



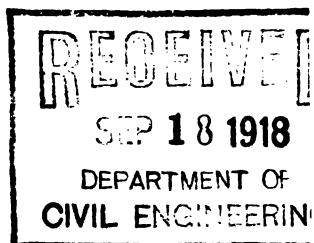
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THE S I C

TEST OF A TRAY PLATE STORAGE BATTERY

BY

OLIVER W. BURK. 1905

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M
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C. E. JOHNSON. 1905

100-443887-100

151
Data,- Battery of the tray type made and installed by Smith Storage Battery Co., Binghamton, N. Y. Two piles of 23 cells, each occupying floor space 28" x 40" each. Rated at 55 volts per pile, capacity 200 ampere hours, having normal discharge rate of 25 amperes.

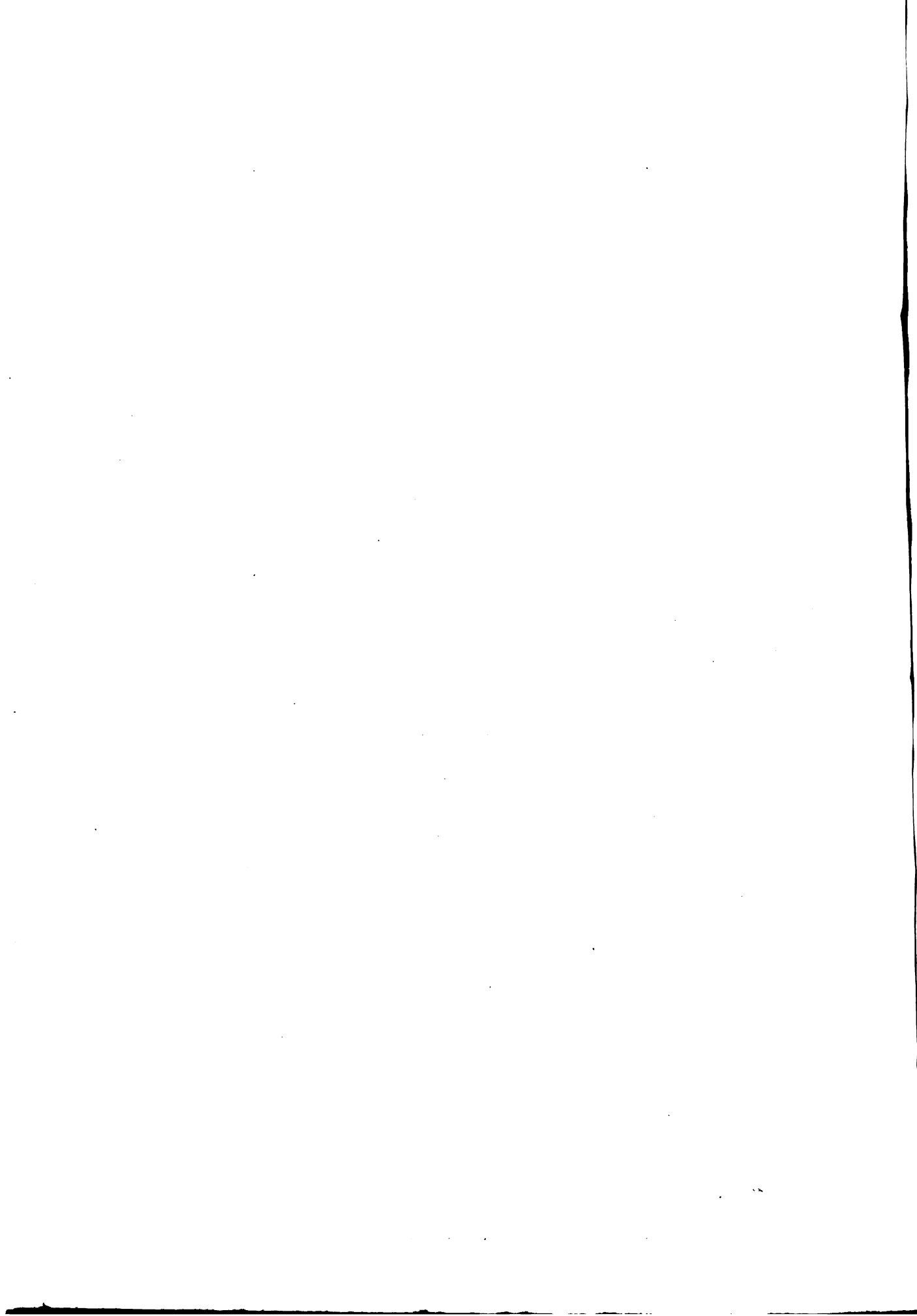
The storage battery, for so many years regarded by engineers with suspicion, seems of late to have found the line of work for which it is especially adapted and the activity in storage battery development seems to indicate that it is an essential part of a commercially successful electric power plant whose load is not steady. Various things, such as the evolution of gasses, the space required and the limited size of glass electrolyte containers now manufactured seem to throw the balance in favor of the tray plate battery invented by Mr. M. C. Smith, especially in installations where large units are employed.

