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FINAL REPORT

~~on~~

Improving Performance and Reliability of Sealed Secondary Type Nickel Cadmium Storage Batteries for Satellite and Space Application

~~Performed Under~~

NASA Contract NAS 5-977

(NASA CR-53258)

for

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2

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National Aeronautics and Space Administration
Goddard Space Flight Center
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I. PURPOSE OF CONTRACT

The objective of this contract is to develop and improve both the hermetic seal and the operational temperature range of the nickel-cadmium "space battery." The work covered by this contract involves three assignments. The first assignment involves the development of the hermetic seal. This assignment is subdivided into the following three phases:

ASSIGNMENT I

Phase I - To study the available and most suitable leak detection techniques and to determine the magnitude of leakage of the present seal (both heliarc weld seal and glass - to - metal seal).

Phase II- Improve glass - to - metal seal and investigate new hermetic seal materials such as ceramics and improved glass formulations.

Phase III-The reduction of leakage of the seals by the use of improved construction techniques and hermetic seal materials such as high alumina ceramics.

ASSIGNMENT II

The second assignment involves the study and evaluation of new separator materials. This study is divided into the following phases:

Phase I - Electrical and chemical resistance in 40% potassium hydroxide electrolyte.

Phase II- Determination of the correct volume of electrolyte to fill cells constructed with the new separators and the 72°F ambient operational characteristics.

Phase III-Assemble and test cells with optimized filling as determined

in phase 2 and test at 72°F, 32°F, 0°F and 165°F.

ASSIGNMENT III

This portion of the contract is a study of the magnetic field strength of a ten cell battery and an investigation to minimize the magnetic field intensity created by connecting the ten cells in series arrangement.

II DATA AND DISCUSSION

A. ASSIGNMENT I

The work of this research contract concerned itself with two main tasks. Assignment I was designed to improve the reliability of the hermetic seal of the cylinderical nickel- cadmium battery. This task was divided into the following three phases:

Phase I -

Various available leak detection techniques were investigated. These ranged from the bubble type tests which depend on the observation of bubbles as a criteria of failure to helium and argon mass spectrometers. The bubble tests involved immersion of the part to prescribed depths in liquids such as water, alcohol with a vacuum, water with a wetting agent, heated silicone oil etc. The sensitivity of the bubble tests range from approximately $4X10^{-4}$ cc/sec. to $6X10^{-7}$ cc/sec. The mass spectrometer type leak detectors utilizing trace gases such as helium, argon, radio-active halogen have sensitivities of 10^{-9} to 10^{-12} cc/sec.

The decision was made that the leakage rate for a satellite battery should conform to or be better than one standard cubic centimeter of air/inch of seal as per Mil-S-8484 (USAF) for a Grade A seal. The test conditions for this seal are defined under Mil-Std-202B Condition C. A Consolidated Electrodynamics Co. leak detector modified for the detection of either helium or argon was therefore purchased for this investigation. Tests were conducted utilizing various mass spectrometer techniques ie. the spray technique, the probe technique and the vacuum technique. It was decided that helium would be used for all investigations of battery components since the detection of helium is more sensitive and less prone to background interference than is

argon. The vacuum technique, utilizing helium as a tracer was used for the determination of the magnitude of leakage in the present hermetic seal. The leak rate of the glass to metal seal employed at the start of this contract was found to range from 4.7×10^{-5}cc to 5.0×10^{-9}cc/sec. with an average of approximately 3.8×10^{-7} atm/sec. These figures represent the helium leak rate for a total of 2.26 inches of glass to metal seal on the hermetic cover. Table I graphically illustrates the range and average of our pre-contract type hermetic covers. Table II shows the conversion of measured leak rate (on the glass to metal seal) from atm. cc/sec. to cc/year per inch of seal for both helium and air. These tables indicate that the standard glass to metal seal ranged from a Grade A seal to a Grade C seal as defined in Mil-S-8484 (USAF)

Phase II -

A study of the various cause of leakage in the glass - to - metal seal.

Three causes of leakage in the glass to metal seal were found. They are as follows: (a) Groves cut into the sides of the positive terminal pin during the manufacturing process. (b) Irregular tool marks in the contact surfaces of the machined cover blank and (c) The degree of oxidation of the positive terminal pins. Corrective measures were instituted to eliminate the first two defects. Centerless ground rod terminal pins of 52 alloy were obtained and coined cover blanks were manufactured to avoid irregular surfaces.

GLASS-TO-METAL SEAL LEAKAGE RATE - PRIOR TO CONTRACT

Interval (atm.cc/sec.)	Score	f
$1.0 \times 10^{-5} - 4.9 \times 10^{-5}$	//	2
$5.0 \times 10^{-6} - 9.9 \times 10^{-6}$	//	2
$1.0 \times 10^{-6} - 4.9 \times 10^{-6}$	~~////~~ ~~////~~ ~~////~~ ///	18
$5.0 \times 10^{-7} - 9.9 \times 10^{-7}$	~~////~~ ////	9
$1.0 \times 10^{-7} - 4.9 \times 10^{-7}$	~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~	40
$5.0 \times 10^{-8} - 9.9 \times 10^{-8}$	~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~	45
$1.0 \times 10^{-8} - 4.9 \times 10^{-8}$	~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ //	27
$5.0 \times 10^{-9} - 9.9 \times 10^{-9}$	/	1
$1.0 \times 10^{-9} - 4.9 \times 10^{-9}$		0
	Total n =	144

The geometric configuration of the current glass-to-metal seal has a total linear dimension of 2.26 in. Table II shows the conversion of measured leak rate on our glass-to-metal seal covers from atm. cc/sec. to atm. cc/sec./ inch of seal for both helium and air.

TABLE I

GLASS-TO-METAL SEAL LEAKAGE RATE - PRIOR TO CONTRACT

	Average	Minimum	Maximum
Measured Rate of leakage of He(atm.cc/sec.)	3.78×10^{-7}	5.0×10^{-9}	4.7×10^{-5}
Rate of He per inch of seal (atm.cc/sec./in.)	1.68×10^{-7}	2.21×10^{-9}	2.08×10^{-5}
Rate of He per inch of seal per year(cc/year/in.)	5.52	.0699	661
Rate of He leakage per year converted to air leakage (cc/year/in.)	5.05	.064	602

The above table indicates that the present standard glass-to-metal seal ranges from a Grade A seal (min. value above) to a Grade C seal (max. value above) as defined in MIL-S-8484 (USAF).

TABLE II

Several covers using Corning 9010 glass which failed leak tests were sectioned and large bubbles were noted to be present at the interface of the terminal pin and glass. The matrix formed by the glass was found to be coarse with only a small amount of the glass forming a bond with the terminal pin. This initiated tests to evaluate the effect of the degree of oxide formation upon the glass-to-metal bond. Results showed that the covers with non-oxidized pins exhibited a much finer glass matrix than the original samples with virtually no large bubbles at the interface. In addition, a new formulation recommended by Corning glass called No. 0088 was tested and found to be superior to the 9010 type.

The above investigation yielded a significant shift in the leak rates of the glass to metal type seals. Table III illustrates the range and average of the measured leak rates on the improved version of the glass to metal seal. The major portion of these seals were in the 1.0×10^{-7} to 4.9×10^{-9} cc/sec. range. Table IV shows the conversion of the measured leak rates in Table III in atm cc/sec. to air leakage in cc/year.

This table indicates that the glass to metal seal as manufactured now falls well within the 1 cc/year/inch of seal maximum leak rate specified for a Class A seal. There are, however, some very bad seals included in the distribution which makes mandatory the testing of all hermetic seals before assemblying into satellite batteries.

Interval (ATM cc/Sec.)	Score	F
1.0×10^{-6} - 4.9×10^{-6}	////	4
5.0×10^{-7} - 9.9×10^{-7}	/	1
1.0×10^{-7} - 4.9×10^{-7}	~~////~~ /	6
5.0×10^{-8} - 9.9×10^{-8}	/	1
1.0×10^{-8} - 4.9×10^{-8}	//	2
5.0×10^{-9} - 9.9×10^{-9}		0
1.0×10^{-9} - 4.9×10^{-9}	~~////~~ /	126
	Total N =	140

TABLE III

GLASS-TO-METAL SEAL LEAKAGE RATE - IMPROVED VERSION

Leakage Rate	Average	Min.	Max.
Measured Rate of Leakage of HE (Atm cc/Sec.)per 2.26 inch of seal	4.18×10^{-9}	1.88×10^{-9}	4.9×10^{-6}
Rate of HE per inch of seal - ATm cc/Sec./In	1.85×10^{9}	$.83 \times 10^{-9}$	2.17×10^{-6}
Rate of HE per inch of seal per Year (cc/Year/In	.0585	.0263	68.2
Rate of HE Leakage per Year Converted to Air Leakage (¢c/Year/In)	.0532	.0240	62.2

TABLE IV

Phase III

This portion of the contract was concerned with the investigation and development of the ceramic type seal. A corrosion study of sixteen promising glass and ceramic type hermetic sealing materials was also conducted in this section.

The ceramic to metal seal was investigated with the hope of reducing the strain cracks in the glass which developed during the heliarc welding process. Furthermore, the ceramics were thought to be more resistant to electrolyte corrosion. Preliminary investigations of ceramic seals indicated that they were capable of helium leak rates equal to or better than those which could be expected from the glass - to - metal seals. The raw ceramics were also greatly superior in terms of their corrosion resistance and strength factors.

The first stage of this program was the investigation of the chemical resistance of the ceramics to exposure to 30% potassium hydroxide at 150°F. Table V lists the resistance of sixteen materials to the above exposure conditions. Corrosion resistance was measured in terms of milligrams of weight loss per square inch of surface area. On the basis of this test we selected 96% alumina type ceramics for the new ceramic - to-metal seals. It can be seen from Table V that the ceramics are highly attractive in terms of their corrosion resistance in comparison to the glass type materials.

RESISTANCE OF SEAL MATERIALS TO 30% KOH

Identification	Type of Material	Weight Loss/Unit Area - mg/in^2 at 150°F. 7 Days	14 Days	30 Days	60 Days
Corning 9010	Glass	13.8	67.6	278	421+
Corning G-12	Glass	12.5	31.5	81.0	97.0 (41 days)
Corning 8161	Glass	23.5	40.3	146.0	185.0 (41 days)
Corning 0088 (1)	Glass	14.0	26.0	83	114
Mansol 41-060	Glass	17.3	93.0	243.0	300
Harveg 2100	Mica-filled glass	312	Test ended - not resistant		
Mycalex Supramica 620 BB	Lead Borate Mica-filled glass	-	-	not resistant	
Ceramic for Industry 694 (at 150°F).	Alumina 96%	1.84	5.02	11.2	14.2
Ceramic for Industry 694 (at 200°F).	Alumina 96%	27.6	43.7	51.0	57.0
Shaw Instrument Co. 99.7%	Pure Alumina 99%	0	0	0	5.22
Shaw Instrument Co. 9095	Alumina	13.0	26.2	43.0	60.3
Shaw Instrument Co. 9097	Alumina 95-97%	8.7	10.0	11.8	14.4
American Lava 243 - 475	Forsterite Zirconium Ceramic	4.22 15.15	9.5 43.4	21.5 80.3	28.1 150.0
Diamonite P-3142-1	Alumina 95-97% -	-	6.76	7.38	7.89
RCA BK 14026-81	Alumina 85-96 6%	4.5	-	+1.70	+6.89

TABLE V

The second stage of the ceramic development was a detailed study of differences in metalizing on ceramics from different manufacturers. Generally, it was found that (a) the thicker the metalizing the poorer the bond strength and (b) that leakers mostly occurred on the inner braze which is designed as a matched seal. A matched seal requires that the positive terminal cup have expansion characteristics to match those of the ceramic - Kovar, Ceramaseal and Fernico 5 have proved to be the most suitable materials for our type ceramic seal. Furthermore, the matched seal requires that the temperature of the brazing operation be extremely well controlled since at too high a temperature the inner cup shrinks too quickly, pulling the metalizing from the surface of the ceramic. The present ceramic seal looks good. Future design, however, indicates that an all, compression type seal would be more reliable since the difficulties involved in manufacturing the matched inner seal would be eliminated. An investigation of the heliarc welding process was also conducted at this time. Our work with can and cover materials and heliarc welding techniques has led us to the conclusion that the material employed for can and cover should be of the same materials. Plating tended to lead to difficulties if it were not securely bonded to the base material. The actual techniques

used during the heliarc welding process and the protection of the core and glass or ceramic seal from excessive heat were the most important part of this operation. After a considerable amount of special training for the heliarc welding operators, techniques were evolved which led to improvements in the welding part of the hermetic seal process.

B. ASSIGNMENT II

GENERAL DISCUSSION

One of the most critical components of the nickel-cadmium space battery is the separator material. The material used must be absorptive, allow the passage of ions, be highly permeable to oxygen for recombination and must be unaffected by 40% KOH solution over a wide range of operational and storage temperatures of -40°F to +165°F. In addition, the separator must be physically resistant to abrasion, separation and other conditions encountered when the battery is subject to shock, vibration, and acceleration. The separator program of this contract was designed to expose the batteries to the worse environmental conditions.

A subcontract was let with Radiation Applications Inc., of Long Island City, New York to develop and to produce test samples of radio active graft copolymerized materials to be used as battery separators. These materials are a new approach to the development of separators for sealed cells. The theory being, that they enhance the characteristics of the basic synthetic fibers by the addition of secondary groups which may have ion exchange characteristics as well as hydrophillic properties lending themselves to strong absorption of electrolyte. The technique of producing a separator of this type involves exposing the basic plastic film or non-woven material to a radio active source, thereby creating free radical sites for the copolymerization of a selected monomer which then may or may not add ion exchange characteristics. The following basic requirements must be met prior to acceptance of any of these materials for test purposes:

1. Thickness not greater than .010 inches.

2. Material must be flexible enough to permit core rolling operation in a dry condition.
3. A resistance in 30% KOH of not more than .050 ohms./sq. in. when subjected to a DC current of 0.10 ampere sq. in.
4. A tear strength sufficient to permit rolling of core, and to withstand vibration and shock of final component without damage.

PHASE I - ELECTRICAL RESISTANCE IN 30% Potassium Hydroxide.

The separator materials submitted were exposed to 40% potassium hydroxide for a period of 10 days at 72°F to 200°F. Materials which indicated no degradation as evidenced by decrease in physical strength or coloring of the electrolyte were then tested for the electrical resistance in 30% potassium hydroxide.

Table VI is a list of all separator materials evaluated under this contract with a comparison of their resistivities, thicknesses and a figure called "KOH retention". This is defined as the ratio of the weight of the material after a two hour immersion in KOH versus dry weight.

Table VII is a list of separators which were investigated by Radiation Applications but not submitted to Sonotone for the various reasons noted. Radiation Applications reported that repeated attempts have been made to prepare usable samples based on nylons or flurocarbons without success. In order to increase the conductivity of these separators it is necessary to increase the level of grafting to a point where the films become extremely brittle.

Sample No.	Type	Resistivity 30% KOH	Thickness (inches)	KOH Retention
7095-1	Polypropylene Carboxylic graft	.034 ohms/in^2	.001	3.4
-2	Polypropylene Carboxylic graft	.041 " "	.002	4.9
-3	H.D. Polyethylene Quaternaryamine graft	.043 " "	.003	3.4
-4	Oriented polypropylene carboxylic graft	.058 " "	.002	2.2
-6	Non-woven polypropylene carboxylic graft	.052 " "	.026	7.0
-7	Low density polyethylene carboxylic graft	.080 " "	.003	7.9
-8	Cellophane-Styrene graft	.042 " "	.002	3.1
-9	Cellophane-Styrene Acrylonitrile	.047 " "	.002	2.9
-10	Non-woven polypropylene-quaternized Amine graft	.052 " "	.015	rejected
-11	Non-woven polypropylene-carboxylic acid graft	.048 " "	.025	rejected

TABLE VI
(Cont.)

Sample No.	Type	Resistivity 30% KOH	Thickness (inches)	KOH Retention
7095-12	Non-woven polypropylene strong acid graft	.050	.030	rejected
-13	Non-woven rayon-Styrene graft	.035	.010	9.6
-14	Non-woven rayon-styrene-acrylonitrile graft	.034	.010	11.6
-16	Non-woven polypropylene carboxylic graft	-	-	rejected
-17	Non-woven polypropylene basic graft	.054	.009	4.0
-18	Woven teflon-carboxylic graft	.052	.005	1.3
-19	Non-woven polypropylene carboxylic graft	.046	.006	1.7
-20	Non-woven polypropylene	.040	.005	2.3
	Standard non-woven polypropylene	.037	.007	3.5
	Standard cellulose	.028	.006	4.2

KOH retention is defined as the weight of the material after a 2 hour soak in KOH compared to dry weight.

TABLE VI

C. ASSIGNMENT III

The purpose of this phase of the program was to determine whether or not a 10 "D" cell battery would create the maximum allowable magnetic field intensity of 10^{-5} gauss at a point 3 feet from the battery.

A magneto-meter sensitive enough to make this measurement was not available, therefore, an alternative A.C. method was devised. This technique involved impressing a 1.0 amp. A.C. current thru the battery. The resulting current induced in a calibrated coil was measured by a wave analyzer thru a matched gain transformer. The measuring arrangement is illustrated in Fig. 1.

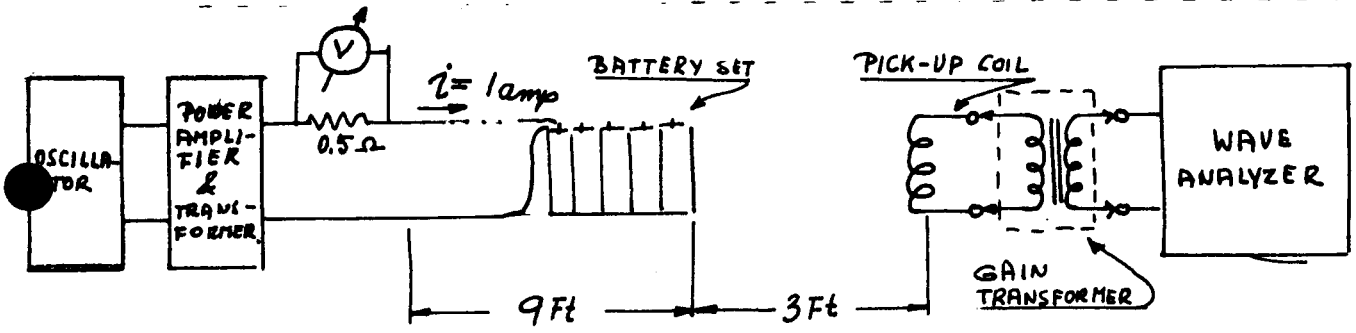


Fig. 1 Measuring Arrangement

REQUIREMENT

Maximum allowable magnetic-field intensity $H_{Max} = 10^{-5}$ Gilbert per centimeter. 3 ft. from source.

CALIBRATION OF PICK-UP-COIL

The magnetic-field intensity of our Helmholtz coil 19 given by

$$H = \frac{0.9 N I^A}{R\ cw} \text{ gilbert per cw.} \quad ; \quad n = 200, \quad R = 6 \cdot 2{,}54 = 15.24 \text{ cw}$$

Its impedance at 1000 CPS is $\mathcal{L} = 26 + j105$ OHMS from which $L = 16.7$ mHy. When E = 3.2v RMS is applied across coil - terminals the current in the coil, for 1000 CPS, is

$$I = \frac{E}{R + j\omega L} = \frac{3.2}{26 + j\,6280 \cdot 0{,}0167} = \frac{3.2}{26 + j\,105} = 0{,}0296 \text{ Amp.}$$

or

$$H = \frac{0{,}9 \cdot 200 \cdot 0{,}0296}{6 \cdot 2.54} = \frac{3 \cdot 0{,}296}{2{,}54} = 0{,}35 \text{ gilbert per cw.}$$

PLACING THE PICK-UP COIL (SEE FIG. 1) IN THAT MAGNETIC FIELD THE GENERATED OPEN CIRCUIT VOLTAGE IS 0.48 V RMS. HENCE $H = 10^{-5}$ CORRESPONDS TO

$$\frac{0,48}{0,35} \cdot 10^{-5} = 1,37 \cdot 10^{-5} \text{ Volt.} = 13,7\,\mu V.$$

THE EQUIVALENT CIRCUIT OF PICK-UP-COIL MAY NOW BE DRAWN AS INDICATED IN FIG. 2.

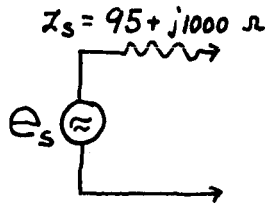
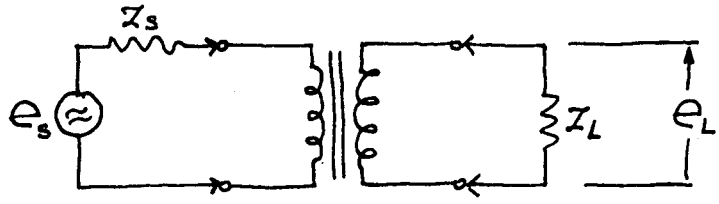


FIG. 2 EQUIVALENT CIRCUIT FOR PICK-UP-COIL INDICATING IMPEDANCE VALUE AT 1000 CPS. AND OPEN CIRCUIT VOLTAGE $e_s = 13.7\,\mu V$ FOR $H = 10^{-5}$ GILBERT PER CENTIMETER

SINCE THE WAVE ANALYZER'S MOST SENSITIVE RANGE IS $30\,\mu V$ FULL-SCALE, THE INSERTION OF A GAIN TRANSFORMER BETWEEN PICK-UP-COIL AND WAVE ANALYZER PROVIDES MORE CONVENIENT READINGS AT SUCH A LOW LEVEL. THE COMBINED EQUIVALENT CIRCUIT AND CALIBRATION IS INDICATED IN FIG. 3.



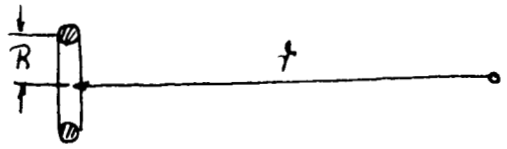
$$G = 20 \log_{10} \frac{e_L}{e_s}$$
$$= 20 \log_{10} 4.2 = 12,5 \text{ dB}$$

FIG. 3. EQUIVALENT CIRCUIT WHEN THE GAIN TRANSFORMER IS PLACED BETWEEN PICK-UP-COIL AND WAVE ANALYZER. Z_L IS THE INPUT IMPEDANCE OF WAVE ANALYZER AND ITS VALUE IS ABOUT 0.1 MEG. OHM, e_L IS THE VOLTAGE ACROSS ZL, AND G IS THE INSERTION GAIN (FROM SOURCE GENERATOR TO LOAD).

OUR FIGURE FOR WAVE ANALYZER READING NOW FOR $H = 10^{-5}$ GILBERT PER CM IS

$$e_L = 13.7 \times 4.2 = 57.5 \text{ V}$$

MAGNETIC-FIELD INTENSITY OF A LOOP OF RADIUS R FOR CURRENT i



NOTE

$$\frac{\text{No of emu}}{\text{No of MKS}} = \frac{4\pi}{10^3}$$

$$H_{Axis}^{MKS} = \frac{1}{2}\frac{R^2 n i}{(R^2+r^2)^{3/2}} \approx \frac{1}{2}\frac{R^2 n i}{r^3} \qquad \text{IF} \quad r >> R$$

$$H_{Axis}^{emu} \cong \frac{4\pi}{10^3}\frac{R^2 n i\, 10^2}{2\, r^3} = \frac{2\pi \cdot 10^{-1} \cdot R^2 \cdot n i}{r^3}$$

IF $R = 1$ cm, $r = 100$ cm $n = 1$, AND $i = 1$ Amp. THEN

$$H_{Axis}^{emu} = \frac{2\pi \cdot 10^{-1}}{10^6} = 2\pi \cdot 10^{-7}$$

FOR $H_{Axis}^{emu} = 10^{-5}$ WITH $r = 100$ cm, $n = 1$, AND $i = 1$ AMP.

$$R = \sqrt{\frac{10^{-5}}{2\pi \cdot 10^{-7}}} = 4 \text{ cm}$$

THIS RESULT MAY BE INTERPRETED IN TERMS OF EFFECTIVE LOOP RESULTING FROM WIRING WHEN BATTERIES ARE CONNECTED; I.E., THE LOOP THAT CONTRIBUTES TO THE OVERALL MAGNETIC-FIELD INTENSITY SHOULD NOT BE GREATER IN AREA THAN 50 SQ. CM. WHEN CARRYING 1 AMPERE IF THE FIELD IS TO BE LESS THAN 10^{-5} GILBERT PER CM. AT 1 METER.

