COMPARATIVE TESTS ON FARM LIGHTING PLANTS.

A THESIS

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By

H. V. Hoffman G. E. Lankton

Candidates for the Degree of

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THESIS

PREFACE

The authors in the selection of this thesis did so with the following objects in mind.

First; That by so doing they would be better acquainted with the principle of various types of farm lighting plants.

Second; That these plants could be studied and enough data taken during the tests whereby the farmer might learn the necessary points of construction and the performance of each type of plant, so that he might get the best plant for his use; such as efficiency of the plant and its out-put.

Third; That we might give to the institution some data in compact form so that it might be looked over and comparative tests run at any time.

The thesis itself consists of a series of tests run on a number of farm lighting plants which could be easily understood by the layman and he can draw his conclusions very easily.

In preparing this thesis we were very unfortunate, due to the fact that it was possible to obtain only a limited number of plants.

The railroad conditions were such that the plants promised us did not arrive in time to use and run extended tests upon them, therefore we were compelled to use only the plants around the college, which could be brought in easily.

INTRODUCTION.

All farm lighting plants generally consist of a gasoline engine and generator, most of them having a battery in addition for stand-by service, while others are automatically controlled.

The plants using a storage battery for stand-by service must be run at certain intervals to keep the battery at a fully charged condition as near as possible so that the full load can be carried without injury to the battery and also that it may be available at all times.

The automatic lighting plant is so constructed, so that by turning on a light the plant is automatically started, there-by furnishing the necessary current. The use of this plant demands that the engine and generator be running whenever lights are required, this also does away with a battery, except as a starter for the engine.

This thesis contains only the tests made upon plants which included a storage battery.

TEST No. 1. Efficiency Test.

Readings were taken of line voltage and current, the battery voltage and hydrometer readings also the amount of gasoline used. The time of the test was noted and the efficiency computed from this data.

TEST No. 2. Out-put Test.

Readings of the voltage and current were taken at various loads. A rheostat was used as a load and the battery cut off. This test shows the characteristic voltage and current relations of the plant.

TEST No. 3. Efficiency of the plant at various loads.

Readings of the line voltage and current were taken. A definite load was applied and the quantity of gasoline used was accurately measured, also the length of the test was noted. The effeciency of the plant was then computed and plotted. A larger load was then applied and the same readings taken as before.

Curves of these tests were drawn showing the out-put at various loads, also the efficiency of each plant at different loads.

The efficiencies were determined as follows:

$$\frac{\text{Line voltage} \times \text{current} \times \text{time} \times 2546}{746 \times 18800 \times \text{wgt. of gas in pounds}} = \text{Efficiency.}$$

2546 = No. of B. T. U. per H. P. hr.

746 = Watts per H. P.

18800 = Assumed B. T. U. per lb. of gas.

PLANT "A".

Efficiency Test No. 1. DATA

Voltage	Amperes	Time	Hydrometer	Weight of Gas.
38	8.2	1:24	1225	
39.4	10.3	1:40	"	
39	9.6	1:50	"	
39.5	9.8	2:00	"	
39.5	9.6	2:10	"	
39.5	9.2	2:20	"	3.75 #
39.5	9.20	2:30	"	
39.3	9.0	2:40	"	
40.0	8.6	2:50	1235	
40.0	8.4	3:00	"	
40.0	7.8	3:10	"	
40.0	7.8	3:20	"	
41.0	7.6	3:30	1240	
41.0	7.6	3:40	"	
42.0	7.4	3:50	"	
42.0	7.3	4:00	"	
42.1	6.4	4:10	"	
42.0	6.0	4:16	1245	
40.2	8.86	2.866		3.75 # of Gas.

Computations:

$$\frac{2.866 \times 40.2 \times 8.86 \times 2546}{746 \times 18800 \times 3.75} = 4.84\ \%$$ Thermal Efficiency.

PLANT "A".

Test No. 2.

Characteristic Out-put Test.

DATA

Volts	Amps.
40	10
40	11
40	12
38.5	13
37.5	14
37	15
37	15.8
37	16.45
36	17
36	18.2

Temperature rise of field coils 30 - 40 degrees F.

PLANT "A"

Test No. 3.

Efficiency of Plant at various loads.

