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FOREWORD

This report was prepared by Gulton Industries for the Flight Accessories Laboratory, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio, under contract NO. AF 33(600)-42397. It is our pleasure to acknowledge the assistance of Mr. J. Cooper of the Flight Accessories Laboratory, who is the task manager.

The research was performed in the Research Department of the Alkaline Battery Division of Gulton Industries.

ABSTRACT

This report covers the first phase of a research and development program leading to improved, long life, reliable, high watt hour-per-pound, sealed silver-cadmium batteries.

A comprehensive literature survey has been conducted. Included are all items of interest relative to previous development effort and their current capabilities.

Data is given on special silver oxide-electrodes and comparison data on a commercial plate.

Design recommendations for meeting the desired performance requirements are proposed and discussed.

PUBLICATION REVIEW

The publication of this report does not constitute approval by the Air Force of the findings or conclusions contained herein. It is published for the exchange and stimulation of ideas.

This report has been reviewed and is approved.

FOR THE COMMANDER:

Signature 

Title G. W. SHERMAN, Chief
Flight Vehicle Power Branch

Laboratory Flight Accessories Laboratory

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I. SUMMARY

The objective of the first phase of this research and development program has been to conduct a literature survey on the state-of-the-art of silver-cadmium batteries. The literature review has pointed out several developments and problems.

The main problems and limitations found to date are associated with the silver-oxide electrode and the separator.

The properties of the silver-oxides are listed and each is discussed. The availability of the silver in the electrochemical reaction is a function of the temperature used during the sintering operation. The stability of silver II oxide is adversely affected by the presence of free silver on the electrode. Discharges at the higher voltage plateau can be prolonged by incorporating an inert conductive matrix within the electrode and by avoiding the presence of unoxidized silver.

The separator must be inert to oxidation and have the ability to screen out colloidal silver, rather than to complex soluble silver ions. The separator must at the same time be porous. These requirements are met at the present time by using several layers of different type separators.

Preliminary experiments were conducted on silver oxide electrodes prepared by impregnating a compound of silver into sintered nickel plates and depositing the silver therein at very low temperatures. The results attained were very promising. The electrode embodies the improvements suggested in this study.

Manuscript released by the authors February, 1961, for publication as a WADD Technical Report.

II. INTRODUCTION

The objective of this program is to provide a long life, deep cyclic, secondary silver-cadmium battery for military aerospace vehicles.

This objective is similar to work currently being carried out on another major alkaline battery system - the nickel-cadmium battery. The state-of-the-art for the nickel-cadmium battery is much further advanced, but there are two significant reasons for interest in the silver-cadmium system:

1. The silver system can potentially yield about twice the watt-hours per pound of the nickel system.
2. The silver system can be made nonmagnetic if necessary, which may be of importance for scientific satellites containing instruments for the measurement of magnetic fields.

Gulton Industries, Inc. has been very active in the development of hermetically sealed alkaline batteries for use in space applications and has significantly advanced the art, both in the development of a truly hermetically sealed container and in the development of a cell capable of operation when completely sealed.

The Alkaline Battery Division of Gulton Industries submitted to AMC Aeronautical Systems Center, a proposal in response to Purchase Request No. PR99856 for a research and development program on silver-cadmium batteries. As a result of this proposal, Contract No. AF 33(600)-42397 was awarded and the effective starting date was 23 November 1960.

The following are the objectives of the silver-cadmium battery program which is the subject of this report:

1. To conduct a literature survey.
2. To develop an improved silver electrode by impregnation or silver salt decomposition.

3. To procure or develop a more satisfactory separator. Application of coatings to the electrode or separator base and evaluation of separator combinations will comprise this phase.

4. To perform a fundamental study of the silver-oxide electrode directed toward providing a higher coefficient of utilization of the active materials and increased watt-hours per pound.

5. To fabricate prototype cells.

6. To evaluate cell and battery performance.

These objectives are based on the Requirements and Design Goals of Work Statement PR99856, the pertinent paragraphs of which are as follows:

3.1 The battery shall be capable of 4 amps discharge for 35 minutes with voltage maintained at 27.5 volts + 1.5 volts -4.5 volts.

3.2 The battery shall be capable of storing sufficient energy in 55 minutes to satisfy the requirement of paragraph 3.1.

3.3 The battery shall be capable of 11,000 discharge-charge cycles as outlined in paragraph 3.1 and 3.2 above, while operating in a temperature range $-20^{\circ}F$ to $+120^{\circ}F$.

3.4 The battery weight shall be kept to a minimum with a design goal of 6.5 pounds.

3.5 The battery shall be capable of withstanding vibration as specified in accordance with Procedure XIV of Specification MIL-E-5272C (ASG) except that 10 G should be used in lieu of 20 G.

3.6 The battery shall be capable of withstanding acceleration in accordance with Procedure III of MIL-E-5272C (ASG) except that 18 G should be used in lieu of 14 G.

3.7 The battery shall be capable of withstanding shock as outlined in paragraph 4.15.5.1 of MIL-E-5272C (ASG) except that 40 G shall be used in lieu of 15 G.

3.8 The battery shall be capable of operation in any position.

3.9 The battery shall be capable of operation in a zero "G" environment.

3.10 Consideration should be given to minimum volume.

3.11 As a design goal the battery shall be capable of operation in a vacuum of 10^{-9} mm of Hg.

3.12 The battery shall be capable of operation without maintenance throughout its entire cycle life.

3.13 The cell case shall not be one of the poles of the battery.

3.14 The cell case shall have a rectangular cross section.

III DISCUSSION

A. LITERATURE SURVEY

The literature survey required under this contract covers a two months period for the review of all previous development and capabilities of silver-cadmium batteries. This survey and subsequent analysis of the problem will result in recommended designs for meeting the goals set forth under Item 3 of the Work Statement. A search of the chemical literature has been conducted for articles concerning materials, electrodes and electrode reactions which have a bearing on the silver-cadmium battery. Most of the references studied so far deal primarily with silver-oxide electrodes and separators. The silver-oxide electrode references discuss preparation, charge-discharge reactions, solubility, limitations and electrical resistance. The separator references discuss membranes, additives, combination separators and resistance to oxidation.