RANDOM NOISE IN MAGNETIC-FIELD INTENSITY MEASUREMENT

WHEN THE PICK-UP COIL OF FIG. 1 CONNECTED TO THE WAVE ANALYZER THROUGH THE GAIN TRANSFORMER AND WITH NO CURRENT FLOWING IN THE BATTERY CIRCUIT THE WAVE ANALYZER READS 10 μV AT 1000 CPS. HENCE

$$e_{s_{RANDOM}} = \frac{10}{4.2} = 2.4\ \mu V$$

OR

$$H_{RANDOM} = \frac{0.35}{0.48}\, 2.4 \cdot 10^{-6} = 1.75 \cdot 10^{-6} \text{ gilbert per cm.}$$

MAGNETIC-FIELD INTENSITY DUE TO CURRENT FLOWING IN BATTERY CIRCUIT

WHEN THE BATTERIES ARE CONNECTED TOGETHER AS INDICATED IN FIG. 4 THE READING ON WAVE ANALYZER, I.E. e_L, LESS THAN 10μV FOR ANY POSITION OF BATTERY SET AT 3 FT. DISTANCE FROM PICK-UP COIL AND 1 AMP. RMS.

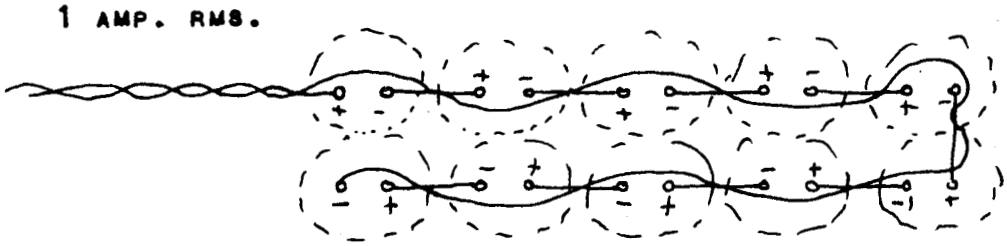


FIG. 4 TOP VIEW OF 10 SERIES CONNECTED "D" SIZE CELLS SHOWING WIRING ARRANGEMENT THAT IS RECOMMENDED.

DECREASING THE DISTANCE FROM 3 FT. TO 1.5 FT. e_L INCREASES TO 50μV IN ONE PARTICULAR BATTERY SET POSITION. THIS POSITION IS APPROXIMATELY INDICATED IN FIG. 5.

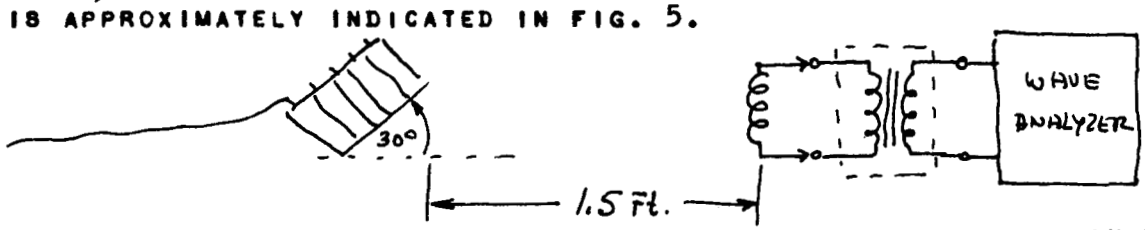


FIG. 5 DIAGRAM OF PARTICULAR BATTERY SET POSITION IN WHICH THE MAXIMUM MAGNETIC-FIELD INTENSITY IS PRODUCED BY THE SET WHEN WIRED AS THAT OF FIG. 4 AND 1 AMP. FLOWING THROUGH THE SET.

IF THE BATTERIES ARE CONNECTED TOGETHER ACCORDING TO FIG. 6 e_L= 180μV AT 3 FT. AND 800μV AT 1.5 FT. WITH THE SAME POSITION AS INDICATED IN FIG. 5 AND FOR CURRENT OF 1 AMP.

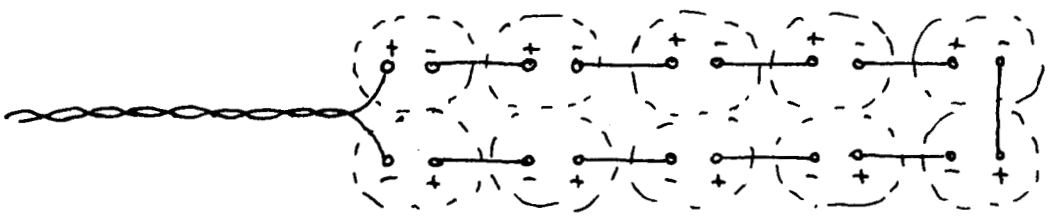


FIG. 6 TOP VIEW OF 10 SERIES CONNECTED "D" SIZE CELLS SHOWING WIRING ARRANGEMENT THAT SHOULD NOT BE USED.

TABLE I.

DISTANCE BETWEEN PICK-UP COIL AND THE 10-CELL BATTERY OF "D" SIZE CELLS							
1.5 Ft.				3 Ft.			
WIRING ARRANGEMENT	BATTERY SET POSITION	$e_L^{\mu V}$	H^{emu}	WIRING ARRANGEMENT	BATTERY SET POSITION	$e_L^{\mu V}$	H^{emu}
Fig. 4.	Fig. 5	50	$0.87 \cdot 10^{-5}$	Fig. 4	ANY	LESS THAN 10	LESS THAN $1.7 \cdot 10^{-6}$
Fig. 6.	Fig. 5	800	$1.4 \cdot 10^{-4}$	Fig. 6	Fig. 5	180	$3.1 \cdot 10^{-5}$

CONCLUSION

IT HAS BEEN SHOWN THAT THE WIRING ARRANGEMENT PLAYS AN IMPORTANT ROLE IN KEEPING THE MAGNETIC-FIELD INTENSITY AT LOW LEVEL. MORE PRECISELY FROM TABLE 1 IT IS OBVIOUS THAT IT IS NOT THE BATTERY SET THAT BUILDS UP THE MAGNETIC-FIELD INTENSITY BUT THE LOOP THAT RESULTS FROM CONNECTING CELLS TOGETHER. MOREOVER, SINCE THIS LOOP IS SURROUNDED BY IRON MATERIAL, ONE MAY EXPECT A DISTORTED FIELD. A SIMPLE CALCULATION MAY VERIFY THAT IT IS SO. IN FIG. 6 THE PHYSICAL DIMENSIONS OF WIRING LOOP ARE 14 CM. AND 3 CM. THE AREA OF SUCH A LOOP IS 42 SQ. CM. WE MAY REPLACE THE LOOP WITH AN EQUIVALENT AREA OF A CIRCLE WHICH HAS A RADIUS

$$R = \sqrt{\frac{42}{\pi}} = 3.66 \text{ cm}$$

THE MAGNETIC-FIELD INTENSITY 1 METER FROM LOOP WHEN 1 AMP. IS FLOWING IN THE LOOP IS

$$H_{Axis} = \frac{2\pi \cdot 10^{-1} \, \frac{42}{\pi}}{10^6} = 0.84 \cdot 10^{-5} \text{ gilbert per cm.}$$

HOWEVER, FROM ACTUAL MEASUREMENT WE FOUND $H = 3.1 \cdot 10^{-5}$ GILBERT PER CM. AND IT IS NOT PERPENDICULAR TO THE LOOP ENCLOSED BY WIRING (SEE FIG. 5).

Since the battery set contributes to the magnetic-field intensity less than 0.177×10^{-5} Gilbert per cm. (See Table 1) one may interpret this result so that a loop surrounded by iron material generates a distorted field that in this particular case is about 12.7 DB higher at one point than it would be in the absence of iron material.

In order to keep magnetic-field intensity at low level twisted wire has to be used and so connected to the cells that the loop resulting from this connection be as small as possible.

PHASE II

This section of the separator evaluation program was designed to determine the correct electrolyte volume to be used in sealed cells for each separator which passed the electrical and chemical resistance requirements of Phase I. Phase II was conducted according to Test Plan 2 of the Technical Proposal for Radiation Applications Inc., as follows:

TEST PLAN 2

A. Assemble 15 experimental cells. Fill 3 groups of 5 cell with 3 levels of KOH. Assemble 6 control cells. All control cells are to be constructed with standard 7 Mil Polypropylene separator.

B. Perform 3 normal charge - discharge cycles in 75°F ±5°F ambient on all cells. Charge at 8 hour rate. Discharge at 1 hour rate.

C. Perform 50 automatic charge - discharge cycles in 75°F ±5°F ambient removing 50% of capacity at the 1 hour rate.

D. Perform 2 manual charge - discharge cycles as in section b to determine amount of degradation.

DISCUSSION OF TEST RESULTS PHASE II

RAI #7095-6 (Appendix P. i - iii)

This separator was eliminated from further testing after Test Plan 2, Sec. D. as a result of poor performance. The non-woven polypropylene test separator was 26 mils thick necessitating the removal of active plate area. Furthermore, this material resulted in a high internal resistance cell.

RAI #7095-7 (Appendix P. iv - vii)

This separator is a membrane type (low density polyethylene-carboxylic-graft). This separator compared favorably with the control cells during

cycling conducted according to Test Plan 2. This separator was eliminated after Test Plan 2 as a result of high cycling temperature during automatic cycling (in excess of 120°F), which resulted in increasingly poor performance.

RAI #7095-8 (Appendix P. viii - x)

Membrane type separator (cellophane styrene graft). This separator was eliminated after Test Plan 2. Pressure build up in cells during life cycling resulted in a number of cell ruptures. Bulging cell cases eliminated the remainder of the cells in this group. Degree of bulging was dependent on the amount of electrolyte that the cells were filled with ie. 17, 18, 19% of core weight.

RAI #7095-9 (Appendix P. xi - xv)

Membrane type separator (cellophane styrene acrylonitrile graft). This separator is similar to 7095-8 and was eliminated after Test Plan 2 as all cells exhibited bulging after charge cycle number 8. In addition, the end of discharge temperatures were too high and would have caused eventual degradation of the cellulosic type material.

RAI #7095-10, 11, 12.

The above three separators are all based on grafted non-woven polypropylene material. They were all rejected for exceeding the maximum allowable thickness specification. See Table VI.

RAI #7095-13 (Appendix P. xvi - xxi)

Non-woven rayon based material (rayon - styrene graft.)

This separator performed well on cycling plan of Test Plan 2. Capacity and voltage levels were equivalent to control cells. This separator was subsequently cycled according to Test Plan 3 at the various temperatures.

RAI #7095-14 (Appendix P. xxi -xxviii)

Non-woven rayon based material (rayon - styrene acrylonitrile graft). This separator's performance characteristics were the same as those of 7095-13. Cells were advanced to cycling regimen of Test Plan 3.

RAI #7095-17 (Appendix P. xxix -xxxi)

Non woven polypropylene based material (basic graft).

This separator yielded good room temperature performance on a few of the cells, but because of erratic results on others it was decided not to proceed with the temperature cycling as per Test Plan 3.

RAI #7095-18 (Appendix P. xxxii - xxxii-a)

Woven teflon based material (carboxylic graft).

A large incidence of bulging was observed in the test cells during the life cycle program of Test Plan 2. Tests conducted with this separator material immersed in 1.30 specific gravity KOH disclosed a unique unraveling of the teflon fibers. This phenomena coupled with the evidence of high pressure in these cells resulted in the elimination of this material from further cycling per Test Plan 3.

RAI #7095-19 (Appendix P. xxxiii - xliii)

Non woven polypropylene base (carboxylic graft).

This separator exhibited good room temperature performance and was subsequently cycled as per Test Plan 3.

RAI #7095-20 (Appendix P. xliv - liii)

Non woven polypropylene base (sulfonated styrene graft).

This separator in cells filled at the 19% level yielded results superior to the control cells under the cycling regimen of Test Plan 2 and was continued on test as per Test Plan 3.

PHASE III

This section of the separator program was designed to determine the temperature operational characteristics of cells containing separators which passed the room temperature requirements of Phase II. Phase III was conducted according to Test Plan 3 of the "Technical Proposal for Radiation Applications, Inc." as outlined below:

TEST PLAN 3: SECTION I

A. Perform 2 manual charge - discharge cycles at room ambient. Charge cells at 8 hour rate at 75°F ±5°F and discharge at 1 hour rate at 0°F, +32°F and +165°F.

B. Perform 2 manual charge - discharge cycles at room ambient. Charge at 8 hour rate and discharge at 1 hour rate. Charges and discharges to occur in 0°F, +32°F and +165°F ambients.

C. Perform 100 charge - discharge cycles in 0°F, +32°F and +165°F ambients on 3 separate groups of cells. Charge cycle is 325 ma for 7 hours. Discharge cycle is 1.75 ma for 1 hour.

TEST PLAN 3: SECTION II

A. Use six additional experimental and three control cells for 30 day charges in 0°F, +32°F and +165°F ambients. Two experimental and 1 control cell are to be used in each temperature category.

DISCUSSION OF TEST RESULTS PHASE III

A total of four separators were cycled according to Test Plan 3.

They were the two rayon based materials numbers 7095-13 and 7095-14 and two of the polypropylene based fabrics numbers 7095-19 and 7095-20. The characteristics of these materials were as follows:

RAI #7095-13 (Appendix P. xvi - xxi)

Non-woven rayon based material (rayon - styrene graft). This separator exhibited high end of charge voltages during the 100 cycles at 0°F (1.58 vs 1.52 for the controls) and extremely poor capacity at the 165°F cycles. Examination of the test cells indicated complete deterioration of the separator after the 165°F cycling regimen. The material was therefore excluded from further testing after Test Plan 3 Sec. 1C.

RAI #7095-14 (Appendix P. xxi -xxviii)

Non-woven rayon based material (rayon - styrene acrylonitrile graft).

The performance of this separator was almost identical to that of 7095-13 and was eliminated from further testing after the temperature cycling of Test Plan 3 Sec. 1C.

RAI #7095-19 (Appendix P. xxxiii - xlii)

Non-woven polypropylene base (carboxylic graft).

This separator survived all cycles on Test Plan 3. The end of charge voltages which occurred during the cycling of Test Plan 3; Sec. 1C were higher at 0°F than the control cells. This was the one undesirable feature. Performance of the 165°F temperature was possibly poorer than the control cells. In any event, this separator did not give any indication of superiority over the standard polypropylene control cells.

RAI #7095-20 (Appendix P. xliv - liii)

Non-woven polypropylene base (sulfonated styrene graft). This group of test cells exhibited lower end of charge voltages at the $0^{o}F$,$+32^{o}F$ and$+165^{o}F$ than did the control cells during cycles of Sec. 1b. The situation changed by the end of the 100 cycles of Sec. 1c at the $0^{o}F$ ambient. The test cells now developed undesirably high end of charge voltages. The test cells were completely degraded after the 30 day charge at$+165^{o}F$ of Sec. II A. The test cells on the continuous charge cycle of Sec. II A. gave superior performance than did the control cells at the $0^{o}F$ and$+75^{o}F$ ambients. Overall performance of this separator indicates that it might have possible advantages over the standard untreated polypropylene over the temperature range of $0^{o}F$ to$+75^{o}F$ or higher. This slight advantage was probably the result of a capability of withstanding a higher electrolyte filling level. This advantage might also prove useful where the battery would be subjected to high centrifugal spin.

III CONCLUSION

The work done under this contract has led to very definite advancements in the performance and the reliability of the hermetically sealed, cylinderical type, nickel-cadmium "Space battery."

Leak detection techniques and fixtures designed specifically for battery components have been developed and are in constant use in the "Space Battery Laboratory."

The glass-to-metal hermetic seal has been improved to the point where the covers now have leak rates of less than 10^{-9}cc/sec. This is equivalent to .058 cc of air per year per inch of seal.

The ceramic seal was evaluated and improved under this contract. It, too, has a leak rate of less than 10^{-9}cc/sec.

Experience has been gained in the manufacturing technique and control required to turn out a more reliable product.

The latest improvement in the ceramic seal is the use of vacuum tube grade of silver brazing alloy in place of the 82% gold -18% nickel braze. The silver braze has proven more reliable.

The ductility factor of the silver results in less likelihood of tearing the metallizing from the ceramic. This contract

III CONCLUSION - Cont'd.

has pointed out the need for new improvements in ceramic seals. Sonotone is now engaged in research investigating new seals.

Under Assignment II we investigated various irradiated separator materials. The only one which showed promise was 7095-20 - a non-woven polypropylene with a strong acid graft. This material, however, did not offer any outstanding advantages over our standard type polypropylene, especially at high operating temperatures. Cold temperature performance was slightly better, probably as a result of the higher electrolyte filling. This increased filling level is a result of the higher electrolyte retention characteristics of the separator. This may also improve the characteristics of the cell under high centrifugal spin. A by-product of this investigation was the evolvement of a testing technique useful in evaluating separators for cylindrical type rechargeable nickel-cadmium batteries as well as a performance criterion against which new materials may be evaluated.

Under Assignment III it was shown that the intercell wiring arrangement is a more important factor in creating magnetic field intensity than the battery itself and that this field can be kept at a minimum by a proper wiring arrangement.

IV PERSONNEL

The following is a list of Sonotone personnel who have expended time, effort and direction on this contract:

Hector, Dr. L. Grant	Vice-President in Charge of Technical Operations and Director of Sonotone Corporation. Head of coordination of research, product development, manufacturing and quality control. With Sonotone since 1946. BA, Oberlin, MA and PhD, Columbia University. National Union Radio Corporation: Director of Research and Engineering, in charge of research development, quality control and factory engineering. University of Buffalo: Professor of physics, 1924-1941. Taught elementary physics and advanced courses in electron theory. In charge of graduate student research. Author of four textbooks on physics. Member American Association for the Advancement of Science, American Physics Society, American Society for Quality Control, Acoustical Society of America, Institute of Radio Engineers, Sigma XI, Honorary Scientific Society.

Mundel, August B.	Director of Engineering, Sonotone Corporation, 1945 to date. Research Engineer, Sonotone Corporation, 1934-1945. Master of Science in Engineering, University of Michigan, 1934. Member AIEE, Vice President and Fellow, American Society for Quality Control. Associated with Sonotone nickel-cadmium battery activities since 1949.
Belove, Louis	Director of Space Battery Laboratory. With Sonotone since 1947: Development of sealed cells for satellite applications. Vacuum tube chemistry, filament coatings. Plastic molding processes. Application of chemical principles to electronic development and miniaturization. BA, chemistry and education, City College of New York. Special courses in radio electronics. 1946-1947 - Fratell-Branca, research chemist on organic syntheses. 1943-1945 - Rockefeller Institute of Medical Research, chemist on physical chemistry projects.
Baumstark, Dr. George A.	Chief Engineer and Director of the Battery Improvement Laboratory, Sonotone Corporation, 1953 to present; Senior Engineer 1949-1953;

	Assistant Research Director, Nickel-Cadmium Battery Company, 1948-1949; Research Chemist, Parker Rust Proof Company, 1945-1948; Senior Engineer, Metallurgical Department, Firestone Tire and Rubber Company, 1943-1945; Research Engineer, Bethlehem Steel Company, 1936-1943; PhD. in Physical Chemistry.
Ryan, Winslow, E.	Administrative Executive, Sonotone Corporation, Battery Improvement Laboratory, 1953 to present; Head of Testing Department Research Laboratory, Nickel-Cadmium Battery Company, Easthampton, Mass., 1947-1950. BS in Chemistry, 1940, University of Massachusetts, Amherst, Mass.
Voyentzie, Peter	Project Engineer. With Sonotone since 1956. 1956 - Engineer in charge of Quality Control, Chemistry Laboratory. 1960 - Project Engineer, Space Laboratory. BA, Degree in Chemistry, New York University 1956. Member of the Electro Chemical Society.
McCormick, R.	Engineering Associate, Battery Improvement Laboratory, Sonotone Corporation, 1954 to present. Associate of Applied Science in Electrical Technology, Westchester Community College, 1954.

	Evening student in Brooklyn Polytechnical College for a B.S. in Chemical Engineering 1957 to present.
Fisher, Donald	Engineering Associate
Daria, Mary	Engineering Associate
Christ, Charles	Assistant Engineer
Volpe, Donald	Technician
Meyer, L.	Technician

IV. APPENDIX

Separator Number	Pages
7095-6	i - iii
7095-7	iv - vii
7095-8	viii - x
7095-9	xi - xv
7095-13	xvi - xxi
7095-14	xxii - xxviii
7095-17	xxix - xxxi
7095-18	xxxii - xxxii-a
7095-19	xxxiii - xliii
7095-20	xliv - liii
Hermetic Seal	liv

SUMMARY OF DATA

TEST PLAN 2; SEC. B. SEPARATOR # 7095-6

CYCLING RATES:

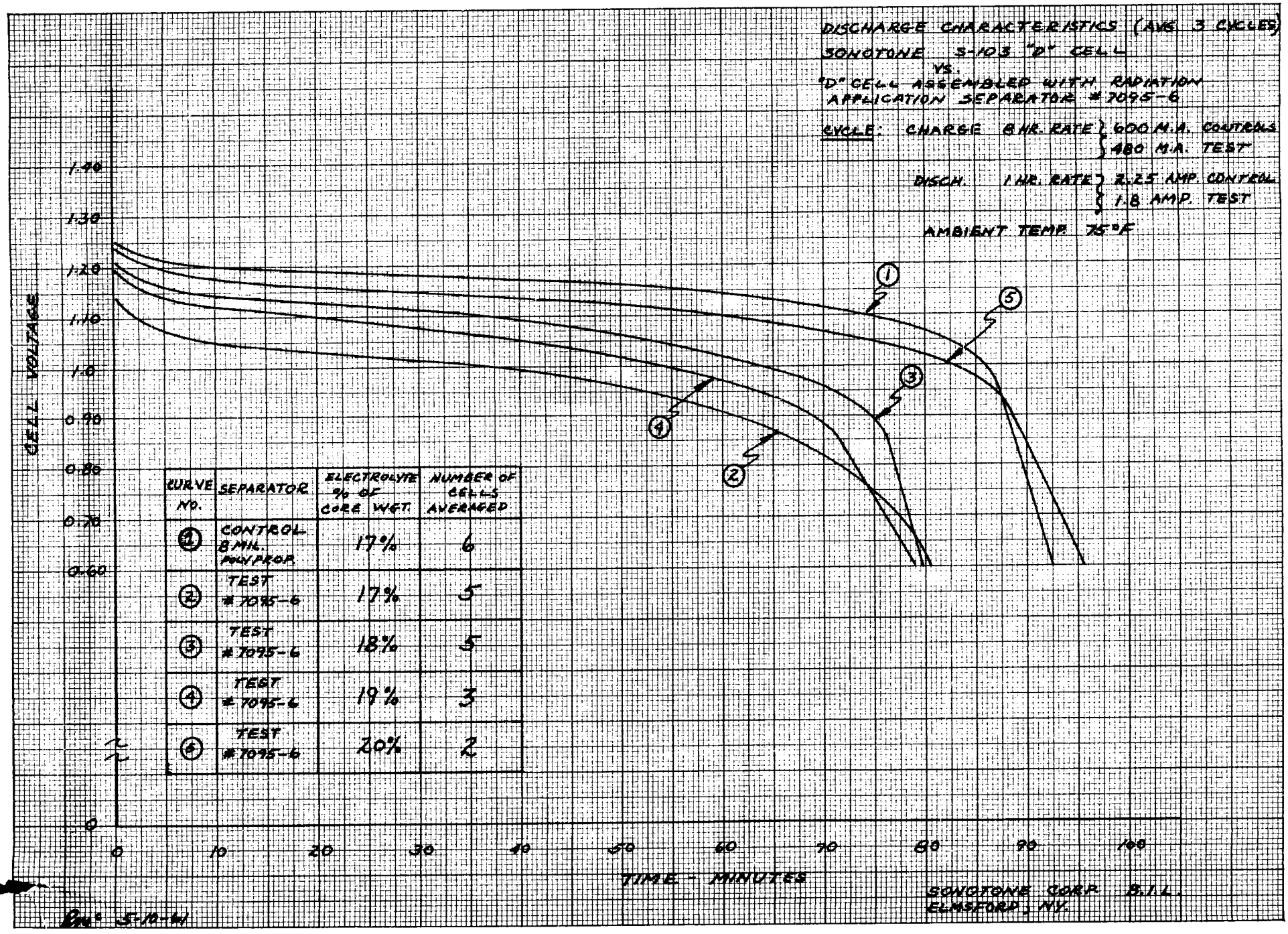
CHARGE 8 HR. { 600 M.A. (CONTROLS)
480 M.A. (TEST)

