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MANUFACTURING METHODS AND TECHNOLOGY FOR HERMETICALLY SEALED LI--ETC(U)
OCT 76 M G ROSANSKY, R M TEDESCHI DAAB07-76-C-0042
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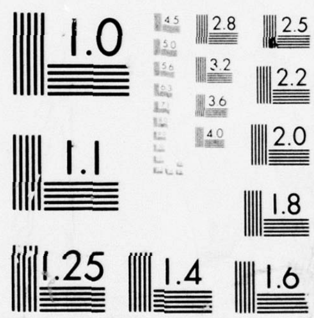
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TECHNICAL REPORT 0042-Q-01 Oct[redacted]

MANUFACTURING METHODS AND TECHNOLOG

HERMETICALLY SEALED LITHIUM SO_2 CELL B

FIRST QUARTERLY REP[redacted].

25 JUN[redacted] TO 30 SEP[redacted]

CONTRACT NO. DAAB07-76-C-0042

76-0042-Q-01

DISTRIBUTION STATEMENT

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Prepared by

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POWER CONVERSION, INC.

70 MACQUESTEN PKWY, SOUTH

MT. VERNON, N.Y. 10550

Prepared for

U.S. ARMY ELECTRONICS COMMAND
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES

OBJECT OF STUDY: Establish hermetically s
cell/battery designs and
techniques necessary to
hardware production leve

MANUFACTURING METHODS AND TECHNOLOGY

FOR HERMETICALLY SEALED LITHIUM

SO_2 CELL BATTERIES

1ST QUARTERLY REPORT FOR PERIOD

25 JUNE 1976 TO 30 SEPTEMBER 1976

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Disposition

This project has been accomplished as part of the US Army Manufacturing and Technology Program, which has as its objective the timely establishment of manufacturing processes, techniques or equipment to insure the efficient production of current or future defense programs.

ABSTRACT

Effort has commenced on the MM&T program to establish the fabrication techniques and requirements necessary to meet hardware production levels as specified in the subject contract. A PERT/TIME Network was developed to define specific management and engineering objectives within the overall program. Initial hermetic cell and battery component design has been developed to meet and/or exceed all performance, safety and environmental specifications. The basic system concepts for electrolyte fill and dispensing, core winding, cathode/anode manufacture and hermetic closure have been defined to permit subsequent integration within an operational production line. Interface with automated equipment manufacturers continue in order to define specific machine elements and initiate hardware procurement within the time frame of the PERT/TIME Network.

PURPOSE

The basic objectives of this program are to:

a) establish the producibility of the specified hermetically sealed lithium cells and batteries by mass production techniques and facilities;

b) establish and improve quality control surveillance and inspection;

c) initiate process improvements to minimize overall fabrication costs and time.

The program consists of six (6) primary components:

- Battery and Cell Design
- Electrolyte Preparation and Dispensing System
- Core Winding Machine Design
- Cathode Manufacture
- Anode Manufacture
- Welding Equipment Design

Evaluation of the above independent tasks will be conducted in parallel to permit subsequent integration within an operational manufacturing process.

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I. INTRODUCTION

The Manufacturing Methods and Technology (MM&T) Project No. 2759371 to Establish Automatic Electrode Production for Lithium Hermetic Cells requires the establishment of production techniques for hermetic lithium cell components, cells and batteries to meet production levels delineated in the contract. Specifically, the following hermetic batteries will be manufactured utilizing the automatic electrode processes established under this program:

BA-5590 ( )/U	BA-5574 ( )/U
BA-5585 ( )/U	BA-5841 ( )/U
BA-5090 ( )/U	BA-5100 ( )/U
BA-5842 ( )/U	BA-5567 ( )/U
BA-5568 ( )/U	BA-5598 ( )/U

The production engineering goals of this program are to perform the necessary design, development, engineering, fabrication of special tooling and construction of test facilities and limited production equipment to obtain confirmatory sample approval; and to establish a pilot line and pilot run for the purpose of demonstrating a manufacturing process.

As a result, Power Conversion, Inc. will establish a Pilot Line and demonstrate the capability of this line with at least 20% of the Pilot Run units. The rates to be met are:

5,000 "D" Type Cells in an eight-hour day.

2,500 cells other than "D" Type* cells in an eight-hour day.

*Other than "D" type cells are those cells to be utilized in the fabrication of the deliverable batteries.

II. GENERAL DESCRIPTION AND RELATED STATE-OF-THE-ART

As required under this program, PCI will fabricate all batteries and cells utilizing a non-reserve lithium organic electrolyte sulfur dioxide system. PCI has been manufacturing these types of cells over the past five years. The following description will **briefly** delineate the basic state-of-the-art cell composition and fabrication techniques.

A. Cell Composition

The basic cell consists of the following components:

a) A lithium anode
b) A porous carbon cathode
c) A sulfur dioxide/organic solvent electrolyte
d) A steel housing to contain the cell components
e) A non-woven polypropylene separator
f) A hermetic seal

B. Cell Reactions

The cell reactions occurring in this system are:

Anode: $2\,Li \rightarrow 2\,Li^{+} + 2e^{-}$

Cathode: $2\,SO_2 + 2e^{-} \rightarrow S_2O_4^{=}$

Full Cell: $2\,Li + 2\,SO_2 \rightarrow Li_2\,S_2\,O_4 \downarrow$

C. Cell Components

1. Anode

The anode is fabricated from high purity (99.97% pure) lithium metal. It is purchased in foil form on coils in various widths and thicknesses. The range of sizes covered under this program are 0.2" width to 2.0" wide and .010" to .019" thick.

2. Cathode

The cathode is fabricated from a mixture of carbon/binder and solvents which are formed onto an aluminum - expanded metal current collector.

3. SO_2 - Organic Electrolyte

The electrolyte system consists of three components. These components include SO_2, organic solvent and lithium salt. One major constituent of the electrolyte is SO_2. As shown in the full cell reaction, SO_2 is utilized in the cell reaction to form $Li_2S_2O_4$ precipitate. This precipitate is formed in the pores of the cathode during cell discharge. The organic solvent is used to provide increased solubility levels for the lithium salt.

4. Cell Separator

The cell separator prevents direct electrical contact between the anode and cathode while allowing ionic and mass transport flow between them. The separator is fabricated from polypropylene and varies in thickness from .001 to .005 inch depending upon cell performance requirements.

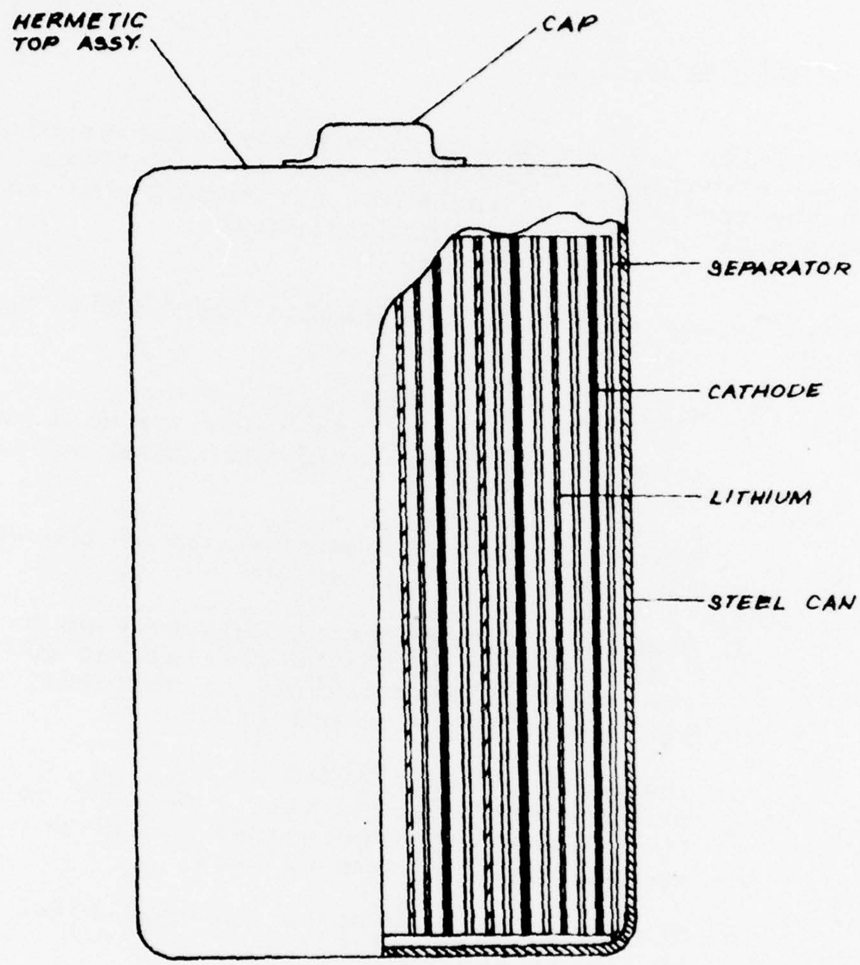
5. Cell Housing

The cell casing is fabricated from cold rolled steel which varies in thickness from 0.019 inches to 0.012 inches. The steel is nickel plated to prevent environmental corrosion. Incorporated in the cell container is the safety vent mechanism. The cell can bottom is coined to a designated pattern. This coining is performed to create a thin wall section in the container. By controlling the parameters of the coined area (width, thickness, and location as well as state of anneal) the pressure at which the cell safety mechanism will activate can be controlled. The cell safety mechanism is presently designed to activate at a pressure of 550 ± 50 psi. Shown in Section V is a more detailed description of this mechanism.

D. Cell Design

The PCI lithium cell design which has been used over the past five years will be used as the basis for the required cells and batteries. Design modifications will be implemented as required to facilitate automated assembly and reduce overall fabrication costs. The design chosen allows flexibility in achieving wide performance capability as well as being amenable to automatic production.

The components as described previously are arranged within the cell as shown in Figure 1. The basic cell structure consists of a cylindrical casing containing a spirally wound electrode core. This core is composed of a lithium foil anode, polypropylene separator and a plate type cathode. These components are sandwiched together, insulated by the separator and wound to form a spiral which is subsequently assembled within the nickel plated steel can. This type of construction provides increased electrode surface area capable of yielding high current discharge rates over a wide temperature range.



CROSS SECTION CELL

FIGURE 1

III. FABRICATION PROCESSES

The fabrication processes which have been utilized at PCI over the past five years are primarily manual with some semi-automatic operations. The following brief description outlines the current techniques utilized at PCI in component and battery manufacture.

A. Cathode Manufacture

The cathode as described previously consists of a composite structure containing carbon and polytetrafluoroethylene (PTFE) resins which are formed onto an expanded aluminum metal current collector.

The present method of fabricating the cathode consists of:

1. Mixing quantities of carbon/binder, and solvent in proper ratios depending upon cell type to be manufactured and number of cells to be fabricated.
2. Weighing out of proper amounts of the wet mix material for a cathode sheet.
3. Dispensing the material in a solvent mix and drying to remove the solvent and allow the carbon/binder mixture to uniformly disperse onto the aluminum grid.
4. The sheet is then sized by rolling, predried and die cut to size. Current collector tabs are then welded to the screen utilizing resistance welders.
5. The individual cathodes are then final dried to remove residual solvent.

B. Anode Manufacture

The anode consists of a single structure of pure lithium in ribbon form, onto which is "staked" a copper collector tab. Fabrication of the anode consists of obtaining the lithium in coil form to specified width and thickness. The material is manually cut to length and a copper tab is pressed into the soft malleable lithium. Anode manufacture is performed in a controlled humidity environment because of the high reactivity of lithium with trace amounts of moisture.

C. Cell Assembly

Cell assembly is performed within a controlled humidity environment. This is necessary to prevent moisture contamination of the internal cell components.

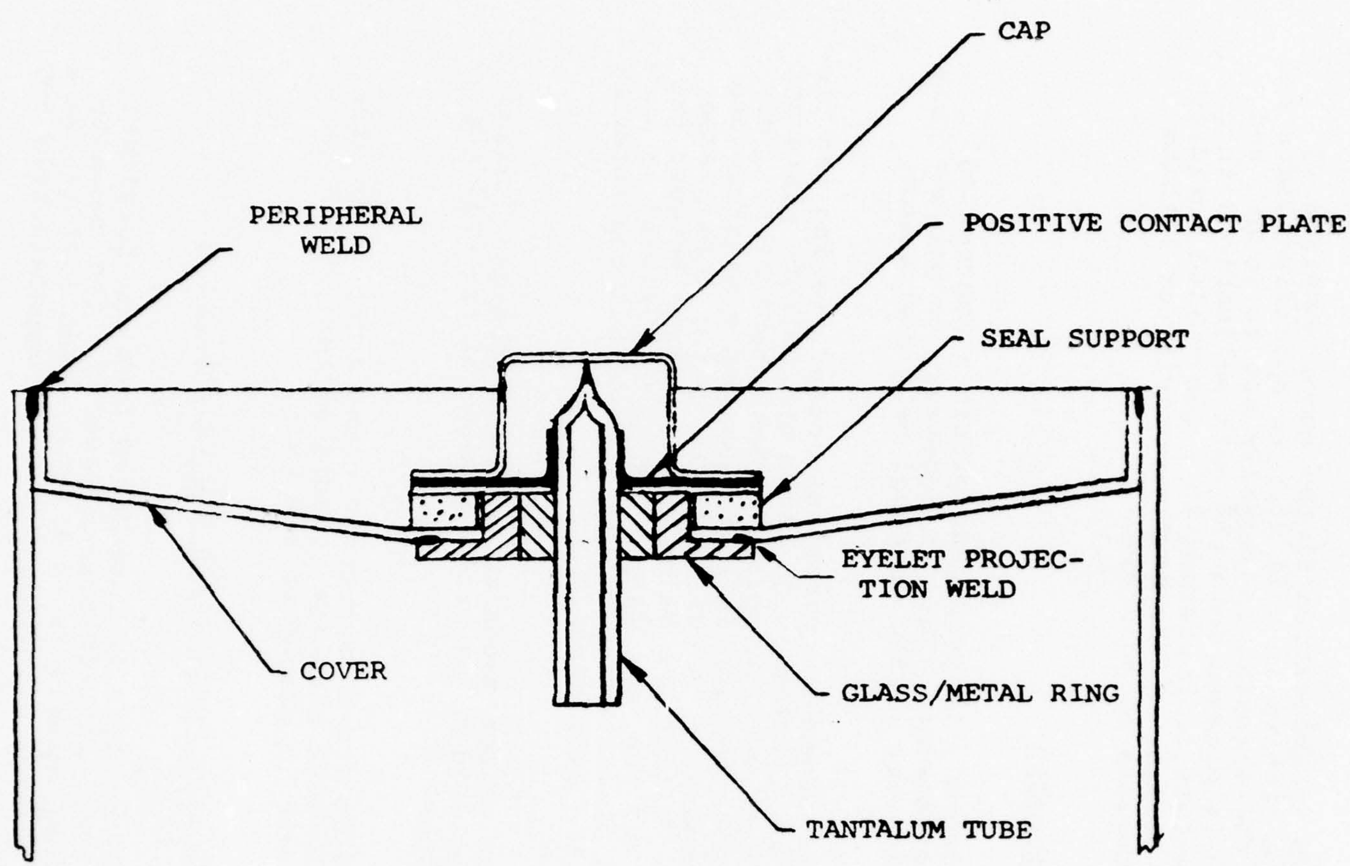
The cell assembly operations include taking the previously formed lithium anode plate and cathode plate and separating them with the polypropylene separator. This sandwiched construction is then wound on a mandrel into a spiral, separator is cut, and the spiral core placed into a can. Resistance welds are then made between the copper tab and the cell case. The positive weld is made between the aluminum tab on the cathode and the terminal located in the cell cover.

The can is peripherally welded to the can utilizing a plasma arc welder. A cross section of the cell top is shown in Figure 2.

The cells are subsequently transferred to an area where a polyvinyl chloride irradiated heat shrink protective sleeve is placed on the cell.

D. Electrolyte Preparation and Cell Filling

The electrolyte is formulated from the previously described components in mixing vessels. The capacity of the mixing vessels is 15 liters. Each 15-liter tank yields sufficient electrolyte mix for approximately 600 "D" cells.



CROSS SECTION CELL TOP

FIGURE 2

Electrolyte filling consists of dispensing the electrolyte into a partially evacuated cell to predetermined weight specification.

The final fill operation consists of hermetic closure of the fill port located within the center of the hermetic top assembly.

IV. PROGRAM EVALUATION & REVIEW TECHNIQUE

A PERT system has been proposed as a means of comparing current performance and status against planned performance, thereby revealing possible problem areas and permitting timely corrective action on the causes rather then the symptoms of the problems. This PERT Network is a flow diagram which gives a graphic representation of the requirements and relationships for various disciplines from the point of view of time and effort and consists of significant activities and events. In estimating the length of time to complete an activity, a "most likely" time figure was used, as opposed to an optimistic or pessimistic one. The critical path of the PERT Network reflects the path that requires the longest period of time to traverse.

This PERT Network has been designed and the expected elapsed times of each activity are shown in Figure 3.

The following is a list of the major tasks covered in the PERT Network:

1. Cell & Battery Design
2. Electrolyte & Fill System Design & Manufacturing
3. Core Winding and Assembly Machine Design and Manufacture
4. Cathode Machine Design and Manufacture
5. Anode Machine Design and Manufacture
6. Welding Systems Design and Integration

The above tasks are represented in the Network by its major horizontal "arms". As work progresses on these initially independent items they may then be integrated into an operational production system. This first occurs at location C7 during fabrication of the

Contract NO DAABOT

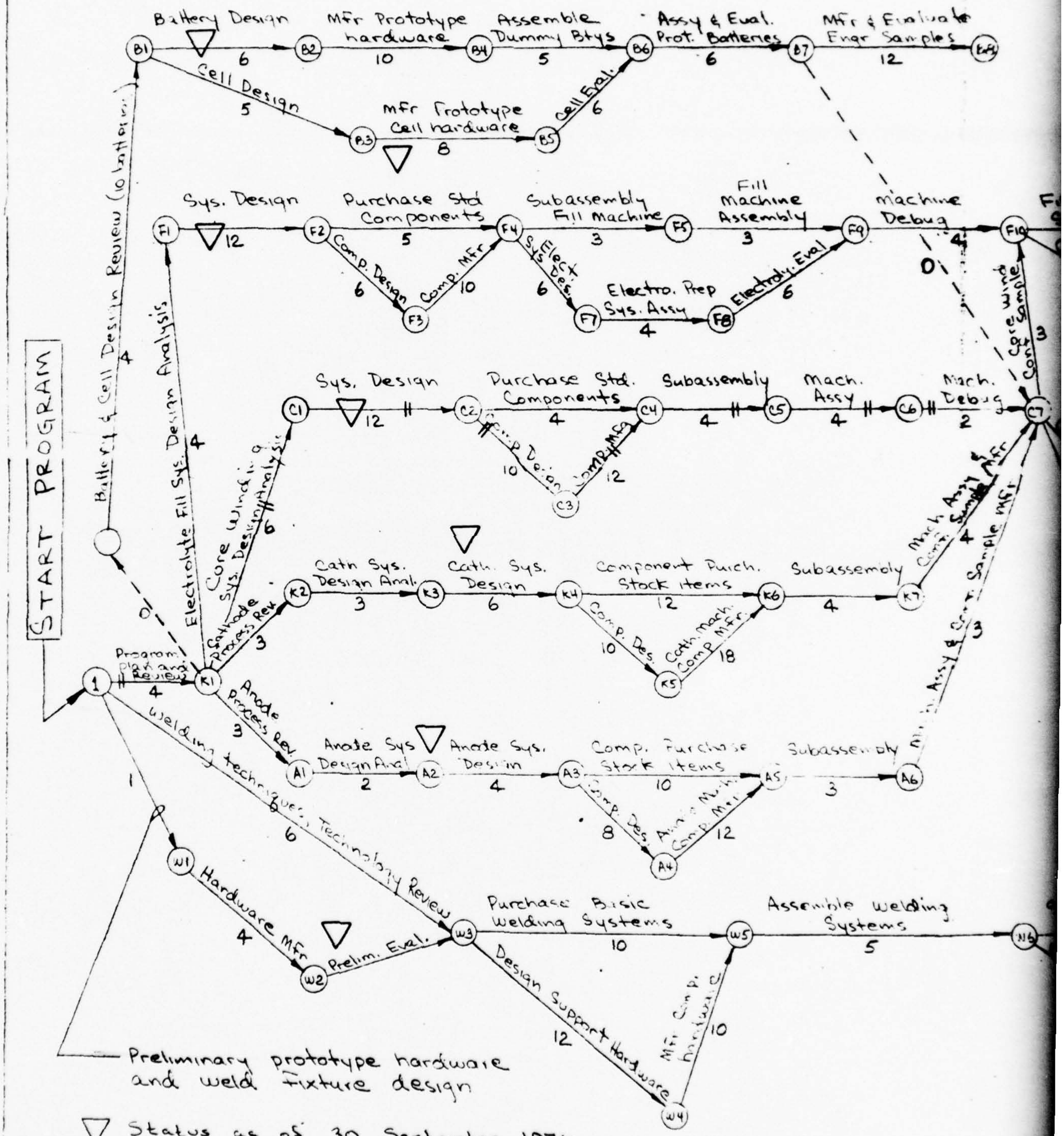
Program Evaluation and Revi

(PERT/TIME)

Key:

B = Battery & cell design
F = Electrolyte Fill system Design
C = Core Winding Machine Design
K = Cathode mfg machine Design
A = Anode mfg Machine Design
W = Welding Equipt Design

FIG 1



Status as of 30 September 1976

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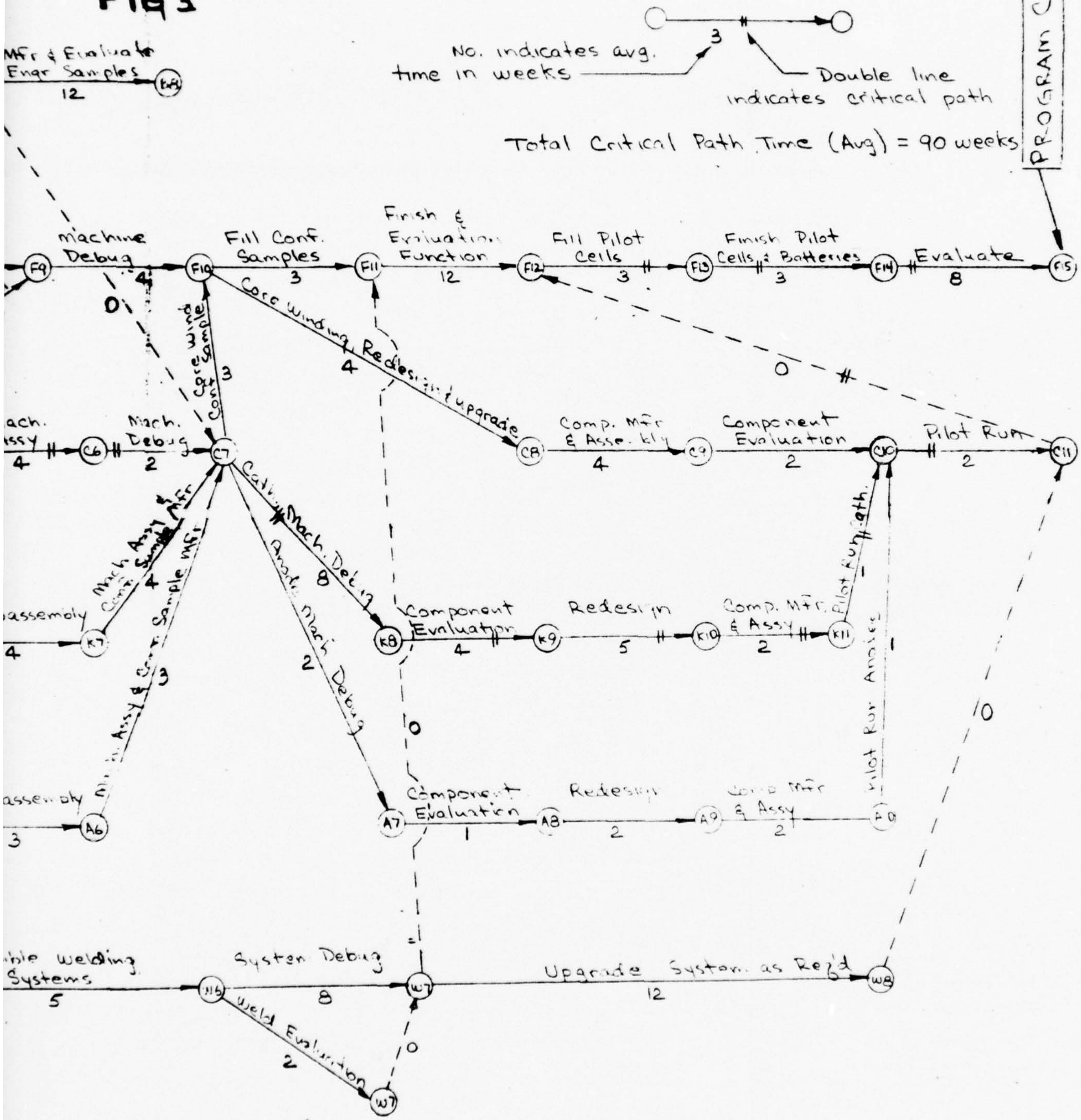
FIG 3



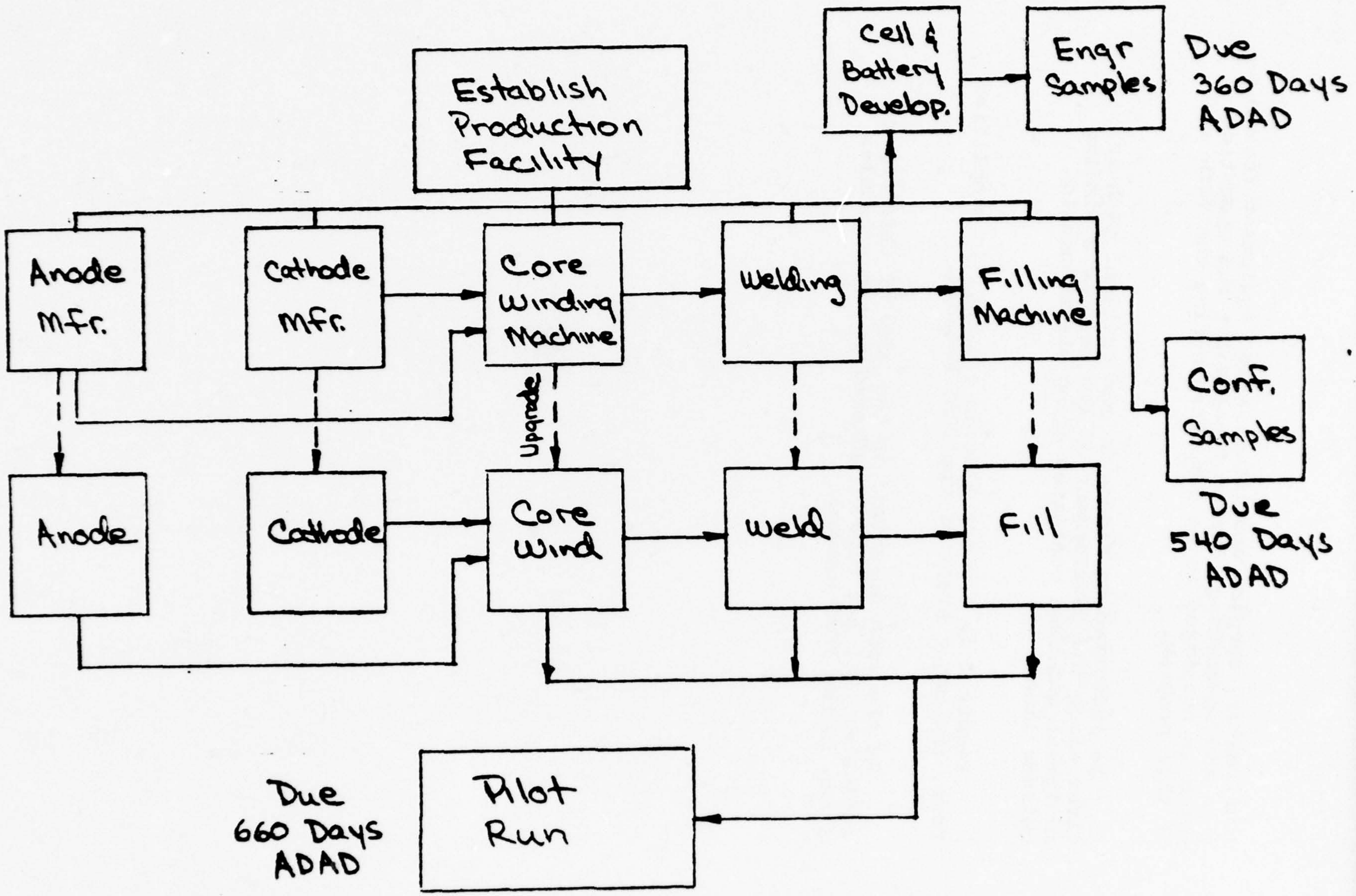
confirmatory samples and later, after equipment reevaluation and up-grading, during final pilot run operation which is estimated to be completed during the 90th week of this program.

As indicated in Figure 3, the critical path is first along the development of the cell core winding equipment and then continues along the automatic cathode line.

Figure 4 is a block diagram showing, in simplified form, the major areas of the PERT Network.

As the work described in the body of this report indicates, PCI has closely adhered to the schedules shown in the PERT Network.

Contract JAAB07-76-C-0042 July, 76
Power Conversion Inc



Work Breakdown Structure

V. MANUFACTURING PROCESS DEVELOPMENT

A. Cell and Battery Design

The subject contract requires the design and fabrication of ten different types of batteries which will utilize hermetically sealed cells. Such cells will conform to the specifications imposed under SCS-459, Batteries, Primary Lithium Organic dated 17 May 1974.

1. Cell Design

An analysis was performed to determine the specific cell design configurations which will meet or exceed the performance, safety and environmental specifications. The basic design considerations were as follows:

- Discharge Capacity and Rate
- Operational Voltage Limits
- Start-up Requirements
- Dimensional Configuration and Weight Restrictions
- Environmental Requirements
- Cell Safety
- Fabrication and Material Costs

These designs were based upon maintaining the proper stoichiometric proportions of the active components, electrode utilization efficiency, available internal cell volume and minimum current density levels especially during high current pulsed duty cycles.

Cell sub-assembly component prototypes are presently being constructed to verify conformance to the required dimensional configuration. Each cell component will be exposed to each of the assembly and test environments to permit early definition and isolation of any problem areas. Such information will be necessary to properly design and select the various automatic equipment which will be used for this program. In addition, timely corrective action will help prevent re-occurrence of these problems during the engineering prototype manufacture phase.

Test cells will be constructed during the next reporting period to demonstrate cell performance under the required electrical and thermal discharge profiles. Design modifications and improvements will be made based upon these test results.

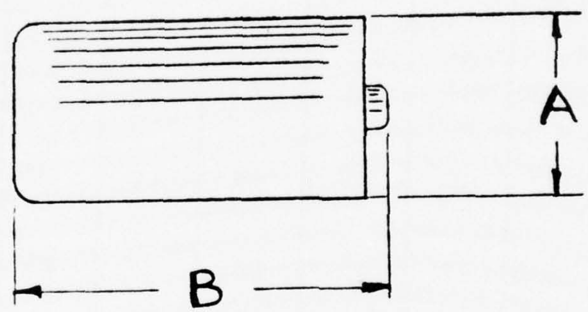
2. Cell Safety

Our primary concern has been the development of effective safety mechanisms to insure non-hazardous operation under all conditions of storage, use and operation. Basic considerations for such safety mechanisms were system reliability, effectiveness, economics and adaptability to automated production.

The proposed vent structure located in the base of the cell can essentially consists of three longitudinal ribs and a coined vent section as shown in Figure 6. The coined area is subsequently annealed to reduce shear strength and minimize stress corrosion. Vent

FIGURE 5

CELL OUTLINE DIMENSIONS



BATTERY TYPE	BA-5598	BA-5100	BA-5590 -5842	BA-5585	BA-5567 -5568	BA-5841	BA-5574	BA-5090
DIMENSION "A" (DIAMETER)	1.500	1.500	1.325	1.000	.910	.625	.625	.565
DIMENSION "B" (HEIGHT)	1.970	1.070	2.375	2.340	.575	2.620	1.310	.980
CASE THICKNESS	.019	.019	.019	.019	.019	.012	.012	.012

TABLE 1

CELL ELECTRODE CHARACTERISTICS

BATTERY TYPE	5598	5100	5590	5842	5585	5567	5568	5841	5574	5090
ANODE										
Length	27.0	27.0	21.0	11.5	23.0	11.5	10.0	5.5	5.5	4.5
Width	1.375	.562	1.625	1.625	1.625	.200	.200	2.125	.750	.500
Thickness	.012	.012	.012	.019	.008	.012	.012	.010	.010	.010
Weight (gm)	3.9	1.8	3.6	3.1	2.6	.24	.21	1.0	.36	.2
CATHODE										
Length	28.0	28.0	22.0	12.0	24.0	12.0	10.5	6.0	6.0	5.0
Width	1.375	.562	1.625	1.625	1.625	.200	.200	2.125	.750	.500
Thickness	.033	.033	.033	.040	.020	.033	.033	.024	.024	.024
ELECTROLYTE										
Weight (gm)	34	20	34	34	15	4.5	3.5	8.0	4.0	2.5
CELL WEIGHT (gm)	90	37	85	85	58	12	12	23	12	7
CURRENT REQUIREMENTS (amps)	.95 .048	.093	3.0 .64 .05	.175	3.0 .64 .05	.056	.090	.12	.115	.013
CATHODE SURFACE AREA (cm^2)	497	226	461	252	503	31	27	165	58	32
CURRENT DENSITY LEVEL (ma/cm^2)	1.91 .10	.41	6.5 1.4 .11	.69	6.0 1.3 .10	1.81	3.33	.73	1.98	.41

pressure is controlled by the overall geometry of the ribs, the dimensional configuration of the coined section and the state of annealing. Essentially, the ribbed section acts as a cantilever which transmits pressure to the coined section. Cell venting is caused by shearing of the coined section which results in complete venting of the pressurized electrolyte and cell deactivation.