Voltage	Amperes	Time in hours	Wgt. of Gas/#	Eff. %.
39.125	7.075	.456	.475	4.84 %
37.33	9.9	.394	.48	5.5 %
31.875	12.36	.478	.485	7.02 %
24.22	14.25	.472	.5	5.92 %

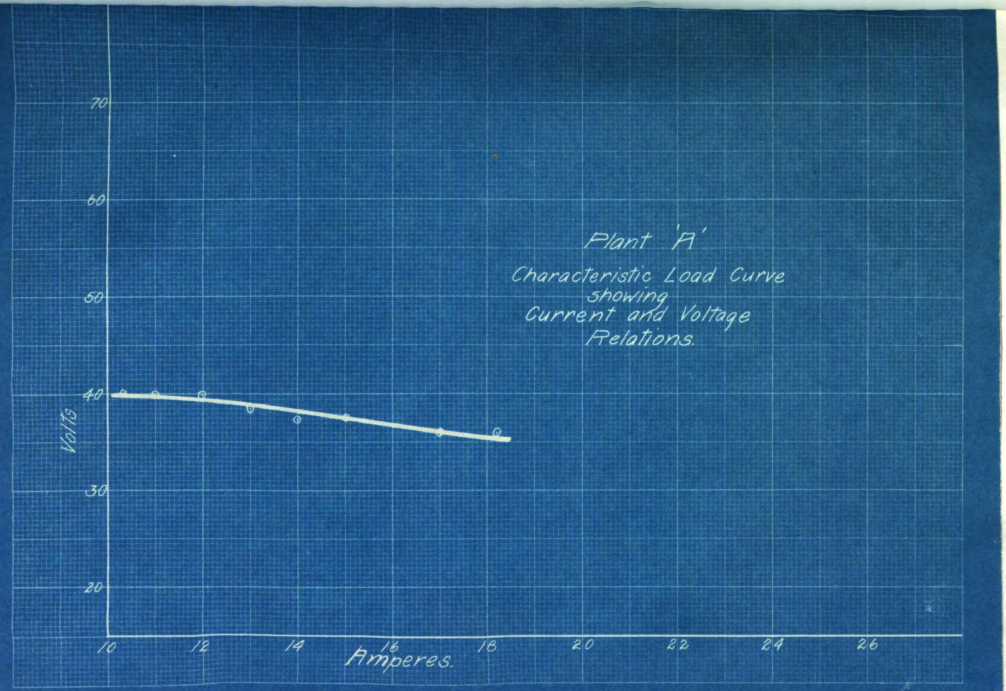
Computations:

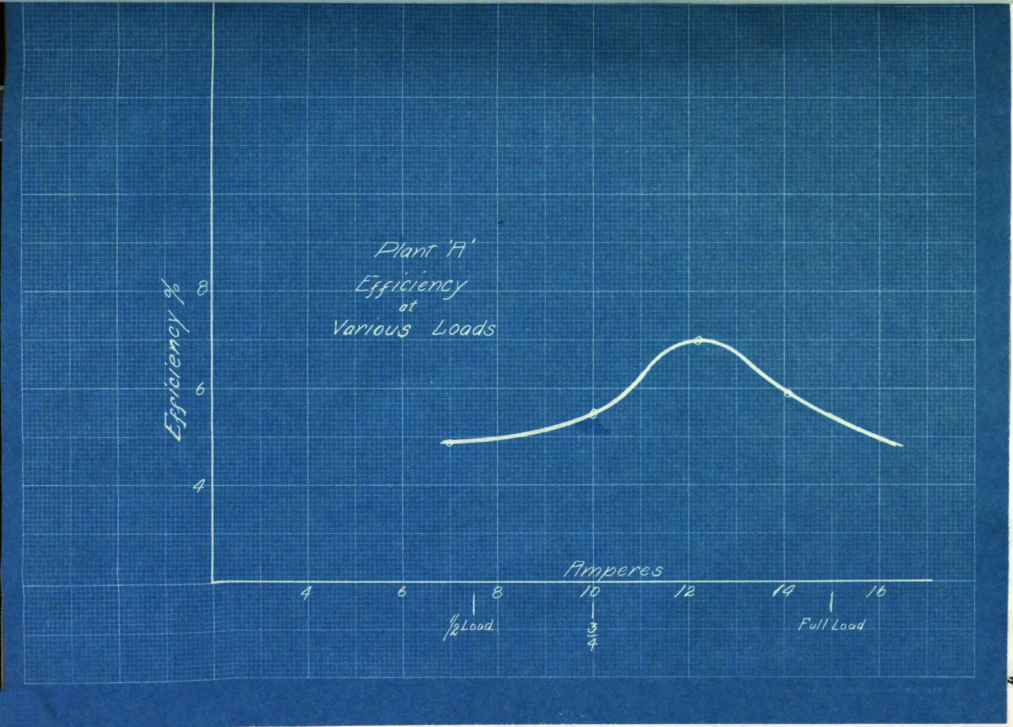
$$\frac{39.125 \times 7.075 \times .456 \times 2546}{746 \times 18800 \times .475} = 4.84\ \%$$ at one half load.