16 HR { 300 M.A. (CONTROLS)
240 M.A. (TEST)

DISCHARGE 5 HR. RATE { 560 M.A. (CONTROLS)
450 M.A. (TEST)

1 HR. RATE { 2.25 AMP. (CONTROLS)
1.8 AMP. (TEST)

CELLS		CONTROL	TEST	TEST	TEST	TEST
SEPARATOR TYPE		POLY PROP.	7095-6	7095-6	7095-6	7095-6
SEPARATOR THICKNESS		8 MIL.	26 MIL	26 MIL.	26 MIL.	26 MIL
ELECTROLYTE - % CORE WGT.		17%	17%	18%	19%	20%
NO. CELLS AVERAGED		6	5	5	3	2
CYCLE #1 — CHARGE 16 HR. DISCH. 5 HR RATE AMB. TEMP. 75°F	END OF CHARGE VOLT.	1.40	1.42	1.42	1.42	1.41
	END OF CHARGE TEMP.	80°F	80°F	81°F	80°F	80°F
	5 SEC. VOLT. - DISCH.	1.33	1.32	1.32	1.31	1.32
	MID. VOLT AT 1.0V E.P.	1.21	1.16	1.18	1.17	1.195
	TIME TO MIN. 1.0 VOLT	403	308	305	308	366
	TIME TO MIN. 0.60 VOLT	422	358	325	340	379
AVG. CYCLE 2,3 & 4 — CHARGE 8 HR. DISCH. 1 HR. RATE AMB. TEMP. 74°F	END OF CHARGE VOLT	1.41	1.44	1.42	1.44	1.42
	END OF CHARGE TEMP.	80°F	82°F	82°F	83°F	83°F
	5 SEC. VOLT. - DISCH.	1.25	1.14	1.21	1.19	1.24
	MID VOLT AT 1.0V E.P.	1.17	1.03	1.11	1.08	1.13
	TIME TO MIN. 1.0 VOLT	86.1	40.4	62.8	56.8	82.0
	TIME TO MIN. 0.60 VOLT	42.5	80.5	79.3	78.8	95.5
SUPP. DISCH. AT 5 HR. RATE - MIN TO 0.60V.		17.9	57.0	41.6	54.0	29.7



CURVE NO.	SEPARATOR	ELECTROLYTE % OF CORE WGT.	NUMBER OF CELLS AVERAGED
1	CONTROL 8 MIL. POLYPROP.	17%	6
2	TEST # 7095-6	17%	5
3	TEST # 7095-6	18%	5
4	TEST # 7095-6	19%	3
5	TEST # 7095-6	20%	2

FIGURE 1

SUMMARY OF DATA

TEST PLAN 2; SEC. D. SEPARATOR #7095-6

Cells		Control	Test 17%	Test 18%	Test 19%	Test 20%
Separator Type		8 Mil P.P.	7095-6	7095-6	7095-6	7095-6
Electrolyte - % Core Wgt.		17%	17%	18%	19%	20%
No. Cell Averaged.		6	5	5	3	2
Cycle After 50 Automatic Cycles As Per Test Plan 2; Sec. C.						
Avg. 2 Cycles:						
Charge 8 Hr.	End. Ch. Volt.	1.37	1.41	1.39	1.42	1.39
Disch 1 Hr. Rate	5 Sec. Volt.	1.23	1.15	1.165	1.145	1.19
Amb. Temp. 75°F.	Mid. V. 1.0V	1.15	1.06	1.105	1.07	1.125
	Time to Minutes 1.0V	45.5	37.9	41.0	30.1	42.3
	Time to Minutes 0.60v	63.0	55.1	55.8	53.0	62.8
Supp. Disch. at 5 Hr. Rate To 0.60V Time		26.0	25.0	28.2	31.0	23.8
Avg. of Three (3) Cycles Before 50 Automatic Cycles As Per Test Plan 2, Sec. B.						
Charge 8 Hr.	End Ch. Volt.	1.41	1.44	1.42	1.44	1.42
Disch. 1 Hr. Rate.	5 Sec. Volt.	1.25	1.14	1.21	1.19	1.24
Amb. Temp. 75°F.	Mid. V. 1.0V	1.17	1.03	1.11	1.08	1.13
	Time to Minutes 1.0V	86.1	40.4	62.8	56.8	82.0
	Time to Minutes 0.60V	92.5	80.5	79.3	78.8	95.5
Supp. Disch. at 5 Hr. Rate to 0.60v		17.9	57.0	41.6	54.0	29.7

SUMMARY OF DATA

TEST PLAN 2; SEC. B. SEPARATOR # 7095-7

Cycling Rates:

Charge 8 Hr. 600 M. A.

16 Hr. 300 M. A.

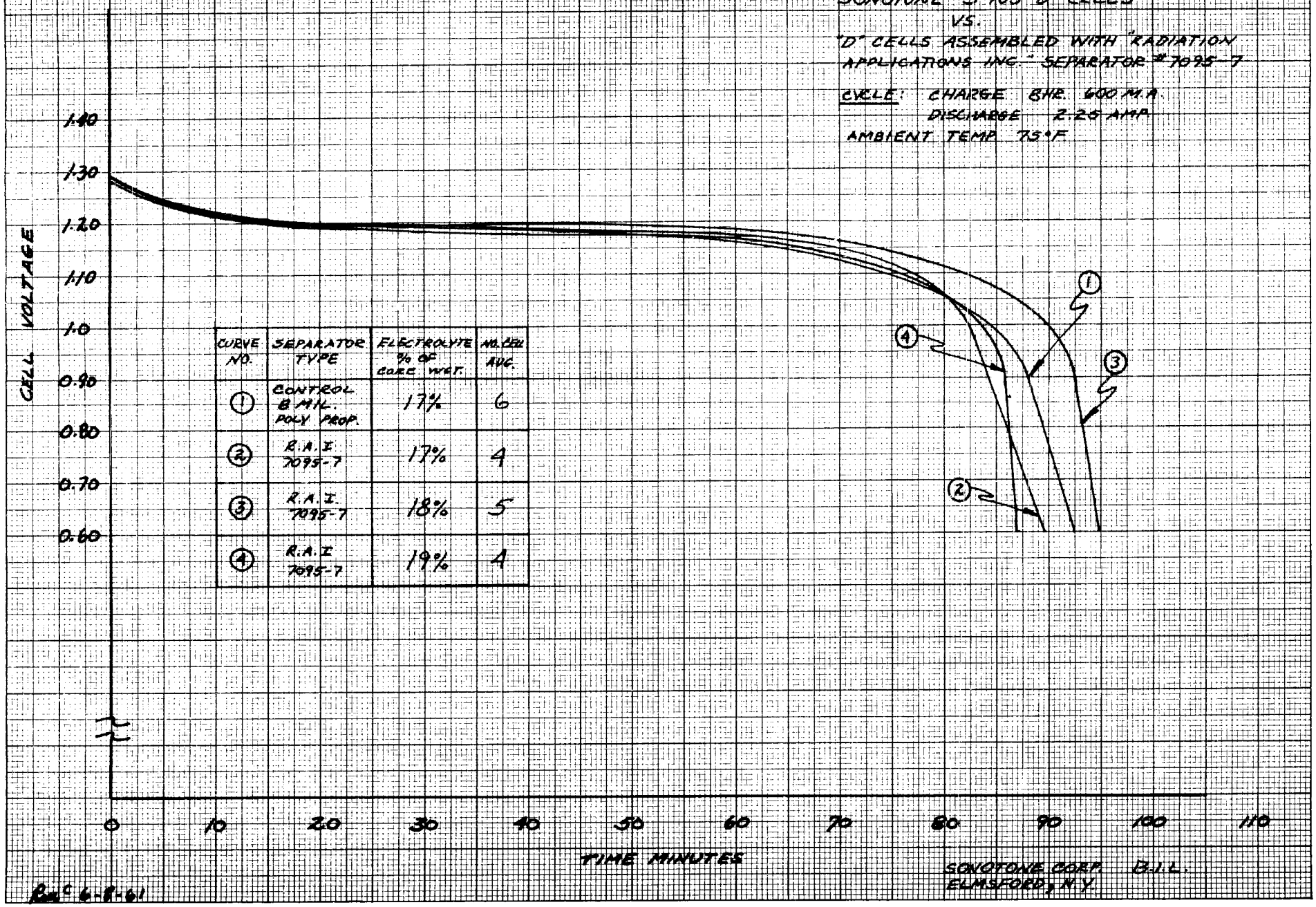
Discharge 5 Hr. Rate 560 M.A.

1 Hr. Rate 2.25 Amp.

Cells		Control	Test	Test	Test
Separator Type		Poly Prop.	7095-7	7095-7	7095-7
Separator Thickness - Mils.		8	3	3	3
Electrolyte - % Core Wgt.		17%	17%	18%	19%
No. Cells Averaged		6	4	5	4
No. of Cells Which Developed Snorts		0	0	0	1
Cycle #1	End of Charge Voltage	1.44-	1.42	1.42	1.41
Charge 16 Hr.	End of Charge Temp.	76°	76°	76°	76°
Disch. 5 Hr. Rate	5 Sec. Voltage	1.34*	1.33	1.34-	1.34-
Amb. Temp. 75°F	Mid. Volt. at 1.0V E.P.	1.21	1.20	1.21	1.22
	Time to 1.0V (Min.)	384.8	393.7	395.6	386.2
	Time to 0.6V (Min.)	396.7	398.7	401.4	392.8
Avg. Cycle #2, 3 & 4					
	End of Charge Volt.	1.45	1.45	1.45	1.43
Charge 8 Hr.	End of Charge Temp.	81°F	81°F	81°F	81°F
Disch. 5 Hr. Rate	5 Sec. Voltage	1.29	1.29	1.29	1.28
Amb. Temp. 75°F	Mid. Volt. at 1.0V E.P.	1.18	1.19	1.19	1.19
	Time to 1.0V (Min.)	84.2	84.1	89.7	83.2
	Time to 0.6V (Min.)	92.4	89.7	94.7	87.1
Supp. Disch. at 5 Hr. Rate to 0.6V (Min.)		16.3	18.5	17.9	11.2

DISCHARGE CHARACTERISTICS (AVG. 3 CYCLES)
SONOTONE S-103 "D" CELLS
VS.
"D" CELLS ASSEMBLED WITH "RADIATION APPLICATIONS INC." SEPARATOR #7095-7

CYCLE: CHARGE 8HR. 600 M.A.
DISCHARGE 2.25 AMP.
AMBIENT TEMP. 73°F



CURVE NO.	SEPARATOR TYPE	ELECTROLYTE % OF CORE WGT.	NO. PER AVG.
1	CONTROL 8 MIL. POLY PROP.	17%	6
2	R.A.I. 7095-7	17%	4
3	R.A.I. 7095-7	18%	5
4	R.A.I. 7095-7	19%	4

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6-8-61

DATA RECORDED DURING AUTOMATIC CYCLING.

TEST PLAN 2; SEC. C R.A.I. SEP. #7095-7

END OF CHARGE VOLTAGE

	CONTROLS						17% TEST				18% Test					19% TEST				
CELL #	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	1	2	3	4	5
CYCLE #																				SHORTED CELL
12	1.39	1.38	1.39	1.40	1.39	1.41	1.41	1.43	1.39	1.40	1.40	1.41	1.41	1.41	1.45	1.39	1.38	1.39 +	1.40	
21	1.38	1.37	1.37	1.39	1.38	1.40	1.39	1.41	1.37	1.38	1.39	1.39	1.37	1.37	1.42	1.37	1.38	1.37 +	1.38	
27	1.39	1.38	1.38 +	1.39	1.39	1.40	1.40	1.43	*	1.39	1.39	1.40 +	1.39	1.40	1.43	1.38	1.40	1.38	1.40	
32	1.39	1.38	1.39	1.39	1.39	1.40	1.41	1.42	-	1.39	1.39	1.40	1.39	1.40	1.44	1.39	1.40	1.39	1.40	
48	1.39	1.38	1.37	1.40	1.39	1.39 +	1.41	1.41	-	1.39	1.39	1.40	1.40	1.39	1.44	1.39	1.40	1.39	1.40	

NOTE: * CELL (17% TEST) EXPLODED DURING DISCHARGE #24.

R CELLS WERE DRIVEN REVERSE BEFORE THE DISCHARGE CYCLE WAS COMPLETED.

AT THE END OF CHARGE.

CY#	CONTROLS						17% TEST				18% TEST					19% TEST				
CELL #	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	1	2	3	4	5
27	101	111	112	110	110	105	107	118	-	109	109	116	120	118	114	112	116	118	116	-
50	102	110	111	112	111	108	110	117	-	112	110	119	124	117	116	112	117	119	115	-

SUMMARY OF DATA

TEST PLAN 2; SEC. D R.A.I. SEPARATOR #7095-7

Cycling Rates:

Charge 600 M.A. - 8 Hr.

Discharge 2.25 Amp. (End Pt. 1.0v; 0.60V)

Cells		Controls	Test	Test	Test
Separator Type		P.P	7095-7	7095-7	7095-7
Electrolyte - %Core wt.		17%	17%	18%	19%
Avg. Three (3) Cycles Before Test Plan 2; Sec. C. (50 Automatic Cyclers)					
Charge: 600 M.A.	End Ch. Volt	1.45	1.45	1.45	1.43
Disch. 2.25 Amp.	5 Sec. Volt.	1.29	1.29	1.29	1.29
Amp. Temp. 75°F	Mid. V. 1.0V	1.18	1.19	1.19	1.19
	Time to 1.0V	84.2	84.1	89.7	83.2
	Time to 0.60V	92.4	89.7	94.7	87.1
Supp. Disch. at 560 M.A. to 0.60V (Time)		16.3	18.5	17.9	11.2
First Cycle After Test Plan 2; Sec.C					
Charge: 600 M.A.	End Ch. Volt.	1.39	1.40	1.41	1.40
Disch. 2.25 Amp.	5 Sec. Volt.	1.25	1.25	1.25	1.25
Amp. Temp. 80°F	Mid V. to 1.0V	1.17	1.19	1.19	1.19
	Time to 1.0V	46.9	49.1	51.4	58.1
	Time to 0.60V	58.4	56.6	56.8	65.0
Supp. Disch. at 560 M.A. to 0.60V (Time)		33.4	37.9	35.5	27.0
Second Cycle After Test Plan 2; Sec.C.					
Charge: 600 M.A.	End Ch. Volt.	1.43	1.43	1.43	1.42
Disch. 2.25 Amp.	5 Sec. Volt.	1.28	1.28	1.26	1.26
Amp. Temp. 80°F	Mid. V. to 1.0V	1.19	1.19	1.19+	1.19+
	Time to 1.0V	76.6	61.7	56.2	58.8
	Time to 0.60V	86.6	68.0	62.4	63.5
Supp. Disch. at 560 M.A. to 0.60V (Time)		27.0	41.0	32.4	27.1

SUMMARY OF DATA

Cycling Rates:

8 Hr. Charge - 600 M.A.
1 Hr. Discharge - 2.25 Amp.

R.A.I. SEPARATOR #7095-8

Cells	Control	Test	Test	Test
Separator Type	Poly Propylene	7095-8	7095-8	7095-8
Electrolyte - %Core Wt.	17%	17%	18%	19%
No. Of Cells	5	5	5	5

Avg. of Three (3) Cycles Before Test Plan 2; Sec. C.

Charge - 8 Hr. Rate	End of Charge Volt	1.43	1.45	1.47	1.47
Discharge - Hr. Rate	Range	.06	.05	.03	.03
Amb. Temp. 80°F	5 Sec. Volt.	1.30	1.31	1.31	1.30
	Range	.06	.03	.04	.04
Discharge	Mid. Volt (1.0V EP)	1.17	1.20	1.19	1.19
	Range	.04	.04	.02	.03
	Time to 1.0 Volt. (Min.)	86.6	100.7	94.1	97
	Range	18.2	32	14.8	13.4
	Time to 0.60 Volt (Min.)	96.3	107.6	103.8	103.7
	Range	13.9	28.1	22.4	18.4

Avg. of Two (2) Cycles After Test Plan 2; Sec. C

	No. Of Cells	5	4	3	3
Charge 8 Hr. Rate	End of Charge Volt.	1.41	1.46	1.51	1.47
Discharge 1 Hr. Rate	Range	.07	.13	.06	.06
Amb. Temp. 80°F	5 Sec. Volt.	1.24	1.25	1.23	1.23
	Range	.04	.06	.02	.02
Discharge	Mid Volt. (1.0V E.P.)	1.16	1.17	1.14	1.15
	Range	.12	.06	.03	.07
	Time to 1.0 Volt (Min)	61.7	70.9	46.2	33.7
	Range	40.8	30.5	31.3	6.7
	Time to 0.60 Volt (Min)	75	84.6	67.4	60.9
	Range	43.8	25.6	10.5	21.9

DATA RECORDED DURING AUTOMATIC CYCLING

TEST PLAN 2; SEC. C. R.A.I. SEPARATOR # 7095-8

CYCLE #	CONTROLS 1	2	3	4	5	17% TEST 1	2	3	4	5	18% TEST 1	2	3	4	5	1	2	3	4	5
							A					B						C		
2	1.41	1.40	1.37	1.39	1.40	1.51	1.50	1.44	1.48	1.47	1.51	1.50	1.60	1.50		1.53	1.50	1.48	1.52	1.56
12	1.44	1.45	1.42	1.45	1.43	1.45		1.46	1.58	1.45	1.47	1.49	1.65	1.52		1.63	1.49		1.61	1.61
19	1.54	1.41	1.38	1.39	1.40	1.53		1.43	1.46	1.48	1.61	1.51	1.65	1.55		1.60	1.52		1.60	1.62
22	1.48	1.41	1.39	1.40	1.40	1.54		1.44	1.45	1.52	1.65	1.50	1.50	1.58		1.68	1.52		1.62	1.72
25	1.48	1.41	1.39	1.40	1.40	1.51		1.44	1.45	1.52	1.52	1.50	1.51	1.48		1.54	1.53		1.48	1.60
34	1.48	1.41	1.39	1.39	1.41	1.52		1.44	1.44	1.62	1.51	1.51	1.50	1.47		1.51	1.62		1.47	1.52
37	1.47	1.41	1.39	1.40	1.41	1.52		1.43	1.44	1.66	1.51	1.51	1.54	1.48		1.47	1.61		1.48	1.47
44	1.46	1.41	1.39	1.39	1.40	1.54		1.44	1.44	1.59	1.51	1.58	1.49	1.47		1.51	1.57		1.47	1.49
46	1.47	1.42	1.40	1.40	1.41	1.54		1.44	1.44	1.50	1.52	1.58	1.50	1.46		1.52	1.56		1.47	1.52
50	1.42	1.42	1.40	1.41	1.42	1.48		1.46	1.46	1.54	1.55	1.60	1.55	1.42		1.58	1.62		1.42	1.55

NOTE: A CELL RUPTURED DURING CHARGE #3
B CELL RUPTURED DURING CHARGE #2
C CELL RUPTURED DURING CHARGE #12

CYCLE: CHARGE 0.685 AMP - 7 HRS.

DISCHARGE 2.25 AMP - 1 HR.

DATA RECORDED DURING AUTOMATIC CYCLING

TEST PLAN 2; SEC. C. R.A.I. SEPARATOR #7095-8

CYCLE #	CONTROL					17% TEST					18% TEST					19% TEST				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3	1.13	1.15	1.15	1.15	1.15	1.18	1.17	1.16	1.19	1.16	1.17		1.16	1.17	1.17	1.15	1.17	1.17		1.19
4	1.18	1.18	1.18	1.18	1.18	1.20		1.19	1.21	1.18	1.19		1.18	1.20	1.19	1.18	1.18	1.19	1.19	1.20
16	1.11	1.13	1.12	1.14	1.13	1.16		1.14	1.16	1.14	1.16		1.14	1.14	1.16	1.14	1.16		1.15	1.16
19	1.11	1.14	1.14	1.14	1.14	1.16		1.16	1.16	1.15	1.17		1.16	.98	1.16	1.11	1.16		1.14	1.15
22	1.12	1.16	1.15	1.16	1.15	1.18		1.17	1.17	1.17	1.15		1.15	.89	1.16	1.04	1.17		1.12	1.06
25	1.10	1.15	1.14	1.15	1.14	1.17		1.15	1.16	1.16	1.10		1.15	.48	1.10	.56	1.16		1.08	.79
34	1.07	1.15	1.14	1.15	1.15	1.18		1.16	1.16	1.15	1.07		1.14	R	1.05	.92	1.05		1.06	R
37	1.02	1.14	1.14	1.15	1.14	1.16		1.16	1.15	1.13	1.04		1.13	R	1.01	.91	1.02		1.03	R
44	1.03	1.16	1.14	1.16	1.15	1.18		1.17	1.15	1.14	1.06		1.13	R	1.02	.97	1.08		1.04	R
46	.96	1.15	1.12	1.14	1.13	1.17		1.16	1.14	1.13	1.03		1.12	R	.97	.95	1.05		1.01	R
50	.93	1.14	1.13	1.15	1.14	1.15		1.15	1.13	1.13	.99		1.11	R	.99	.93	1.0		1.0	R

NOTE: VOLTAGE WAS RECORDED AT THE END OF 40 MINUTES (CYCLE #4)

R = CELL WAS REVERSED AT THE END OF DISCHARGE CYCLE.

SUMMARY OF DATA

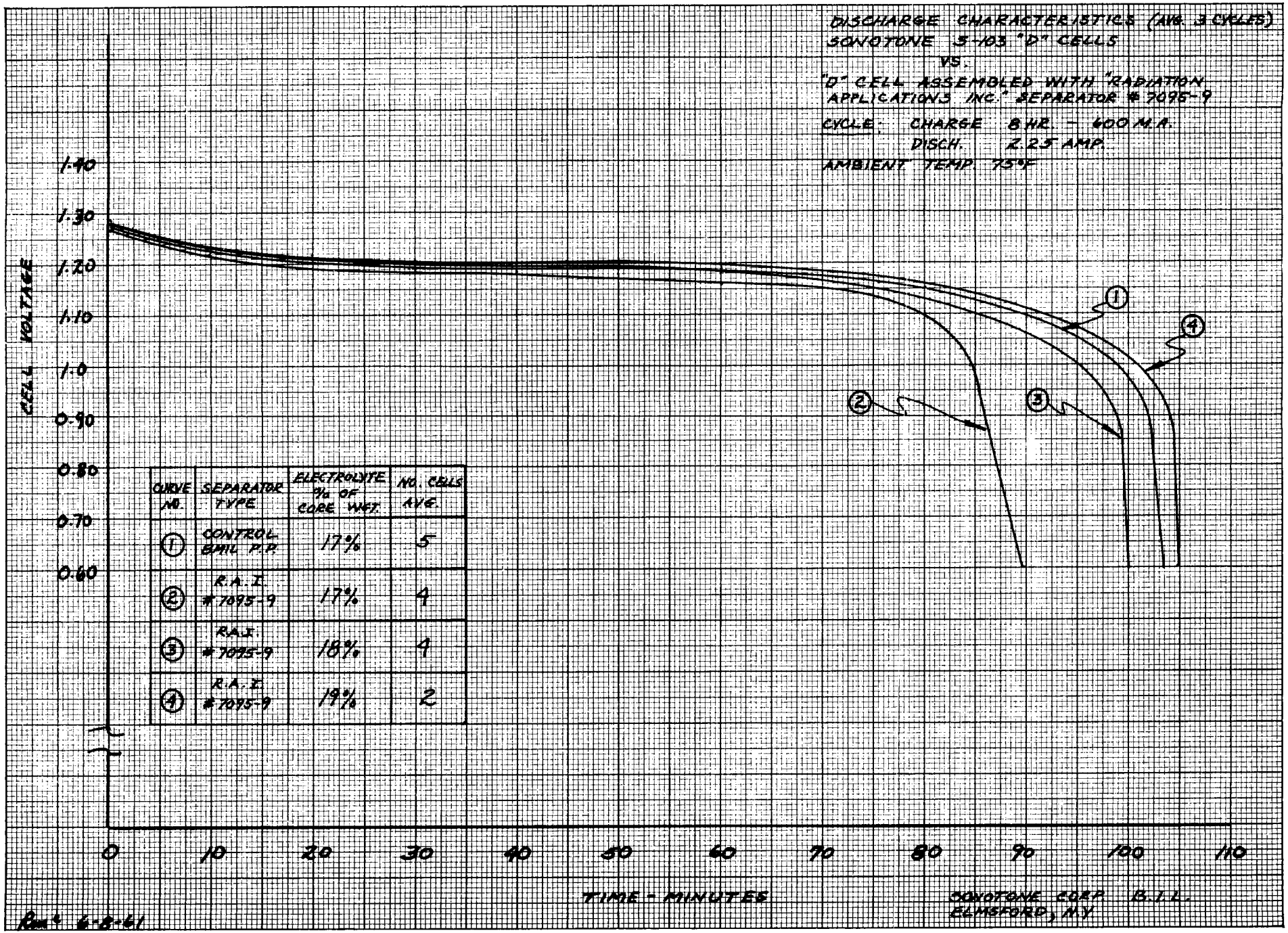
TEST PLAN 2; SEC. b. SEPARATOR #7095-9

Cycling Rates:

Charge 8 Hr. 600 M. A.
16 Hr. 300 M. A.

