V., 1.30V. and 1.30V. After a period of cycling or when evidence of loss of capacity during cycling is indicated, it is intended to make checks for restoring capacity similar to those used for the Sonotone cells.

## VI. PROGRAM FOR THE NEXT PERIOD

1. Continue and record data on cycle-life tests in progress at 25°C, -10°C, and 50°C.
2. Continue evaluation of data being accumulated.
3. Continue investigation of failed cells.

FINANCIAL CONDITION

CONTRACT NAS 5-1048

MONTHLY PROGRESS REPORT NO. 30

20 SEPTEMBER 1963 to 20 OCTOBER 1963

| | |
|---|---|
| * Funds Expended During Report Period | $ 701 |
| * Commitments | None |
| * Total Funds Expended Including Commitments | $55,542 |
| * Funds Remaining | $ 1,225 |

* All amounts are less G & A and Fee

## POST FAILURE TEST ON GOULD NATIONAL CELLS

The following Open Circuit Stand Voltage tests and Capacity tests were performed on Gould National Cells Nos. 43, 45 and 49 as they were removed from cycling at the end charge after cycling at 25°C and 40% discharge for 1282 cycles.

### END OF CHARGE - OPEN CIRCUIT VOLTAGE TEST

END OF CHARGE VOLTAGE

| TIME | AMPS | CELLS #43 | #45 | #49 |
|---|---|---|---|---|
| | 1.75 | 1.56 | 1.56 | 1.54 |

OPEN CIRCUIT STAND VOLTAGE

| | | | | |
|---|---|---|---|---|
| 30 min. | 0 | 1.35 | 1.40 | 1.38 |
| 16 hrs. | 0 | 1.34 | 1.36 | 1.36 |
| 20 hrs. | 0 | 1.34 | 1.36 | 1.35 |

DISCHARGE VOLTAGE

| | | | | |
|---|---|---|---|---|
| 1 min. | 1.75 | 1.19 | 1.28 | 1.24 |
| 15 min. | 1.75 | 1.00 | 1.20 | 1.08 |
| 30 min. | 1.75 | 0.80 | 1.05 | 1.01 |
| 50 min. | 1.75 | | 0.81 | 0.87 |
| 60 min. | 1.75 | | | 0.81 |

| | | | |
|---|---|---|---|
| CAPACITY TO 1.0 VOLT | 0.44AH | 1.03AH | 0.91AH |
| CAPACITY TO 0.6 VOLT | 0.72AH | 1.73AH | 2.14AH |

POST FAILURE TESTS ON GOULD NATIONAL CELLS (Cont'd)

The cells were charged at C/10 for 16 hrs and then given a capacity test and an Open Circuit Voltage test.

| TIME-MIN. | AMPS | CELLS #43 | #45 | #49 |
|---|---|---|---|---|
| END OF CHARGE VOLTAGE | | | | |
| 960 | 0.35 | 1.54 | 1.50 | 1.54 |
| DISCHARGE VOLTAGE | | | | |
| 0 | 0 | 1.37 | 1.38 | 1.38 |
| 1 | 1.75 | 1.25 | 1.29 | 1.27 |
| 10 | 1.75 | 1.13 | 1.21 | 1.11 |
| 30 | 1.75 | 1.11 | 1.09 | 1.10 |
| 60 | 1.75 | 1.06 | 0.92 | 1.02 |
| 80 | 1.75 | 1.00 | | 0.96 |
| 100 | 1.75 | 0.80 | | 0.84 |
| CAPACITY TO 1 VOLT | | 2.25AH | 1.39AH | 1.88AH |
| CAPACITY TO 0.6 VOLT | | 3.00AH | 2.22AH | 3.15AH |

The cells were then charged at C/10 for 16 hours and given an Open Circuit Stand Voltage Test.

END OF CHARGE VOLTAGE

| TIME-HRS. | AMPS. | #43 | #45 | #49 |
|---|---|---|---|---|
| 16 | 0.35 | 1.54 | 1.50 | 1.54 |
| OPEN CIRCUIT STAND VOLTAGE | | | | |
| 1 | 0 | 1.40 | 1.40 | 1.41 |
| 8 | 0 | 1.36 | 1.36 | 1.37 |
| 80 | 0 | 1.34 | 1.34 | 1.34 |
| 120 | 0 | 1.33 | 1.34 | 1.33 |
| 240 | 0 | 1.32 | 1.33 | 1.32 |

SPECIAL TEST SONOTONE CELLS

CELLS REMOVED FROM TEST AFTER CHARGE ON THE 3297th CYCLE
ENVIRONMENT: 25°C
CHARGE: 125% of Discharge (1.75 amp. for 60 min.)
DISCHARGE: 40% Depth (2.1 amps. for 40 min.)