This type of battery is decidedly different from the cell type in that the plates themselves are electrolyte containers and both sides, top and bottom, are gridded and processed, the upper side being negative and lower positive. This construction is shown in the accompanying photographs. In No. 1 is shown the thickness of the original sheet of lead, which is .125" thick, also the increase in exposed surface resulting from the spinning or gridding process, which leaves a base .0047" thick. No. 2 shows three spun discs cut from a plate. In the upper one can be better seen this increase in exposed surface per unit weight of material. No's. 3 and 4 show the positive and negative plates of a cell type battery. Both have been processed. No. 3 is sponge lead (Pb.) or negative plate. No. 4 is the peroxide (PbO_2) or positive plate. The positive plate is reddish

brown in color. The negative plate is grayish. The difference of the cell plate from the tray plate lies in the fact that the cell of plates are of the same polarity on both sides while the tray plate is made in the form of a tray and is negative on the upper side and positive on the lower side. These trays are nested, the trays being kept from contact with each other by means of porcelain insulators. Enough electrolyte is kept in the lower plate to insure immersion at all times of the lower surface of the plate next above it. Thus one tray really forms a complete cell, consequently the number of cells equals the number of trays minus one, since the upper surface of the top plate and the lower surface of the bottom plate are inactive. As will be seen, this construction obviates the necessity of jumpers, terminals, or other connections on the intermediate cells which reduces the resistance due to poor contacts to zero.

Another feature of advantage claimed for this cell is that it will not fail as quickly as the cell type by the abuse of too long a continued discharge or by a discharge at too rapid a rate, nor will excessive heating result from these abuses. In the cell type the active material of the negative plate hangs suspended and is easily disengaged by abuse. In the tray type the negative is the upper side of the tray and the active material lays or rather is imbedded on this side and cannot become loose and fall out when over-sulphating occurs.

The test was made on two piles (Batterys No's. 1 and 2) of 55 volts each, 200 ampere hours capacity (rated) and having a normal discharge rate of 25 amperes. Each pile occupied a floor space 22" x 40". The batteries were made and installed by Smith Storage Battery Company, Binghamton, N. Y. The installation took place about December 15, 1904 and they were immediately charged up and have been



kept fairly well charged since that time. They were treated with carbonate of soda, about one-half pound per cell, to prevent excessive sulphation.

We took the batteries as we found them and made records of voltages and densities of the individual cells of each battery as shown in Columns I and II, Plates I and II. We then started to charge them and continued charging some time after the voltage reached 2.6 volts per cell charged. The power for these charges was obtained from the generator in the Mechanical Department. In cell No. 1 we put ,150 ampere hours at a rate of about 25 amperes, which rate we maintained as nearly constant as possible throughout the test. (See plate III.) The voltage after charging ,150 ampere hours at 25 ampere rate is recorded in Column III Plate I. We were obliged to let our work stand until Tuesday, May 25rd, 1905, making a period of rest of 70 hours. The voltage and hydrometer readings were again taken and are recorded in Columns IV and V on same page. The battery was then further charged with ,172 ampere hours at a 25 ampere rate making a total charge of ,327 ampere hours. The battery (No.1) was then discharged through a resistance. The discharge was continued until the voltage took a decided drop (See curve No. 1 Plate IX) and the voltage of cells 26-27 and 28, Column VI Plate I, seem to indicate that this was carried too far. It was first discharged 66 ampere hours at a rate of 25 amperes, then allowed to rest 14 hours when it was further discharged 21 ampere hours at a 10 ampere rate, then after a rest of about an hour and a half further discharged 5 ampere hours at 10 ampere rate making a total discharge of 92 ampere hours. The second charge was obtained partly from battery No. 2, using the motor and rotary converter shown in photograph 5 as a booster. The discharge of No. 2 forming part of