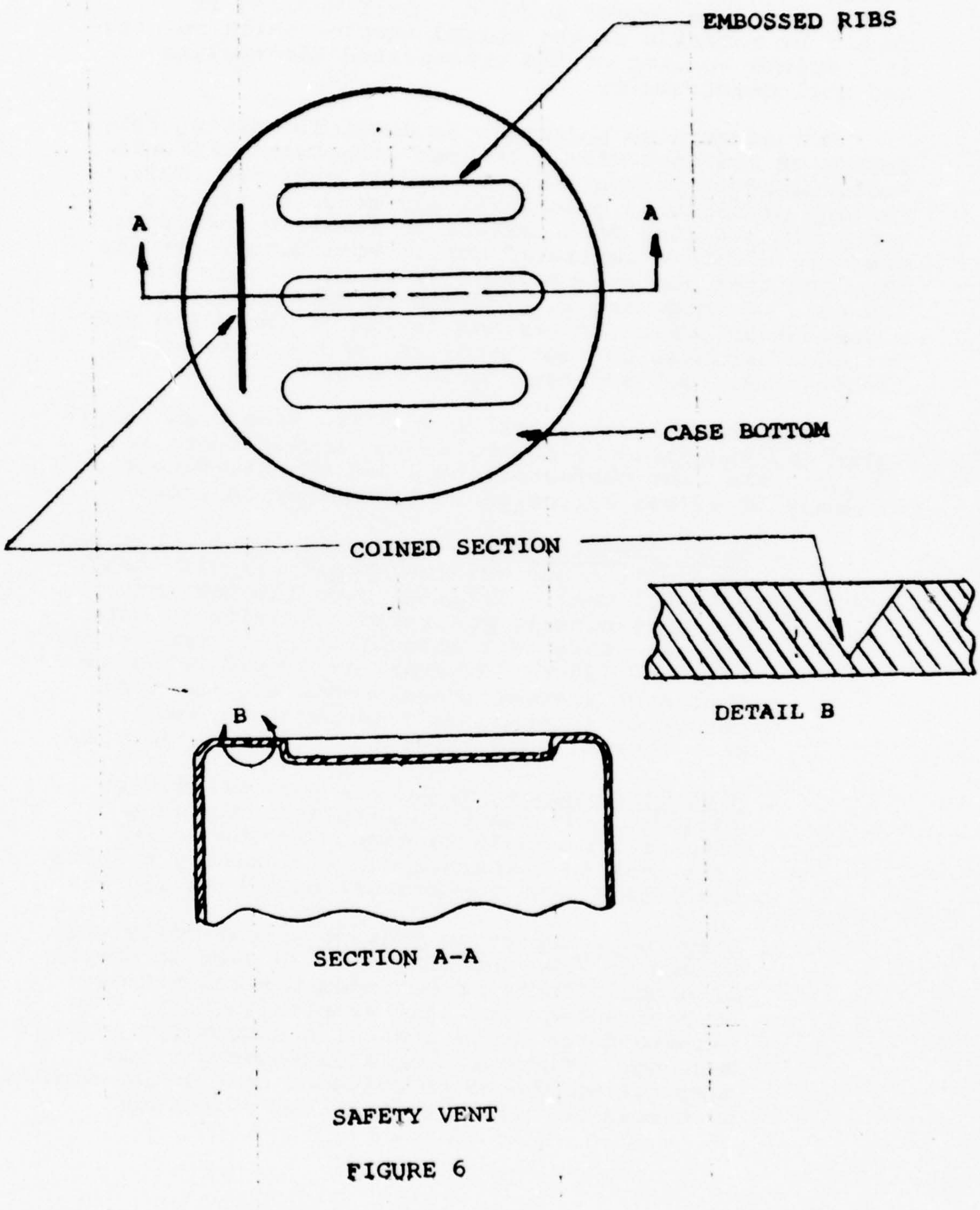
Coined section thickness is monitored during fabrication of the vent within the can structure to assure conformance to pre-established specifications. Cell venting pressure is quantitatively measured using a hydraulic pressure test fixture to simulate the vapor pressure within a completed cell. Preliminary results indicate that venting pressure is approximately 400 - 500 psi. Studies are in progress to determine the quantitative effect of various levels of annealing and material hardness on vent pressure levels in order to assure consistent and reproducible operation.

Completed hermetic cell assemblies have been fabricated and subjected to the following environments to evaluate the vent characteristics and to determine the presence of stress corrosion at the coined section:

- Short Circuit Test - Test cells were subjected to a continuous external short circuit (less than 0.1 ohm). External case temperature was continuously monitored. Results to date indicate safe vent activation at a temperature of 170 - 195^{0}F. However, it should be noted that such thermal measurements are not indicative of internal cell temperature due to poor thermal conductivity of the electrolyte.

- High Temperature Exposure - Test cells were subjected to high temperature levels at a rate of 2^{0}F/minute to determine the actual cell venting temperature. Preliminary results indicate a vent temperature of 220 to 250^{0}F.

- Elevated Temperature Storage - Test cells were stored at 70^{0}C and 100^{0}C for 30 days to determine the effects of extended thermal storage on vent integrity. All samples successfully withstood the above thermal environments without venting. Subsequent cell dis-assembly and examination showed no evidence of electro-chemical or stress corrosion at the vent interface.



SAFETY VENT

FIGURE 6

While the reliability of this venting technique has been demonstrated for cells having a minimum diameter of 1¼ inches, a problem exists for smaller diameters since resultant forces become minimal as cell diameters become relatively small. As an example, the utilization of this technique for a .625 diameter cell would result in only 40 inch-pounds acting on the coined section. In this case, the coined section thickness would be so thin as to make this approach impractical.

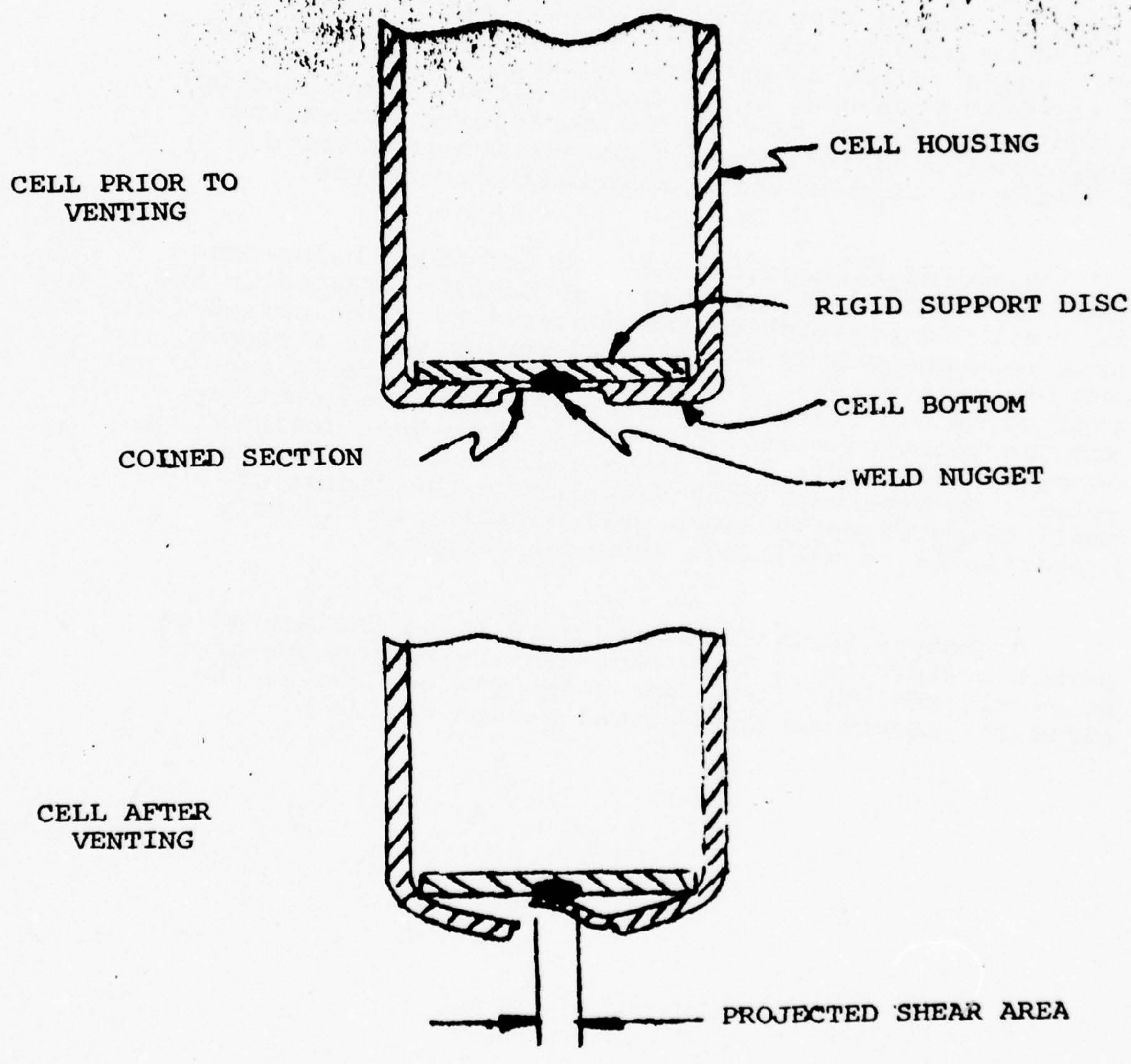
For cells having a diameter of less than 1¼ inches, an alternative venting technique has been developed and is shown in Figure 7. In operation, the support disc tends to remain flat since internal cell pressure is acting on both of its faces. Conversely, the cell bottom begins to bow as pressure increases. At a predetermined pressure, which can be closely regulated by varying the degree of case bottom coining, annealing and nugget diameter, the coined section is sheared allowing venting of the pressurized electrolyte.

A second alternative venting technique being considered consists of a coined vent section located in the can wall and parallel to the center line. The coined area is subsequently annealed to reduce shear strength and minimize stress corrosion. Vent pressure is controlled by the overall geometry of the coined section and the relative state of anneal. This vent design concept will result in a minimal loss of internal cell volume; an important consideration in the design of small diameter cells since cell capacity is directly proportional to available internal volume.

Prototype tooling is presently being fabricated to permit evaluation of both vent designs during the next quarterly period. Such test data will be used as the basis for selecting the optimal design approach.

VENT - SMALL DIAMETER CELLS

FIGURE 7



3. Battery Design

a. BA-5598/U battery will consist of five (5) series connected cells as shown in Figure 8. Nominal output voltage will be 14.4 volts with an auxiliary 3-volt tap. Each section will be protected by a replaceable 3.2 amp time delay fuse. The battery will be encapsulated with flame retardant polyurethane foam. The cell/battery design specifications are shown in Table 2.

b. BA-5100/U

The BA-5100/U battery will consist of two (2) series connected cells as shown in Figure 9. Nominal output voltage will be 5.6 volts. The battery will not be protected by a fuse. The cell/battery design specifications are shown in Table 3.

c. BA-5590/U

The BA-5590/U battery will consist of ten (10) series connected cells as shown in Figure 10. Nominal output voltage of each independent section is 12.0 volts. Each section will be protected with a replaceable C/3 amp fuse. The battery will be encapsulated with flame retardant polyurethane foam. The cell/battery design specifications are shown in Table 4.

d. BA-5842/U

The BA-5842/U battery will consist of four (4) cells connected in two parallel sections as shown in Figure 11. Nominal output voltage will be 5.5 volts. Each section will be protected with type IN91 diodes to prevent reverse discharge between cells in the parallel banks. The battery will be protected with a MVD 3.2 amp time delay fuse on the positive output leg. The battery assembly will be

d. <u>BA-5842/U (Cont'd)</u>

packaged within a steel container with a glass/epoxy header terminal. The assembly will be encapsulated with an epoxy resin to restrain the cells during environmental exposure. Techniques for epoxy application are presently being evaluated to insure that cell safety vent performance will not be adversely affected. The cell/battery design specifications are shown in Table 5.

e. <u>BA-5585/U</u>

The BA-5585/U battery will consist of ten (10) series connected cells as shown in Figure 12. Nominal output voltage of each independent section is 12.0 volts. Each section will be protected with a replaceable C/3 amp fuse. The battery will be encapsulated with flame retardant polyurethane foam. The cell/battery design specifications are shown in Table 6.

f. <u>BA-5567/U</u>

The BA-5567/U battery will consist of one (1) cell enclosed in a plastic case with an insulating space on the bottom. Required positive and negative terminals will be welded in accordance with the battery configuration shown in Figure 13. No fuse is required for this battery. The cell/battery design specifications are shown in Table 7.

g. <u>BA-5568/U</u>

The BA-5568/U battery will consist of five (5) series connected cells as shown in Figure 14. Nominal output voltage will be 12.5 volts. The battery will not be protected with a fuse. The completed assembly will be packaged within a .015 inch thick wall fiberboard tube and the ends crimped to mechanically restrain the cells. The cell/battery design specifications are shown in Table 8.

h. BA-5841/U

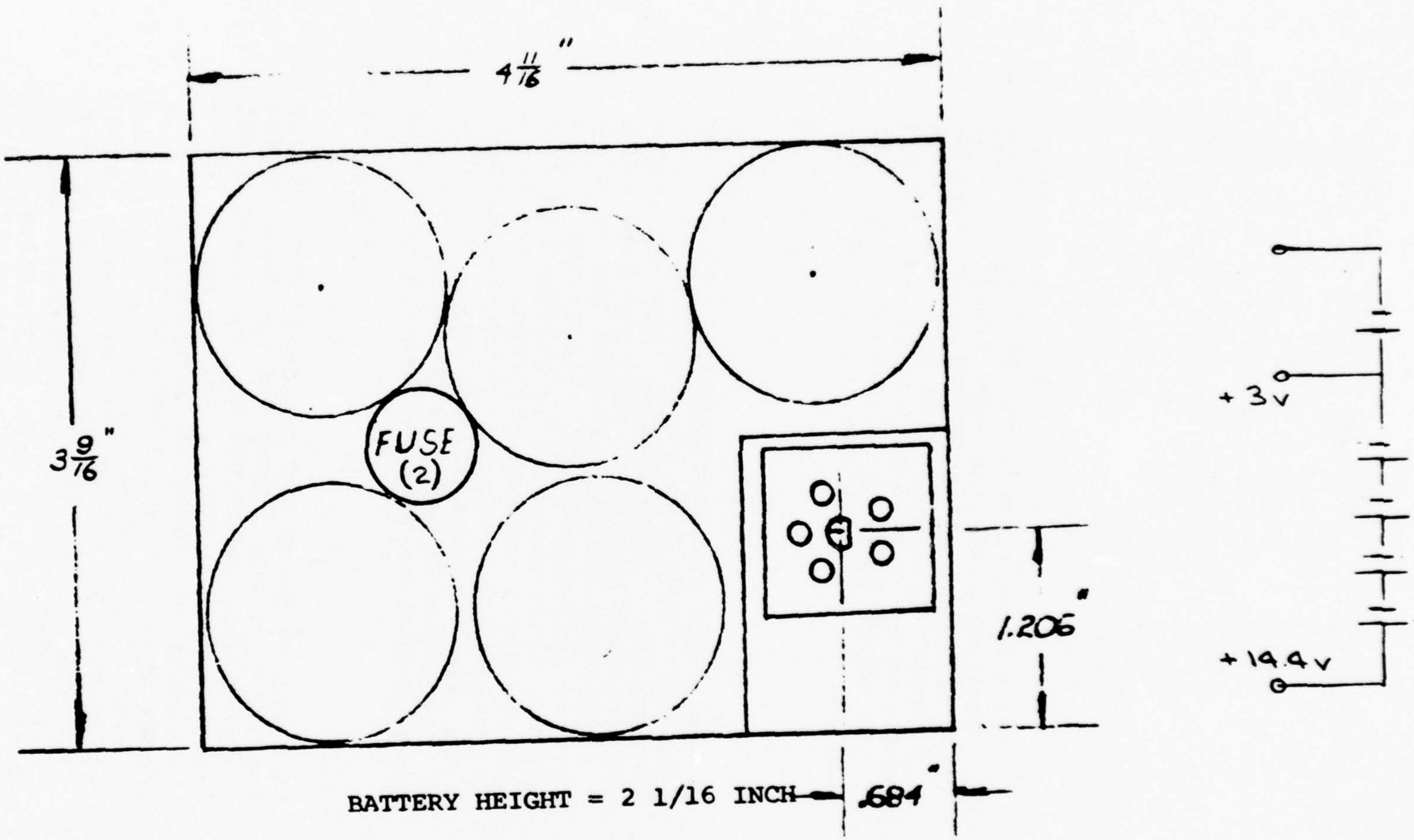
The BA-5841/U battery will consist of six (6) cells stacked in two rows and packaged in a plastic container as shown in Figure 15. The container will be fabricated from a molder phenolic resin with a wall thickness of approximately .040 inch. The external terminals will be coated with silicone rubber sealant, Type RTV-102. The battery will be encapsulated with an epoxy compound capable of withstanding temperatures of -85 to 165^{0}F without deformation. The battery will be protected with a non-replaceable C/3 amp fuse. The cell/battery design specifications are shown in Table 9.

i. BA-5574/U

The BA-5574/U battery will consist of two (2) series connected cells as shown in Figure 16. The battery assembly will be packaged within a .025 inch thick extruded PVC tube. Press fit connector/cap assemblies will be cemented at each end using Araldite 502 or equivalent. This connector will serve as the positive battery terminal. The sleeve end will be filled with silicone rubber sealant, Type RTV-102. The battery will not be protected by a fuse. The cell/battery design specifications are shown in Table 10.

j. BA-5090/U

The BA-5090/U battery will consist of three (3) series connected cells as shown in Figure 17. The battery will not be protected by a fuse. The battery will be packaged within a cold rolled steel case. Snap-on type terminals ANSI XVII will be used. The cell/battery design specifications are shown in Table 11.



BATTERY HEIGHT = 2 1/16 INCH

BA-5598/U BATTERY AND SCHEMATIC

FIGURE 8

TABLE 2

BA-5598/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after a 5 sec. pulse through a 2.5 ohm resistance load
Discharge Capacity	55 hours to 2.0 volts against duty cycle shown below after two weeks storage at 160F and discharge at -20F

BA-5598/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	5
Dimensions:	
Height	2.062 ± .062 inch
Length	4.687 ± .062 inch
Width	3.562 ± .062 inch
Weight (max.)	1.5 lbs.
Connector	P/N 103-11M (Connector Corp.)
Battery Jacket	Waterproof paperboard

ELECTRICAL

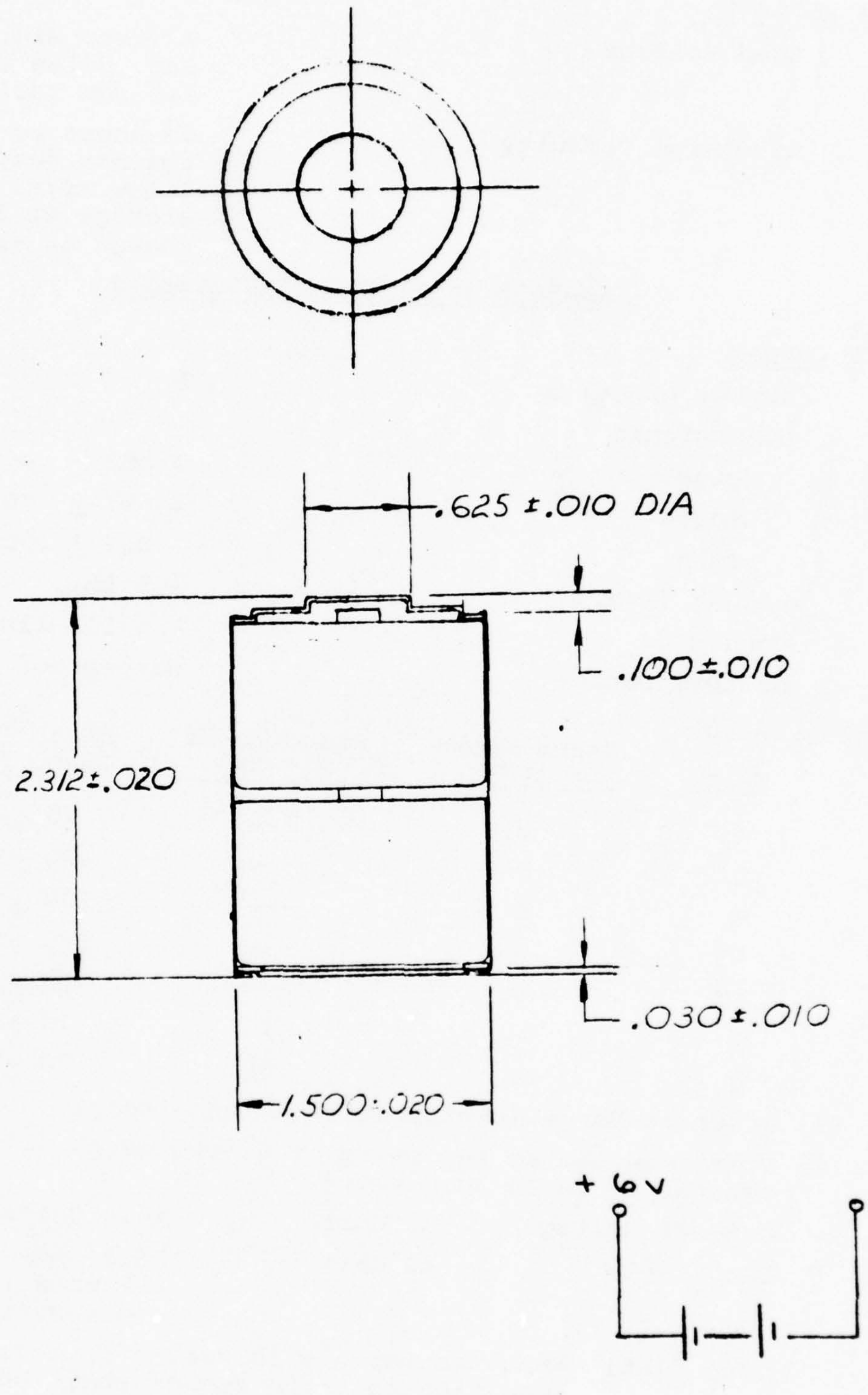
Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch(1) Temp., F	Service(2) Hours
I	0	---	70 ±2	50
L	0	---	-20 ±3	35
H	0	---	130 ±3	50
HT	4	---	130 ±3	45
LT	4	---	-20 ±3	30
T	-	13	70 ±2	45
D	-	52	70 ±2	45

(1) After 16 hours stabilization at test temp.

(2) Time required at beginning of discharge shall not exceed o.5 seconds to reach 10.0 volts.

Cut-off Voltage	A2 unit	10.0 volts
Duty Cycle	A2 unit	14.2 ohms for 2 minutes 291 ohms for 18 minutes and repeat

Drop Test: When the battery is tested in accordance with this specification, the socket shall not move beyond the limits specified herein nor shall the components shift within the jacket, or preclude the battery from meeting specified "I" capacity test performed at the conclusion of the jacket integrity test.



BA-5100/U BATTERY & SCHEMATIC

FIGURE 9

TABLE 3

BA-5100/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2.5 volts minimum after 5 sec. through 5-ohm level
Discharge Capacity	23 hours to 2.25 volts with load of 30 ohms at -20F following 2 weeks storage at 160F

BA-5100/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	2
Dimensions:	
Diameter	1.500 inch
Height	2.562 inch
Weight (max.)	85 grams
Connector	See SCS-459/9 Sheet 1 of 5

ELECTRICAL

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch[(1)] Temp.,F	Service[(2)] Hours
I	0	---	70 ±2	40
L	0	---	-20 ±3	21
H	0	---	130 ±3	37
HT	4	---	130 ±3	34
LT	4	---	-20 ±3	19
T	-	13	70 ±2	35
D	-	52	70 ±2	36

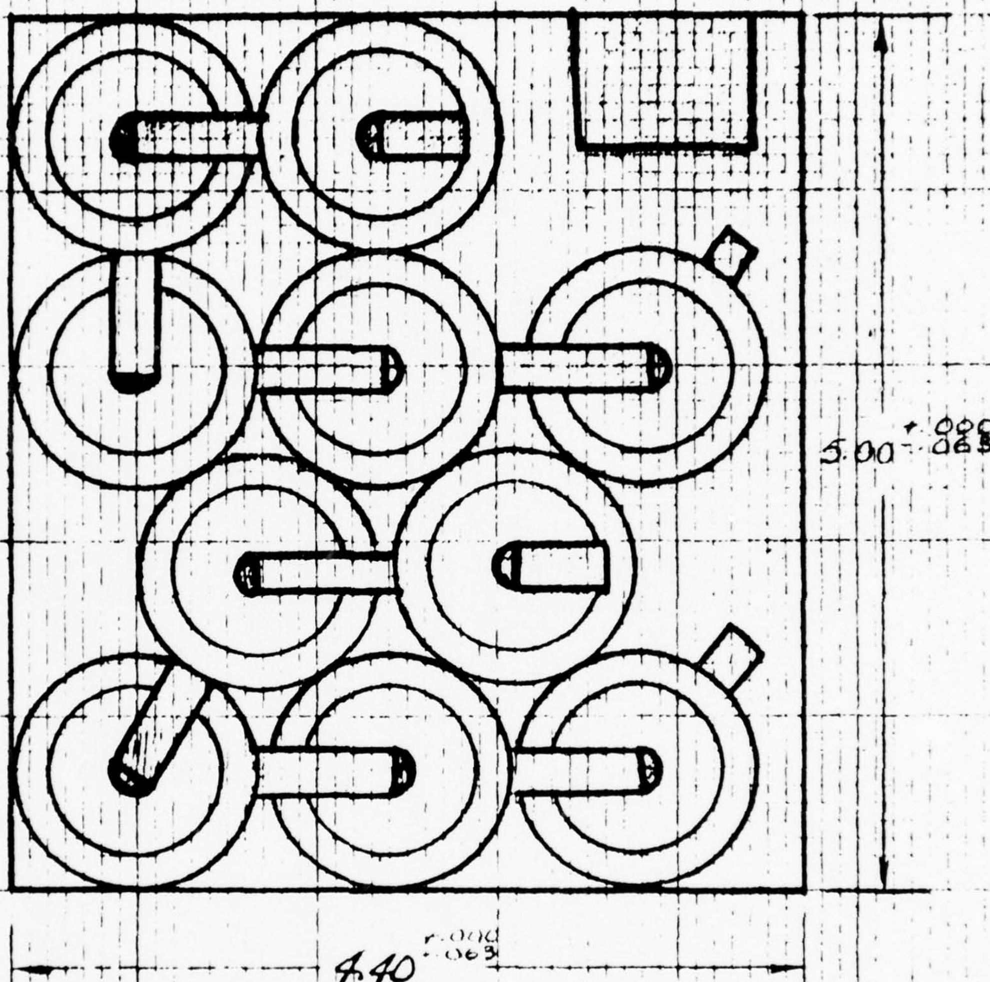
(1) After 16 hours stabilization at test temp.

(2) Initial closed circuit voltages below 4.5 volt can not exceed 1.0 second duration.

Voltage max.	6.0 volts
Cut-off Voltage	4.5 volts
Load	60 ohms continuous
Pulse Capability	Under a load of 10 ohms voltage to be above 5.0 volts for a period of 30 seconds

FIGURE 10

BA-5590/U BATTERY & SCHEMATIC



BATTERY HEIGHT 2.450 +000 -063

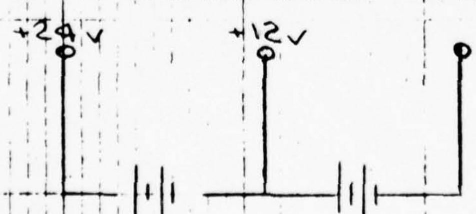


TABLE 4

BA-5590/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after 5 sec. through 2.5 ohms
Discharge Capacity	26.5 hours to 2.0 volts with cyclic load according to duty cycle shown below except resistance load multiplied by 0.1 at -20F following two weeks storage at 160F

BA-5590/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	10
Dimensions:	
Height	5.00 + .000 - .003 inch
Length	4.40 + .000 - .003 inch
Width	2.45 + .000 - .063 inch
Weight (max.)	2.25 lbs.
Connector	Miniature Circular Per Drawing ES-C-211486
Battery Jacket	Waterproof paperboard

ELECTRICAL Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch(1) Temp., F	Service(2) Hours
I	0	---	70 ±2	48
L	0	---	-20 ±3	24
H	0	---	130 ±3	42
HT	4	---	130 ±3	38
LT	4	---	-20 ±3	21
T	-	13	70 ±2	28
D	-	52	70 ±2	28

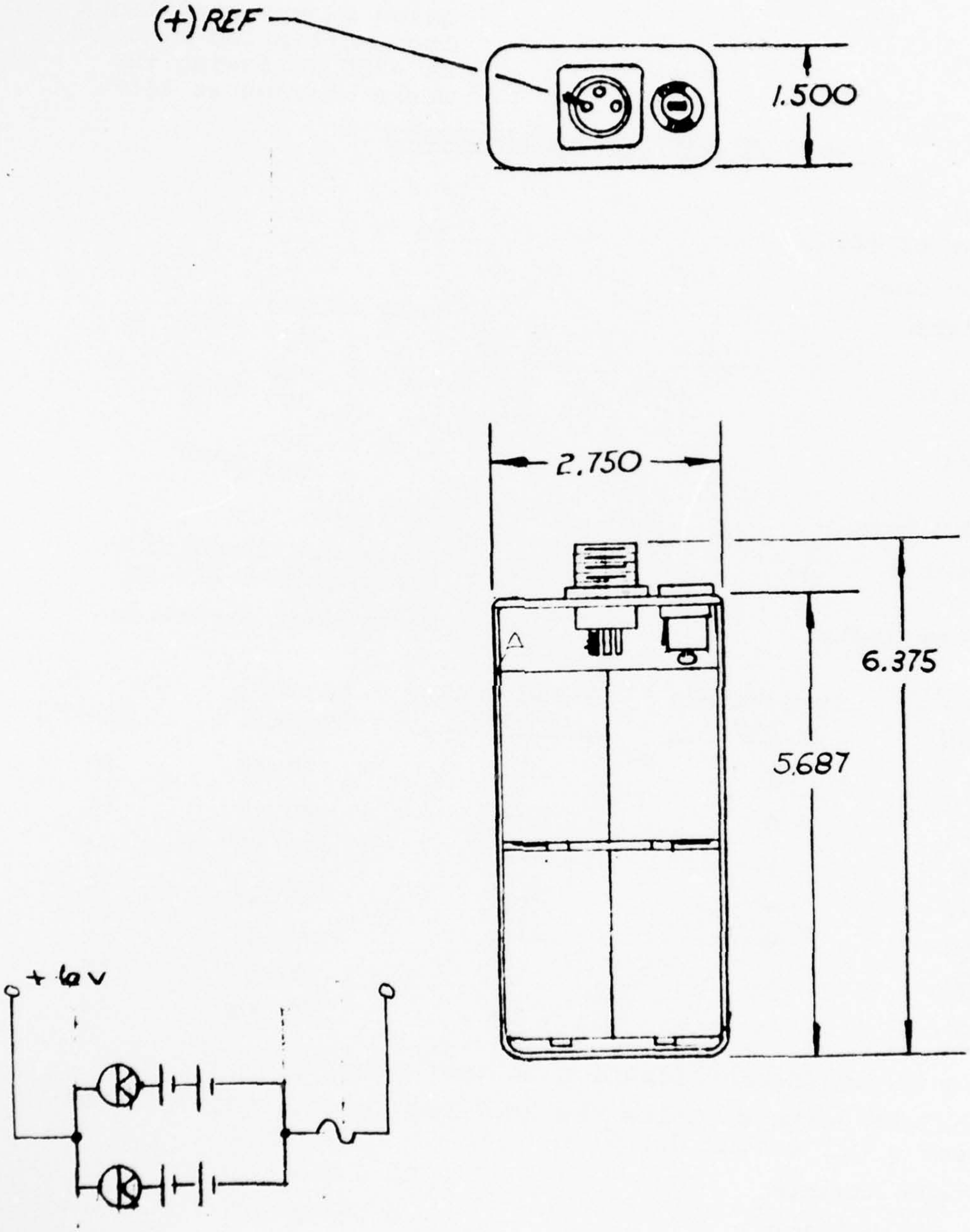
(1) After 16 hours stabilization at test temp.

(2) Transient voltages below the 20.0 volt end voltage can not exceed a 0.1 second duration

Voltage Maximum	32 volts
Cut-off Voltage	20 volts

Duty Cycle: Battery consisting of two (2) 12 volt sections connected in series shall be discharged through 39 ohms for 1 min*, then through 560 ohms for 9 min and repeat

*An 8 ohm pulse load will be applied during the first 100 ms of each 1 min cycle.