CYCLING

| | CYCLE | CELL NO. 57 | CELL NO. 58 | CELL NO. 59 |
|---|---|---|---|---|
| A. | CHARGE (ABOVE) | CYCLE RATE - 1.75 amp. for 60 min. | CYCLE RATE - 1.75 amp. for 60 min. | CYCLE RATE - 1.75 amp. for 60 min. |
| | DISCHARGE: | CYCLE RATE - 2.1 amps. to 0.6V End Point CAPACITY 2.1 AH | CYCLE RATE - 2.1 amps. to 0.6V End Point CAPACITY 2.69 AH | CYCLE RATE - 2.1 amps. to 0.6V End Point CAPACITY 2.75 AH SHORTED 16 hrs |

INDIVIDUAL CELLS

| | | | | |
|---|---|---|---|---|
| B. | CHARGE: | CYCLE RATE - 1.75 amp. to return 125% of above Capacity - Charged 2.62 AH | CONSTANT POTENTIAL - 1.45V to return 125% of above Capacity - Charged 3.36 AH | CONSTANT POTENTIAL - 1.45V to return 125% of above Capacity - Charged 3.44 AH |
| | DISCHARGE: | CYCLE RATE - 2.1 amps. to 0.6V End Point CAPACITY 2.0 AH | CYCLE RATE - 2.1 amps. to 0.6V. End Point CAPACITY 2.63 AH | C/2 (1.75 amp.) to 0.6V End Point CAPACITY 2.98 AH |
| C. | CHARGE: | CONSTANT POTENTIAL - 1.45V to return 125% of above Capacity - Charged 2.54 AH | CONSTANT POTENTIAL - 1.45V to return 125% of above Capacity - Charged 3.28 AH | CONSTANT POTENTIAL - 1.45V for 4 hrs. Charged - 3.98 AH |
| | DISCHARGE: | C/2 (1.75 amps.) to 0.6V CAPACITY 2.46 AH | C/2 (1.75 amp.) to 0.6V CAPACITY 2.88 AH | C/2 (1.75 amp.) to 0.6V CAPACITY 3.19 AH |

| | CYCLE | CELL NO. 57 | CELL NO. 58 | CELL NO. 59 |
|---|---|---|---|---|
| D. | CHARGE: | CONSTANT POTENTIAL - 1.47V for 8 hrs. Charged 4.5 AH | CONSTANT POTENTIAL - 1.45V for 16 hrs. Charged 4.30 AH | CONSTANT POTENTIAL - 1.45V for 16 hrs. Charged 5.20 AH |
| | DISCHARGE: | C/2 (1.75 amp.) to 0.6V CAPACITY 3.05 AH | C/2 (1.75 amp.) to 0.6V CAPACITY 3.45 AH | C/2 (1.75 amp.) to 0.6V CAPACITY 3.00 AH |
| E. | CHARGE: | CONSTANT POTENTIAL - 1.45V for 16 hrs. Charged 5.7 AH | | |
| | DISCHARGE: | C/2 (1.75 amp.) to 0.6V CAPACITY 3.4 AH | | |

## DISPOSITION OF SONOTONE CELLS - 20 OCTOBER 1963

Cells - Failed Initial Tests - - - - - - - - - - - 6
Cells - Failed in Cycling to Date - - - - - - - - 4
Cells - Now Cycling - - - - - - - - - - - - - - - 40

## CELLS FAILED INITIAL TESTS

Electrolyte Leakage - - - - - - - - - - - - - - 4
Electrical Leakage - - - - - - - - - - - - - - 2

## CELLS FAILED IN CYCLING TO DATE

25°C - 40% Discharge (537 cycles) - - - - - - - - - 1
50°C - 10% Discharge (3288 cycles) - - - - - - - - 1
50°C - 10% Discharge (4079 cycles) - - - - - - - - 1
50°C - 10% Discharge (4281 cycles) - - - - - - - - 1
Total 4

## CELLS NOW CYCLING

At 25°C - 10% Discharge - - - - - - - - - - - - - - 10
At 25°C - 25% Discharge - - - - - - - - - - - - - - 10
At 25°C - 40% Discharge - - - - - - - - - - - - - - 3
At 50°C - 10% Discharge - - - - - - - - - - - - - - 7
At -10°C - 10% Discharge - - - - - - - - - - - - - - 10
Total 40

## DISPOSITION OF GOULD NATIONAL CELLS - 20 OCTOBER 1963

Cells - Failed Initial Tests - - - - - - - - - - - 23
Cells - Failed in Cycling - - - - - - - - - - - - 10
Cells - Now Cycling - - - - - - - - - - - - - - - 30
Cells - Not Used in Cycling - - - - - - - - - - - 2*