$$\frac{37.33 \times 9.9 \times .394 \times 2546}{746 \times 18800 \times .48} = 5.5\ \%$$ at three-quarters load.

$$\frac{12.36 \times 31.875 \times .478 \times 2546}{746 \times 18800 \times .486} = 7.02\ \%$$ at 6/7 load.

$$\frac{14.25 \times 24.22 \times .472 \times 2546}{746 \times 18800 \times .5} = 5.92\ \%$$ at full load.


Plant 'A'
Characteristic Load Curve
showing
Current and Voltage
Relations.
Volts
70
60
50
40
30
20
10
12
14
16
18
20
22
24
26
Amperes.


Plant 'A'
Efficiency
at
Various Loads
Efficiency %
8
6
4
Amperes
4
6
8
10
12
14
16
1/2 Load
3/4
Full Load

PLANT "B"

Test No. 1.

Efficiency Test.

Volts	Amperes	Time	Hydrometer	Weight of Gas.
39.5	15	1:55	1235	
40.	16.2	2:25	1240	
40.	18.2	2:40	1250	
40.	16.4	3:00	1250	2.58 #
40.	16.8		1250	
40.	14.	3:40	1260	
40.	13.	3:50	1265	
40.	10.8	4:00	1270	
40.	15.	4:15	1275	
39.9	14.8	2:33 Hrs.		

$$\frac{2.33 \times 39.9 \times 2546}{746 \times 1880 \times 2.58} = 9.69\ \%$$ Thermal efficiency.

PLANT "B"

Test No. 2.

Characteristic Out-put Test.

Volts	Amps.
36	6.7
36	7.0
36	8.2
36	9.3
36	10.4
35.5	11.2
35	11.9
36	13.4
36	14.2
36	15.3
35.5	15.6
35	16.
35	17.2
34	18.3
34	22.
34	24.

Temperature rise of fields 39 - 40 degrees F.

PLANT "B"

Test No. 3.

Efficiency of plant at various loads.

