THE APPLICATION OF ELECTRICITY TO AGRICULTURE

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By

Frank Meriwether Somerville, Jr., B. S.

The Application of Electricity to Agriculture

Introduction

This is a problem which has in the last few years grown into national importance. Electrical energy is now replacing other forms of energy to turn the wheels of industry and is turning them more economically. If the industrial world can use electricity to simplify its operations is it not a logical conclusion that the agricultural world can use it for the same purpose? There are, of course, differences between manufacturing and farming that offer many difficulties to the use of electricity on the farm. Therefore the object of research along this line is to overcome these difficulties. So much has been done with electricity that nothing seems impossible. At present the farmer can use electricity to make his home more comfortable as well as lighten the load on the farm housewife. This is a great step toward getting the farmers to use electrical energy to perform the major operations on the farm. Create a demand and the supply will come in time.

The more progressive leaders of the electric light and power industry realize that the farmers throughout the United States want, and should have electric service. No industry has grown more rapidly, or with greater certainty of progress, than the electric light and power industry. Indeed the history of the growth and development of this "silent partner" of every phase of our social business and industrial life is most interesting and instructive. However, until recently, because of the problems involved in economically furnishing the farmer electrical energy for his use, the remarkable development of this industry during the last fifty years has taken place in cities and in smaller communities, inter-connected by means of high voltage transmission lines.

It is truly appreciated that ways and means must be found to provide the farmer this desired electric service. The first essential in connection with the correct solutinn of the whole question of properly serving the farmer, at rates the light and power companies can afford to offer him and he can afford to pay, is to come to a common understanding of the real problems involved. Among these problems are: the generation of electrical energy required for his service; the transportation of that energy from its production source to the farmers premises; and the enlargement of the extent to which the farmer is able to utilize this energy so delivered to him.

From the foregoing it is seen that the farmer desires electrical energy and the problems involved to prevent him from receiving it. The National Government is working on these problems as well as the individual states and there are some interesting data now available.

Rural use of electric power is growing rapidly. Electric light and power companies are appointing men whose sole duty relates to the supervision of rural electrification development. Seventeen state committees on the Relation of Electricity to Agriculture spread from New Hampshire on the east to California on the west, from Alabama in the south to Minnesota on the north, with a goodly representation in the corn belt.

Study of the possibilities for the use of electricity on the farm has become an established project in agricultural experiment stations. Farmers, agricultural leaders, electrical men, and manufacturers are at work on the problem. Such efforts properly coordinated are certain to bring results of a definite nature.

In fact, we already have rural electric service and every month sees more rural lines built. The prospects are that the coming year will bring a marked increase in the number of farms having electric service.

Today there are at least 1,500,000 farms within reasonable reach of primary distribution systems. This is somewhat less than one-fourth of the total number of farms. With an average of three farms per mile this means rural distribution lines to reach 170 times across this continent - and at the minimum figure of $1,000 per mile, will represent an investment of $500,000,000.00.

The construction of transmission lines involves only half of the proposition. If the farmer is to get all he should out of electrical energy he must put it to work. This will require wiring of buildings and installation of equipment. It is safe to say, then, that twice as much will be spent on the farms as in the building of transmission lines. Thus it appears that this is a $1,500,000,000.00 undertaking.

There is still much to be done in properly constructing and adapting electrically-driven equipment to agricultural conditions or making the changes in farm practices to take full advantage of electrical possibilities.

Some interesting facts are shown about power used on the farm by the United States Department of Agriculture Bulletin No. 1348, "An Appraisal of Power Used on Farms in the United States", by C. D. Kinsman:

Agriculture uses practically as much primary power as all manufacturing and central stations combined, the total being approximately 16,000,000,000 horsepower hours. The cost of using this power amounted to about $3,000,000,000.00 for 1924, or about 19 cents per horsepower hours. Electricity can, in many cases, be used in place of more costly power and to replace man power.

Permanent good is sure to come of the present cooperative investigation of the use of electricity on the farm, according to L. T. Taber, master of the National Grange.