Discharge 5 Hr. Rate 560 M.A.
1 Hr. Rate 2.25 Amp.

	Cells	Controls	Test	Test	Test
	Separator Type	Poly Prop.	7095-9	7095-9	7095-9
	Separator Thickness-Mils	8	2.5	2.5	2.5
	Electrolyte - % of Core Wgt.	17%	17%	18%	19%
	No. Cells Averaged	5	4	4	2
	No. Of Cells Which Developed Shorts	0	0	0	1
Cycle #1	End Of Charge Voltage	1.41	1.43	1.43	1.42
Charge 16 Hr.	End Of Charge Temp.	76°F	76°F	76°F	76°F
Disch. 5 Hr. Rate	5 Sec. Voltage	1.33	1.32	1.33	1.33
Amb. Temp. 75°F	Mid. Voltage to 1.0V EP	1.21+	1.21	1.22	1.22
	Time to 1.0V (Min)	420.1	387.2	403.8	407.8
	Time to 0.60V (Min)	426.3	405.2	409.9	415.1
Avg. Cycles 2,3&4	End Of Charge Voltage	1.42	1.46	1.45	1.45
Charge 8 Hr.	End Of Charge Temp.	81°F	83°F	81°F	81°F
Disch. 1 Hr. Rate	5 Sec. Voltage	1.28	1.27	1.29	1.29
Amb. Temp. 75°F.	Mid. Voltage to 1.0V E.P.	1.19	1.18	1.20	1.20
	Time to 1.0V Min.	98.6	84.4	95.3	101.9
	Time to 0.60V Min.	103.5	89.8	100.0	104.7
	Supp. Disch. At 5 Hr. Rate to 0.60V (Min.)	15.4	15.3	16.6	11.6


DISCHARGE CHARACTERISTICS (AVG. 3 CYCLES)
SONOTONE S-103 "D" CELLS
VS.
"D" CELL ASSEMBLED WITH "RADIATION APPLICATIONS INC." SEPARATOR # 7095-9
CYCLE: CHARGE 8 HR. - 600 M.A.
DISCH. 2.25 AMP.
AMBIENT TEMP. 75°F
CELL VOLTAGE
1.40
1.30
1.20
1.10
1.0
0.90
0.80
0.70
0.60
0
10
20
30
40
50
60
70
80
90
100
110
TIME - MINUTES
1
2
3
4
CURVE NO. | SEPARATOR TYPE | ELECTROLYTE % OF CORE WGT. | NO. CELLS AVG.
1 | CONTROL EMIL P.P. | 17% | 5
2 | R.A.I. # 7095-9 | 17% | 4
3 | R.A.I. # 7095-9 | 18% | 4
4 | R.A.I. # 7095-9 | 19% | 2
SONOTONE CORP. B.I.L.
ELMSFORD, N.Y.
Rev. 6-8-61

DATA RECORDED DURING AUTOMATIC CYCLING
TEST PLAN 2; SEC. C. R.A.I. SEP. #7095-9

END OF CHARGE VOLTAGE

CELL TYPE	CONTROLS					17% TEST				18% TEST				19% TEST	
CELL NO.	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
CYCLE # 8	1.39	1.40	1.39	1.39	1.39	1.46	1.48	1.49	1.52	1.47	1.47	1.50	1.46	1.52	1.50
12	1.39	1.40	1.39	1.39	1.39	1.48	1.47	1.50	1.51	1.48	1.47	1.51	1.48	1.53	1.51
21	1.38	1.39	1.38	1.38	1.38	1.46	1.43	1.47	1.47	1.45	1.43	1.46	1.42	1.49	1.46
27	1.38	1.39	1.38	1.38+	1.39	1.48	1.46	1.52	1.51	1.47	1.46	1.52	1.45	1.53	1.49
49	1.39	1.38	1.38	1.38	1.39	1.48	1.47	1.51	1.50	1.48	1.47	1.50	1.47	1.53	1.48+

NOTE: BULGED CELL CASES WERE OBSERVED ON ALL TEST CELLS AT CHARGE CYCLE #8

CELL TEMPERATURES RECORDED DURING CYCLING ^{0}F.

AT THE END OF CHARGE

CELL TYPE	CONTROLS					17% TEST				18% TEST				19% TEST	
CELL NO.	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
CYCLE #															
37	98	100	101	103	100	103	108	110	109	111	108	108	100	97	101
50	101	105	107	105	104	105	109	116	112	113	1.131	107	103	100	102

DATA RECORDED DURING AUTOMATIC CYCLING
TEST PLAN 2; SEC. C. R.A.I. SEP. #7095-9

END OF DISCHARGE VOLTAGE

CELL TYPE	CONTROLS					17% TEST				18% TEST				19% TEST	
CELL NO.	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
CYCLE #															
1	1.12	1.18	1.18	1.18	1.18	1.16	1.13	1.18	1.18	1.19	1.18	1.18	1.17	1.19	1.18
4	1.15	1.15	1.15	1.15	1.15	1.11	1.10	1.14	1.15	1.16	1.13	1.15	1.14	1.16	1.16
13	1.14	1.13	1.15	1.13	1.14	1.13	1.10	1.13	1.15	1.15	1.13	1.15	1.14	1.16	1.16
42	1.14	1.13	1.14	1.14	1.14	1.15	1.15	1.13	1.15	1.15	1.14	1.14	1.14	1.15	1.15
50	1.14	1.13	1.14	1.13	1.13	1.14	1.14	1.14	1.15	1.15	1.14	1.14	1.15	1.15	1.15

NOTE: BULGED CELL CASES WERE OBSERVED ON ALL TEST CELLS AT CHARGE CYCLE #8

AT THE END OF DISCHARGE

CELL TYPE	CONTROLS					17% TEST				18% TEST				19% TEST	
CELL NO.	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
CYCLE #															
37	100	107	110	111	104	127	124	125	127	116	123	121	110	117	119
50	104	112	112	113	109	137	139	135	136	118	131	131	112	122	127

CELL TEMPERATURES RECORDED DURING CYCLING °F

SUMMARY OF DATA

TEST PLAN 2; SEC. D R.A.I. SEP. #7095-9

Cells		Controls	Test	Test	Test
Separator Type		P.P.	7095-9	7095-9	7095-9
Electrolyte - % Core Wgt.		17%	17%	18%	19%
Avg. Three (3) Cycles Before Test Plan 2; Sec. C					
Charge - 8 Hr.	End. Ch. Volt.	1.42	1.46	1.45	1.45
Disch. 1 Hr. Rate	5 Sec. Volt.	1.28	1.27	1.29	1.29
Amb. Temp.	Mid. V. (1.0V)	1.19	1.18	1.20	1.20
	Time to 1.0V	98.6	84.4	95.3	101.9
	Time to 0.60V	103.5	89.8	100.0	104.7
Supp. Disch. at 560 M.A. to 0.60V		15.4	15.3	16.6	11.6
Avg. Two (2) Cycles After Test Plan 2; Sec. C					
Charge - 8 Hr.	End. Ch. Volt.	1.42	1.50	1.48	1.50+
Disch. 1 Hr. Rate	5 Sec. Volt.	1.29	1.28	1.28+	1.295
Amb. Temp.	Mid. V (1.0V)	1.195	1.20	I.20+	1.21+
	Time to 1.0V	86.9	95.3	98.2	107.5
	Time to 0.60V	96.9	103.6	106.1	112.3
Supp. Disch at 560 M.A. to 0.60V		15.1	12.7	12.8	15.4

SUMMARY OF DATA

Cycling Rates:

8 Hr. Charge - 600 M.A.
1 Hr. Discharge - 2.25 Amp.

R.A.I. SEPARATOR #7095-13

Cells	4 Control	Test	Test	Test
Separator Type	Poly Propylene	7095-13	7095-13	7095-13
Electrolyte-% Core Wt.	17%	17%	18%	19%
No. of Cells				

Avg. of Three (3) Cycles Before Test Plan 2; Sec. C

	No. Of Cells	4	5	5	5
Charge 8 Hr. Rate	End of Charge Volt	1.46	1.46	1.45	1.45
Discharge - 1 Hr. Rate	Range	.14	.04	.05	.05
Amb. Temp. 80°F					
Discharge	5 Sec. Volt.	1.30	1.30	1.31	1.31
	Range	.03	.01	.03	.02
	Mid. Volt (1.0VEP)	1.17	1.19	1.20	1.20
	Range	.01	.02	.02	.01
	Time to 1.0V (Min)	83.5	93.9	100.8	101
	Range	17.2	6.0	14.4	10.5
	Time to 0.60V (Min)	88.4	97.6	103.4	103.6
	Range	19.1	6.4	15.4	12.9

Avg. of Two (2) Cycles After Test Plan 2; Sec. C

	No. Of Cells	4	5	5	5
Charge 8 Hr. Rate	End of Charge Volt	1.42	1.44	1.44	1.42
Discharge 1 Hr. Rate	Range	.10	.11	.15	.12
Amb. Temp. 80°F	5 Sec. Volt.	1.27	1.27	1.27	1.28
	Range	.04	.04	.06	.05
Discharge	Mid. Volt (1.0V EP)	1.17	1.17	1.17	1.16
	Range	.02	.04	.06	.13
	Time to 1.0V (Min)	66.6	80.5	75.6	85.2
	Range	11.3	24.3	28.9	31.2
	Time to 0.6V (Min)	80.1	88.2	87.7	90.0
	Range	9.1	11.5	26.3	28.0

DATA RECORDED DURING AUTOMATIC CYCLING

TEST PLAN 2; SEC. C R.A.I. SEPARATOR #7095-13

END OF CHARGE VOLTAGE

CELL #	CONTROLS 1	2	3	4	17% TEST 1	2	3	4	5	18% TEST 1	2	3	4	5	19% TEST 1	2	3	4	5
CYCLE #2	1.40	1.43	1.41	1.39	1.39	1.38	1.37	1.40	1.39	1.39	1.39	1.37	1.36	1.37	1.40	1.39	1.38	1.38	1.39
12	1.43	1.52	1.44	1.44	1.43	1.44	1.44	1.44	1.42	1.43	1.43	1.45	1.43	1.44	1.52	1.43	1.43	1.42	1.43
19	1.40	1.42	1.40	1.38	1.39	1.39	1.38	1.40	1.40	1.40	1.48	1.39	1.37	1.38	1.48	1.39	1.38	1.38	1.40
22	1.40	1.42	1.40	1.39	1.39	1.39	1.39	1.40	1.40	1.40	1.38	1.39	1.37	1.38	1.48	1.39	1.39	1.38	1.39
25	1.41	1.42	1.39	1.39	1139	1.39	1.38	1.40	1.40	1.40	1.38	1.39	1.37	1.38	1.45	1.39	1.39	1.38	1.40
34	1.41	1.42	1.40	1.39	1.40	1.49	1.39	1.40	1.40	1.40	1.38	1.40	1.38	1.38	1.42	1.39	1.39	1.38	1.40
37	1.41	1.42	1.39	1.39	1.39	1.39	1.39	1.40	1.40	1.40	1.38	1.39	1.38	1.38	1.43	1.39	1.39	1.38	1.39
44	1.41	1.41	1.39	1.39	1.40	1.39	1.39	1.40	1.40	1.40	1.38	1.39	1.38	1.39	1.41	1.41	1.39	1.38	1.40
46	1.42	1.42	1.40	1.40	1.40	1.40	1.40	1.41	1.41	1.41	1.39	1.40	1.38	1.39	1.42	1.40	140	1.39	1.40
50	1.41	1.41	1.40	1.40	1.40	1.40	1.40	1.40	1.41	1.41	1.40	1.40	1.39	1.40	1.44	1.40	1.40	140	1.41

DATA RECORDED DURING AUTOMATIC CYCLING

TEST PLAN 2; SEC C, R.A.I. SEPARATOR #7095-13

END OF DISCHARGE VOLTAGE

	CONTROLS				17% TEST					18% TEST					19% TEST				
	1	2	3	4	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
CYCLE #3	1.13	1.13	1.13	1.13	1.16	1.16	1.16	1.17	1.16	1.18	1.17	1.16	1.16	1.18	1.19	1.18	1.17		1.18
4	1.18	1.18	1.18	1.18	1.20	1.20	1.19	1.20	1.19	1.20	1.20	1.19	1.20	1.20	1.21	1.20	1.20	1.20	1.20
16	1.13	1.13	1.13	1.13	1.15	1.15	1.14	1.16	1.15	1.16	1.15	1.14	1.14	1.16	1.18	1.16	1.15	1.16	1.16
19	1.14	1.14	1.14	1.14	1.16	1.16	1.15	1.16	1.16	1.18	1.16	1.16	1.16	1.17	1.18	1.17	1.16	1.16	1.18
22	1.15	1.15	1.16	1.15	1.17	1.17	1.17	1.18	1.17	1.18	1.18	1.16	1.17	1.18	1.19	1.18	1.17	1.17	1.18
25	1.14	1.14	1.15	1.14	1.17	1.16	1.16	1.17	1.17	1.18	1.17	1.16	1.16	1.18	1.18	1.18	1.16	1.17	1.18
34	1.14	1.14	1.15	1.14	1.17	1.16	1.16	1.17	1.17	1.18	1.17	1.16	1.16	1.18	1.18	1.18	1.17	1.17	1.18
37	1.14	1.14	1.14	1.14	1.17	1.16	1.16	1.16	1.16	1.18	1.16	1.15	1.16	1.17	1.18	1.18	1.16	1.16	1.18
44	1.15	1.15	1.15	1.14	1.17	1.16	1.16	1.17	1.17	1.18	1.17	1.15	1.16	1.18	1.18	1.18	1.16	1.16	1.18
46	1.14	1.14	1.14	1.13	1.17	1.16	1.15	1.16	1.16	1.18	1.16	1.15	1.15	1.17	1.18	1.17	1.16	1.16	1.17
50	1.13	1.13	1.14	1.13	1.16	1.16	1.16	1.16	1.16	1.17	1.16	1.14	1.14	1.17	1.17	1.17	1.16	1.16	1.17

NOTE: VOLTAGE WAS RECORDED AT THE END OF 40 MINUTES (CYCLE #4)

CYCLE: CHARGE 0.685 AMP. - 7 HRS.

DISCHARGE 2.25 AMP. - 1 HR.

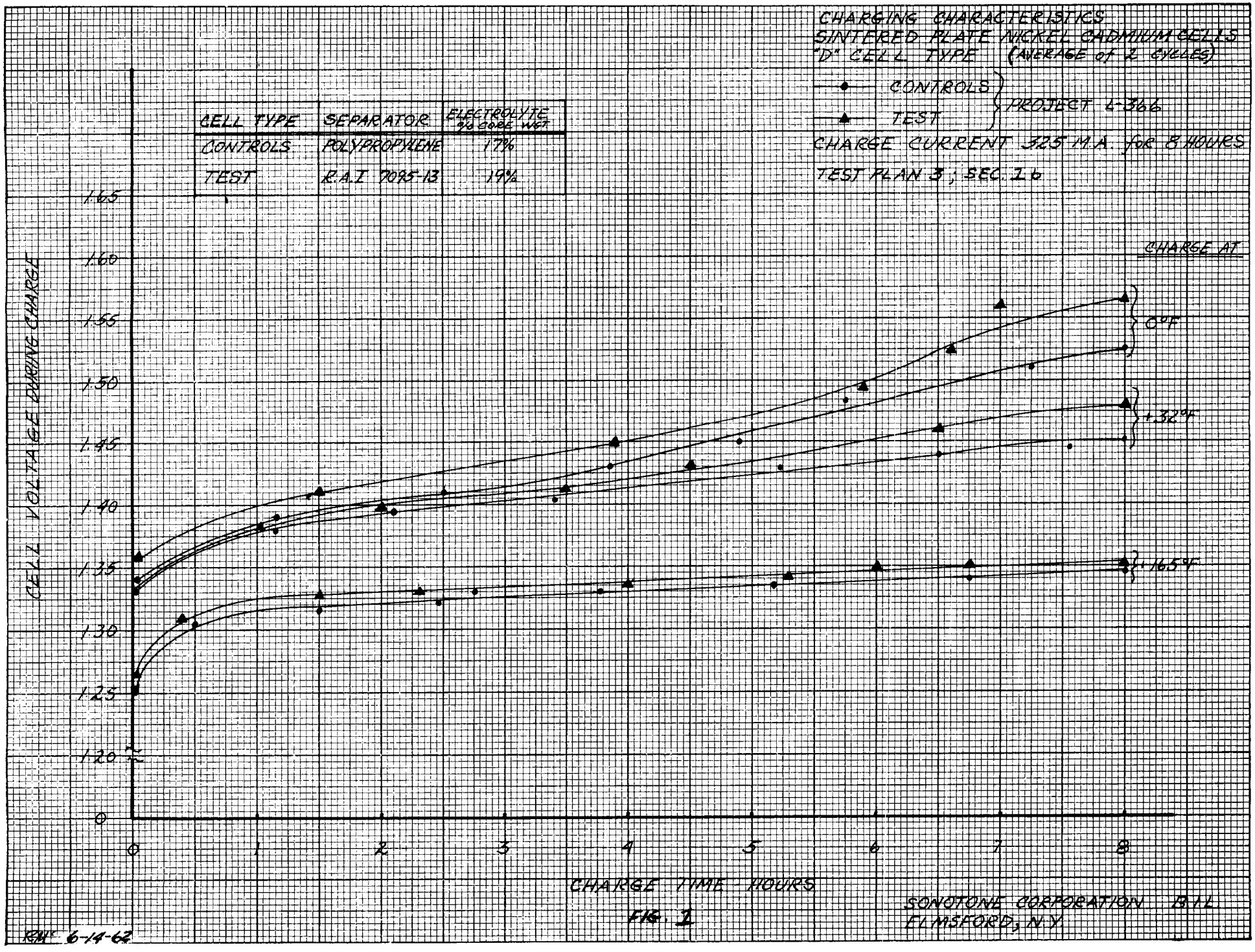

CHARGING CHARACTERISTICS
SINTERED PLATE NICKEL CADMIUM CELLS
"D" CELL TYPE (AVERAGE of 2 CYCLES)
CONTROLS
TEST
PROJECT 4-366
CHARGE CURRENT 325 M.A. for 8 HOURS
TEST PLAN 3 ; SEC. 1 b
CELL TYPE | SEPARATOR | ELECTROLYTE % of CORE WET
CONTROLS | POLYPROPYLENE | 17%
TEST | R.A.I 7095-13 | 19%
CHARGE AT
0°F
+32°F
+165°F
CELL VOLTAGE DURING CHARGE
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
0
0
1
2
3
4
5
6
7
8
CHARGE TIME HOURS
SONOTONE CORPORATION B.I.L.
ELMSFORD, N.Y.
RMF 6-14-62

FIG. 1

R.A.I. SEPARATOR 7095-13 TEST PLAN 3 SEC. 1C

END OF CHARGE VOLTAGE

AMBIENT	165°F					+32°F					0°F				
CELL TYPE	Control		Test			Control		Test			Control		Test		
CELL #	1	2	1	2	3	1	2	1	2	3	1	2	1	2	3
CYCLE #2	1.31	1.31+	1.33	1.33	1.32	1.47	1.47	1.50	1.48	1.48	1.50	1.50	1.52	1.51	1.50
10	1.32	1.32	1.34	1.34	1.33	1.47	1.47	1.50	1.49	1.49	1.52	1.53	1.56	1.54	1.53
13	1.32	1.32	1.33	1.33	1.34	1.48	1.48	1.50+	1.49	1.49	1.52	1.51	1.55	1.55	1.54
30	1.33	1.33	1.34	1.33	1.34	1.47	1.47	1.52	1.50	1.50	1.53	1.52	1.58	1.57	1.55
54	1.33	1.33	0.15	0.04	1.36	1.47	1.47	1.54	1.50	1.50	1.54	1.52	1.59	1.58	1.57
67	1.33+	1.33+	0.10	0.05	1.37	1.48	1.48	1.53	1.49	1.50	1.53	1.52	1.59	1.58	1.57
84	1.33	1.33	0.10	0.04	1.36	1.47	1.46	1.54	1.49+	1.50	1.52	1.52	1.58+	1.58	1.57
100	1.33	1.34	0.10	0.04	1.37	1.47	1.46	1.53	1.50	1.50	1.53	1.52	1.59	1.58	1.58

R= CELL REVERSED AT END OF DISCHARGE.

R.A.I. SEPARATOR 7095-13 TEST PLAN 3 SEC. 1C

CONT.

END OF DISCHARGE VOLTAGE

AMBIENT	165°F					+ 32°F					0°F				
CELL TYPE	Control		Test			Control		Test			Control		Test		
CELL #	1	2	1	2	3	1	2	1	2	3	1	2	1	2	3
CYCLE # 7	1.10	1.11	.90	.96	1.0	.1.20	1.21	1.20	1.18	1.17	1.20	1.20	1.19	1.18	1.18
19	1.03	1.08	R	R	.91	1.19	1.20	1.20	1.18	1.18 +	1.20	1.20	1.19	1.16 +	1.17
33	1.05	1.09	"	"	.83	1.19	1.20	1.22	1.19	1.19	1.22	1.22	1.19	1.17	1.18
54	1.08	1.10	"	"	.41	1.22	1.22	1.22	1.19	1.19	1.20	1.21	1.19	1.18	1.17
67	1.04	1.05	"	"	.22	1.20	1.20	1.20	1.18	1.17	1.22	1.21	1.19	1.17	1.17
78	1.04	1.04	"	"	R	1.21	1.21	1.21	1.18	1.18	1.21	1.21	1.19	1.18	1.17
83	1.04	1.03	"	"	"	1.22	1.22	1.20	1.17	1.17	1.22	1.20	1.20	1.18	1.17
94	1.05	1.02	"	"	"	1.21	1.21	1.20	1.18	1.18	1.21	1.21	1.19	1.16 +	1.18
100	1.04	1.02	"	"	"	1.20 +	1.20	1.20	1.18	1.18	1.22	1.20	1.20	1.18	1.18 +

R CELL REVERSED AT END OF DISCHARGE

CYCLE CHARGE 325M.A. - 7 HR.
DISCH. 1.75 AMP - 1 HR.
AMBIENT TEMP. AS LISTED

NOTE: ALL TEST CELLS CONTAIN 19% ELECTROLYTE

ALL CONTROL CELLS CONTAIN 17% ELECTROLYTE.

xd

SUMMARY OF DATA

TEST PLAN 2; SEC. b. SEPARATOR # 7095-14

CYCLING RATES:

CHARGE 16 HR. - 300 M. A.

8 HR. - 600 M. A.

DISCHARGE 5 HR. RATE 560 M. A.