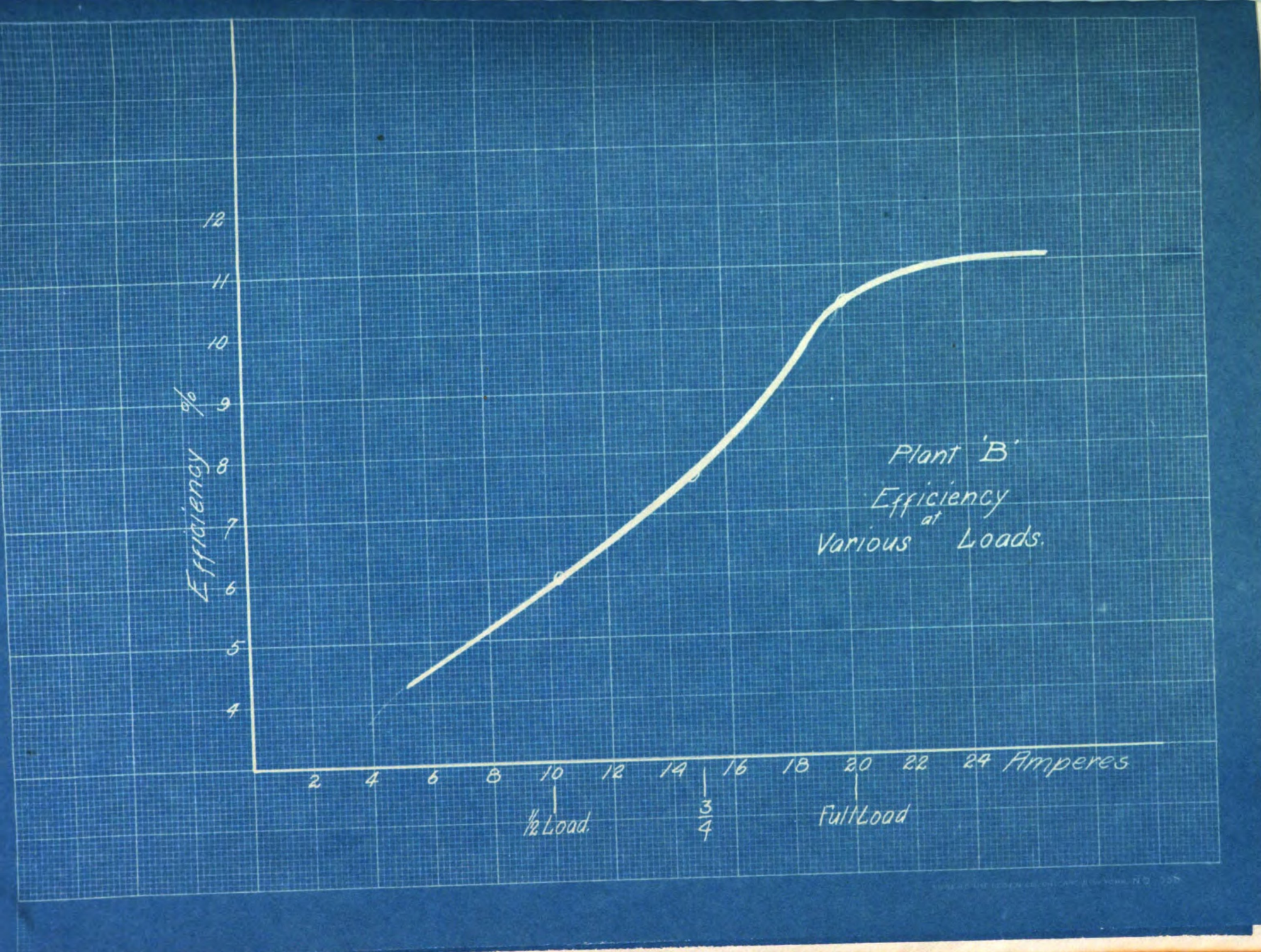
Voltage	Amperes	Time in hours	Weight of Gas/#	Eff. %
57.	10.25	.404	.756	6. %
49.6	14.93	.434	.757	7.525 %
40.	20.	.25	.348	10.49 %

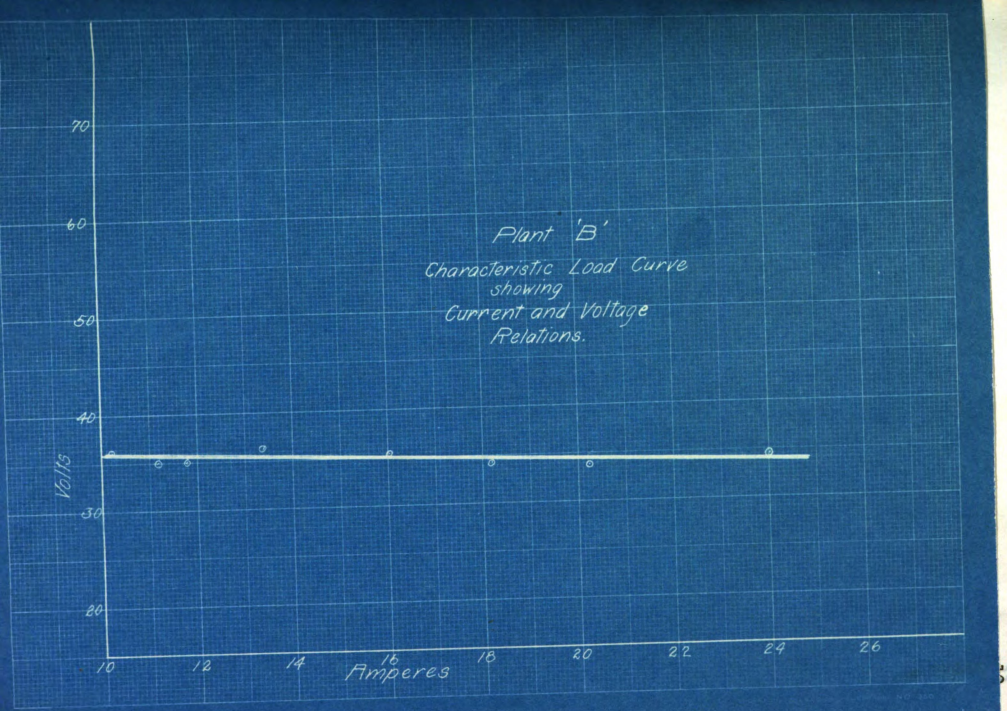
Computations:

$$\frac{57 \times 10.25 \times .404 \times 2546}{746 \times 18800 \times .756} = 6\% \text{ at 1/2 load.}$$

$$\frac{49.6 \times 14.93 \times .434 \times 2546}{746 \times 18800 \times .757} = 7.625\% \text{ at}$$

$$\frac{40. \times 20 \times .25 \times 2546}{746 \times 18800 \times .348} = 10.49\% \text{ at full load.}$$


Plant 'B'
Efficiency
at
Various Loads.
Efficiency %
12
11
10
9
8
7
6
5
4
2
4
6
8
10
12
14
16
18
20
22
24
Amperes
½ Load.
3/4
Full Load


Plant 'B'
Characteristic Load Curve
showing
Current and Voltage
Relations.
Volts
70
60
50
40
30
20
10
12
14
16
18
20
22
24
26
Amperes

PLANT "C". Test No. 1.

DATA. Efficiency Test.

Voltage	Amperes	Time	Hydrometer	Weight of gas used.
49.	15	1:50	1175	
49.	14.5	2:00	"	
49.	14.5	2:10	"	
49.	13.	2:20	"	
49.	14.5	2:30	"	
49.	14.5	2:40	"	
49.	14.25	2:50	1200	
49.	14.50	3:00	"	
49.	14.50	3:10	"	
49.	14.25	3:20	"	
49.	14.25	3:30	"	
49.	14.25	3:40	"	
48.5	14.25	3:50	"	
48.5	14.25	4:00	"	
48.	14.25	4:10	"	
48.	14.25	4:20	"	
48.	14.25	4:30	"	
48.	14.25	4:40	"	
48.	14.25	4:50	"	
48.	14.25	5:00	"	
47.75	13.75	5:10	"	
48.	13.50	5:20	"	
48.	14.75	5:30	1225	4 # 10.5 oz.
48.6	14.25	3 hours 40 min.		

Computations:

$$\frac{48.6 \times 14.25 \times 3.66 \times 2546}{746 \times 18800 \times 4.656} = 9.94\ \%\ \text{Thermal Efficiency.}$$

PLANT "C"

Test No. 2.

Characteristic Out-put Test.

DATA

Volts	Amperes
58.	10.5
54.	12.
50.	13.
48.	14.
45.	15.
43.	16.
41.	17.
36.	18.5
30.	22.
26.	24.
20.	26.5

Temperature Rise 35 - 40 Degrees F.

PLANT "C"

Test No. 3.

Efficiency of Plant at Various Loads.

Voltage	Amperes	Time in Hours	Wgt. of Gas/#	Eff. %
58.	10.25	.25	.604	6.249 %
54.75	12.7	.35	.5235	8.48 %
43.75	16.36	.36	.646	7.4 %
35.6	20.	.1835	.3422	6.92 %

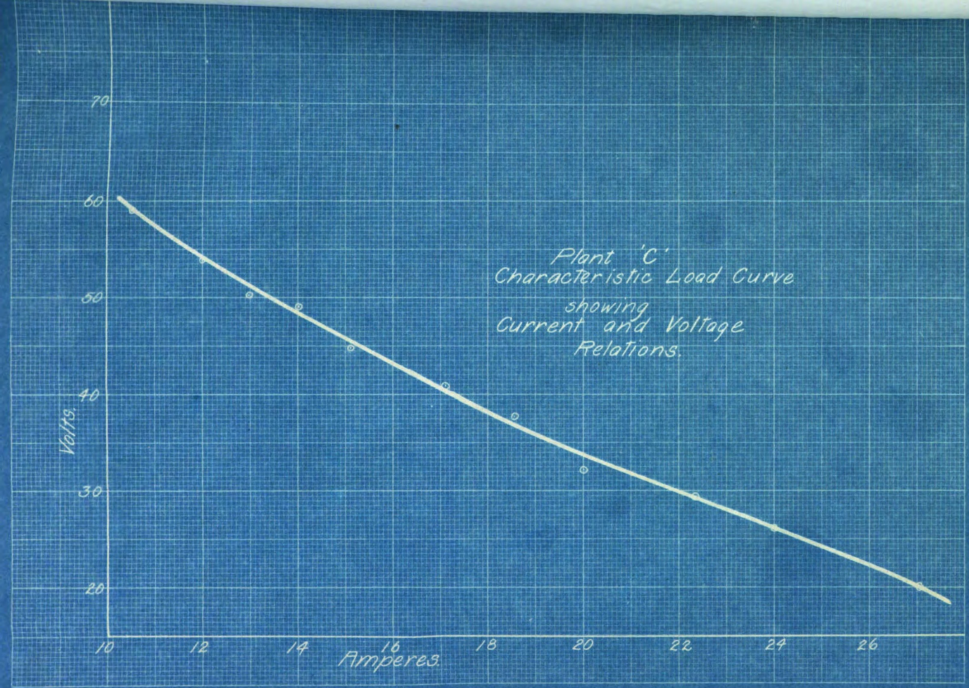
Computation:

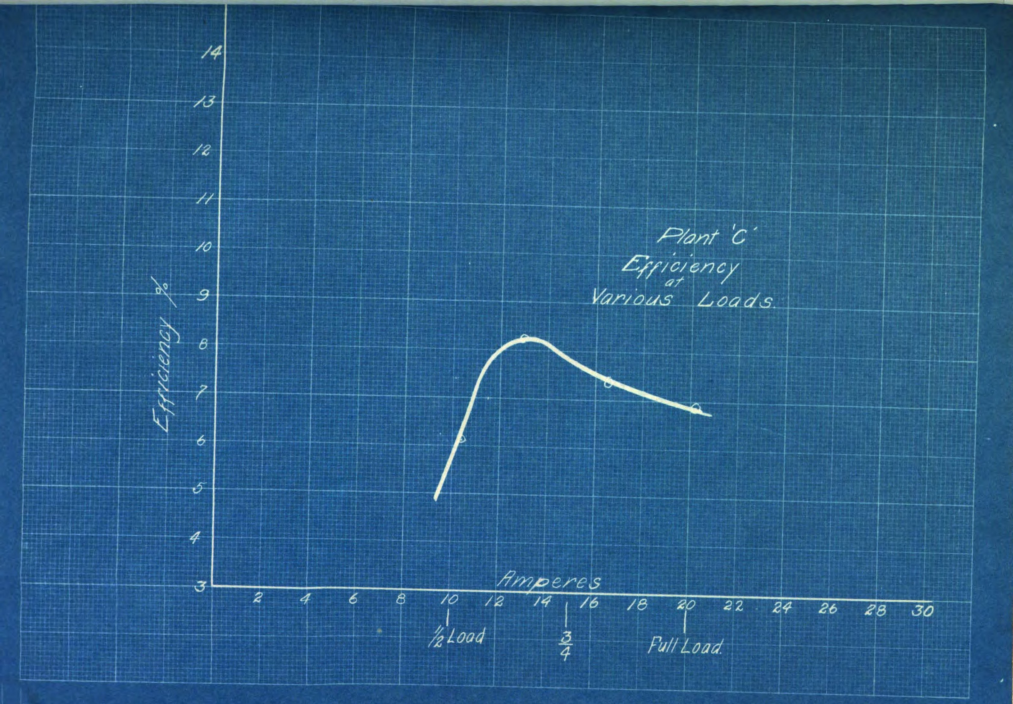
$$\frac{58. \times 10.25 \times .35 \times 2546}{746 \times 18800 \times .604} = 6.249\ \%$$

$$\frac{54.75 \times 12.7 \times .35 \times 2546}{746 \times 18800 \times .5235} = 8.48\ \%$$

$$\frac{43.75 \times 16.35 \times .366 \times 2546}{746 \times 18800 \times .646} = 7.4\ \%$$

$$\frac{35.6 \times 20 \times .1835 \times 2546}{746 \times 18800 \times .3422} = 6.92\ \%$$ at full load.


Plant 'C'
Characteristic Load Curve
showing
Current and Voltage
Relations.
Volts.
70
60
50
40
30
20
10
12
14
16
18
20
22
24
26
Amperes.