BA-5842/U BATTERY & SCHEMATIC

FIGURE 11

TABLE 5

BA-5842/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after 5 sec. through 2.5 ohms
Discharge Capacity	26.5 hours to 2 volts with 175 mA load at -20F following two weeks storage at 160F

BA-5842/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	4
Dimensions:	
Height	5.687 inch
Width	1.500 inch
Length	2.750 inch
Weight (max.)	20 ounces
Connector	MS3102A10SL4P (Bendix)
Battery Potting	Epoxy; capable of withstanding -65C to 75C

ELECTRICAL

Maximum Voltage 6 volts

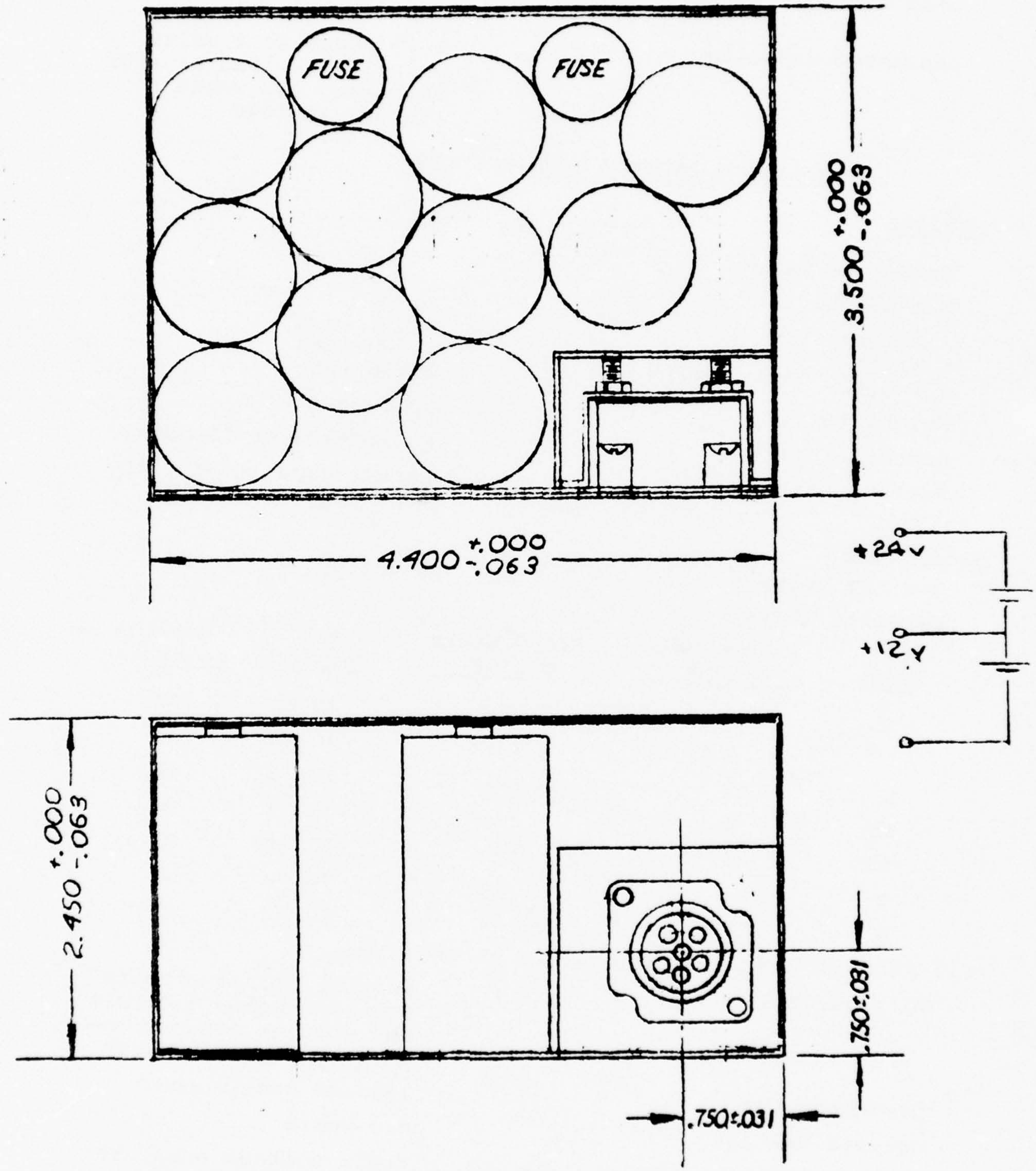
Capacity Tests

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch[(1)] Temp., F	Service in Hours
I	0	---	70 ±2	48
L	0	---	-20 ±3	24
H	0	---	130 ±3	42
HT	4	---	130 ±3	40
LT	4	---	-20 ±3	23
T	-	13	70 ±2	43
D	-	52	70 ±2	43

(1) After 16 hours stabilization at test temp.

Voltage delay	Initial closed-circuit voltages below 4.0 volt end voltage can not exceed 1.0 sec. duration
Discharge Load	.350 mA continuous
Cut-off Voltage	4.0 volts

Closed-Circuit Voltage: Closed circuit voltage shall be observed for a period of 30 seconds with a D.C. Voltmeter, using a load resistance of 11 ohms and a minimum permissible voltage of 4.0 volts



BA-5585/U BATTERY & SCHEMATIC

FIGURE 12

TABLE 6

BA-5585/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after 5 sec. through 2.5 ohms
Discharge Capacity	13.2 hrs. to 2.0 volts with cyclic load according to duty cycle shown below except resistance load multiplied by 0.1 at -20F following two weeks storage at 160F

BA-5585/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	10
Dimensions:	
Height	3.50 + .000 / - .003 inch
Length	4.40 + .000 / - .063 inch
Width	2.45 + .000 / - .063 inch
Weight	1.75 lbs.
Connector	Miniature Circular per Drawing ES-C-211488
Battery Jacket	Waterproof paperboard

ELECTRICAL

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch(1) Temp., F	Service(2) Hours
I	0	---	70 ±2	24
L	0	---	-20 ±3	12
H	0	---	130 ±3	21
HT	4	---	130 ±3	19
LT	4	---	-20 ±3	10
T	-	13	70 ±2	14
D	-	52	70 ±2	14

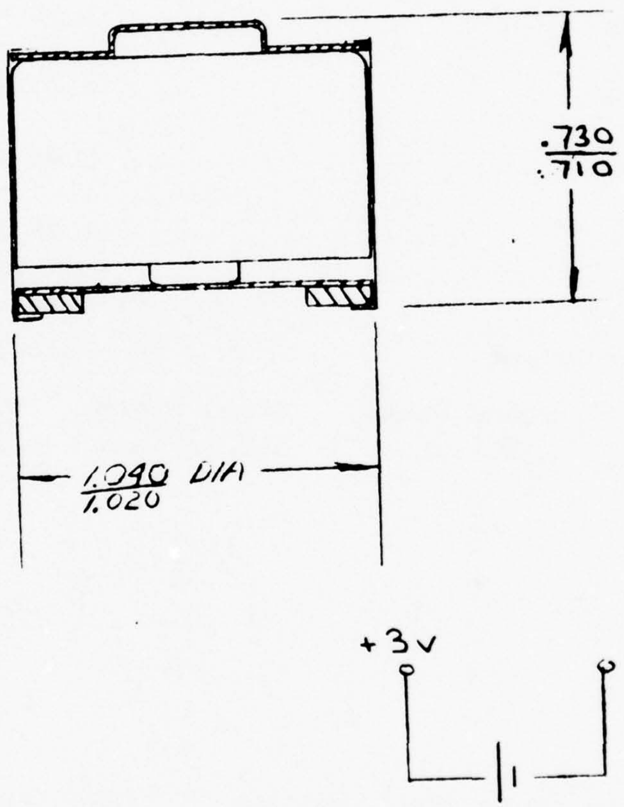
(1) After 16 hours stabilization at test temp.

(2) During initial one minute of discharge transient voltages can not be below 20.0 volts for greater than 0.1 second duration.

Cut-off Voltage: 20 volts

Duty Cycle: Battery consisting of two (2) 12 volt sections connected in series shall be discharged through 39 ohms for 1 min.*, and then through 560 ohms for 9 min. and repeat.

*An 8 ohm pulse load will be applied during the first 100 ms of each 1 min. load discharge.



BA-5567/U BATTERY & SCHEMATIC

FIGURE 13

TABLE 7

BA-5567/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts minimum after 5 second pulse through a 10 ohm resistance load
Discharge Capacity	13.2 hours to 2.0 volts against duty cycle shown below after two weeks storage at 160F and discharge at -20F

BA-5567/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	1
Dimensions:	
Diameter	1.030 ± .030 inch
Height	.718 ± .031 inch
Weight (max.)	20 grams
Terminal	See Figure
Battery Jacket	Waterproof paperboard

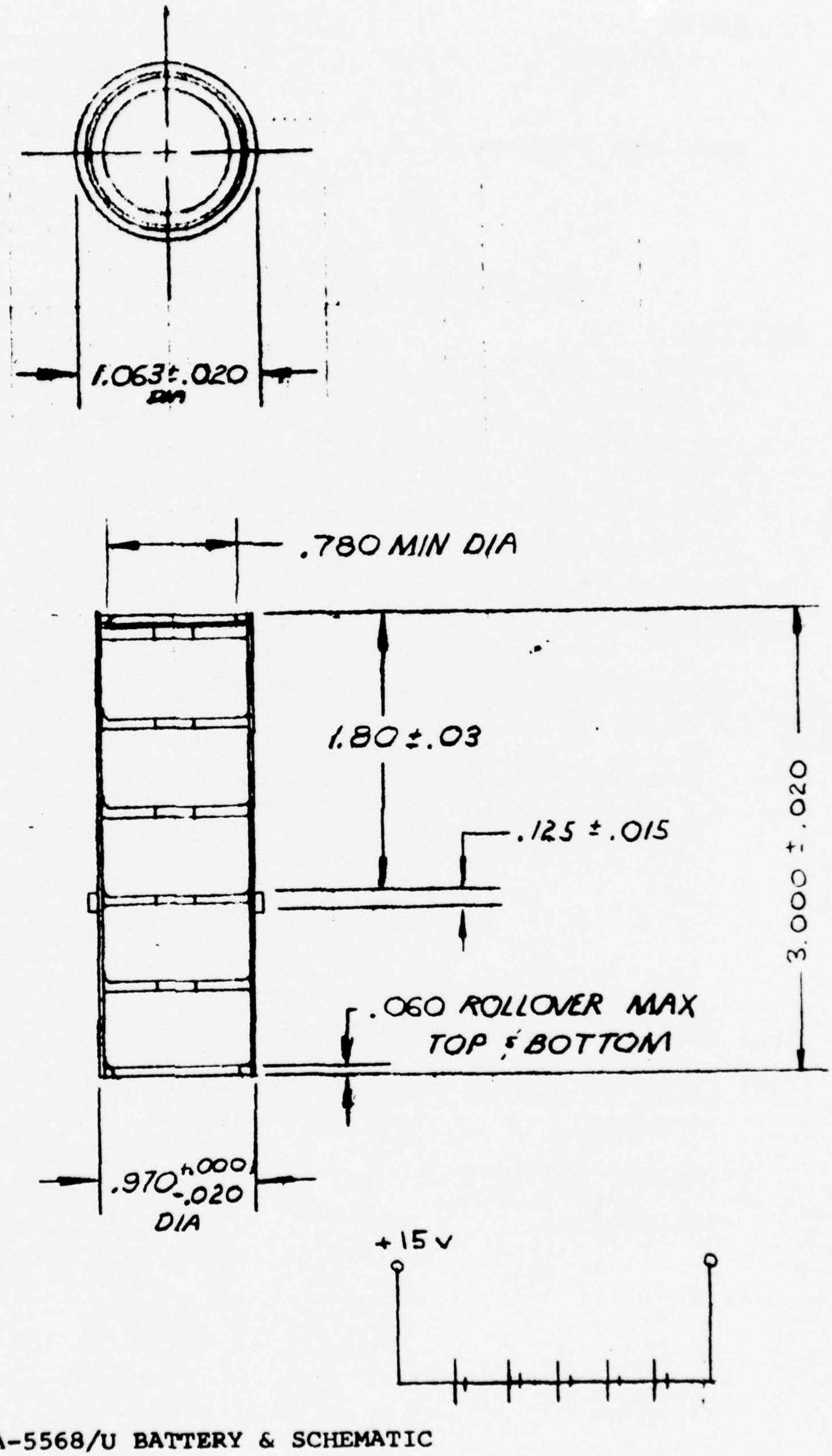
ELECTRICAL

Test	Stand Weeks @ 160F	Stand Weeks @130F	Disch[(1)] Temp., F	Service[(2)] Hours
I	0	---	70 ±2	20
L	0	---	-20 ±3	12
H	0	---	130 ±3	13
HT	4	---	130 ±3	17
LT	4	---	-20 ±3	10
T	-	13	70 ±2	17
D	-	52	70 ±2	18

(1) After 16 hours stabilization at test temp.

(2) Time required at beginning of discharge to reach 2.0 volts shall not exceed 1 second when using a load resistance of 50 ohms.

Cut-off Voltage	2.0 volts
Duty Cycle	Constant discharge through a 50 ohm resistance



BA-5568/U BATTERY & SCHEMATIC

FIGURE 14

TABLE 8

BA-5568/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after 5 sec. pulse with a 10 ohm resistance load
Discharge Capacity	7.7 hours to 2.0 volts against duty cycle shown below after two weeks storage at 160F and discharge at -20F (Load resistance x .2)

BA-5568/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	5
Dimensions:	
Diameter	0.94 ± .03 inch
Height	3.00 ± .05 inch
Weight (max.)	85 grams
Connector	None required
Battery Jacket	Hi-Impact ABS plastic or equivalent, olive drab No. 24087 per FED STD-595

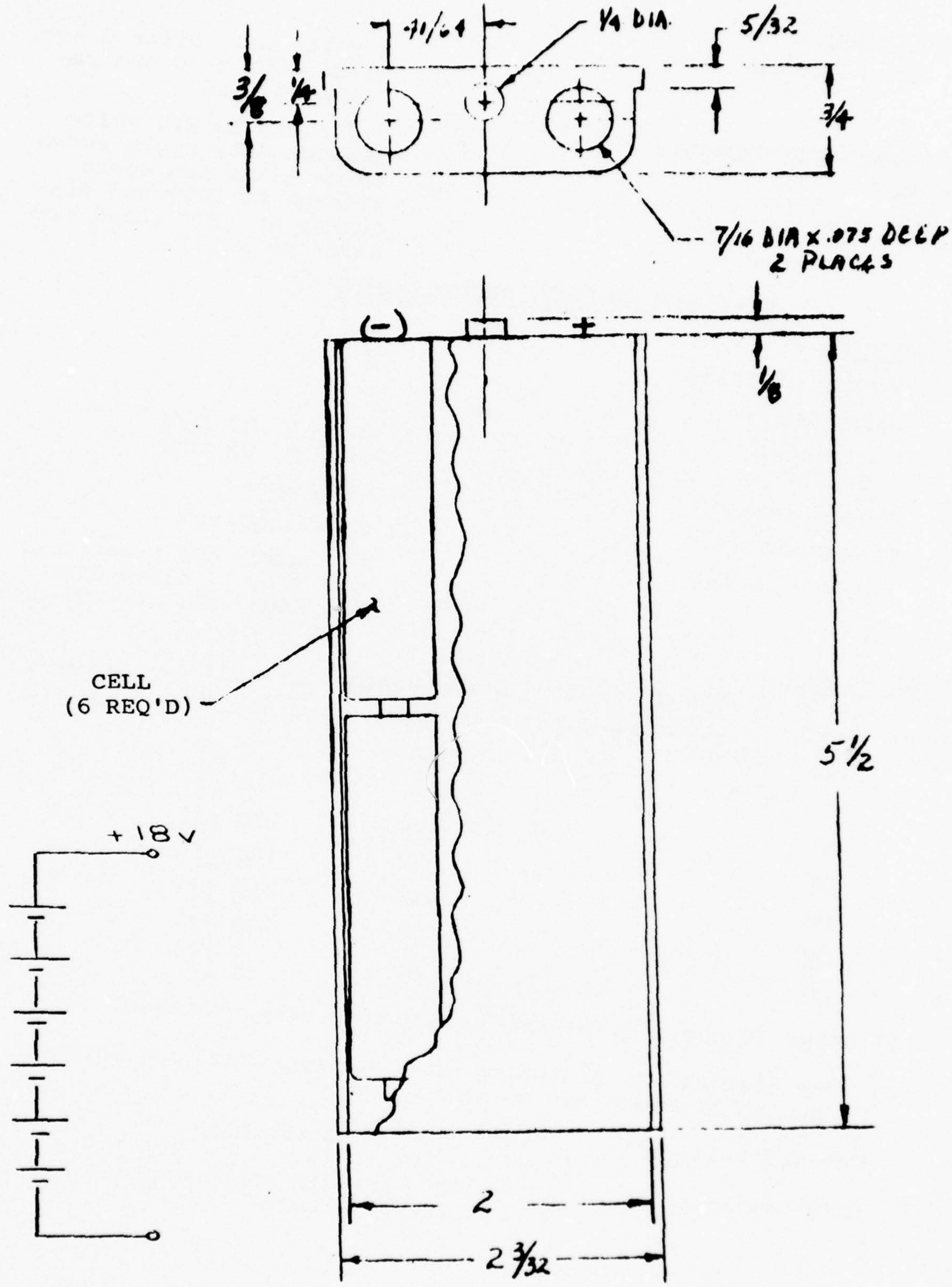
ELECTRICAL

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch Temp., F (1)	Service Hours (2)
I	0	---	70 ±2	12
L	0	---	-20 ±3	7
H	0	---	130 ±3	10
HT	4	---	130 ±3	9
LT	4	---	-20 ±3	6
T	-	13	70 ±2	10
D	-	52	70 ±2	10

(1) After 16 hours stabilization at test temp. voltage.

(2) Time required at beginning of discharge shall not exceed 1 second to reach 9.0 volts.

Cut-off Voltage	10.0 volts
Duty Cycle	150 ohms constant resistance



BA-5841/U BATTERY & SCHEMATIC

FIGURE 15

TABLE 9

BA-5841/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after 5 sec. through 8-ohm load
Discharge Capacity	24.2 hours to 1.8 volt with load of 70 ohms at -20F following 2 weeks storage at 160F

BA-5841/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	6
Dimensions:	
Height	.750 inch
Width	2.093 inch
Length	5.625 inch
Weight (max.)	10 ounces
Connectors	Located at one end of battery and covered with silicone rubber RTV-102

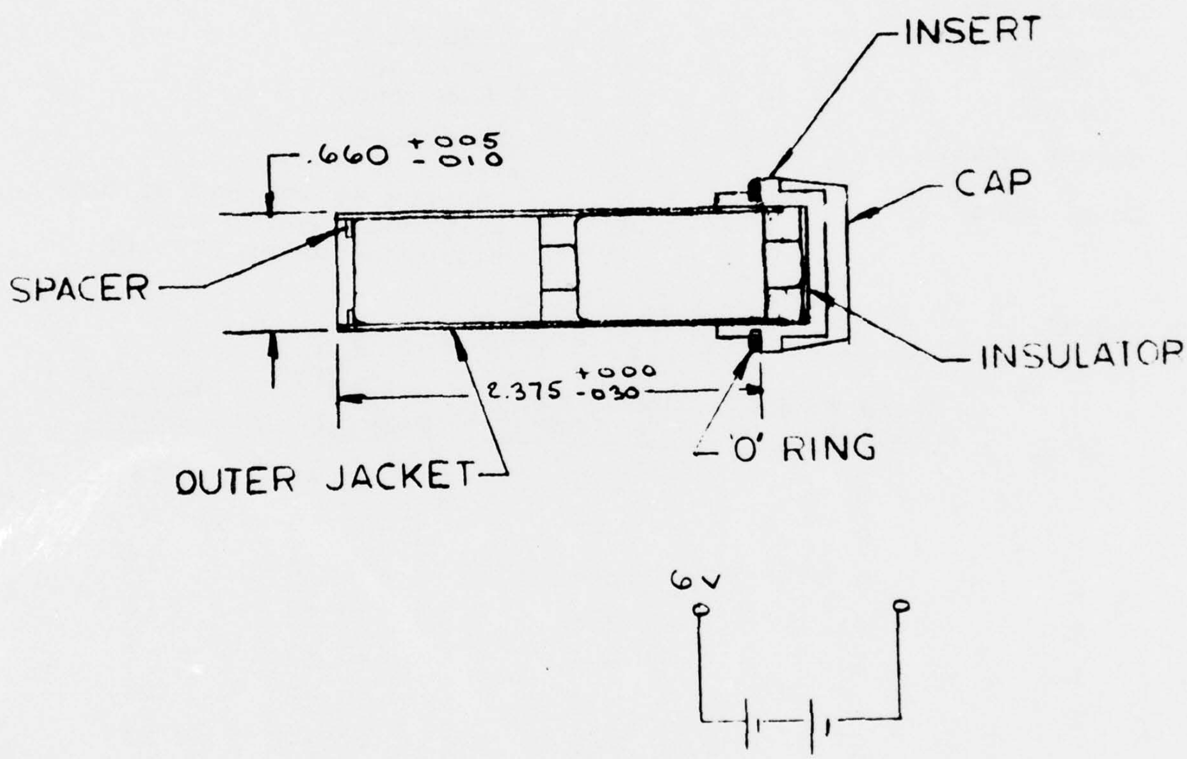
ELETRICAL

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch[(1)] Temp., F	Service[(2)] Hours
I	0	---	70 ± 2	15
L	0	---	-20 ± 3	8
H	0	---	130 ± 3	13
HT	4	---	130 ± 3	12
LT	4	---	-20 ± 3	7
T	-	13	70 ± 2	13
D	-	52	70 ± 2	13

(1) After 16 hours stabilization at test temp.

(2) Closed circuit voltages below 10.8 volts can not exceed 1.0 second duration

Voltage max.	18.0 volts
Cut-off Voltage	13.2 volts
Load	135 ohms continuous
Pulse Capability	Under a load of 24 ohms voltage to be above 12 volts for a period of 30 seconds



BA-5574/U BATTERY & SCHEMATIC

FIGURE 16

TABLE 10

BA-5574/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts min. after 5 sec. through 2 ohm
Discharge Capacity	4.4 hours to 2.0 volts with load of 23.5 ohms at -20F following 2 weeks storage at 160F

BA-5574/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	2
Dimensions:	
Height	1.84 inch
Dia. Cell Stack	.660 inch
Dia. Cap	1.0 inch
Weight (max.)	1.65 oz.
Connector	Positive formed by threaded insert SCS-459/7, Figure 3 Negative formed at silicone rubber end.

ELECTRICAL

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch Temp.,F (1)	Service Hours (2)
I	0	---	70 ±2	8
L	0	---	-20 ±3	4
H	0	---	130 ±3	7.5
HT	4	---	130 ±3	6.5
LT	4	---	-20 ±3	3.5
T	-	13	70 ±2	7
D	-	52	70 ±2	7

(1) After 16 hours stabilization at test temp.

(2) Initial closed circuit voltages below 4.0 can not exceed 1 second duration

Voltage (max.)	6 volts
Cut-off Voltage	4.0 volts
Load	47 ohms continuous
Pulse Capability	Under a load of 40 ohms, voltage to be above 4.0V for period of 30 seconds

FIGURE 17

BA-5090/U BATTERY AND SCHEMATIC

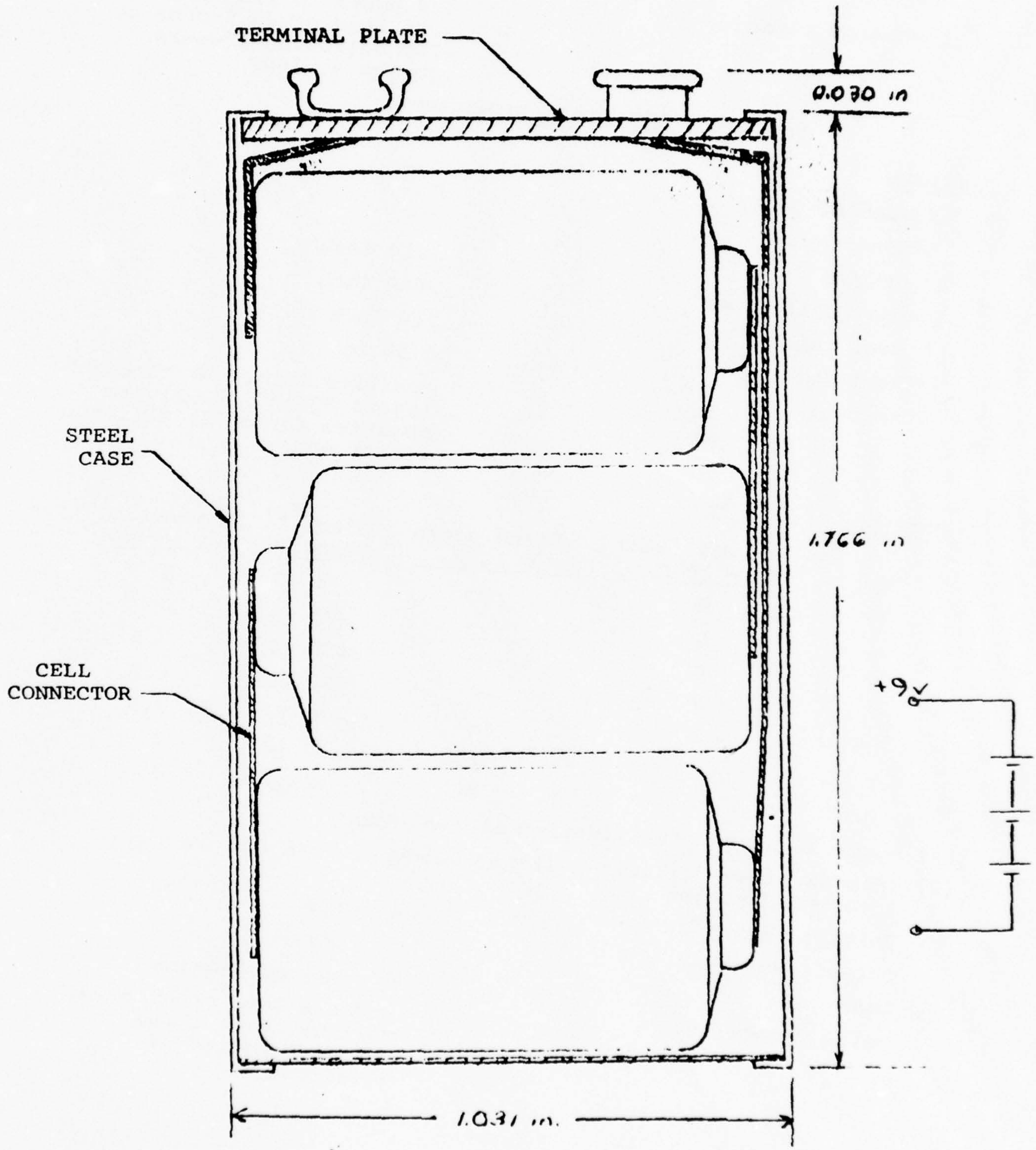


TABLE 11

BA-5090/U CELL REQUIREMENTS

ELECTRICAL

Load Voltage	2 volts minimum after 5 seconds pulse through a 20 ohm resistance load
Discharge Capacity	33 hours to 2.0 volts against duty cycle shown below after two weeks storage at 160F and discharge at -20F

BA-5090/U BATTERY REQUIREMENTS

PHYSICAL

Number of Cells	3
Dimensions:	
Height	1.906 inch
Length	1.031 + .000 / - .062 inch
Width	.656 + .000 / - .062 inch
Weight (max.)	50 grams
Terminals	Miniature snap on type ANSIXVII
Battery Jacket	Cold rolled steel

ELECTRICAL

Test	Stand Weeks @ 160F	Stand Weeks @ 130F	Disch. Temp., F (1)	Service Hours (2)
I	0	---	70 ± 2	55
L	[illegible]	---	-20 ± 3	30
H	[illegible]	---	130 ± 3	50
HT	4	---	130 ± 3	46
LT	4	---	-20 ± 3	26
T	-	13	70 ± 2	48
D	-	52	70 ± 2	48

(1) After 16 hours stabilization at test temperature

(2) During initial one minute discharge transient voltage below 6 volts can not exceed a 1 second duration.

Cut-off Voltage	6 volts
Duty Cycle	636 ohm resistance

B. Anode Fabrication

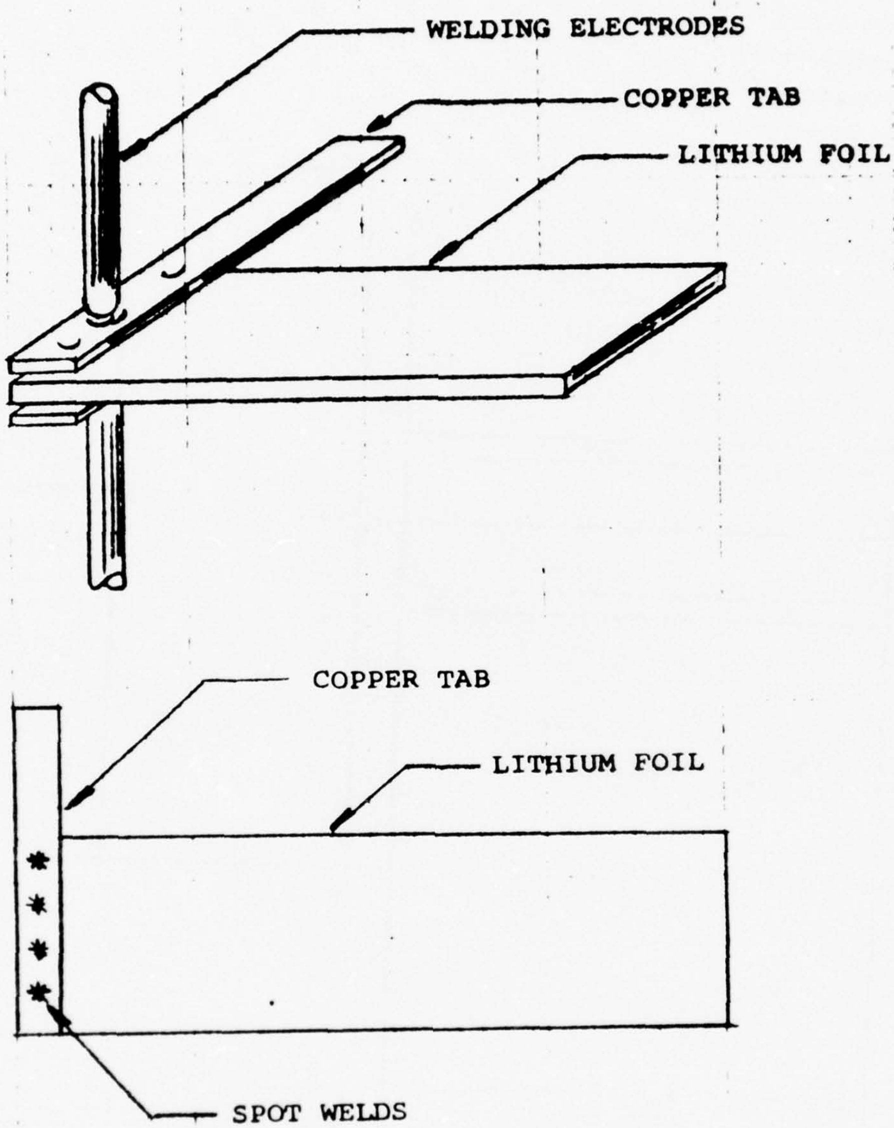
The negative electrodes for the Li/SO_2 battery system consists of high purity lithium foil with a conductor tab welded to one end as shown in Figure 18. A tabulation showing the lengths, widths and thicknesses for the various anodes required for this program is shown in Table 1.

A machine is being designed that will essentially integrate the operations that are presently being performed manually to fabricate completed anodes automatically. These basic operations consists of: a) cutting the lithium foil to the specified length (the lithium is presently being supplied on metal sppols as shown in Figure 19); and b) welding a tab to one end of the lithium strip.

A typical spool contains approximately 181 grams of .019 x 1 5/8 wide (D size) lithium which would be enough material for 55 cells.

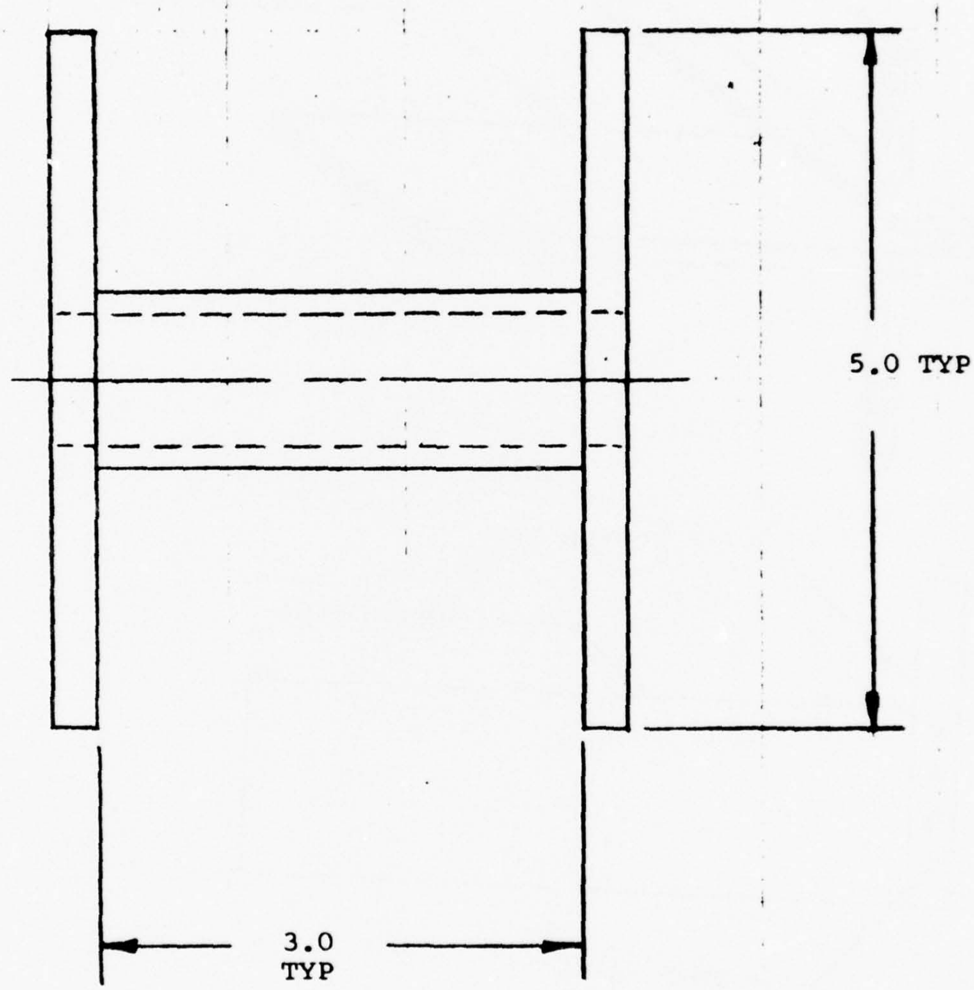
1. Lithium Cutting

Since metallic lithium has the inherent characteristics of "sticking" to most materials and a ductility that may be equated to lead, the selection of the proper technique for cutting this material becomes critical. During this quarterly period, PCI has investigated two techniques for cutting lithium foil that are amenable to an automated process. The use of a traditional "guillotine" type cutter (see Figure 20) with automatic feed was investigated but found to be unsuitable. One basic difficulty with this approach is that the lithium is displaced downward after cutting (a requirement for this type of shearing action) which presented a material transport problem in subsequent tabbing operations. The second problem relates to cutting blade materials. The steel blades normally used with this equipment have a tendency to build up a layer of lithium which results in release problems for the cut lithium strips. Attempts were made to replace the steel blades with plastic materials such as polypropylene but this resulted in excessive blade wear.