A generation ago it would have been supposed that electrical development and the use of electrical energy was of little concern to the farmer; that those in the cities and towns were more vitally interested in this mighty and mysterious power than those who till the soil.

It is probably that we are yet in the infancy in the use of electricity. This is obviously true as applied to agriculture. Any organization that directs its attention toward a better understanding of the relation of electricity to rural life will perform an invaluable service.

Review of Literature

It might be well to sketch in a general way waht has been done in a practical as well as an experimental way in the use of electricity on the farm.

Everything indicates that electric lighting, whether of farm or city dwellings and premises, is well established and a more or less economical practice presenting advantages in convenience, economy of time, cleanliness, and safety from fire hazard so as to leave little room for argument against it.

The heating of houses by electricity is not by any means an established practice. The greatest objection being the expense connected with this method of heating. However, this can be a means of increasing the electrical load but is not advisable if it is used to increase the load factor only. The United States Reclamation Service found on its Minidoka project that heating by electricity was impracticable where fule could be obtained at reasonable prices.

In spite of the unfavorable reports concerning the use of electricity for house heating, the practice offers a problem for consideration. The heating load will add very much to the total farm load, thereby reducing the rate. The fuel problem in many sections of the country is also becoming a serious one, and with the development of efficient electric heating devices the time may come when electric heating will become a serious consideration.

Experience has shown that it is not a very economical practice to use electricity for cooking purposes. But here again is offered a means of increasing total consumption, thereby reducing the rates. Comparative tests of gas and electricity for cooking,under the same conditions with an arbitrarily selected commercial stove, showed that electricity was about 4.5 times as costly as gas for cooking various meats, and about 6 times as costly for heating water. Similar tests in England gave about the same results. The solution of this problem then is two fold. The food specialist must determine ranges of temperatures and other conditions for the best and most economical cooking of different foods. Then the engineer must develop electrical cooking apparatuses which will satisfactorily meet the cooking requirements, with a minimum loss of heat and use of energy.

The use of electricity in meat curing has been found to offer possibilities worthy of note as a means of building up a rural electric load. There are experiments on record which show that the passage of an electrical current thru a vat containing meat in pickle is an effective curing process. It seems that meat will cure much more rapidly by using a system of electrodes in the vat containing the line thru which an electric current is passed than by the usual method. This process seems to indicate that the sodium chlorid is disassociated by the electric current and recombined in the meat, forming sodium hypochlorite, thus bringing the meat into a closer contact with a strong antiseptic. However, much more investigational work will have to be done along this line before this process will be feasible.

When we come to discuss the use of electricity as a means of performing the mechanical operations of the farms, such as the belt, shaft, direct drive, and traction jobs around the farmstead and in the field, we have reached, perhaps, the largest oppoetunity for the use of electricity on the farm. The smaller motor jobs around the house have about reached their maximum development, except possibly in minor mechanical detail. The larger motor jobs about the farm offer more difficulties, because of the varyihg factors.of the driven machines that must be taken into consideration. However, these factors must be taken into consideration when motors are to be used as a source of energy.

One of the largest possible uses of electrical power on the farm and one that offers the greatest difficulties, is its use in field work for such jobs as plowing, multivation, etc. The greatest drawback or problem which presents itslef in this connection is the means of carrying the current to the moving machine. Evidently this will have to be transmitted indirectly through the use of storage batteries or by direct means employing a cable from a transmission line. Neither method seems to have been solved thus far. Experiments in this country and abroad have tried the cable fed type of tractor but they did not prove very satisfactory. Some experiments in France made use of a windless stationed at one end of the field and from it was operated a cable to draw the cultivating machines. By this method 8.5 to 15 acres could be plowed in 12 hours. However, these methods do not compare favorably with our rather flexible gas tractors of today.