Plant 'C'
Efficiency
at
Various Loads.
Efficiency %
14
13
12
11
10
9
8
7
6
5
4
3
Amperes
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
½ Load
¾
Full Load.

Plant "D"

Test No. 2.

Characteristic Out-put Test.

Volts	Amperes.
46.	16.2
51.	15.
55.	14.4
58.	13.4
62.	12.
63.5	11.2
64.25	10.4
67.	9.8
69.5	9.0
71.5	8.1
76.	6.8
78.5	4.5
84.	3.8
87.	2.5
89.5	1.8
91.	1.0
95.	.7

PLANT "D"

Test No. 3.

Efficiency of Plant at Various Loads.

Voltage	Amperes	Time in Hrs.	Wgt. of Gas/#	Eff. %
79.61	6.86	.08	.223	3.72 %
52.14	13.94	.089	.2352	6.32 %
47.4	18.2	.146	.22	10.34 %
40.	25.2	.083	.106?	14.2 %
34.	30.	.10	.1595?	11.6 %

Computation:

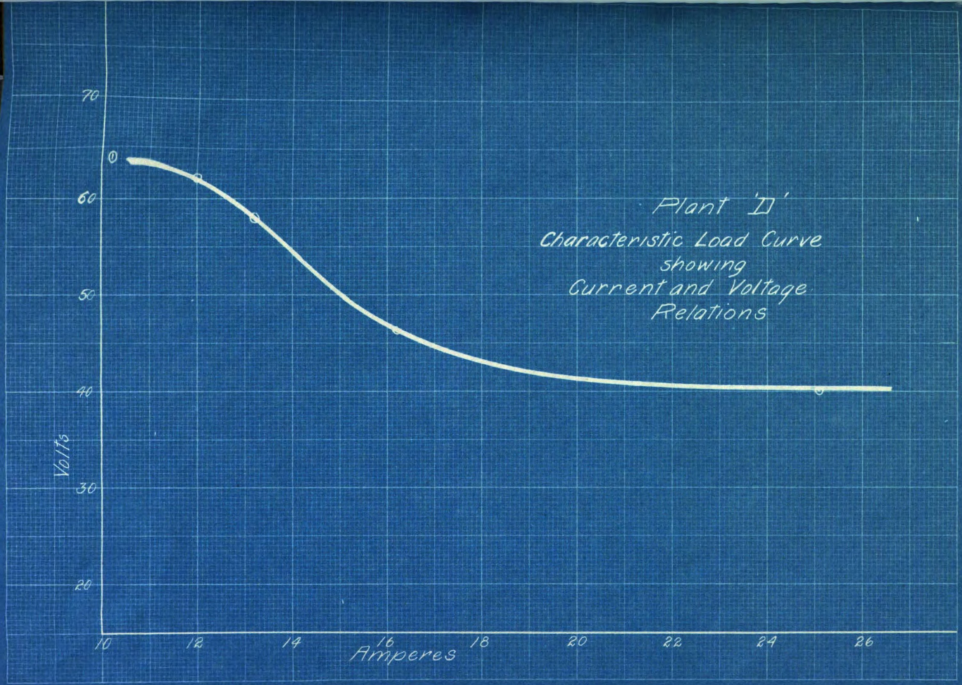
$$\frac{79.61 \times 6.86 \times .08 \times 2546}{746 \times 18800 \times .223} = 3.72\ \%$$

