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Research and Development Technical Report
ECOM-0129-F

WATER ACTIVATED ZINC-SILVER OXIDE

PRIMARY BATTERY

FINAL REPORT

By
C. C. BROWN

JUNE, 1973

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND · FORT MONMOUTH, N.J.

CONTRACT DAAB07-71-C-0129

EAGLE-PICHER INDUSTRIES, INC.
Joplin, Missouri

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16 February 1971 to 15 March 1973

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DA PROJECT NO. 1T0627 05A 0530277

Prepared by

C. C. Brown

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Couples Department
Electronics Division
Eagle-Picher Industries, Inc.
Joplin, Missouri

For

U. S. ARMY ELECTRONICS COMMAND, FORT MONMOUTH, N. J.

ABSTRACT

This report describes the design, development, manufacture and evaluation testing of a Zinc-Silver Oxide reserve battery in accordance with "Technical Guidelines for Water Activated Zinc-Silver Oxide Battery". This includes a description of the design effort, the design, the test program, the test equipment and the test results. The evaluation testing showed compliance with the requirements of the technical guidelines.

FOREWORD

This work was performed for Power Sources Division, Electronics Components Laboratory, U.S. Army Electronics Command, Fort Monmouth, New Jersey, under Contract DAAB07-71-C-0129. This report is prepared in accordance with DD1423, Exhibit A under the above contract and is intended to describe the complete program.

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1.0 GENERAL

The work performed under this contract consisted of the design, development and fabrication of sixty (60) batteries as described in the following paragraphs and selection of thirty (30) of these units for test in accordance with 2-f of "Technical Guidelines for Water Activated Zinc-Silver Oxide Battery" and Table I herein.

2.0 DESIGN FEATURES

2.1 Cell Design

The cell design effort was begun with the design approach described in Eagle-Picher proposal EPP-1170-474/DMH which was in turn based on an Eagle-Picher internally developed battery with performance characteristics similar to those required by this contract. The proposed design called for one (1) negative and two (2) positive plates in each cell. The area of each of these plates was 5.25 square inches and the total weight of positive material was 28.8 grams and of negative material was 23.6 grams. Cells were fabricated with this plate design and with two (2) layers of membrane separation on the positive plate and one (1) layer of absorbent separation on the negative plate. These cells, when tested, failed to yield the required capactiy before the cutoff voltage was reached. When approximately half of the expected capactiy was expended the voltage dropped noticeably to a lower level which was maintained for a short time then gradually decreased to the point of cutoff. These voltage characteristics can be seen in the curve of Figure 1.

These cells were disassembled and it was determined that the active material was not being completely utilized because the potassium hydroxide electrolyte was not being dispersed enough to completely activate the positive plates. In order to correct this cells were fabricated with a layer of absorbent separation between the positive plate and the membrane separation and other cells with no separation on the positive plate and with two (2) layers of both membrane and absorbent separation on the negative plate. Neither of these designs produced any significant improvement in the performance.

The next step was to fabricate cells with the same positive plate area and active material as the first design but only half the length of the first design. This produced a cell with four (4) positive and three (3) negative plates. Since the same weight plates were used as the original design, excess negative material was in the cell because three (3) plates were required to balance the four (4) positive plates. These cells produced the expected capacity, 8.9 ampere hours, at a voltage .05 to .08 VDC above that of the first design.

Cells were then fabricated using the shorter plate design but with lighter negative plates to provide the proper active material ratio, positive-to-negative. In order to fit the specified battery outline, these plates were shorter than the first half-length cells. These changes resulted in a design with six (6) positive and five (5) negative plates each of 1.69 square inches, producing a total negative area of 8.55 square inches and positive area of 10.12 square inches. The negative material weight is 21.0 grams for the five (5) plates and the positive material weight is 30.35 grams for six (6) plates. These cells provided good voltage and capacity in excess of that required by the specification.

2.2 Case Design

The major controlling factor in the case design was the cell configuration which would meet the specified electrical requirements. Because a short multiple plate cell was required to achieve the required electrical performance, the orientation of the cells would have to be across the short dimension of the specified envelope. With this cell configuration, the method of activation must then be determined.

The cells will activate quicker from the end because the separation is open at the end allowing the water to flow directly in between the layers of separation and the plates. The short cell configuration described above fits into the specified envelope leaving room for the activation channel along one side and the connector on the end as shown in Figure 2. In order to prevent electrolyte leakage and allow escape of the gases generated during stand and discharge, porous teflon vent filters, also shown in Figure 2, were provided at both ends of the cells. This allows the gas to escape freely with the battery in any position since both vents could not be covered by electrolyte at the same time.

The first method of sealing tried was to provide a neoprene gasket, on all of the cells, which would be compressed by the cover which contained the vent filters. Leakage occurred around the neoprene gasket which was attributed to uneven compression of the gasket.

The next sealing method tried consisted of providing a common manifold which activated all cells, reference Figure 2. An expansion stopper is provided in the end of this manifold through which the water can be added. After completion of the activation, the stopper is then installed in the activation port to prevent electrolyte leakage. The gas generated after activation is vented throught the porous teflon filters. This method worked well in sealing the unit. Although there was some free electrolyte left in the manifold during discharge, there was no leakage.

This case was fabricated from plastic (MIL-P-21105). The vibration and shock tests were performed on this case with no detrimental effects. The first batteries fabricated had the plate leads and intercell connectors on the end opposite the activation manifold. This resulted in shorting between the plates and the plate leads. The shorting was caused by insufficient clearance between the plates and the end of the cell case. On the other batteries fabricated, the intercell connections and plate leads were placed on the end next to the activation manifold where there was more head room. This type of fabrication prevented shorting of the plate lead wires.

3.0 BATTERY FABRICATION

The batteries were assembled in plastic cases (Figure 2) which were fabricated here in our plant. After formation of the positive plate strips, the plates were cut to size and wrapped with separation. The negative plates are cut to sized and wrapped with separator then placed alternately with the positive plates to make a cell. The cells are immediately inserted into the case as they are assembled. After all the cells are placed into th- the case, the cover is installed and sealed in place. The cells are then interconnected and lead wires routed to the power output connector. The cell interconnections are then covered with potting. The top and bottom vent strips are then installed and sealed. The units are then painted and the labels and activation plug installed.

4.0 TEST PERFORMANCE

The test units were loaded as follows:

Section	Condition A 2 min. Load 1	Condition A 18 min. Load 2	Condition B Continuous Load	End Voltage
	(ohms)	(ohms)	(ohms)	
A_1	6.76 ± 1%	O.C.	N/A	2.12
A_2	14.2 ± 1%	291 ± 1%	28.75 ± 1%	10.0

The actual test setup was as shown in Figures 3 and 4.

The batteries were activated with water stabilized for 8 hours minimum at the same temperature as the battery except when the battery was below 40°F. Then the water was stabilized for 8 hours minimum at 40°F. The Immediate Discharge Tests were started five (5) minutes after the start of activation.

When specified, shock and vibration loads as follows were applied to the test unit:

Vibration: Sine, 0.06 in DA
Sweep, 1 cpm from 10 to 55 to 10 cps
Duration, 95 ± 5 min/axis, 3 axis

Shock: Average acceleration during first 3ms is 75 g's
Peak acceleration, 125 to 175 g's
One shock in each of 3 directions
Three shocks total

The batteries were activated in accordance with the instructions attached to each battery which is as follows. The battery was removed from its protective packaging and held in the vertical position with

TABLE I

TEST PLAN

TEST DESCRIPTION	LOAD CONDITION	SPECIMEN NUMBERS
Immediate Discharge at 75°F	A	1 - 4
Immediate Discharge at 125°F		5 - 6
Immediate Discharge at 0°F		7 - 8
Immediate Discharge at -20°F		9 - 10
Discharge at 75°F following 7 days activated storage at 75°F		11 - 12
Discharge at 75°F following 100 hours activated storage at 125°F		13 - 14
Immediate Discharge at 75°F following exposure to mechanical vibration and shock		15 - 16
Immediate Discharge at 75°F while being exposed to mechanical shock		17 - 18
Immediate Discharge at 75°F while being exposed to vibration	A	19 - 20
Immediate Discharge at 75°F	B	21 - 22
Immediate Discharge at 125°F		23 - 24
Immediate Discharge at 0°F		25 - 26
Immediate Discharge at -20°F		27 - 28
Discharge at 75°F following 7 days activated storage at 75°F	B	29 - 30

the activation opening at the top (Ref. Figure 2). The unit was filled with water and held in that position for two (2) minutes, then the unit was filled again and rotated 180° so that the activation opening was at the bottom and held in that position two (2) minutes. The plug was then removed and the excess water poured out and the plug was again installed. All activations were completed in the five (5) minutes allowed.

5.0 TEST SUMMARY

Table II gives a summary of test results for the thirty (30) units tested. The low temperatures produced marginal results in the A_1 Section, when discharged at Condition A. This was especially noted at -20°F. This is probably due to the loaction of the cells being on the end of the battery and their load being open circuit 90% of the time, results in their temperature being lower than average temperature of the cells in the A_2 Section. The A_2 Section was marginal at 0°F and very poor at -20°F when discharged at Load Condition B. The only reason that could be determined for poor operation at Condition B loads was the difference in the rate.

Low capacity in the A_1 Section of Specimens 11, 14, 15 and 16 was experienced during original testing caused by a cell-to-cell short through a poor seal around the bottom vent opening as shown in Figure 5. This opening in the seal allowed zinc dendrites to form between the cells producing a high resistance short. This could be prevented on future batteries fabricated by placing individual vent patches over the bottom vents as shown in Figure 6.

This would not change the seal method but would permit inspection of each seal to verify that no voids are in the seal. This method was used on five (5) units which were tested to the original environments where the shorting occurred. There was no shorting in any of these units. The thirty (30) units delivered have the revised seals in accordance with Figure 6 .

TABLE II

SUMMARY OF TEST RESULTS

SPEC. NO.	SERIAL NO.	TEST DESCRIPTION	A_1 SECTION (HOURS) Required	A_1 SECTION (HOURS) Results	A_2 SECTION (HOURS) Required	A_2 SECTION (HOURS) Results	TEST DATE	LOAD COND.
1	14	Immediate Discharge at 75°F	60	108	60	68	6/5/72	A
2	11	Immediate Discharge at 75°F	60	123	60	78	6/5/72	
3	60	Immediate Discharge at 75°F	60	97	60	81	6/5/72	
4	1	Immediate Discharge at 75°F	60	84	60	71	6/5/72	
5	4	Immediate Discharge at 125°F	60	89	60	81	6/5/72	
6	13	Immediate Discharge at 125°F	60	87	60	74	6/5/72	
7	19	Immediate Discharge at 0°F	50	84	50	72	6/27/72	
8	45	Immediate Discharge at 0°F	50	80	50	72	6/27/72	
9	37	Immediate Discharge at -20°F	30*	69	30*	23	6/13/72	
10	54	Immediate Discharge at -20°F	30*	52	30*	12	6/13/72	
11	78	Discharge at 75°F following 7 day activated stand at 75°F	50	68	50	60	6/13/72	
12	42	Discharge at 75°F following 7 day activated stand at 75°F	50	86	50	82	6/13/72	
13	22	Discharge at 75°F following 100 hour activated stand at 125°F	50	62	50	75	6/13/72	
14	47	Discharge at 75°F following 100 hour activated stand at 125°F	50	76	50	76	6/13/72	
15	74	Immediate Discharge at 75°F following exposure to mechanical vibration and shock	60	90	60	79	6/19/72	
16	24	Immediate Discharge at 75°F following exposure to mechanical vibration and shock	60	64	60	78	6/19/72	
17	5	Immediate Discharge at 75°F while being exposed to mechanical shock	60	87	60	80	6/19/72	
18	7	Immediate Discharge at 75°F while being exposed to mechanical shock	60	101	60	77	6/19/72	
19	8	Immediate Discharge at 75°F while being exposed to vibration	60	103	60	79	6/19/72	
20	34	Immediate Discharge at 75°F while being exposed to vibration	60	102	60	82	6/19/72	A
21	9	Immediate Discharge at 75°F	N/A	N/A	18	26:45	6/5/72	B
22	18	Immediate Discharge at 75°F			18	18	6/5/72	
23	20	Immediate Discharge at 125°F			18	25	6/7/72	
24	59	Immediate Discharge at 125°F			18	26	6/7/72	
25	46	Immediate Discharge at 0°F			15	15:15	6/14/72	
26	31	Immediate Discharge at 0°F	N/A	N/A	15	16:50	6/14/72	B

(continued on next page)

TABLE II (Continued)

Spec. No.	Serial No.	Test Description	A_1 SECTION (Hours) Required	A_1 SECTION (Hours) Results	A_2 SECTION (Hours) Required	A_2 SECTION (Hours) Results	Test Date	Load Cond.
27	21	Immediate Discharge at -20°F	N/A	N/A	10*	5	6/13/72	B
28	53	Immediate Discharge at -20°F			10*	1	6/13/72	
29	35	Discharge at 75°F following 7 day activated stand at 75°F			15	23	6/7/72	
30	36	Discharge at 75°F following 7 day activated stand at 75°F	N/A	N/A	15	24	6/7/72	B

* -20°F Test is a Design Goal.

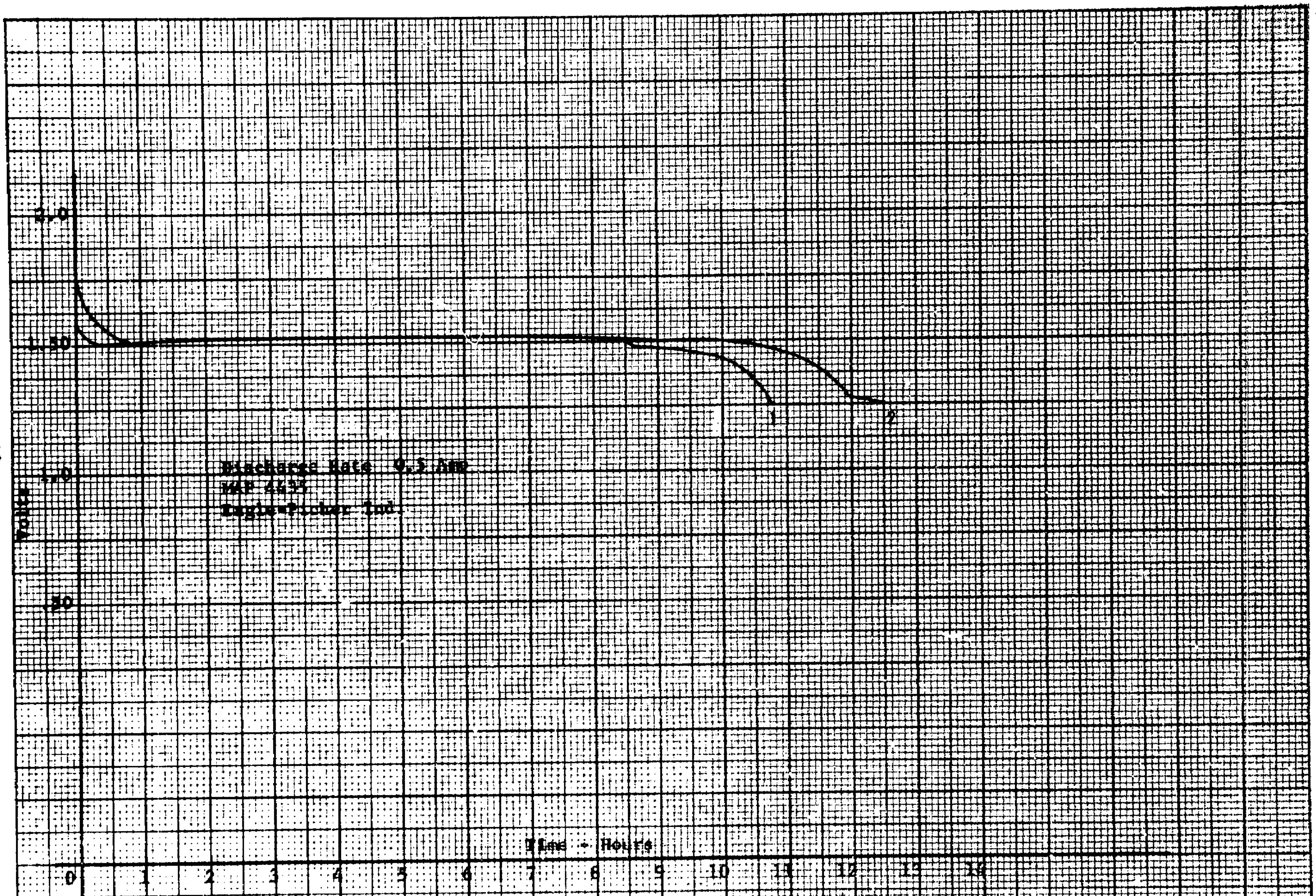
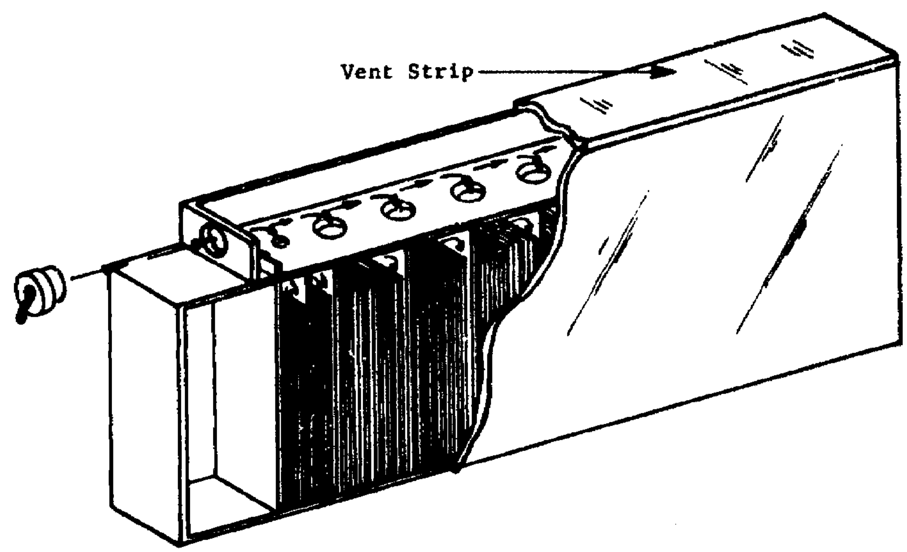