While this subject of plowing with electricity is under discussion it will be interesting to note another possibility in this connection. In England it was found that applying a negative charge to the moldboard of a plow that the draft was lessened. This was explained by the fact that by electroendosmose the negative charge of the soil colloids, water in moist soil, will move toward the negative electrode under the action of an electric current. This action would cause water to move to the moldboard of a plow which will act as a lubricant and reduce the draft.

The use of electric motors to drive the larger farming operations is a promising possibility for the use of electricity on the farm. There have been experiments carried on in this country and abroad along this line with varying results. Experiments in Canada, England, and the United States seem to indicate that silo filling, feed grinding, threshing, etc., by electric motors was just as cheap as the use of a steam engine or gas engine. Experiments in Germany were just the opposite, indicating the electricity for these same operations was much higher than the use of a steam engine. The outcome of these experiments strongly indicates the ultimate necessity of overhauling practically all of the larger power operation with a view of effecting the application of smaller power units operating over a larger period of time. This conclusion was reached due to the attendent power losses of electricity.

Irrigation and drainage in sections where this form of work has to be carried on offers a fine opportunity for electricity to be used in rural districts. Both of these operations usually require considerable amount of pumping, which in many cases will justify the construction of a transmission line, after which smaller farm operations can be secured without additional cost. Most of the experimental work along this line has been by the U. S. Bureau of Public Roads under the Department of Agriculture and Bureau of Reclamation under the Department of Interior.

Often fires are built in orchards or orange groves at times when there was danger of frost. The same result could be reached by heating the orchard with electricity. Various experiments have been carried out along this line by the New Zeland Dept. of Agriculture. Also stations in Utah, California, New Mexico, and Alabama have done some work of this nature. It was found that orchard heat could be raised from 1 degree F. to 4 degrees F., depending upon the wind and other varying factors, by the use of 100 horsepower of electrical energy distributed over the given area. This practice of course would not be practicable with a small area but offers a possibility where a large and valuable crops is concerned.

Dairying offers another opportunity for a ruralelectrical load. The small individual dairy can be operated as cheaply by electricity as other forms of power. The large plants can better afford a central power station where steam can be used for motive power as well as for heating purposes. In dairying the use of electricity for sterilizing milk offers a possibility for the use of electrical energy. Experiments in England show that the passage of a high voltage current through milk decreases the bacteria present, especially those of the Bacillus Coli and tubercle bacilli family. These experiments seemed to indicate that this was a very effective way of purifying milk.

Experiments in the use of electricity in the artificial lighting of poultry houses seem to be somewhat of a contradictory nature, but the majority of experiments indicate that in lighted poultry houses egg production was increased. The most marked effect was not so much the total annual increase in production as that of the winter months. This would be a durable effect to increase your egg production during the winter months when the price of eggs is high.

The heating of incubators is another use to which electricity can be put in connection with poultry production. The ease with which electric heating can be automatically controlled is a great advantage in incubation.

The use of electricity in crop production has held the attention of scientists in this and other countries for several decades. Experiments with so called electro-culture have been along certain lines, such as, stimulation by electric light, by overhead atmospheric electrical discharge, by soil electrification, and by electrical seed treatment either direct or indirect.

A long series of studies were conducted at the New York Cornell Station on the influence of the electric arc light upon greenhouse plants. These showed as a whole that the use of an electric arc light promoted assimilation, hastened growth and maturity, was capable of producing natural flavors and colors in fruits, and increased the production of flowers. Other experiments in this country indicated the superiority of the ruby light for radishes and the violet light for lettuce.

Austrian experiments seem to indicate that varying the duration and intensity of light stimulated the growth of some crops. German experiments showed that seeds germinated earlier under the influence of electric lights.

The results of experiments in overhead electrical treatment of crops have been many and varied. Experiments in this country with vegetables showed that plants subjected to high frequency electrification produced greater increases than any other form of treatment. Experiments in Bohemia in which insulated wire nets were stretched about 12 to 15 feet above the crop and subjected to a current of from 70,000 to 50,000 volts and from .7 to .8 millamperes showed a marked increase in growth of beets. Other German experiments showed that a high frequency current caused a marked increase in growth and chlorophyll formation. English experiments showed that overhead electrification markedly increased crops such as oats.