the charge of No. 1 was 136 ampere hours at a rate of about 30 amperes. A further charge of 69 ampere hours at a 25 ampere rate was made making a total charge of 205 ampere hours. The battery was then partly discharged (See curve 2 plate IX) into cell No. 2 and then further discharged through a resistance with 15 hours between discharges to recuperate. The first of this discharge was 94 ampere hours at about 25 amperes. The discharge was discontinued allowing a period of 15 hours to elapse when it was further discharged 14 ampere hours at an 11 ampere rate, making a total discharge of 108 ampere hours. The condition of the battery after partly discharging is given in Column VI, Plate I as are also the voltage conditions 15 hours later also after total discharge and 15 hours after total discharge. (Columns VII, VIII and IX, Plate 1) In Column X it will be noticed that the cells have in general recuperated but number 23 has changed polarity but by the voltages in cells 1-23 inclusive, except 21, it may be seen that a further discharge of these cells could have been made without danger of injury to them. A charge was then made of 130 ampere hours at a 24 ampere rate (See curve 3, Plate IX) and after about ten hours a further charge of 91 ampere hours at about 12 amperes was made (See curve 4, Plate IX). The three lower plates showed by the voltage readings (Column X, Plate 1) that it would be advisable to put an extra charge into them separately. We did this by using the lower terminal of the lower cells for positive terminal and clamping a piece of lead plate to the second tray above the base tray for the negative terminal. We charged into these cells 34 ampere hours at a 26 ampere rate. This made the total charge of these three plates 347 ampere hours. This was called a slow charge because the latter

part of the charge was made at about one-half the normal rated rate. The rate discharge following this charge was 18 amperes at the beginning and 8 at the end of the discharge. The discharge was continuous. The total discharge was 144 ampere hours. By referring to Column XII, Plate I, it will be seen that though this discharge was carried too far for the lower cells, yet they are left in better condition than on the previous discharges. If we notice the voltage reading of Number 21 we may infer that were it not for the abuse to the lower cells the discharge might have been continued farther. The test of battery No. 2 was conducted in much the same way as No. 1 but better results were obtained. The condition in which we found the battery is shown in Columns I and II, Plate II. The preliminary charge was obtained from the generator in the Mechanical Department. The first charge was made on Saturday May 20th. We charged in 212 ampere hours at a 27 ampere rate (See curve 1 Plate X) then discontinued until May 22, when a further charge of 88 ampere hours at about 26 amperes was made which made the total 291 ampere hours. The condition of the battery at this time is shown in Columns III and IV, Plate II. Though the voltages of this battery are more uniform than in No. 1, it appears that the density of the electrolyte in the upper cells is too low while in the lower ones it is too high; this is further emphasized in Column VII in the same plate. The discharge was started at 7 o'clock A.M., May 24th and continued until discharged. The total discharge was 140 ampere hours at a 31 ampere rate. The hydrometer and voltage readings after discharge are shown in Columns V and VI, Plate III. Notice the marked difference in output over No. 1. The second charge (See curve 2 plate X) was made at nearly normal rate. On May 24th, the battery was charged with 86 ampere hours at a 27

ampere rate and after a fifteen hour rest was further charged with 183 ampere hours at a rate of about 24 making the total charge 269 ampere hours. The discharge took place May 25th when 146 ampere hours were discharged at a 26 ampere rate. This we called normal discharge. The next test was made on slow charge and discharge (See curve 3, Plate X). After 127 ampere hours had been charged in at a 12 ampere rate the charge was discontinued for 11 hours when a further charge of 116 ampere hours at an 12 ampere rate was made. This made the total 243 ampere hours.

The discharge was started May 26 and 26 ampere hours were discharged at a 12 ampere rate. After 15 hours the discharge was continued when 108 ampere hours were taken off at a 10 ampere rate. This made a total discharge of 165 ampere hours at a rate of about 10 amperes. After a further lapse of 9 hours the discharge was continued and 51 ampere hours were drawn off at a 10 ampere rate. The Voltage for this discharge is given in Column VII, Plate II. These readings show that this discharge was continued too long for the lower three cells. We were convinced early in the tests that for this type of battery that the hydrometer test was of little value in ascertaining the condition of charge or discharge and placed more dependence on the voltage readings. It will be noted that the cells of battery No. 2 registered a very uniform voltage in nearly all tests but the fact is again evident here, as in connection with battery No. 1, that the density of the electrolyte of the lower cells is highest and the cells finish their discharge sooner than the upper ones. By a comparison of the voltages of Column VIII, Plate I with voltages in Column V, Plate II, the increased efficiency of battery No. 2 over No. 1 may be explained.

Lyman Lyndon states that a fair commercial figure for watt efficiency is 80%. The highest efficiency we obtained was 67%. The general conclusions we can draw are that the voltage test is the most reliable for ascertaining condition of charge; that the electrolyte must, in this type of battery, be drawn off from the lower cells and introduced into the upper cells from which it could drip down assuring a more uniform density of the electrolyte in the various cells of the battery; the test was not exhaustive and can be considered only as a preliminary test to making all conditions favorable to a test on which comparisons could be made with other installations.

Following is the data and curves:

The lack of uniformity is due partly to the necessitated frequent interruptions and lack of a source of power which we could at all times control and which was not uniform.

RECORD of BATTERY No. 1.