Following is a summary and review of the literature perused to date.

1. General

The primary advantage of the silver-cadmium system is in applications where weight, space and high-rate operation are chief requirements. The choice of grid[1] for the active material affects the voltage and discharge characteristics. The electrode reaction is -

$$AgO/Cd/H_2O \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} Cd(OH)_2/Ag \qquad [1]$$

The average potential is 1.06 volts and the theoretical watt-hours/lb. is 101, which is reduced approximately 65% in a practical battery

due to structural and current-carrying components. The end-of-charge voltage is between 1.65 and 1.7 volts. In practical cells it is claimed that the following characteristics are achievable: 25-30 WH/lb, an average life of about 500 deep cycles, an internal pressure of 26 psi for a $\frac{C}{50}$ charging rate in sealed cells.

2. Silver Oxide Electrode

The literature references are most replete on the subject of the silver oxide electrode, but usually in conjunction with the zinc negative electrode system. Some do, however, refer to the silver-cadmium developments.

The silver electrode itself is formed by the thermal decomposition of Ag_2O, usually at 550°C to 800°C, onto a suitable grid. The resultant electrode is porous and is readily converted to active oxides when anodized. The charge reaction denotes the formation of two oxides as follows:

$$2Ag + 2OH \longrightarrow Ag_2O + H_2O + 2e \quad [2]$$

$$Ag_2O + 2OH \longrightarrow Ag_2O_2 + H_2O + 2e \quad [3]$$

The properties of the oxides differ in many important aspects and are directly related to the main problems associated with the development of long life "sealed" silver-cadmium secondary batteries.

Silver I oxide, Ag_2O, has high electrical resistance. Le Blanc and Sachse[3] give the specific resistance as about 10^8 ohm -cm. Another significant property is the solubility of Ag_2O in alkaline solutions. The solubility product at 25°C is 2 x 10 -8[4]. The solubility [5] and rate of solubility is

at least partly responsible for the poor shelf life characteristics. The solubility of Ag_2O increases with increasing hydroxyl ion concentration and temperature[7].

During the first step of charge, only Ag_2O was found to be formed by Xray analysis[8]. When Ag_2O pellet[9] was discharged, the reduced Ag was formed at the grid and not at the electrolyte boundary. On discharge removal of $O^=$ ions proceed from the grid toward the electrode-electrolyte interface. The current path available is a significant factor since the $O^=$ ions begin to migrate from the areas where the current enters the electrode. The cathodic process involves the removal of $O^=$ ions from the oxide by $K(H_2O)_4^+$ ions (hydrated K^+ ions).

The fall in potential from the higher AgO plateau during discharge is determined more by the resistance of the Ag_2O formed than by the increase of current density on the AgO since it was possible to get up to 40% of the discharge capacity at the higher voltage level over a modest range of current densities from small wire electrodes[10].

Silver II oxide has low electrical resistance and is insoluble in alkaline solutions[11]. AgO is unstable forming Ag_2O. The reaction AgO ($2AgO \longrightarrow Ag_2O + \frac{1}{2} O_2$) [4] in contact with KOH at 30°C yields a decomposition rate of approximately 16%/yr. and 45% at 45°C/yr.[12] The surface of an AgO electrode tends to become covered with a layer of Ag_2O, which possibly could retard the rate of decomposition of the underlying AgO. It can also be noted that during light overcharge less silver might dissolve and diffuse than on stand or discharge.

The AgO discharge mechanism on a pellet of AgO indicates formation of Ag O at the grid proceeding toward the electrolyte boundary[13].

Discharge data shows a two-stage voltage plateau. The higher plateau represents but a fraction of the capacity theoretically available. This indicates a conglomorate, rather than a true compound, as confirmed by Dirkee. The higher voltage level on discharge of AgO is unpredictable. The capacity delivered at this voltage depends on current density and other conditions. It disappears on stand without loss in total capacity[14] as follows:

$$AgO + Ag \longrightarrow Ag_2O \qquad [5]$$

Prolonged charging fails to convert all the silver to the divalent state. Polarization on discharge of AgO explains why less than half the discharge capacity is delivered at the higher voltage level[15]. This raises the possibility that the $AgO \longrightarrow Ag_2O$ process is polarized to such an extent that it operates at the lower potential of $Ag_2O \longrightarrow Ag$. The process depends on current density on the surface layer of AgO. When this exceeds a certain level, the potential drops. With increasing amounts of Ag_2O, this highly resistive material may bring about an IR drop in the electrode itself. Polarization of AgO is determined to some extent by the concentration of the KOH, by the cathodic process involving the removal of $O^=$ ions from the oxide by (hydrated K^+ ions) $K(H_2O)_4^+$

$$\begin{matrix} Ag = O \\ \\ Ag = O \end{matrix} + \begin{matrix} H \\ \diagdown \\ O \\ \diagup \\ H \end{matrix} + 2e \longrightarrow Ag\ O + 2OH^-$$

and by the transport of $O^=$ ions through the electrode material.

A study on chargeability of the silver electrode at various rates, electrolyte concentrations and temperatures indicated[16] that: 1) the capacity decreased as the charge rates increased; 2) capacity decreased much more rapidly in 30% KOH than in 35% KOH; and 3) the amount of charge at the Ag/Ag_2O potential plateau is a

fairly reliable measure of how much of a charge the electrode is going to accept. The initial condition of the electrode surface of the plate seems to be important and merits further study as to charge acceptance[17]. When gassing potential is reached, some O_2 is still added to the electrode to approximately 10% of the current passed[18].

It is stated[19] that it was possible to get equal discharge capacities and voltage plateaus from each silver oxide, AgO and Ag_2O, by maintaining good electrical contact with the AgO grains. This was done by incorporating inert, highly conductive matrices into the electrode.

Electroformed plates gave longer discharge rates at the AgO plateau because there was better contact between AgO grains. The electroformed plates resulted in a highly porous, deposited silver electrode with pores of 1 micron. During charge, however, the electroformed plates did not oxidize completely. The electroformed electrode is claimed[20] to be stronger and to yield a higher voltage during discharge than pasted AgO electrodes. The electroformed plates resulted in a 20% first plateau when discharged at a 6-7 hour rate and 10% at the 3 hour rate.