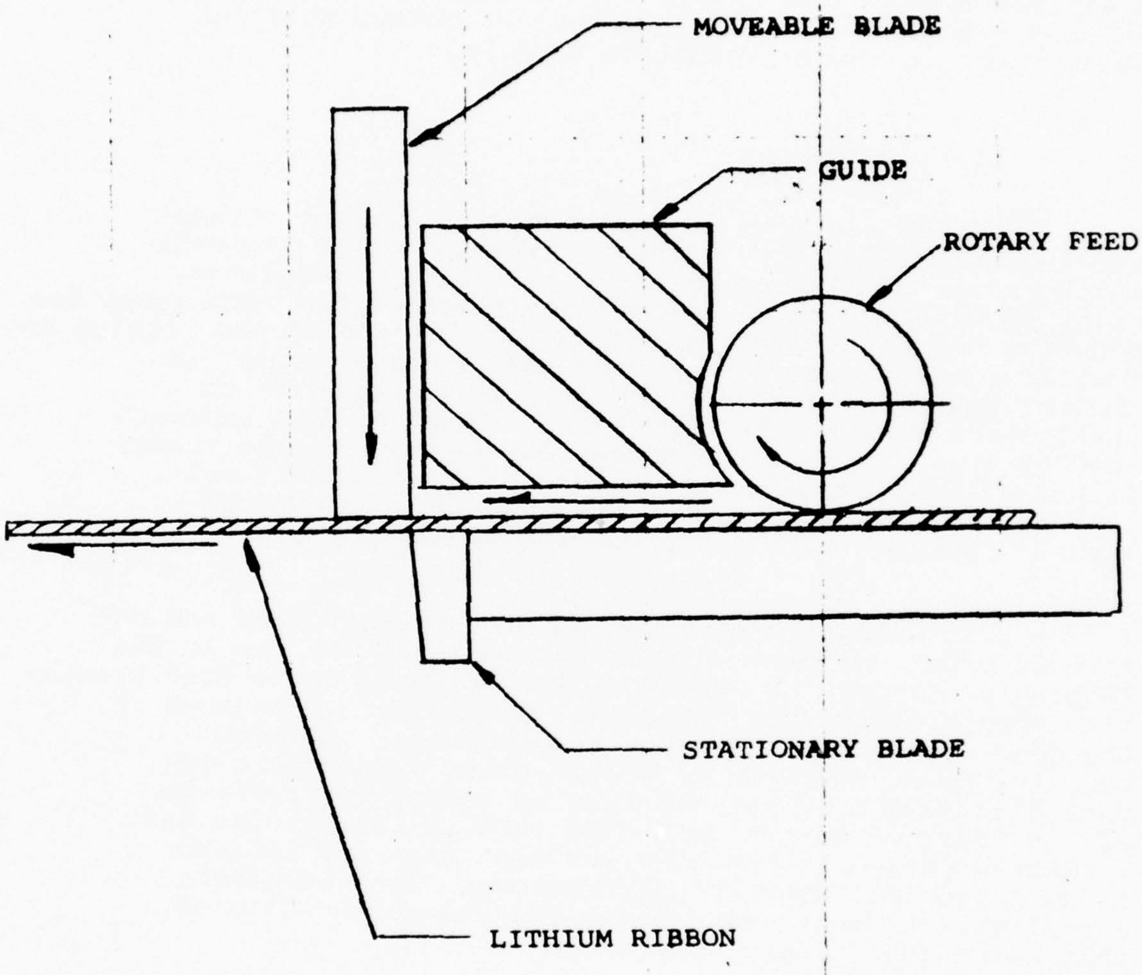
NEGATIVE TAB RESISTANCE WELD

FIGURE 18



SPOOL FOR LITHIUM FOIL

FIGURE 19



GUILLOTINE CUTTER

FIGURE 20

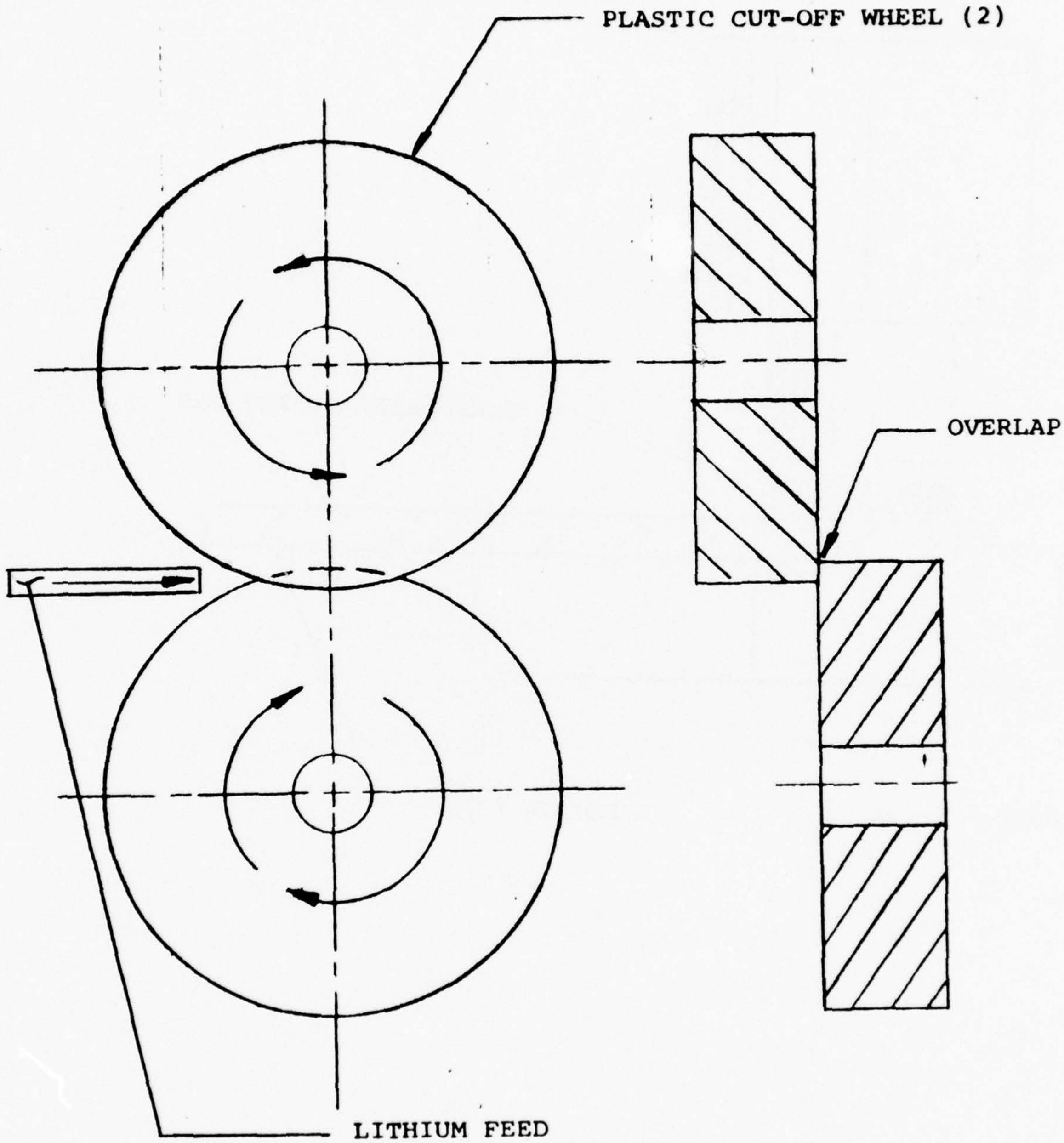
The second technique investigated for lithium cutting, which has proved to be satisfactory, consists of passing the foil between two rotating plastic wheels (see Figure 21). This approach has been demonstrated and results in a clean reproducable cut with minimum cutting wheel wear. By utilizing plastic wheels fabricated from either high density polyethylene or polypropylene, the lithium sticking problem has been minimized and does not interfere with machine function. PCI has decided to employ this type of rotary slitting wheel for the anode production machine.

2. Lithium Tabbing

The anode tab acts as the electrode current collector and is subsequently welded to the inside of the cell casing after completion of the core winding operations. Prior to this contract, PCI had investigated two techniques for securing the .005" thick copper tab to the end of the lithium anode. The first technique consisted of resistance welding (using molybdenum electrodes) the copper tab directly to the lithium as shown in Figure 18. Although this approach results in a tab which is adequately secured to the anode, it was ultimately rejected because of unacceptable calculated production rates and the inability to control lithium "splash" during the welding operation.

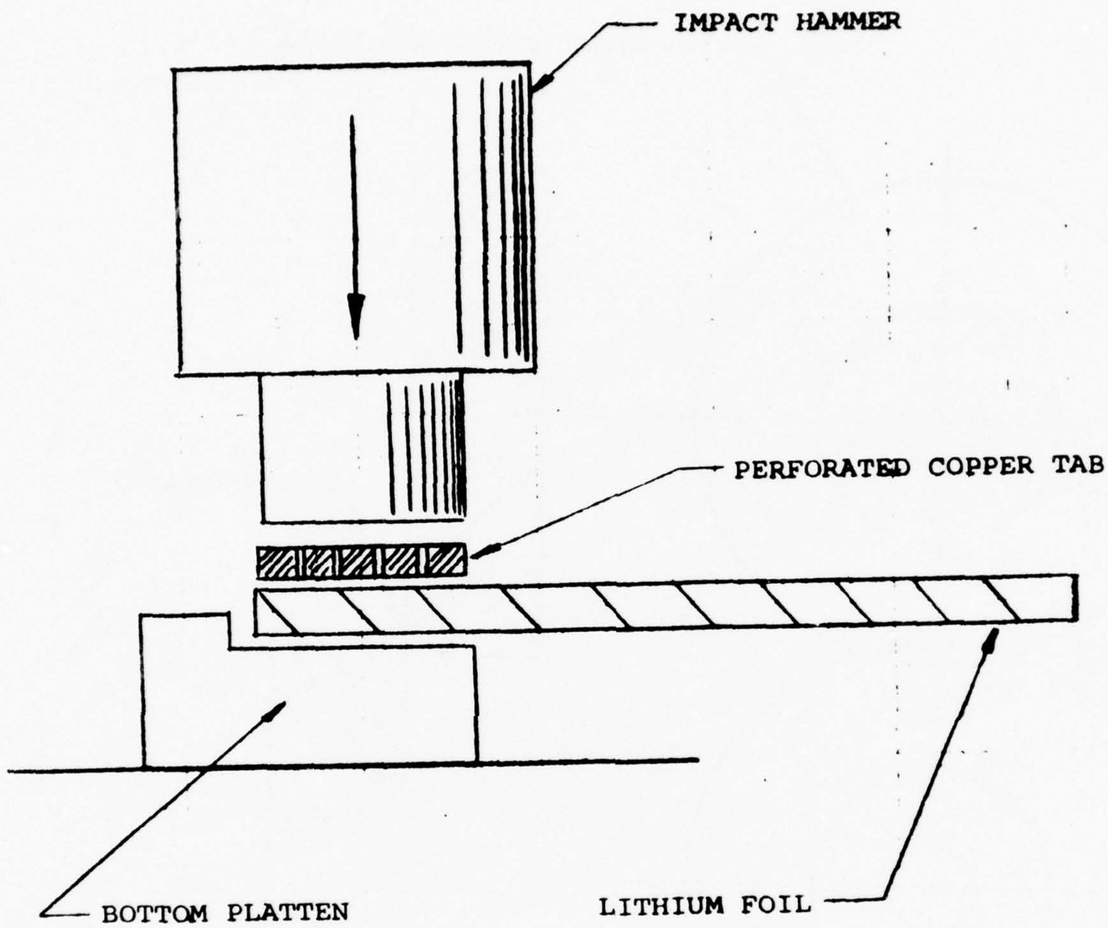
A cold welding technique was also investigated and developed prior to this contract for securing the tab to the lithium anode that is reproducible and amenable to high production. Specifically, the tab is: a) prepierced in an area of the cold weld; b) placed in its appropriate position over the anode and then c) struck using a pneumatic impact electrode over the tab face as indicated in Figure 22. In addition to the cold weld that is formed, the tab is further keyed in place by the fact that the lithium is extruded into the tab perforations. Both mechanical and electrical tests have indicated the suitability of this technique for production.

During the next report period, PCI will complete the design stages of integrating the previously discussed anode tab cold welding technique and finalized lithium rotary slitter design into the prototype production machine. This machine will be designed to achieve the specified production rate of 5,000 "D" size anode components per normal eight-hour shift.



ROTARY SLITTER

FIGURE 21



IMPACT WELD

FIGURE 22

C. Cathode (Positive Electrode) Fabrication

The positive electrode for the Li/SO_2 cell consists of a carbon/binder structure which has been formed onto an expanded aluminum grid. A cross section of this structure is illustrated in Figure 23 and a tabulation showing the cathode lengths, widths and thicknesses for the various battery types required under this contract is shown in Table 1.

Work during this quarterly period has been directed towards developing a continuous technique for fabricating cathodes at rates consistent with program goals. Two potential manufacturing processes for fabricating cathodes have been investigated concurrently. The processes are being studied with the objective of:

a) Minimizing developmental problems;

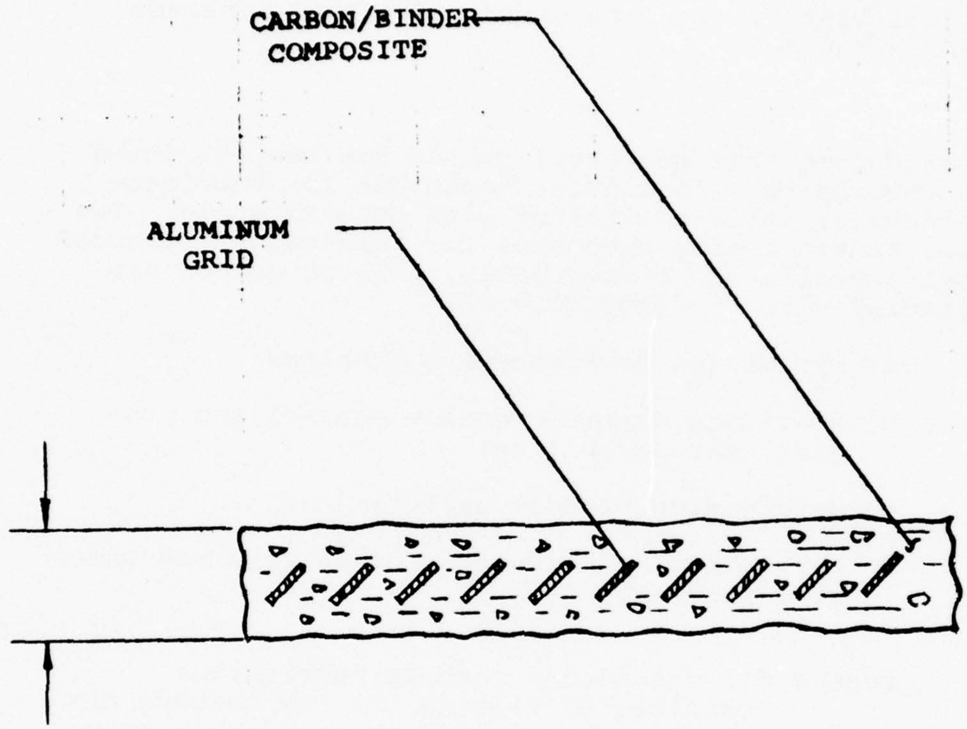
b) Providing maximum process control and product reproducibility;

c) Maintaining product quality;

d) Achieving the production goals required under this program.

One process for continuous cathode fabrication consists of flowing the raw cathode mix through a controlled orifice followed by lamination onto an expanded grid substrate. Control of cathode thickness, width, porosity and solvent content is a function of the dimensional configuration of the discharge orifice and the rate of material transfer. Preliminary bench scale experiments have indicated that this approach is viable. However, two problem areas were encountered:

1. Due to large amounts of solvent present in the raw mix, solvent is expelled during material transfer resulting in a solvent gradient at the orifice. This caused a gradual reduction in material flow rate as the "wet" material at the feed end was unable to displace the "dry" material at the orifice. By initially reducing the



POSITIVE ELECTRODE CROSS SECTION

FIGURE 23

amount of trapped solvent within the raw mix, this gradient can probably be minimized.

2. Uncontrolled feeding of the raw mix to the orifice resulted in a non-uniform cathode sheet. The solution to constant feed is still being investigated but it appears that a "side packer", that is, an auxiliary device to maintain a constant feed rate, may resolve this problem.

Another process currently being studied for automating cathode fabrication is one based on the continuous filtration of the raw mix. Specifically, this process consists of depositing a coating of the carbon/binder mixture onto an expanded grid substrate by rotational filtration. Since the expanded grid is available in continuous lengths and the cathode slurry is easily pumped and filtered, a continuous rather than a batch type process is possible. The cathode weight per unit area is controlled by filtration rate and filter surface speed. Following filtration, the cathode is further dried, compressed to force the coating into the openings of the expanded grid and final dried to a pre-determined solvent level. This technique is presently being evaluated by PCI together with a number of equipment manufacturers.

A second filtration type technique which has been investigated for continuous cathode manufacture consists of a horizontal traveling belt type filter. This filter receives the raw mix through a feed box which maintains even distribution across the entire width of the moving filter belt.Solvent is drawn through the filter media by a series of modular vacuum chambers. As the cake laden filter belt approaches the discharge end of the machine, the cake is further compressed by a series of compression rollers prior to its removal from the belt.

During the next quarterly period, work will be directed towards selecting the ultimate continuous cathode manufacturing technique that will be utilized under this program and component designs and procurement will be initiated.

D. <u>Core Winding</u>

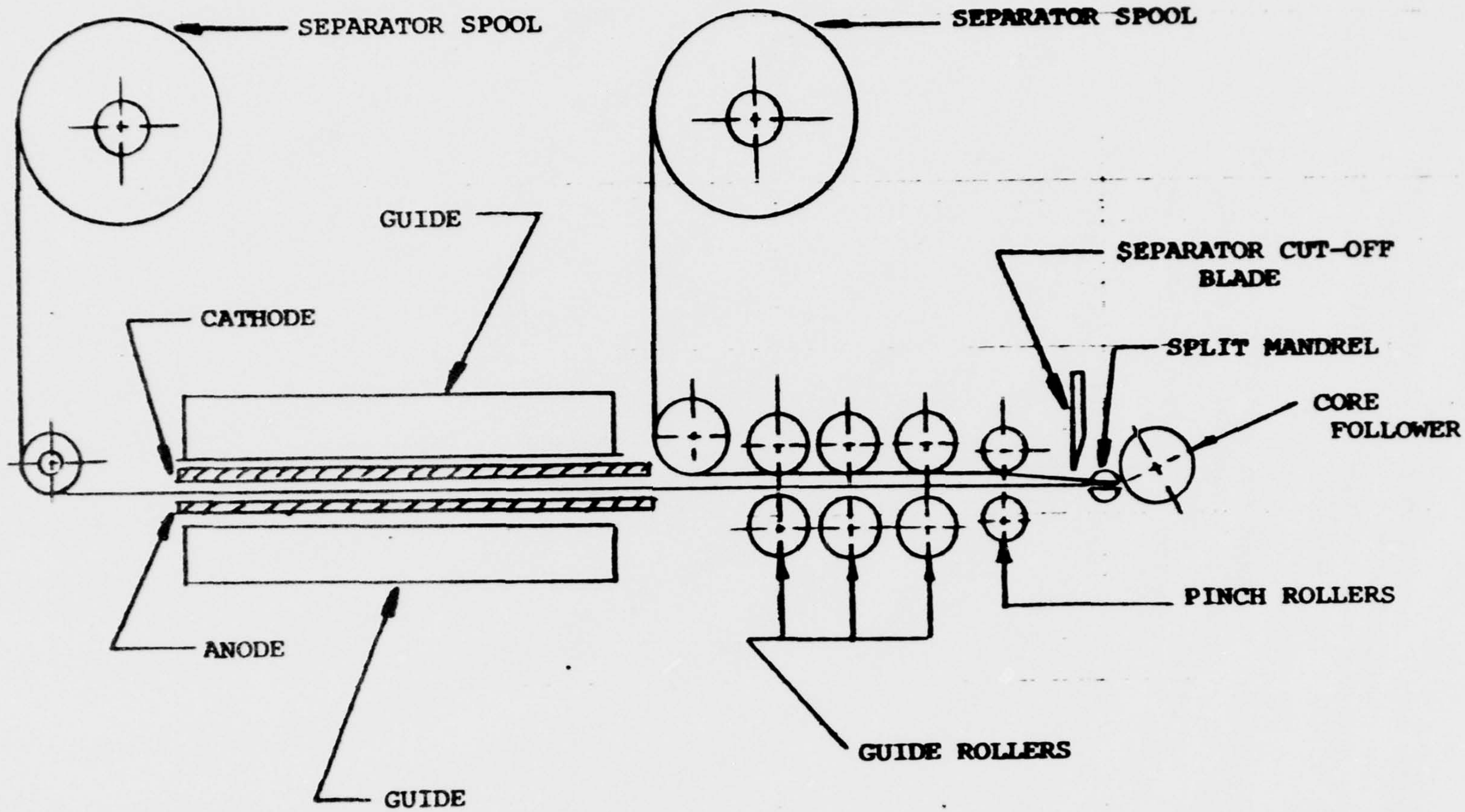
During this quarterly reporting period, designs for a semi-automatic core winding machine have progressed through the conceptual design stages to equipment procurement. The core winder will automatically wind the previously described anode, cathode and separator laminate into a tightly wound spiral configuration.

Winding tension will be closely monitored to maintain a consistent electrode configuration and minimize lateral slippage of the electrodes. Mechanical alignment of the electrode components is critical to avoid electrical short circuits and insulation resistance breakdowns between the electrodes. In addition, the connection tabs must be accurately positioned to permit subsequent electrical connections at the next station.

Figure 24shows the basic core winding machine and its principle operating components. Two rolls of separator material are threaded through the guide and pinch rollers. This is initially performed at the beginning of each roll and automatically thereafter.

The operator places the anode and cathode in the appropriate guide and initiates the start sequence. The feed rollers transfer the material onto a split mandrel. As the mandrel begins to rotate, its speed overcomes one-way clutches built into the feed rollers and the material is wound into a core. After a programmed number of revolutions, the separator is cut and the mandrel stops revolving. A spring loaded roller restrains the core on the mandrel.

The operator places a cell can over the core and the split mandrel rotates in the reverse direction to release the core, leaving the assembled winding inside the can. As the operator is preparing the next set of electrodes, the machine automatically advances the separator



CORE WINDER

FIGURE 24

through the guide and into the prepositioned slot in the mandrel. The complete cycle will consume less than 10 seconds and one operator will be capable of producing over 2,500 cores per day.

Two machines will be used for full production of 5,000 units per day. Room is available to permit subsequent incorporation of a *syntron* can loader to minimize the time required for core removal and installation.

E. Electrolyte Preparation & Dispensing

1. Electrolyte Preparation

In order to achieve a manufacturing rate of 5,000 "D" size cells per day, a system capable of supplying 40 gallons of electrolyte is required. The system must be highly reproducible and easy to operate and maintain.

The key to consistent electrolyte preparation is the transfer of exact amounts of dry ingredients to an enclosed mixing vessel. All of the chemicals purchased have a certified level of purity.
Cartridge type molecular sieves will be used to further enhance overall purity levels. The vent ports of the component storage vessels will be pressurized with dry nitrogen to assure that no additional contamination is introduced into the system.

Two methods of component metering were evaluated during this period. A load cell type automatic weighing system was investigated whereby component quantities delivered are obtained by storage tank weight differences. Studies indicated that problems would be encountered during storage tank changes, requiring system recalibration. It was determined that owing to the susceptibility of this system to general mishandling (with resultant weighing errors) it should not be used where a high degree of accuracy is required.

A system of automatic pumping using positive displacement flow meters will be used to transfer the liquid to the mixing vessel. This system will use a central ratio flow control programmer to monitor and control the flow of organic solvents with respect to the referenced SO_2 flow. This technique requires that only one flow be changed in order to adjust the total quantity of liquid pumped to the mixing vessel. The exact ratio of liquids is maintained independent of the total quantity of electrolyte being mixed.

The lithium salt will be pre-measured into cartridges and sealed to exclude contamination. It will then be fed directly into the reaction vessel through a fitting located in the cover.

One problem encountered in the electrolyte preparation is the heat of solution generated by the SO_2/solvent/Li salt mixing. If the heat is not removed, high tank pressures are encountered and tank venting becomes necessary. To overcome this, a heat exchanger will be used to cool the solvents before SO_2 addition and remove the heat generated as mixing occurs. This technique will assure consistent electrolyte component ratios. The tank would be a 50 gallon vessel capable of withstanding up to 150 psi internal pressure. It incorporates a glass covered variable speed empeller to insure complete mixing of the components.

A schematic diagram indicating the proposed electrolyte transfer and mixing system is shown in Figure 25.

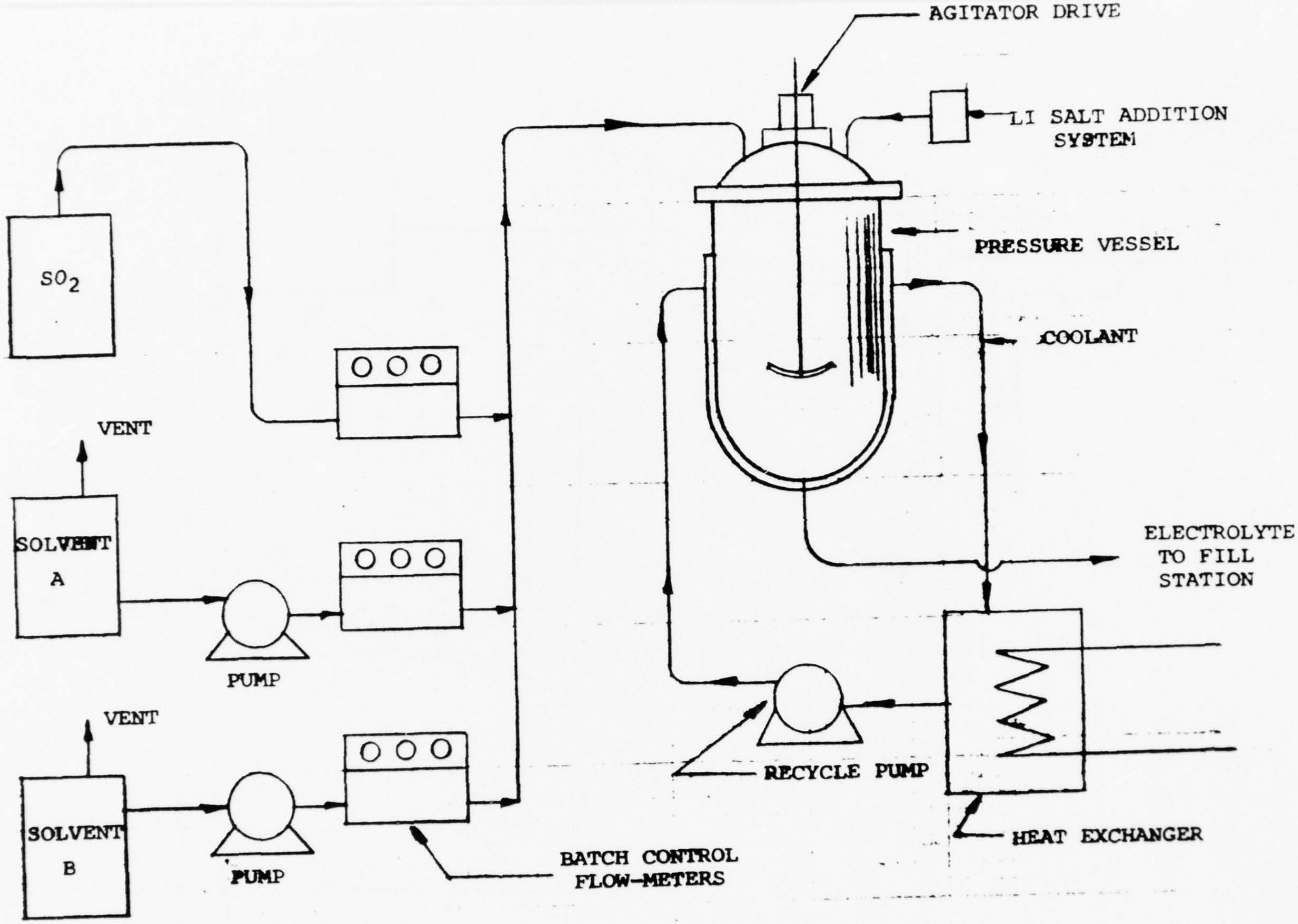
2. *Electrolyte Dispensing*

The proposed electrolyte next must be transferred to a dispensing station which design studies indicated will consist of a fill head, a control valve, and a vacuum pump. The basic system is shown in Figure 26.

The cell is automatically inserted into a special fitting in the fill valve.

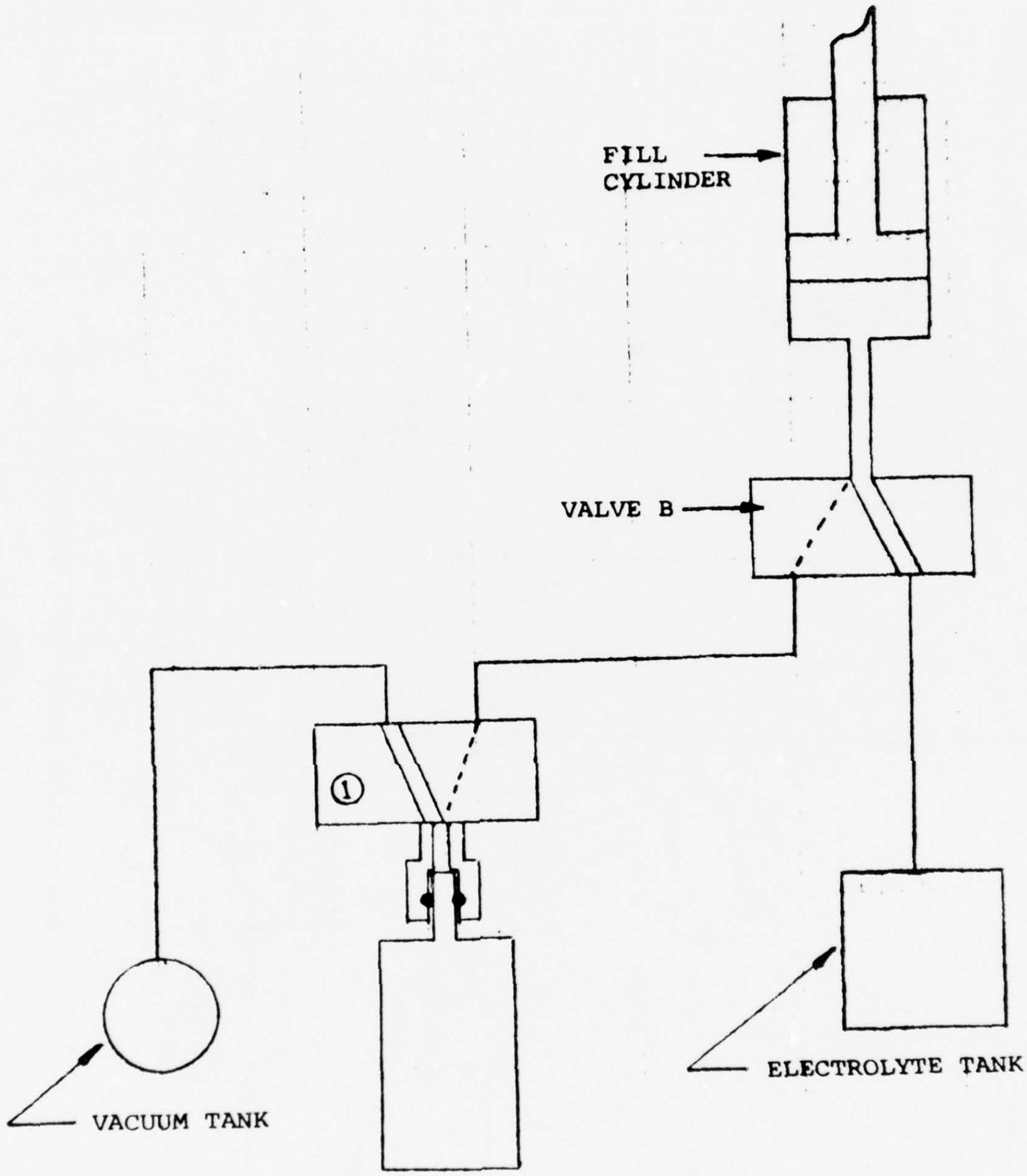
Previously, during assembly, the cell was sealed in an atmosphere of dry gas. In valve position 1, the cell is partially evacuated to a predetermined residual dry gas pressure that corresponds to the desired proportion of dry gas in the finished cell. This residual air allows for thermal expansion of the electrolyte. The valve is next changed to position 2 which disconnects it from the vacuum pump and connects it to the electrolyte tank. Because the tank pressure is higher than the residual gas pressure, the electrolyte flows into the cell until pressure equilibrium is reached. At this stage, the valve is placed in a neutral closed position.

The final operation is automatic sealing of the fill tube. This is done with a special sealing unit incorporated into the fill head.