* One cell bulged, one leaked after initial tests

## CELLS FAILED INITIAL TESTS

Electrolyte Leakage - - - - - - - 23
Electrical Leakage - - - - - - - - - 2 (Failed Both Initial Tests)

## CELLS FAILED IN CYCLING

At 50°C - 10% Discharge (2666 cycles) - - - - - - - - - - - 1
At 50°C - 10% Discharge (2973 cycles) - - - - - - - - - - - 1
At 50°C - 10% Discharge (3216 cycles) - - - - - - - - - - - 1
At 50°C - 10% Discharge (3372 cycles) - - - - - - - - - - - 1
At 50°C - 10% Discharge (3576 cycles) - - - - - - - - - - - 1
At 25°C - 40% Discharge (864 cycles) - - - - - - - - - - - 2
At 25°C - 40% Discharge (1262 cycles) - - - - - - - - - - - 3
Total 10

## CELLS NOW CYCLING

At 25°C - 10% Discharge - - - - - - - - - - - 10
At 50°C - 10% Discharge - - - - - - - - - - - 5
At -10°C - 10% Discharge - - - - - - - - - - - 5

At 25°C - 25% Discharge - - - - - - - - - - - 10

NOTE: This last group totaling 10 cells is from the group of 23 cells reported as having electrolyte leakage. They were sent to the manufacturer for examination, returned to this facility, and are now cycling as indicated.

## DISPOSITION OF GULTON CELLS - 20 OCTOBER 1963

Cells - Failed Initial Tests - - - - - - - - - - - 7
Cells - Failed in Cycling - - - - - - - - - - - - 4
Cells - Now Cycling - - - - - - - - - - - - - - 36
Cells - Not Used in Cycling - - - - - - - - - - - 3*

* 3 Cells bulged after initial tests

## CELLS FAILED INITIAL TESTS

Electrolyte Leakage - - - - - - - - - - - - 5
Electrical Leakage -- - - - - - - - - - - - 2

## CELLS FAILED IN CYCLING TO DATE

At 25°C - 10% Discharge (2263 cycles) - - - - - - - - - - - 1
At 25°C - 25% Discharge (1298 cycles) - - - - - - - - - - - 1
At 25°C - 25% Discharge (1270 cycles) - - - - - - - - - - - 1
At 25°C - 25% Discharge (1416 cycles) - - - - - - - - - - - 1
Total 4

## CELLS NOW CYCLING

At 25°C - 10% Discharge - - - - - - - - - - - 9
At 25°C - 25% Discharge - - - - - - - - - - - 7
At 50°C - 10% Discharge - - - - - - - - - - 10
At -10°C - 10% Discharge - - - - - - - - - - 10
Total 36

* - Cells cycling on special test are the three cells reported above as having bulged after initial tests.

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |

| | |
|---|---|
| CONDITIONING: Chg: 125% of dischg, 60 min, Dischg: 10% Depth, 40 min. | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 3.5 AH | TEMP: RH: |
| MANUFACTURER: Sonotone | M. NO: |
| INSTRUMENTS: Milliammeter, D.C. Sensitive Research, Model UUP, 1/2%<br>Voltmeter, D.C. Weston 931, 5000 ohms/volt, 1/2% | TESTED BY: D. M.<br>LAB SUP CHECK: H. B.<br>ENGRG CHECK: I. I. |

| CELL NO. | 4684 | 4742 | 4827 | 4914 | 4999 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTS | | | |
| 64 | 1.42 | 1.42 | 1.43 | 1.42 | 1.42 |
| 65 | 1.57 | 1.57 | 1.58 | 1.58 | 1.58 |
| 66 | 1.58 | 1.59 | 1.59 | 1.59 | 1.59 |
| 68 | 1.48 | 1.49 | 1.49 | 1.48 | 1.49 |
| 74 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 |
| R39 | 1.44 | 1.45 | 1.56 | 1.55 | 1.54 |
| R40 | 1.44 | 1.44 | 1.45 | 1.44 | 1.44 |
| R41 | 1.45 | 1.45 | 1.46 | 1.45 | 1.45 |
| R42 | 1.59 | 1.60 | 1.62 | 1.60 | 1.62 |
| R43 | 1.45 | 1.46 | 1.46 | 1.45 | 1.45 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 64 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| 65 | 1.23 | 1.23 | 1.23 | 1.23 | 1.23 |
| 66 | 1.23 | 1.22 | 1.22 | 1.23 | 1.22 |
| 68 | 1.24 | 1.23 | 1.23 | 1.24 | 1.23 |
| 74 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| R39 | 1.21 | 1.20 | 1.04 | 1.05 | 1.05 |
| R40 | 1.23 | 1.23 | 1.23 | 1.23 | 1.22 |
| R41 | 1.23 | 1.24 | 1.24 | 1.24 | 1.23 |
| R42 | 1.25 | 1.25 | 1.24 | 1.24 | 1.24 |
| R43 | 1.24 | 1.24 | 1.24 | 1.23 | 1.23 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |
| CONDITIONING: Chg: 125% of dischg, 60 min; Dischg: 10% Depth, 40 min. | | | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 3.5 AH | | | TEMP: RH: |
| MANUFACTURER: Gould National | | | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | | | TESTED BY: D. M. |
| | | | LAB SUP CHECK: H. B. |
| | | | ENGRG CHECK: I. L. |