1 HR. RATE 2.25 AMP.

CELLS		CONTROL	TEST	TEST	TEST
SEPARATOR TYPE		P. P.	#7095-14	#7095-14	#7095-14
SEPARATOR THICKNESS		8 MIL.	10 MIL	10 MIL.	10 MIL.
ELECTROLYTE % CORE WT.		17%	17%	18%	19%
NO. CELLS AVG.		5	5	2	5
CYCLE #1	END OF CHARGE V	1.39	1.40	1.38	1.38
CHARGE 16 HR.	5 SEC. VOLT	1.31	1.31	1.30+	1.31
DISCH. 5 HR. RATE	MID. V AT 1.0VEP	1.21	1.21	1.21-	1.21
AMB. TEMP. 75°F	TIME TO 1.0V	359.4	356.2	343.2	373.3
	0.60V	369.2	361.4	348.6	379.2
AVG. CYCLE 2,3&4	END OF CHARGE V	1.41-	1.44	1.42-	1.42
	5 SEC. VOLT.	1.30	1.27+	1.27+	1.28-
CHARGE 8 HR.					
DISCH. 1 HR. RATE	MID V AT 1.0VEP	1.18+	1.17	1.18	1.18+
AMB. TEMP. 75°F	TIME TO 1.0V	87.7	87.1	88.6	93.3
	0.60V	92.8	90.9	91.9	97.3
SUPP. DISCH AT 5 HR. RATE - MIN. 0.6V		19.0	8.5	6.3	8.9

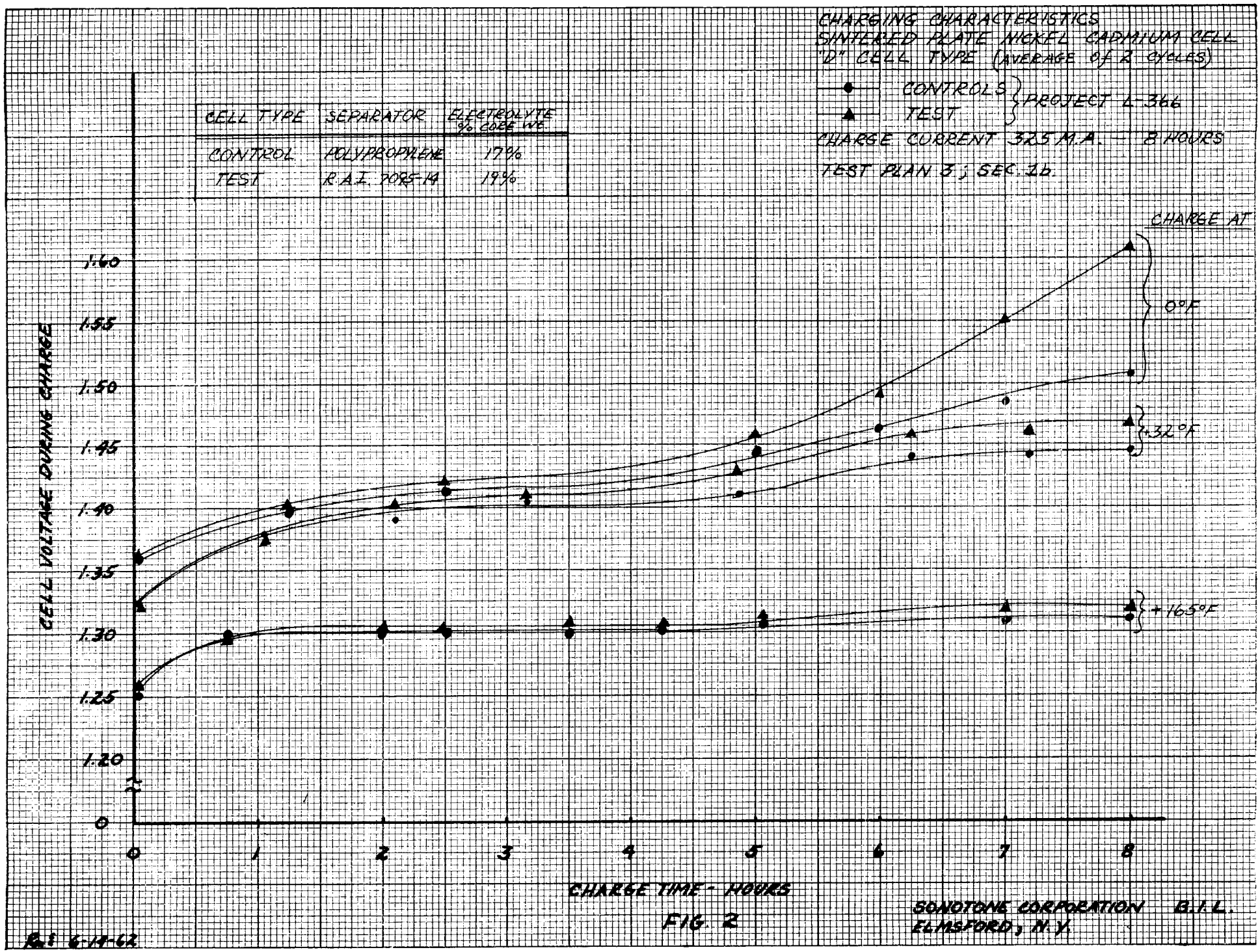
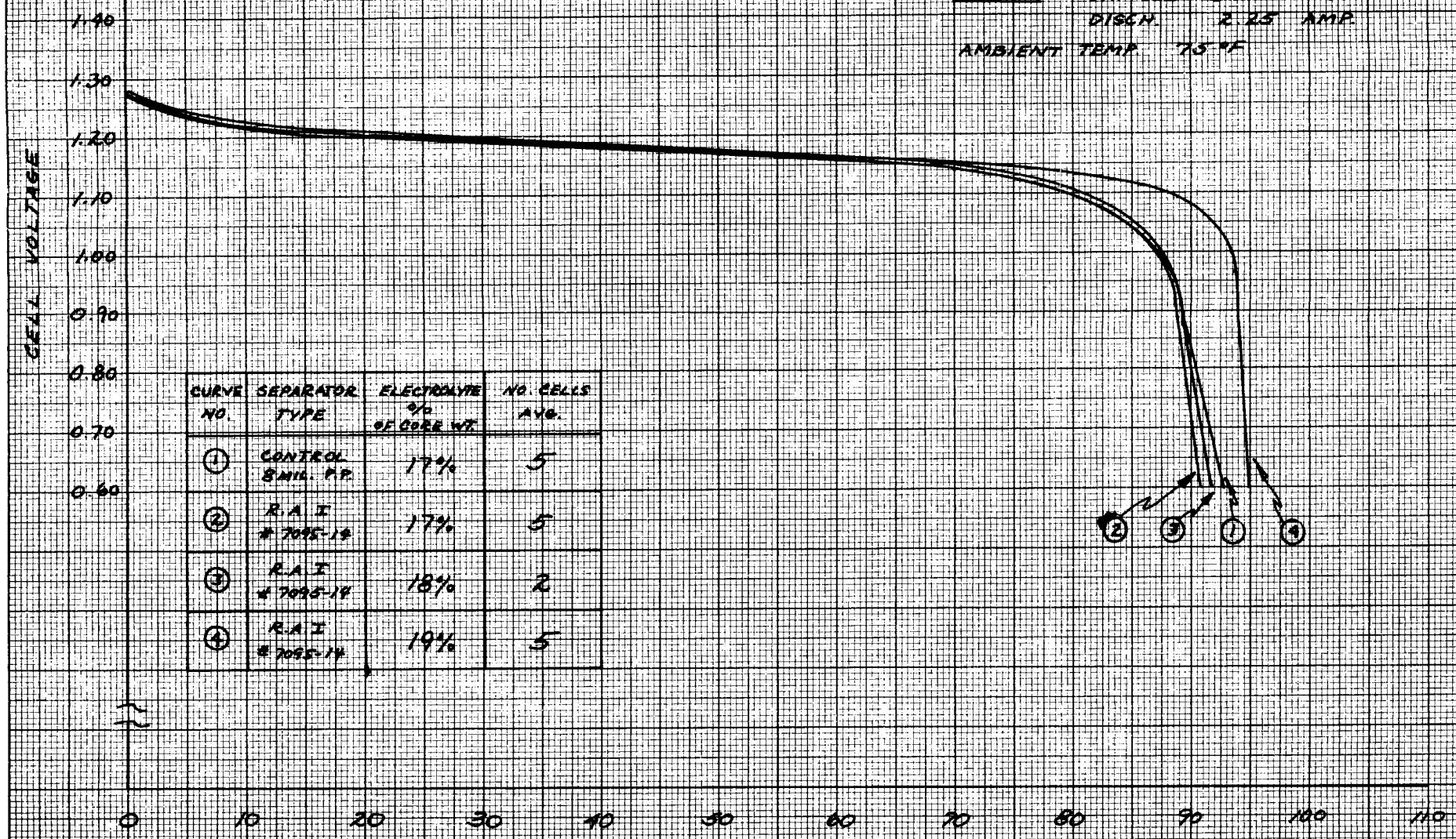

CHARGING CHARACTERISTICS
SINTERED PLATE NICKEL CADMIUM CELL
"D" CELL TYPE (AVERAGE OF 2 CYCLES)
CONTROLS
TEST
PROJECT L-366
CHARGE CURRENT 325 M.A. — 8 HOURS
TEST PLAN 3; SEC. 1b.
CELL TYPE | SEPARATOR | ELECTROLYTE % CORE WT.
CONTROL | POLYPROPYLENE | 17%
TEST | R.A.I. 70RS-14 | 19%
CHARGE AT
0°F
+32°F
+165°F
CELL VOLTAGE DURING CHARGE
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
0
0
1
2
3
4
5
6
7
8
CHARGE TIME - HOURS
SONOTONE CORPORATION B.I.L.
ELMSFORD, N.Y.
R.S. 6-14-62

FIG. 2

DISCHARGE CHARACTERISTICS (AVG 3 CYCLES)
SONOTONE "D" CELLS (CONTROLS)
VS.
"D" CELL ASSEMBLED WITH "RADIATION APPLICATIONS INC." SEPARATOR #7095-14

CYCLE: CHARGE 8 HR. – 600 M.A.
DISCH. 2.25 AMP.

AMBIENT TEMP. 75 °F



CURVE NO.	SEPARATOR TYPE	ELECTROLYTE % OF CORE WT.	NO. CELLS AVG.
1	CONTROL SMIC. P.P.	17%	5
2	R.A.I #7095-14	17%	5
3	R.A.I #7095-14	18%	2
4	R.A.I #7095-14	19%	5

Date: 7-27-61

SONOTONE CORP. G.I.L.
ELMSFORD, N.Y.

APX

DATA RECORDED DURING AUTOMATIC CYCLING
TEST PLAN 2; SEC. C. R.A.I. SEP. # 7095-14

END OF CHARGE VOLTAGE

CELL #	CONTROLS 1	2	3	4	5	17% TEST 1	2	3	4	5	18% TEST 1	2	19% TEST 1	2	3	4	5
CYCLE #																	
6	1.39	1.40	1.40	1.40	1.39	1.39	1.40	1.48	1.40	1.45	1.44	1.40	1.48	1.39	1.40	1.40	1.40
16	1.40	1.39	1.39	1.39	1.40	1.38+	1.40+	1.48	1.39	1.43	1.42	1.39	1.45	1.38	1.39	1.38	1.40
34	1.38	1.38	1.38	1.40	1.39	1.38	1.40	1.45	1.39	1.46	1.42	1.36	1.46	1.39	1.39	1.39	1.39
43	1.38	1.37+	1.37+	1.38+	1.38+	1.38	1.41	1.46	1.39	1.44	1.43	1.38	1.47	1.39	1.39	1.38	1.39
47	1.38	1.38	1.38	1.39	1.39	1.38	1.40	1.44	1.39	1.44	1.42	1.39	1.46	1.39	1.39	1.39	1.38+

CELL TEMPERATURE RECORDED DURING CYCLING °F

CELL #	AT THE END OF CHARGE CONTROLS 1	2	3	4	5	17% TEST 1	2	3	4	5	18% TEST 1	2	19% TEST 1	2	3	4	5
CYCLE #																	
16	91	93	96	99	96	100	100	103	104	100	102	103	106	103	105	101	98
43	103	105	103	102		103	104	107	106	104	106	106	101	104	104	102	102

DATA RECORDED DURING AUTOMATIC CYCLING
TEST PLAN 2; SEC. C. R.A.I. SEP. #7095-14

CON'T.

END OF DISCHARGE VOLTAGE

	CONTROLS					17% TEST					18% TEST		19% TEST				
CELL #	1	2	3	4	5	1	2	3	4	5	1	2	1	2	3	4	5
CYCLE #																	
14	1.14	1.12+	1.14-	1.12	1.14+	1.14	1.10	1.13	1.14	1.13	1.10	1.15	1.15	1.14	1.13	1.15	1.15
18	1.15	1.14+	1.15	1.14+	1.15	1.15	1.12	1.14+	1.16-	1.14	1.12	1.16	1.16	1.15	1.14	1.16	1.15
35	1.10	1.08	1.11	1.10	1.11	1.12	1.07	1.11	1.13	1.11	1.09	1.11	1.13	1.10	1.11	1.11	1.12
38	1.13	1.10	1.12+	1.11	1.10	1.13	1.08	1.12	1.13	1.12	1.09	1.13	1.13	1.12	1.12	1.11	1.13
41	1.12	1.03	1.11	.97	1.11	1.11	1.04	1.11	1.12	1.10	1.06	1.14	1.14	1.11	1.11	1.12	1.12
43	1.10	.99	1.09	.77	1.09	1.08	1.0	1.09	1.11	1.09	1.03	1.13	1.13	1.08	1.10	1.10	1.10
47	1.10	1.0	1.10-	.83	1.10	1.07	.99	1.09	1.11	1.10	.99	1.12	1.13	1.04	1.10	1.09	1.11

CELL TEMPERATURE RECORDED DURING CYCLING ^{0}F

AT THE END OF DISCHARGE

	CONTROLS					17% TEST					18% TEST		19% TEST				
CELL #	1	2	3	4	5	1	2	3	4	5	1	2	1	2	3	4	5
CYCLE #																	
16	94	97	97	95	98	103	107	106	104	102	107	104	101	105	105	103	98
43	100	100	100	104	102	101	100	103	103	102	108	106	104	108	107	105	101

SUMMARY OF DATA

CYCLING RATES:

8 HR. CHARGE - 600 M. A.
1 HR. DISCHARGE - 2.25 AMP.

TEST PLAN 2; SEC. D R.A.I. SEP. #7095-14

CELLS		CONTROL	TEST	TEST	TEST
SEPARATOR TYPE		P. P.	7095-14	7095-14	7095-14
ELECTROLYTE % CORE WT.		17%	17%	18%	19%
AVG. THREE (3) CYCLES BEFORE TEST PLAN 2; SEC. C					
CHARGE - 8 HR	END OF CH. VOLT.	1.41	1.44	1.42	1.42
DISCHARGE 1 HR	5 SEC. VOLT.	1.30 -	1.27 +	1.27 +	1.28 -
AMB. TEMP. 80°F	MID. VOLT (1.0V)	1.18 +	1.17	1.18	1.18 +
	TIME TO 1.0V	87.7	87.1	88.6	93.3
	0.60V	92.8	90.9	91.9	97.3
SUPP. DISCH. AT 5 HR. RATE TO 0.60V (560 M.A.)					
AVG. OF TWO (2) CYCLES AFTER TEST PLAN 2; SEC. C.					
CHARGE - 8 HR.	END OF CH. VOLT	1.42	1.50	1.49	1.46
DISCHARGE 1 HR.	5 SEC. VOLT.	1.29	1.26 +	1.26	1.26
AMB. TEMP. 80°F	MID. VOLT (1.0V)	1.19	1.17	1.16	1.19
	TIME TO 1.0V	84.1	82.9	76.1	85.9
(560 M.A,)	0.60V	90.3	92.1	86.7	93.7
SUPP. DISCH. AT 5 HR. RATE TO 0.60V		23.6	11.3	8.1	12.2

R.A.I. SEPARATOR 7095-14 TEST PLAN 3 SEC. 1C

END OF CHARGE VOLTAGE

AMBIENT	165°F						32°F					0°F		
CELL TYPE	CONTROL		TEST		CONTROL		TEST			CONTROL		TEST		
CELL #	1	2	1	2	1	2	1	2	3	1	2	1	2	3
CYCLE #2	1.31	1.32	1.33	1.34	1.47	1.47	1.58	1.48	1.48	1.52	1.54	1.63	1.53	1.54
10	1.32	1.32	1.34	1.34	1.46	1.46	1.59	1.48	1.48	1.50	1.52	1.60	1.52	1.54
13	1.32	1.33	1.33	1.34	1.47	1.47	1.60	1.49	1.48	1.52	1.54	1.60	1.53	1.54
30	1.32	1.32	1.32	1.34	1.48	1.48	1.60	1.50	1.49	1.53	1.54	1.61	1.54	1.54
54	1.31	1.33	0.15	1.30	1.48	1.48	1.61	1.50	1.50	1.52	1.54	1.62	1.56	1.58
67	1.32	1.32	0.10	0.16	1.48	1.47	1.61	1.51	1.51	1.52	1.53	1.62	1.56	1.60
84	1.32	1.32	0.12	0.10	1.48	1.47	1.61	1.51	1.52	1.51	1.54	1.61	1.58	1.60
100	1.32	1.32	0.10	0.05	1.47	1.47	1.62	1.51	1.52	1.52	1.54	1.61	1.60	1.60

END OF DISCHARGE VOLTAGE

AMBIENT	165°F						32°F					0°F		
CELL TYPE	CONTROL		TEST		CONTROL		TEST			CONTROL		TEST		
CELL #	1	2	1	2	1	2	1	2	3	1	2	1	2	3
CYCLE #7	1.06	1.07	1.0	.96	1.20	1.20	1.20	1.19	1.18	1.20	1.20	1.18	1.18	1.18
19	1.02	1.06	.83	.93	1.19	1.18	1.19	1.16	1.17	1.18	1.20	1.16	1.16	1.16
33	1.03	1.07	.62	.84	1.19	1.18	1.19	1.17	1.17	1.20	1.21	1.18	1.17	1.18
54	1.08	1.09	R	.33	1.20	1.19	1.20	1.19	1.18	1.20	1.20	1.18	1.18	1.18
67	1.04	1.02	R	R	1.20	1.19	1.19	1.18	1.17	1.19	1.20	1.17	1.17	1.18
78	1.03	1.02	"	"	1.20	1.20	1.19	1.18	1.17	1.20	1.21	1.18	1.17	1.18
83	1.02	1.01	"	"	1.19	1.20	1.19	1.18	1.17	1.19	1.20	1.18	1.17	1.18
94	1.02	1.01	"	"	1.19	1.19	1.20	1.18	1.18	1.20	1.20	1.18	1.18	1.18
100	1.02	1.0	"	"	1.20	1.20	1.20	1.18	1.18	1.20	1.21	1.17	1.18	1.18

R CELL REVERSED AT END OF DISCHARGE

CYCLE: CHARGE 325 MA - 7 HRS.
DISCH. 1.75 AMP. - 1 HR.
AMBIENT TEMP. AS LISTED

NOTE: ALL TEST CELLS CONTAIN 19% ELECTROLYE
ALL CONTROL CELLS CONTAIN 17% ELECTROLYTE

SUMMARY OF DATA

CYCLING RATES:

8 HR. CHARGE - 600 M. A.
1 HR. DISCHARGE 2.25 AMP.

R.A.I. SEPARATOR # 7095-17

CELLS	CONTROL	TEST	TEST	TEST
SEPARATOR TYPE	POLY PROPYLENE	7095-17	7095-17	7095-17
ELECTROLYTE % CORE WGT.	17 %	17%	18%	19%

AVG. OF THREE (3) CYCLES BEFORE TEST PLAN 2; SEC. C.

	NO.CELLS	5	5	5	5
CHARGE 8 HR. RATE	END OF CHARGE VOLT	1.45	1.48	1.43	1.44
DISCHARGE - 1 HR. RATE	RANGE	.11	.15	.04	.09
AMB. TEMP. 80°F	5 SEC. VOLT.	1.29	1.25	1.28	1.27
	RANGE	.03	.05	.05	.08
DISCHARGE	MID. VOLT. (1.0V EP)	1.18	1.17	1.18	1.18
	RANGE	.03	.07	.04	.06
	TIME TO 1.0V (MIN.)	91.4	74	85.3	76.4
	RANGE	12.3	29.7	42.5	35.3
	TIME TO 0.6V (MIN)	96.5	78	87.7	79.2
	RANGE	8.9	31.2	43.5	35.8

AVG. OF TWO (2) CYCLES AFTER TEST PLAN 2; SEC. C.

	NO. CELLS	5	5	5	5
CHARGE - 8 HR. RATE	END OF CHARGE VOLT	1.41	1.55	1.45	1.48
DISCHARGE 1 HR. RATE	RANGE	.06	.10	.10	.06
AMB. TEME. 80°F	5 SEC. VOLT.	1.26	1.26	1.27	1.25
	RANGE	.04	.04	.05	.05
DISCHARGE	MID. VOLT (1.0VEP)	1.18	1.15	1.18	1.17
	RANGE	.06	.15	.05	.12
	TIME TO 1.0V (MIN.)	69.4	56.2	77.7	66.6
	RANGE	27.3	41.5	21.9	35
	TIME TO 0.6V (MIN.)	80.9	75.0	83.5	78.3
	RANGE	18.9	27.5	21.1	28.7

DATA RECORDED DURING AUTOMATIC CYCLING
TEST PLAN 2; SEC. C. R.A.I. SEPARATOR #7095-17

END OF CHARGE VOLTAGE

	CONTROLS																			
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
CYCLE #																				
2	1.49	1.38	1.38	1.46	1.39	1.39	1.38	1.37	1.46	1.43	1.40	1.37	1.36	1.37	1.38	1.42	1.38	1.40	1.39	1.40
12	1.41	1.40	1.39	1.49	1.41	1.51	1.42	1.55	1.49	1.47	1.43	1.40	1.39	1.39	1.41	1.44	1.42	1.47	1.44	1.42
19	1.39	1.38	1.38	1.50	1.41	1.51	1.42	1.57	1.50	1.48	1.43	1.39	1.38	1.38	1.40	1.43	1.40	1.44	1.43	1.43
22	1.39	1.38	1.38	1.44	1.41	1.52	1.44	1.58	1.52	1.48	1.44	1.39	1.38	1.38	1.40	1.44	1.40	1.45	1.44	1.43
25	1.40	1.39	1.39	1.45	1.42	1.52	1.46	1.59	1.53	1.48	1.44	1.39	1.38	1.39	1.39	1.44	1.42	1.45	1.47	1.44
34	1.40	1.39	1.38	1.46	1.42	1.52	1.46	1.60	1.54	1.48	1.46	1.40	1.38	1.40	1.42	1.46	1.43	1.46	1.48	1.44
37	1.40	1.39	1.38	1.45	1.41	1.52	1.45	1.60	1.54	1.49	1.46	1.39	1.38	1.39	1.41	1.45	1.42	1.45	1.46	1.44
44	1.39	1.38	1.38	1.42	1.41	1.53	1.46	1.59	1.45	1.50	1.48	1.40	1.39	1.40	1.42	1.45	1.43	1.47	1.48	1.45
46	1.40	1.40	1.39	1.42	1.41	1.54	1.46	1.62	1.56	1.50	1.49	1.40	1.38	1.40	1.42	1.44	1.42	1.46	1.46	1.45
50	1.41	1.41	1.40	1.43	1.42	1.53	1.45	1.62	1.54	1.46	1.48	1.42	1.42	1.42	1.42	1.44	1.44	1.46	1.48	1.46

CYCLE: CHARGE 0.685 AMP. - 7 HRS.
DISCHARGE 2.25 AMP. - 1 HR.