2.0
1.50
1.0
.50
Volts
Discharge Rate
Eagle-Picher Ind.
1
2
Time - Hours
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

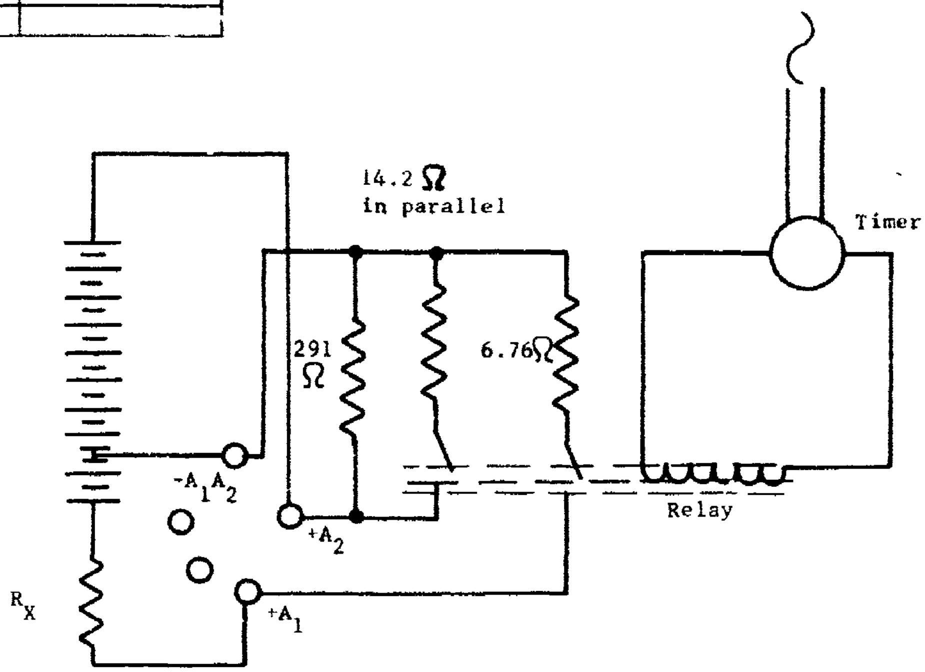
FIGURE 1



MAP 4435 ACTIVATION SYSTEM
AND ASSEMBLY LAYOUT

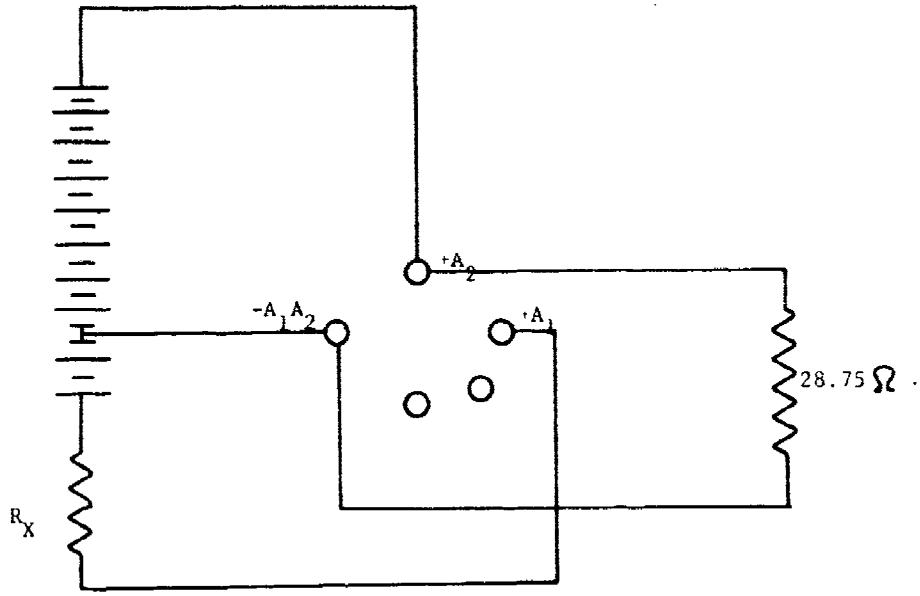
FIGURE 2

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ± ANGLES ± 3 PLACE DECIMALS ±.010 2 PLACE DECIMALS ±.03	CONTRACT NO. DATE ______	EAGLE PICHER INDUSTRIES, INC. COUPLES DEPARTMENT JOPLIN, MISSOURI
	PREPARED CHECKED ENGINEER	DISCHARGE SCHEMATIC LOAD CONDITION A
		SIZE A | CODE IDENT NO. 81855 | DRAWING NO. FIGURE 3
		SCALE | SHEET

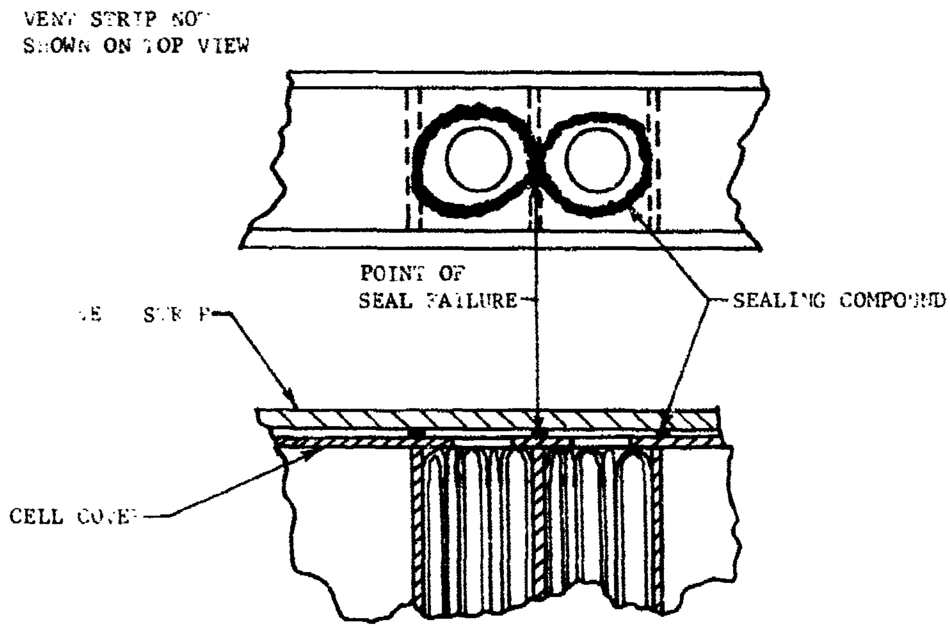
APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ± ANGLES ± 3 PLACE DECIMALS ±.010 2 PLACE DECIMALS ±.03	CONTRACT NO. DATE ______	EAGLE PICHER INDUSTRIES, INC. COUPLES DEPARTMENT JOPLIN, MISSOURI
	PREPARED	DISCHARGE SCHEMATIC LOAD CONDITION B
	CHECKED	
	ENGINEER	

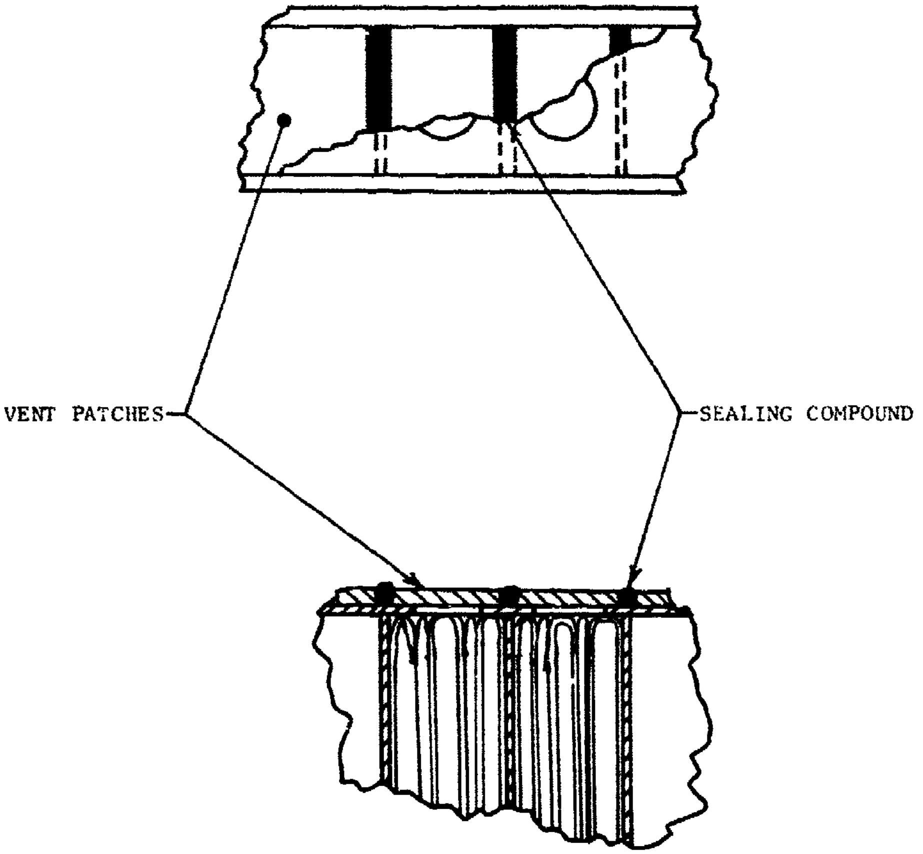
SIZE	CODE IDENT NO.	DRAWING NO.
A	81855	FIGURE 4
SCALE		SHEET

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ± ANGLES ± 3 PLACE DECIMALS ±.010 2 PLACE DECIMALS ±.03	CONTRACT NO. DATE	EAGLE PICHER INDUSTRIES, INC. COUPLES DEPARTMENT JOPLIN, MISSOURI
	PREPARED	ORIGINAL VENT SEAL
	CHECKED	
	ENGINEER	
		SIZE A · CODE IDENT NO. 81855 · DRAWING NO. FIGURE 5
		SCALE N/A · SHEET

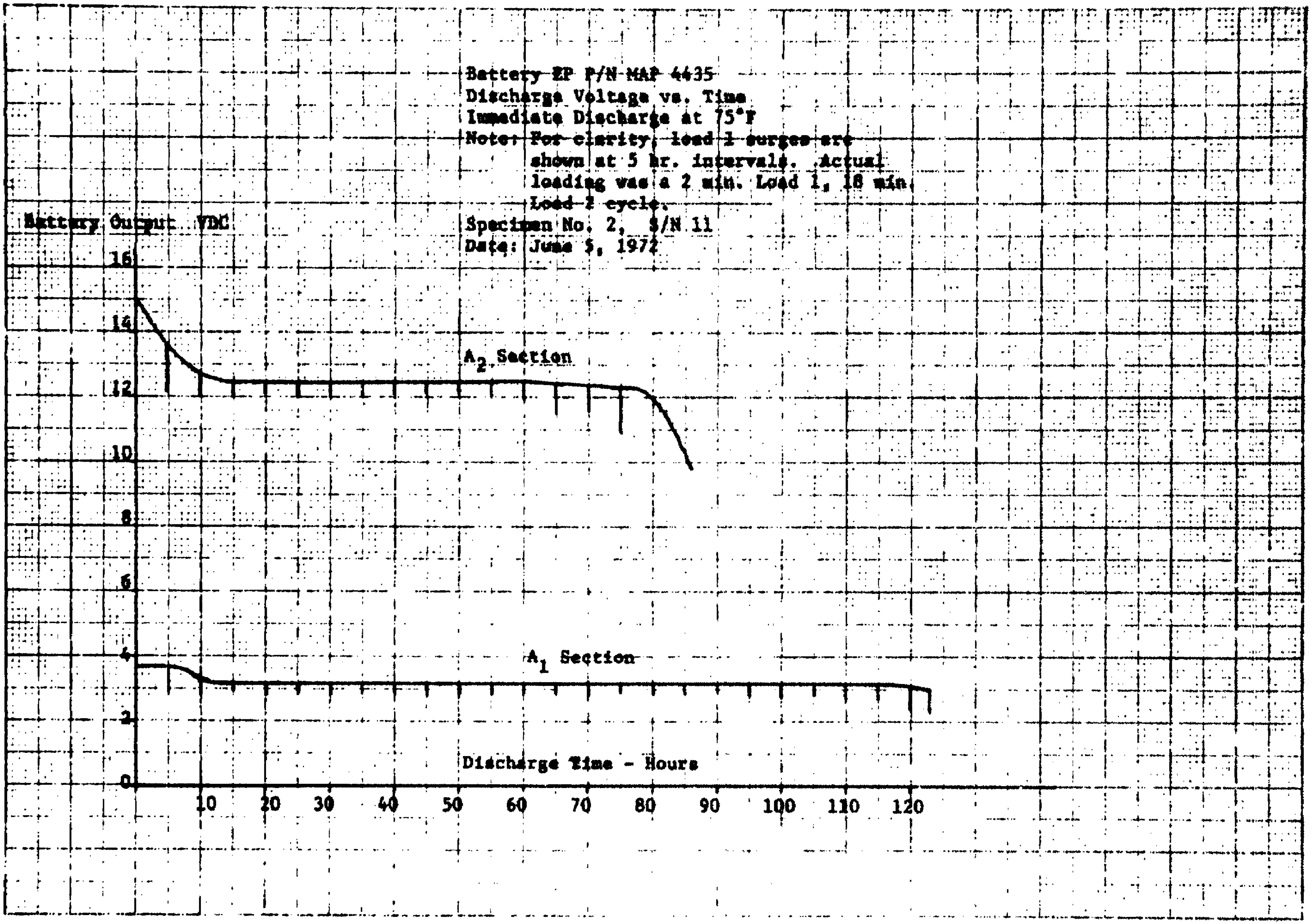
APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED

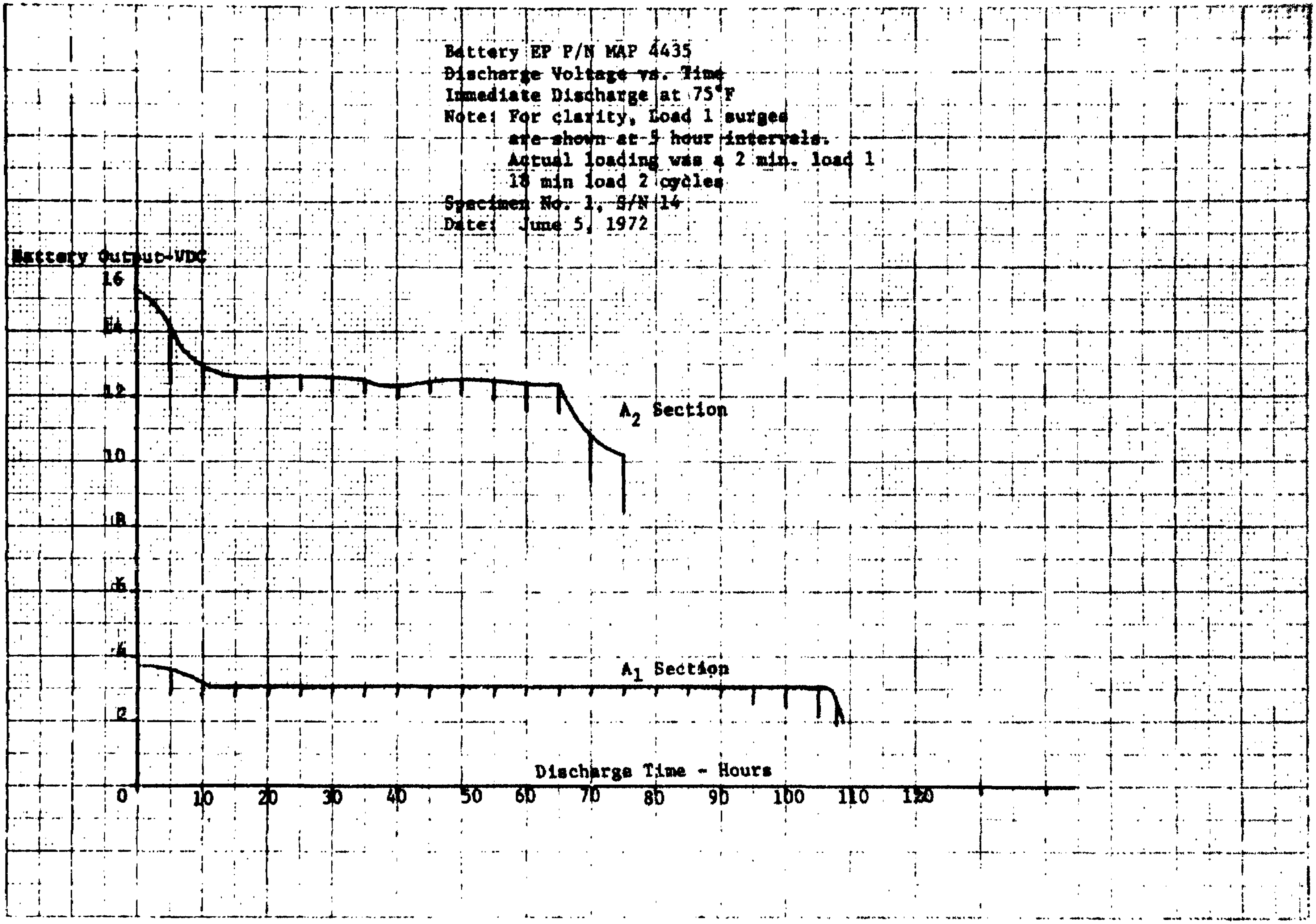


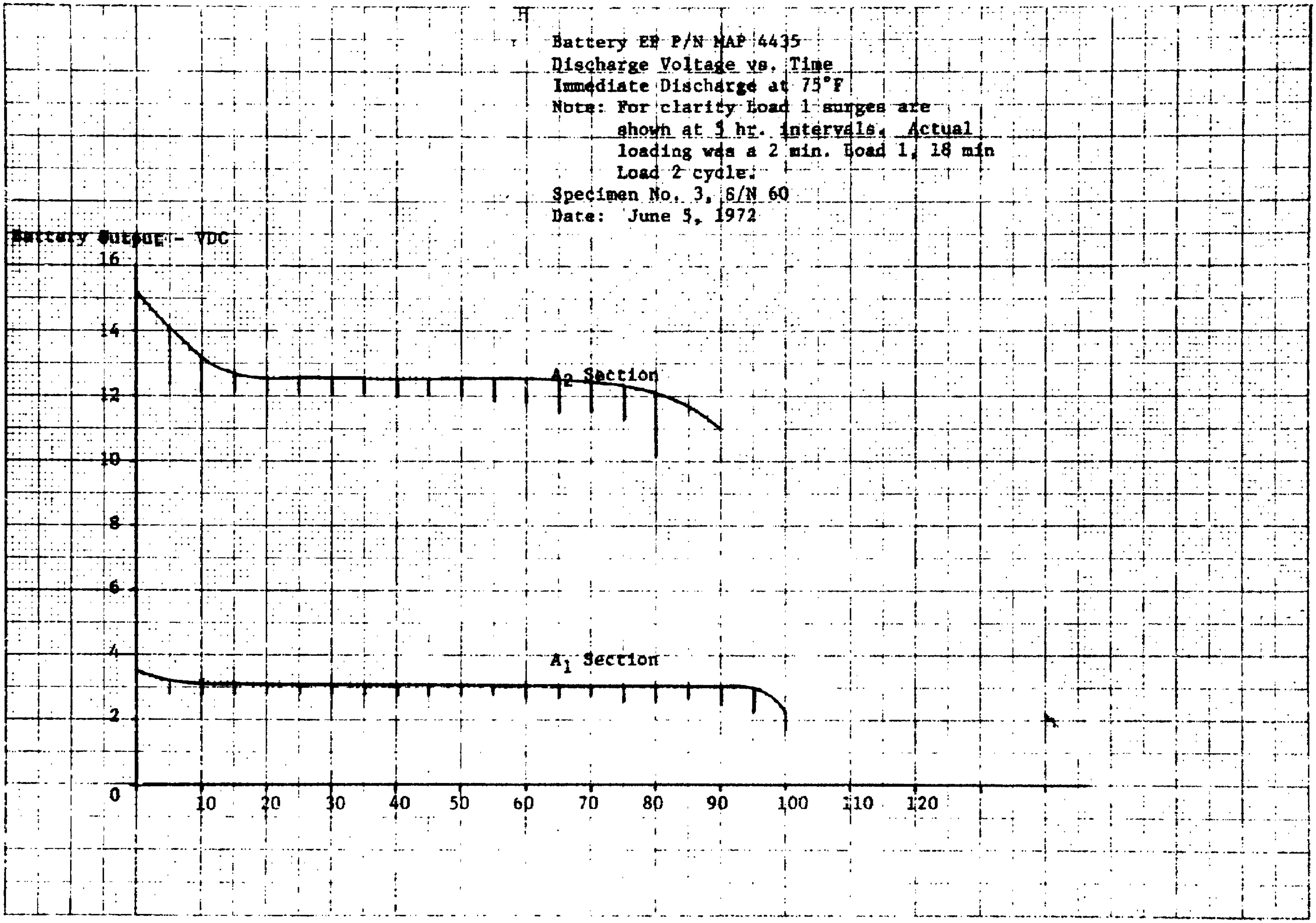
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ± ANGLES ± 3 PLACE DECIMALS ±.010 2 PLACE DECIMALS ±.03	CONTRACT NO. DATE ______	EAGLE PICHER INDUSTRIES, INC. COUPLES DEPARTMENT JOPLIN, MISSOURI
	PREPARED / CHECKED / ENGINEER	REVISED VENT SEAL
		SIZE A · CODE IDENT NO. 81855 · DRAWING NO. FIGURE 6
		SCALE N/A · SHEET

APPENDIX I

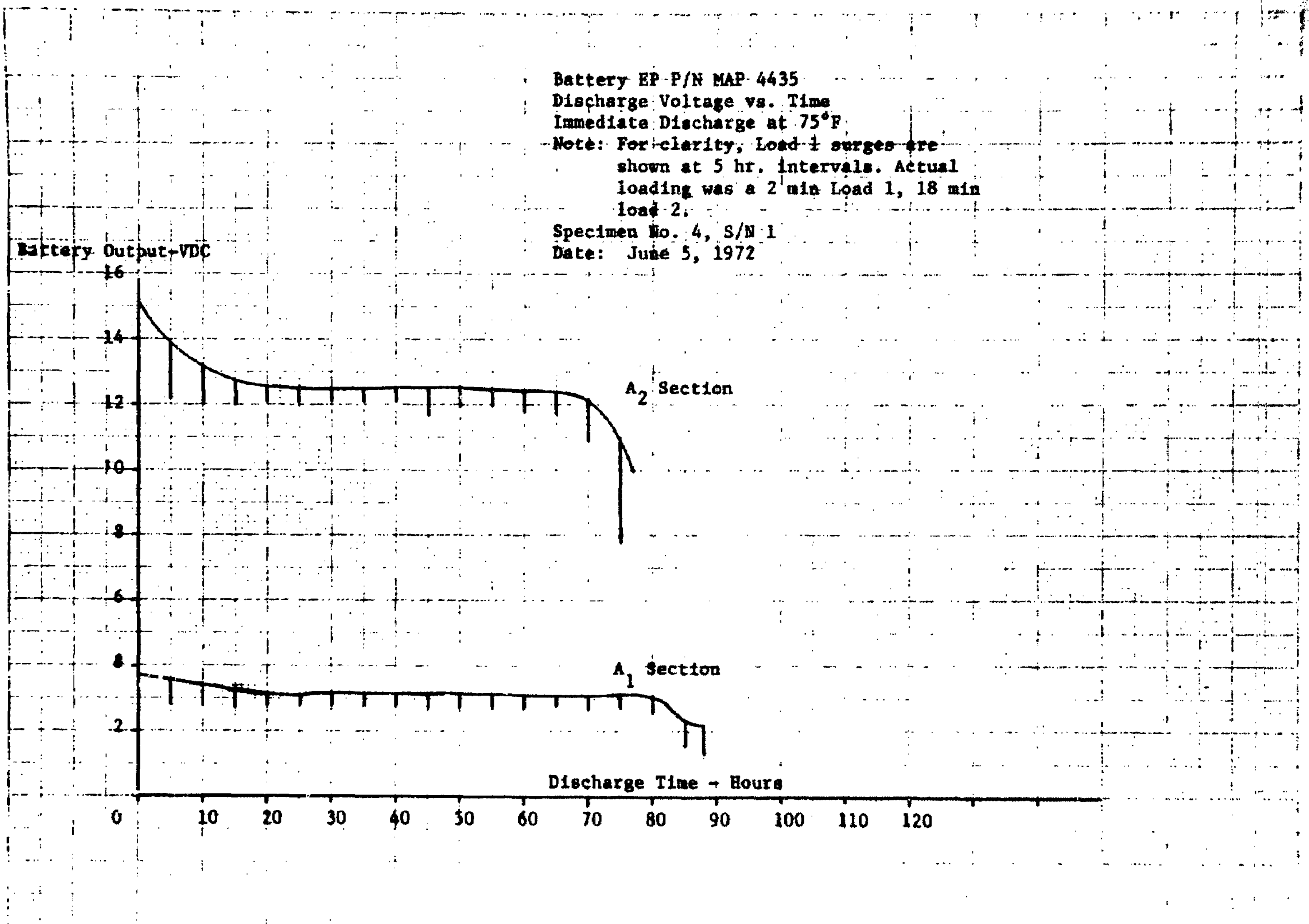
TEST DATA

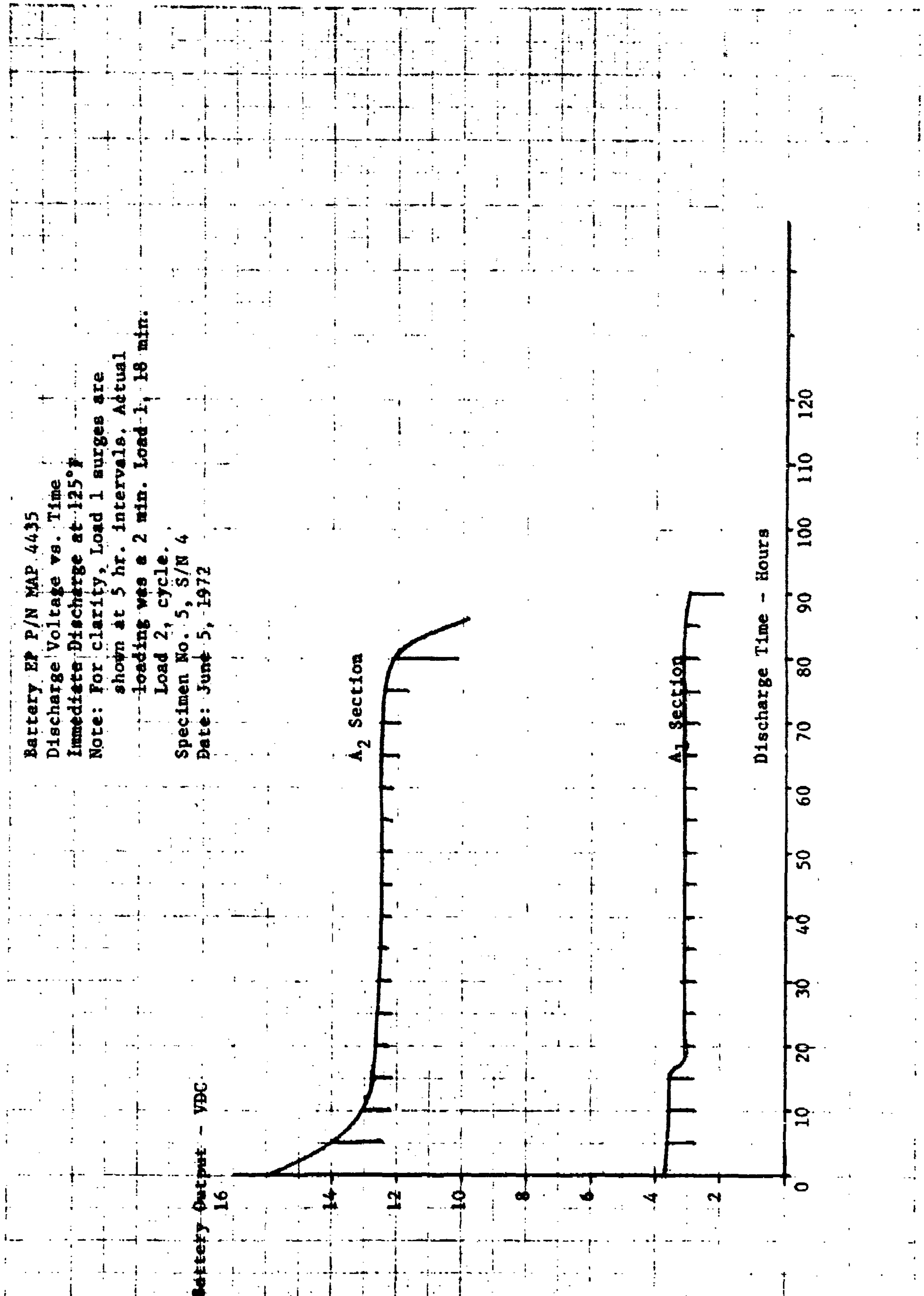

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F
Note: For clarity, load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 2, S/N 11
Date: June 5, 1972
Battery Output VDC
16
14
12
10
8
6
4
2
0
A_2 Section
A_1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120


Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F
Note: For clarity, Load 1 surges
are shown at 5 hour intervals.
Actual loading was a 2 min. load 1
18 min load 2 cycles
Specimen No. 1, S/N 14
Date: June 5, 1972
Battery Output-VDC
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
A_2 Section
A_1 Section
Discharge Time - Hours

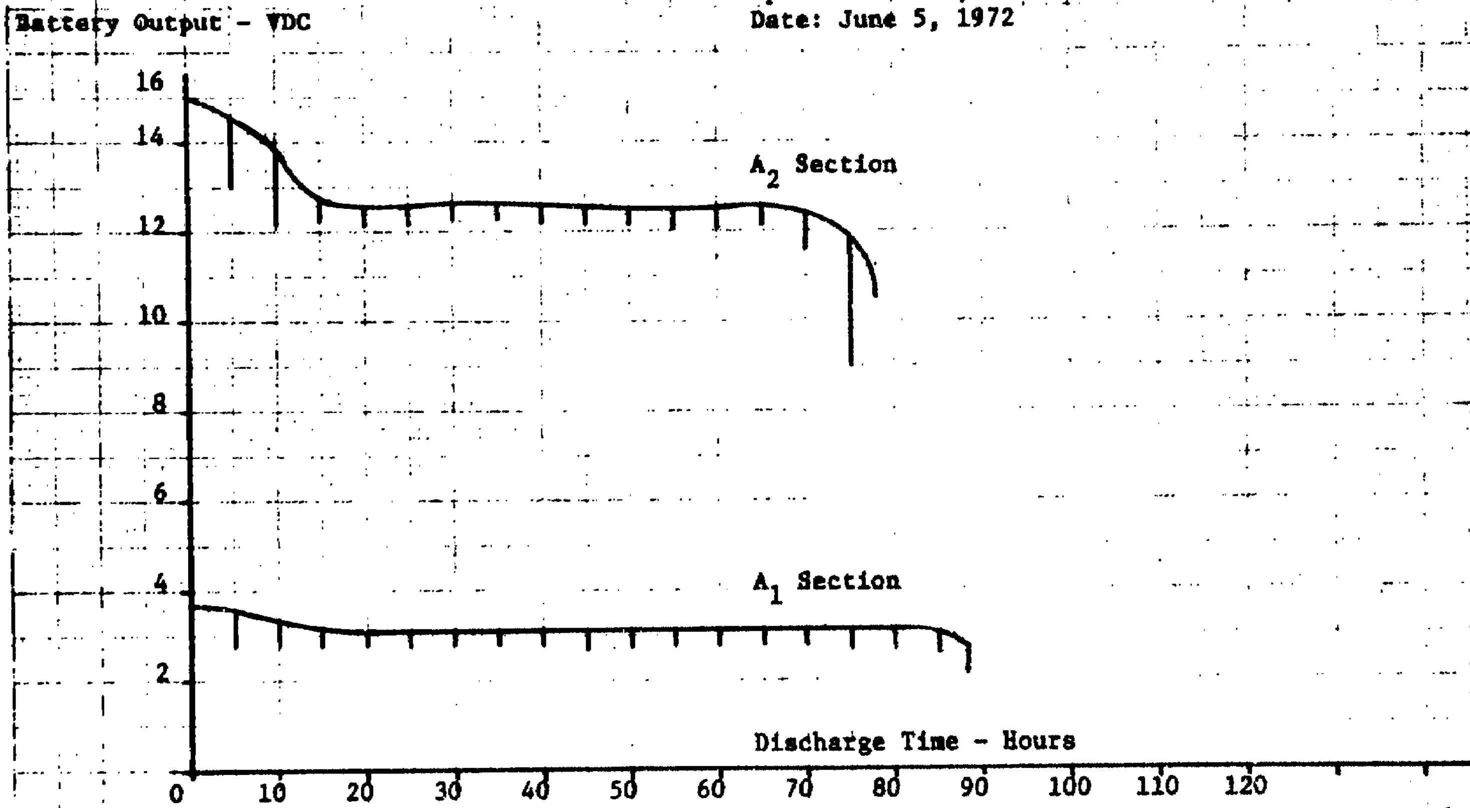


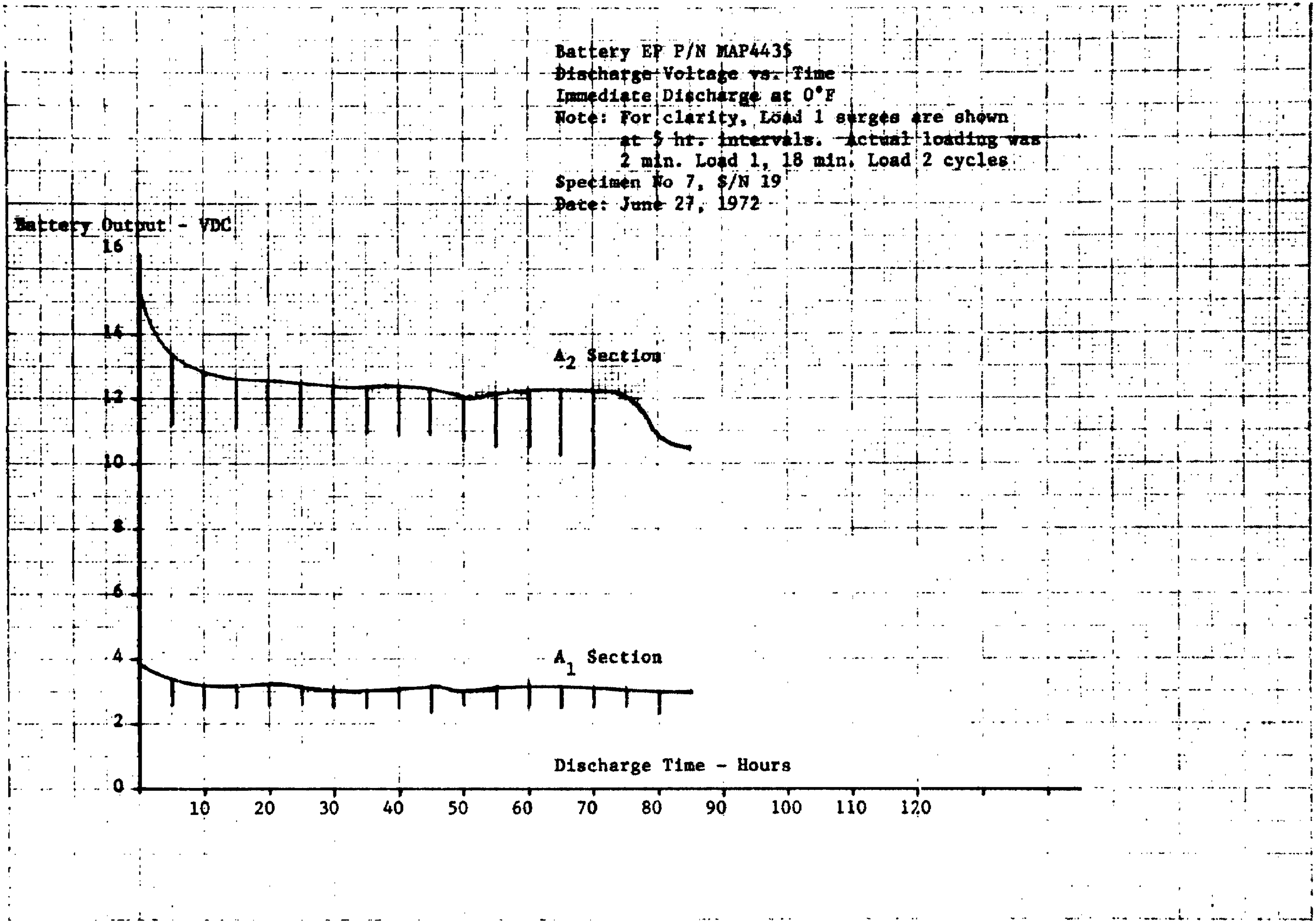
Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F
Note: For clarity Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min. Load 1, 18 min Load 2 cycle.
Specimen No. 3, S/N 60
Date: June 5, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
A2 Section
A1 Section