| CELL NO. | CYCLE NUMBER 4684 | 4742 | 4827 | 4914 | 4999 |
|---|---|---|---|---|---|
| | END OF CHARGE VOLTAGE | | | | |
| 1 | 1.46 | 1.46 | 1.46 | 1.46 | 1.46 |
| 6 | 1.46 | 1.47 | 1.47 | 1.46 | 1.47 |
| 8 | 1.45 | 1.46 | 1.46 | 1.45 | 1.45 |
| 9 | 1.46 | 1.47 | 1.47 | 1.46 | 1.46 |
| 10 | 1.49 | 1.50 | 1.50 | 1.49 | 1.50 |
| 12 | 1.43 | 1.44 | 1.44 | 1.44 | 1.44 |
| 14 | 1.47 | 1.4[illegible] | 1.48 | 1.48 | 1.48 |
| 15 | 1.46 | 1.46 | 1.46 | 1.46 | 1.46 |
| 22 | 1.46 | 1.47 | 1.47 | 1.47 | 1.47 |
| 24 | 1.45 | 1.45 | 1.46 | 1.45 | 1.46 |
| | END OF DISCHARGE VOLTAGE | | | | |
| 1 | 1.28 | 1.27 | 1.28 | 1.27 | 1.27 |
| 6 | 1.28 | 1.28 | 1.29 | 1.28 | 1.28 |
| 8 | 1.28 | 1.27 | 1.26 | 1.27 | 1.26 |
| 9 | 1.29 | 1.28 | 1.28 | 1.28 | 1.28 |
| 10 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |
| 12 | 1.26 | 1.27 | 1.26 | 1.25 | 1.23 |
| 14 | 1.28 | 1.29 | 1.2[illegible] | 1.28 | 1.28 |
| 15 | 1.27 | 1.27 | 1.27 | 1.27 | 1.26 |
| 22 | 1.28 | 1.28 | 1.28 | 1.28 | 1.27 |
| 24 | 1.28 | 1.28 | 1.28 | 1.28 | 1.27 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |

| | |
|---|---|
| CONDITIONING: Chg: 125% of dischg, 60 min; Dischg: 10% Depth, 40 Min. | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 9 Cell Group, Batch 6 [illegible] | TEMP: RH: |
| MANUFACTURER: Gulton | M. NO: VO-6HS |
| INSTRUMENTS: Same as Data Page 1 | TESTED BY: D. M. |
| | LAB SUP CHECK: H. B. |
| | ENGRG CHECK: I. I. |

| CELL NO. | 4684 | 4742 | 4827 | 2714 | 4999 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTAGE | | | |
| 628 | 1.42 | 1.42 | 1.42 | 1.42 | 1.43 |
| 638 | 1.41 | 1.41 | 1.42 | 1.42 | 1.42 |
| 644 | 1.44 | 1.43 | 1.44 | 1.43 | 1.44 |
| 647 | 1.43 | 1.44 | 1.45 | 1.43 | 1.43 |
| 648 | 1.40 | 1.41 | 1.41 | 1.40 | 1.40 |
| 653 | 1.43 | 1.43 | 1.43 | 1.42 | 1.43 |
| 822 | 1.43 | 1.43 | 1.43 | 1.42 | 1.43 |
| 825 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 |
| 827 | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 628 | 1.24 | 1.24 | 1.24 | 1.23 | 1.23 |
| 638 | 1.26 | 1.25 | 1.26 | 1.25 | 1.26 |
| 644 | 1.27 | 1.26 | 1.26 | 1.26 | 1.26 |
| 647 | 1.28 | 1.26 | 1.25 | 1.25 | 1.26 |
| 648 | 1.25 | 1.24 | 1.24 | 1.24 | 1.24 |
| 653 | 1.26 | 1.26 | 1.26 | 1.26 | 1.25 |
| 822 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |
| 825 | 1.27 | 1.26 | 1.27 | 1.26 | 1.26 |
| 827 | 1.26 | 1.27 | 1.26 | 1.26 | 1.26 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |

| | |
|---|---|
| CONDITIONING: Chg: 125% of dischg, 60 min; Dischg: 25% Depth, 40 min. | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 3.5 AH | TEMP: RH: |
| MANUFACTURER: Sonotone | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | TESTED BY: L. M. |
| | LAB SUP CHECK: H. B. |
| | ENGRG CHECK: I. I. |

| CELL NO. | CYCLE NUMBER 4384 | 4442 | 4527 | 4614 | 4699 |
|---|---|---|---|---|---|
| | END OF CHARGE VOLTAGE | | | | |
| 60 | 1.49 | 1.49 | 1.49 | 1.48 | 1.48 |
| 61 | 1.48 | 1.49 | 1.49 | 1.48 | 1.48 |
| R49 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 |
| R50 | 1.49 | 1.49 | 1.50 | 1.49 | 1.49 |
| R51 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| R52 | 1.48 | 1.45 | 1.48 | 1.48 | 1.47 |
| R53 | 1.47 | 1.45 | 1.47 | 1.47 | 1.46 |
| R55 | 1.47 | 1.48 | 1.48 | 1.48 | 1.47 |
| R56 | 1.51 | 1.51 | 1.53 | 1.51 | 1.50 |
| R57 | 1.49 | 1.48 | 1.48 | 1.48 | 1.48 |
| | END OF DISCHARGE VOLTAGE | | | | |
| 60 | 1.18 | 1.18 | 1.18 | 1.17 | 1.18 |
| 61 | 1.18 | 1.17 | 1.18 | 1.17 | 1.18 |
| R49 | 1.16 | 1.15 | 1.16 | 1.16 | 1.16 |
| R50 | 1.18 | 1.17 | 1.17 | 1.17 | 1.18 |
| R51 | 1.19 | 1.18 | 1.18 | 1.18 | 1.18 |
| R52 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 |
| R53 | 1.18 | 1.17 | 1.17 | 1.17 | 1.18 |
| R55 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 |
| R56 | 1.19 | 1.18 | 1.18 | 1.18 | 1.18 |
| R57 | 1.18 | 1.17 | 1.17 | 1.17 | 1.17 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |

| | |
|---|---|
| CONDITIONING: Chg: 125% of discng, 60 min; Dischg: 25% Depth, 40 min. | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 3.5 AH | TEMP: RH: |
| MANUFACTURER: Gould National | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | TESTED BY: D. M. |
| | LAB SUP CHECK: H. S. |
| | ENGRG CHECK: I. L. |

| CELL NO. | CYCLE NUMBER 1571 | 1629 | 1714 | 1801 | 1886 |
|---|---|---|---|---|---|
| | | END OF CHARGE VOLTAGE | | | |
| 3 | 1.46 | 1.[illegible] | 1.[illegible] | 1.46 | 1.49 |
| 5 | 1.48 | 1.48 | 1.48 | 1.48 | 1.49 |
| 7 | 1.56 | 1.56 | 1.56 | 1.56 | 1.58 |
| 11 | 1.46 | 1.46 | 1.46 | 1.46 | 1.49 |
| 13 | 1.53 | 1.53 | 1.52 | 1.52 | 1.53 |
| 16 | 1.49 | 1.49 | 1.48 | 1.49 | 1.49 |
| 30 | 1.46 | 1.49 | 1.48 | 1.46 | 1.49 |
| 37 | 1.55 | 1.55 | 1.54 | 1.55 | 1.56 |
| 39 | 1.51 | 1.52 | 1.51 | 1.51 | 1.52 |
| 40 | 1.49 | 1.49 | 1.4[illegible] | 1.49 | 1.49 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 3 | 1.26 | 1.25 | 1.24 | 1.24 | 1.24 |
| 5 | 1.21 | 1.21 | 1.20 | 1.20 | 1.20 |
| 7 | 1.10 | 1.03 | 1.13 | 1.10 | 1.06 |
| 11 | 1.26 | 1.25 | 1.25 | 1.25 | 1.25 |
| 13 | 1.13 | 1.12 | 1.11 | 1.11 | 1.10 |
| 16 | 1.25 | 1.24 | 1.24 | 1.24 | 1.24 |
| 30 | 1.25 | 1.24 | 1.24 | 1.24 | 1.24 |
| 37 | 0.94 | 0.91 | 0.90 | 0.90 | 0.90 |
| 39 | 1.23 | 1.22 | 1.22 | 1.22 | 1.21 |
| 40 | 1.25 | 1.24 | 1.25 | 1.25 | 1.24 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |

| | |
|---|---|
| CONDITIONING: Chg: 125% of dischg, 50 min; Dischg: 25% Depth, 40 min. | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 7 Cell Group, Rated 6 AH | TEMP: RH: |
| MANUFACTURER: Gulton | M. NO: VO-6HS |
| INSTRUMENTS: Same as Data Page 1 | TESTED BY: D. M. |
| | LAB SUP CHECK: H. B. |
| | ENGRG CHECK: I. L. |

| CELL NO. | 4384 | 4442 | 4527 | 4614 | 4699 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTAGE | | | |
| 660 | 1.47 | 1.47 | 1.47 | 1.46 | 1.46 |
| 661 | 1.48 | 1.48 | 1.49 | 1.48 | 1.48 |
| 804 | 1.51 | 1.52 | 1.52 | 1.51 | 1.51 |
| 812 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 |
| 816 | 1.46 | 1.46 | 1.47 | 1.46 | 1.46 |
| 818 | 1.45 | 1.46 | 1.46 | 1.46 | 1.46 |
| 820 | 1.46 | 1.[illegible] | 1.47 | 1.46 | 1.47 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 660 | 1.20 | 1.20 | 1.19 | 1.19 | 1.19 |
| 661 | 1.19 | 1.19 | 1.18 | 1.18 | 1.18 |
| 804 | 1.18 | 1.18 | 1.18 | 1.17 | 1.17 |
| 812 | 1.20 | 1.20 | 1.19 | 1.19 | 1.19 |
| 816 | 1.20 | 1.20 | 1.19 | 1.19 | 1.19 |
| 818 | 1.19 | 1.19 | 1.18 | 1.18 | 1.18 |
| 820 | 1.20 | 1.19 | 1.19 | 1.18 | 1.19 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 25°C | | | Report 30 |

| | |
|---|---|
| CONDITIONING: Chg: 125% of dischg. 60 min; Dischg: 40% Depth, 40 min. | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 3 Cell Group, Rated 3.5 AH | TEMP: RH: |
| MANUFACTURER: Sonotone | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | TESTED BY: D. M. |
| | LAB SUP CHECK: H. B. |
| | ENGRG CHECK: I. L. |

| CELL NO. | 3297 | 3298 | 3327 | 3414 | 3499 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTAGE | | | |
| 57 | * | 1.26 | 1.52 | 1.51 | 1.51 |
| 58 | * | 1.51 | 1.51 | 1.51 | 1.52 |
| 59 | * | 1.52 | 1.51 | 1.51 | 1.51 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 57 | * | 1.19 | 1.17 | 1.16 | 1.16 |
| 58 | * | 1.20 | 1.15 | 1.18 | 1.17 |
| 59 | * | 1.20 | 1.19 | 1.18 | 1.18 |

* Cycling of cells interrupted for 14 days at this point for special tests

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 50°C | | | Report 30 |
| CONDITIONING: Chg: 150% of dischg, 60 min; Dischg: [illegible]% Depth, 40 min. | | | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 7 Cell Group, Rated 3.5 AH | | | TEMP: RH: |
| MANUFACTURER: Sonotone | | | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | | | TESTED BY: L. M. |
| | | | LAB SUP CHECK: H. B. |
| | | | ENGRG CHECK: I. L. |

| CELL NO. | CYCLE NUMBER 4464 | 4542 | 4627 | 4714 | 4799 |
|---|---|---|---|---|---|
| | | END OF CHARGE VOLTAGE | | | |
| 67 | 1.41 | 1.42 | 1.41 | 1.41 | 1.41 |
| 70 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 |
| 71 | 1.39 | 1.40 | 1.40 | 1.40 | 1.40 |
| R45 | 1.36 | 1.37 | 1.37 | 1.37 | 1.37 |
| R46 | 1.37 | 1.37 | 1.37 | 1.38 | 1.36 |
| R47 | 1.37 | 1.39 | 1.37 | 1.37 | 1.36 |
| R48 | 1.37 | 1.3[illegible] | 1.35 | 1.36 | 1.38 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 67 | 1.17 | 1.18 | 1.17 | 1.17 | 1.17 |
| 70 | 1.17 | 1.[illegible] | 1.17 | 1.16 | 1.16 |
| 71 | 1.10 | 0.85 | 0.97 | 1.00 | 1.00 |
| R45 | 1.19 | 1.20 | 1.21 | 1.20 | 1.19 |
| R46 | 1.20 | 1.20 | 1.20 | 1.22 | 1.16 |
| R47 | 1.19 | 1.22 | 1.[illegible] | 1.13 | 1.17 |
| R48 | 1.19 | 1.2[illegible] | 1.[illegible] | 1.19 | 1.19 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 50°C | | | Report 30 |