DATA RECORDED DURING AUTOMATIC CYCLING

TEST PLAN 2; SEC. C. R.A.I. SEPARATOR #7095-17

END OF DISCHARGE VOLTAGE

	CONTROLS					17% TEST					18% TEST					19% TEST				
CYCLE #	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3	1.15	1.15	1.15	1.13	1.15	1.0	1.15	1.15	1.10	1.16	1.15	1.15	1.17	1.16	1.17	1.11	1.15	1.16		1.16
4	1.18	1.18	1.18	1.16	1.18	1.11	1.19	1.20	1.15	1.20	1.18	1.19	1.20	1.20	1.20	1.16	1.20	1.20	1.20	1.20
16	1.10	1.12	1.12	1.12	1.12	.92	1.14	1.14	1.02	1.12	1.14	1.14	1.16	1.14	1.16	1.04	1.14	1.14	1.16	1.15
19	1.12	1.12	1.14	1.13	1.14	.94	1.14	1.15	1.05	1.14	1.15	1.15	1.16	1.16	1.16	1.08	1.16	1.18	1.17	1.16
22	1.14	1.14	1.15	1.14	1.15	.98	1.16	1.16	1.09	1.16	1.15	1.18	1.17	1.18	1.11	1.07	1.16	1.18	1.17	1.17
25	1.13	1.14	1.15	1.14	1.15	.96	1.15	1.16	1.07	1.14	1.16	1.16	1.17	1.16	1.18	1.09	1.17	1.16	1.17	1.16
34	1.12	1.13	1.15	1.14	1.15	.96	1.15	1.16	1.07	1.15	1.16	1.17	1.18	1.17	1.18	1.08	1.17	1.16	1.17	1.17
37	1.12	1.13	1.14	1.14	1.13	.94	1.14	1.15	1.04	1.14	1.15	1.16	1.18	1.16	1.18	1.05	1.16	1.15	1.16	1.16
44	1.14	1.15	1.16	1.15	1.16	1.0	1.16	1.16	1.10	1.16	1.16	1.18	1.18	1.18	1.19	1.10	1.18	1.17	1.17	1.18
46	1.10	1.10	1.12	1.12	1.12	.95	1.19	1.15	1.04	1.14	1.15	1.16	1.18	1.17	1.18	1.04	1.16	1.15	1.15	1.16
50	1.11	1.13	1.14	1.13	1.13	.94	1.14	1.14	1.04	1.13	1.14	1.16	1.17	1.16	1.17	1.03	1.16	1.14	1.14	1.16

NOTE: VOLTAGE WAS RECORDED AT THE END OF 40 MINUTES (CYCLE #4)

CYCLE: CHARGE 0.685 AMP. - 7 HRS.
DISCHARGE 2.25 AMP. 1 HR.

pax

SUMMARY OF DATA

CYCLING RATES:

8 HR. CHARGE 1600 M.A.
DISCHARGE 2.25 AMP.

R.A.I. SEPARATOR # 7095-18

CELLS		CONTROL	TEST	TEST	TEST
SEPARATOR TYPE		POLY PROPYLENE	7095-18	7095-18	7095-18
ELECTROLYTE - % CORE WGT.		17%	17%	18%	19%
NO. OF CELLS		5	6	5	6
AVERAGE OF THREE (3) CYCLES BEFORE TEST PLAN 2; SEC. C					
CHARGE DISCHARGE AS ABOVE AMB. TEMP. 75°F	END OF CHARGE VOLTAGE	1.45	1.44	1.44	1.43
	RANGE	.09	.02	.02	.02
DISCHARGE	5 SEC. VOLTAGE	1.31	1.30	1.31	1.30
	RANGE	.03	.01	.02	.01
	MID. VOLTAGE (1.0VEP)	1.19	1.18	1.19	1.19
	RANGE	.02	.01	.02	.02
	TIME TO 1.0V (MINUTES)	93.4	100.4	106.7	1.04
	RANGE	11	19	12.8	23.6
	TIME TO 0.60V (MINUTES)	98.3	104.3	111.2	109.1
	RANGE	11.6	20.2	14.9	22.6
AVERAGE OF TWO (2) CYCLES AFTER TEST PLAN 2; SEC. C.					
	NO. CELLS	5	6	5	6
CHARGE DISCHARGE AS ABOVE AMB. TEMP. 75°F	END OF CHARGE VOLTAGE	1.46	1.45	1.48	1.45
	RANGE	.08	.04	.16	.10
DISCHARGE	5 SEC. VOLTAGE	1.28	1.28	1.28	1.25
	RANGE	.08	.02	.03	.05
	MID VOLTAGE (10V EP)	1.19	1.18	1.18	1.17
	RANGE	.09	.03	.03	.07
	TIME TO 10v (MINUTES)	71.5	76.7	77.7	71
	RANGE	24.1	13.2	6.2	15.5
	TIME TO 0.60v (MINUTES)	79.9	83.9	83.2	81
	RANGE	14.2	12.9	9.0	10.8

DATA RECORDED DURING AUTOMATIC CYCLING

TEST PLAN 2; SEC. C. R.A.I. SEPARATOR #7045-18

CYCLE { CHARGE 0.685 AMP - 7 HRS.
DISCHARGE 2.25 AMP. - 1 HR.

END OF CHARGE VOLTAGE

	CONTROLS					17% TEST						18% TEST					19% TEST					
CYCLE #	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	6
3	1.40	1.40	1.38	1.39	1.42	1.42	1.42	1.38	1.42	1.52	1.43	1.42	1.46	1.48	1.44	1.40	1.47	1.55	1.46	1.44	1.44	1.45
6	1.37	1.38	1.36	1.37	1.37	1.41	1.40	1.37	1.40	1.47	1.42	1.42	1.44	1.55	1.43	1.41	1.45	1.56	1.45	1.43	1.43	1.53
9	1.38	1.38	1.38	1.38	1.40	1.41	1.41	1.36	1.41	1.43	1.44	1.42	1.45	1.51	1.46	1.42	1.44	1.43	1.46	1.44	1.43	1.54
14	1.38	1.38	1.38	1.37	1.39	1.42	1.42	1.36	1.41	1.41	1.44	1.43	1.44	1.42	1.47	1.42	1.44	1.40	1.46	1.43	1.42	1.46
17	1.39	1.39	1.38	1.40	1.42	1.43	1.37	1.42	1.41	1.41	1.45	1.44	1.44	1.42	1.48	1.43	1.44	1.40	1.46	1.44	1.42	1.43
20	1.38	1.38	1.38	1.38	1.40	1.41	1.42	1.37	1.42	1.41	1.44	1.44	1.44	1.43	1.48	1.42	1.45	1.41	1.45	1.44	1.42	1.46
25	1.40	1.39	1.39	1.39	1.38	1.42	1.44	1.38	1.43	1.42	1.46	1.44	1.46	1.44	1.50	1.43	1.46	1.42	1.46	1.46	1.44	1.44
34	1.38	1.38	1.38	1.38	1.38	1.41	1.43	1.38	1.42	1.40	1.46	1.44	1.44	1.41	1.44	1.42	1.43	1.41	1.45	1.45	1.42	1.41
37	1.38	1.38	1.38	1.38	1.38	1.42	1.43	1.37	1.38	1.40	1.46	1.44	1.44	1.41	1.43	1.42	1.43	1.42	1.45	1.45	1.42	1.41
40	1.38	1.38	1.38	1.38	1.38	1.31	1.42	1.38	1.41	1.38	1.45	1.43	1.44	1.40	1.41	1.41	1.41	1.40	1.44	1.44	1.41	1.40
46	1.38	1.37	1.37	1.38	1.38	1.42	1.42	1.37	1.41	1.38	1.46	1.43	1.33	1.38	1.40	1.41	1.41	1.39	1.44	1.45	1.40	1.39

END OF DISCHARGE VOLTAGE

	CONTROLS					17% TEST						18% TEST					19% TEST					
CYCLE #	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	6
1	1.09	1.12	1.16	1.13	1.16	1.15	1.17	1.16	1.17	1.17	1.15	1.18	1.18	1.15	1.17	1.16	1.16	1.18	1.16	1.18	1.16	1.13
6	1.13	1.13	1.12	1.12	1.14	1.12	1.13	1.13	1.12	1.15	1.14	1.14	1.15	1.15	1.14	1.12	1.15	1.15	1.14	1.15	1.13	1.16
9	1.12	1.08	1.06	1.10	1.13	1.09	1.12	1.08	1.10	1.14	1.13	1.12	1.14	1.14	1.14	1.10	1.14	1.14	1.14	1.15	1.11	1.15
15	1.15	1.16	1.14	1.13	1.14	1.14	1.16	1.13	1.14	1.15	1.16	1.15	1.16	1.14	1.16	1.14	1.16	1.15	1.16	1.16	1.12	1.13
21	1.08	1.02	1.02	1.04	1.07	.98	1.08	.98	1.08	1.11	1.12	1.08	1.12	1.13	1.12	1.02	1.13	1.13	1.11	1.14	1.07	1.14
26	1.08	1.02	1.03	1.06	1.08	.94	1.08	1.0	1.08	1.12	1.13	1.07	1.13	1.14	1.13	1.04	1.14	1.14	1.12	1.14	1.07	1.10
35	.96	1.01	1.02	1.06	1.08	.93	1.06	.99	1.07	1.11	1.06	1.11	1.11	1.11	1.02	1.12	1.12	1.09	1.13	1.08	1.08	1.08
38	1.02	1.08	1.08	1.09	1.11	1.03	1.10	1.0	1.10	1.12	1.12	1.10	1.13	1.12	1.13	1.14	1.12	1.13	1.11	1.11	1.17	1.10
41	1.04	1.10	1.10	1.10	1.09	1.04	1.10	1.06	1.10	1.12	1.12	1.13	1.12	1.13	1.06	1.12	1.13	1.12	1.14	1.09	1.10	1.10
47	.42	.96	.96	.98	.99	.83	1.03	.30	1.02	1.05	1.10	1.0	1.10	1.10	1.10	.93	1.06	1.11	1.08	1.10	.94	1.06
53	.04	.35	1.01	1.02	1.03	.90	1.04	.62	1.04	1.05	1.11	1.05	1.11	1.11	1.11	1.0	1.09	1.12	1.10	1.11	1.0	1.08

RAI SEPARATOR 7095-19 TEST PLAN 2

Cycling Rates Charge 600 M.A. - 8 Hr.

Discharge 2.25 Amp.

Cells	CONTROLS	TEST	TEST	TEST
Separator Type	POLY PROPYLENE	7095-19	7095-19	7095-19
Electrolyte	17%	17%	18%	19%
No. of Cells Tested	7	8	8	8

Average of Three (3) Cycles Before Test Plan 2; Sec. C.

Charge	As Above	End of Charge Volt.	1.42	1.41	1.43	1.44
Discharge		Range	.03	.03	.04	.05
Amb. Temp. 75°F		5 Sec. Voltage	1.26	1.26	1.26	1.27
		Range	.03	.02	.03	.02
	Discharge	Mid.Voltage (1.0V EP)	1.15	1.14	1.16	1.16
		Range	.04	.03	.03	.04
		Time to 1.0v (Minutes)	83.2	94.1	95.8	99.2
		Range	19.8	18.8	43.6	15.3
		Time to 0.60V (Minutes)	89.7	104.3	102.5	102.9
		Range	18.4	11.4	36.6	17.6

Average Of Two (2) Cycles After Test Plan 2; Sec. C.

Charge	As Above	Number Cells Bulged	4	0	1	3
Discharge		End of Charge Volt.	1.41	1.41	1.42	1.43
Amb. Temp. 75°F.		Range	.06	.03	.05	.04
		5 Sec. Voltage.	1.26	1.24	1.25	1.27
		Range	.10	.03	.04	.04
	Discharge	Mid.Voltage (1.0VEP)	1.18	1.16	1.16	1.16
		Range	.12	.04	.05	.04
		Time to 1.0V (Minutes)	64.2	62.0	78.8	86.6
		Range	59.4	15.3	50.6	52.5
		Time to 0.60V	82.5	76.4	94.8	103.9
		Range	51.6	24.3	38.4	21.9

SEPARATOR 7095-19

DATA RECORDED DURING AUTOMATIC CYCLING - TEST PLAN 2; SEC. C

CYCLE { CHARGE 685 ma. - 7 HR. / DISCH. 2.25 A. - 1 HR.

END OF CHARGE VOLTAGE

CYCLE #	CONTROLS 1	2	3	4	5	6	7	17% TEST 1	2	3	4	5	6	7	8	18% TEST 1	2	3	4	5	6	7	8	19% TEST 1	2	3	4	5	6	7	8
3	1.48	1.42	1.42	1.42	1.42	1.41	1.42	1.40	1.39	1.38	1.40	1.40	1.40	1.39	1.39	1.39	1.41	1.42	1.42	1.39	1.40	1.42	1.38	1.43	1.42	1.42	1.39	1.41	1.40	1.42	1.40
12	1.40	1.42	1.44	1.43	1.44	1.42	1.43	1.43	1.42	1.41	1.41	1.41	1.42	1.42	1.41	1.40	1.42	1.45	1.47	1.40	1.42	1.44	1.40	1.45	1.44	1.45	1.42	1.41	1.42	1.43	1.42
21	1.41	1.46	1.44	1.44	1.45	1.43	1.44	1.48	1.42	1.41	1.42	1.42	1.45	1.43	1.42	1.46	1.42	1.48	1.52	1.52	1.44	1.46	1.42	1.49	1.45	1.48	1.43	1.42	1.44	1.46	1.43
24	1.44	1.46	1.44	1.44	1.46	1.42	1.43	1.46	1.42	1.42	1.43	1.42	1.45	1.43	1.42	1.46	1.42	1.48	1.50	1.42	1.43	1.44	1.41	1.48	1.43	1.46	1.42	1.42	1.43	1.45	1.42
27	1.45	1.42	1.44	1.44	1.46	1.43	1.44	1.48	1.42	1.42	1.44	1.43	1.44	1.43	1.43	1.48	1.43	1.48	1.52	1.44	1.44	1.46	1.40	1.48	1.44	1.47	1.42	1.40	1.42	1.45	1.42
30	1.45	1.45	1.43	1.43	1.46	1.42	1.43	1.48	1.42	1.42	1.45	1.43	1.48	1.44	1.43	1.47	1.43	1.48	1.50	1.44	1.44	1.46	1.40	1.48	1.44	1.47	1.42	1.39	1.42	1.44	1.42
33	1.46	1.45	1.43	1.44	1.46	1.42	1.43	1.50	1.42	1.42	1.44	1.43	1.52	1.44	1.43	1.46	1.43	1.49	1.48	1.44	1.44	1.46	1.41	1.49	1.44	1.47	1.42	1.40	1.43	1.44	1.43
48	1.50	1.46	1.45	1.44	1.56	1.43	1.44	1.55	1.44	1.42	1.45	1.43	1.50	1.45	1.43	1.51	1.42	1.52	1.50	1.44	1.45	1.46	1.42	1.5[illegible]	1.44	1.45	1.44	1.42	1.44	1.45	1.41
50	1.51	1.46	1.44	1.44	1.62	1.43	1.44	1.54	1.46	1.43	1.45	1.45	1.54	1.46	1.44	1.53	1.43	1.53	1.53	1.44	1.45	1.46	1.42	1.53	1.44	1.47	1.41	1.43	1.45	1.46	1.42

END OF DISCHARGE VOLTAGE

CYCLE #	CONTROLS 1	2	3	4	5	6	7	17% TEST 1	2	3	4	5	6	7	8	18% TEST 1	2	3	4	5	6	7	8	19% TEST 1	2	3	4	5	6	7	8
1	1.10	1.16	1.16	1.15	1.01	1.12	1.14	1.10	1.14	1.12	1.16	1.15	1.16	1.10	1.13	1.13	1.17	1.03	1.16	1.15	1.16	1.17	1.15	1.18	1.18	1.17	1.16	1.18	1.15	1.16	1.18
4	1.10	1.14	1.15	1.14	1.09	1.08	1.13	1.08	1.10	1.07	1.12	1.12	1.12	1.02	1.10	1.13	1.14	1.03	1.12	1.12	1.14	1.14	1.12	1.14	1.15	1.14	1.14	1.14	1.13	1.15	1.15
6	1.12	1.15	1.16	1.14	1.07	1.12	1.14	1.10	1.12	1.11	1.13	1.13	1.12	1.08	1.12	1.13	1.14	1.08	1.14	1.14	1.14	1.14	1.13	1.14	1.14	1.14	1.14	1.15	1.13	1.14	1.15
9	1.10	1.14	1.15	1.13	1.09	1.10	1.12	1.09	1.11	1.10	1.12	1.12	1.12	1.06	1.11	1.13	1.14	1.06	1.10	1.13	1.14	1.14	1.12	1.14	1.14	1.14	1.14	1.14	1.13	1.14	1.15
21	1.07	1.10	1.15	1.14	.89	1.08	1.13	1.03	1.08	1.08	1.12	1.13	1.10	1.04	1.09	1.13	1.14	1.04	1.13	1.13	1.14	1.14	1.11	1.15	1.14	1.14	1.14	1.15	1.12	1.13	1.15
25	1.0	1.12	1.13	1.11	.74	1.01	1.14	1.01	1.04	1.02	1.10	1.12	1.07	.98	1.09	1.12	1.12	1.0	1.09	1.10	1.12	1.12	1.06	1.13	1.13	1.12	1.12	1.14	1.11	1.12	1.13
28	1.05	1.15	1.16	1.14	.91	1.01	1.14	1.03	1.08	1.09	1.12	1.14	1.10	1.05	1.10	1.14	1.15	1.09	1.05	1.14	1.14	1.14	1.12	1.15	1.15	1.15	1.14	1.16	1.13	1.14	1.15
31	.98	1.12	1.13	1.12	.60	1.06	1.11	1.0	1.09	1.02	1.10	1.12	1.07	1.05	1.11	1.12	1.13	1.08	1.05	1.11	1.12	1.13	1.08	1.13	1.13	1.12	1.12	1.13	1.11	1.11	1.13
43	.89	1.14	1.15	1.14	.23	1.12	1.13	1.02	1.07	1.04	1.08	1.12	1.09	1.03	1.08	1.12	1.14	1.01	1.08	1.11	1.14	1.15	1.13	1.15	1.14	1.14	1.14	1.16	1.12	1.13	1.15
46	.94	1.14	1.16	1.14	.14	1.13	1.14	1.02	1.07	1.09	1.07	1.12	1.06	1.03	1.08	1.12	1.14	1.01	1.13	1.12	1.14	1.05	1.13	1.15	1.14	1.15	1.14	1.16	1.12	1.13	1.15
48	.83	1.15	1.16	1.15	.10	1.14	1.14	1.02	1.08	1.06	1.09	1.13	1.06	1.05	1.09	1.13	1.15	1.02	1.02	1.11	1.14	1.15	1.13	1.15	1.15	1.15	1.15	1.17	1.12	1.13	1.15
51	.73	1.14	1.16	1.14	R	1.14	1.14	1.02	1.08	1.05	1.08	1.12	1.09	1.04	1.08	1.11	1.14	1.01	1.07	1.10	1.14	1.15	1.13	1.15	1.14	1.14	1.14	1.16	1.11	1.13	1.14

NOTE: R CELL WAS REVERSE AT THE END OF DISCHARGE

R.A.I. SEPARATOR 7095-19 TEST PLAN 3; SEC 1A.

CHARGE 325 M.A. - 8 HR.

DISCHARGE 1.75 AMP. TO 1.0V E.P.

SEC. 1 A:

CHARGE AT 75°F - DISCHARGE AT 75°F (AVG. 2 CYCLES)

	CONTROL CELLS			TEST CELLS	
	AVG.	RANGE	N=9	AVG.	RANGE
N=6					
END OF CHARGE VOLT	1.40	.03		1.41	.04
5 SEC. DISCH. VOLT.	1.26	.01	(STAND TIME	1.26	.02
MID. VOLT (10V E.P.)	1.18	.02	4½ HRS.)	1.17	.01
MINUTES TO 1.)V	67.8	6.5		63.3	.23
MINUTES TO 0.60V	72.7	6.8		66.1	26.3

CHARGE AT 75°F - DISCHARGE AT 0°F (AVG. 2 CYCLES)

	AVG.	RANGE		AVG.	RANGE
N=6			N=9		
END OF CHARGE VOLT.	1.40	.01		1.41	.03
5 SEC. DISCH. VOLT.	1.22	.02	(STAND TIME	1.18	.05
MID VOLT. (1.0V EP)	1.14	.03	22 HRS.)	1.10	.08
MINUTES TO 1.)V	42.5	10.1		32.1	16.3
MINUTES TO 0.60V	46.5	8.9		32.8	15.3
SUPP. DISCH TO 0.60V (75°F)	19.1	12		16.1	9

CHARGE AT 75°F - DISCHARGE AT 32°F (AVG. 2 CYCLES)

	AVG.	RANGE		AVG.	RANGE
N=6			N=9		
END OF CHARGE VOLT.	1.40	.02		1.41	.03
5 SEC. DISCH. VOLT.	1.24	.02	(STAND TIME	1.20	.04
MID VOLT. (10VEP)	1.15	.03	16 HRS.)	1.13	.05
MINUTES TO 1.0V	53.7	8.3		45.8	18.4
MINUTES TO 0.60V	55.1	9		50.6	19.1

CHARGE AT 75°F - DISCHARGE AT 165°F (AVG. 2 CYCLES)

	AVG.	RANGE		AVG.	RANGE
N=6			N=9		
END OF CHARGE VOLT	1.40	.02		1.42	.03
5 SEC. DISCH. VOLT	1.20	.02	(STAND TIME	1.18	.03
MID VOLT (1.0V EP)	1.15	.03	6 HRS.)	1.15	.04
MINUTES TO 1.0V	71.7	10.7		66.8	18.4
MINUTES TO 0.60V	78.6	12.3		73.2	19.3

NOTE: STAND TIME REFERS TO TIME AT DISCH. AMBIENT PRIOR TO DISCH.

R.A.I. SEPARATOR 7095-19 TEST PLAN 3 (CON'T)

SEC. 1b:

CHARGE AT 0°F - DISCHARGE AT 0°F (AVG. 2 CYCLES)

	CONTROL CELLS			TEST CELLS	
N=6	AVG.	RANGE	N=9	AVG.	RANGE
END OF CHARGE VOLT.	1.51	.04		1.59	.05
5 SEC. DISCH. VOLT.	1.27	.02		1.27	.03
MID. VOLT. (1.0V EP)	1.17	.02	(STAND TIME	1.15	.04
MINUTES TO 1.0V EP	79.7	9.9	16 HRS.)	72.6	20.9
MINUTES TO 0.60V EP	83.8	3		75.8	19.8
SUPP. DISCH. TO 0.60V (75°F)	4.8	2.1		8.4	4.3

CHARGE AT +32°F - DISCHARGE AT 32°F (AVG. 2 CYCLES)

N=6	AVG.	RANGE	N=9	AVG.	RANGE
END OF CHARGE VOLT.	1.43	.02		1.45	.10
5 SEC. DISCH. VOLT.	1.28	.01	(STAND TIME	1.27	.02
MID. VOLT. (1.0V EP)	1.19	.01	16 HRS.)	1.18	.02
MINUTES TO 1.0V EP	90	7.8		81.5	29.3
MINUTES TO 0.60V EP	92.9	7.3		83.2	31.1
SUPP. DISCH. TO 0.60V (75°F)	2.1	3.0		4.1	5.7

CHARGE AT +165°F - DISCHARGE AT 165°F (AVG. 2 CYCLES)

N=6	AVG.	RANGE	N=9	AVG.	RANGE
END OF CHARGE VOLT.	1.32	-		1.31+	.02
5 SEC. DISCH. VOLT.	1.18	.02	STAND TIME	1.18	.02
MID VOLT. (1.0V EP)	1.10	.04	16 HRS.	1.09	.09
MINUTES TO 1.0V EP)	51.8	4.1		47.8	35
MINUTES TO 0.60V EP	60.1	13.2		64.3	45.5

NOTE: STAND TIME REFERS TO ELAPSED TIME BETWEEN CHARGE & DISCH.