It was found that the temperature of sintering markedly affects the available capacity from 90% of theoretical to 50% in the temperature range of 450°C to 700°C, respectively. The coefficient of utilization[21] is also reduced in that the silver is never completely converted to Ag_2O. Conversion was less than 60%, depending on the density of the silver. Maximum conversion of $Ag \rightarrow Ag_2O$ was 80% in 28% KOH. The reaction $Ag + AgO \rightarrow Ag_2O$ probably does not occur appreciably during a charge, since it is very slow[22]. It does, however, react on stand[23].

AgO was found[24] to be stable in water at 100°C. It decomposes slightly in alkali at room temperature. Silver oxide I does not affect the rate, whereas the presence of silver accelerates the decomposition.

The application of trace quantities of cadmium to the silver oxide electrode seems to enhance the discharge at the higher voltage plateau[25].

Another project[26] reports limiting concentrations of silver to 0.75 gms/sq. in. and cadmium to 1.2 gms/sq. in. so as to prevent cracking and breaking of plates during rolling to make "D" cells. The performance at 275 cycles is down to 44% of capacity with all cells containing high resistance shorts to the extent that the open circuit voltage is zero in 48 hours.

3. Separators

Separator literature is also quite voluminous in that the separator must perform many functions which have a direct bearing on battery life and on the reproducibility of battery characteristics. The separator is in all probability the weakest link. A good separator should have most of the following properties.

a) Low electrical resistance (0.050 ohm-in.^{2})

b) Stability in strong alkali (tensile strength and dimensional changes)

c) Ability to retain electrolyte upon acceleration up to 25 G

d) Stability in the temperature range from -60 to +140°F.

e) Ability to prevent migration of silver ions and colloidal silver

f) Inertness to oxidation, particularly by silver oxides

These properties are met to date by using a combination of several different separators as layers between plates, each layer providing a specific function. A typical arrangement is to place an ionic membrane against the silver positive electrode followed by a light woven nylon fabric and a piece of cellulosic mat against the negative electrode. The necessity for the separator sandwich may be regarded as a temporary expediency.

One reference[27] describes the coating of positive plates with magnesium hydroxide followed by air drying, which converts the $Mg(OH)_2$ to MgO and $MgCO_3$. The purpose of the coating is to isolate the separator from direct contact with the silver oxides, thus retarding oxidation.

The silver oxide electrode requires separators which will prevent the loss of colloidal silver and the migration of silver ions and, at the same time, resist oxidation. Cellophane does not resist oxidation and gradually accumulates reduced silver which causes a permanent loss of capacity. Shair et al[28] coated polymeric materials such as dynel, acrylonitrile and polyvinyl chloride with various coordination compounds of polyamines cross-linked with acid formaldehyde solutions. The resultant separators increased life to over 120 cycles in silver-zinc systems. Since that time[29] two other varieties of ionic membranes have been tested. Polypor WA, or weak acid type of exchange resin (200 mesh) and Polypor WB, or weak base type, have been applied to woven nylon from a solution of PVC-acrylonitrile copolymer in dimethyl formamide and then leached with water to form pores. It was found that:

1) If the membrane material is chemically inert, and the pore structure capable of performing as a colloidal filter, it will operate successfully in the silver cell.
2) Polypor WA was better because of its ability to screen out colloidal silver rather than to complex soluble silver ions.

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B. SILVER ELECTRODE PREPARATION

1. Experimental Gulton Electrodes

Prior to November 23, 1960, special silver oxide electrodes were prepared by impregnating a compound of silver into a sintered nickel plate. The silver was thermally deposited within the nickel matrix at low heat. The purpose of this study was to investigate the effect of a nickel grid on the silver oxide-cadmium electrode system, and thereby to decide on the feasibility of a silver-cadmium battery system utilizing the well known advantages of sintered nickel construction for both electrodes.

Studies were made using an 0.6 AH silver oxide electrode, wherein the silver had been deposited within a sintered nickel matrix. The negative was a standard Gulton cadmium sintered nickel electrode. The electrolyte used was 38% KOH in which the plates were suspended about one inch apart. No separator was used at this time. The results with this system indicate definite desirable possibilities as can be seen from the discharge data shown in Table I and Figure 1.

It should be particularly noted that up to 45% of the discharge capacity is available at the higher AgO potential. This capability is a desirable one because of the increased watt-hours/lb. which is available at the initially higher potential. Efforts have previously been made in the industry to work at the higher potential with only limited success.

Table I

DISCHARGE DATA FOR EXPERIMENTAL SILVER-CADMIUM CELL

Discharge Current (Amperes)	Voltage (Volts) E_1	Voltage (Volts) E_2	Capacity (Amp. Hours)	Capacity at E_1 (% of total)[1]
0.5	1.38	1.07	0.50	45%
1.0	1.30	1.02	0.50	45%
2.0	1.10	0.82	0.53	45%
5.0	----	0.90	0.58	None
1.0[2]	1.30	1.02	0.53	45%

Notes:

(1) E_1 = AgO Potential
E_2 = Ag_2O Potential

(2) After 12 hour open circuit stand

(3) For discharge curve see Figure 1

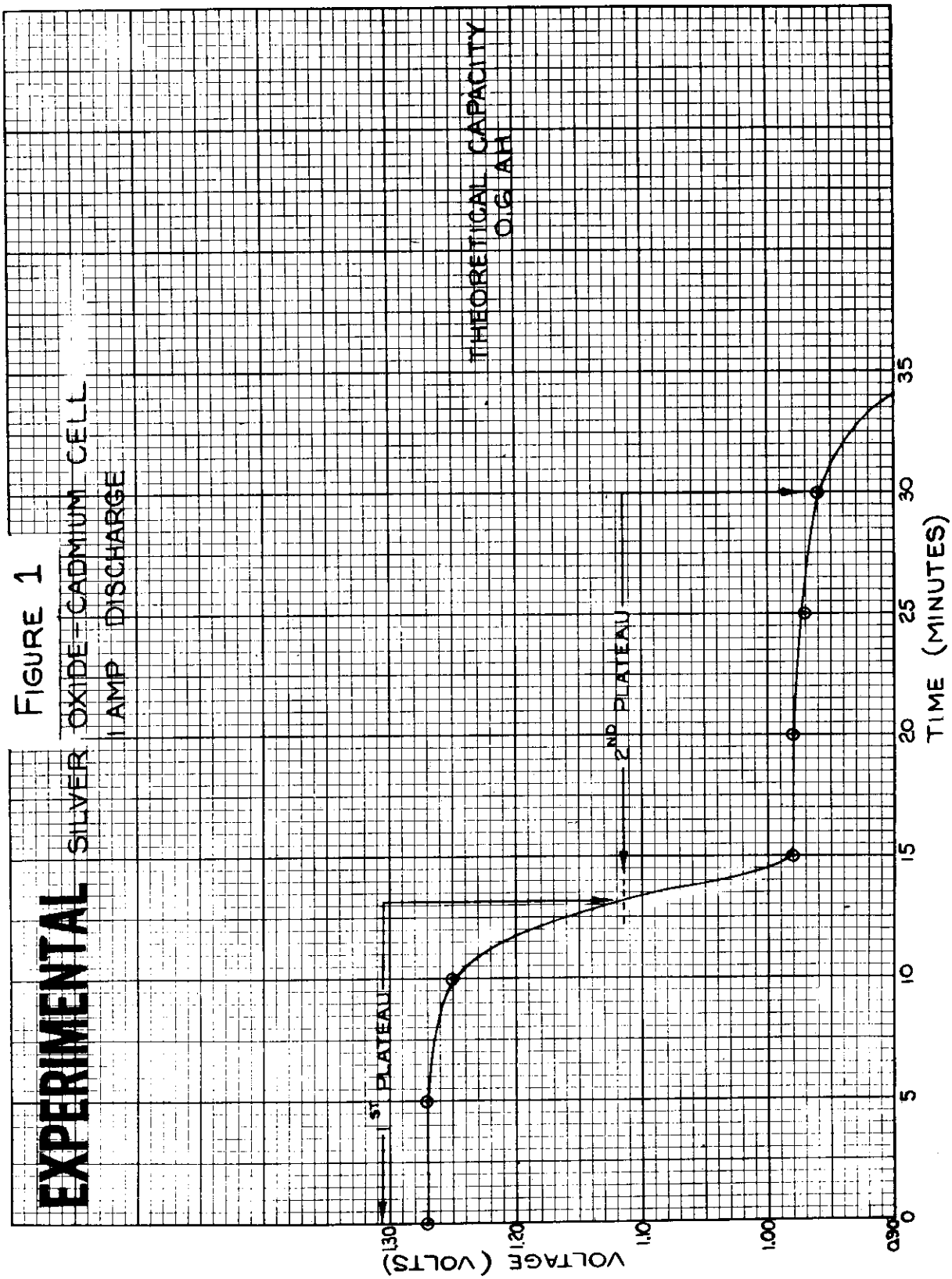


FIGURE 1

Another plate was impregnated with a greater amount of silver so as to check its compatibility with the requirements and objectives of this contract, as follows:

Before loading:

a) Weight - 7.9 gms

b) Dimensions - 6.6 x 5.7 x .09 cm

c) Porosity - 72%

After loading:

a) Weight - 12.2 gms

b) Porosity - 55%

c) Theoretical capacity - 2.10 AH

d) Weight of silver - 4.3 gms

Table 2 shows discharge data for the Gulton experimental silver-cadmium electrode discharged against standard Gulton cadmium plates (normally used for nickel-cadmium cells).

The performance of this silver oxide electrode indicates a high order of active material utilization, both at the one hour rate, C, and at the 5C rate. The discharge proceeds with about 41% of capacity available at the higher potential plateau at the C rate and 36% available at the 5C rate. These results are attributed mainly to the following properties of this electrode:

a) High porosity (55%)

b) Silver deposited at low temperature (100-200^{o}C)

c) Sintered nickel matrix, yielding improved conductivity between oxide grains and supporting matrix.

Table II

DISCHARGE DATA FOR EXPERIMENTAL SILVER-CADMIUM CELL

Discharge Current (Amperes)	Voltage (Volts) E_1	Voltage (Volts) E_2	Capacity (Amp. Hrs.)	Capacity at E_1 (% of Total)	Total Capacity (% of Theoretical)
2.0	1.36	1.09	1.86	41%	89%
10.0	1.28	1.02	1.84	36%	88%

Notes:

(1) E_1 = AgO Potential
E_2 = Ag_2O Potential

(2) Theoretical capacity = 2.10 AH

(3) See figures 2 and 3 for discharge curves

A control run on a commercial silver plate was made for comparison with the findings as indicated below and in Table III.

2. Commercial Electrode

Physical characteristics of loaded plate:

a) Weight - 8.50 gms

b) Dimensions - 6.6 x 6.0 x .04 cm

c) Porosity - 31%

d) Weight of silver (-screen weight) - 7.6 gms

e) Theoretical capacity - 3.80 AH

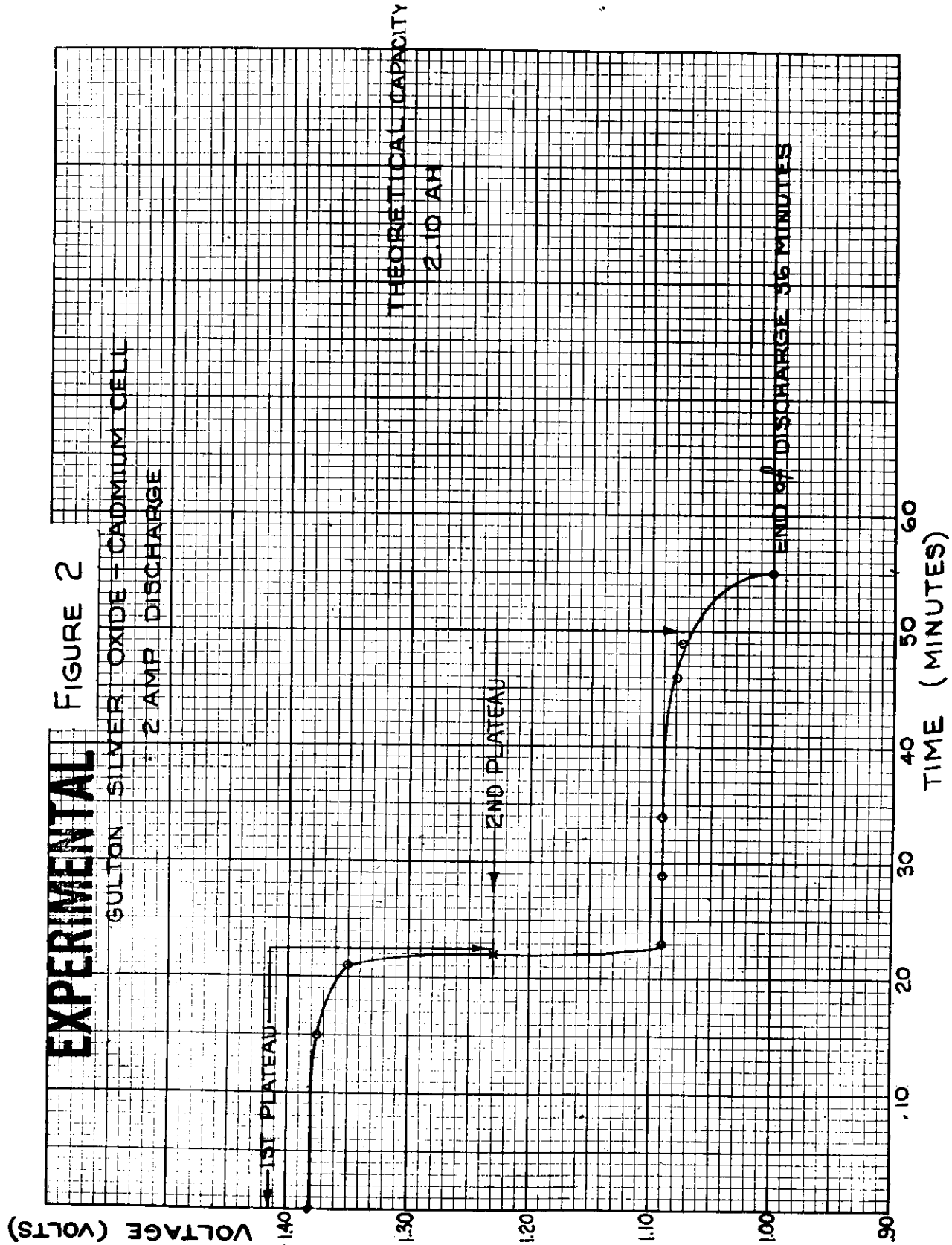


FIGURE 2

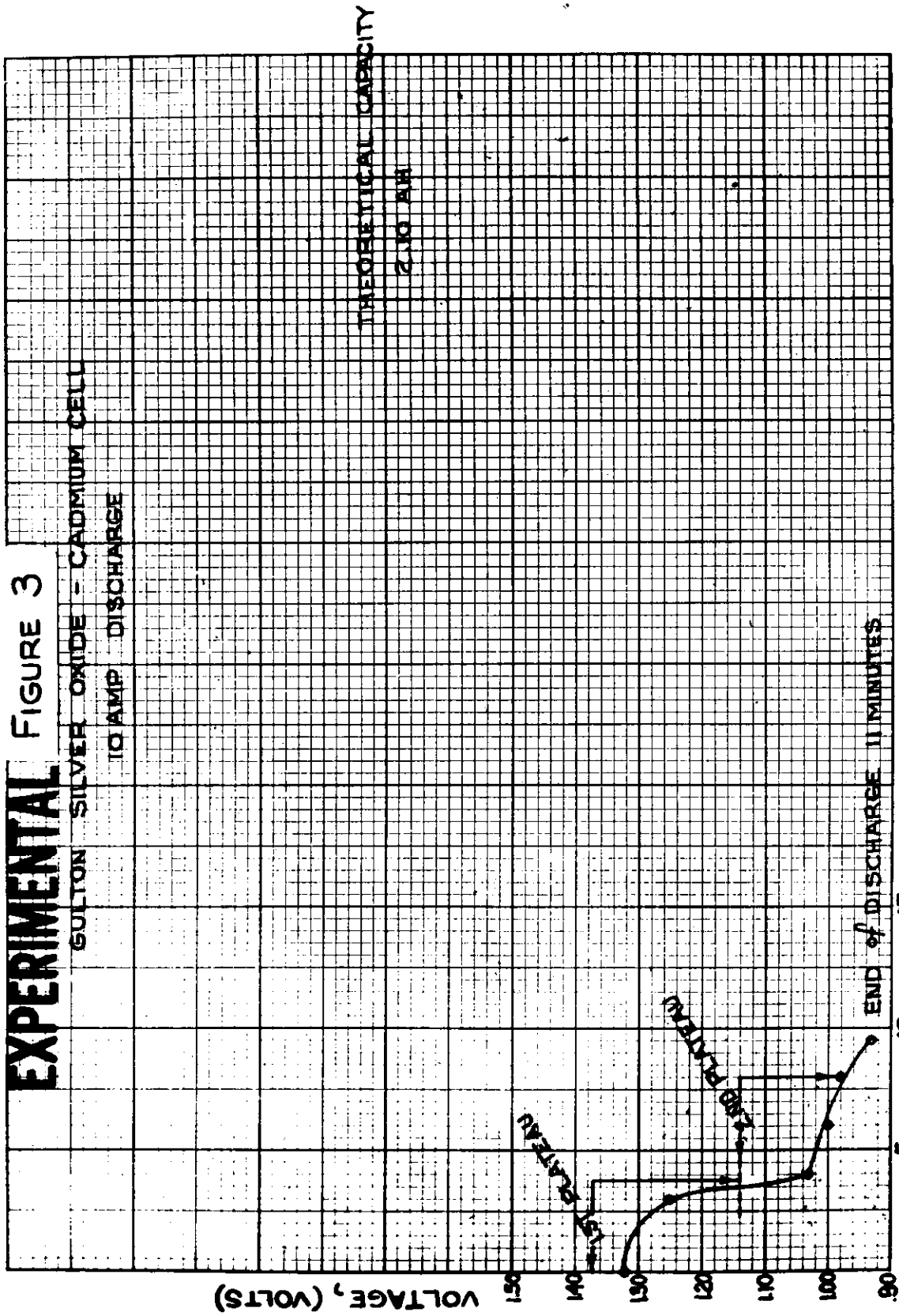


FIGURE 3

Table III

DISCHARGE DATA FOR "COMMERCIAL"