Experiments in Scotland on overhead application of a high tensian current over a period of a five year rotation failed to produce an increase worth the cost of treatment.

Electroculture by passing a current thru the soil has not been experimented with as much as that of charges in the atmosphere. Yet enough of this has been done to establish the possibility of it being feasible. Early experiments along this line at the Utah Station showed that electricity passed through the ground by a net work of wires 10 inches deep increased the yield of several field crops.

Experiments at the Massachusetts Station in which noninsulated copper wires were placed about 2 inches in the soil caused an increase in several root crops when a current was passed thru the wires at stated periods throughout the growing season.

Many German experiments showed that a continuous current passed thru the soil had a harmful effect on the growth of plants. These contradictory results prove that more must be known about this form of electroculture before it can be used commercially.

Experiments both in this country and abroad in the treatment of seed with electricity were rather unfavorable. There did not seem to be any benefit derived by treating seed with an electrical current. As yet little is known about this treatment and it may prove to be a very desirable process when the proper conditions are known.

These experiments while highly theoretical at present offer lines of research which may prove to be of great material benefit to mankind in the future. So much that seemed impossible has been done with electricity in the past few years that it is quite possible for it to come to the farmer's aid in what now seems impossible and impracticable.

Object

To obtain reliable information on the methods, costs and use of electricity on the farms of Virginia.

Problem

An investigation of the present available sources of electric power, covering its application to agriculture.

1- To what extent is electricity now being used, and for what purposes, on the farms of the State?
2- What are the methods of supplying electric service to rural customers?
3- What are the costs of supplying electric service to rural customers?

Procedure

The following questionnaire was sent to the larger power companies in the State:

Questionnaire to Power Companies

1. Number of farm customers you are serving. ______________
______________________________.

2. Average annual amount of current each farm customer consumes. ______________.

3. Average no. of farm customers to the mile of transmission line. ______________.

4. Type of contract. ______________
____
____
______________________________.

5. Rates charged farm customers. ______________.

6. Method of financing the rural transmission line. ______________
____
____
______________________________.

7. Names and addresses of farm customers. ______________
____
____
______________________________.

8. Does your rural custom pay? ______________
______________________________.

The above questionnaire was mainly to determine about how much of this state was using central station power and to get the names and addresses of the farmers using central station power, in order that a questionnaire could be sent to them.

Summary of Questionnaire Sent to the Power Companies

Questions	Answers
1. No. of farm customers served ------------	Average 86.
2. Annual amt. of current each uses--	574 K.W.H.
3. No. of customers to the mile of trans. line.-------------	Average 2
4. Type of contract--	Customer pay so much of initial cost of line, which is paid back by Co. in per cent of current used in next certain no. of years.
5. Rates charged.----	Average 11.38 cents per K.W.H.
6. Method of financing	Same as in contract.
8. Profitable to Co.	50% stated yes.

Note. One outstanding point to be noted in this summary is the comparative small amount of current used by the small consumer.

A questionnaire was sent out to farmers obtaining current from a transmission line in order that it might be determined what kind of service these sustomers were receiving and the cost to them.

Following is a summary of the answers received from the above questionnaire. In this summary there are some very interesting points brought out.