	May 19		May 20	May 23		May 23	May 24	May 25	
	Before charge		fully charged	after standing charged 70 hrs.		partly discharged	16 hrs. after part. disch.	after total discharge	
No.	Voltage	Density	Voltage	Voltage	Density	Voltage	Voltage	Voltage	Den
1	2.00	1.160	2.10	2.00	1.190	1.98	2.00	2.00	1.17
2	1.80	1.030	1.90	1.90	1.050	1.80	1.85	1.80	1.0
3	1.88	1.080	2.00	1.90	1.095	1.90	1.90	1.85	1.0
4	1.93	1.130	2.10	1.95	1.140	1.95	1.90	1.90	1.1
5	1.95	1.140	2.10	1.95	1.150	1.95	1.95	1.95	1.15
6	1.95	1.150	2.10	2.00	1.160	1.95	1.95	1.90	1.14
7	1.99	1.200	2.10	2.00	1.200	2.00	2.00	1.95	1.16
8	1.99	1.200	2.10	2.00	1.210	2.00	2.00	1.95	1.17
9	2.00	1.200	2.10	2.00	1.210	2.00	2.00	1.95	1.18
10	2.00	1.200	2.15	2.00	1.215	2.00	2.00	2.00	1.20
11	2.01	1.205	2.10	2.00	1.215	2.00	2.00	1.98	1.19
12	2.01	1.205	2.10	2.00	1.220	2.00	2.00	1.95	1.19
13	2.00	1.200	2.15	2.00	1.210	2.00	2.00	1.95	1.19
14	1.99	1.195	2.10	2.00	1.205	2.00	2.00	1.95	1.17
15	2.01	1.205	2.15	2.00	1.215	2.00	2.00	2.00	1.19
16	2.02	1.215	2.15	2.00	1.235	2.00	2.00	2.00	1.21
17	2.03	1.215	2.15	2.00	1.235	2.00	2.00	2.00	1.20
18	2.03	1.230	2.15	2.00	1.235	2.00	2.00	2.00	1.25
19	2.03	1.230	2.15	2.05	1.245	2.00	2.00	2.00	1.25
20	2.02	1.230	2.15	2.05	1.245	2.00	2.00	2.00	1.25
21	2.02	1.225	2.15	2.05	1.260	1.85	2.06	0.50	1.23
22	2.02	1.225	2.15	2.00	1.240	2.00	2.00	1.70	1.22
23	2.02	1.230	2.15	2.05	1.245	2.00	2.05	2.00	1.22
24	2.02	1.235	2.15	2.10	1.245	2.00	2.03	0.50	1.22
25	2.02	1.235	2.20	2.10	1.245	2.00	2.05	0.70	1.23
26	2.05	1.255	2.20	2.10	1.265	0.80	1.80	0.30	1.24
27	2.10	1.270	2.20	2.10	1.280	1.50	2.10	0.10	1.26
28	1.26	1.305	2.20	1.00	1.315	0.00	0.00	0.00	1.30
Col.	I	II	III	IV	V	VI	VII	VIII	IX

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Following is the data and curves:

The lack of uniformity is due partly to the necessitated frequent interruptions and lack of a source of power which we could at all times control and which was not uniform.

RECORD of BATTERY No. 1.

	May 19		May 20	May 23		May 23	May 24	May 25
	Before charge		fully charged	after standing charged 70 hrs.		partly discharged	16 hrs. after part. disch.	after total discharge
No.	Voltage	Density	Voltage	Voltage	Density	Voltage	Voltage	Density
1	2.00	1.160	2.10	2.00	1.190	1.99	2.00	2.00 1.17
2	1.80	1.030	1.90	1.90	1.030	1.80	1.85	1.80 1.0
3	1.88	1.080	2.00	1.90	1.095	1.90	1.90	1.85 1.0
4	1.93	1.130	2.10	1.95	1.140	1.95	1.90	1.90 1.1
5	1.95	1.140	2.10	1.95	1.150	1.95	1.95	1.95 1.15
6	1.95	1.150	2.10	2.00	1.160	1.95	1.95	1.90 1.14
7	1.99	1.200	2.10	2.00	1.200	2.00	2.00	1.95 1.18
8	1.99	1.200	2.10	2.00	1.210	2.00	2.00	1.95 1.19
9	2.00	1.200	2.10	2.00	1.210	2.00	2.00	1.95 1.18
10	2.00	1.200	2.15	2.00	1.215	2.00	2.00	2.00 1.20
11	2.01	1.205	2.10	2.00	1.215	2.00	2.00	1.98 1.19
12	2.01	1.205	2.10	2.00	1.220	2.00	2.00	1.95 1.19
13	2.00	1.200	2.15	2.00	1.210	2.00	2.00	1.95 1.19
14	1.99	1.195	2.10	2.00	1.205	2.00	2.00	1.95 1.17
15	2.01	1.205	2.15	2.00	1.215	2.00	2.00	2.00 1.19
16	2.02	1.215	2.15	2.00	1.235	2.00	2.00	2.00 1.21
17	2.03	1.215	2.15	2.00	1.235	2.00	2.00	2.00 1.20
18	2.03	1.230	2.15	2.00	1.235	2.00	2.00	2.00 1.25
19	2.03	1.230	2.15	2.05	1.245	2.00	2.00	2.00 1.25
20	2.02	1.230	2.15	2.05	1.245	2.00	2.00	2.00 1.25
21	2.02	1.225	2.15	2.05	1.250	1.85	2.06	0.50 1.23
22	2.02	1.225	2.15	2.00	1.240	2.00	2.00	1.70 1.22
23	2.02	1.230	2.15	2.05	1.245	2.00	2.05	2.00 1.22
24	2.02	1.235	2.15	2.10	1.245	2.00	2.03	0.50 1.22
25	2.02	1.235	2.20	2.10	1.245	2.00	2.05	0.70 1.23
26	2.05	1.255	2.20	2.10	1.265	0.80	1.80	0.30 1.24
27	2.10	1.270	2.20	2.10	1.280	1.50	2.10	0.10 1.26
28	1.26	1.305	2.20	1.00	1.315	0.00	0.00	0.00 1.30
Col.	I	II	III	IV	V	VI	VII	VIII IX