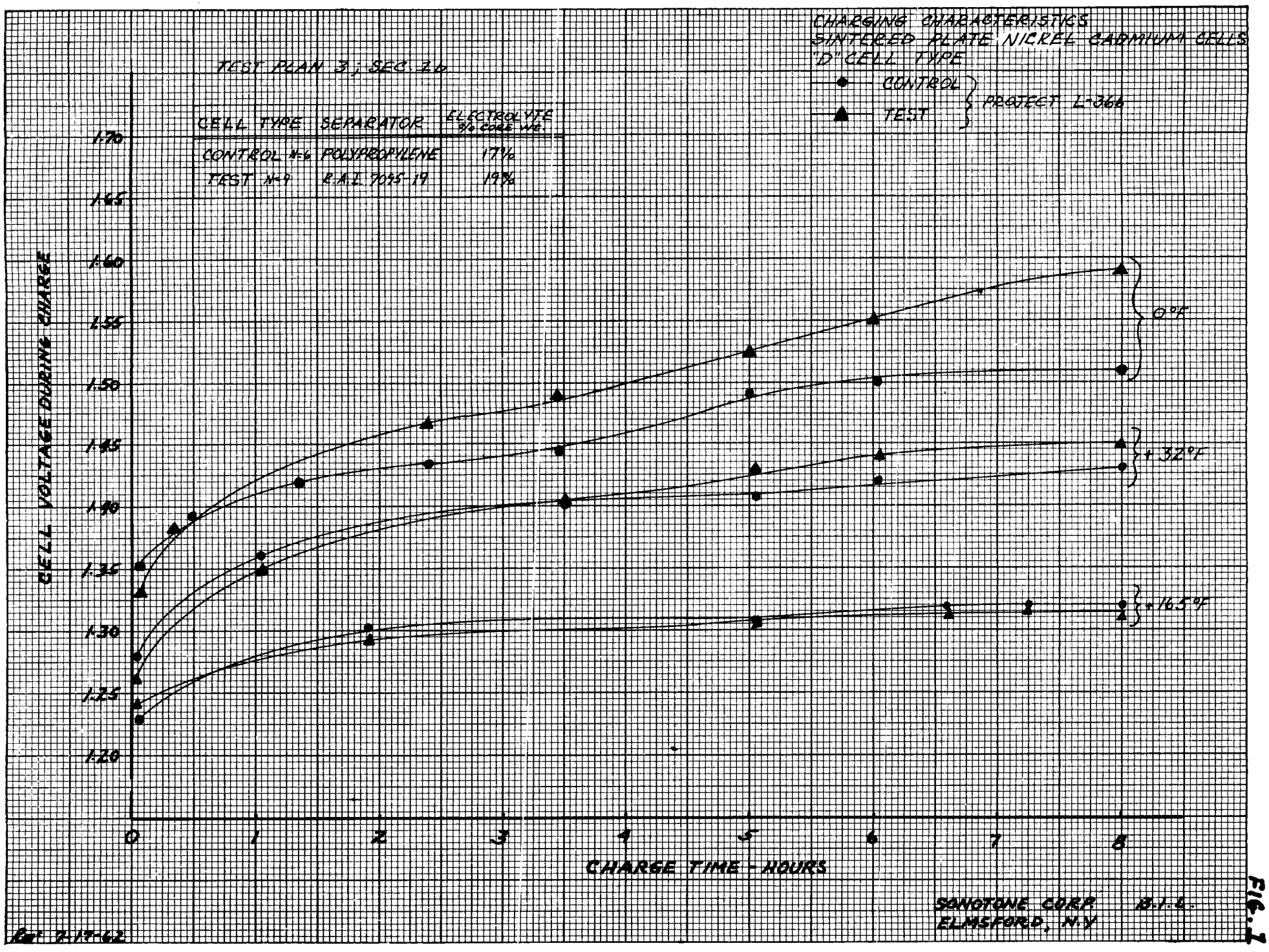

CHARGING CHARACTERISTICS
SINTERED PLATE NICKEL CADMIUM CELLS
"D" CELL TYPE
CONTROL
TEST
PROJECT L-366
TEST PLAN 3; SEC. 2b
CELL TYPE | SEPARATOR | ELECTROLYTE % CORE WT.
CONTROL N-6 | POLYPROPYLENE | 17%
TEST N-9 | R.A.I. 7055-19 | 19%
CELL VOLTAGE DURING CHARGE
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
0
1
2
3
4
5
6
7
8
CHARGE TIME - HOURS
0°F
+32°F
+165°F
SONOTONE CORP.
ELMSFORD, N.Y.
B.I.L.
Rev. 2-17-62

FIG. 7

R.A.I. SEPARATOR 7095-19 TEST PLAN 3; SEC 1C

END OF CHARGE VOLTAGE

AMBIENT	+165°F					+32°F						0°F				
CELL TYPE	CONTROL		TEST			CONTROL		TEST				CONTROL		TEST		
	1	2	1	2	3	1	2	1	2	3	4	1	2	1	2	3
CYCLE # 2	1.32	1.32	1.32	1.32	1.32	1.44	1.45	1.45	1.46	1.46	1.45	1.49	1.50	1.55	1.50	1.50
8	1.32	1.32	1.32	1.31	1.32	1.45	1.46+	1.47	1.47	1.47	1.47	1.52	1.53	1.56	1.51	1.50+
11	1.32	1.32	1.32	1.32	1.32	1.47	1.47	1.50	1.48	1.48	1.48	1.52	1.53	1.56	1.52	1.52
20	1.32	1.32	1.32	1.31	1.32	1.47	1.47	1.50	1.48	1.48	1.48	1.52	1.53	1.57	1.52	1.52
38	1.32	1.32	1.32	1.31	1.32	1.47	1.47	1.50	1.48	1.47	1.48	1.54	1.55	1.60	1.54	1.55
40	1.32	1.32	1.32	1.32	1.33	1.48	1.48	1.49	1.48	1.46	1.48	1.56	1.57	1.63	1.55	1.55
43	1.32	1.32	1.32	1.32	1.33	1.47	1.47	1.49	1.48	1.46	1.48	1.57	1.55	1.64	1.55	1.55
46	1.33	1.32	1.32	1.32	1.33	1.48	1.48	1.49	1.48	1.44	1.48	1.56	1.56	1.65	1.54	1.56
55	1.33	1.32	1.32	1.32	1.33	1.48	1.48	1.49	1.49	1.45	1.48	1.55	1.56	1.66	1.56	1.56
73	1.33	1.33	1.33	1.32	1.33	1.47	1.47	1.50	1.48	1.47	1.46	1.54	1.57	1.66	1.56	1.56
79	1.33	1.33	1.33	1.32	1.33	1.45+	1.46	1.50	1.48	1.47	1.47	1.56	1.57	1.66	1.56	1.57
88	1.33	1.33	1.33	1.33	1.32+	1.46	1.46	1.49	1.48	1.46	1.48	1.56	1.57	1.67	1.56	1.56
91	1.33	1.33	1.33	1.33	1.34	1.46	1.46	1.49	1.48	1.46	1.48	1.57	1.58	1.67	1.57	1.57
94	1.33	1.33	1.33	1.33	1.34	1.46	1.46	1.49	1.48	1.46	1.47	1.55	1.57	1.68	1.56	1.57
103	1.34	1.33	1.33	1.33	1.34	1.46	1.46	1.48	1.48	1.45	1.47	1.55	1.57	1.67	1.56	1.57

CONTROL N 2 AT EACH AMBIENT

TEST N 3 AT EACH AMBIENT

CYCLE CHARGE 325 M.A. 7 HR.
DISCH. 175 AMP 1 HR.
AMBIENT TEMP. AS LISTED

R.A.I. SEPARATOR 7095-19 TEST PLAN 3; SEC 1C

END OF DISCHARGE VOLTAGE

AMBIENT	+165°F					+32°F						0°F				
CELL TYPE	CONTROL		TEST			CONTROL		TEST				CONTROL		TEST		
	1	2	1	2	3	1	2	1	2	3	4	1	2	1	2	3
CYCLE #1	1.10	1.12	1.10	1.01	.96	1.20	1.21	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.19	1.19
5	1.04	1.08	1.04	R	R	1.18	1.20	1.19	1.18	1.18	1.18	1.20	1.20	1.19	1.19	1.17
18	.60	.89	.71	R	R	1.17	1.18	1.17	1.17	1.18	1.18	1.17	1.17	1.18	1.18	1.17
23	.41	.73	R	R	R	1.18	1.18	1.16	1.15	1.17	1.16	1.18	1.18	1.18	1.18	1.16
27	.20	.76	R	R	R	1.16	1.17	1.17	1.16	1.16	1.16	1.18	1.18	1.16	1.16	1.14
36	R	.80	R	R	R	1.16	1.17	1.16	1.16	1.16	1.16	1.18	1.18	1.16	1.16	1.15
40	R	.83	R	R	R	1.17	1.17	1.16	1.15	1.16	1.16	1.17	1.17	1.16	1.16	1.14
51	R	.80	R	R	R	1.17	1.17	1.16	1.15	1.16	1.16	1.17	1.17	1.16	1.16	1.14
57	R	.81	R	R	R	1.16	1.16	1.15	1.15	1.14	1.15	1.17	1.17	1.16	1.16	1.14
63	R	.83	R	R	R	1.17	1.17	1.16	1.15	1.16	1.16	1.18	1.18	1.17	1.16	1.14
74	R	.77	R	R	R	1.15	1.15	1.14	1.13	1.14	1.14	1.15	1.16	1.14	1.14	1.14
83	R	.80	R	R	R	1.14	1.14	1.12	1.10	1.12	1.12	1.13	1.13	1.12	1.12	1.10
86	R	.75	R	R	R	1.14	1.13	1.12	1.12	1.11	1.12	1.13	1.13	1.12	1.12	1.11
92	R	.79	R	R	R	1.13	1.13	1.12	1.11	1.11	1.11	1.13	1.13	1.12	1.11	1.10
103	R	.76	R	R	R	1.13	1.13	1.11	1.10	1.12	1.12	1.12	1.13	1.11	1.10	1.10

CONTROL N=2 AT EACH AMBIENT
TEST N=3 AT EACH AMBIENT

CYCLE CHARGE 325 MA 7 HR.
DISCH. 1.75 AMP. 1 HR.
AMBIENT TEMP. AS LISTED.

R.A.I. SEPARATOR 7095-19; TEST PLAN 3

SEC.1d (AFTER LIFE CYCLE):

CHARGE 75°F - DISCHARGE 75°F

CELLS WHICH WERE LIFE CYCLED AT 0°F (AVG. 2 CYCLES):

	CONTROL CELLS (2)				TEST CELLS (3)			
	BEFORE		AFTER		BEFORE		AFTER	
	AVG.	R	AVG.	R.	AVG.	R	AVG.	R.
END OF CH. VOLT	1.41	.01	1.40	-	1.43	.01	1.40	-
5 SEC. DISCH. VOLT	1.27	.02	1.22	.01	1.27	-	1.22	.01
MID. VOLT (1.0V EP)	1.18	-	1.16	.01	1.18	.01	1.17	.01
MINUTES TO 1.0V	76	2.8	73.5	1.1	69.2	8.9	63.7	20
MINUTES TO 0.60V	79.6	4.3	81.3	5.5	74.7	12.3	66.1	21.4

CELLS WHICH WERE LIFE CYCLED AT +32°F (AVG. 2 CYCLES):

	CONTROL CELLS (2)				TEST CELLS (3)			
	BEFORE		AFTER		BEFORE		AFTER	
	AVG.	R	AVG.	R	AVG.	R	AVG.	R
END OF CH. VOLT.	1.41	-	1.40	-	1.43	.01	1.40	-
5 SEC. DISCH. VOLT	1.28	.02	1.20	.01	1.26	.02	1.22	.01
MID. VOLT (1.0V EP)	1.18	.01	1.16	-	1.18	.01	1.17	-
MINUTES TO 1.0V	72.8	8.1	63.5	2	67.3	8.7	58.4	11.2
MINUTES TO 0.60V	76.6	0.8	67.6	3.2	72.5	11.4	60.6	10

CELLS WHICH WERE LIFE CYCLED AT +165°F (AVG. 2 CYCLES):

	CONTROL CELLS (2)				TEST CELLS (3)			
	BEFORE		AFTER		BEFORE		AFTER	
	AVG.	R	AVG.	R	AVG.	R	AVG.	R
END OF CH. VOLT	1.41	.02	1.46	.01	1.43	.01	1.46	.01
5 SEC. DISCH. VOLT	1.28	.02	1.21	-	1.26	.02	1.20	.02
MID. VOLT (1.0V EP)	1.18	.01	1.14	.02	1.18	.01	1.13	.04
MINUTES TO 1.0V	75.4	2.8	36.8	6.4	66.6	4.4	34.8	3.9
MINUTES TO 0.60V	80.4	3.2	41.6	11.8	76.3	7.3	37.1	6.6

TEST PLAN 3; SEC. II A

CELL VOLTAGE DURING 30 DAY CHARGE

R.A.I. SEPARATOR 7095-19

CHARGE RATE 325 M.A.

AMBIENT TEMP.	165°F					75°F				
CELL TYPE	Control		Test			Control		Test		
	1	2	1	2	3	1	2	1	2	3
START	1.37	1.28	1.29	1.29	1.34	1.38	1.37	1.37	1.34	1.37
1 DAY	1.34	1.34	1.33	1.32	1.35	1.49	1.46	1.46	1.44	1.45
2	1.34	1.33	1.33	1.32	1.34	1.48	1.44	1.44	1.42	1.44
3	1.31	1.31	1.31	1.30	1.33	1.44	1.42	1.42	1.41	1.42
6	1.30	1.31	1.31	1.31	1.34	1.46	1.41	1.41	1.40	1.41
9	1.30	1.31	1.31	1.30	1.34	1.47	1.40	1.40	1.39	1.40
12	1.31	1.31	1.32	1.32	1.35	1.45	1.44	1.44	1.43	1.44
18	1.31	1.30	1.31	1.31	1.35	1.43	1.43	1.43	1.43	1.43
20	1.30	1.30	1.31	1.31	1.35	1.41	1.43	1.41	1.41	1.44
21	1.30	1.31	1.31	1.30	1.36	1.39	1.42	1.42	1.41	1.43
25	1.30	1.31	1.31	1.31	1.37	1.39	1.41	1.41	1.41	1.42
27	1.31	1.31	1.32	1.32	1.38	1.40	1.42	1.42	1.41	1.42
30	1.32	1.32	1.32	1.32	1.38	1.39	1.42	1.42	1.40	1.42

AMBIENT TEMP.	0°F				
CELL TYPE	Control		Test		
	1	2	1	2	3
	1.39	1.33	1.36	1.39	1.38
	1.59	1.58	1.62	1.65	1.64
	1.67	1.66	1.58	1.65	1.58
	1.64	1.63	1.57	1.61	1.57
	1.60	1.60	1.59	1.61	1.56
	1.60	1.59	1.57	1.60	1.55
	1.66	1.61	1.62	1.65	1.59
	1.64	1.61	1.60	1.63	1.57
	1.65	1.60	1.60	1.64	1.58
	1.65	1.60	1.60	1.63	1.57
	1.65	1.61	1.60	1.64	1.58
	1.63	1.61	1.60	1.64	1.57
	1.61	1.61	1.59	1.64	1.59

DISCHARGE AT 1.75 AMPERS

24 HOUR STAND AT 75°F.

TEST PLAN 3; SEC. II A

CELL VOLTAGE DURING 30 DAY CHARGE

R.A.I. SEPARATOR 7095-19

CON'T.

CELL TYPE	CONTROL		TEST			CONTROL		TEST		
	1	2	1	2	3	1	2	1	2	3
OPEN CIR. VOLTAGE	1.24	1.23	1.22	1.24	1.22	1.28	1.32	1.32	1.31	1.32
5 SEC. VOLT	1.14	1.14	1.12	1.12	1.09	1.21	1.22	1.23	1.22	1.25
MID. VOLT (1.0V)	1.05	1.03	1.02	1.06	1.02	1.16	1.17	1.17	1.16	1.17
Time to 1.0V (Min)	64	70	32.3	28	3	98	129.6	108.1	109	112
Time to 0.60 V Min.	111	115	99	92.5	86	119	149	119.2	128	124

CONTROL		TEST		
1	2	1	2	3
1.26	1.26	1.26	1.26	1.34
1.20	1.20	1.21	1.19	1.22
1.12	1.14	1.14	1.15	1.14
97.5	140.7	147.2	104.2	160
130.3	156	162	133	164.8

SUMMARY OF DATA

TEST PLAN II: R.A.I. SEPARATOR 7095-20

Cycling Rates:

8 Hr. Charge - 600 M.A.
1 Hr. Discharge - 2.25 Amp.

Cells		Control	Test	Test	Test
Separator Type		Poly Propylene	7095-20	7095-20	7095-20
Electrolyte % Core Wgt.		17%	17%	18%	19%
No. of Cells Tested		6	* 7	* 7	9
Avg. of Three (3) Cycles Before Test Plan 2; Sec. C.					
Charge	End of Charge Volt.	1.41	1.41	1.41	1.43
Discharge As Above	Range	± .02	± .04	± .02	± .04
Amb. Temp. 78°F	5 Sec. Voltarg.	1.27	1.26	1.27	1.27
	Range	± .02	± .03	± .02	± .03
Discharge	Mid. Volt. (1.0V	1.18	1.17	1.16	1.17
	Range	.02 ± .02	± .04	± .03	± .03
	Time to 1.0v (Min)	84.7	74.8	78.4	85.9
	Range	± 17.5	± 21.4	± 20.6	± 20
	Time to 0.60v (Min.)	87.6	81.4	85.8	91.9
	Range	± 15.9	± 22.1	± 20.0	± 15
Avg. of Two (2) Cycles After Test Plan 2; Sec. C. (50 Life Cy. At Room Temp.)					
Charge	End of Charge Volt.	1.38	1.38	1.38	1.37
Discharge As Above	Range	-	± .01	± .01	± .01
Amb. Temp.	5 Sec. Voltage	1.29	1.29	1.28	1.29
	Range	± .02	± .02	± .03	± .02
Discharge	Mid. Volt 1.0V EP	1.19	1.21	1.18	1.18
	Range	± .01	± .02	± .03	± .02
	Time to 1.0V Min.	72.8	66.7	73.4	84.1
	Range	± 22.2	± 23.8	± 19.3	± 20.4
	Time to 0.60V Min.	95.9	84.6	93.9	107.5
	Range	± 21.5	± 38	± 18.4	± 21

* NOTE: TWO (2) CELLS IN 17% TEST GROUP SHORTED DURING 1st CYCLE)
ONE (1) CELL IN 18% TEST GROUP SHORTED DURING 1st CYCLE

R.A.I SEPARATOR #7095-20

DATA RECORDED DURING AUTOMATIC CYCLING TEST PLAN 2; SEC. C

END of CHARGE VOLTAGE

	CONTROLS						17% TEST							18% TEST							19% TEST								
	1	2	3	4	5	6	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	9
CYCLE # 8	1.42	1.43	1.41	1.41	1.41	1.42	1.44	1.42	1.44	1.42	1.42	1.42	1.43	1.44	1.43	1.44	1.44	1.42	1.43	1.42	1.43	1.44	1.44	1.41	1.42	1.41	1.44	1.43	1.46
10	1.42	1.42	1.41	1.41	1.42	1.42	1.44	1.42	1.44	1.42	1.42	1.42	1.43	1.44	1.43	1.44	1.44	1.42	1.44	1.42	1.43	1.44	1.44	1.42	1.42	1.42	1.43	1.43	1.46
19	1.41	1.42	1.41	1.40	1.41	1.41	1.44	1.43	1.44	1.43	1.42	1.41	1.43	1.44	1.43	1.44	1.44	1.43	1.43	1.42	1.43	1.44	1.44	1.41	1.41	1.42	1.41	1.43	1.45
50	1.41	1.44	1.41	1.41	1.41	1.41	1.43	1.41	1.42	1.42	1.42	1.41	1.43	1.44	1.42	1.44	1.44	1.42	1.42	1.43	1.42	1.44	1.43	1.42	1.41	1.42	1.42	1.43	1.46

AMBIENT TEMP. 76°F

CYCLE { CHARGE 685 MA. - 8 HRS.
DISCH 1.75 AMP - 1 HR

R.A.I SEPARATOR #7095-20

DATA RECORDED DURING AUTOMATIC CYCLING TEST PLAN 2; SEC. C

END of DISCHARGE VOLTAGE

CYCLE #	CONTROLS						17% TEST							18% TEST							19% TEST								
	1	2	3	4	5	6	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	9
1	1.15	1.16	1.17	1.18	1.16	1.15	1.13	1.17	1.09	1.16	1.13	1.16	1.16	1.11	1.18	1.16	1.14	1.16	1.11	1.17	1.19	1.17	1.15	1.17	1.16	1.18	1.13	1.19	1.17
5	1.14	1.15	1.15	1.16	1.14	1.14	1.10	1.16	1.10	1.14	1.12	1.15	1.14	1.12	1.16	1.15	1.13	1.14	1.09	1.15	1.16	1.14	1.14	1.15	1.14	1.16	1.12	1.17	1.15
9	1.14	1.16	1.15	1.16*	1.14	1.14	1.13	1.16	1.12	1.15	1.14	1.16	1.15	1.13	1.16	1.15	1.14	1.15	1.12	1.16	1.16	1.15	1.14	1.16	1.14	1.16	1.14	1.16	1.15
13	1.14	1.16	1.14	1.16	1.15	1.15	1.13	1.16	1.11	1.15	1.14	1.15	1.15	1.12	1.16	1.16	1.13	1.14	1.11	1.16	1.16*	1.15	1.14	1.16	1.14	1.16	1.13	1.16	1.15
23	1.13	1.16	1.14	1.14	1.14	1.13	1.12	1.14	1.10	1.13	1.11	1.14	1.15	1.13	1.16	1.15	1.14	1.13	1.11	1.15	1.16	1.15	1.14	1.16	1.14	1.16	1.13	1.16	1.15
30	1.11	1.15	1.12	1.14	1.14	1.13	1.12	1.13	1.10	1.13	1.10	1.14	1.15	1.12	1.14	1.14	1.13	1.13	1.11	1.14	1.15	1.14	1.13	1.13	1.14	1.16	1.13	1.15	1.14
33	1.11	1.15	1.11	1.12	1.13	1.12	1.12	1.13	1.08	1.12	1.08	1.12	1.14	1.12	1.15	1.15	1.13	1.12	1.10	1.14	1.15	1.14	1.13	1.15	1.14	1.16	1.12	1.15	1.14
42	1.13	1.17	1.13	1.14	1.14	1.14	1.14	1.15	1.13	1.16	1.13	1.14	1.16	1.14	1.16	1.17	1.15	1.15	1.11	1.16	1.17	1.16	1.15	1.18	1.16	1.17	1.14	1.16	1.15
45	1.10	1.16	1.10	1.13	1.14	1.13	1.12	1.14	1.10	1.14	1.11	1.13	1.16	1.13	1.15	1.16	1.14	1.14	1.09	1.16	1.16	1.15	1.14	1.16	1.15	1.17	1.14	1.16	1.15
50	1.11	1.15	1.11	1.12	1.13	1.13	1.12	1.13	1.11	1.15	1.12	1.12	1.15	1.13	1.15	1.15	1.14	1.14	1.08	1.16	1.16	1.15	1.14	1.17	1.14	1.16	1.14	1.15	1.14

R.A.I. SEPARATOR 7095-20 TEST PLAN 3

CHARGE 325 M.A. - 8 HRS.

DISCH. 175 AMP. 1.0V & 0.60V E.P.

SEC. 1a

CHARGE AT 75°F - DISCHARGE AT 75°F - (AVG. 2 CYCLES)

	CONTROL CELLS (6)		TEST CELLS (8)	
	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.40	.02	1.39	.02
5 SEC. DISCH. VOLT.	1.27	.03 (STAND TIME 4 HRS.)	1.30	.04
MID. VOLT (10V EP)	1.19	.04	1.20	.04
MINUTES TO 1.0V	63.2	.4	66.5	8.7
MINUTES TO 0.60V	68.6	.4	71	7.8

CHARGE AT 75°F - DISCHARGE AT 0°F (AVG. 2 CYCLES)

	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.40	.01	1.39	.03
5 SEC. DISCH. VOLT.	1.18	.08 (STAND TIME 6½ HRS.)	1.22	.06
MID. VOLT (1.0V EP)	1.09	.10	1.14	.08
MINUTES TO 1.0V	28	12.6	30.9	11.6
MINUTES TO 0.60V	40.6	16.6	44.4	18.9
SUPP. DISCH TO 0.60v (75°F)	23		28.6	

CHARGE AT 75°F - DISCHARGE AT +32°F (AVG. 2 CYCLES)

	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.42	-	1.41	.01
5 SEC. DISCH. VOLT.	1.19	.06 (STAND TIME 7 HRS.)	1.23	.04
MID VOLT (1.0V EP)	1.10	.11	1.15	.04
MINUTES TO 1.0V	23.5	12.7	36.1	18.6
MINUTES TO 0.60V	34.4	9.9	48.8	15.9

CHARGE AT 75°F - DISCHARGE AT+165°F (AVG. 2 CYCLES

	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.41	.01	1.41	.02
5 SEC. DISCH. VOLT	1.18	.02 (STAND TIME 5½ HRS.)	1.19	.02
MID VOLT. (1.0V EP)	1.15	.02	1.15	.02
MINUTES TO 1.0V	74.2	9.2	77.2	9.4
MINUTES TO 0.60V	81.5	12.6	85.5	11.6

NOTE: STAND TIME REFERS TO HOURS AT TEMP. BEFORE DISCH. COMMENCED.