ELECTROLYTE TRANSFER & MIXING SYSTEM

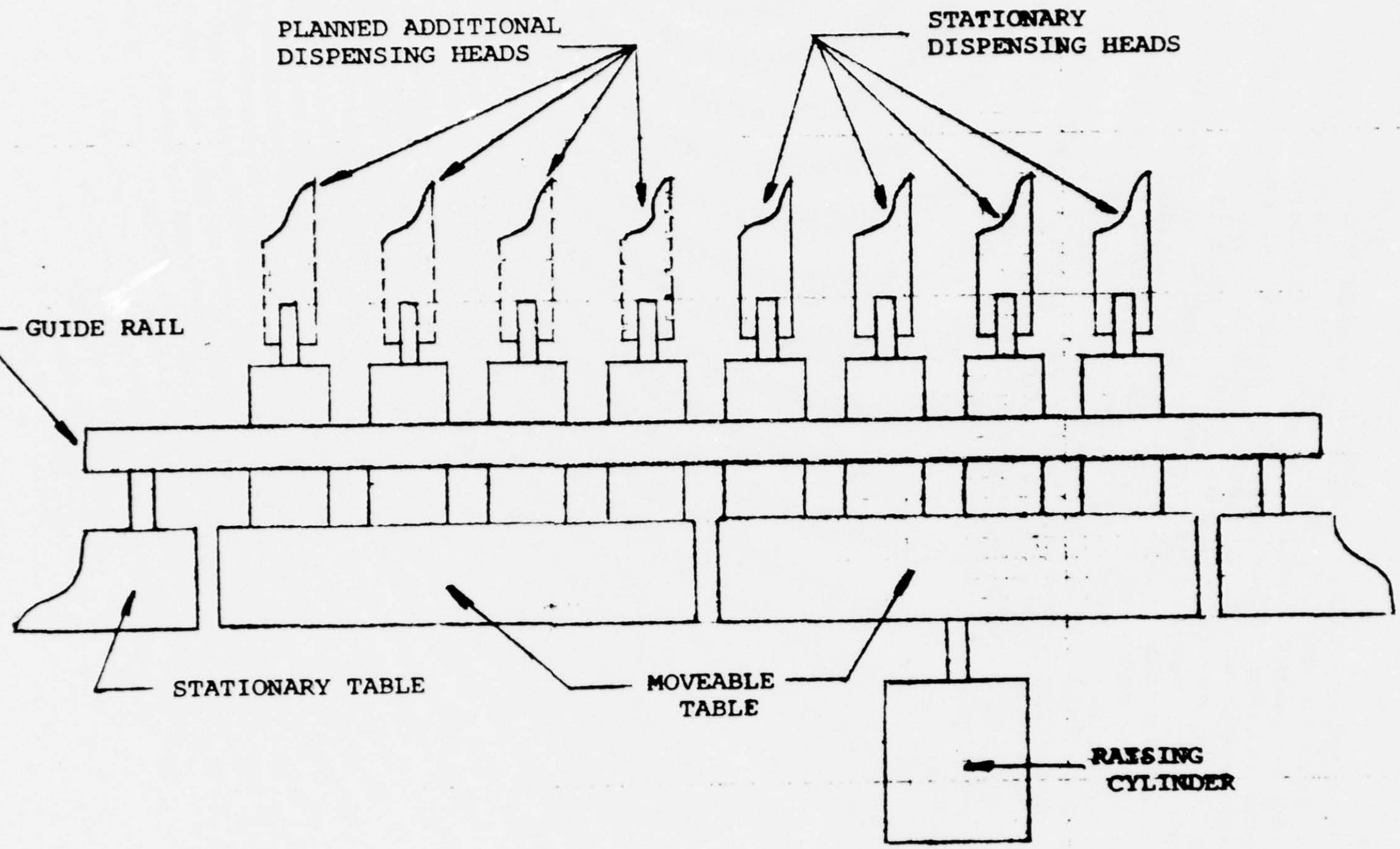
FIGURE 25



ELECTROLYTE DISPENSING STATION

FIGURE 26

Originally a rotary table containing 8 work stations was planned. An operator would load the cells which would then be automatically fed to the fill head. Based on present filling techniques, two fill stations with a 10 second cycle would be needed to fill 5000 units/day. With the new hermetic cell design this is no longer practical. Because of the small inside diameter of the tantalum tube (.050"), longer cycle times are needed to insure complete filling, especially with the larger size cells. A cycle of 20 seconds appears more than ample to fill all cells fabricated under this program. The 4 station in-line system shown in Figure 27 will be used. One operator will be capable of filling over the 5000 units/day. The system can also be easily extended to 6 or 8 stations by the simple addition of extra fill heads.



ELECTROLYTE FILL SYSTEM - IN-LINE

FIGURE 27

F. Hermetic Seal and Cell Closure

During this first quarterly period, a major effort has been directed toward establishing a hermetic cell top design and developing the closure techniques needed to meet the required hardware production levels. Basic design considerations were hermeticity requirements, overall reliability, economics and adaptability to automated production. The specific areas presently being investigated are as follows:

- Glass/Metal Seal Assembly
- Eyelet/Top Resistance Weld
- Cell Peripheral Weld
- Fill Tube Closure
- External Electrical Connection

1. Glass Seal Assembly

Previous to the start of this program, extensive research was conducted to develop an optimal glass seal configuration and an appropriate electrolyte fill technique. As a result, the glass-to-metal hermetic seal assembly as shown in Figure 2 was selected. This assembly consists of a tantalum fill tube, a nickel plated steel eyelet and a glass insulator preform. The assembly is subsequently fused to effect an hermetic compression seal which will meet all electrical, thermal and environmental requirements. Prototype seals were fabricated and tested to quantitatively measure the leakage rate using a helium mass spectrometer. The results indicate a maximum leak rate of 2×10^{-8} cc/sec helium which is well within the specified limits of the contract.

We are presently investigating the use of a common eyelet design which can be utilized for all required cell sizes. This would minimize tooling and fixturing costs and simplify cell top construction.

An alternative approach to the above as shown in Figure 28 , is also being considered. This design would incorporate the seal eyelet and cell top into one piece part which would eliminate the eyelet/top weld operation and a potential source of electrolyte leakage. Tooling required to fabricate this part is presently under evaluation.

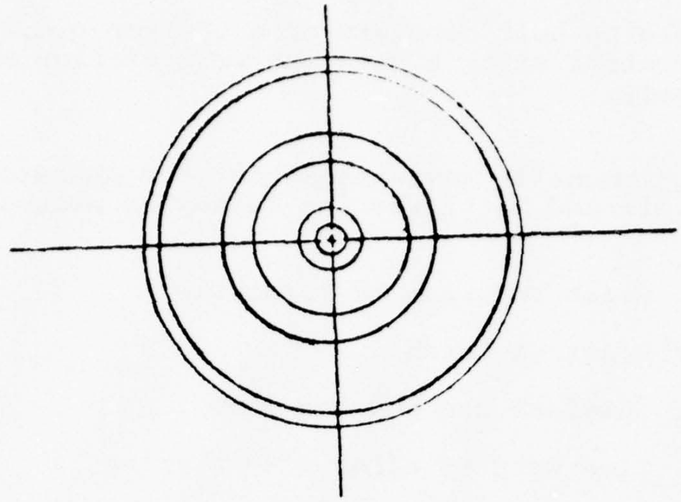
One problem associated with the resistance welding of the internal cathode tab to the fill tube has been uncovered. This problem is primarily due to the formation of a tenacious oxide during the glass fusion process. Attempts were made to chemically remove this oxide but the deoxidizing solutions tried were subsequently found to attack the glass seal. PCI plans to use a mechanical abrasion technique to remove the oxide until the glass seal vendors correct this condition. Use of a weldable inter-connection tab material is also being evaluated as an interim solution.

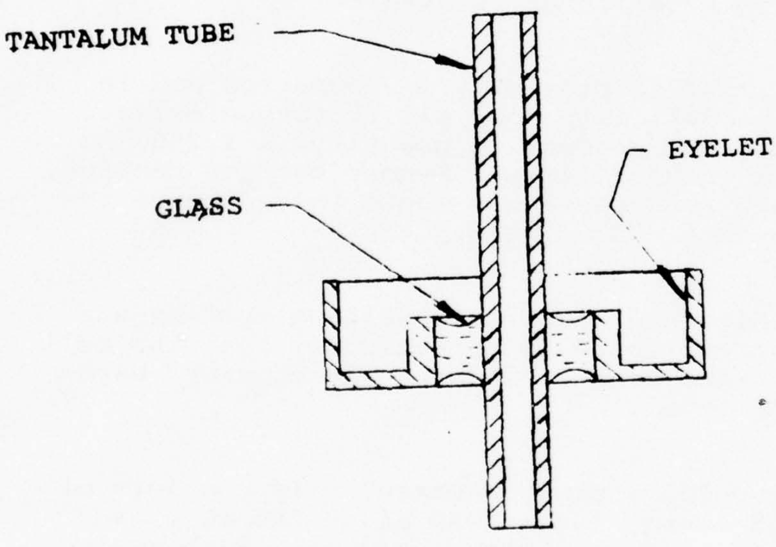
2. Eyelet/Top Resistance Weld

The nickel plated steel eyelet contains a peripheral weld projection. This projection concentrates the electrical power and mechanical force to a localized area during the resistance weld to effect a hermetic seal. Prototype samples were fabricated using a 100 KVA resistance welder equipped with a low inertia head which provides quick response at constant pressure as the projection collapses and the parts are fused. The units were subsequently inspected and tested to quantitatively measure the leakage rate using a helium mass spectrometer. Maximum leak rate observed was 2×10^{-8} cc/sec helium which is well within the specified limits of the contract.

3. Cell Peripheral Weld

Hermetic closure of the cell periphery is presently being accomplished using a plasma arc welding process as shown in Figure 2 . Heat is essentially produced by a restricted arc between a non-consumable electrode and the workpiece. When the arc is initiated through a gaseous column, some of the gas becomes ionized which results in a higher arc temperature and a concentrated heat pattern.





HERMETIC TOP ASSEMBLY

FIGURE 28

The welding unit consists of a 200 amp D.C. power supply, a control unit, a rotating work station and a torch assembly.

The equipment is semi-automatic; the operator loads the cell and initiates the following programmed cycle:

1. Start rotation of turntable

2. Position torch

3. Initiate arc and gas flow

4. Time weld to allow 1/8" overlap

5. Terminate arc and gas flow

6. Retract torch

7. Stop rotation of turntable

This equipment is presently in operation and is being used to hermetically seal all prototype cells. However, the maximum production quantity is 1,250 "D" diameter (1.312 inch) cells per 8-hour day per machine. Four welders and four operators would therefore be required to produce 5,000 units/day.

Laser welding and resistance welding systems are presently being evaluated to hermetically seal the cell periphery at a rate consistent with the required hardware production level.

The laser welding process essentially consists of focusing a high energy laser beam along the cell can/top interface to produce a structural weld with minimum heat transfer. This is particularly important due to the low melting point of the polypropylene separator and insulators. Localized melting of such components may cause electrical short circuits and insulation resistance breakdowns within the cell.

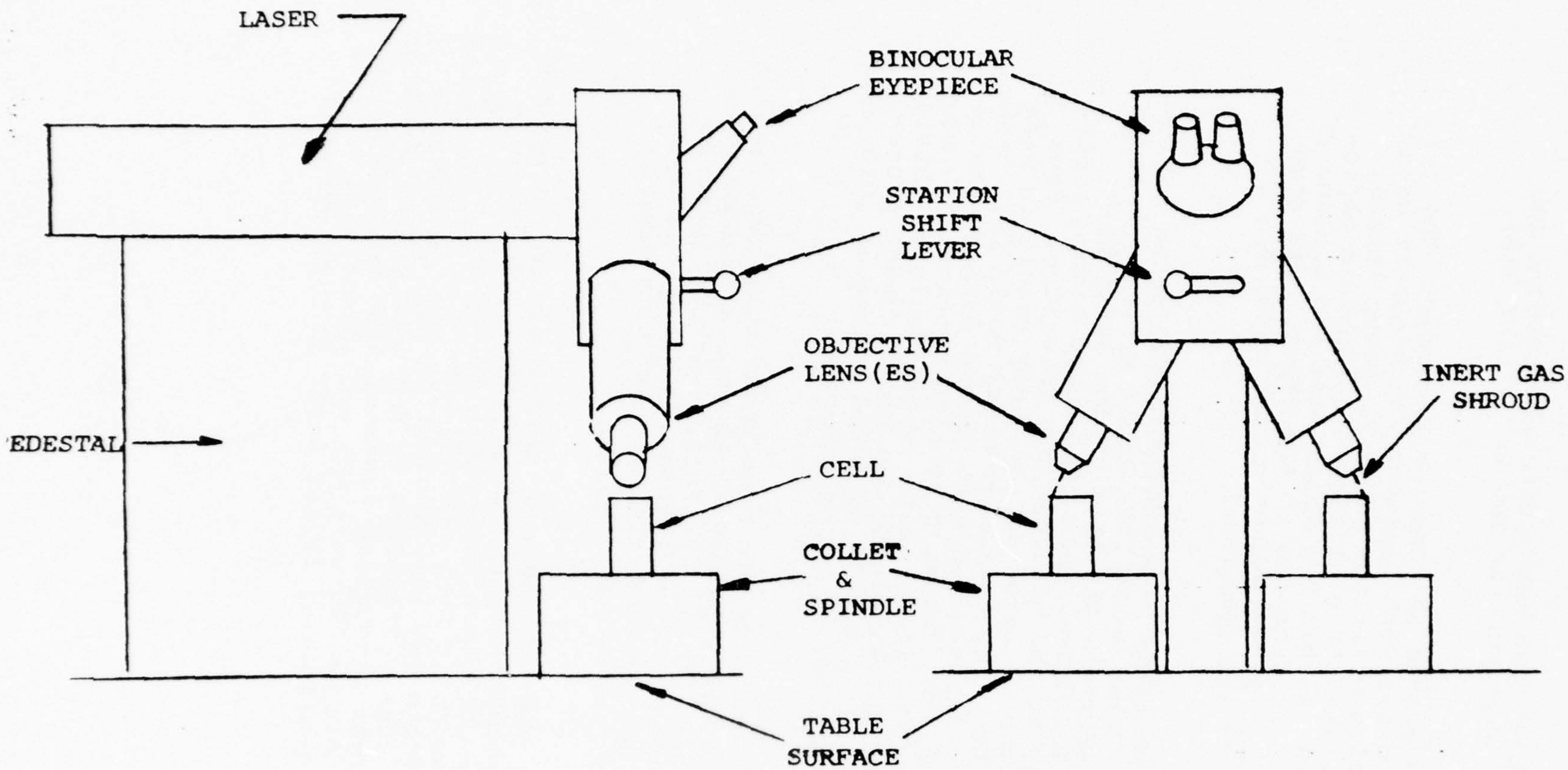
Tests to date have been performed using a 200 watt continuous wave neobium YAG welder (Nd YAG).

A proposed system is shown in Figure 29. The system provides for two work stations which permit welding at one station while the other is being loaded. This is accomplished by utilizing two separate objective lens systems within the laser head and a means of optically switching from one to the other. The complete system would be interlocked to prevent any potential danger to the operator.

Some difficulties have been encountered in obtaining acceptable welds using this laser system. Because of the extremely small diameter of the laser beam (<.010 inch), all dimensional tolerances become critical; especially at the cell can/top interface. Gaps and edge mismatch as large as .003" may result in weak areas within the peripheral weld which could fail under the internal cell pressures encountered during service. Total runout of the fixturing is also critical and must be kept within .002 inch. This is difficult to obtain with a rotating quick-release collet. Present prototype fixturing has a total indicated runout of .010 inch and is in the process of being reworked.

One method used to minimize these tolerance requirements is to defocus the laser beam into a broader pattern. Spot sizes up to .020 inch have been obtained but with a corresponding decrease in energy input/unit area. The weld time must therefore be increased to compensate for the energy loss.

With the 200 watt system, weld times are 11 seconds for a 1.312 inch diameter cell using a .010 inch size spot. With a .020 inch spot size, 14 seconds is required. Weld cycles as short as 5 seconds have also been achieved but weld strength was insufficient to sustain the cell working pressures. Therefore, a 5 second cycle, which is required to meet production rates of 5000 units/day, seems impractical using a 200 watt system. Additional efforts will be performed using larger laser welding systems.



LASER WELDING SYSTEM

FIGURE 29

Resistance welding of the cell periphery can be accomplished by utilizing the blunt can edge (projection) which is formed during the clip-off operation.

Preliminary welds on large diameter cells have been unsuccessful due to the limited power of in-house welders (100 KVA). Arrangements are being made with several manufacturers to projection weld prototype cells on larger 200 KVA machines. A feasibility study is also being made to determine if smaller diameter cells can be projection welded using available in-house equipment. The advantages of this system are short cycle time (up to 10,000 units/day) and low operational cost.

4. Fill Tube Closure

The final step in the fabrication of a hermetic cell is closure of the electrolyte fill tube. This operation is presently being performed in a two stage sequence. The first stage is a preliminary tube clip-off which is accomplished at the electrolyte dispensing station. This provides a temporary seal and allows for inter-station transfer. Final hermetic closure of the tube is performed at a separate station where all critical welding parameters can be controlled and monitored.

A problem was encountered with final fill tube closure due to non-uniform hardness of the tantalum tube material after glass seal fabrication. Corrective action is presently underway to correct this discrepancy.

5. External Electrical Connection

Electrical connection of the external positive terminal will be accomplished as shown in Figure 2 . A steel eyelet is initially resistance welded to the tantalum tube to provide a contact surface for subsequent welding. An insulative washer is used to prevent the eyelet from contacting the glass-to-metal seal. A washer is installed below the eyelet for mechanical support during subsequent welding. A flanged cap is then resistance welded to the eyelet to provide a positive "button" contact.

6. Seal Evaluation Program

A complete test program has been established to evaluate the aforementioned glass-to-metal seals and hermetic welding techniques. Two hundred (200) prototype cells were fabricated and stored under various thermal profiles to determine the long term electrolyte leakage rates and to ascertain the effects of electrochemical corrosion on the internal seal components.

During this quarterly period, it became necessary to terminate the above tests due to defective glass seal eyelet projection welds. These defective welds were caused by a residual oxide layer which was formed during the glass seal fabrication. This problem has now been corrected by the glass seal vendors.

Two hundred (200) additional prototype cells are presently being constructed and the subject test program will be re-initiated.

VI. CONCLUSIONS

During the present quarter, work has proceeded in accordance with the planned engineering objectives as defined in the PERT/TIME NETWORK. These objectives include selection of specific mass production fabrication techniques and equipment and implementation of such techniques in the construction of the required cells and batteries.

The initial cell and battery designs have been completed. Preliminary results indicate that all performance, environmental and safety requirements will be met and/or exceeded.

Various systems for the preparation and dispensing of electrolyte have been reviewed. Basic considerations include optimization of proper mix ratios, minimization of moisture contamination and metering of precise electrolyte quantity.

A basic core winding system has been finalized to automate electrode winding at a rate of 2500 units/day. The electrodes will be automatically aligned and wound into a core structure for subsequent installation within a prepared cell can assembly. The basic machine concept has been finalized and component selection and equipment fabrication is presently underway.

Two approaches for continuous cathode fabrication have been considered for achieving the production goals of this program. The first process includes the transfer of raw cathode mix through an orifice followed by lamination onto an expanded aluminum grid. Solvent gradients and non-uniform feeding problems have been experienced with this approach. The second process consists of a process utilizing both a rotational and horizontal filtration process which filters the mix and deposits the cathode on the expanded aluminum grid in a continuous operation.

Anode fabrication will be accomplished using a system which will cut continuous rolls of lithium to a pre-selected length and lamination of a perforated tab to one end of the lithium strip. The selected process utilizes two rotating slitting wheels which are indexed along a continuous lithium strip and a pneumatic impact electrode for welding of the perforated tab.

Various welding techniques are presently being evaluated to accomplish hermetic closure of the cell components. Projection welding of the glass/metal seal to the cover assembly is considered the optimal welding technique and will be used for all required cell types. The peripheral weld can be accomplished using laser, plasma-arc or projection weld techniques. Evaluation of each technique is presently underway and final selection will be based upon their ability to meet the hermeticity specifications and the required production rates. Fill tube closure techniques have been finalized and successfully demonstrated on prototype cells.

VII. PROGRAM FOR 2ND QUARTER

The proposed program for the next reporting period will include the following:

- Procurement of cell and battery prototype hardware and piece parts
- Fabrication of initial cell and battery components and sub-assemblys
- Finalization of cell and battery design configuration in accordance with the requirements of SCS-459, Batteries, Primary Lithium Organic dated 17 May 1974.
- Finalization of equipment design and procurement of required standard components.

VIII. IDENTIFICATION OF PERSONNEL

Dr. Stewart M. Chodosh - (Contract Administrator/ Program Manager) (180 hrs)

Dr. Chodosh has over fifteen years of experience in the area of energy conversion including research and development, project direction and managerial administration. The past five years have been devoted exclusively to all aspects of lithium battery technology. Responsibilities have included project direction of programs for the military and its prime contractors, applications engineering and manufacturing process improvements. He is presently responsible for general contract administration and overall program management which includes work-load scheduling and definition, establishment of priorities and coordination of all program efforts.

Bruce Jagid - (Senior Engineer) (335 hrs)

Mr. Jagid has over twelve years experience in the field of energy conversion systems including the direction of development engineering programs and marketing administration. His responsibilities have included the conceptual design and development of energy sources for both military and commercial markets and the evaluation and assessment of system applications and performance characteristics. He is presently responsible for the scheduling and defining of all manufacturing activities and overall surveillance of program milestones.

Martin G. Rosansky - (Senior Engineer) (336 hrs)

Mr. Rosansky has been engaged in the research and development of various electro-chemical power systems. His responsibilities have included program management and administration, establishment of quality assurance criteria, organization of electrode production facilities and applications engineering. He is presently responsible for the coordination, scheduling and surveillance of all engineering efforts and activities.

Richard M. Tedeschi - (Engineer) (141 hrs)

Mr. Tedeschi has over eight years experience in the areas of engineering and manufacturing where his prime responsibilities included the research, development and manufacturing engineering of photographic equipment. During the past year, he has been involved with the fabrication and evaluation of proposed cell and battery designs which include material/ equipment performance evaluation, manufacture, scheduling and surveillance of critical manufacturing processes.

James L. Maguire - (Supervisor) (209 hrs)

Mr. Maguire has over twenty years experience in fields relating to the design, fabrication and evaluation of both semi-automatic and automatic electromechanical equipment. His present responsibility includes the supervision and surveillance of all phases of cell and battery manufacture and assembly.

Mr. James Harris - (Technician) (238 hrs)

Mr. Harris has worked in the lithium battery field for the past five years and is cognizant of test requirements, specialized test equipment and test data reporting as required for various military sponsored programs. He is presently responsible for the supervision and surveillance of cell electrolyte preparation and dispensing operations.

Mr. Julius Cirin - (Technician) (154 hrs)

Mr. Cirin has extensive educational background in the field of communications electronics. He presently assists in the surveillance of critical cell and battery assembly operations and in the set-up of in-process tooling and equipment.

Mr. Prakash Jog - (Engineer) (141 hrs)

Mr. Jog has twelve years experience in the areas of manufacturing and industrial engineering including time study analysis, tooling and equipment design and implementation of in-process product improvements. He is presently responsible for tooling design and evaluation and for the preparation of all required cell/battery engineering drawings, specifications and operational procedures.

Mr. N. Bartilucci - (Technician) (182 hrs)

Mr. Bartilucci is presently responsible for the supervision and surveillance of all lithium dry-room assembly operations. His responsibilities also include the set-up and calibration of all required cell assembly equipment and monitoring of in-process cell assembly processes.

Mr. Anandaram Joshi - (Test Engineer) (142 hrs)

Mr. Joshi is presently responsible for the performance of all required cell and battery electrical, environmental and safety tests. Such duties include data reporting and analysis, design and fabrication of test circuits and test equipment calibration and maintenance.

APPENDIX

ELECTRONICS COMMAND TECHNICAL REQUIREMENTS

SCS-459 17 MAY 1974

SCS-459 AMENDMENT 3 25 JULY 1975

ELECTRONICS COMMAND
TECHNICAL REQUIREMENTS

SCS-459
17 May 1974

BATTERIES, PRIMARY, LITHIUM ORGANIC

1. SCOPE

1.1 Scope. - This specification covers primary batteries of the non reserve type composed of electrochemical cells utilizing a lithium anode with an organic type electrolyte.

1.2 Classification. -

1.2.1 Type designation. - The type designation of lithium organic primary batteries shall be in the following form, (SEE 3.1 and 6.1):

BA-	5030	/U
Component	Battery Type number	Installation indicator
(1.2.1.1)	(1.2.1.2)	(1.2.1.3)

1.2.1.1 Component. - Primary batteries are identified by the two-letter symbol "BA" followed by a hyphen.

1.2.1.2 Battery type number. - The battery type number identifies the basic design of the battery (See 3.1) and consists of a four digit number in the 5001 through 5999 series.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

L-P-378	Plastic Film, Polyethylene Thin Gage
L-P-390	Plastic, Molding Material, Polyethylene, Low and Medium Density
QQ-C-576	Copper Flat Products with Slit, Slit and Edge-rolled, Sheared, Sawed, or Machine Edges, (Plate, Bar, Sheet, and Strip)
QQ-N-290	Nickel Plating (Electrodeposited)

FEDERAL (Cont'd)

QQ-S-571	Solder: Lead Alloy, Tin Lead Alloy, and Tin Alloy; Flux Cored Ribbon and Wire, and Solid Form.
QQ-S-781	Strapping, Steel, Flat and Seals.
QQ-T-191	Terne Sheets (Long Ternes)
PPP-B-585	Box, Wood, Wirebound
PPP-B-601	Box, Wood, Cleated-plywood
PPP-B-621	Box, Wood, Nailed and Lock-Corner
PPP-B-636	Box, Fiberboard
PPP-F-320	Fiberboard, Corrugated and Solid, Sheet Stock (Container grade) and Cut Shapes
PPP-T-60	Tape, Pressure-Sensitive Adhesive, Waterproof for Packaging and Sealing
PPP-T-76	Tape, Pressure-Sensitive Adhesive Paper, Water Resistant (For Carton Sealing)
PPP-T-97	Tape, Pressure-Sensitive Adhesive, Filament Reinforced

MILITARY

MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermo-setting
MIL-W-76	Wire and Cable, Hook-up, Electrical Insulated
MIL-W-6858	Welding, Resistance, Aluminum, Magnesium, Non-hardening Steels or Alloys, Heat-resisting Alloys, and Titanium Alloys, Spot and Seam
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-B-43014	Boxes, Water Resistant Paperboard, Folding, Set-up and Metal-stayed

STANDARDS

FEDERAL

FED.STD.NO. 595	Colors

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-147	Palletized and Containerized Unit Loads 40 Inch x 48 Inch Pallets, Skids, Runners, or Pallet Type Base

(Copies of specifications, standards, specification sheets and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Military specification sheets for individual battery types. - Detail requirements or exceptions applicable to individual types are specified on the military specification sheets associated with this specification. In the event of any conflict between requirements of this specification and the individual military specification sheet the latter shall govern.

3.2 Classification of requirements. - The requirements for the product are classified herein as follows:

Requirement	Paragraph
Selection of specifications and standards	3.3
First Article	3.4
Materials and components	3.5
Design and construction	3.6
Insulation resistance	3.7
Dielectric strength	3.8
Capacity	3.9
Initial voltage delay	3.10
Vibration	3.11
Mechanical shock	3.12
Altitude	3.13
Labeling and marking	3.14
Workmanship	3.15

3.3 Selection of specification and standards. - Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

3.4 First Article.- Batteries furnished under this specification shall be a product which has been tested, and passed the first article inspection specified herein.

3.5 Materials and components. - When a definite material or component is specified, it shall be in accordance with the applicable specification or requirement listed in Table I. When deemed necessary by the Government, certification from the source of the material or component will be required. In the absence of certification from the source, a certificate of analysis or certified inspection data will be required. (See para 4.4 and 4.4.1) All basic materials or components, used in the manufacture of cells and batteries, which are not specified herein, shall be certified for conformance to the manufacturer's design specification either by the manufacturer or his supplier.

3.5.1 Metals. - All metals which do not enter into the basic electrochemical reaction of the cell shall resist or be treated to resist corrosion.

3.5.1.1 Dissimilar metals. - When dissimilar metals which would adversely affect battery performance are used in intimate contact with each other, protection against electrolysis and corrosion shall be provided.

3.6 Design and construction. - Batteries shall be of the design, construction, physical dimensions, weight, and polarity specified in 3.1.

3.6.1 Battery voltages. -

3.6.1.1 Open-circuit voltage. - The open-circuit voltage shall not exceed the maximum voltage specified. (See 3.1 and 4.7.5.1)

3.6.1.2 Closed-circuit voltage. - The closed-circuit voltage shall be not less than the minimum voltage specified. (See 3.1 and 4.7.5.2)

TABLE I - Materials and Components

Materials or components	Applicable specifications or requirements (See 4.4)	Methods of test (See 4.4.1)
Solder 1/	QQ-S-571	
Soldering Flux 2/	MIL-F-14256	
Metals	3.5.1	
Nickel plating	QQ-N-290	
Wire	MIL-W-76	
Plastic, Molded	MIL-M-14, type MFE	
Plastic polyethylene ...	L-P-390, type 1	
Tape	PPP-T-60	
Insulating, impregnating potting and sealing compounds	3.6.2	4.7.1.1.1
Filler or padding	3.6.3	4.7.1
Cell-block-container material	3.6.4 and 3.8	4.7.2
Intercell separation ...	3.6.5	4.7.2
Jackets, metallic 3/ ...	3.6.10.1	
Jackets, non-metallic...	3.6.10.2	4.7.2
Terminal mounting plate.	3.8	4.7.2

1/ For electrical connections, type Sn40 or higher tin content shall be used.

2/ If other fluxes are used, they shall not affect the performance of the battery or reduce its shelf life.

3/ Test methods 4.7.2 is applicable only for metallic jackets of material other than terneplate.

3.6.2 Insulating, impregnating, potting and sealing compounds. - The insulating, impregnating, potting, and sealing compounds shall exclude moisture from insulating material without impairing its electrical characteristics. When tested as specified in 4.7.1.1.1 the potting and sealing compounds shall not flow at high temperature, nor crack or draw away from the sides of a container at low temperature sufficiently to impair electrical connections. Voids within the potted battery, except the socket well, shall be adequately filled with microcrystalline wax, asphalt, wood blocks, or wax-impregnated chipboard, or equivalent material.

3.6.3 Filler or padding. - Filler or padding shall be a cushioning electrically nonconducting material which maintains its insulating characteristics under adverse environmental conditions. If adverse environmental conditions affect this material, then it shall be isolated from the electrical components by an insulating material that maintains its electrical characteristics.

3.6.4 Cell-block containers. - Cell-block container shall be an insulating material surrounding a group or a stack of individual cells.

3.6.5 Intercell separation. - A separator shall be placed between cells in series connected multicell batteries. The separator shall be an insulating material.

3.6.6 Intercell connections. - Intercell connections shall be spot welded in accordance with MIL-W-6858, Class B. Connections between cell block and terminal shall be so insulated or positioned as to avoid contact with other conducting material and/or jacket of the battery. When insulated wire is soldered to terminal lugs, it shall not be bared more than 3/32 inch from the lug nor shall it extend more than 3/32 inch beyond the lug.

3.6.7 Age of cells. - The minimum age of cells, from the time of their fabrication to the time of their presentation for acceptance inspection as batteries, shall be 5 days. The maximum age of cells, from the time of their fabrication to the time of their shipping date, shall be 120 days. Batteries shall be submitted for acceptance inspection not more than 45 days prior to the shipping date.

3.6.8 Terminals. - Terminals shall be provided as specified in individual specification sheets. The type, dimensions, location, and mounting are cited therein. (3.1)

3.6.9 Safety feature. - Each cell of the battery shall contain a feature so that any potentially explosive condition caused by sustained external or internal shorting or incineration will cause the safety feature to activate and thus preclude an explosion. In addition to this safety precaution each complete battery shall be fused with a 2 ampere time delay fuse. If a battery type is composed of more than one section, each individual section shall be fused separately with a 2 ampere time delay fuse.

3.6.10 Jackets. - The jackets may consist of either metallic or nonmetallic material. The contents of multicell batteries shall fit snugly enough in the jackets to minimize movement of the cells. Jackets covering one or more cylindrical cells stacked end on end, and having open top and open bottom, shall be so attached to the cells as to prevent them from slipping out when held or shaken vertically. The bottom opening of the jacket shall be of the size specified. (See 3.1)

3.6.10.1 Metallic jackets. -

3.6.10.1.1 Prior to battery fabrication. - The inside of the jacket, when other than terneplate, shall be coated or lined with an electrolyte corrosion resistant material.

3.6.10.1.2 As a fabricated battery. - The outside of the battery shall have a coating to protect the jacket from corrosion during or at the conclusion of any of the tests specified herein. The contents of the jacket shall be completely insulated from the metal unless otherwise specified. The jacket shall not become permanently distorted nor open at any of its seams after being subjected to the test specified in 4.7.3.1. The test of 4.7.3.1 shall be applicable to batteries weighing 5 pounds or more.

3.6.10.2 Nonmetallic jacket. - When wax coating a nonmetallic jacket, microcrystalline wax or equal shall be used. All excess wax shall be removed from the external surfaces of the jacket.

3.6.10.3 Jacket integrity. - Metallic jackets shall show no evidence of water penetration and nonmetallic jackets shall not fall apart and the seams shall remain intact when tested as specified in 4.7.3.2. The battery, following water immersion for a period of 48 hours shall provide at least 95% of the specified capacity when discharged in accordance with 4.7.6.1.1.

3.6.10.4 Color of jackets. - The color of exposed surfaces of jackets shall match one of the following lusterless greens 34079, 34086, 34087, 34096, 34102, 34127, and 34128 per Federal Standard No. 595.

3.6.11 Cell construction. - Construction shall be such that it will be impossible for one cell to be short-circuited by coming in contact with another cell of the same type when placed end to end.