RECORD of BATTERY №2.

	MAY 20		MAY 23		MAY 24		JUNE 1
	Before Charge		Fully Charged		After discharge		Discharged
№	Voltage	Density	Voltage	Density	Voltage	Density	Voltage
1	1.75	1010	1.90	1125	1.85	1030	2.00
2	1.88	1090	1.95	1135	1.95	1120	1.90
3	1.98	1145	2.00	1180	1.95	1130	1.90
4	1.98	1145	2.03	1190	1.95	1160	1.95
5	1.98	1175	2.03	1210	2.00	1180	1.95
6	1.98	1175	2.03	1210	2.00	1160	2.00
7	1.98	1190	2.03	1215	2.00	1180	2.00
8	1.98	1190	2.03	1215	2.00	1180	2.00
9	1.95	1180	2.03	1210	2.00	1180	2.00
10	1.95	1175	2.03	1205	2.00	1180	2.00
11	1.95	1165	2.03	1205	2.00	1180	2.00
12	1.98	1165	2.03	1200	2.00	1180	2.00
13	1.98	1180	2.03	1205	2.00	1180	2.00
14	1.98	1180	2.03	1205	2.00	1180	2.00
15	1.98	1175	2.03	1210	2.00	1180	2.00
16	1.98	1195	2.03	1230	2.00	1180	2.00
17	1.98	1185	2.03	1215	2.00	1180	2.00
18	1.98	1185	2.03	1220	2.00	1180	2.00
19	1.98	1185	2.03	1225	2.00	1200	2.00
20	1.98	1185	2.03	1220	2.00	1200	2.00
21	1.98	1185	2.05	1225	2.00	1200	2.00
22	2.05	1190	2.05	1225	2.00	1200	2.00
23	2.05	1200	2.05	1240	2.00	1200	2.00
24	1.30	1190	2.05	1230	2.00	1200	2.00
25	1.80	1215	2.05	1250	2.00	1240	2.00
26	2.00	1185	2.05	1240	2.00	1200	0.05
27	2.05	1240	2.10	1275	2.10	1240	1.00
28	2.05	1250	2.10		1.40	1280	-0.05
Col.	I	II	III	IV	V	VI	VII