R.A.I. SEPARATOR 7095-20 TEST PLAN 3 (CON'T.)

SEC. 1b.

CHARGE AT 0°F - DISCHARGE AT 0°F (AVG. 2 CYCLES)

	CONTROL CELLS (6)		TEST CELLS (8)	
	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.57	.12	1.53	.12
5 SEC. DISCH. VOLT	1.24	.10 (STAND	1.27	.06
MID. VOLT (1.0V EP)	1.12	.10 TIME 16 HR	1.15	.06
MINUTES TO 1.0V	71.1	25.2	75.4	25.8
MINUTES TO 0.60V	84	10.3	84.1	13.3
SUPP. DISCH TO .6V AT 75°F	74.5		71.1	

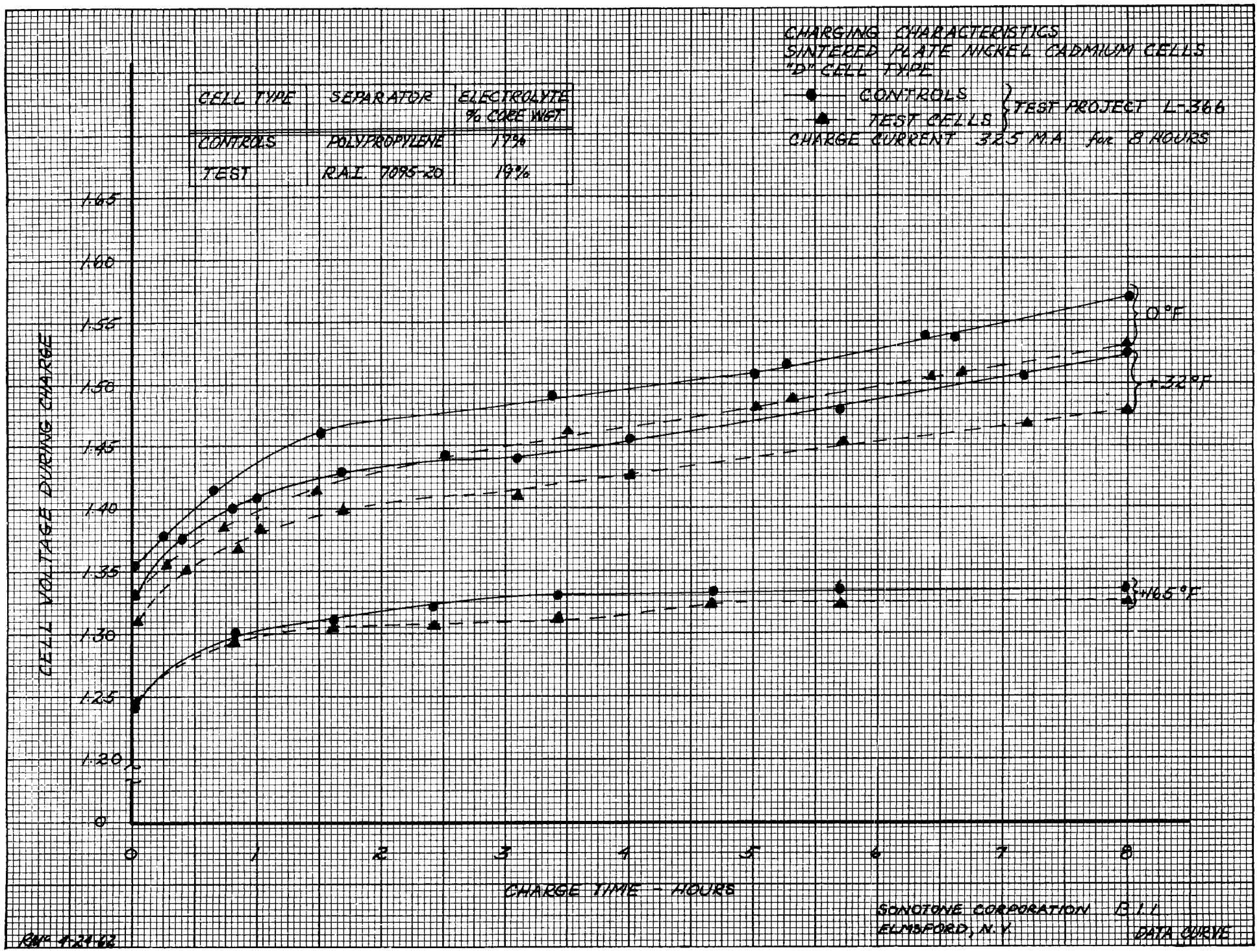
CHARGE AT +32°F - DISCHARGE AT +32°F (AVG. 2 CYCLES)

	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.52	.23	1.48	.05
5 SEC. DISCH. VOLT.	1.17	.22 (STAND TIME 16 17¼ HRS.	1.26	.06
MID VOLT (1.0V EP)	1.09	.15	1.17	.08
MINUTES TO 1.0V EP	45.3	52.7	67	18.8
MINUTES TO 0.60V	67.7	11.2	74.5	8.5
SUPP. DISCH TO .6V AT 75°F	15.8		23.6	

CHARGE AT +165°F - DISCHARGE AT +165°F (AVG. 2 CYCLES)

	CONTROL CELLS (6)		TEST CELLS (8)	
	AVG.	RANGE	AVG.	RANGE
END OF CHARGE VOLT.	1.34	.01	1.32	.02
5 SEC. DISCH. VOLT.	1.18	.03 (STAND TIME 16½ HRS.)	1.18	.04
MID. VOLT (1.0V EP)	1.13	.03	1.12	.07
MINUTES TO 1.0V	48.9	12.4	48.5	14.3
MINUTES TO 0.60V	59.5	9.8	56	14.3

NOTE: STAND TIME REFERS TO ELAPSED TIME BETWEEN CHARGE & DISCH.


CHARGING CHARACTERISTICS
SINTERED PLATE NICKEL CADMIUM CELLS
"D" CELL TYPE
CONTROLS
TEST CELLS
TEST PROJECT L-366
CHARGE CURRENT 325 MA for 8 HOURS
CELL TYPE | SEPARATOR | ELECTROLYTE % CORE WGT
CONTROLS | POLYPROPYLENE | 17%
TEST | R.A.I. 7095-20 | 19%
0°F
+32°F
+165°F
CELL VOLTAGE DURING CHARGE
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
0
1
2
3
4
5
6
7
8
CHARGE TIME - HOURS
SONOTONE CORPORATION
ELMSFORD, N.Y.
B.I.I.
DATA CURVE

XLix

R.A.I. SEPARATOR 7095-20 TEST PLAN 3; SEC. I.

END OF CHARGE VOLTAGE

AMBIENT	+165°F				+32°F					+0°F				
CELL TYPE	CONTROL		TEST		CONTROL		TEST			CONTROL		TEST		
CELL NO.	1	2	1	2	1	2	1	2	3	1	2	1	2	3
CYCLE # 1	1.32	1.32	1.32	1.31	1.54	1.54	1.50	1.50	1.49	1.54	1.52	1.52	1.59	1.50
4	1.32	1.32	1.32	1.32	1.55	1.56	1.56	1.56	1.54	1.58	1.57	1.57	1.70	1.56
16	1.34	1.34	1.34	1.35	1.56	1.56	1.66	1.60	1.55	1.61	1.60	1.76	1.79	1.61
19	1.35	1.34	1.34	1.34	1.56	1.57	1.65	1.61	1.55	1.58	1.57	1.76	1.73	1.59
23	1.34	1.34	1.34	1.34	1.55	1.56	1.64	1.60	1.54	1.58	1.56	1.76	1.72	1.58
26	1.34	1.33	1.33	1.34	1.55	1.56	1.64	1.58	1.54	1.59	1.57	1.76	1.72	1.68
29	1.34	1.34	1.34	1.34	1.54	1.54	1.62	1.58	1.52	1.58	1.56	1.76	1.70	1.50
38	CELL SHORTED AT DISCH. #29	1.34	1.34	1.34	1.52	1.53	1.62	1.58	1.54	1.58	1.55	1.76	1.65	1.60
45		1.34	1.34	1.34	1.54	1.55	1.56	1.54	1.52	1.57	1.56	1.58	1.69	1.58
57		1.34	1.34	1.34	1.52	1.52	1.61	1.56	1.53	1.58	1.56	1.66	1.69	1.58
60		1.35	1.35	1.34	1.52	1.52	1.62	1.58	1.54	1.58	1.56	1.66	1.68	1.58
63		1.36	1.35	1.34	1.52	1.52	1.62	1.58	1.53	1.57	1.56	1.68	1.66	1.58
67		1.36	1.36	1.37	1.52	1.53	1.63	1.60	1.55	1.60	1.57	1.73	1.69	1.60
81		1.36	1.36	1.36	1.52	1.52	1.62	1.60	1.55	1.58	1.57	1.78	1.68	1.61
90		1.35	1.35	1.34	1.51	1.51	1.61	1.58	1.54	1.58	1.56	1.60	1.67	1.60
99		1.36	1.36	1.35	1.50	1.50	1.60	1.56	1.52	1.57	1.56	1.67	1.65	1.61

END OF DISCHARGE VOLTAGE

AMBIENT	+165°F				+32°F					+0°F				
CELL TYPE	CONTROL		TEST		CONTROL		TEST			CONTROL		TEST		
CELL NO.	1	2	1	2	1	2	1	2	3	1	2	1	2	3
CYCLE # 1	.80	.94	1.10	1.04	.96	.96	1.12	1.12	1.19	1.13	1.16	1.16	.98	1.16
4	.72	.78	1.08	1.06	1.03	1.02	1.18	1.17	1.21	1.15	1.18	1.18	1.09	1.18
16	1.04	.90	.97	1.02	1.0+	1.0	1.16	1.15	1.19	1.11	1.16	1.16	.94	1.16
19	1.02	.89	.98	1.01	1.01	1.0	1.16	1.16	1.19	1.12	1.16	1.16	.95	1.16
23	.82	.70	.92	1.0	1.02	1.0	1.16	1.15	1.18	1.12	1.16	1.16	.94	1.16
26	.94	.92	1.02	1.01	1.03	1.02	1.16	1.10	1.20	1.14	1.17	1.17	.98	1.17
29	0	.74	.93	.99	1.03	1.02	1.16	1.16	1.18	1.12	1.16	1.16	.95	1.16
38		R	.24	.96	.99	.98	1.14	1.13	1.16	1.10	1.14	1.15	.86	1.15
42		-.30	.30	.90	1.02	1.0	1.14	1.14	1.18	1.12	1.16	1.16	.89	1.16
57		-.08	.48	.79	1.05	1.04	1.16	1.15	1.18	1.13	1.17	1.17	.92	1.17
60		-.06	-.24	.20	1.05	1.04	1.16	1.16	1.18	1.12	1.16	1.17	.89	1.16
66		R	R	R	1.03	1.02	1.15	1.15	1.17	1.14	1.18	1.18	.92	1.17
84		R	R	R	1.02	1.01	1.14	1.15	1.16	1.14	1.18	1.18	.86	1.18
87		R	R	R	1.01	1.0	1.14	1.15	1.16	1.13	1.17	1.17	.85	1.17
90		R	R	R	1.0	1.0	1.14	1.15	1.14	1.13	1.17	1.17	.81	1.17
99		R	R	R	1.0	1.0	1.15	1.16	1.18	1.13	1.17	1.17	.82	1.17

CELL SHORTED AT DISCH. #29

CYCLE { CHARGE - 325 M.A. 7 HR.
DISCH. - 1.75 AMP. 1 HR.
AMBIENT TEMP. AS LISTED

NOTE: TEST CELLS CONTAIN 19% ELECTROLYTE

Rev. 5-22-62.

6-8-62
TABLE 4

R.A.I. SEPARATOR 7095-20 TEST PLAN 3

SEC. 1d (AFTER LIFE CYCLE):

CHARGE 75°F - DISCHARGE 75°F

CELLS WHICH WERE LIFE CYCLED AT 0°F (AVG. 2 CYCLES)

	CONTROL CELLS (2)				TEST CELLS (3)			
	BEFORE		AFTER		BEFORE		AFTER	
	AVG.	R	AVG.	R	AVG.	R.	AVG.	R
END OF CHARGE VOLT	1.39	.02	1.44	.01	1.39	.02	1.42	.09
5 SEC. DISCH. VOLT	1.28	.02	1.27	.02	1.30	.01	1.25	.10
MID VOLT (1.0VEP)	1.20	.01	1.17	.02	1.20	.01	1.13	.17
MINUTES TO 1.0V	63.9	8	69.1	0.2	66.9	9.7	61.6	35
MINUTES TO 0.60V	68.2	7.6	72.2	0.7	71.3	12.6	73.9	13.9

CELLS WHICH WERE CYCLED AT +32°F (AVG. 2 CYCLES)

	CONTROL CELLS (2)				TEST CELLS (3)			
	BEFORE		AFTER		BEFORE		AFTER	
	AVG.	R	AVG.	R	AVG.	R	AVG.	R.
END OF CHARGE VOLT	1.40	-	1.44	.01	1.39	.02	1.41	.01
5 SEC. DISCH. VOLT	1.27	.02	1.16	.04	1.30	-	1.28	.02
MID VOLT (1.0VEP)	1.18	.01	1.05	.04	1.21	.03	1.19	.02
MINUTES TO 1.0V	61.9	6.7	33.4	3.2	65.7	13.2	73.1	7.2
MINUTES TO 0.60V	67.4	7.3	58.9	3.3	69.3	14.8	78.4	5.9

CELLS WHICH WERE LIFE CYCLED AT +165°F (AVG. 2 CYCLES)

	CONTROL CELLS (2)				TEST CELLS (2)			
	BEFORE		AFTER		BEFORE		AFTER	
	AVG.	R	AVG.	R	AVG.	R	AVG	R
END OF CHARGE VOLT	1.40	-	1.57	.15	1.38	.01	1.44	.02
5 SEC. DISCH. VOLT	1.27	.03	0.80	.29	1.30	-	1.27	.03
MID VOLT (1.0VEP)	1.18	.03	-	-	1.20	-	1.14	.02
MINUTES TO 1.0V	63.5	8.8	-	-	68.9	9.5	36.7	13.7
MINUTES TO 0.60V	70	6.4	13.8	19.6	73.2	7.5	51.5	8.3

TEST PLAN 3; SEC. IIA

CELL VOLTAGE DURING 30 DAY CHARGE

R.A.I. SEPARATOR 7095-20

AMBIENT TEMP.	165°F					75°F				
CELL TYPE	CONTROL		TEST			CONTROL		TEST		
	1	2	1	2	3	1	2	1	2	3
START	1.34	1.34	1.32	1.30	1.30	1.38	1.38	1.45	1.38	1.38
1 DAY	1.35	1.32	1.35	1.33	1.33	1.42	1.42	1.40	1.40	1.40
2	1.35	1.31	1.35	1.32	1.33	1.42	1.39	1.39	1.39	1.39
6	1.34	1.30	1.34	1.30	1.31	1.38	1.38	1.38	1.36	1.36
7	1.32	1.30	1.34	1.30	1.31	1.38	1.38	1.39	1.36	1.36
8	1.32	1.29	1.34	1.29	1.30	1.37	1.38	1.39	1.36	1.36
9	1.33	1.30	1.34	1.30	1.30	1.38	1.38	1.39	1.35	1.36
12	1.32	1.30	1.34	1.30	1.31	1.38	1.38	1.39	1.35	1.36
13	1.32	1.30	1.34	1.30	1.30	1.38	1.38	1.38	1.34	1.36
14	1.33	1.30	1.34	1.30	1.30	1.38	1.38	1.38	1.34	1.35
15	1.33	1.31	1.34	1.30	1.30	1.39	1.38	1.38	1.33	1.33
16	1.33	1.30	1.34	1.30	1.30	1.38	1.38	1.38	1.34	1.32
18	1.33	1.30	1.33	1.30	1.30	1.37	1.38	1.37	1.33	1.32
19	1.33	1.30	1.33	1.30	1.30	1.38	1.38	1.38	1.34	1.33
24	1.33	1.30	1.33	1.30	1.30	1.38	1.38	1.38	1.34	1.32
25	1.34	1.30	1.32	1.30	1.30	1.38	1.38	1.38	1.34	1.32
28	1.32	1.28	1.32	1.30	1.30	1.39	1.40	1.39	1.35	1.33
30	1.33	1.30	1.32	1.30	1.30	1.39	1.40	1.39	1.36	1.33

DISCHARGE AT 1.75 AMPERES
20 HOUR STAND AT 75°F

CELL TYPE	CONTROL		TEST			CONTROL		TEST		
	1	2	1	2	3	1	2	1	2	3
OPEN CIRCUIT VOLTAGE	1.26	1.23	.68	1.07	.54	1.32	1.34	1.31	1.27	1.27
5 SEC. VOLT.	1.04	1.12	-	-	-	1.25	1.27	1.26	1.22	1.23
MID. VOLT (1.0 V)	1.01	1.05	-	-	-	1.17	1.18	1.18	1.17	1.17
TIME TO 1.0V (MIN)	3.9	15	-	-	-	83	90	123	105.3	96.9
TIME TO 0.60 (MIN)	45.1	72.3	-	-	-	111.5	114.6	134	120	115.1

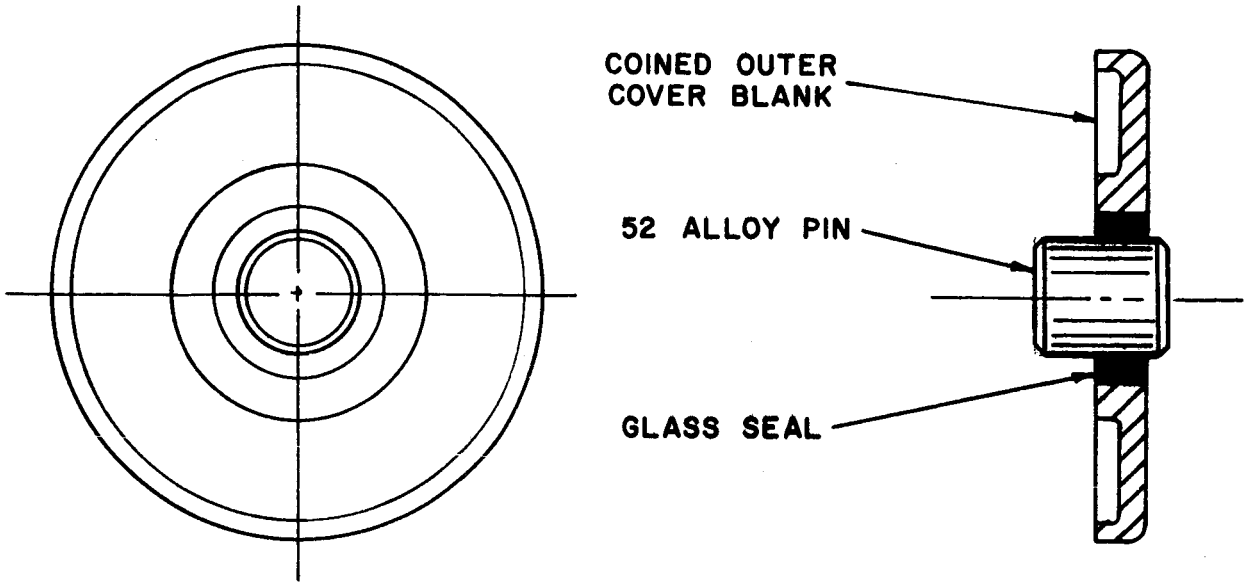
TEST PLAN 3; SEC. II A CON'T.

CELL VOLTAGE DURING 30 DAY CHARGE

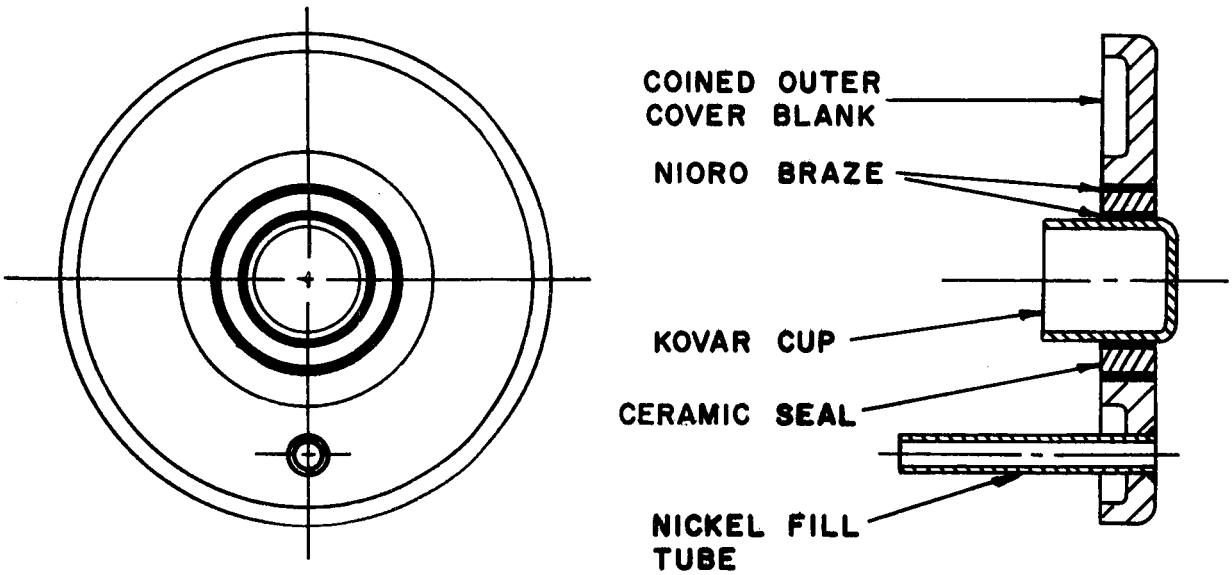
R.A.I. SEPARATOR 7095-20

AMBIENT TEMP.	0°F				
CELL TYPE	CONTROL		TEST		
	1	2	1	2	3
START	1.42	1.44	1.42	1.45	1.42
1 DAY	1.46	1.48	1.46	1.65	1.46
2	1.52	1.50	1.62	1.62	1.58
6	1.54	1.54	1.56	1.56	1.56
7	1.57	1.58	1.55	1.54	1.58
8	1.55	1.58	1.54	1.50	1.56
9	1.54	1.54	1.52	1.54	1.56
12	1.54	1.52	1.50	1.48	1.56
13	1.50	1.48	1.48	1.44	1.51
14	1.52	1.48	1.46	1.42	1.53
15	1.54	1.54	1.50	1.44	1.54
16	1.53	1.50	1.48	1.42	1.52
18	1.52	1.50	1.46	1.39	1.50
19	1.52	1.51	1.46	1.40	1.51
24	1.55	1.54	1.47	1.39	1.53
25	1.58	1.56	1.47	1.40	1.53
28	1.58	1.50	1.47	1.37	1.50
30	1.57	1.55	1.44	1.38	1.52

CELL TYPE	CONTROL		TEST		
	1	2	1	2	3
OPEN CIRCUIT VOLTAGE	1.28	1.28	1.25	1.26	1.26
5 SEC. VOLT.	1.24	1.29	1.21	1.17	1.22
MID. VOLT (1.0 V)	1.16	1.16	1.16	1.09	1.16
TIME TO 1.0V MIN.	148.3	175.2	131.4	51.4	1.52
TIME TO 0.60V MIN.	163.3	183	146.2	99.2	166



GLASS TO METAL SEAL



CERAMIC TO METAL SEAL