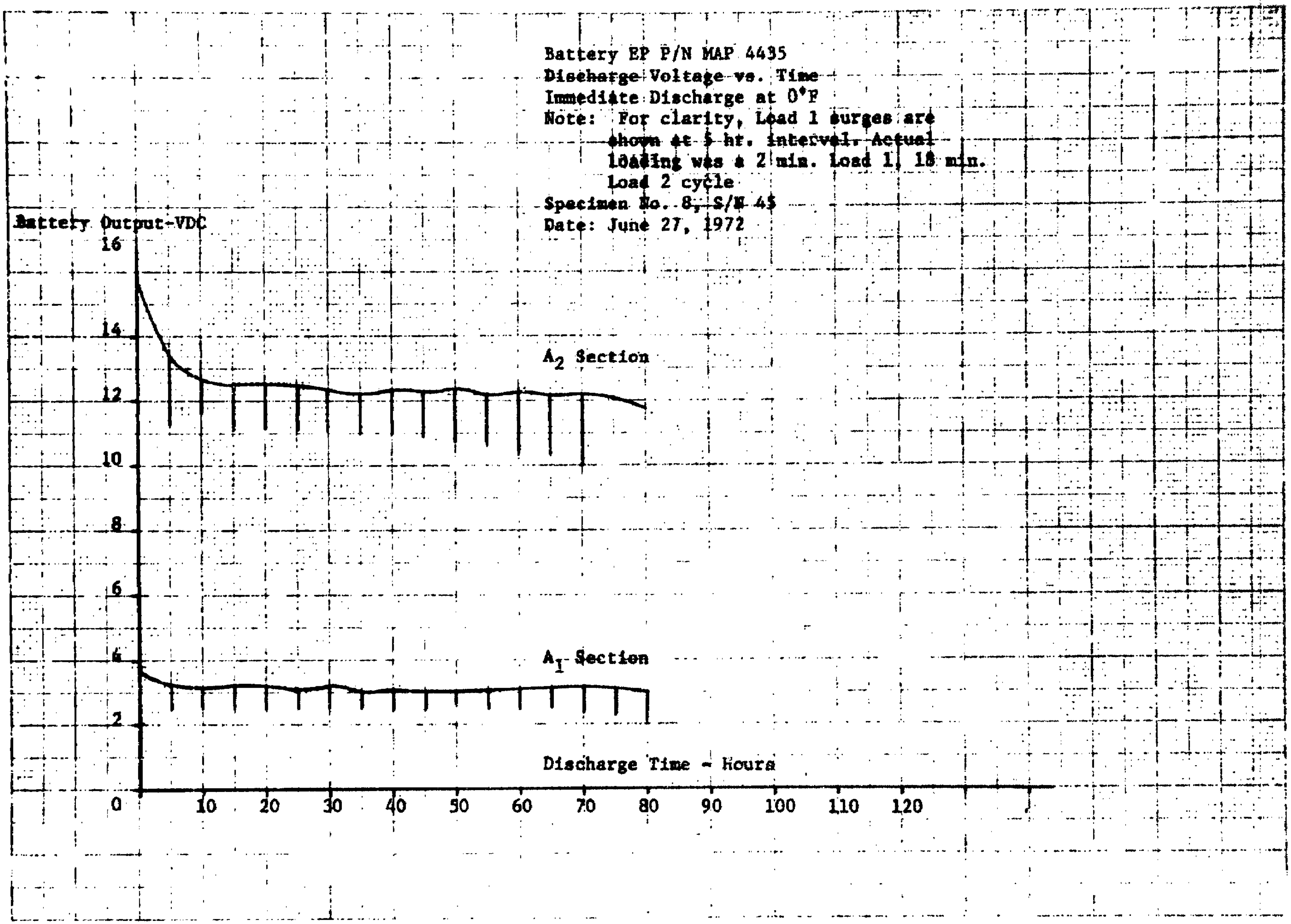

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min Load 1, 18 min load 2.
Specimen No. 4, S/N 1
Date: June 5, 1972
Battery Output-VDC
16
14
12
10
8
6
4
2
A_2 Section
A_1 Section
Discharge Time → Hours
0
10
20
30
40
50
60
70
80
90
100
110
120

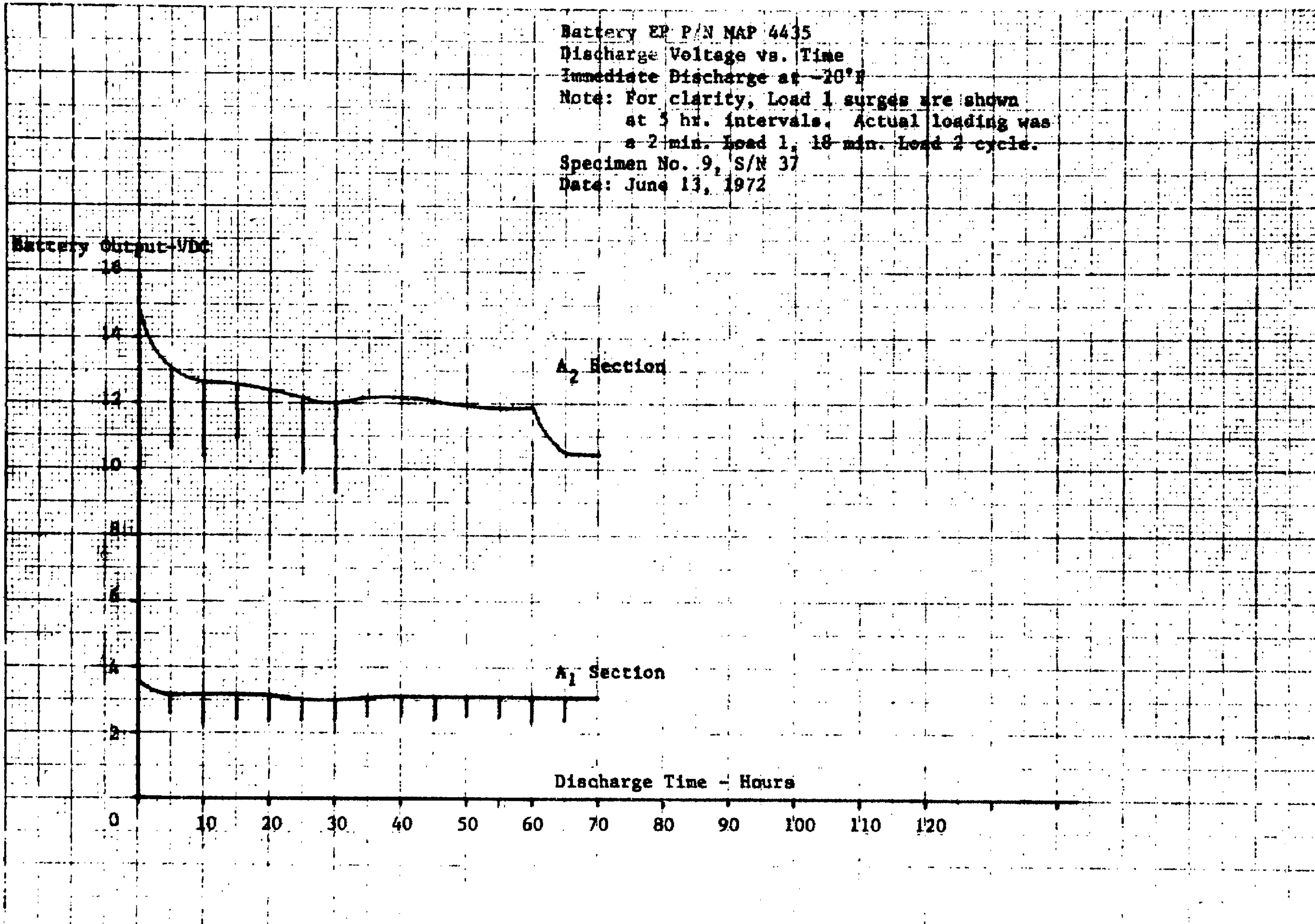

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 125°F
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2, cycle.
Specimen No. 5, S/N 4
Date: June 5, 1972
A_2 Section
A_1 Section
Battery Output - VDC
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
Discharge Time - Hours

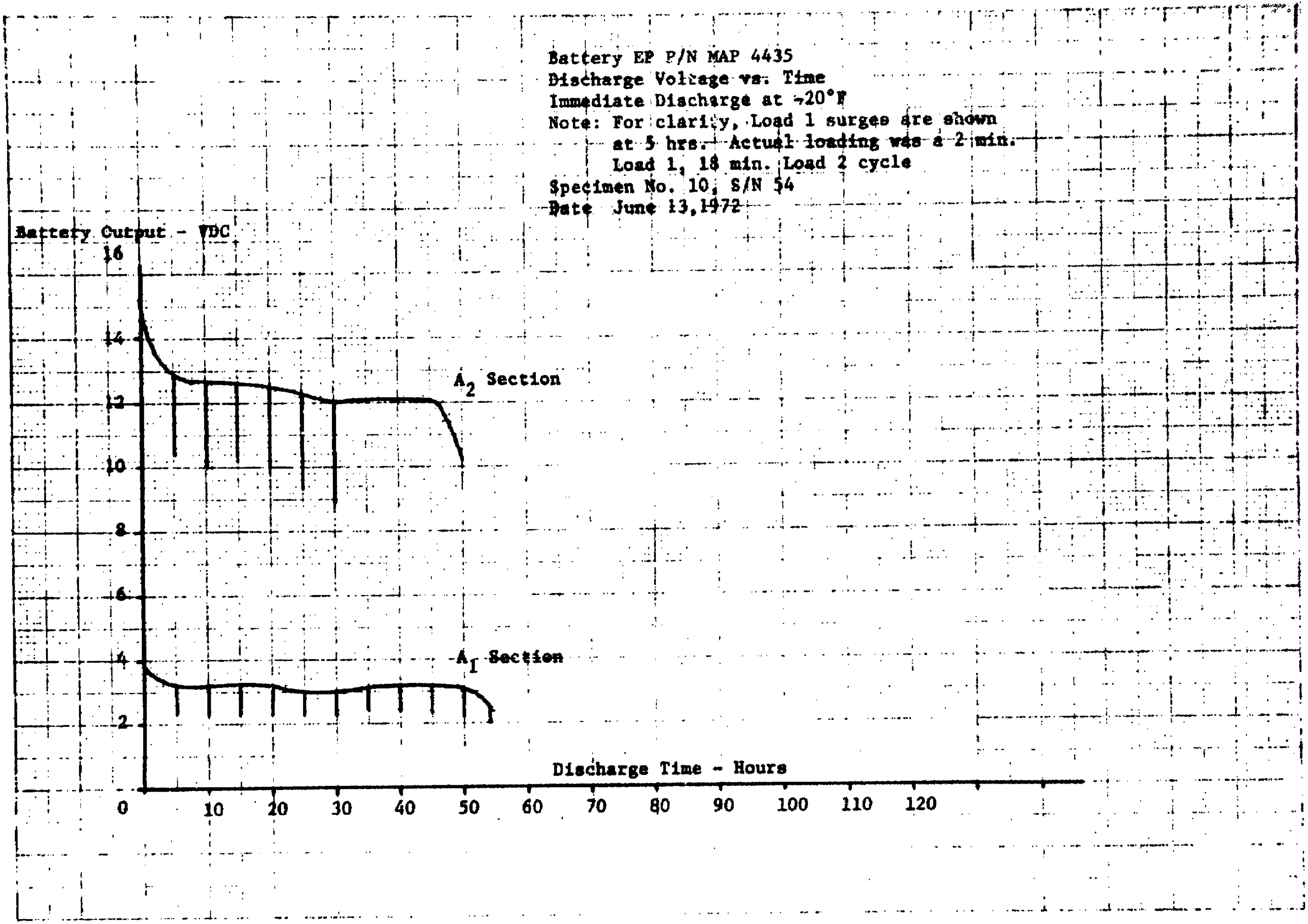
Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 125°F
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min, Load 1, 18 min. Load 2, cycle.
Specimen No. 6, S/N 13
Date: June 5, 1972