BATTERY NO. 1-

PRELIMINARY TEST

NORMAL TEST

SLOW TEST

CHARGE			DISCHARGE			CHARGE			DISCHARGE			CHARGE			DISCHARGE		
TIME	VOLTS	AMP.	TIME	VOLTS	AMP.	TIME	VOLTS	AMP.	TIME	VOLTS	AMP.	TIME	VOLTS	AMP.	TIME	VOLTS	AMP.
7-00	72	22	5-00	54	10	7-00	64	35	2-00	54	33	4-15	59	24	7-15	54	16
7-30	72	23	5-30	40	23	7-30	64	31	2-30	52	30	4-30	60	23	7-30	52	15
8-00	73	23	6-00	48	23	8-00	65	31	3-00	52	20	5-00	61	24	8-00	52	15
8-30	73	23	6-30	48	23	8-30	67	30	3-30	50	26	5-30	62	24	8-30	53	15
8-00	73	22	7-30	47	23	9-00	67	30	4-00	50	26	6-00	62	23	9-00	52	16
9-30	73	22	8-00	40	23	9-30	68	28	4-30	47	24	6-30	64	24	9-30	52	16
10-00	73	25	8-30			10-00	70	31	5-00	46	22	7-00	64	24	10-00	52	13
10-30	73	28	DISCHARGE DISCONTINUED FOR 13 HR.			10-30	70	29	5-00	42	24	7-30	65	24	10-30	53	14
11-00	74	28				11-00	72	30	DISCONTINUED FOR 15 HR.			8-00	66	23	11-00	50	13
11-30	74	27	9-00	50	12	11-30	73	27	9-45	51	13	8-30	68	21	11-30	40	13
12-00	74	23	10-00	50	11	CHARGE 9:15-CONTINUED FOR 12 HR.			10-00	50	11	9-00	70	21	12-00	48	12
12-30	74	25	10-30	42	10				10-30	46	11	9-30	71	21	12-30	48	12
1-00	74	24	11-00	41	10	9-45	43	23	11-00	45	11	10-00	73	24	1-00	48	12
1-30	74	23	11-30	41	10	10-00	73	23				DISCONTINUED FOR 10 HR.			1-30	48	11
CHARGE DISCONTINUED FOR 7 1/2 HR.			12-00	38	10	10-30	73	25				8-30	72	17	2-00	48	12
8-00	64	32	DISCONTINUED FOR 1 1/2 HR.			11-00	73	25				9-00	72	16	2-30	48	11
9-30	73	26	1-20	43	20	11-30	73	22				9-30	71	14	3-00	48	11
10-00	73	28	1-30	40	10	12-00	73	22				11-00	70	14	3-30	47	10
11-00	73	27	1-45	30	10	12-45	73	20				10-30	71	14	4-00	46	10
11-30	73	27										11-00	70	11	4-30	46	10
12-00	72	25										11-30	70	11	5-00	45	11
12-30	72	25										12-00	70	12	5-30	44	10
1-00	72	25										12-30	70	12	6-00	42	10
1-30	72	25										1-00	70	13	6-30	42	8
2-00	72	25										1-30	70	12			
2-30	72	25										2-00	70	12	34 AMP/Hr		
3-00	72	25										2-30	70	13	WERE NOW CHARGED		
3-30	72	25										3-00	70	12	INTO THREE LOWER PLATES		
4-00	73	26										3-30	70	12			

1ST CHARGE = 158

2ND = 170

TOTAL =

337 AMP.HR.

1ST 68 AMP.HR.

2ND = 21 " "

3RD = 5 " "

TOTAL =

94 AMP.HR.

FIRST CHARGE

= 136 AMP.HR.

2ND = 69 AMP.HR.

TOTAL CHARGE

= 205 AMP.HR.

1ST DISCHARGE

= 94

2ND = 14

TOTAL = 108 AMP.HR.

1ST 130 AMP.HR.

2ND = 91 " "

TOTAL = 221 AMP.HR.

TOTAL = 144 AMP.HR.