3.6.12 Manufacturing processes. - The contractor shall maintain records on all manufacturing processes he employs for the preparation, fabrication and/or refining of cell and battery components. These records should be available to the Government upon request. The records shall be so maintained that any battery can be identified with respect to material used, batch number, component supplier, and any other pertinent process data.

3.6.12.1 Time order production. - Time order production will be maintained on cell and battery fabrication. Cells, as they are produced, are to be numbered consecutively and will be used for each successive battery fabrication.

3.7 Insulation resistance. - The insulation resistance between any two terminals not electrically connected, and between all ungrounded terminals and the jacket of the battery, shall be not less than five megohms when tested as specified in 4.7.7.

3.8 Dielectric strength. - When applicable materials are tested as specified in 4.7.2, there shall be no voltage breakdown during the entire test period.

3.9 Capacity. - When the battery is tested for capacity as specified in 4.7.6 the time required to terminate the discharge as specified in 4.7.6.5 shall be not less than the minimum time specified. (3.1)

3.10 Initial voltage delay. - When the battery is tested for capacity, the time required at the beginning of discharge for the battery units to reach end voltage after the load is applied shall not be more than the time specified. (3.1)

3.11 Vibration. - After the batteries have been tested as specified in 4.7.8 they shall meet the visual and mechanical and battery voltage requirements (see 3.6.1 through 3.6.1.2). There shall be no voltage fluctuations during the test.

3.12 Mechanical shock. - After the batteries have been tested as specified in 4.7.9 they shall meet the visual and mechanical and battery voltage requirements (See 3.6.1 through 3.6.1.2).

3.13 Altitude. - After the batteries have been tested as specified in 4.7.11 they shall meet the visual and mechanical and battery voltage requirements. (See 3.6.1 through 3.6.1.2)

3.14 Labeling and marking. - All labeling and marking shall be clear and legible throughout all the tests specified herein. Labeling and marking shall be black. Metallic and plastic jackets may have the labeling and marking embossed, or die depressed, in which case it may be the same color as the background.

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MANUFACTURING METHODS AND TECHNOLOGY FOR HERMETICALLY SEALED LI--ETC(U)
OCT 76 M G ROSANSKY, R M TEDESCHI DAAB07-76-C-0042
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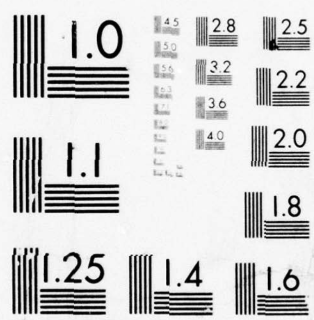


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-

3.14.1 Labels. - Each battery shall have a label positioned as specified in 3.1. If there is insufficient space to show all required information on one face of the battery, it shall be contained on another face. There shall be no information on the label other than the following:

BATTERY, PRIMARY, LITHIUM ORGANIC

Type Designation

(Contract Number) _ _ _

(Code) _ _ _ _

Manufacturer's name

(Trade name may also be used)

Manufacturer's plant

EXAMPLE:

BATTERY, PRIMARY, LITHIUM ORGANIC
BA-5270/U
DAAB05-73-C-1234
0373
John E Doe Company
JODOCO
Batteryville, N.J.

NOTE: The code may be placed on the bottom of single-cell batteries.

3.14.1.1 Code. - The code shown shall indicate the month and year of manufacture of the battery by means of a four-digit number in which the first two digits shall indicate the number of the month and the last two digits shall indicate the year. Months earlier than the tenth month shall be a single digit preceded by "0".

EXAMPLES:

A battery manufactured in March 1973 will bear the code "0373".

A battery manufactured in November 1973 will bear the code "1173".

When a battery is completed during the last three working days of a month, or the first three working days of the subsequent month, the manufacturer is permitted to use either month as the date to be coded.

3.14.2 Special marking. - A black band, extending around approximately one third (1/3) of the battery length, shall be provided on each jacket. The term "LITHIUM BATTERY" shall appear in bold lusterless green lettering (same as jacket color) on the black portion of the jacket in the locations indicated on the applicable specification sheet. (See 3.1)

3.14.3 Terminal marking. - On batteries having socket-type terminals, all markings such as polarity, voltage, and the unit of battery (A, B, C, etc.) shall appear on the face of the battery bearing the socket. On other type terminals, the terminal markings may appear on the top or the side of the battery, or both. Markings shall indicate clearly the terminals to which they refer.

3.15 Workmanship. - Batteries shall be processed in such a manner as to be uniform in quality and shall be free from defects that will affect their life, serviceability, interchangeability, or appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specifications where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities. - Test equipment and inspection facilities shall be of sufficient accuracy, quality and quantity to permit performance of the required inspection. The supplier shall establish calibration of inspection equipment to the satisfaction of the Government. Inspection equipment furnished by the Government for performing certain inspection at supplier's plant, will be calibrated by the supplier and maintained by the Government.

4.1.1.1 Instrument accuracy. -

4.1.1.1.1 Voltmeters and ammeters. - All voltmeters and ammeters used in testing the batteries shall be accurate within 1 percent of the full-scale value. The voltmeter and ammeter ranges shall be such that all readings are taken on the upper half of the scale. The sensitivity of voltmeters shall be not less than 1,000 ohms per volt.

4.1.1.1.2 Resistor tolerance. - During all tests involving discharge through a resistance, such resistance shall be accurate within the following percentages:

	Percent
Up to and including 25,000 ohms	0.5
From above 25,000 ohms to and including 1 megohm	1.0
Above 1 megohm	5.0

In determining the resistance used as a test load, the resistance of all continuously operating voltmeters shall be considered as part of the specified load.

4.1.1.1.3 Timing. - Timing equipment shall be accurate within 0.5 percent.

4.2 Classification of inspection. - The examination and testing of batteries shall be classified as follows:

(a) Materials and components inspection. (See 4.4)

(b) First article inspection. (See 4.5)

(c) Quality Conformance inspection.

(1) Inspection of product for delivery. (See 4.6.1)

(2) Inspection of preparation for delivery. (See 4.6.2)

4.3 Inspection conditions. - Except as otherwise specified herein, all examinations and tests shall be performed at a temperature of 80° ± 20°F. (26.7° ± 11.1°C.), ambient atmospheric pressure, and relative humidity.

4.4 Materials and components inspection. - Materials and components inspection shall consist of verification by certification from the source that the materials and components used in fabricating the batteries are in accordance with applicable requirements prior to such fabrication. In the absence of certification from the source a certificate of analysis or certified inspection data shall be required as proof of conformance to applicable requirements. Materials and components involved are listed in table I.

4.4.1 Samples of materials and components. - For those items listed in table I for which the specification requirement does not reference a subsidiary specification, eight samples of materials or components, treated and processed as they would be in the finished batteries, shall be inspected.

4.5 First article. First article inspection shall be performed by the supplier as specified in 4.5.1 through 4.5.1.2.

4.5.1 Sample batteries. - The supplier shall fabricate per Table II the required quantity of batteries constituting a first article inspection lot.

4.5.1.1 Inspection routine. - First article inspection shall consist of all the examinations and tests per Table II. One sample battery, untested, is to remain at the supplier's plant and to be available as a standard for comparative purposes.

Table II First Article Inspection

Group	No. of Batteries	Examination and Test	Requirement Paragraph	Method of Test Paragraph
I	20	Visual-mechanical examination	3.6 & 3.15	4.7.1
	20	Battery voltage	3.6.1	4.7.5, 4.7.5.1 & 4.7.5.2
	20	Dimensions & weight	3.6	4.7.4 & 4.7.4.1
	20	Mechanical shock	3.12	4.7.9
	20	Vibration	3.11	4.7.8
	20	Altitude	3.13	4.7.11
	20	Insulation resistance	3.7	4.7.7
	20	Capacity tests	3.9 & 3.10	4.7.6.1 thru 4.7.6.6
IA	10	"I" test @ 70°F	3.9 & 3.10	4.7.6.1.1
IB	5	"L" test @ -20°F	3.9 & 3.10	4.7.6.1.2
IC	5	"H" test @ 130°F	3.9 & 3.10	4.7.6.1.3
II	20	Visual-mechanical examination	3.6 & 3.15	4.7.1
	20	Battery voltage	3.6.1	4.7.5, 4.7.5.1 & 4.7.5.2
	20	Storage & capacity tests	3.9 & 3.10	4.7.6.1 thru 4.7.6.6
IIA	10	"HT" test @ 130°F after 4 weeks storage @ 160°F	3.9 & 3.10	4.7.6.1.5
IIB	10	"LT" test @ -20°F after 4 weeks storage @ 160°F	3.9 & 3.10	4.7.6.1.4
III	15	Battery voltage	3.6.1	4.7.5, 4.7.5.1 & 4.7.5.2
IIIA	10	Safety feature	3.6.9,	4.7.10
IIIB	5	Jacket Integrity	3.6.10.3	4.7.3.2, 4.7.6.1.1
III	15	Visual mechanical examination	3.6 & 3.15	4.7.1
IV	1	Untested-reference sample	-	4.5.1.1

4.5.1.2 Failure. - If one or more sample batteries fail to meet any of the first article examinations and tests, the supplier shall immediately make the remedial changes. The supplier at no additional cost to the government shall be required to submit additional first article samples for reinspection. A description of the corrective action taken or to be taken shall be included in the first article inspection report.

4.6 Quality conformance inspection.

4.6.1 Inspection of product for delivery. - The contractor shall perform the inspection specified in 4.4 and 4.6.1.2 through 4.6.1.5.3. This does not relieve the contractor of his responsibility for performing any additional inspection which is necessary to control the quality of the product and to assure compliance with all specification requirements. The government will review and evaluate the contractor's inspection procedures and examine the contractor's inspection records. In addition, the Government--at its discretion--may perform all or any part of the specified inspection, to verify the contractor's compliance with specified requirements. (See 6.3) Test equipment for Government verification inspection shall be made available by the contractor.

4.6.1.1 A lot shall be defined as the quantity of batteries of any one type, of any one code, and produced at any one place of manufacture on any one contract, submitted at one time to quality conformance inspection.

4.6.1.1.1 Shipment lot. - The shipment lot (Ns) is the quantity of batteries (exclusive of the number of batteries required as samples) of any one type, of any one code, and produced at any one place of manufacture on any one contract.

4.6.1.1.2 Contract lot. - The contract lot (N) is the total of all batteries (exclusive of the number of batteries required as samples) of any one type, delivered in one or more shipment lots, under the terms of any one contract.

4.6.1.2 Group A inspection. - Each unit on contract or purchase order shall be inspected for conformance to the inspections specified in Table III. Discrete lots shall be formed from units that pass this inspection. Factors of lot composition not defined herein, or in the contract or purchase order, shall be in accordance with MIL-STD-105. Each lot shall be subjected to sampling inspection, utilizing the procedures of MIL-STD-105, using the general inspection levels and AQL's indicated in Table III.

Table III Group A Inspection

Examination and Test	Requirement Paragraph	Method of Test Para.	AQL		Insp Level
			Major	Minor	
Visual-Mechanical	3.6 & 3.15	4.7.1	1.0%	4.0	II
Battery Voltage	3.6.1	4.7.5 4.7.5.1 & 4.7.5.2	1.0%	-	II

4.6.1.3 Group B Inspection. - This inspection, including sampling, shall conform to Table IV and to special procedures for small-sample inspection of MIL-STD-105. Group B inspection shall be performed in the order listed in Table IV on the same sample batteries and shall normally be performed on inspection lots that have passed group A inspection.

Table IV Group B Inspection

Examination and Test	Requirement Paragraph	Method of Test Paragraph	Inspection	
			AQL	Level
Subgroup 1				
Dimensions & weight	3.6	4.7.4 & 4.7.4.1	0.65%	S-1
Insulation resistance	3.7	4.7.7	0.65%	S-1
Battery voltage	3.6.1	4.7.5 & 4.7.5.1	0.65%	S-1
Safety feature	3.6.9	4.7.10	0.65%	S-1
Visual & mechanical	3.6 & 3.15	4.7.1	1% Major 4% Minor	S-1 S-1
Subgroup 2				
Mechanical shock	3.12	4.7.9	2.5	S-1
Vibration	3.11	4.7.8	2.5	S-1
Altitude	3.13	4.7.11	2.5	S-1
Battery voltage	3.6.1	4.7.5 & 4.7.5.1	2.5	S-1
Jacket integrity	3.6.10.3	4.7.3.2	2.5	S-1
Visual & mechanical	3.6 & 3.15	4.7.1	1% Major 4% Minor	S-1

4.6.1.4 Group C Inspection. - Group C inspection shall consist of (a) HT capacity test with 130°F discharge after only 2 week storage at 160°F, and (b) LT capacity test with -20°F discharge after only 2 week storage at 160°F.

4.6.1.4.1 Sampling Plan. - Ten (10) samples each shall be taken at random from the first 20% of production batteries fabricated in each monthly shipment lot.

4.6.1.4.2 Group C failures. - Action required relative to Group C failures shall be as specified in contract or purchase order. More than one failure per sample group of ten shall constitute a failure of the monthly production lot. A failure is any sample having one or more of the following deficiencies:

(1) Insufficient service

(2) Excessive initial voltage delay

(3) Battery exceeds dimensional tolerances after discharge.

4.6.1.5 Group D Inspection. - Group D inspection shall be performed at the Government inspection facility (See 6.1(f)) on sample batteries in accordance with Table V. Shipment of the lot represented by the sample batteries shall not be heldup pending the results of group D inspection.

4.6.1.5.1 Sampling plan. - A sample of n_s batteries shall be selected at random from production for each shipment lot in amounts determined from the following formula. The sample size shall be rounded off in the case of fractions to an adjacent integer (up or down for each shipment lot), so that exactly n batteries have been assigned to each capacity test (T and LT), when the sample for the shipment of the contract lot has been drawn.

$$n_s = a + \frac{N_s}{N} (2n)$$

Where:

a = 3 when D capacity test is specified (See 3.1), otherwise a = 0.

n_s = number of batteries to be taken from each shipment lot

N_s = number of batteries in the shipment lot

N = number of batteries in the contract lot (See Table VI)

n = number of batteries to be taken from the contract lot for each of the two capacity tests, T and LT, in accordance with Table VI. (Total number of batteries selected equals 2n).

4.6.1.5.1.1 Smaller-than-shipment (subshipment) lots. - At the supplier's option selection of sample batteries (see 4.6.1.5.1) may be made on a smaller-than-shipment (subshipment) lot basis. In such case, the sample size for the subshipment lot shall bear the same ratio to the sample size for the shipment lot as the subshipment lot bears to the shipment lot.

4.6.1.5.1.2 Allocation of sample batteries for group D inspection. - The number of batteries, n_s, selected from a shipment lot (see 4.6.1.5.1) shall be assigned at random for group D inspection, as follows:

(a) The quantity of batteries ($2n\ N_s/N$) in the sample of the first shipment lot shall be taken at random and assigned to the capacity tests. The first battery shall be assigned to the T test and the second to the LT test. This shall be repeated until all the batteries have been assigned. This sequence of assignment of sample batteries to the two capacity tests shall be resumed in each succeeding shipment lot at the same point at which it ended in the previous shipment lot.

(b) The assignment of batteries to capacity tests shall result in the allocation of exactly n batteries to each of the two capacity tests after the final shipment on the contract lot is made. If necessary the sample size n_s taken from the last shipment lot of a contract shall be adjusted so that this result is achieved.

Table V Group D Inspection

Storage & Capacity Tests	Requirement Paragraph	Method of Test Paragraph (4.7.6.1 thru 4.7.6.6)
Subgroup I (Adjustment Purposes)		
Capacity T	3.9 & 3.10	4.7.6.1.6
Capacity LT	3.9 & 3.10	4.7.6.1.4
Subgroup II (Gov't Control Purposes)		
Capacity D	3.9 & 3.10	4.7.6.1.7

Table VI Sample Size and Acceptance Number for Each Capacity Test Under Subgroup I of Group D

Contract lot size "N"	Sample size "n" for each Subgroup I Capacity test from contract lot	1/ Acceptance Numbers T and LT Tests
0 to 110	2/ 5	2/ -
111 to 500	15	3
501 to 800	25	5
801 to 1300	35	7
1301 to 3200	50	9
3201 to 8000	75	13
8001 to 22,000	110	18
22,000 to 110,000	150	24
over 110,000	225	34

1/ When the number of capacity values falling below the minimum requirements specified (See 3.1) for a given test is equal or less than the associated acceptance number, the contract lot from which the sample was drawn has met the requirements of that test.

2/ Determination of compliance specified in 4.6.1.5.2 shall not apply to contract lot sizes of less than 111.

4.6.1.5.2 Compliance. - The entire contract lot shall be considered as complying when the T and LT test results show compliance.

4.6.1.5.2.1 Determination of compliance. - To determine whether the contract lot conforms to the specified T and LT requirements, the number of batteries in the sample with capacity values below the minimum capacity value specified in 3.1 for the T and LT test shall be compared with the applicable acceptance numbers for sample sizes n in table VI. When the number for a given test is less than or equal to the corresponding acceptance number, the contract lot complies with the requirements of that test. When the number is greater than the acceptance number, the contract lot does not comply. This comparison shall be made for tests T and LT.

4.6.1.5.2.2 Missing capacity values. - If, for any reason, upon the completion of the T and LT tests, there are fewer than n valid capacity values available for each test for the evaluation of contract lot quality, the missing values shall be set equal to the applicable requirement.

4.6.1.5.3 Noncompliance.

4.6.1.5.3.1 Subgroup I. - If the capacity test results do not show compliance with the requirements as defined in 4.6.1.5.2, the entire contract lot shall be considered as not complying with requirements of this specification and an adjustment shall be made.

4.6.1.5.3.2 Subgroup II. - If the number of failures found during capacity test D exceeds fifteen (15) percent of the number of samples subjected to this test, the contract lot is considered non-conforming, and the conditions of paragraph 6.2 are applicable.

4.6.2 Inspection of preparation for delivery. - Sample items and packs shall be selected and inspected as specified in Specification MIL-P-116 to verify conformance with requirements in Section 5 herein.

4.7 Methods of examination and tests. -

4.7.1 Visual and mechanical examination. - Batteries shall be examined to determine compliance with all applicable requirements and characteristics listed in Table VII.

Table VII Visual and Mechanical Examination

Requirement	Reference Paragraph
External	
Design and construction 1/	3.6
Terminals	3.6.8
Jackets	3.6.10
Age of cells	3.6.7
Insulating, impregnating Potting and sealing compounds	3.6.2
Labeling and marking	3.14
Workmanship	3.15

1/ With exception of dimensions and weight which shall be performed in group B inspection. (See 4.6.1.3)

TABLE VIII Classification of Visual and Mechanical Examination Defects

Categories	Defects
Major	
101	Improper assembly causing parts to be inoperative or unsafe in service.
102	Deformed or damaged parts which are inoperative or malfunction in service.
103	Cell aging requirement not met.
104	Contact surfaces obstructed by insulation materials so that electrical use is affected.
105	Torn nonmetallic jackets - any tear or rip with dimension greater than 1/2 inch.
106	Improper jacket closure.
107	Insulating parts or materials missing, damaged, or improperly located so as to affect electrical performance.
108	Location, polarity and marking of terminals not as specified.
109	Labeling and marking wrong, missing or illegible so that utilization is affected.
110	External and internal threads missing, wrong size or so damaged to prevent proper use.
111	Electrolyte leakage caused by missing or defective sealing or closure.
112	Welded or soldered connections improperly made so as to adversely affect battery performance.
Minor	
201	Improper assembly which could reduce efficiency of operation but not render battery inoperative or unsafe in service.
202	Deformed or damaged parts which do not adversely affect electrical performance.
203	Inferior insulating parts or materials which do not adversely affect electrical performance.
204	Contact surfaces obstructed by insulating materials which will not cause mechanical or electrical failure in service.
205	Burrs or imperfections which do not interfere with proper use in operation, assembly or disassembly, or cause unsafe condition in service.
206	Improper marking which doesn't hamper utilization or identification of the battery.

4.7.1.1.1 Flow or shrinking. - Potting and sealing compounds, when used, shall be placed in a container, approximately 3 inches wide by 6 inches long by 3/4 inch high, to within 1/4 inch of the top. The temperature of the compound within the container shall be raised to 160°F ± 5°F. (71.1° ± 2.8°C.) and the container shall be held in an inverted position for 24 hours. Then the temperature of the compound shall be lowered to 0° ± 5°F. (-17.8° ± 2.80°C). The flow or cracking or shrinking of the compound from the sides of the container shall be noted. If flow is noted at 160° ± 5°F. (71.1° ± 2.8°C) five batteries of type involved shall be exposed to 160° ± 5 F. (71.1° ± 2.8°C) storage for 24 hours with terminals resting in lowest possible position. At the end of this exposure period batteries shall be examined to determine that there is no impairment of electrical contact. (See 3.6.2)

4.7.2 Dielectric strength. - Applicable specimens of material and components shall be conditioned for 48 hours at 160° ± 2°F. (71.1° ± 1.1°C.) and a relative humidity of 50 ± 15 percent, then for 1 hour at 70° ± 5°F. (21.1° ± 2.8°C.) and a relative humidity of 50 ± 15 percent. Each specimen of material shall then be placed between two electrodes in such a manner that the electrodes will make contact with both sides of the specimen being tested. Each electrode shall have a diameter of 2 inches with the edge rounded to a radius of 1/4 inch, so that the contact surface is a circle 1 1/2 inches in diameter. The specimen shall extend at least 1/2 inch beyond the electrode surfaces around the entire circumference of the electrode to prevent flash-over at the edge of the specimen. The specimens of material shall be subjected to a potential of 1,000 volts root mean square, alternating current, at commercial frequency, for a period of 1 minute. The transformer used shall be rated not less than 1/2 kilovolt-ampere and shall be capable of delivering up to 10,000 volts root mean square, 60-cycle alternating current, to the electrodes. The applied voltage shall be increased, starting at zero voltage, at an approximate rate of 500 volts per second.

4.7.3 Jackets. -

4.7.3.1 Metallic jackets. - Metallic jacketed batteries weighing five pounds or more shall be loaded by applying weights totalling 100 pounds evenly distributed over the top of the battery and shall remain so loaded at least one minute. The condition of the jacket shall be observed. (See 3.6.10.1.2)

4.7.3.2 Jacket Integrity. - Batteries shall be immersed to within 1/4 inch of the top of the jacket in water maintained at a temperature of 160° ± 5°F (71.1° ± 2.8°C) for a period of 48 hours. The condition of the jacket and its seams shall be observed. (See 3.6.10.3) Each battery shall then be dried at $160^\circ {+3^\circ F \atop -7^\circ F}$ $\left(71.1^\circ {+1.7^\circ C \atop -3.9^\circ C}\right)$ for 24 hours and tested in accordance with 4.7.6.1.1.

4.7.4 Dimensions and weight. - Batteries shall be examined by gaging or measuring and by weighing to determine conformance.

4.7.4.1 Dimensions. - All dimensions shall include any coating which may be used, and shall remain within the specified tolerances throughout the required tests. When box gages are used, batteries, loaded with the following weights, shall pass freely through the applicable gage openings:

(a) Batteries weighing less than 5 pounds - loading weight of 5 pounds.

(b) Batteries weighing 5 pounds or more - loading weight equal to the weight of the battery.

The inside dimensions of the box gage shall be the specified maximum outside dimensions of the battery.

4.7.5 Battery Voltage. -

4.7.5.1 Open-circuit voltage. - A direct current voltmeter of proper range and sensitivity shall be used to measure the open-circuit voltage.

4.7.5.2 Closed-circuit voltage. - A direct current voltmeter of proper range and sensitivity shall be used to measure the closed circuit voltage utilizing resistance specified. (See 3.1)

4.7.6 Capacity. -

4.7.6.1 Capacity Tests. - Sample batteries selected for capacity tests specified in the individual specification sheet (3.1) shall be stored and discharged as applicable, in accordance with 4.7.6.1.1 through 4.7.6.6. At the beginning of each discharge test the initial voltage shall be determined in accordance with 4.7.6.6.

4.7.6.1.1 Capacity Test I. - Discharge at 70° ± 2°F without previous storage.

4.7.6.1.2 Capacity Test L. - Discharge at -20° ± 3°F after storage at -20° ± 3°F for a minimum of sixteen (16) hours.

4.7.6.1.3 Capacity Test H. - Discharge at 130° ± 3°F after storage at 130° ± 3°F for a minimum of sixteen (16) hours.

4.7.6.1.4 Capacity Test LT. - Discharge at -20° ± 3°F after four (4) weeks storage at 160°F and a minimum of sixteen (16) hours at -20° ± 3°F.

4.7.6.1.5 Capacity Test HT. - Discharge at 130° ± 3°F after four (4) weeks storage at 160°F and a minimum of sixteen (16) hours at 130° ± 3°F.

4.7.6.1.6 Capacity Test T. - Discharge at 70° ± 2°F after thirteen (13) weeks storage at 130°F.

4.7.6.1.7 Capacity Test D. - Discharge at 70° ± 2°F after fifty-two (52) weeks storage at 70°F.

4.7.6.2 Storage conditions. - The storage conditions specified in Table IX shall prevail during storage periods specified. Normal conditions shall be maintained insofar as possible. Deviations from normal conditions are permitted provided that: (1) The extreme conditions specified in Table IX do not exist for more than ten percent (cumulative) of the specified storage periods; and (2) that at no time are the extreme conditions exceeded.

4.7.6.3 Storage. - Sample batteries (packaged per contract) shall be stored at applicable storage conditions for the specified period. (See 3.1) The storage period shall be considered to have started from the date the batteries are actually placed in storage. At the conclusion of the storage period the outside of the battery container shall be examined for corrosion. (See 3.6.10)

4.7.6.4 Stabilization preceding discharge. - Following storage, and conditioning, when applicable, the batteries shall be further stored for 48 hours at ambient discharge conditions . Prior to initiation of discharge, L and LT test samples shall be stored at -20° ± 3°F and H and HT test samples at 130° ± 3°F for a minimum of sixteen (16) hours.

4.7.6.5 Discharge. - Following stabilization the batteries shall be discharged at the ambient discharge conditions as specified. The discharge shall be terminated when any one of the following conditions occur:

(a) The battery voltage or the voltage of any one unit falls below the specified test-end voltage. (For batteries requiring discharge alternately through two resistances, the voltage shall be read during the final minute of the heavier-load period.)

(b) The battery dimensions exceed the maximum specified. (See 3.1)

Table IX Storage Test Conditions

Kind of Storage	Normal Conditions		Extreme Conditions	
	Temperature	Relative Humidity (per cent)	Temperature	Relative Humidity (per cent)
T Storage	130° + 3°F - 4°F (54.4° + 1.7°C) (- 2.2°C)	NA	108°F (42.2°C) thru 126°F (52.2°C) and 133°F (56.1°C) thru 135°F (57.2°C)	NA
D Storage	70° ± 5°F (21.1° ± 2.8°C)	50 ± 20	60°F (15.6°C) thru 65°F (18.3°C) and 75°F (23.9°C) thru 80°F (26.7°C)	10 thru 30 and 70 thru 90
HT and LT Storage	160° + 3°F - 7°F (71.1° + 1.7°C) (- 3.9°C)	NA	140°F (60°C) thru 153°F (67.2°C) and 163°F (72.8°C) thru 165°F (73.9°C)	NA

4.7.6.6 Initial voltage delay. - At the start of the capacity discharge test, batteries shall be monitored with an oscillograph to determine the time in fractions of a second required for battery units to reach minimum voltage after the specified loads are applied as stipulated in the individual specification sheet. (3.1)

4.7.7 Insulation resistance. - Insulation-resistance test shall be performed, except as otherwise specified. (See 3.1) Batteries shall be stored for a period of 48 hours at 70° ± 5°F. (21.1° ± 2.8°C.) and a relative humidity of 50 ± 15 percent. After storage and while at these conditions, the insulation resistance shall be measured by applying a direct-current potential of 500 ± 20 volts between any two terminals not electrically connected and between all ungrounded terminals and the container of the battery. The insulation resistance of batteries having a nonmetallic container shall be measured by the use of a 1 inch-square copper plate making physical contact with the container. The plate shall be placed with the broad surface against any area of any surface of the jacket other than that on which the battery terminals are located.

4.7.8 Vibration. - Only multi-cell batteries shall be subjected to vibration. Each battery shall be rigidly clamped to the platform of a vibration machine in a manner approximating as closely as practicable the manner in which the batteries are clamped when in use. (See 3.1) A simple harmonic motion shall be applied having an amplitude of 0.03 inch (0.06 - inch total maximum excursion). The frequency shall be varied at the rate of 1 cycle per second per minute between the limits of 10 and 55 cycles per second. The entire range of frequencies and return shall be traversed in 95 ± 5 minutes for each mounting position, (direction of vibration) of the battery. The batteries shall be vibrated in three equal periods in mutually perpendicular directions, one of which shall be perpendicular to the terminal face of the battery. Open-circuit voltage shall be observed for 30 seconds during the last quarter of each of the three vibration periods.

4.7.9 Mechanical shock. - Only multi-cell batteries shall be subjected to mechanical shock. Each battery shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of the battery. Each battery shall be subjected to a total of three shocks of equal magnitude. The shocks shall be applied in each of three mutually perpendicular directions. Each shock shall be applied in a direction normal to a face of the battery. The faces of the battery are identified by their position in relation to the front face (the face which bears the label.) For each shock, the battery shall be accelerated in such a manner that during the first 3 milliseconds the minimum average acceleration is 75 gravity units (G). The peak acceleration shall be between 125 to 175 G.

4.7.10 Safety feature. - Each sample battery shall be subjected to a direct short, i.e., less than 0.1 ohm, until the circuit is broken by the safety feature. The maximum current and time required to activate the safety feature shall be determined and recorded. Following the direct shorting all batteries shall be placed in a temperature of $1000 {}^{+100}_{-0}$ °F for a period of 15 minutes during which period of time no explosion shall occur. During exposure to the 1000°F test a battery fire is permissible providing all other conditions of the test have been met.

4.7.11 Altitude. - Batteries shall be placed in an altitude chamber, in which the pressure is maintained at a value corresponding to an altitude of 50,000 feet and the temperature is kept at 75 ± 5°F, for a period of six (6) hours.

5. PREPARATION FOR DELIVERY. -

5.1 Preservation and packaging. - Preservation and packaging shall be level A or C as specified. (See 6.1(d))

5.1.1 Level A. -

5.1.1.1 Cleaning. - Each battery shall be cleaned in accordance with process C-1 of MIL-P-116.

5.1.1.2 Drying. - Each battery shall be dried with applicable procedure of MIL-P-116.

5.1.1.3 Preservation application. - None required.

5.1.1.4 Unit packaging. - Each battery shall be individually packaged in accordance with Method 1C-2 of MIL-P-116. Each battery shall be placed in a close-fitting box conforming to MIL-B-43014, Form 1, Style II, Type A, Class A. Box closure shall be in accordance with the appendix of the box specification. Place each boxed battery in a bag, fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils. The bag closure shall be by heat seal.

5.1.1.4.1 Intermediate packaging. - When specified a quantity of batteries, bearing the same stock number, packaged as specified in 5.1.1.4, shall be placed in close fitting box conforming to MIL-B-43014, Form 1, Style II, Type A, Class A, not to exceed the weight limitation of 20 pounds. Box closure shall be in accordance with the appendix of the box specification.

5.1.2 Level C. - Batteries shall be preserved and packaged in a manner that will afford adequate protection against physical and environmental damage during shipment, handling and limited intransit storage.

5.2 Packing. - Packing shall be level A, B, or C as specified. Shipping containers for all levels shall be capable of stacking and supporting superimposed loads during shipment and storage without damaging the container(s) or its contents.

5.2.1 Level A. -

5.2.1.1 Consolidation. - A quantity of batteries, packaged as specified in 5.1, shall be packed with a close-fitting fiberboard box conforming to PPP-B-636, type CF, class weather-resistant. Box closure shall be as specified in the appendix of the box specification. To facilitate palletization, fiberboard boxes shall be uniform in size and contain equal quantities of the packaged items to the greatest extent practicable.

5.2.1.2 Palletized load. - A quantity of containers, packed as specified in 5.2.1.1, shall be placed on a pallet, load type 1, conforming to MIL-STD-147. A fiberboard cap shall be employed over the load having two sides extending down the stacked load at least 12 inches to accommodate marking requirements. The cap shall be fabricated of fiberboard conforming to PPP-F-320, class weather-resistant, W5s, or V3c. The load shall be "bonded" to the pallet by strapping.

5.2.1.3 Less than palletized load. - When quantities per destination are less than a pallet load, the containers packed as specified in 5.2.1.1 shall be waterproofed, with tape conforming to PPP-T-76, in accordance with the taping requirements of the appendix of the box specification. A quantity of the waterproofed containers shall be placed within a close-fitting box conforming to PPP-B-585, style 2 or 3, class 3. When the gross weight exceeds 200 pounds, or the container length and width is 48 x 24 inches or more and the weight exceeds 100 pounds, 3 x 4 inch skids, laid flat, shall be applied in accordance with the requirements of the container specification, or if not specified in the specification, in a manner which will adequately support the item and facilitate the use of material handling equipment. Closure and strapping shall be in accordance with the applicable container specification or appendix thereto except that metal strapping shall conform to QQ-S-781, type 1, class B.

5.2.2 Level B.-

5.2.2.1 Consolidation. - A quantity of batteries, packaged as specified in 5.1, shall be packed as specified in 5.2.1.1.

5.2.2.2 Palletized load. - A quantity of containers, packed as specified in 5.2.2.1, shall be palletized as specified in 5.2.1.2.

5.2.2.3 Less than palletized load. - When quantities per destination are less than a pallet load, the containers packed as specified in 5.2.2.1 shall be reinforced by pressure-sensitive filament tape conforming to PPP-T-97, type IV as specified in the appendix of the box specification. No further packing shall be required.

5.2.3 Level C. -

5.2.3.1 Consolidation. - A quantity of batteries, packaged as specified in 5.1, shall be packed as specified in 5.2.1.1, except that the fiberboard boxes shall be class domestic.

5.2.3.2 Palletized load. - A quantity of containers, packed as specified in 5.2.3.1, shall be palletized as specified in 5.2.1.2, except that fiberboard cap shall be class domestic.