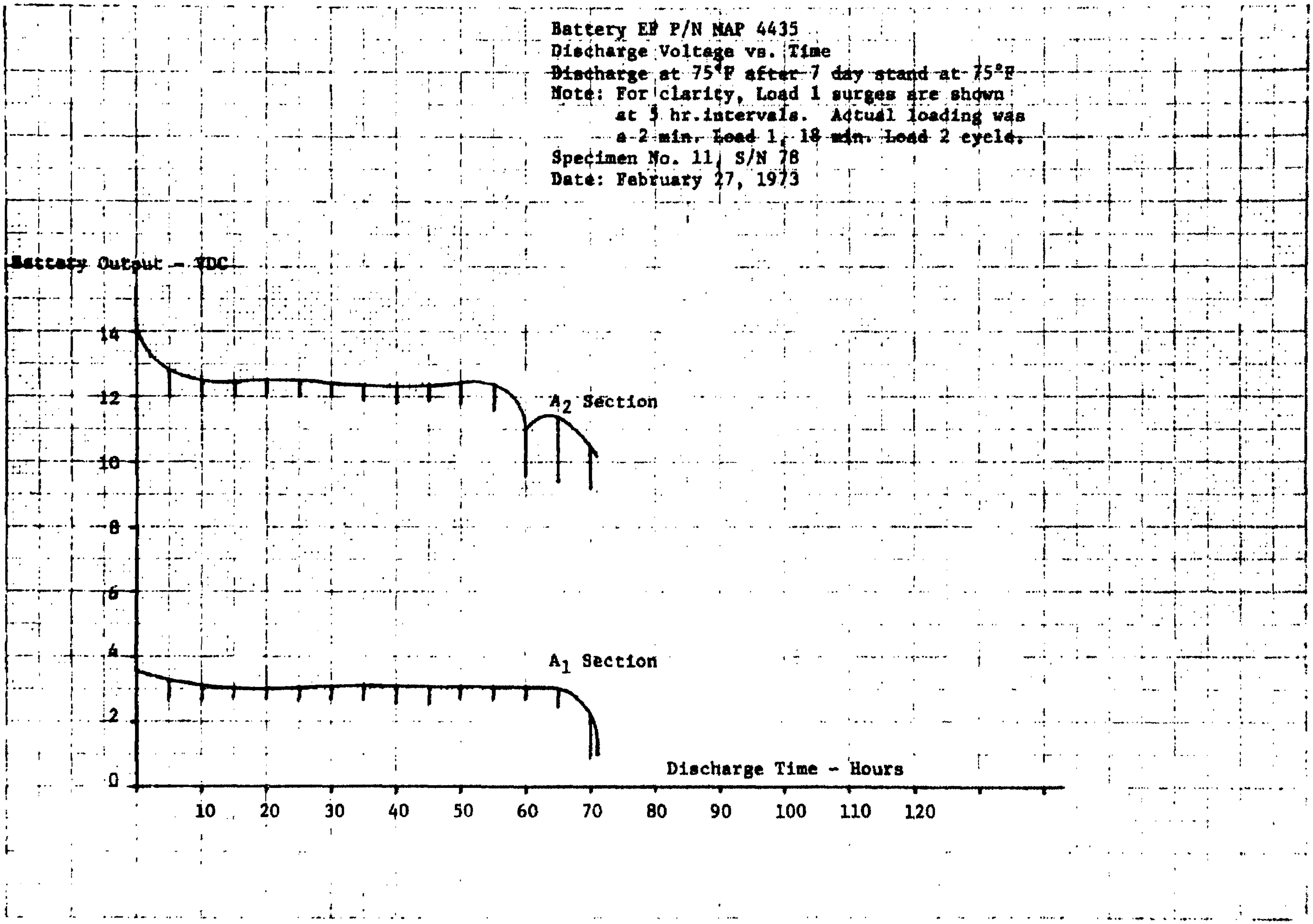


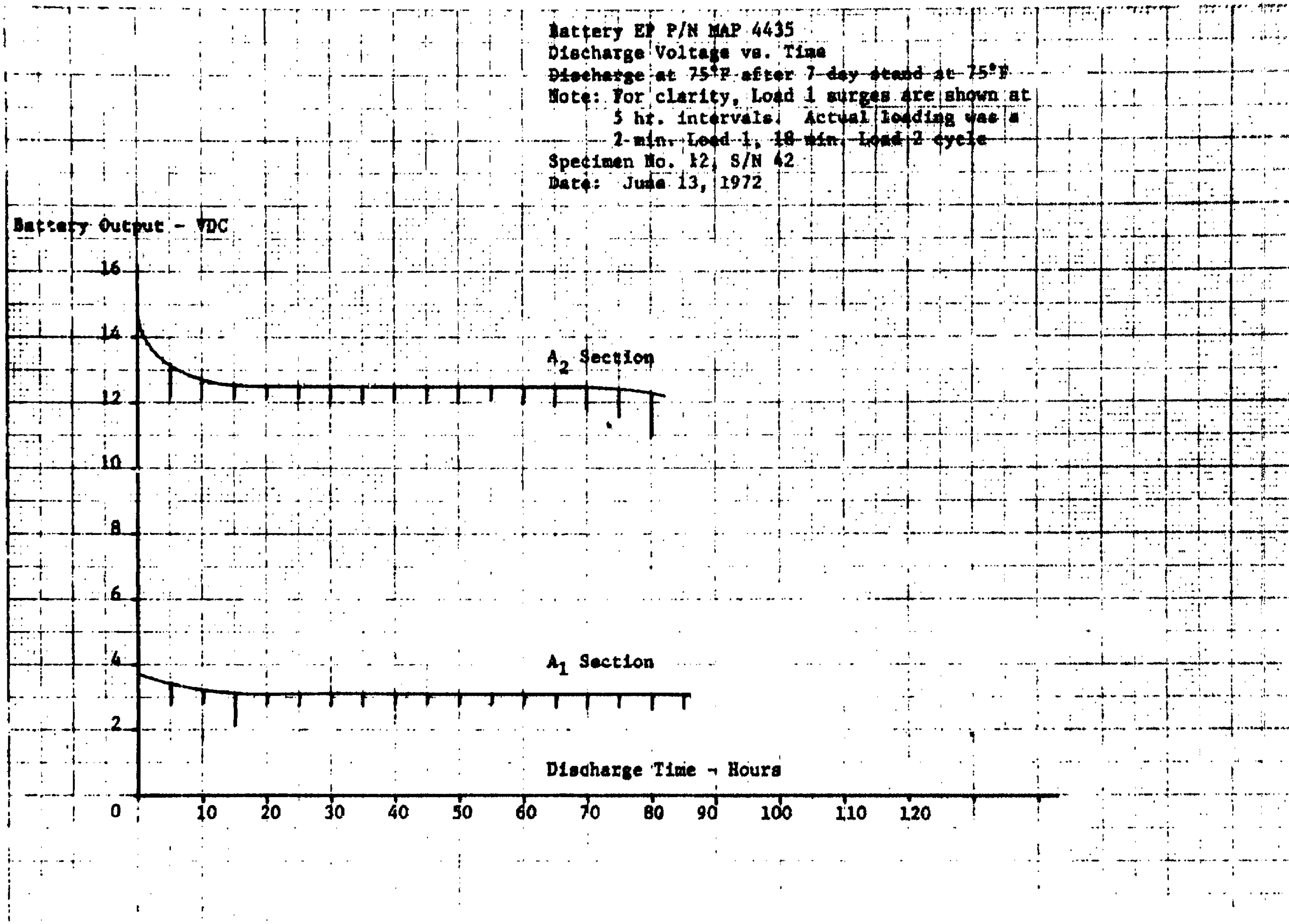

Battery EP P/N MAP4435
Discharge Voltage vs. Time
Immediate Discharge at 0°F
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was 2 min. Load 1, 18 min. Load 2 cycles
Specimen No 7, S/N 19
Date: June 27, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A2 Section
A1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

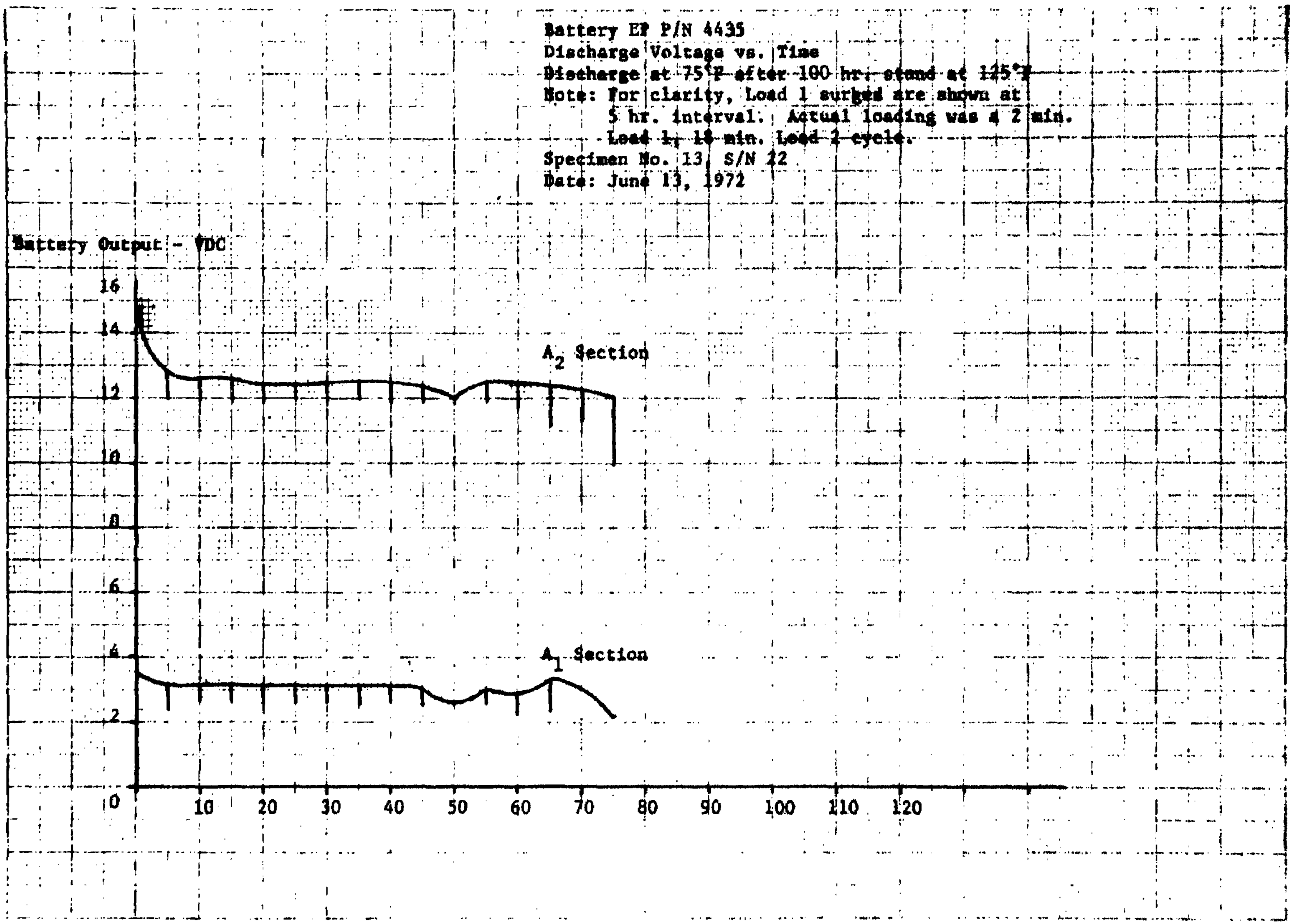

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 0°F
Note: For clarity, Load 1 surges are shown at 5 hr. interval. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle
Specimen No. 8, S/N 45
Date: June 27, 1972
Battery Output-VDC
16
14
12
10
8
6
4
2
0
A2 Section
A1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

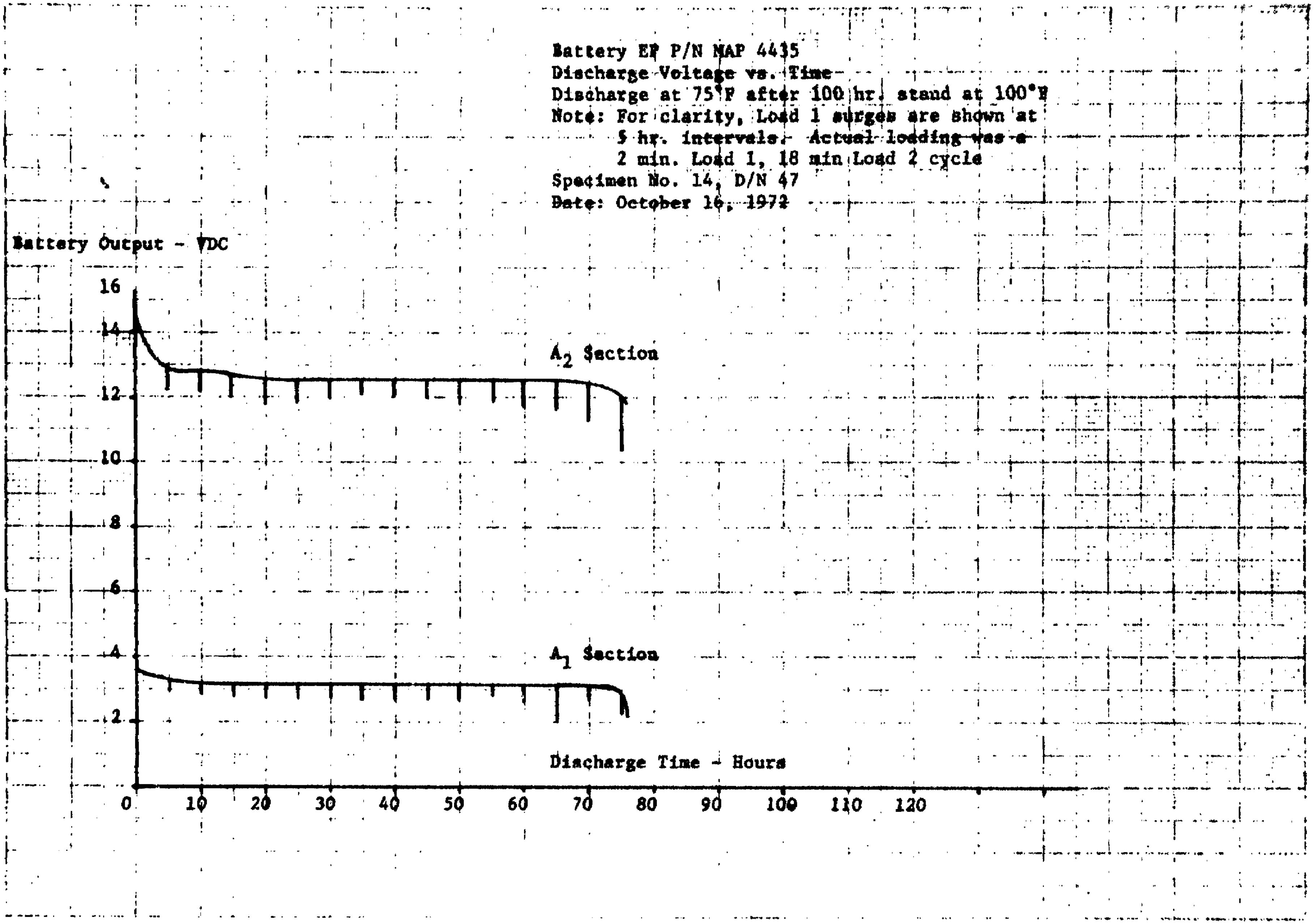

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at -20°F
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 9, S/N 37
Date: June 13, 1972
Battery Output-VDC
A$_2$ Section
A$_1$ Section
Discharge Time - Hours
0
10
20
30
40
50
60
70
80
90
100
110
120

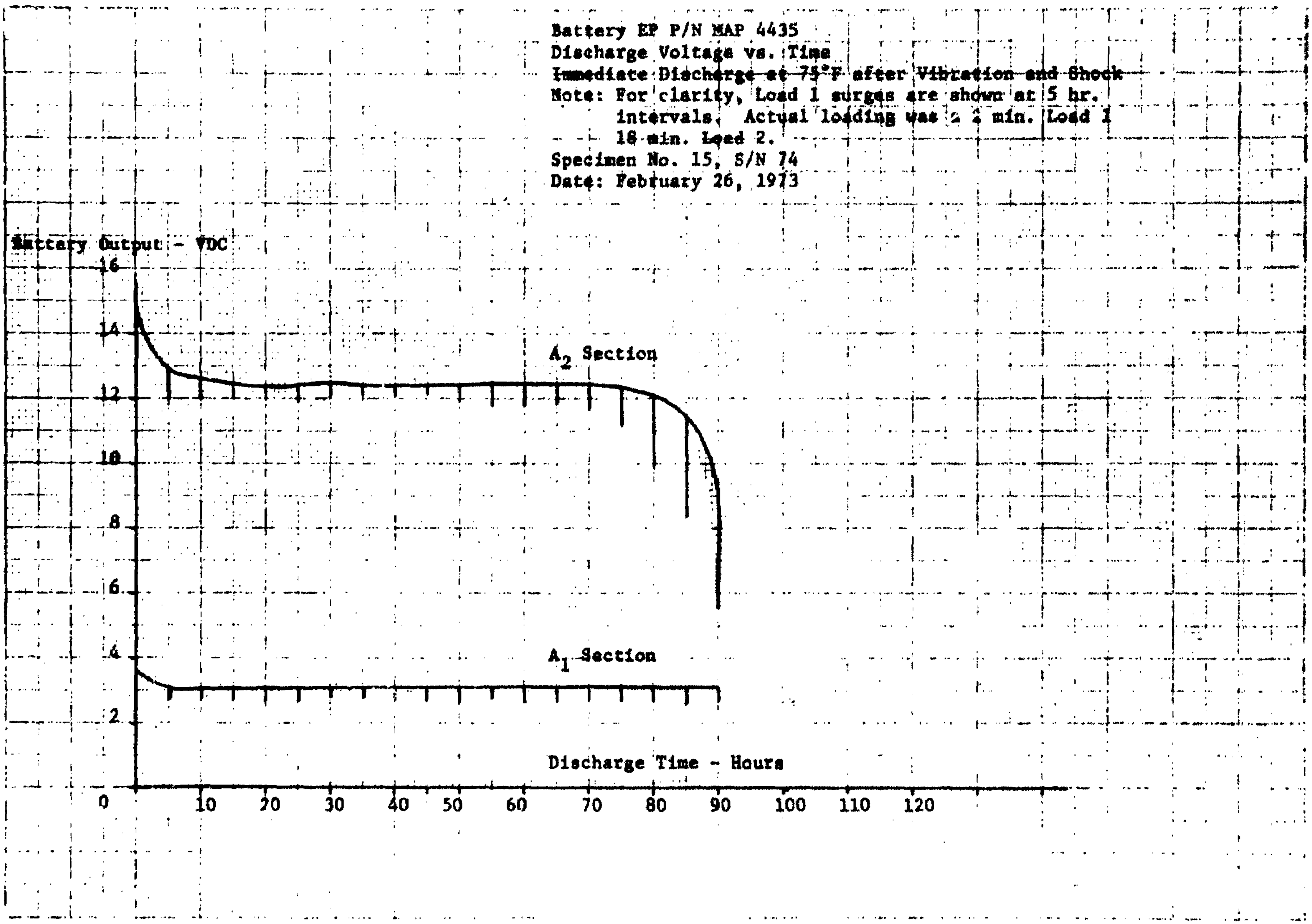

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at -20°F
Note: For clarity, Load 1 surges are shown
at 5 hrs. Actual loading was a 2 min.
Load 1, 18 min. Load 2 cycle
Specimen No. 10, S/N 54
Date June 13,1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A₂ Section
A₁ Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

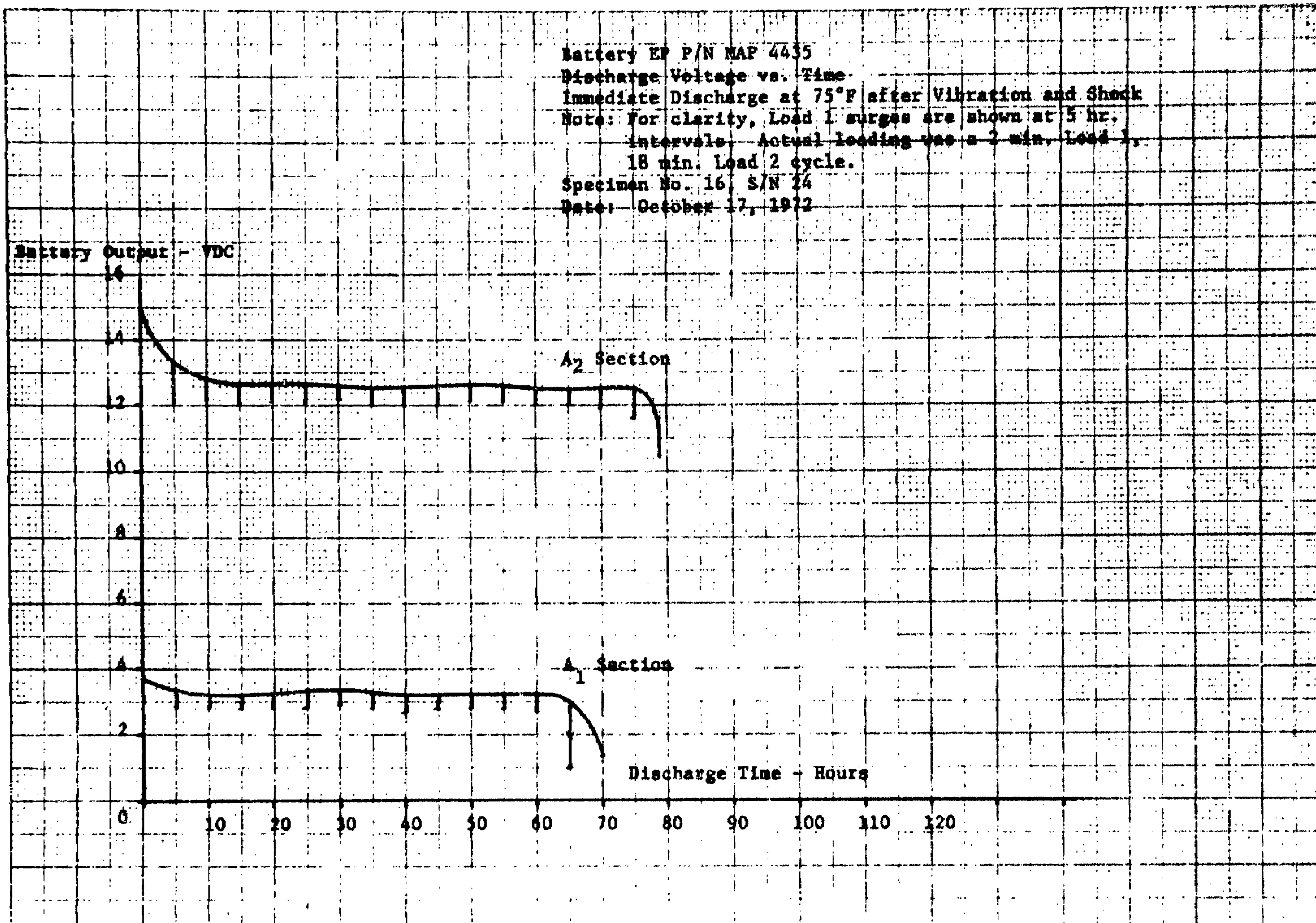

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Discharge at 75°F after 7 day stand at 75°F
Note: For clarity, Load 1 surges are shown at 5 hr.intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 11, S/N 78
Date: February 27, 1973
Battery Output - VDC
14
12
10
8
6
4
2
0
A2 Section
A1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