BATTERY NO. 2-

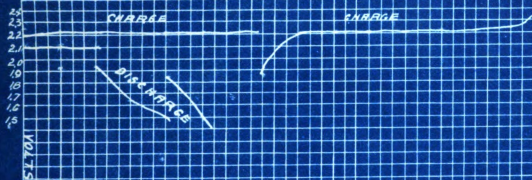
PRELIMINARY TEST

NORMAL TEST

SLOW TEST

CHARGE			DISCHARGE			CHARGE			DISCHARGE			CHARGE			DISCHARGE		
TIME	VOLTS	AMP	TIME	VOLTS	AMP	TIME	VOLTS	AMP	TIME	VOLTS	AMP	TIME	VOLTS	AMP	TIME	VOLTS	AMP
12-00	62	30															
12-30	66	24	7-00	54	35	2-00	62	31	4-15	55	25	7-15	60	15	4-00	56	13
1-00	67	23	7-30	53	32	2-30	62	25	4-30	55	24	7-30	61	14	4-30	56	14
1-30	67	22	8-00	52	32	3-00	62	27	5-00	55	20	8-00	61	14	5-00	56	12
2-00	68	27	8-30	51	31	3-30	63	24	5-30	55	28	8-30	61	14	5-30	56	12
2-30	68	26	9-00	50	31	4-00	63	23	6-00	53	27	9-00	61	15	6-00	56	12
3-00	68	25	9-30	50	32	4-30	63	21	6-30	52	26	9-30	61	14	DISCONTINUED FOR 15 HR.		
3-30	69	27	10-00	46	35	5-00	64	21	7-00	52	20	10-00	62	14	9-00	56	10
4-00	69	27	10-30	42	30	5-30	64	22	7-30	51	20	10-30	61	12	9-30	56	8
4-30	69	26	11-00	30	30	DISCONTINUED FOR 15 HR.			8-00	50	27	11-00	61	12	10-10	56	7
5-00	69	27	11-30	31	26	9-00	62	22	8-30	48	27	11-30	61	12	10-30	56	12
5-30	69	28				9-30	64	23	9-00	48	24	12-00	62	11	11-00	56	10
6-00	70	28				10-00	66	21	9-30	46	22	12-30	62	11	11-30	56	9
6-30	69	25				10-30	68	25	9-50	44	25	1-00	62	11	12-00	56	9
7-00	70	28				11-00	70	22				1-30	62	11	12-30	56	9
7-30	70	27				11-30	72	22				2-00	62	11	1-00	56	9
8-00	70	28				12-00	72	22				2-30	62	11	1-30	56	9
CHARGE WAS DISCONTINUED FOR 14 HR.						12-30	73	22				3-00	62	10	2-00	56	9
						1-00	74	22				3-30	62	10	2-30	56	9
9-45	73	22				1-30	74	25				4-00	62	9	3-00	56	9
10-30	73	25				2-00	75	20				4-30	62	9	3-30	56	9
11-00	73	23				2-30	74	27				5-00	62	9	4-00	55	9
11-30	73	22				3-00	74	26				5-30	63	9	4-30	54	9
12-45	72	20				3-30	74	26				6-00	63	9	5-00	54	9
						4-30	74	25				6-30	63	9	5-30	54	9
						4-45	74	25				DISCONTINUED FOR 14 HR.			6-00	53	9
												8-00	65	17	7-00	53	9
												8-00	68	17	8-00	53	9
												10-00	68	17	9-00	52	8
												11-00	68	17	DISCONTINUED FOR 3 HR.		
												12-00	69	18	6-30	54	10
1st = 212 AMP.HR.	TOTAL = 140 AMP.HR.		1st = 86	TOTAL =		1st = 86	TOTAL =		1st = 127 AMP.HR.	TOTAL =		1st = 127 AMP.HR.	TOTAL =		1st = 127 AMP.HR.	TOTAL =	
2nd = 60 AMP.HR.	TOTAL = 260 AMP.HR.		2nd = 163	TOTAL = 146 AMP.HR.		2nd = 163	TOTAL = 146 AMP.HR.		2nd = 116 AMP.HR.	TOTAL =		2nd = 116 AMP.HR.	TOTAL =		2nd = 116 AMP.HR.	TOTAL =	
TOTAL = 281 AMP.HR.			TOTAL = 260 AMP.HR.			TOTAL = 260 AMP.HR.			3rd = 31			3rd = 31			3rd = 31		
									243 AMP.HR.			243 AMP.HR.			243 AMP.HR.		

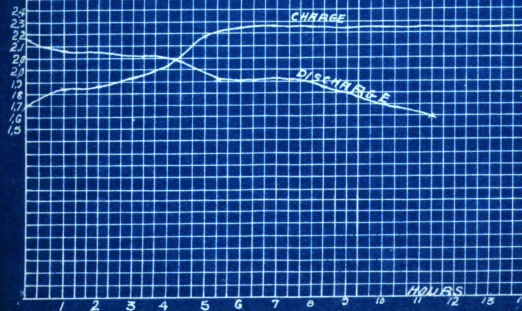
PRELIMINARY CHARGE AND DISCHARGE OF BATTERY NO-1-



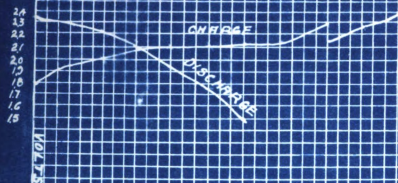
NORMAL CHARGE AND DISCHARGE OF BATTERY NO-1-



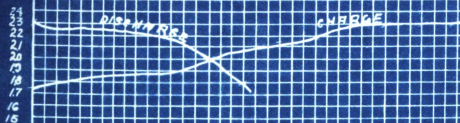
SLAW CHARGE AND DISCHARGE OF BATTERY NO-1-



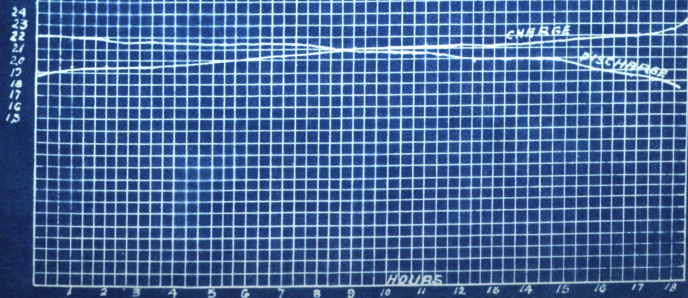
ABNORMAL CHARGE AND DISCHARGE OF BATTERY NO. 2