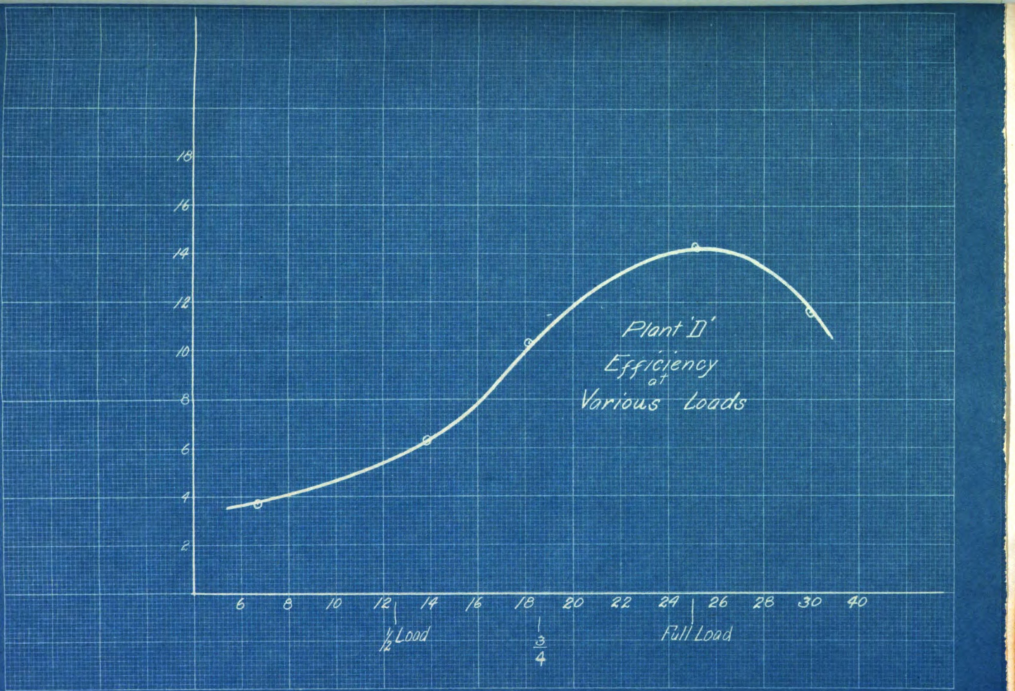
$$\frac{52.14 \times 13.94 \times .009 \times 2546}{746 \times 18800 \times .2352} = 6.32\ \%$$

$$\frac{47.4 \times 18.2 \times .146 \times 2546}{746 \times 18800 \times .146} = 10.34\ \%$$

$$\frac{40 \times 25.2 \times .083 \times 2546}{746 \times 18800 \times .106?} = 14.2\ \%$$

$$\frac{34 \times 30 \times .10 \times 2546}{746 \times 18800 \times .1595?} = 11.6\ \%$$


Plant 'D'
Characteristic Load Curve
showing
Current and Voltage
Relations
Volts
70
60
50
40
30
20
10
12
14
16
18
20
22
24
26
Amperes


Plant 'D'
Efficiency
of
Various Loads
18
16
14
12
10
8
6
4
2
6
8
10
12
14
16
18
20
22
24
26
28
30
40
½ Load
¾
Full Load

CONCLUSION.

The results from this thesis point out that each plant has its relative merits. Some of them would be advantageous to the plant and some of them would be advantageous to the user.

The results taken from the test on "Plant A" show that it has the lowest efficiency of the three plants. It may be considered as a constant voltage plant, the voltage dropping about five volts from practically no load to twenty percent over load. Its efficiency is highest between three-quarters and full load.

No trouble was encountered in starting and operating this plant. It has a high speed engine, it being directly connected to the generator which was rated at 1800 R. P. M.

The results taken from the test on "Plant B" show that it has a rather high efficiency. It has the best efficiency at full load. The voltage is practically constant from no load to full load, dropping off very little at twenty-five percent overload. Quite a little trouble was met in starting which was found to be in the carburetor. It being one that was very difficult to adjust.

The speed was moderate, running in the neighborhood of 1000 R. P. M.

"Plant C" was not quite as efficient as "Plant A", it having the highest efficiency between one-half and three-quarters load. At full load the efficiency was rather low. It is far from a constant voltage plant. The test showed the voltage dropped from 60 volts at practically no-load to 20 volts at twenty-five percent over-load. This plant operates at 1000 R. P. M. No trouble in starting or running was encountered.

"Plant D" is a new plant, it being just received from the factory. The efficiency is rather good for its type of construction. The engine is not automatically governed and has to be regulated by the throttle in the carburetor. The voltage regulation is rather poor but is fairly well governed when the battery is in the circuit.

Of the four plants tested two of them have been used for demonstrating purposes mostly, the other two have been used for extensive tests; the students have overhauled them and made a careful study of the plants.

When buying a farm lighting plant the following points are almost necessary to know; How much of a load

is expected on the plant, will it carry the load over an extended period or at a peak load? How is the efficiency, is the plant simple of construction and easy to operate not needing an engineer to take care of it while running? The batteries are a very important part of the plant, their type and construction is necessary to note as the life of the plant and its ability to hold up depends upon the battery.

INDEX

Plants tested in this thesis were

Plant A Lalley Light Plant

Plant B Genco Light Plant

Plant C Delco Electric Light Plant

Plant D United Engine Companys Light Plant.