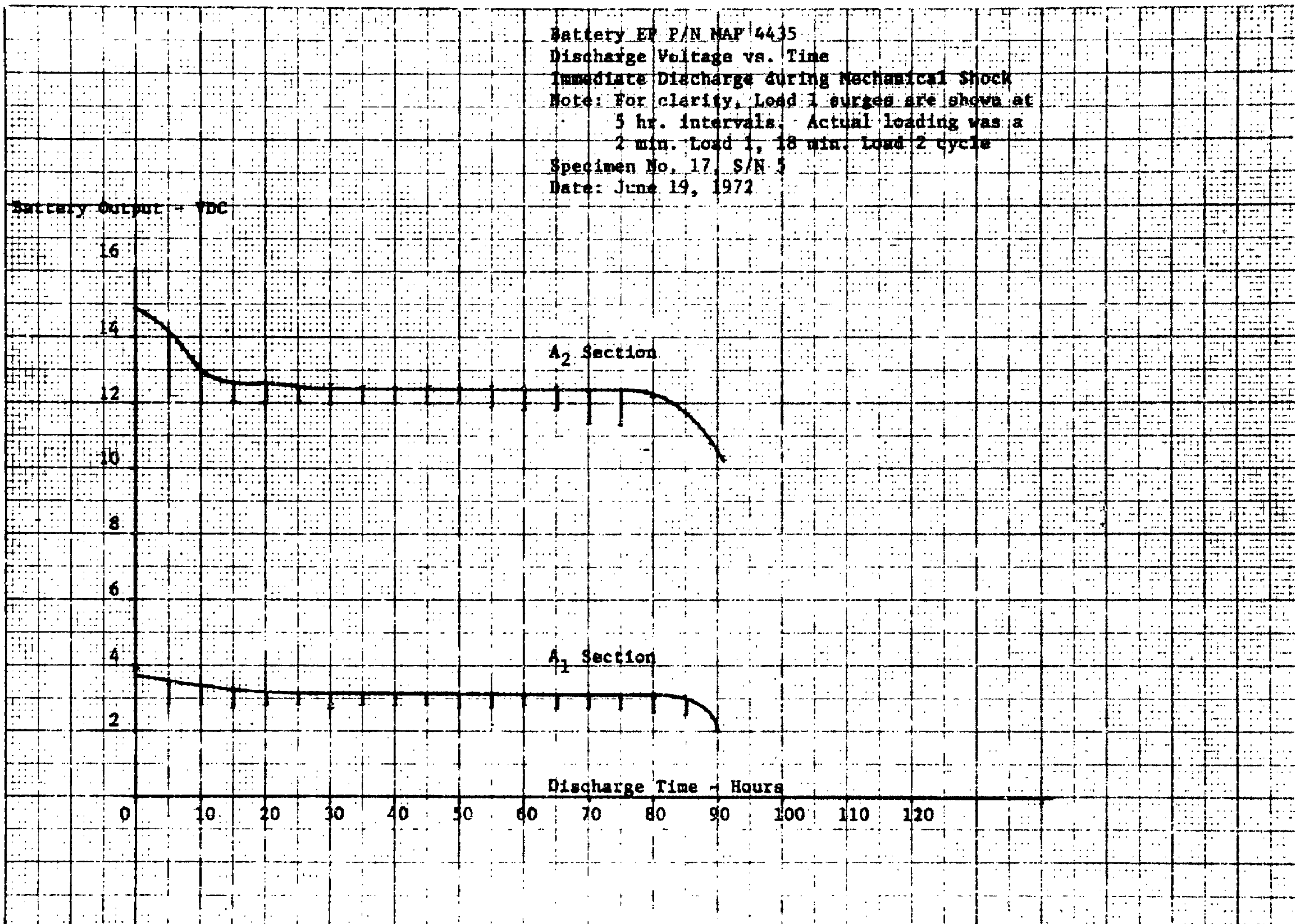

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Discharge at 75°F after 7 day stand at 75°F
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle
Specimen No. 12, S/N 42
Date: June 13, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A_2 Section
A_1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

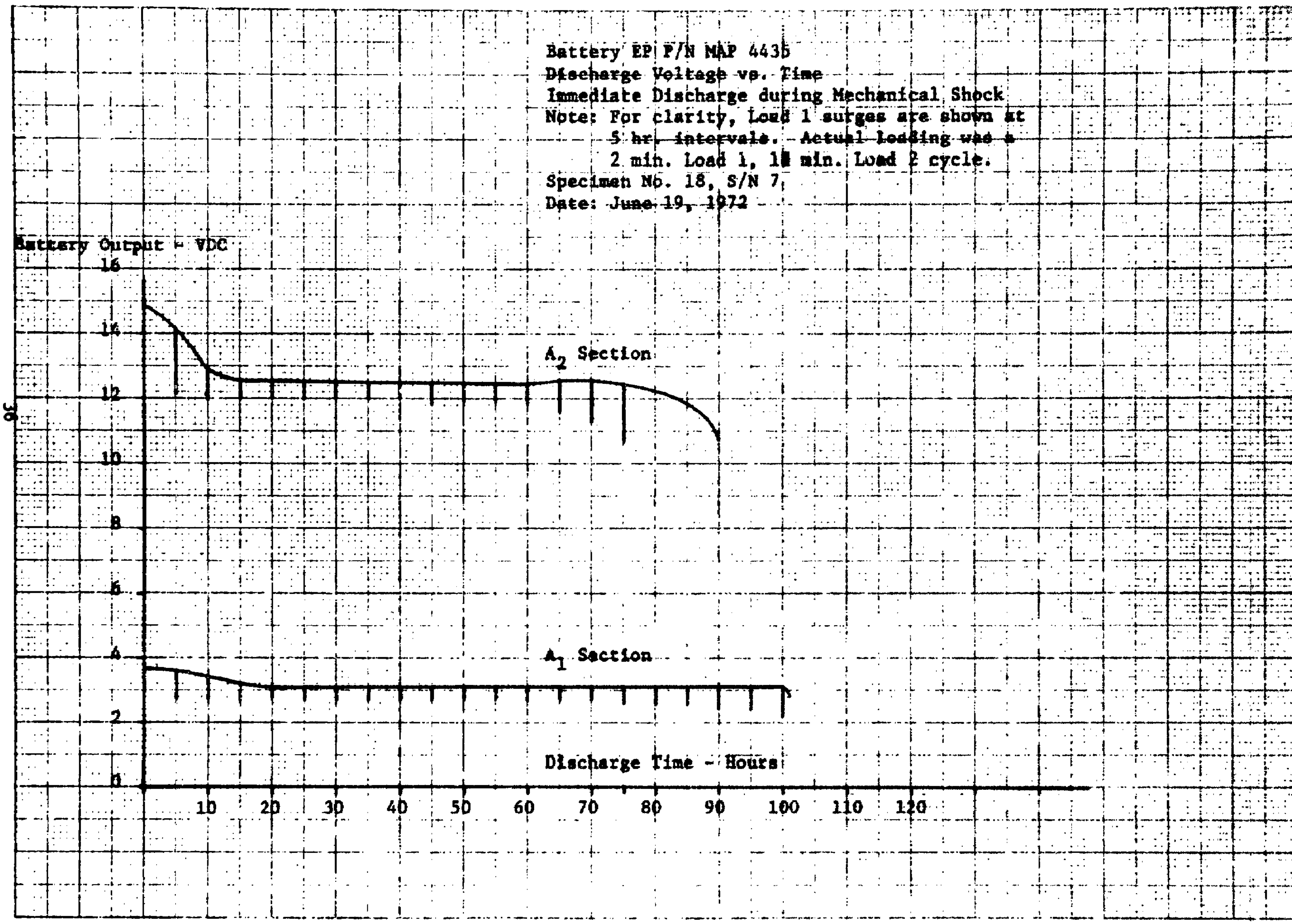

Battery EP P/N 4435
Discharge Voltage vs. Time
Discharge at 75°F after 100 hr. stand at 125°F
Note: For clarity, Load 1 surges are shown at
5 hr. interval. Actual loading was 4 2 min.
Load 1, 18 min. Load 2 cycle.
Specimen No. 13 S/N 22
Date: June 13, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
A_2 Section
A_1 Section

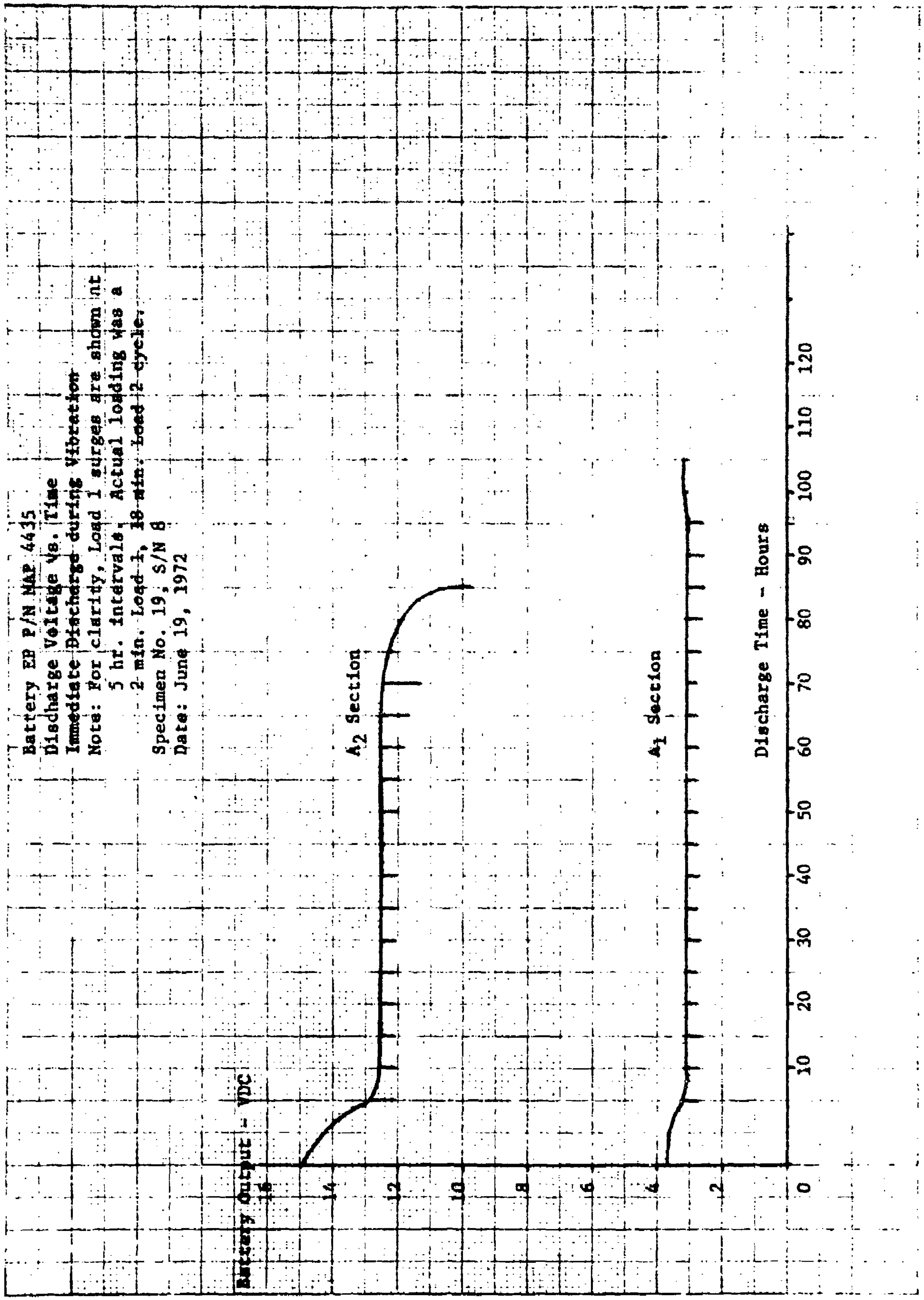

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Discharge at 75°F after 100 hr. stand at 100°F
Note: For clarity, Load 1 surges are shown at
5 hr. intervals. Actual loading was a
2 min. Load 1, 18 min Load 2 cycle
Specimen No. 14, D/N 47
Date: October 16, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
A_2 Section
A_1 Section
Discharge Time - Hours
0
10
20
30
40
50
60
70
80
90
100
110
120

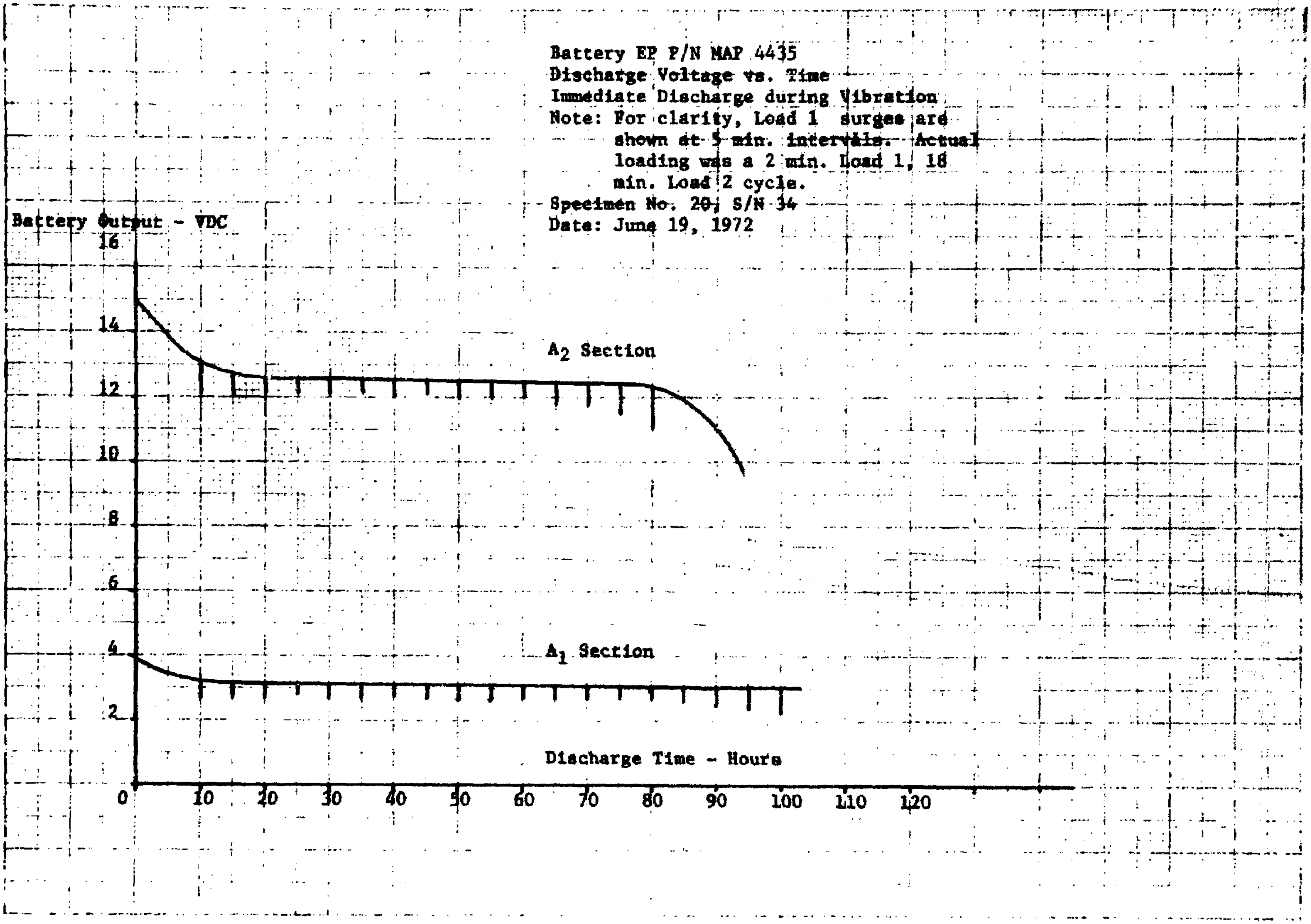

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F after Vibration and Shock
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was ≈ 2 min. Load 1 18 min. Load 2.
Specimen No. 15, S/N 74
Date: February 26, 1973
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A_2 Section
A_1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