See next page

SUMMARY OF QUESTIONNAIRES FROM FARMERS

SUPPLIED WITH ELECTRICITY FROM TRANSMISSION LINES

QUESTIONS :	ANSWERS
Those having an individ ual plant before connected with power line?:	44.5% Yes 55.5% No.
Years you have been served with power Line?:	4.6% Years Average
Service interrupted often? :	100% No.
Voltage of distrb. line:	2300 Volts most common.
Transformer capacity? :	1½ K.V.A. Most Common
Cost per yr. not including interest? :	$106.27 Average.
Monthly service charge?:	$8.51 Average 33.3% did not answer.
Basis of charge? :	Per K.W. hour consumed plus rural charge.
Cost construction trans. lines? :	$722.66 Average 16.6% had none of this cost to pay. 16.6% were personal lines.
Length of line? :	2.2 Miles Average
Which source light preferred	
Transmission lines :	98%
Individual plant :	2%
Why line? :	Cheaper, more power, less trouble.
Current used per yr. :	835 K.W.H. per yr. per customer. 44.4% did not answer.
Use current for power as well as light. :	88.8% Yes 11.1 % Lights only.
Appliances - :	44.4% Pumps
:	44.4% Ranges
:	38.8% Irons
:	33.8% Vac. Cleaners
:	33.8% Meters
:	27.7% Milking Machines

continued next page

Summary of Questionnaire from farmers supplied with electricity from transmission lines - continued -

Questions	:	Answers
Appliances -	:	16.6% Washing machines
	:	11.1% Churns
	:	5.5% Fans
	:	5.5% Refrigerators
	:	5.5% Sewing machines
	:	5.5% Cream separators
	:	5.5$ Toasters
	:	5.5% Grinders
	:	5.5% Sorting tables.

One points worthy of note is the comparative short time that these customers have been using electric service, a little less than five years on an average. Naturally then it can be assumed that rural electric service from this source is in its infancy. This fact also bears a striking relation withthe amount of current consumed per year per customer, as shown by this summary. This figure, it will be seen, is 835 K.W.H. average per customer for a year. The farmer has not had electricity long enough to realize that the more current he uses the cheaper it will be. This is shown by the rates the Va. Electric and Power Co. charge: for 100 K.W.H. per month, and less, a rate of $.10 per K.W.H. is charged, for 150 K.W.H. per month $.07 is charged. The rate decreases as the amount used increases, until only $.02 per K.W.H. is charged where 20,000 K.W.H. are used. Take for example a consumer using 100 K.W.H. per month, this will be 1200 K.W.H. per year at $.10 per K.W.H. It will total $120.00. Now take the consumer who uses 150 K.W.H. per month. He will use

1800 K.W.H. per year at $.07 per K.W.H., making a total charge of $126.00. It is plainly seen that the second consumer only pays $6.00 for the additional 600 K.W.H. that he uses over the first consumer. Therefore a farmer is not economizing who is using the smallest amount of current. Of course this statement must be interpreted correctly. He is economizing when the least amount of current is consumed to perform a certain job, but he is not when his grand total consumption is small. In other words, it is economical to perform an many individual jobs with electricity as possibly, with as small a waste on each job as can be obtained, thereby increasing your total load.

Farmers must learn this principle before rural electrification can be profitable to him and the company furnishing it.

Another point of interest in this summary is the service the customers are receiving, all of them replying that very few interruptions in current ever occurred.

The cost of this type of rural electric service as shown by this summary will be discussed later when it is compared with the other types of service.

On the whole this summary speaks very well for the rural consumer who is located close to a power station. It shows that the average distance of each customer from the source of current to be a little over 2 miles. It tells us little of the problem of the customer who is a distance from any electrical power station. Yet a start must be made and familiarity with rural electrification by the rural consumer will solve the problem in time.

The following questionnaire was sent to about seven hundred farmers throughout the state having individual electric lighting plants. This questionnaire was sent out in order that it might be determined just what phases of rural electrification present themselves in this means of supplying the farmer with electricity.

#5609

DEPARTMENT OF AGRICULTURAL ENGINEERING,
V.P.I., BLACKSBURG, VA.

Questionnaire for Farmers Having Individual Lighting Plants.