| CONDITIONING: | DATE: |
|---|---|
| Chg: 150% of dischg, 60 min; Dischg: 10% Depth, 40 min. | 20 Oct. 1963 |
| MATERIAL: Ni-Cad 5 Cell Group, Rated 3.5 AH | TEMP: RH: |
| MANUFACTURER: Gould National | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | TESTED BY: D. M. |
| | LAB SUP CHECK: H. B. |
| | ENGRG CHECK: I. L. |

| CELL NO. | 4484 | 4542 | 4627 | 4714 | 4799 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTAGE | | | |
| 23 | 1.43 | 1.42 | 1.42 | 1.42 | 1.42 |
| 28 | 1.42 | 1.39 | 1.40 | 1.42 | 1.43 |
| 31 | 1.42 | 1.41 | 1.40 | 1.40 | 1.40 |
| 32 | 1.43 | 1.42 | 1.42 | 1.42 | 1.42 |
| 33 | 1.40 | 1.41 | 1.42 | 1.41 | 1.43 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 23 | 1.16 | 1.16 | 1.17 | 1.17 | 1.15 |
| 28 | 1.20 | 1.18 | 1.18 | 1.22 | 1.21 |
| 31 | 1.21 | 1.22 | 1.21 | 1.20 | 1.20 |
| 32 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| 33 | 1.19 | 1.20 | 1.20 | 1.14 | 1.20 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at 50°C | | | Report 30 |
| CONDITIONING: Chg: 150% of dischg, 60 min; Dischg: 10% Depth, 40 min. | | | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 6 AH | | | TEMP: RH: |
| MANUFACTURER: Gulton | | | M. NO: VO-6HS |
| INSTRUMENTS: Same as Data Page 1 | | | TESTED BY: D. M. |
| | | | LAB SUP CHECK: H. B. |
| | | | ENGRG CHECK: I. L. |

| CELL NO. | 4484 | 4542 | 4627 | 4714 | 4799 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTAGE | | | |
| 602 | 1.41 | 1.41 | 1.41 | 1.41 | 1.39 |
| 604 | 1.38 | 1.38 | 1.38 | 1.37 | 1.37 |
| 610 | 1.39 | 1.37 | 1.39 | 1.38 | 1.40 |
| 611 | 1.39 | 1.38 | 1.39 | 1.39 | 1.39 |
| 616 | 1.41 | 1.41 | 1.41 | 1.42 | 1.41 |
| 624 | 1.40 | 1.38 | 1.40 | 1.40 | 1.40 |
| 719 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 |
| 765 | 1.41 | 1.41 | 1.41 | 1.41 | 1.41 |
| 778 | 1.41 | 1.41 | 1.41 | 1.41 | 1.41 |
| 779 | 1.41 | 1.40 | 1.41 | 1.41 | 1.41 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 602 | 1.24 | 1.24 | 1.23 | 1.24 | 1.22 |
| 604 | 1.20 | 1.17 | 1.17 | 1.17 | 1.14 |
| 610 | 1.20 | 1.15 | 1.19 | 1.16 | 1.21 |
| 611 | 1.23 | 1.22 | 1.23 | 1.23 | 1.23 |
| 616 | 1.24 | 1.23 | 1.24 | 1.23 | 1.23 |
| 624 | 1.20 | 1.14 | 1.21 | 1.21 | 1.20 |
| 719 | 1.21 | 1.21 | 1.21 | 1.21 | 1.20 |
| 765 | 1.21 | 1.21 | 1.22 | 1.22 | 1.21 |
| 778 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 |
| 779 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at -10% | | | Report 30 |
| CONDITIONING: Chg: 115% of dischg, 60 min; Dischg: 10% Depth, 40 min. | | | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 3.5 AH | | | TEMP: RH: |
| MANUFACTURER: Sonotone | | | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | | | TESTED BY: D. M. |
| | | | LAB SUP CHECK: H. B. |
| | | | ENGRG CHECK: I. I. |