5.2.3.3 Less than palletized load. - When quantities per destination are less than a pallet load, the containers packed as specified in 5.2.3.1 shall be used as the shipping container. No further packing shall be required.

5.3 Marking. - In addition to any special marking required by the contract or order, interior shipping containers shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Ordering data. - Contractual documents should specify the following:

(a) Title, number, and date of this specification.

(b) Complete battery type designation and the title, number and date of the applicable specification sheet (See 1.2.1 and 3.1).

(c) Date for notice of availability for shipment.

(d) Applicable levels of preservation, packaging and packing, and applicable battery quantities.

(e) Name and address of responsible Government technical activity concerned with First Article Inspection.

(f) Name and address of Government inspection facility performing Group D inspection.

6.1.1 Indirect shipments. - The packaging, packing and marking specified in section 5 apply only to direct purchases by or direct shipment to the Government and are not intended to apply to contracts or orders between the supplier and prime contractor.

6.2 Awarding of contract. - Contracts will be awarded only to suppliers who guarantee to meet the requirements of this specification. No combining of performance requirements should be undertaken. Bids that offer to guarantee higher capacities will receive no special consideration in awarding a contract. Contracts will be awarded to the lowest bidder on a cost-per-unit battery basis provided that all performance requirements are guaranteed. Failure on a prior contract, of a manufacturer's particular battery type to meet any of the performance requirements of this specification, will be adequate cause for rejection of bids on that particular type until the supplier submits certified data proving that --

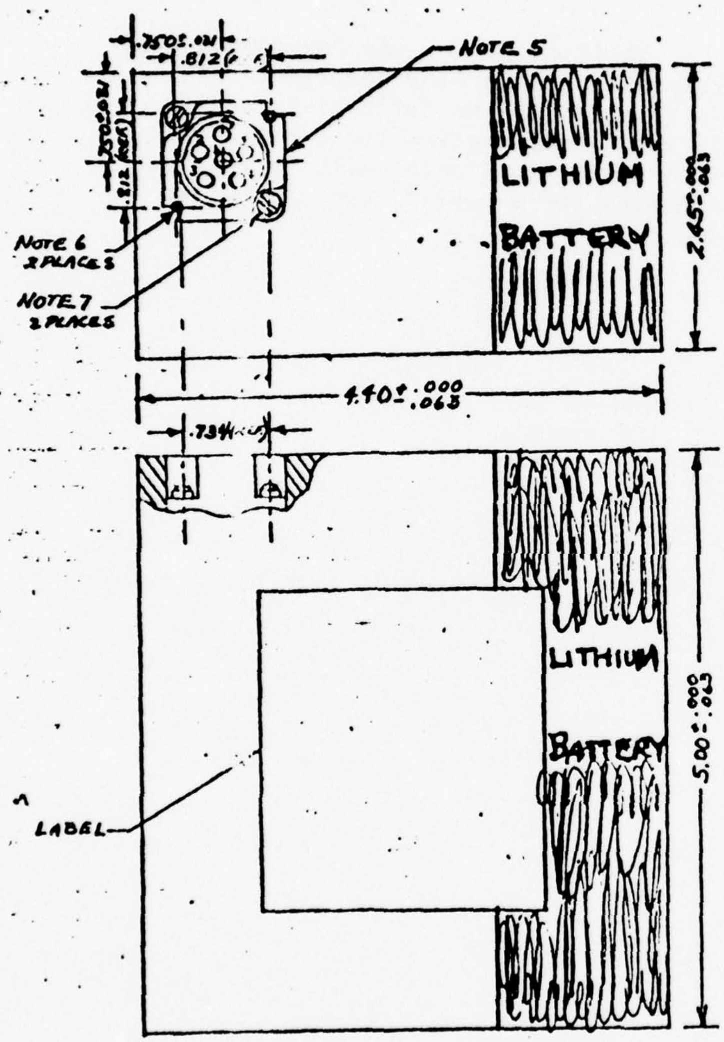
(a) Action has been taken to eliminate the cause of failures; and
(b) The battery meets all the performance requirements of this specification.

6.3 <u>Verification Inspection</u>. - Verification by the Government will be limited to the amount deemed necessary to determine compliance with the contract and will be limited in severity to the definitive quality assurance provisions established in this specification and the contract. The amount of verification inspection by the Government will be adjusted to make maximum utilization of the contractor's quality control system and the quality history of the product.

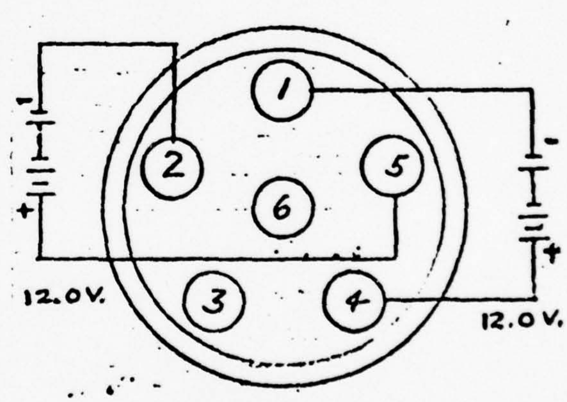
SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5590/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



INCHES	MM
0.031	0.79
0.063	1.60
0.750	19.05
0.812	20.62
2.45	62.23
4.40	111.76
5.00	127.00



SOCKET WIRING SCHEMATIC

FIGURE

Battery, Primary, Lithium Organic BA-5590/U

NOTES:

1. All dimensions are in inches.

2. The battery outer jacket shall be waterproof paperboard. An alternate packaging can be of polyurethane foam or similar lightweight potting with surfaces treated to meet the jacket integrity test.

3. Socket wiring schematic to be printed on jacket in suitable location near the socket on the terminal face of the battery.

4. Top of the connector socket is to be mounted flush with the top surface of the battery case.

5. The battery terminal shall consist of a miniature circular battery connector per Drawing ES-C-211488, Rev. B. Connector shall be mounted in accordance with referenced drawing.

6. Connector socket body configuration shall accept two (2) each 0.156 inch diameter guideposts as shown. Depth of cavity shall be 0.622 inch.

7. Two (2) each battery connector mounting screws: Size #4-40 UNC-2A.

REQUIREMENTS:

Dimensions and configuration: See Figure

Nominal Voltage: 24 volts
(Consisting of two (2) each identical 12 volt sections)

Terminals: Six (6) hole socket type with no obstruction of any holes (See Figure)

Weight:(maximum): 2.25 pounds

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS 459)	Service Requirement in hours
I	48
L	24
H	42
HT	38
LT	21
T	28
D	28

Voltage delay: During the initial one minute of discharge of the two (2) 12 volt sections connected in series for any of the discharge tests covered by this specification, transient voltages below the 20.0 volt end voltage cannot exceed a 0.1 second duration. Subsequently, during the course of any discharge test, anytime the voltage falls below 20.0 volts that point in time will be considered to be the end of service and the test will be considered to be terminated.

First article inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

Visual-mechanical examination
Battery voltage
Dimension and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery consisting of two (2) 12 volt sections connected in series shall be discharged through a 39.0 ohm resistance for 1 minute *, and then through a 560 ohm resistance for 9 minutes **. This cycle shall be repeated continuously to a test end voltage of 20.0 volts.

* An 8 ohm resistance pulse shall be applied during the first 100 milliseconds of each 1 minute load discharge. The pulse voltage shall be monitored continuously throughout the duration of discharge.

** The voltage shall be monitored during the last minute of each 9 minute load discharge for the "H" and "HT" tests only to determine whether the maximum voltage of 32.0 volts is exceeded.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 14.0 ohms and a minimum permissible voltage of 11.0 volts. Readings shall be taken between socket holes and 5 and between socket holes 1 and 4. See socket wiring schematic on the battery.

Cell lot Inspection:

1. Cell Lot. - A cell lot shall consist of 2990 cells of a particular type which are to be used in the fabrication of a specific battery lot. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. - All the cells in a cell lot shall be pulse tested for five (5) seconds with a 2.5 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. - From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at pre-selected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at 160°F $^{+3°F}_{-7°F}$ for two (2) weeks and then at -20° ±3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot of 2990 cells shall be submitted for cell lot inspection.

4. Cell replenishment. - In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of one battery individually packaged per method IC-1 of MIL-P-116. Battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type I, grade B, finish 1, having a uniform thickness of 4.0±0.5 mils with a heat sealed closure. The bagged battery shall be placed in a close-fitting paperboard box conforming to PPP-B-566, variety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

NOTES:

1. All dimensions are in inches.

2. The battery outer jacket shall be waterproof paperboard. An alternate packaging can be of polyurethane foam or similar lightweight potting with surfaces treated to meet the jacket integrity test.

3. Socket wiring schematic to be printed on jacket in suitable location near the socket on the terminal face of the battery.

4. Top of the connector socket is to be mounted flush with the top surface of the battery case.

5. The battery terminal shall consist of a miniature circular battery connector per Drawing ES-C-211488, Rev. B. Connector shall be mounted in accordance with referenced drawing.

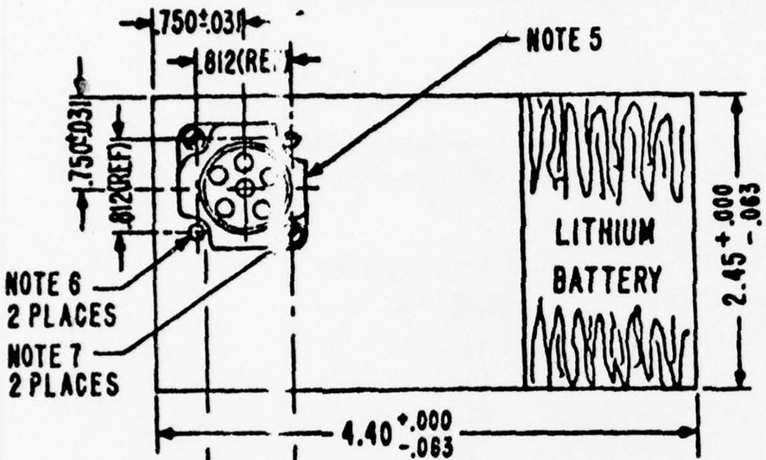
6. Connector socket body configuration shall accept two (2) each 0.156 inch diameter guideposts as shown. Depth of cavity shall be 0.622 inch.

7. Two (2) each battery connector mounting screws: Size #4-40 UNC-2A.

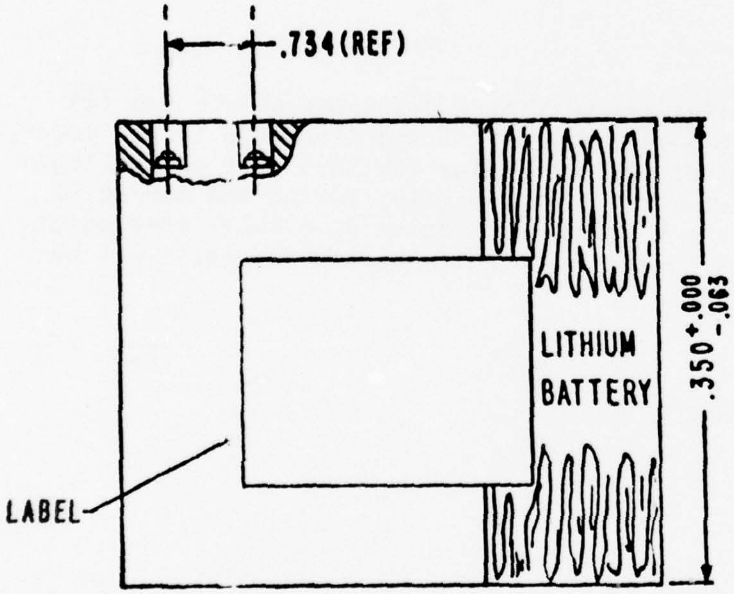
SPECIFICATION SHEET

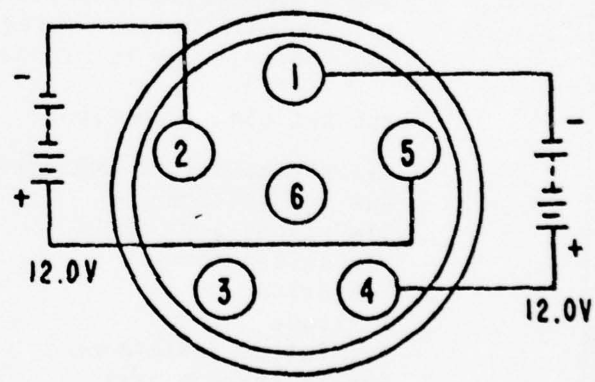
BATTERY, PRIMARY, LITHIUM ORGANIC BA-5585/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



INCHES	MM
0.031	0.79
0.063	1.60
0.750	19.05
0.812	20.62
2.45	62.23
4.40	111.76
3.50	88.9





SOCKET WIRING SCHEMATIC

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5585/U

REQUIREMENTS:

Dimensions and configuration: See Figure

Nominal Voltage: 24 volts
(Consisting of two (2) each identical 12 volt sections)

Terminals: Six (6) hole socket type with no obstruction of any holes (See Figure)

Weight:(maximum): 1.75 pounds

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS 459)	Service Requirement in hours
I	24
L	12
H	21
HT	19
LT	10
T	14
D	14

Voltage delay: During the initial one minute of discharge of the two (2) 12 volt sections connected in series for any of the discharge tests covered by this specification, transient voltages below the 20.0 volt end voltage cannot exceed a 0.1 second duration. Subsequently, during the course of any discharge test, anytime the voltage falls below 20.0 volts that point in time will be considered to be the end of service and the test will be considered to be terminated.

First article inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery consisting of two (2) 12 volt sections connected in series shall be discharged through a 39.0 ohm resistance for 1 minute *, and then through a 560 ohm resistance for 9 minutes **. This cycle shall be repeated continuously to a test end voltage of 20.0 volts.

* An 8 ohm resistance pulse shall be applied during the first 100 milliseconds of each 1 minute load discharge. The pulse voltage shall be monitored continuously throughout the duration of discharge.

** The voltage shall be monitored during the last minute of each 9 minute load discharge for the "H" and "HT" tests only to determine whether the maximum voltage of 32.0 volts is exceeded.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 14.0 ohms and a minimum permissible voltage of 11.0 volts. Readings shall be taken between socket holes 2 and 5 and between socket holes 1 and 4. See socket wiring schematic on the battery.

Cell Lot Inspection:

1. Cell lot. - A cell lot shall consist of 2990 cells of a particular type which are to be used in the fabrication of a specific battery lot. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. - All the cells in a cell lot shall be pulse tested for five (5) seconds with a 2.5 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. - From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government Inspector deems more desirable. The thirty (30) cells shall be stored at 160° $^{+3°F}_{-7°F}$ for two (2) weeks and then at -20° ±3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot of 2990 cells shall be submitted for cell lot inspection.

4. Cell replenishment. - In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

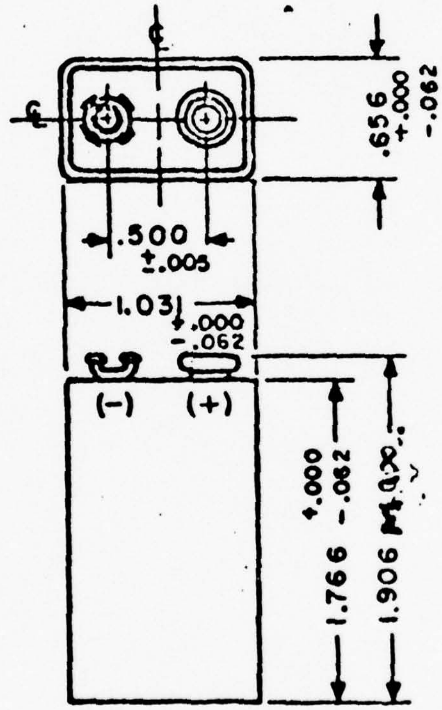
Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of one battery individually packaged per method IC-1 of MIL-P-116. Battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0±0.5 mils with a heat sealed closure. The bagged battery shall be placed in a close-fitting paperboard box conforming to PPP-B-566, variety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5090/U

<u>The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.</u>



FIGURE

Battery, Primary, Lithium Organic BA-5090/U

NOTES:

1. All dimensions are in inches.

2. The maximum radius on all corners shall be 1/8 inch.

3. The battery case material shall be cold rolled steel.

4. The battery connectors shall be mounted in accordance with the figure and shall be miniature snap-on type terminal ANSI XVII.

REQUIREMENTS:

Dimensions and configuration: See Figure

Maximum Voltage: 9 volts

Terminals: Snap on type (see figure)

Weight (maximum): 1.8 ounces (50 grams)

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS 459)	Service Requirement in hours
I	55
L	30
H	50
HT	46
LT	26
T	48
D	48

Voltage delay: During the initial one minute of discharge of the battery discharge tests covered by this specification, transient voltages below the 6.0 volt end voltage cannot exceed a 1 second duration. Subsequently, during the course of any discharge test, anytime the voltage falls below 6 volts that point in time will be considered to be the end of service and the test will be considered to be terminated.

First article inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical Shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery shall be discharged through a 636 ohm resistance to a test end voltage of 6.0 volts.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 60 ohms and a minimum permissible voltage of 6.0 volts.

Cell Lot Inspection:

1. Cell Lot. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 20 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at $160°F {}^{+3°F}_{-7°F}$ for two (2) weeks and then at -20° ± 3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

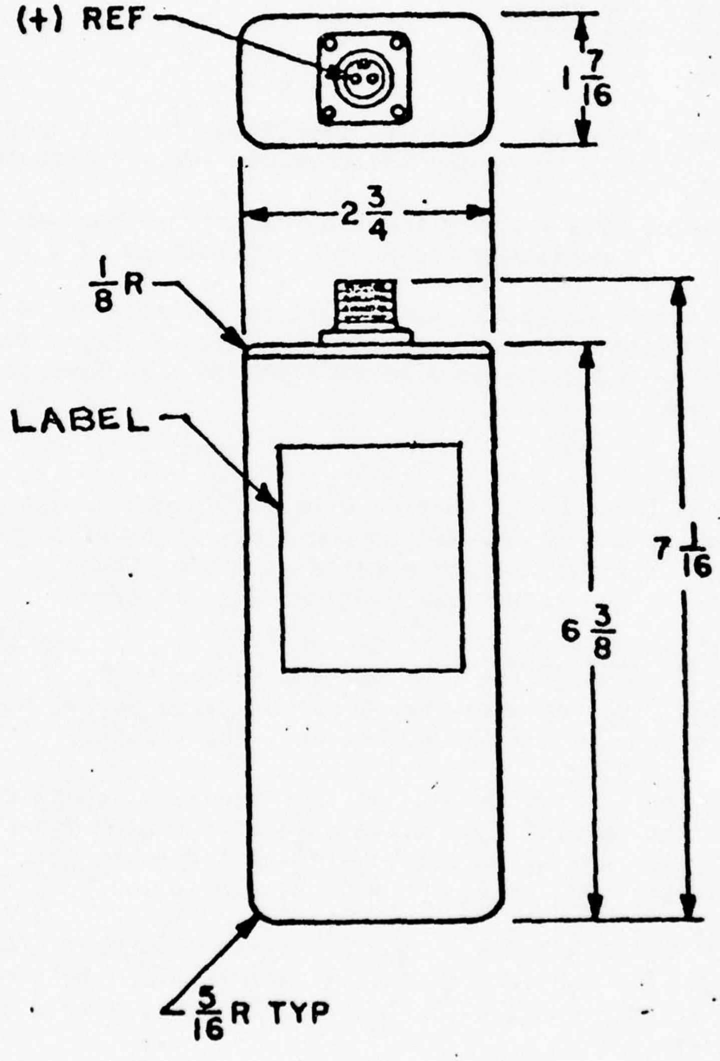
a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

SCS-459/5
20 November 1974

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5842/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



FIGURE

Battery, Primary, Lithium Organic BA-5842/U

Sheet 1 of 4

NOTES:

1. All dimensions are in inches. Unless otherwise specified, tolerances are ± 1/16".

2. Connector type; MS3102A10SL4P, manufactured by Bendix.

3. Battery shall be potted with an epoxy compound capable of withstanding temperatures from -65°C to 75°C, without deforming.

REQUIREMENTS:

Dimensions and configuration: See Figure

Maximum Voltage: 6 volts

Terminals: (See Figure)

Weight (mazimum): 20.0 ounces (568 grams)

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS-459)	Service Requirement in hours
I	48
L	24
H	42
HT	40
LT	23
T	43
D	43

Voltage delay: When the battery is subjected to the capacity tests covered by this specification, initial closed-circuit voltages below the 4.0 volt end voltage cannot exceed a 1.0 second duration.

First article inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery shall be discharged at 350 mA continuously to a test end voltage of 4.0 volts.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 11 ohms and a minimum permissible voltage of 4.0 volts.

Cell Lot Inspection:

1. Cell Lot. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed circuit voltage test. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 2.5 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at $160^{\circ}\ {}^{+3^{\circ}F}_{-7^{\circ}F}$ for two (2)

weeks and then at -20°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same lot test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot shall be submitted for cell lot inspection.

4. Cell replenishment. In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

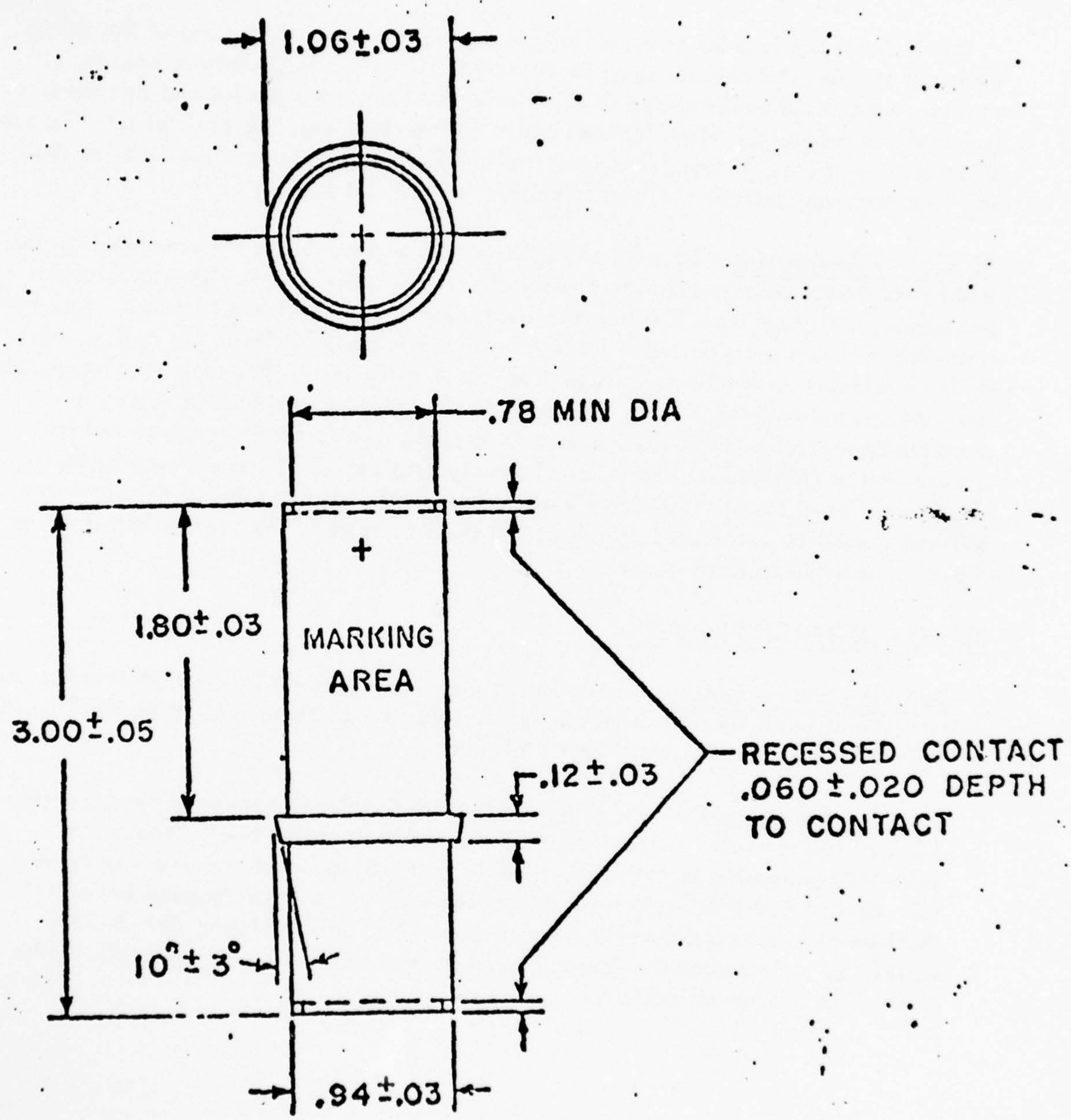
Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of one battery individually packaged per Method IC-1 of MIL-P-116. Battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils with a heat sealed closure. The bagged battery shall be placed in a close-fitting paperboard box conforming to PPP-B-566, variety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5568/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



FIGURE

Battery, Primary, Lithium Organic BA-5568/U

NOTES

1. All dimensions and tolerances shown on figure are in inches.

2. Only the positive (+) marking is required to be shown at the top of the battery jacket.

3. The marking "INSERT THIS END" is required to be shown on the battery jacket at the positive end, 180° from the SCS-459 marking area, with an arrow pointing in the direction of insertion.

4. The battery jacket shall be Hi-Impact ABS plastic or equal, and the color shall be olive drab No. 24087 of FED-STD-595.

REQUIREMENTS:

Dimensions and configuration: See Figure

Maximum voltage: 12.0 volts

Terminals: Flat surface (See Figure)

Weight (maximum): 3 ounces (85 grams)

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity-test requirements shall be as specified below.

Capacity Test (per SCS-459)	Service Requirement in Hours
I	17
L	9
H	15
HT	14
LT	8
T	15
D	15

Voltage delay: When the battery is subjected to the capacity tests specified herein, the time required at the beginning of discharge for the battery to reach a voltage of 9.0 volts after the specified load is applied shall not be more than 1.0 second.

Drop test: When the battery is tested in accordance with this specification, the socket shall not move beyond the limits specified herein nor shall the components shift within the jacket, or preclude the battery from meeting specified "I" capacity test performed at the conclusion of the jacket integrity test.

First Article Inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Drop test
- Jacket integrity
- Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Drop test
- Jacket integrity
- Capacity tests

METHODS OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all capacity tests are specified in basic specification.

(2) Discharge: The battery shall be discharged through a resistance of 250 ohms to a test end voltage of 9.0 volts.

Closed circuit voltage: Closed circuit voltage measurements shall be observed for a period of 30 seconds with a direct current voltmeter of proper range and sensitivity (see basic specification), using load resistances of 50 ohms and a minimum permissible voltage of 10 volts.

Drop test: When performed during First Article Inspection, five (5) each Group 111B test samples shall be subjected to this drop test just prior to performing the jacket integrity test on them. When performed during Quality Conformance Inspection, five (5) each subgroup B_2 test samples just prior to being subjected to integrity test shall have this drop test performed upon them. Each battery shall be dropped three times from a height of 36±2 inches onto a hard surface consisting of concrete or steel, and shall make contact with it. Each battery shall be dropped in such a manner that the battery, at time of release, shall be in each of three different positions in relation to the surface upon which it is dropped in the following manner:

(1) The three (3) inch side of the battery shall be parallel to this surface upon release and shall make contact with it.

(2) The three (3) inch side of the battery shall be perpendicular to this surface upon release so that the positive terminal shall make contact with it.

(3) The three (3) inch side of the battery shall be perpendicular to this surface upon release, so that the negative terminal shall make contact with it.

If any failure occurs, the contractor shall take immediate action to correct the defect and eliminate the cause. However, pending this action, quality conformance acceptance shall be withheld. When the nature of the failure has been determined, and the necessary corrective action taken, the rejected lot and all batteries in process at the time of the failure shall be reworked to eliminate the defect. Reworked lots shall be reinspected using a sample size of eight (8) batteries with no failures permitted.

Cell Lot Inspection:

1. Cell Lot. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 10 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at 160° +3°F for two (2) weeks and then at -20°F ±3°F for a minimum of six (6) hours. Each {-7°F} cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capicity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot shall be submitted for cell lot inspection.

4. Cell replenishment. In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of ten (10) batteries each individually packaged per Method IC-1 of MIL-B-116. Each battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils with a heat sealed closure. The bagged batteries shall be placed in a close-fitting paperboard box conforming to PPP-B-636, type CF, W6c, or W5c, style optional or MIL-B-43014. Closure shall be as specified in the appendix to the applicable box specification.

ELECTRONICS COMMAND
TECHNICAL REQUIREMENTS

SCS-459/6
Amendment 1
25 July 1975

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5568/U

This amendment forms part of Electronics Command Technical Requirements Specification Sheet SCS 459/6 , 20 November 1974.

Page 2

Maximum Voltage. Delete 12.0 volts and substitute 15.0 volts.

Service Requirement in Hours

Delete	Substitute
17	12
9	7
15	10
14	9
8	6
15	10
15	10

Page 3

Discharge: Delete 250 ohms and substitute 150 ohms; delete 9.0 volts and substitute 10.0 volts.

SCS-459/7
20 November 1974

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5574/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.

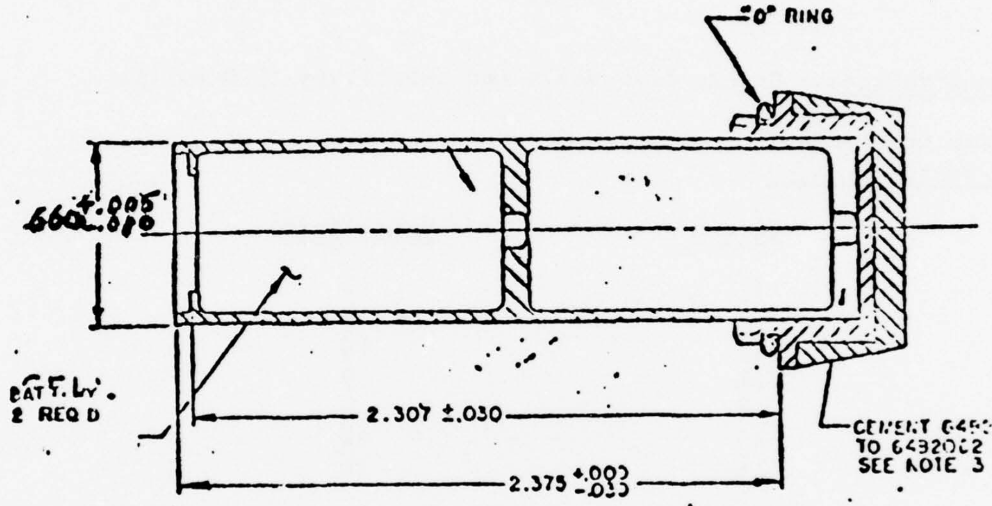


FIGURE 1

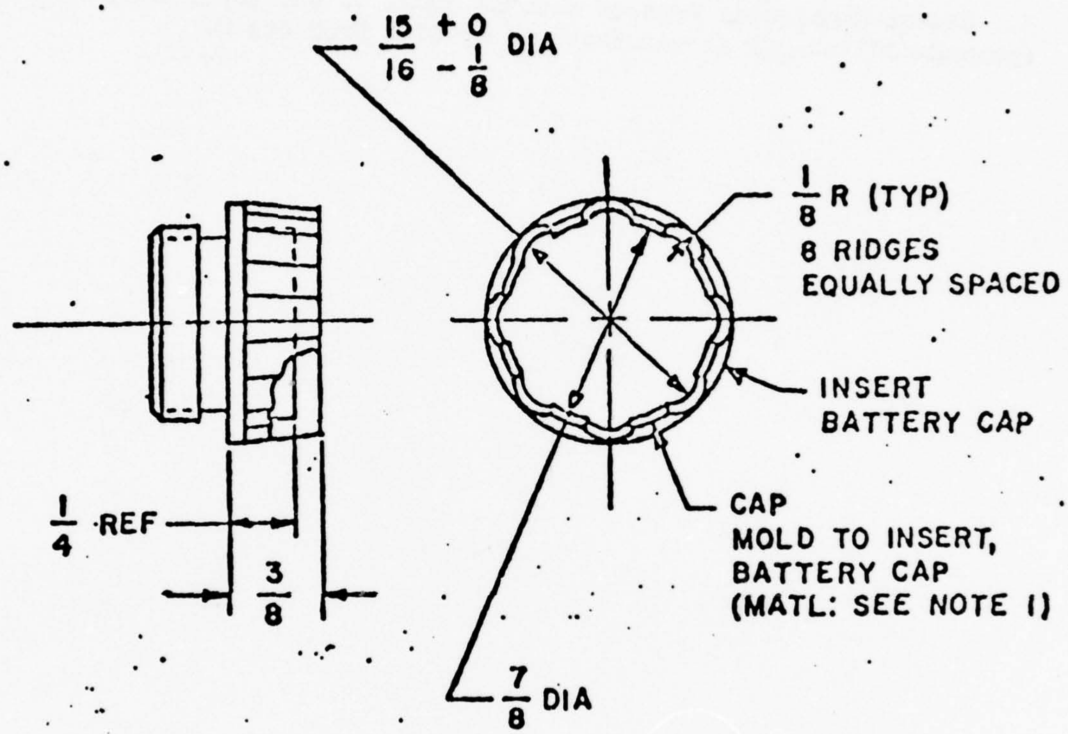
Battery, Primary, Lithium Organic BA-5574/U

NOTES: (Fig. 1)

1. All dimensions are in inches.

2. Fill end of sleeve with silicone rubber. Commercial product must be equal to and interchangeable with silicone rubber sealant Type RTV-102 as manufactured by Silicone Products Dept. General Electric Co. Waterford, NY.

3. Cement-Commercial Product must be equal to and interchangeable with epoxy-Araldites-502 as manufactured by Ciba Products Co.