NORMAL CHARGE AND DISCHARGE OF BATTERY NO. 2



SLOW CHARGE AND DISCHARGE OF BATTERY NO. 2



RESULTS

AMPERE HOUR EFFICIENCY

NORMAL CHARGE AND DISCHARGE

No. 1

$$\text{EFFICIENCY} = \frac{\text{AMPERE HOUR OUTPUT}}{\text{AMPERE HOUR INPUT}} = \frac{100}{256} = 39\%$$

SLOW CHARGE AND DISCHARGE

$$\text{EFFICIENCY} = \frac{144}{254} = 57\%$$

NORMAL CHARGE AND DISCHARGE

No. 2

$$\text{EFFICIENCY} = \frac{144}{274} = 52.5\%$$

SLOW CHARGE AND DISCHARGE

$$\text{EFFICIENCY} = \frac{163}{243} = 67\%$$

VIRTUAL RESISTANCE

$$\text{No. 1} \quad R = \frac{E - E_1}{I}$$

I = CURRENT FLOW

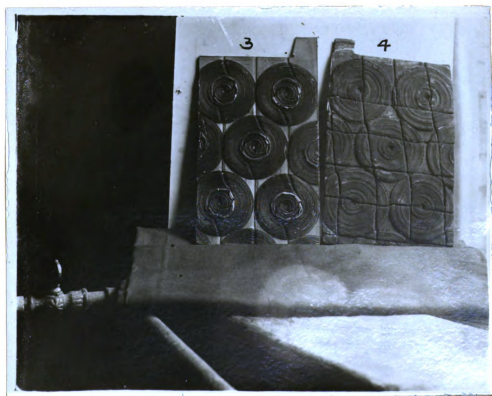
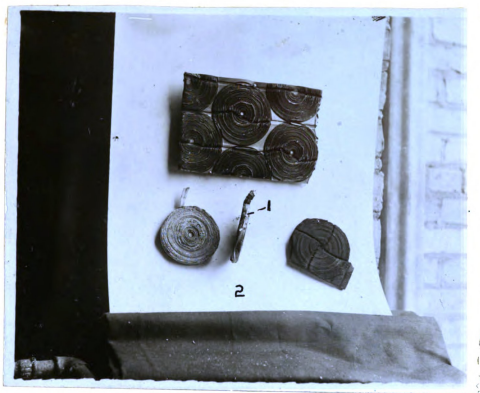
V = CHARGING VOLTAGE

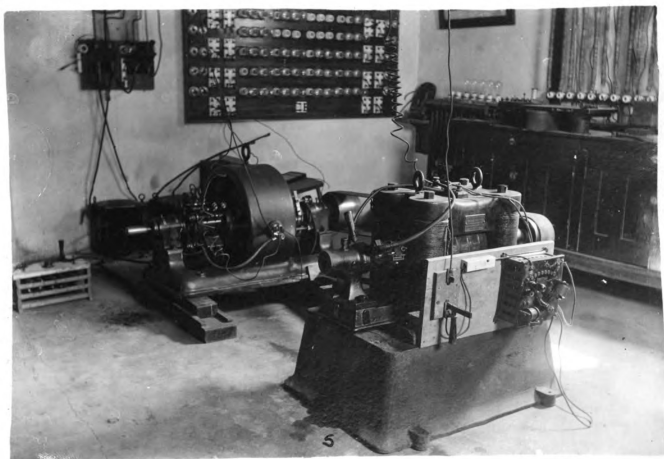
V₁ = VOLTAGE ON OPEN CIRCUIT

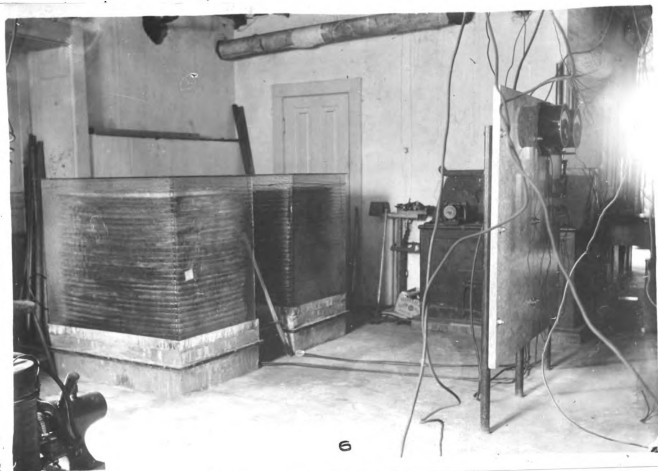
R = VIRTUAL RESISTANCE

$$R = \frac{75 - 65}{25} = 4 \text{ OHM}$$

$$\text{No. 2.} \quad R = \frac{E - E_1}{I} = \frac{75 - 60}{23} = .65 \text{ OHM}$$







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