1. Your name: ______________ Town: ______________
2. Rural Route: ______________
3. Name of plant: ______________
4. When was your plant installed? ______________
5. Has it been in continuous operation? ______________
6. If not, how many hours has it been out of order? ______
7. What have been the principal troubles with your plant? ______________
8. Size of your plant? (In watts, K.W. or H.P.) ______
9. Did you have some kind of light plant before this? ______
10. If so, what kind? ______________
11. How much did your present plant cost, installed? ______
12. If you bought again, would it be the same type? ______
13. If not, what type would you buy? ______________
14. Are you stisfied with your plant? ______________
15. If not, why not? ______________
16. What is the voltage of your plant? ______________

17. Which do you prefer, a direct connected or belted plant? ______

Why? ______

18. How many lights do you use? ______

19. Name the electrical appliances you use: ______

20. How much do you estimate it costs per year for: ______

(a) Gasoline: ______. (d) Labor: ______

(b) Kerosene: ______. (e) Reprs to Eng. and Generator. ______

(c) Oil: ______.

(f) Repairs to battery: ______

22. What is the make of your battery? ______

23. What is its ampere capacity? ______

24. What change would you make in the size battery if you bought again? ______

______

25. How long has your battery been in service? ______

26. How many yrs. of service do you expect to get from your battery? ______

27. How many yrs. did the dealer say you would get? ______

28. What do you estimate the total annual cost of operation to be, including interest on investment and depreciation? ______

29. What do you estimate will be the life of the following parts, until reparis have to be made? ______

(a) Engine? ______ (b) Generator? ______

(c) Battery? ______

30. Would you do without electric lights on the basis of what they are now costing you? ______

31. Can you make an estimate of how much electric lights are worth to you in dollars and cents? ______

32. About how much time is saved per day in doing chores? ___

33. What are the principal advantages of electric lights to you? ______

34. Do your helpers seem better satisfied? ________________

35. As a consequence of electric lights, can you get along with less help? ____________________

If so, with how much less'dollars per mo) ____________

36. Are your children more interested in their home? _____

37. How far are you from an electric power line? ________

38. What advantages do you claim from electric light and power? ______________________________

____

39. Assuming that you wer about to buy a new individual plant costing, say $600.00, how much would you be willing to pay toward the cost of a transmission line, so that you could get service from a central station, providing you wer sure the current would cost no more from this source than from light plant, probably less, and providing you were freed from all further obligation and care of the line, and that this line would be maintained and replaced when worn out, without further cost to you? ____________________ Dollars.

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Following is a summary of the answers to the questionnaire sent to farmers having an individual lighting plant. As is indicated in this summary, the plants employing a storage battery and those that do not use a storage battery, except for starting, are listed separately. This was done in order that comparisons of the two types might be made.

See next page

SUMMARY OF QUESTIONNAIRES FROM 175 FARMERS
HAVING INDIVIDUAL LIGHTING PLANTS.

Questions	Answers: Battery Plants	Answers: Non-Battery Plants
No. of plants	157(100%)	18 (100%)
Name of plants	Delco 78.9%; Matthews 8.2%; Fairbanks-Morse 2.54%; Willys-Knight 2.54%; Lalley 2.54%; WesternElec 1.9%; Westinghouse 1.27%; Almo 0.63%; Edison 0.63%; Phelps 0.63%.	Kohler 100%
Size of plant	750 watts 17.8% 850 " 16.5" 1000 " 8.2" 1250 " 14.0" 1500 " 4.5" 3500 " 2.5% 6000 " 0.6% (110 volts) Ratings given in HP 5.1% Did not ans. 29.9%	800 watts 28% 1500 watts 72%
Voltage of plant	32 volts 98.1% 110 volts 1.9%	110 volts 100%
Ampere hr.cap.of battery	140 (average) 20.4 % wished larger sixe.	Use only small 24 volt starting battery.
Drive direct connected or belted -	Direct 87.5%; Belted 2.54%	Direct 100%
Date plant was installed-	Av. 4.5 yrs.	Av. 1.3 yrs.
Satisfied with plant	Yes 95%; No 5%	Yes 84.5% No 5.5% (cost too much)
Been in continuous use	Yes 93.6%; No 6.4%	Yes 94.5%; No 5.5%
Principal troubles	Minor troubles-spark plugs, exhaust valves, magneto, fuses, meter, and auto switch.	Starting 5.5%; None 94.5%