SILVER-OXIDE ELECTRODE

Discharge Current (Amperes)	Voltage (Volts) E_1	Voltage (Volts) E_2	Capacity (Amp. Hrs.)	Capacity at E_1 (% of Total)	Total Capacity (% of Theoretical)
2.0	1.25	1.04	1.56	34.0%	41.0%

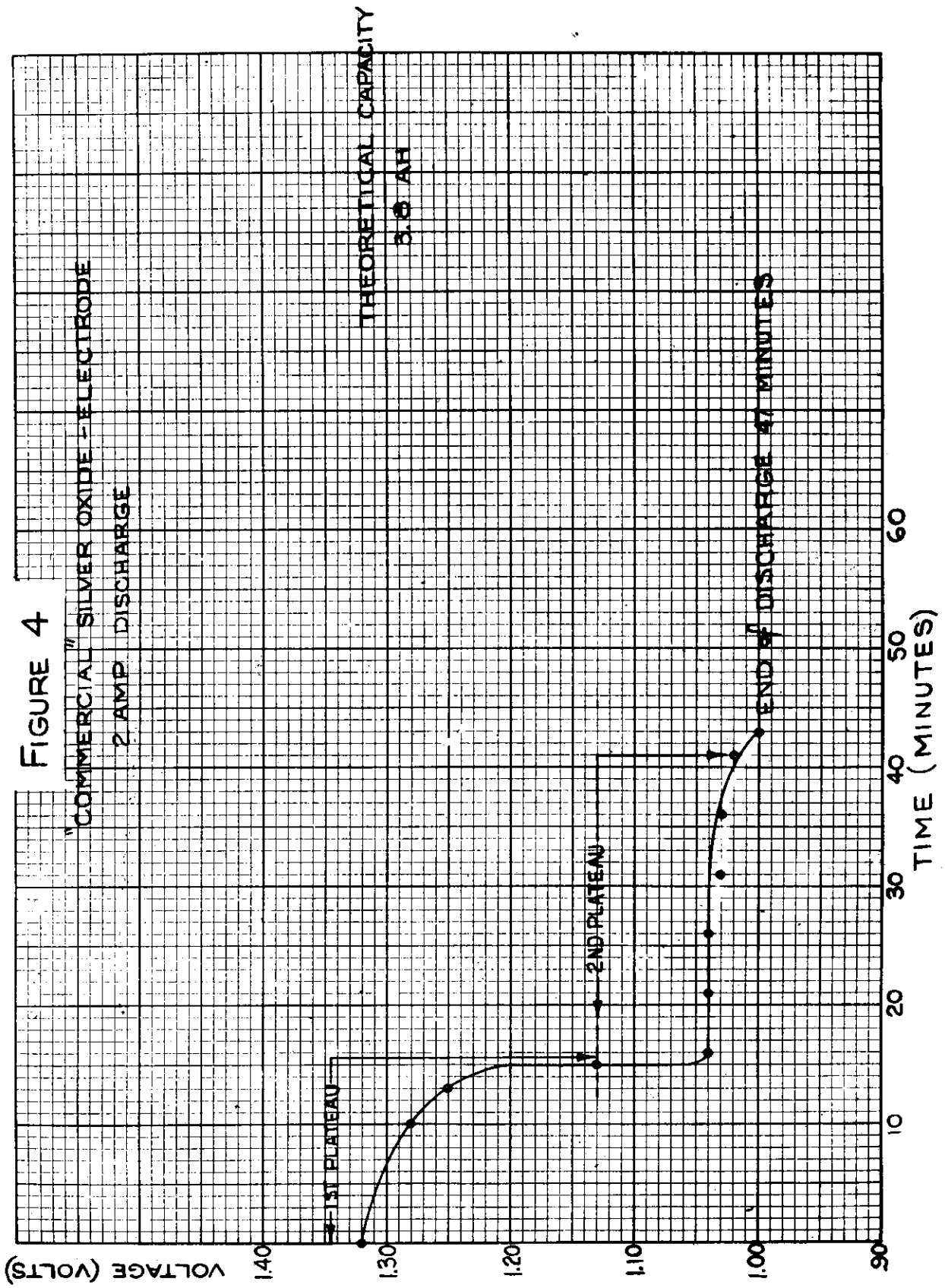
Notes:

(1) E_1 = AgO Potential
E_2 = Ag_2O Potential

(2) Theoretical capacity = 3.80 AH

(3) See figure 4 for discharge data

From Table III it is seen that the voltage during discharge is lower than for the Gulton experimental electrode. The discharge capacity at E_1 is also lower. The greatest difference, however, is the low coefficient of utilization; only 41% of the theoretical capacity compared to 89% for the Gulton electrode.



IV RECOMMENDATIONS

The following recommendations for meeting the goals and requirements as outlined in item 3 of the work statement, PR99856, are based on 1) the results of the literature survey; 2) work done during and prior to contract award; and 3) the performance characteristics of commercial silver oxide positives.