| CELL NO. | 4184 | 4242 | 4327 | 4414 | 4499 |
|---|---|---|---|---|---|
| | | CYCLE NUMBER | | | |
| | | END OF CHARGE VOLTAGE | | | |
| 51 | 1.52 | 1.52 | 1.52 | 1.52 | 1.51 |
| 52 | 1.49 | 1.49 | 1.49 | 1.50 | 1.49 |
| 53 | 1.55 | 1.54 | 1.54 | 1.55 | 1.55 |
| 54 | 1.64 | 1.64 | 1.66 | 1.65 | 1.65 |
| 55 | 1.62 | 1.62 | 1.62 | 1.62 | 1.62 |
| 73 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| R34 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 |
| R35 | 1.60 | 1.59 | 1.60 | 1.59 | 1.59 |
| R36 | 1.50 | 1.50 | 1.50 | 1.50 | 1.51 |
| R38 | 1.62 | 1.62 | 1.62 | 1.60 | 1.61 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 51 | 1.24 | 1.25 | 1.25 | 1.24 | 1.24 |
| 52 | 1.23 | 1.24 | 1.24 | 1.24 | 1.24 |
| 53 | 1.24 | 1.25 | 1.25 | 1.25 | 1.24 |
| 54 | 1.24 | 1.26 | 1.25 | 1.25 | 1.25 |
| 55 | 1.24 | 1.26 | 1.26 | 1.26 | 1.25 |
| 73 | 1.24 | 1.25 | 1.25 | 1.24 | 1.24 |
| R34 | 1.25 | 1.26 | 1.26 | 1.26 | 1.26 |
| R35 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |
| R36 | 1.24 | 1.25 | 1.25 | 1.25 | 1.25 |
| R38 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at -10°C | | | Report 30 |
| CONDITIONING: Chg: 115% of dischg, 60 min; Dischg: 10% Depth, 40 min. | | | DATE: 29 Oct. 1963 |
| MATERIAL: Ni-Cad 5 Cell Group, Rated 3.5 AH | | | TEMP: RH: |
| MANUFACTURER: Gould National | | | M. NO: |
| INSTRUMENTS: Same as Data Page 1 | | | TESTED BY: L. M. |
| | | | LAB SUP CHECK: H. R. |
| | | | ENGRG CHECK: I. L. |

| CELL NO. | 3054 | CYCLE NUMBER 3154 | 3211 | 3284 | 3369 |
|---|---|---|---|---|---|
| | | END OF CHARGE VOLTAGE | | | |
| 25 | 1.53 | 1.52 | 1.52 | 1.52 | 1.53 |
| 26 | 1.54 | 1.53 | 1.54 | 1.54 | 1.54 |
| 27 | 1.56 | 1.56 | 1.56 | 1.57 | 1.57 |
| 35 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
| 38 | 1.54 | 1.54 | 1.55 | 1.54 | 1.55 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 25 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 |
| 26 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 |
| 27 | 1.25 | 1.26 | 1.26 | 1.26 | 1.26 |
| 35 | 1.27 | 1.28 | 1.28 | 1.27 | 1.27 |
| 38 | 1.30 | 1.29 | 1.29 | 1.27 | 1.29 |

# GENERAL DATA SHEET

| TEST | SPEC: | PAR: | TEST NO: |
|---|---|---|---|
| Cycle Life at -10°C | | | Report 30 |
| CONDITIONING: Chg: 115% of Dischg, 60 min; Dischg: 10% Depth, 40 min. | | | DATE: 20 Oct. 1963 |
| MATERIAL: Ni-Cad 10 Cell Group, Rated 6 AH | | | TEMP: RH: |
| MANUFACTURER: Gulton | | | M. NO: VO-6HS |
| INSTRUMENTS: Same as Data Page 1 | | | TESTED BY: D. M. |
| | | | LAB SUP CHECK: H. B. |
| | | | ENGRG CHECK: I. L. |

| CELL NO. | 4184 | CYCLE NUMBER 4242 | 4327 | 4414 | 4499 |
|---|---|---|---|---|---|
| | | END OF CHARGE VOLTAGE | | | |
| 617 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 |
| 619 | 1.60 | 1.59 | 1.60 | 1.60 | 1.60 |
| 620 | 1.54 | 1.54 | 1.55 | 1.54 | 1.54 |
| 623 | 1.55 | 1.55 | 1.56 | 1.55 | 1.55 |
| 627 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 |
| 631 | 1.60 | 1.59 | 1.59 | 1.59 | 1.59 |
| 780 | 1.53 | 1.51 | 1.52 | 1.51 | 1.51 |
| 783 | 1.55 | 1.55 | 1.55 | 1.55 | 1.54 |
| 798 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 |
| 801 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 |
| | | END OF DISCHARGE VOLTAGE | | | |
| 617 | 1.28 | 1.28 | 1.27 | 1.28 | 1.27 |
| 619 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 |
| 620 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |
| 623 | 1.27 | 1.26 | 1.26 | 1.26 | 1.26 |
| 627 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 |
| 631 | 1.29 | 1.28 | 1.28 | 1.28 | 1.28 |
| 780 | 1.20 | 1.29 | 1.29 | 1.29 | 1.29 |
| 783 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 |
| 798 | 1.28 | 1.28 | 1.27 | 1.28 | 1.27 |
| 801 | 1.28 | 1.27 | 1.28 | 1.27 | 1.27 |