Summary continued - from page 23

Estimated life until repairs must be made of -(av)		
(1) Battery	Owners estimate 6.5 yrs. 20.3% did not ans. Dealers claim 7.1 yrs. 38.2% di not ans.	Good for life of plant.
(2) Engine	6.9 yrs. 46.5% did not ans.	6.6 yrs. 66.6% did not a
(3) Generator	7.4 yrs. 55.4% " not ans.	6.6 " 66.6% " " "
Number of lights used	Av. 25.1	Av. 22
Appliances used --	None 42.7% Pumps 28% Irons 24.8% Washiing machines 11.4% Churns 8.9% Vacuum cleaner 8.9% Fans 7.6% Motors 3.1% Separators 2.5% Toasters 1.9% Curling irons 1.9% Refrigerators 1.2% Perculators 1.2% Radio 1.2% Phonographs 0.63% Fan mills 0.63% Corn shellers 0.63% Meat grinders 0.63% Heaters 0.63%	None 22.2% Irons 50% Pumps 22.2% Wash.Mach. 16.6% Vac.Cleaners 16.6% Stove 11.1% Fans 11.1% Toasters 5.5% Percolaters 5.5% Drill 5.5% Motors 5.5% Elec.Cab. 5.5%
Cost of present plant installed includ. wiring	Av. $602.46	Av. $577.22
Annual cost for(av)		
(1) Gasoline	$39.20 32.4% use gaso.	$62.33-16.6% did not ans.
(2) Kerosene	27.10 62.4% " ker. 5% did n.Ans	
(3) Oil	7.15	7.40 - 16.6% did not ans
(4) Labor	7.94	5.00 - 94.5% " " "
(5) Reprs to bat	3.66 86.6% rep. none	None reported.
(6) Reprs to eng. & generator	1.00- 54% reported none	.28 - 94.5% rep. none
Operating exp(tot)	86.05	75.01

Summary of Questionnaires - continued

Questions	Answers: Battery Plants	Answers: Non-Battery Plants
Total annual cost	Overhead Int on invest. $18.07 (½ orig. " @ 6% Depreciation Battery $200 at 20% 40.00 (assum. 5 yrs. life) Engine and Generator $302.46 at 10% 30.24 (Assum 10 yrs life) Wiring $100 at 5% 5.00 Operating Exp. 86.05 Total---- 179.36	Overhead Int. on invest. $----- 17.31 (½)orig invest @ 6% Depreciation- Engine, Generator & Battery $477 at 10% 47.70 (Assum 10 yrs life) Wiring $100 at 5% 5.00 Operat. Exp. 75.01 Total----- $ 145.02
Do without elec. light on basis of what they cost you now -	No 97.5 Yes 2.5%	No 100%
Estimated worth of electric lights	$472.43(Av.) 79.5% did not ans.	$441.30(av) 83.3% did not ans.
Did you have a light plant before?	Yes 15.4%; No 84.6%	Yes 33.3%; No 66.7%
Buy same type again	Yes 77.1%; No 10.8% Undecided 12.1%	Yes 88.9% No 11.1% (One stated Delco)
Advantages --	Convenience, safety, better light, use of elec. appliances, help to housewife, cleaner & time saver.	Same as for battery plant.
Time saved in doing chores	1.7 hrs. pr da. 29.2% did not ans.	1.5 hrs. pr da 88.9% did not ans.
Use less help	Yes 21.2% $14.06(av) No 20.3% 36.9% did not ans.	Yes 33.3% $6.00(Av) 66.7% did not ans.
Helpers better satisfied	Yes 68.7% No 8.2% 23.1% did not ans.	Yes 44.4% 55.6% did not ans.
Children more int. in home	Yes 60.5% 39.5% had no children or did not ans.	Yes 61.1% 38.9% did not ans.
Distance from power line	11.5 mi. (av) 7.6% did not ans.	10.3 mi (av) 5.5% did not ans.

Summary of Questionnaires continued.