A. PROPOSED DESIGN

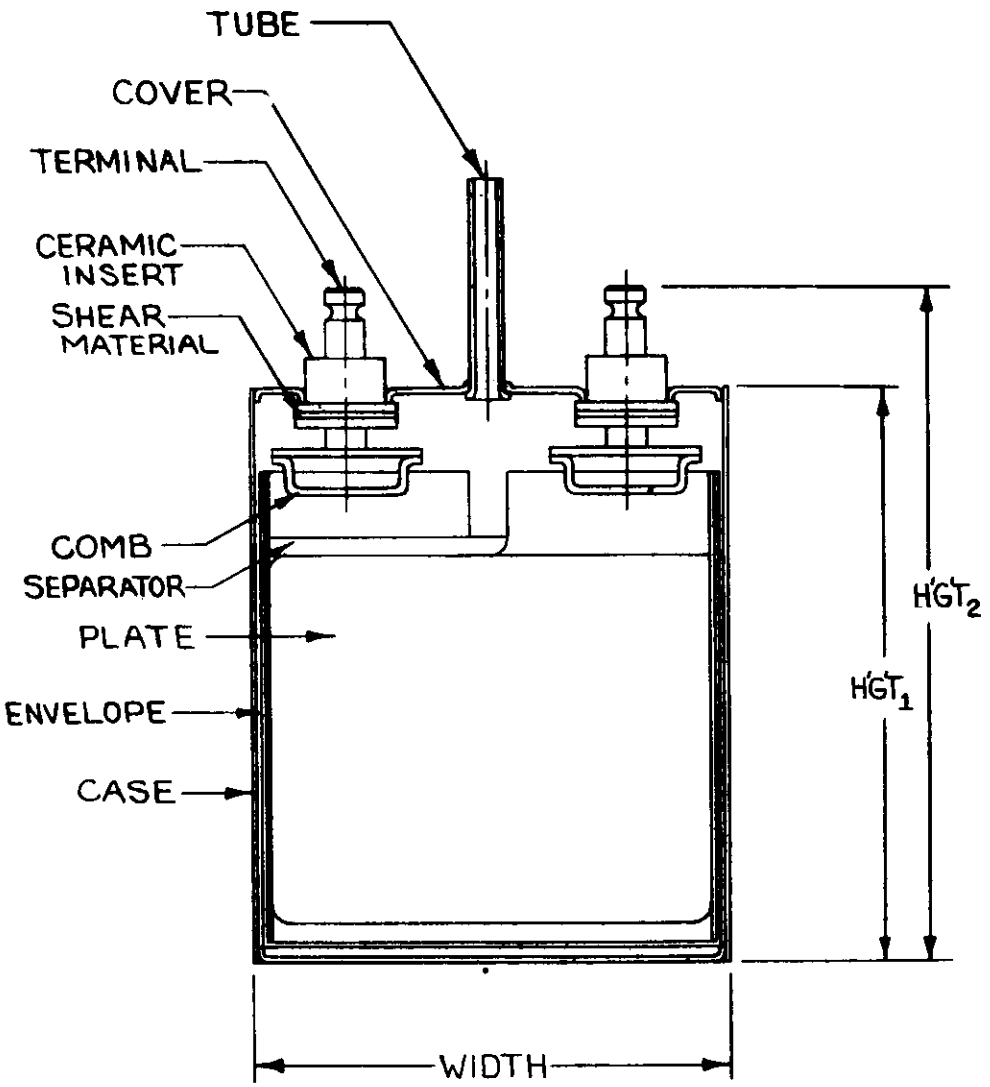
1) Using squat plates, 60 mm high by 70 mm wide by 0.9 mm thick for negative and positive, a cell having a nominal capacity of 6.0 AH is proposed. This would require 3 positive plates and 4 negative plates. The choice of separator used will depend on subsequent analysis and investigation. The configuration of this cell is illustrated in figure 5.

2) Using squat plates, 55 mm high by 48 mm wide by 0.9 mm thick for negative and positive, a cell having a nominal capacity of 6.0 AH is proposed. This would require 5 positive plates and 6 negative plates. The separator used will depend on subsequent analysis. The configuration of this cell is similar to figure 5, except for the final dimensions.

B. DISCUSSION OF PROPOSED DESIGN

For the plates we propose to use standard Gulton sintered nickel plaques which will be impregnated with appropriate active materials; the negative with cadmium and the positive with silver. By using a porous nickel matrix for deposit of active material, the silver-cadmium battery will be capable of high rate discharge and a high coefficient of utilization. The conductivity problem of the lower silver oxide to the electrode will be minimized. The grain structure of the deposited silver can be finer since it is held within the nickel matrix. The temperature at which the active silver electrode material is deposited is lower than the sintering temperature of the more commonly utilized processes and a less dense electrode results.

FIGURE 5.
6 A.H. SILVER CADMIUM CELL



As a consequence, the coefficient of utilization of active material is greater. The higher silver oxide tends to be more stable, since there is less free silver present within the electrode to promote its decomposition. The electrode is thus capable of a higher energy output at both low and high rates. The sintered nickel matrix construction helps to contain active material during acceleration, shock and vibrations.

A comparison of an experimental electrode (utilizing the new technique to deposit silver in a sintered nickel matrix) with commercial sintered silver electrodes indicates that the increased weight of the matrix is offset by the increased utilization of active material. Approximately 92 watt-hours/lb. can be achieved for the positive electrode by either technique. Summarizing, the main advantages of using a sintered nickel construction for the silver oxide electrode are as follows:

a. Greater porosity

b. Higher coefficient of utilization of active material

c. High rate discharge capabilities

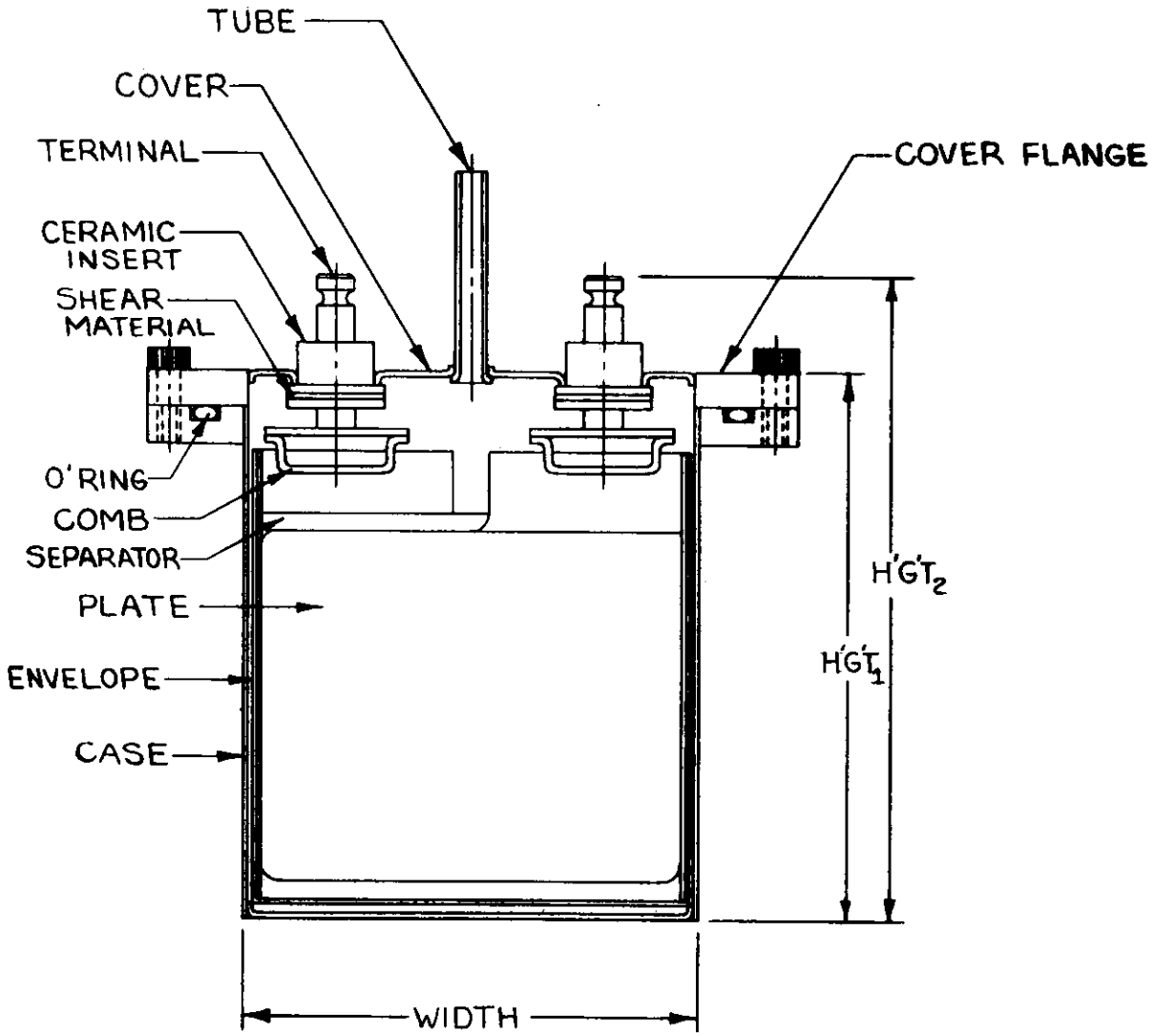
d. Higher wattage level during discharge

e. Equivalent watt-hours/lb.

To fabricate prototype cells which may be disassembled for examination, we propose to incorporate a flanged arrangement to which the cover may be joined in a manner similar to that used for the production of completely hermetically sealed cells. The flanges will be sealed by "O" rings and held together by screws to provide a tight joint, as shown in figure 6.

The voltage regulation requirements make it necessary to consider a 21 cell battery having a regulation between 1.38 volt per cell at start of discharge and 1.09 volt per cell at the end of discharge. In order to keep the weight down, we propose to make 6.0 AH cells which will be subjected to depths of cycle of up to 40%.

FIGURE 6
6 A.H. SILVER CADMIUM CELL



C. TEST PROGRAM

1. Cycling

a) 4 amps discharge for 35 minutes

b) 3.1 amps charge for 55 minutes

(This returns 120% of the removed capacity back into the cell. Depending upon the overcharge characteristics of the cell, this figure may be altered, but it must be held constant for all cells of a given configuration.)

c) 2 amps discharge for 35 minutes

d) 1.6 amps charge for 55 minutes

(This puts 120% back into the cell. Depending upon the overcharge characteristics of the cell, this figure may be altered, but it must be held constant for all cells of a given configuration.)

e) Same as a) and c) except that recharge will be at constant potential. The optimum potential for recharge is to be determined. A preliminary value of 1.60-1.65 volts/cell is considered feasible at present.

f) All charge and discharge schedules will be conducted at the following temperatures: $-20^{\circ}F$, $+78^{\circ}F$ and $+120^{\circ}F$.

g) As many cycles as possible will be attained within the time available.

2. Vibration

Since vibration is not expected to affect the rate of charge or discharge of a cell, it should be sufficient to vibrate a fully charged cell in accordance with procedure XIV of MIL-E-5272C(ASG) with the exception that a maximum of 10 g is specified instead of 20 g in accordance with the subject

contract work statement. Any failure of the structure would result in the electrical failure of the cell; i.e. the plates might short together, etc. Determination of survival of the test by the electrical elements will be made by conducting a capacity check at the 5 hour rate. Failure of the seals will be subsequently checked by pressurizing the cell in a helium atmosphere and then placing it in a vacuum chamber which will be connected to a helium detector. Any helium present will be detected in the vacuum chamber.

3. Acceleration

The cells shall be tested in accordance with procedure III of MIL-E-5272C(ASG). Since the acceleration test period is so short, relative to the time required to determine any change in capacity, capacity checks will be run prior to and subsequent to the acceleration test.

4. Shock

The cells shall be shock tested in accordance with paragraph 4.15.5.1 of MIL-E-5272C(ASG) with the exception that 40 g will be substituted for 15 g in the specification. The apparatus used shall conform to MIL-S-4456. Success or failure of the cell in this test shall be determined by the same steps as those following the vibration test.

5. General

In order that any inherent faults in the construction of cells will not be obscured by continuous failure in one item of the test procedure, the four steps above should be alternated on successive cells tested.

Upon completion of Item 2 (7 months after acceptance of design) two (2) cells in accordance with said approved design and meeting the requirements of paragraph 3 of the Work Statement will be delivered as stipulated.

U.S. GOVERNMENT PRINTING OFFICE : 1961 O—608550