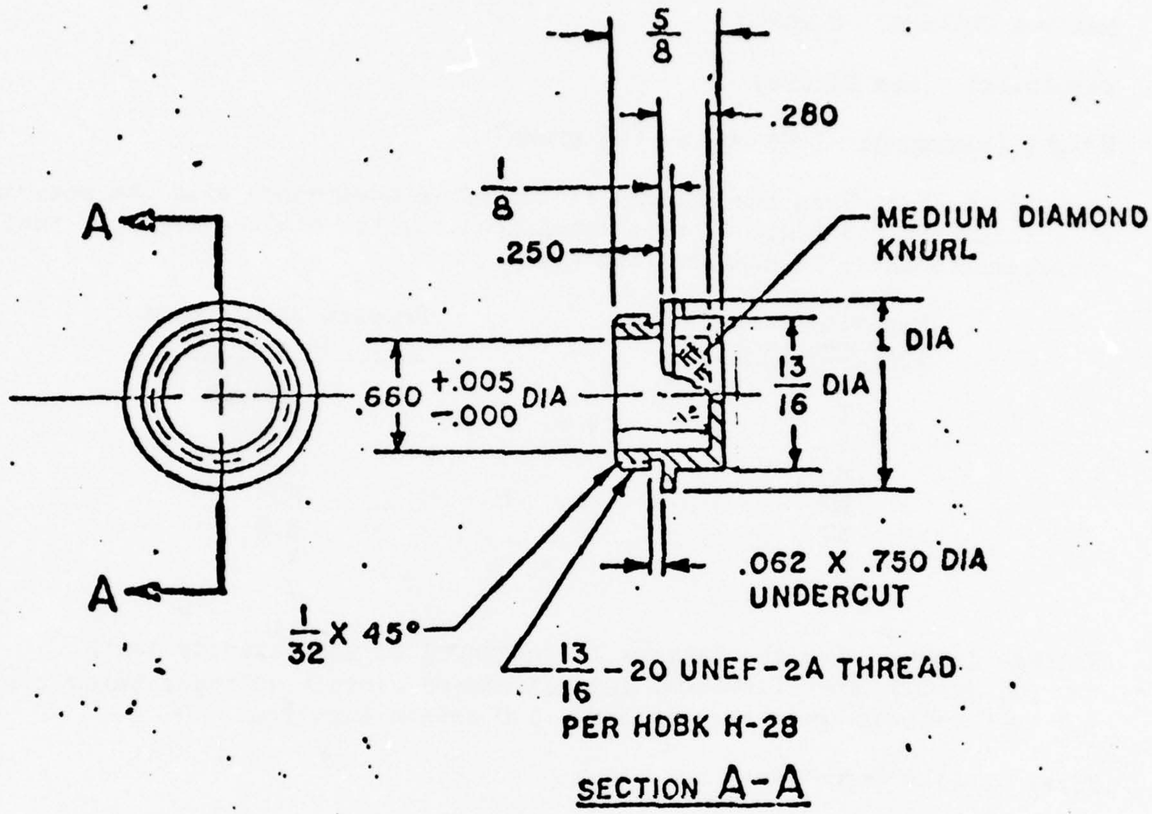


NOTES:

1. MATL: CELLULOSE ACETATE BUTYRATE, GRADE H3, PER SPEC L-P-349.
2. DIMENSIONS ARE IN INCHES.
3. TOLERANCE ON FRACTIONS ± 1/32.
4. O-RING MS29561-5 IS TO BE FURNISHED WITH EACH CAP.

CAP

FIG. 2



NOTES:

1. DIMENSIONS ARE IN INCHES.
2. TOLERANCES (UNLESS OTHERWISE SPECIFIED):

FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	± 3°

INSERT BATTERY CAP

FIG. 3

REQUIREMENTS:

Dimensions and configuration: See Figures

Maximum Voltage: 6 volts

Terminals: (See Figure)

Weight (maximum): 1.65 ounces (46 grams)

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS-459)	Service Requirement in hours
I	8
L	4
H	7.5
HT	6.5
LT	3.5
T	7
D	7

Voltage delay: When the battery is subjected to the capacity tests covered by this specification, initial closed-circuit voltages below the 4.0 volt end voltage cannot exceed a 1.0 second duration.

First article inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery shall be discharged through a 47 ohm resistance to a test end voltage of 4.0 volts.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 40 ohms and a minimum permissible voltage of 4.0 volts.

Cell Lot Inspection:

1. Cell Lot. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 2.0 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at $160° {}^{+3°F}_{-7°F}$ for two (2) weeks and then at -20°F ±3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot shall be submitted for cell lot inspection.

4. Cell replenishment. In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

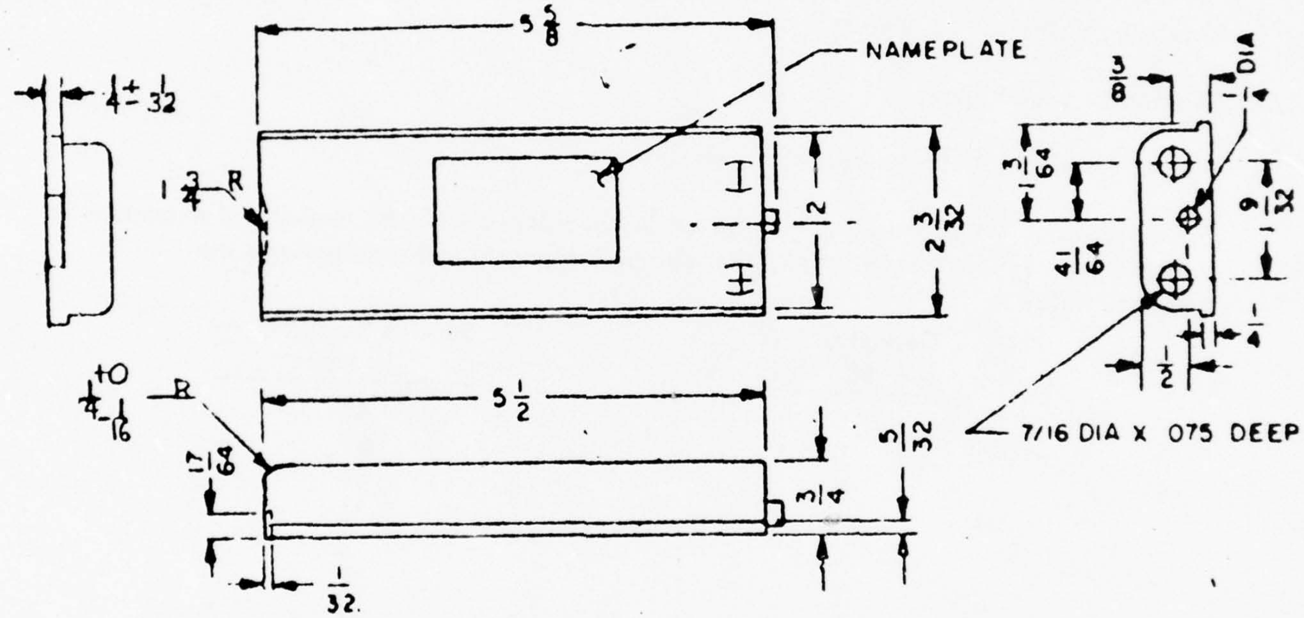
A unit package shall consist of ten (10) batteries each individually packaged per Method 1C-1 of MIL-B-116. Each battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1 grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils with a heat sealed closure. The bagged batteries shall be placed in a close-fitting paperboard box conforming to PPP-B-566, vqriety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

SCS-459/8
20 November 1974

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5841/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



FIGURE

Battery, Primary, Lithium Organic BA-5841/U

NOTES:

1. All dimensions are in inches. Unless otherwise specified, tolerances are ± 1/64".

2. Terminals shall be covered with silicone rubber. Commercial product must be equal to and interchangeable with silicone rubber sealant Type RTV-102 as manufactured by Silicone Products Dept., General Electric Co., Waterford, NY. Terminal markings (+ and -) shall be placed on battery as indicated in figure.

3. Battery shall be potted with an epoxy compound capable of withstanding temperatures from -65°C to 75°C, without deforming.

REQUIREMENTS:

Dimensions and configuration: See Figure

Maximum Voltage: 18.0 volts

Terminals: (See Figure)

Weight (maximum): 10 ounces (284 grams)

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS-459)	Service Requirement in hours
I	44
L	22
H	41
HT	36
LT	23
T	39
D	39

Voltage delay: When the battery is subjected to the capacity tests covered by this specification, initial closed-circuit voltage below the 10.8 volts end voltage cannot exceed a 1.0 second duration.

First article inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

Visual-mechanical examination
Battery voltage
Dimensions and weight
Mechanical shock
Vibration
Altitude
Insulation resistance
Safety feature test
Jacket integrity test
Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery shall be discharged through a 210 ohm resistance to a test end voltage of 10.8 volts.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 24 ohms and a minimum permissible voltage of 12.0 volts.

Cell Lot Inspection:

1. Cell lot. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 8.0 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at $160° {}^{+3°F}_{-7°F}$ for two (2)

weeks and then at -20° ±3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cellssamples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot shall be submitted for cell lot inspection.

4. Cell replenishment. In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of five (5) batteries each individually packaged per Method 1C-1 of MIL-P-116. Each battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils with a heat sealed closure. The bagged batteries shall be placed in a close-fitting paperboard box conforming to PPP-B-566, variety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

ELECTRONICS COMMAND
TECHNICAL REQUIREMENTS

SCS-459/8
Amendment 1
25 July 1975

SPECIFICATION SHEET

BATTERY, PRIMARY LITHIUM ORGANIC BA-5841/U

This amendment forms part of Electronics Command Technical Requirements Specification Sheet SCS 459/8 , 20 November 1974.

Page 2

Service Requirement in Hours

Delete	Substitute
44	15
22	8
41	13
36	12
23	7
39	13
39	13

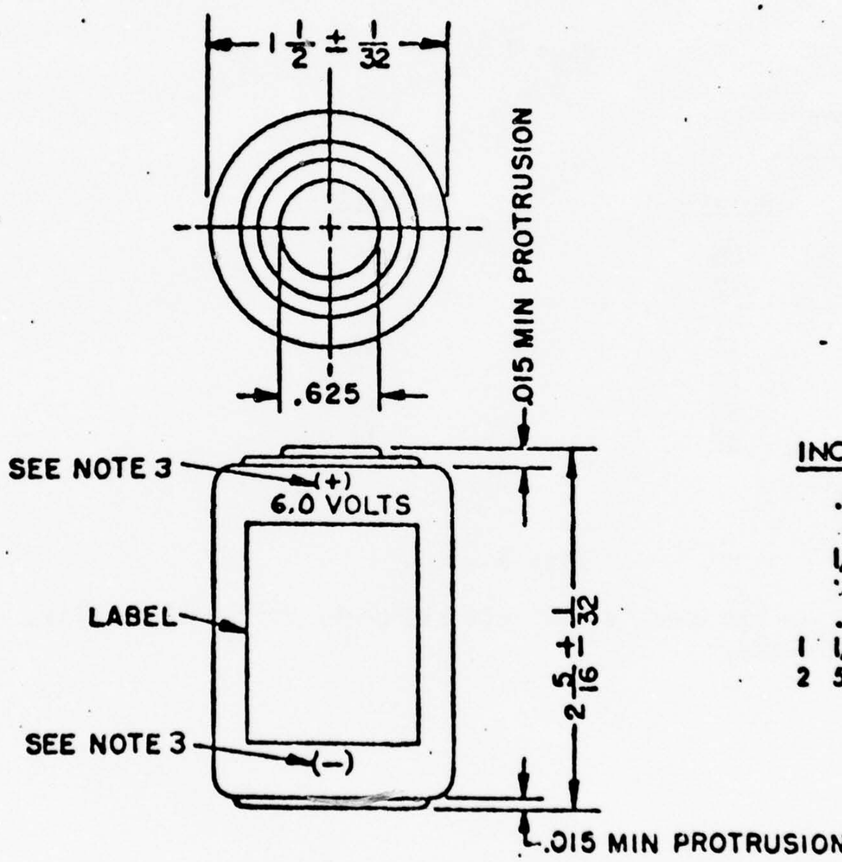
Page 3

Discharge: Delete 210 ohms, stbstitute 135 ohms; delete 10.8 volts, substitute 13.2 volts.

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5100/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



INCHES	MM
.015	0.38
[illegible]	[illegible]
1/32	0.79
[illegible]	[illegible]
.625	15.88
1 1/2	38.10
2 5/16	58.74

FIGURE

Battery, Primary, Lithium Organic BA-5100/U

NOTES:

1. All dimensions shown on figure are in inches. Unless otherwise specified, decimal tolerances are ± .015".

2. The battery case material shall be cold rolled steel.

3. Polarity markings shall be placed on label or top and bottom.

REQUIREMENTS:

Dimensions and configuration: See Figure

Maximum voltage: 6.0 volts

Terminals: Flat surface (See Figure)

Weight (maximum): 3 ounces (85 grams)

Capacity tests: When battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS-459)	Service Requirement in hours
I	40
L	21
H	37
HT	34
LT	19
T	35
D	36

Voltage delay: When the battery is subjected to the capacity tests covered by this specification, initial closed-circuit voltages below the 4.5 volt end voltage cannot exceed a 1.0 second duration.

First article inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests, I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests

METHOD OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery shall be discharged through a 60 ohm resistance to a test end voltage of 4.5 volts.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 10.0 ohms and a minimum permissible voltage of 5.0 volts.

Cell Lot Inspection:

1. Cell Lot. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 5.0 ohm resistance load. Any cell whose voltage falls below 2.5 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at 160° $^{+3°}_{-7°}$F for two (2) weeks and then at -20° ±3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cells shall be submitted for cell lot inspection.

4. Cell replenishment. In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of ten (10) batteries individually packaged per Method 1C-1 of MIL-P-116. Each battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils with a head sealed closure. The bagged batteries shall be placed in a close-fitting paperboard box conforming to PPP-B-566, variety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

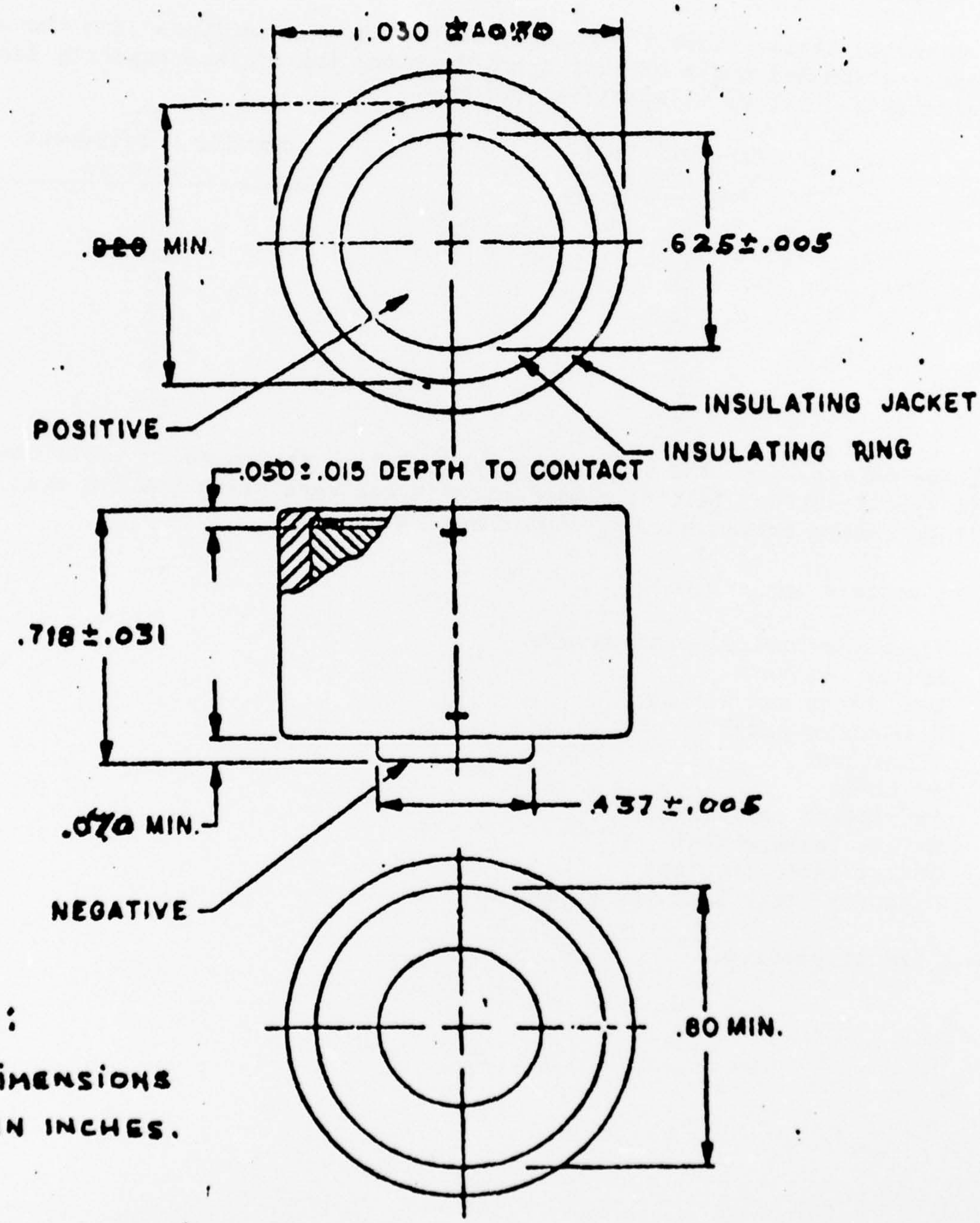
SCS-459/11
20 November 1974

3

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5567/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



NOTE:
ALL DIMENSIONS ARE IN INCHES.

Battery, Primary, Lithium Organic BA-5567/U

REQUIREMENTS:

Dimensions and configuration: See Figure

Maximum Voltage: 3 volts

Terminals: (See Figure)

Weight (maximum): 0.7 ounces (20 grams)

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity test requirements shall be as specified below.

Capacity Test (per SCS 459)	Service Requirement in Hours
I	20
L	12
H	18
HT	17
LT	10
T	17
D	18

Voltage delay: When the battery is subjected to the capacity tests covered by this specification, initial closed-circuit voltages below the 2.0 volt end voltage cannot exceed a 1.0 second duration.

First article inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Jacket integrity test
- Capacity tests

<u>METHOD OF EXAMINATION AND TESTS</u>:

Capacity tests:

(1) Storage: Details on storage conditions for all specified capacity tests are described in basic specification.

(2) Discharge: The battery shall be discharged through a 50 ohm resistance to a test end voltage of 2.0 volts.

Closed circuit voltage: Closed circuit shall be observed for a period of thirty (30) seconds with a direct current voltmeter of proper range and sensitivity, using a load resistance of 10 ohms and a minimum permissible voltage of 2.0 volts.

Cell lot inspection:

1. <u>Cell lot</u>. A cell lot shall consist of a sufficient amount of cells of a particular type which are to be used in the fabrication of a specific battery lot plus an additional thirty cells for acceptance tests. Each of the cell lot shall be subjected to the inspection program outlined herein.

2. <u>Closed-circuit voltage test</u>. All the cells in a cell lot shall be pulse tested for five (5) seconds with a 10 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. <u>160°F Storage test</u>. From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at 160°F $^{+3°F}_{-7°F}$ for two (2) weeks and then at -20° ± [illegible]°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot shall be submitted for cell lot inspection.

4. Cell replenishment. In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random amnner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

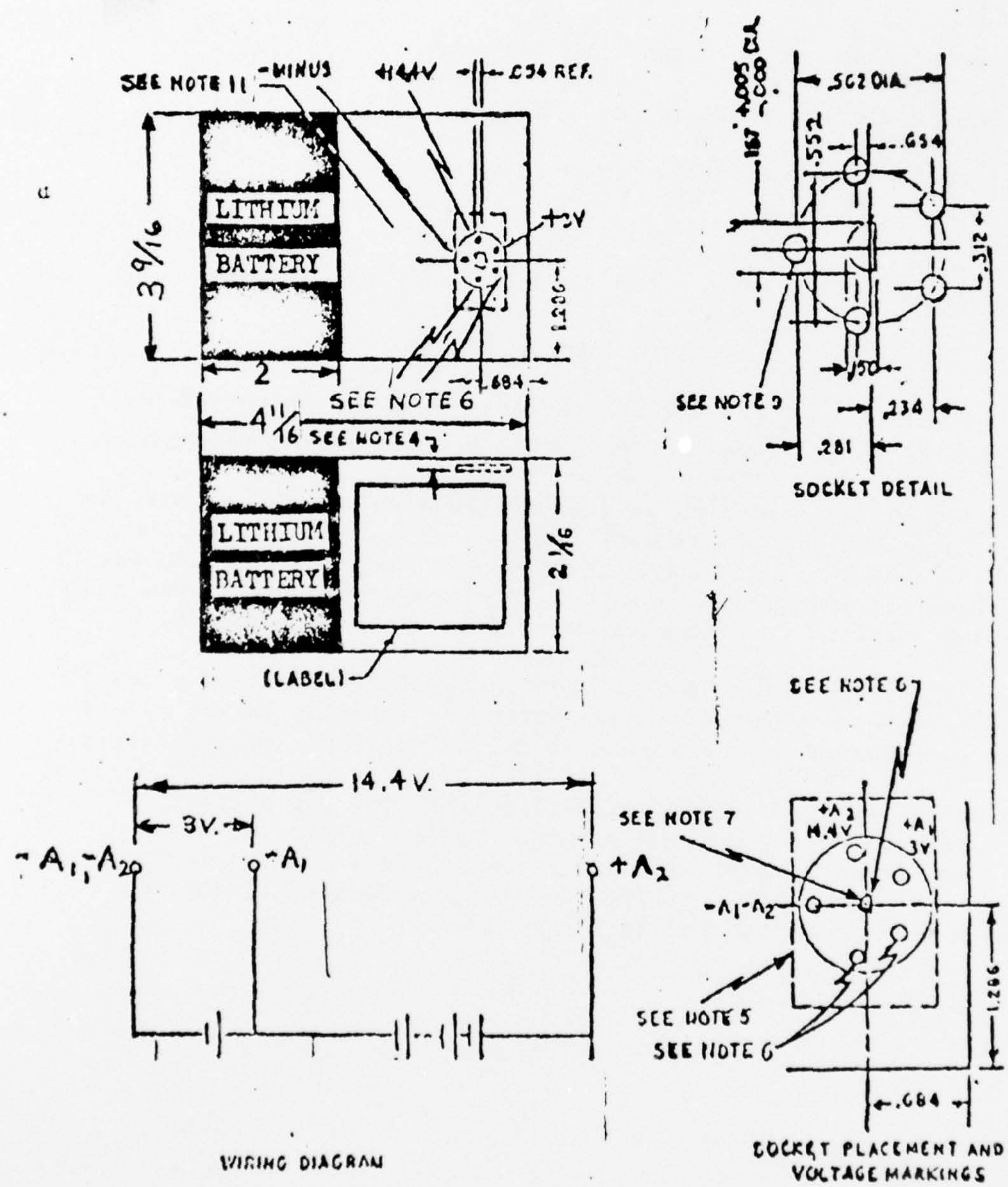
Preservation and packaging: Preservation and packagina shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of twenty (20) batteries individually packaged per Method IC-1 of MIL-P-116. Each battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type 1, grade B, finish 1, having a uniform thickness of 4.0 ± 0.5 mils with a heat sealed closure. The bagged batteries shall be placed in a close-fitting paperboard box conforming to PPP-B-566, variety 2, style optional. Closure shall be as specified in the appendix to the applicable box specification.

SPECIFICATION SHEET

BATTERY, PRIMARY, LITHIUM ORGANIC BA-5598/U

The complete requirements for procuring the lithium organic primary battery type described herein shall consist of this document and the issue in effect of Specification SCS-459.



INCHES	MM
0.005	0.13
0.054	1.37
0.150	3.81
0.187	4.75
0.234	5.94
0.281	7.14
0.312	7.92
0.552	14.02
0.562	14.27
0.684	17.37
1.286	32.66
2.000	50.80
2-1/16	52.39
3-9/16	90.49
4-11/16	119.06

NOTES:

1. All dimensions are in inches.

2. Unless otherwise specified, all tolerances are ±0.005 inch for decimals.

3. Tolerances of length, width and height of battery are ± 1/16 inch for fractions.

4. The minimum depth of socket well shall be 1/2 inch.

5. The size of the insulating plate is optional.

6. Socket insert contact not required.

7. Pin-circle center.

8. "D" hole for plug positioning.

9. Five holes to fit 1/8 in. pins, 7/16 inch in length.

10. Socket must float 3/32 $^{+1/32}_{-1/16}$ in all directions from the specified pin circle center location in the plane of the socket from reference dimension.

11. The printed socket facsimile may be included adjacent to the socket, on the socket side of the battery, in lieu of terminal markings shown in the top view of Fig. 1. The facsimile shall be permanent, legible, include outline of socket, terminal identification shown in aforementioned top view and meet general battery marking requirements covered or referenced herein.

12. On all four (4) sides of the battery "LITHIUM BATTERY" shall be printed in 1/2 inch (approx.) bold lusterless green lettering (same as jacket color) on a black background extending a distance of 2.0 inches from end of battery.

13. The socket shall be supported and mounted so that the top surface of the socket shall not protrude above the adjacent ouside surface of the jacket and shall not be more than 1/16 inch below adjacent outside surface of the jacket when used initially, during, and after subsequent insertions of the mating plug during contractual testing.

REQUIREMENTS:

Dimensions and configuration: See Figure

	A_1 Unit	A_2 Unit
Nominal voltage:	3.0 volts	14.4 volts
Maximum voltages:		
Open circuit	-	15.0 volts
Closed circuit	3.0 volts *	-

* Under a load of 6.76 ohms

Terminals: Five (5) hole socket type with no obstruction of any holes (See Figure)

Weight: (maximum): 1.5 pounds

Capacity tests: When the battery is tested in accordance with the methods of examination and tests of this specification, the minimum capacity-test requirements shall be as specified below.

Capacity Test (per SCS 459)	Service Requirement in hours
I	50
L	35
H	50
HT	45
LT	30
T	45
D	45

Initial voltage delay: When the battery is subjected to the capacity tests specified herein, the time required at the beginning of discharge for the battery to reach a voltage of 10.0 volts after the specified load is applied shall not be more than 0.5 seconds.

Drop test: When the battery is tested in accordance with this specification, the socket shall not move beyond the limits specified herein nor shall the components shift within the jacket, or preclude the battery from meeting specified "I" capacity test performed at the conclusion of the jacket integrity test.

First article inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Drop test
- Jacket integrity
- Capacity tests I, L, H, HT and LT

Cell lot inspection:

Quality conformance inspection:

- Visual-mechanical examination
- Battery voltage
- Dimensions and weight
- Mechanical shock
- Vibration
- Altitude
- Insulation resistance
- Safety feature test
- Drop test
- Jacket integrity
- Capacity tests HT, LT, T and D

METHODS OF EXAMINATION AND TESTS:

Capacity tests:

(1) Storage: Details on storage conditions for all capacity tests are specified in basic specification.

(2) Discharge: The A_2 unit ($-A_1-A_2$ to $+A_2$) shall be discharged through a resistance of 14.2 ohms for 2 minutes, and then through a resistance of 291.0 ohms for 18 minutes. This cycle shall be repeated continuously to a test end voltage of 10.0 volts.

Closed circuit voltage: Closed circuit voltage measurements shall be made with a direct current voltmeter of proper range and sensitivity (see basic specification), using load resistances as shown in the following table:

UNIT	RESISTANCE	MINIMUM PERMISSIBLE VOLTAGE
A_1	6.5 ohms, ± 1%	2.60 volts
A_2	14.2 ohms, ± 1%	12.5 volts

Voltage shall be above "MINIMUM PERMISSIBLE VOLTAGE" within thirty (30) seconds after load is applied.

Drop test: When performed during First Article Inspection, five (5) each Group IIIB test samples shall be subjected to this drop test just prior to performing the jacket integrity test on them. When performed during Quality Conformance Inspection, five (5) each subgroup B_2 test samples just prior to being subjected to integrity test shall have this drop test performed upon them. Each battery shall be dropped once from a height of 30 ± 2 inches onto a hard surface consisting of concrete, wood or steel. The 3 9/16" x 2 1/16" side of the battery nearest the socket shall be parallel to this surface upon release, and shall make contact with it. If any failure occurs, the contractor shall take immediate action to correct the defect and eliminate the cause. However, pending this action, quality conformance acceptance shall be withheld. When the nature of the failure has been determined, and the necessary corrective action taken, the rejected lot and all batteries in process at the time of the failure shall be reworked to eliminate the defect. Reworked lots shall be reinspected using a sample size of eight (8) batteries with no failures permitted.

Cell Lot Inspection:

1. Cell lot. - A cell lot **is defined as** those cells of a particular type which are to be used in the fabrication of a specific battery lot. Each of the cell lots shall be subjected to the inspection program outlined herein.

2. Closed-circuit voltage test. - All the cells in a cell lot shall be pulse tested for five (5) seconds with a 2.5 ohm resistance load. Any cell whose voltage falls below 2 volts during the 5 second pulse period shall be rejected for use in battery fabrication or further cell lot testing.

3. 160°F Storage test. - From a cell lot that has been tested for closed-circuit voltage select thirty (30) cells either in random manner or at preselected intervals, whichever the Government inspector deems more desirable. The thirty (30) cells shall be stored at 160° $^{+3}_{-7}$°F for two (2) weeks and then at -20° ±3°F for a minimum of six (6) hours. Each cell shall be discharged through the equivalent cell load and to the equivalent cell end voltage in accordance with the initial capacity test of this specification sheet.

a. If all thirty (30) cell samples exceed the minimum capacity service requirement by a factor of at least 10%, the lot may be used for fabrication of a single lot of batteries.

b. If there are two (2) or more failures during the capacity testing of the thirty (30) cell samples the cell lot shall be rejected. If only one (1) failure occurs, another twenty (20) cell samples shall be selected from the same lot and this same test shall be repeated. If no failures occur during retesting, the cell lot shall be considered acceptable. If one (1) or more cells fail during retesting, the cell lot shall be rejected and new cell lot of cells shall be submitted for cell lot inspection.

4. Cell replenishment. - In order to replenish the twenty (20) cells consumed by the additional 160°F storage testing, twenty-three (23) cells shall be fabricated when necessary. All shall be subjected to closed-circuit voltage test (2 above). Any cell that fails this test shall be replaced by one that has passed. Three (3) cell samples shall be selected in a random manner from the twenty-three (23) cells that have passed the closed-circuit voltage test. These three (3) cell samples shall be tested in accordance with the 160°F storage test (3 above). No failures are permitted for acceptance of this replenishment lot of twenty (20) cells. If one or more failures occur, the lot of twenty (20) cells shall be rejected and a new lot of twenty-three (23) cells shall be fabricated and three (3) shall be tested. This procedure shall be repeated until no failures occur.

PREPARATION FOR DELIVERY:

Preservation and packaging: Preservation and packaging shall be in accordance with latest issue of basic specification except that no intermediate packaging shall be required and unit packaging shall be as follows:

A unit package shall consist of one battery individually packaged per method IC-1 of MIL-B-116. Battery shall be placed in a barrier bag fabricated of material conforming to L-P-378, type I, grade B, finish I, having a uniform thickness of 4.0 ± 0.5 mils with a heat sealed closure. The bagged battery shall be placed in a close-fitting paperboard box conforming to PPP-B-636, type CF, W6c or W5c, style optional or MIL-B-43014. Closure shall be as specified in the appendix to the applicable box specification.

ELECTRONICS COMMAND
TECHNICAL REQUIREMENTS

SCS-459
Amendment 3
25 July 1975

BATTERIES, PRIMARY, LITHIUM ORGANIC

This amendment forms a part of Electronics Command Technical Requirements SCS-459, 17 May 1974

Page 1

1.1 Delete this paragraph in its entirety and substitute the following:

"1.1 Scope - This specification covers primary batteries of the non-reserve type composed of electrochemical cells utilizing a lithium-organic electrolyte-sulfur dioxide system."

Page 3

3.2 Add "Sulfur Dioxide Gas Leakage" 3.16

Page 7

3.6.9 Safety Features: Delete the last two sentences and substitute the following:

"In addition to this safety precaution each complete battery shall be fused, when necessary, with a replaceable C/3 ampere time delay fuse. If a battery type is composed of more than one section, each individual section shall be fused separately, when necessary, with a replaceable C/3 ampere time delay fuse."

Page 7

Add 3.6.9.1 Safety Diodes - Diodes shall be used in all parallel cell arrangements to prevent charging in the event that one or more cells drops below 2.95 volts each. Each diode employed will be suitably rated so that it does not substantially impair the operating electrical characteristics of the battery.

Page 9

3.14.1 Add "Do not charge, incinerate, or mutilate this battery."

Page 10

Add 3.16 Sulfur Dioxide Gas Leakage - Each cell used in a battery shall have a monthly leakage rate not to exceed 0.005% of the total sulfur dioxide in the cell when tested in accordance with 4.7.12. In addition each cell shall be hermetically sealed having such features as a welded top and a through connector such as a glass to metal seal.

Add 4.7.12 Sulfur Dioxide Gas Leakage Test - Each of the cells used for cell lot acceptance tests called for in the individual specification sheets of this specification shall be weighed to the nearest milligram. The weight of sulfur dioxide used in the design of the cell shall be recorded. At the end of 30 days storage at 160°F the cells shall be removed from the temperature cabinet placed in a desiccator and cooled for at least 2 hours minimum, and then weighed.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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READ INSTRUCTIONS BEFORE COMPLETING FORM

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Effort has commenced on the MM&T program to establish the fabrication techniques and requirements necessary to meet hardware production levels as specified in the subject contract. A PERT/TIME NETWORK was developed to define specified management and engineering objectives within the overall program. Initial hermetic cell and battery component design has been developed to meet and/or exceed all performance, safety and environmental

specifications. The basic system concepts for electrolyte fill and dispensing, core winding, cathode/anode manufacture and hermetic closure have been defined to permit subsequent integration within an operational production line. Interface with automated equipment manufacturers will continue to define specific machine elements and initiate hardware procurement within the time frame of the PERT/TIME NETWORK.