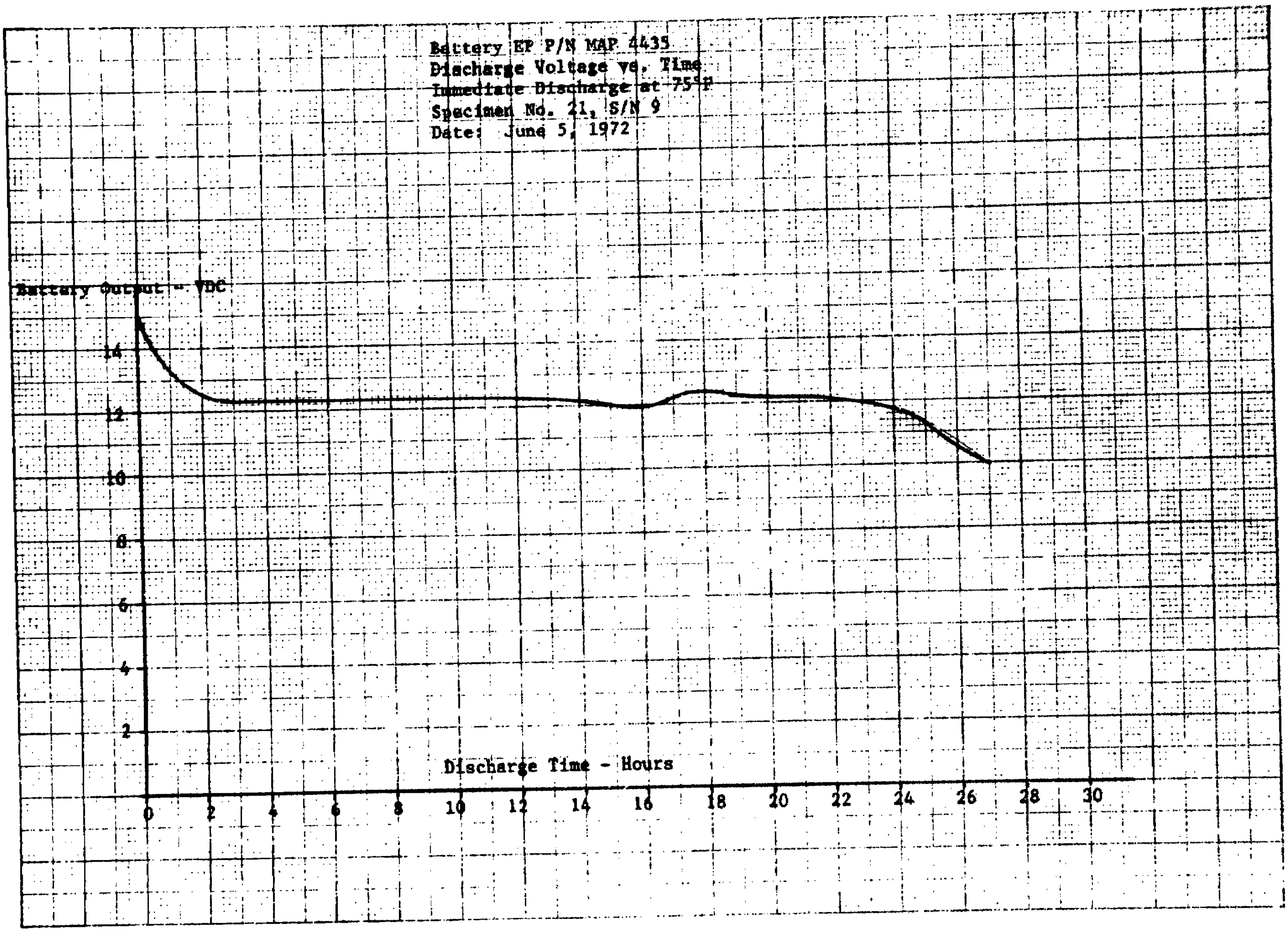

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F after Vibration and Shock
Note: For clarity, Load 1 surges are shown at 5 hr. intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 16, S/N 24
Date: October 17, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A2 Section
A1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120


Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge during Mechanical Shock
Note: For clarity, Load 1 surges are shown at
5 hr. intervals. Actual loading was a
2 min. Load 1, 18 min. Load 2 cycle
Specimen No. 17, S/N 5
Date: June 19, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
A2 Section
A1 Section
Discharge Time - Hours
0
10
20
30
40
50
60
70
80
90
100
110
120

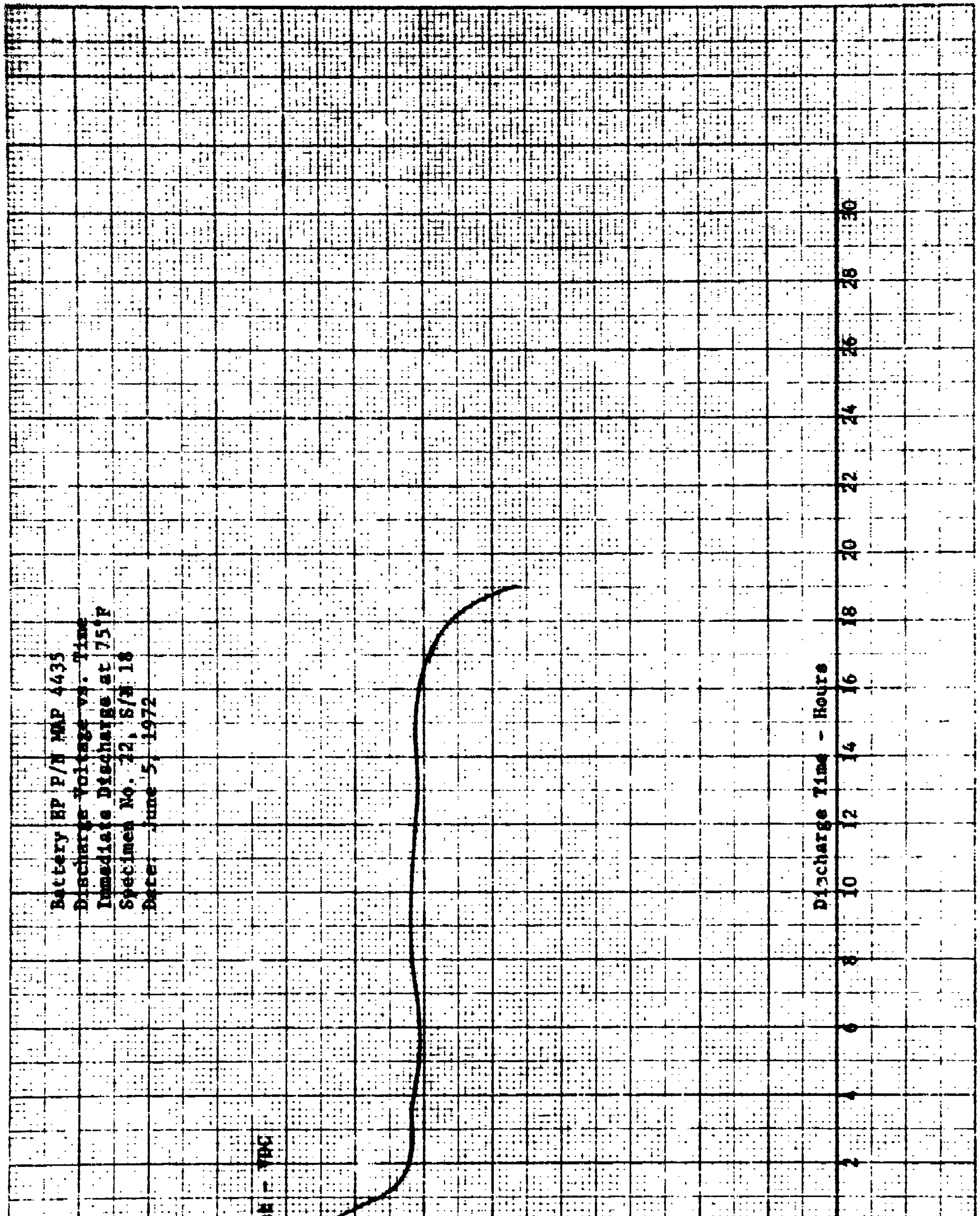

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge during Mechanical Shock
Note: For clarity, Load 1 surges are shown at
5 hr. intervals. Actual loading was a
2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 18, S/N 7
Date: June 19, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A2 Section
A1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

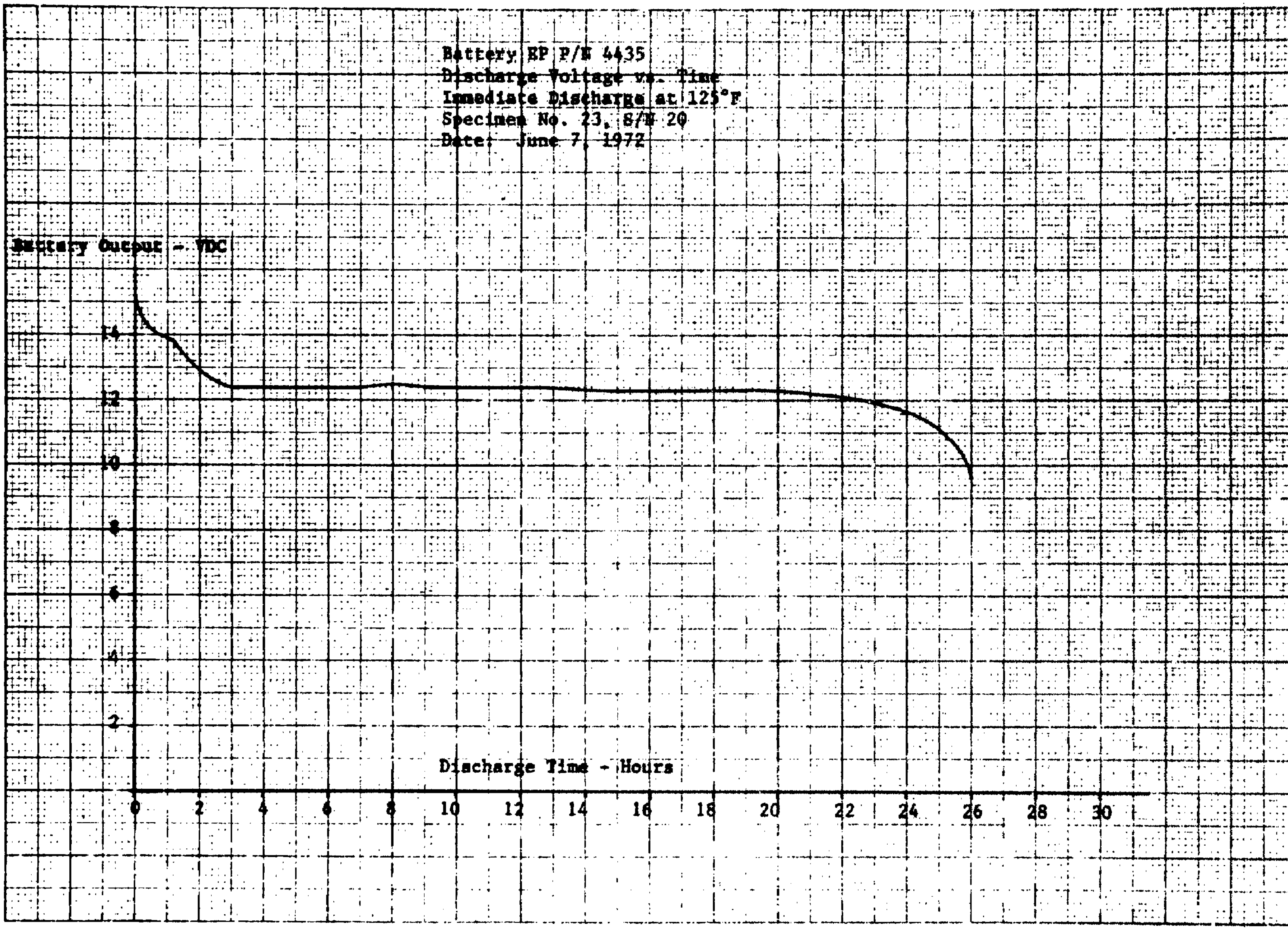

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge during Vibration
Note: For clarity, Load 1 surges are shown at
5 hr. intervals. Actual loading was a
2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 19, S/N 8
Date: June 19, 1972
A_2 Section
A_1 Section
Battery Output - VDC
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
Discharge Time - Hours

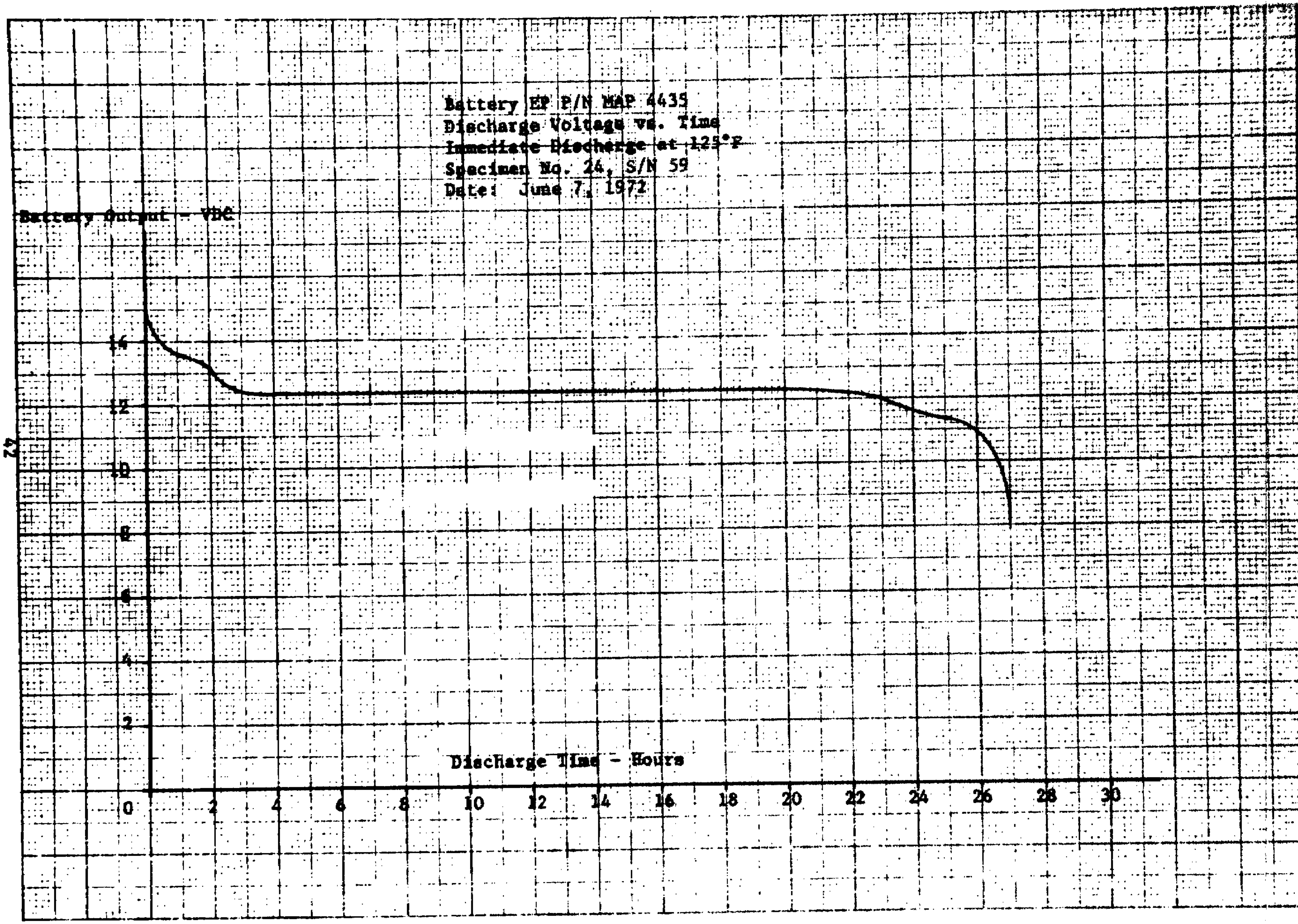

Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge during Vibration
Note: For clarity, Load 1 surges are shown at 5 min. intervals. Actual loading was a 2 min. Load 1, 18 min. Load 2 cycle.
Specimen No. 20; S/N 34
Date: June 19, 1972
Battery Output - VDC
16
14
12
10
8
6
4
2
0
A_2 Section
A_1 Section
Discharge Time - Hours
10
20
30
40
50
60
70
80
90
100
110
120

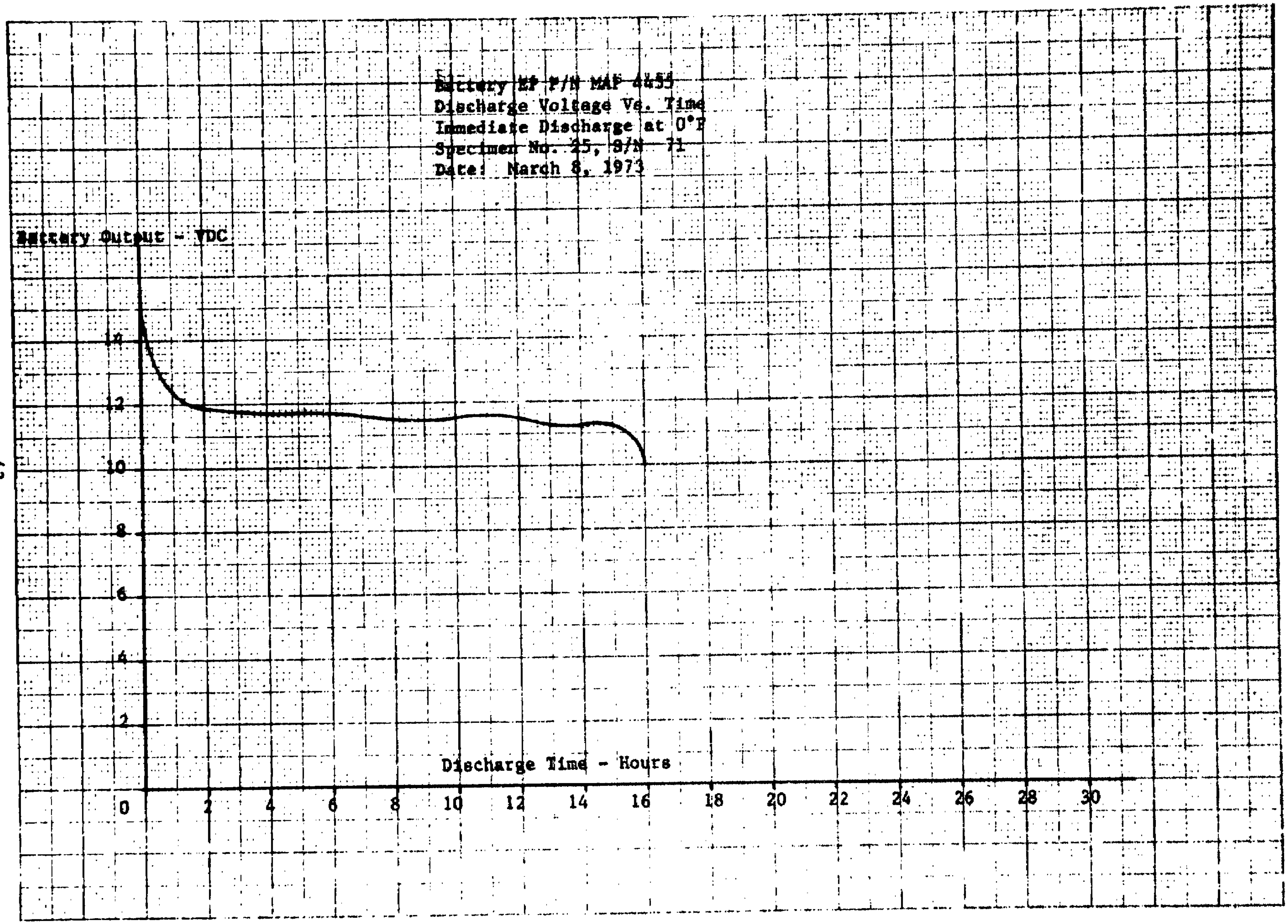


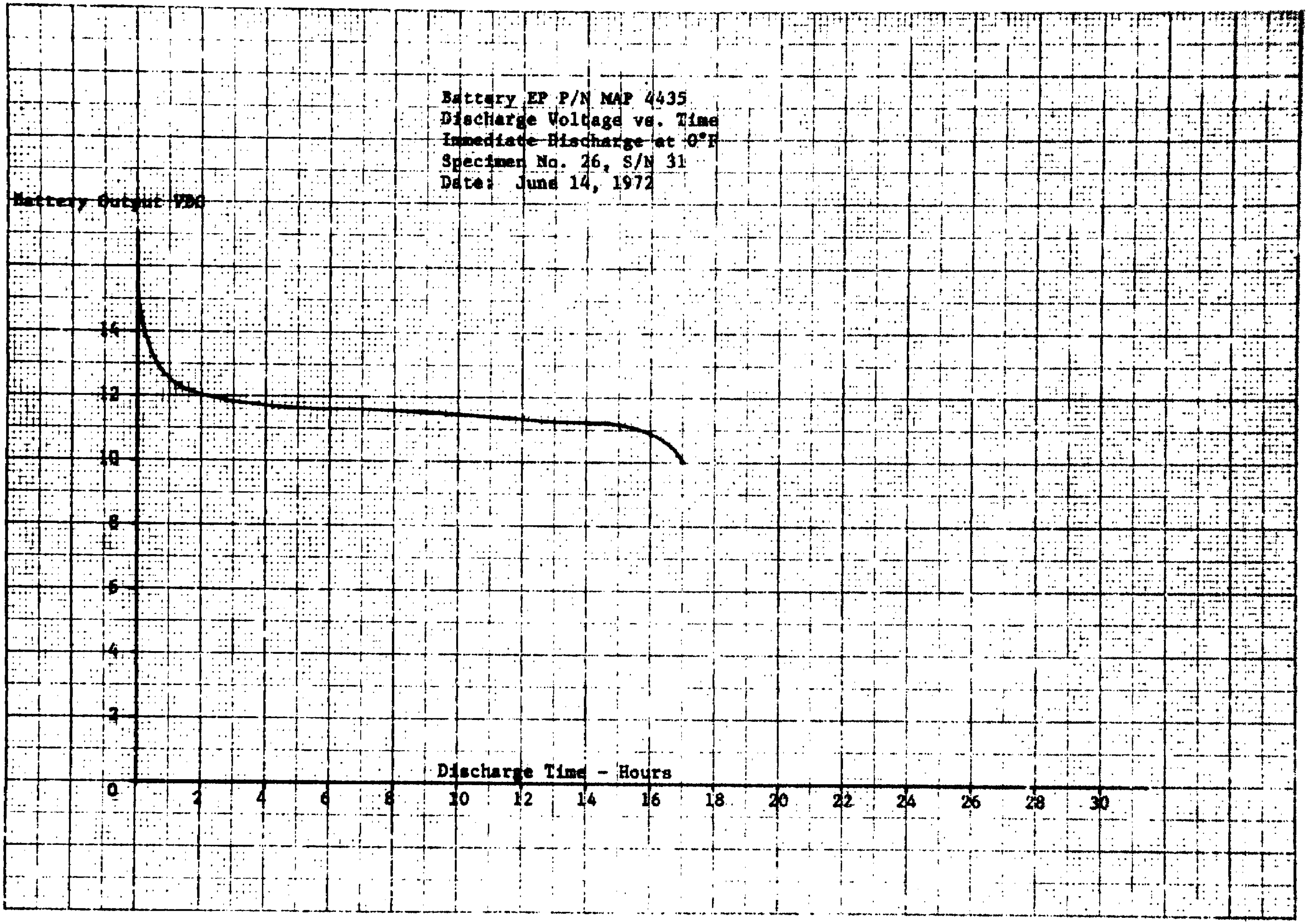
Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F
Specimen No. 21, S/N 9
Date: June 5, 1972
Battery Output - VDC
14
12
10
8
6
4
2
Discharge Time - Hours
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30


Battery HP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 75°F
Specimen No. 22, S/N 18
Date: June 5, 1972
Battery Output - VDC
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Discharge Time - Hours

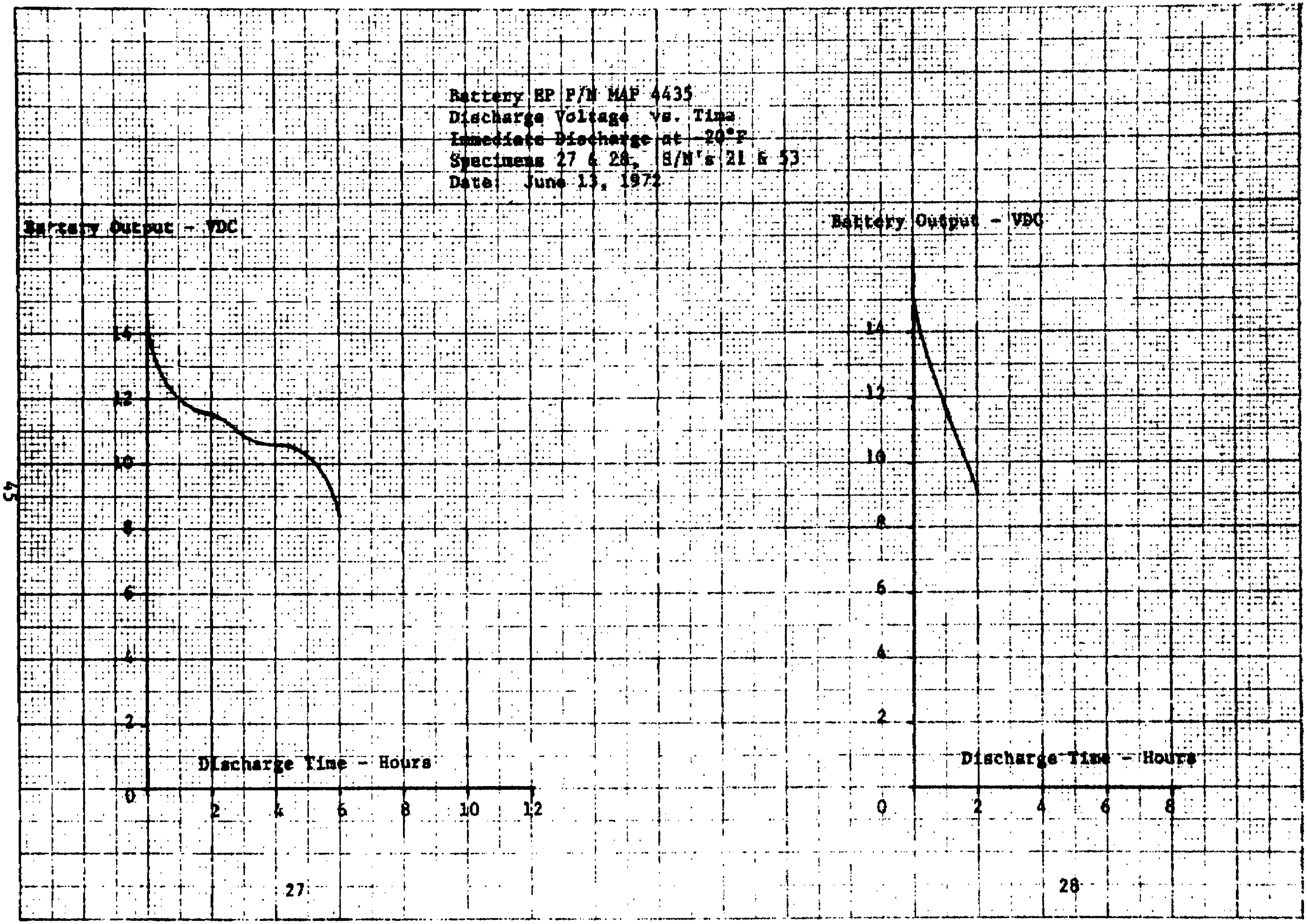

Battery EP P/N 4435
Discharge Voltage vs. Time
Immediate Discharge at 125°F
Specimen No. 23, S/N 20
Date: June 7, 1972
Battery Output - VDC
14
12
10
8
6
4
2
Discharge Time - Hours
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30


Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 125°F
Specimen No. 24, S/N 59
Date: June 7, 1972
Battery Output - VDC
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Discharge Time - Hours

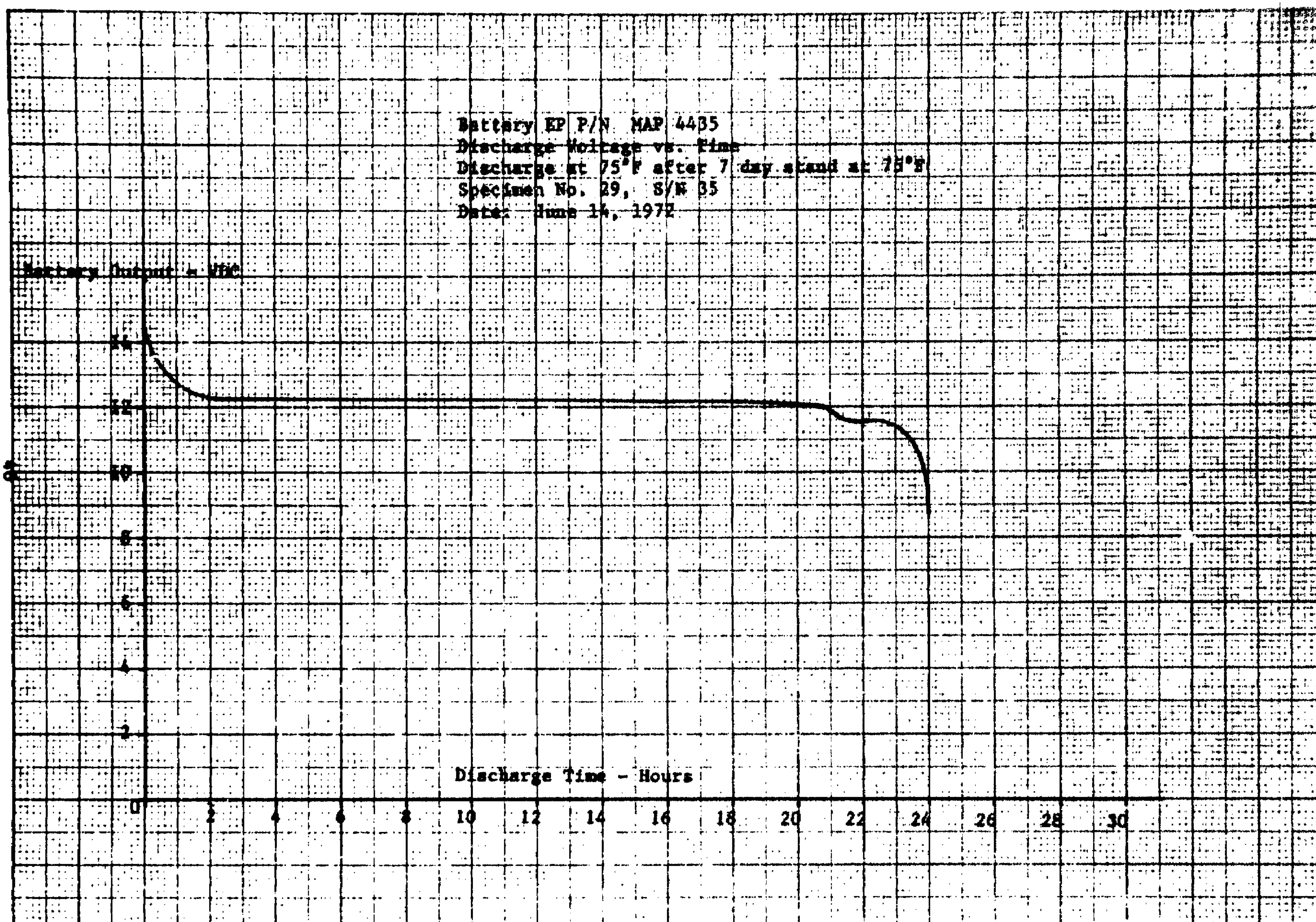

Battery EP P/N MAP 4455
Discharge Voltage Vs. Time
Immediate Discharge at 0°F
Specimen No. 25, S/N 71
Date: March 8, 1973
Battery Output - VDC
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Discharge Time - Hours



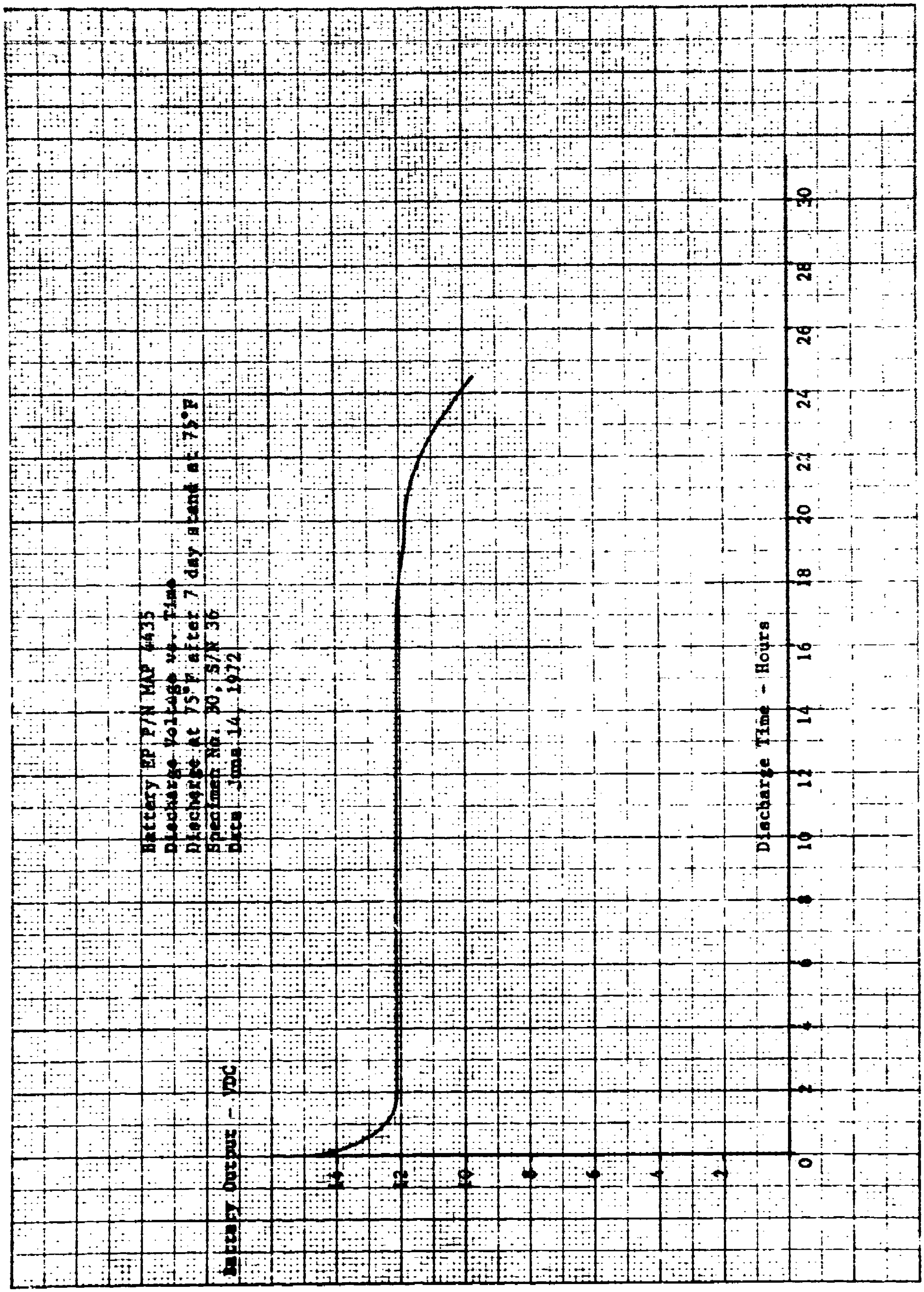
Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at 0°F
Specimen No. 26, S/N 31
Date: June 14, 1972
Battery Output VDC
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Discharge Time - Hours



Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Immediate Discharge at -20°F
Specimens 27 & 28, S/N's 21 & 53
Date: June 13, 1972
Battery Output - VDC
14
12
10
8
6
4
2
0
Discharge Time - Hours
2
4
6
8
10
12
27
Battery Output - VDC
14
12
10
8
6
4
2
0
Discharge Time - Hours
0
2
4
6
8
28



Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Discharge at 75°F after 7 day stand at 75°F
Specimen No. 29, S/N 35
Date: June 14, 1972
Battery Output - VDC
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Discharge Time - Hours


Battery EP P/N MAP 4435
Discharge Voltage vs. Time
Discharge at 75°F after 7 day stand at 75°F
Specimen No. 30, S/N 36
Date June 14, 1972
Battery Output - VDC
2
4
6
8
10
12
14
Discharge Time - Hours
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

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Final Report 16 February 1971 to 15 March 1973

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13. ABSTRACT

This report describes the design, development, manufacture and evaluation testing of a Zinc-Silver Oxide reserve battery in accordance with "Technical Guidelines for Water Activated Zinc-Silver Oxide Battery". This includes a description of the design effort, the design, the test program, the test equipment and the test results. The evaluation testing showed compliance with the requirements of the technical guidelines.

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