Questions	Answers: Battery Plant	Answers: Non-Bat.Plant
Amt. willing to invest in rural line	$463.80(av) 41.4% did not answer.	$600.00(Av) 50% did not ans.

THere are many interesting points brought out in the foregoing summary that it might be well totake up and discuss.

The Delco is by far the most common of the battery plants in use. While the Kohler is the only non-battery plant listed on the summary. It also shows that the smaller size plants are most common with the battery type while the larger size is most common with the non-battery type. This fact may be explained in the additional cost of the large capacity storage batteries over the smaller capacity. Also the additional first cost of the non-battery type is more than offset by the increased power received and there is not a great difference in operating cost between the sizes of these plants.

The comparatively short time this means of serving the farmer with electricity has been in use is also shown. The battery type on the average have been use in general only four and one-half years, while the non-battery type only less than one and one-half years. The automatic plants are rather a recent perfection therefore they have not come into general use as much as the battery plants. The battery plants have been in use only a little longer than rural transmission lines as shown by that summary.

One of the most outstanding results of the questionnaire is the satisfaction the individual plants are rendering. Ninety-five per cent of the battery users and ninety-four and one-half per cent of the non-battery users expressed entire satisfaction with their plants. The only toubles they had had were usually small, mechanical ones which may occur with any machine, but not due to faulty construction or engineering. This seems to indicate a hopeful future in serving the farmer with electricity. He wants it and is satisfied with the way it operates.

There are quite a variety of appliances used, other than lights, with both types of plants. These appliances for the most part being small household ones. They are a great convenience and boon tothe housewife which makes for peace and comfort in the home.

The total cost of operating, including interest on investment, depreciation, etc., shows to average $179.36 for the battery type and $145.02 for the non-battery type. The difference in the cost is mostly due to the depreciation on the battery. The other expenses being about equal in both types of plants.

Compaing the average cost of operating the individual plants with the cost of electricity from a transmission line it will be seen that the transmission line is the dheaper. This is due to the depreciation and interest on investment not being figured in on the transmission line proposition. Most poer companies, at least those of Virginia have a type of contract which provides that the customer must pay a certain amount to build the transmission line after which it becomes the property of the company. The company then pays back to the customer each year for a period of about five years a certain per cent of the original investment based on the amount of current he consumed. The company keeps the line in repair and assumes all responsibility for it. As this is the case the customer does not have to figure in any depreciation on the line.

The answer to the question, as to whether the individual would be willing to do without lights on the basis of what they were now costing him or not, are significant. Ninety-seven and five tenths per cent answered this question in the negative and 100% negative for the non-battery plants. This proves beyond a doubt that this means of supplying the farmer with electricity is a success. The farmer is that type of business man who does not as a rule, keep that which does not pay him. Therefore, his acceptance of the lighting plants proves it worth to him. The lighting plant is a big step in getting the farmer to use electricity on a larger scale. By this means he will become familiar with electricity applied in a small way; its comfort, convenience and economical value. Therefore when the time comes he will give of his means and support with hearty cooperation any project to rural electrification.

The advantages claimed for electricity were those that naturally would be expected, such as, safety, comfort and convenience.

If the average time saved in doing the chores was from one to two hours per day with those small plants it is logically expected that much more time and trouble can be saved from use of electricity for work outside of the household.

Helpers can be done away with and electricity can be substituted in their place. Also the helpers are better satisfied if some of the drudgery is taken from their work.

We hear a lot these days from rural sections about keeping the children on the farm. Of course they are attracted by the bright lights, comforts, etc., of the city. Here is the answer for the farmer. Bring the lights and comforts to the country home and you will not worry about the children staying there. Make your home so attractive that they will not wish to leave. Electricity will do this in the home and in time will lighten the task of the farmer outside of the home.

This summary shows that most of the farmers do not live such a great distance from power lines that it would be impossible to serve them. They also seem to be willing to pay at least as much as an individual plant would cost to obtain service from a power line.

The most outstanding point brought out by this summary is the realization by the farmer that electricity on the farm is feasible, is an economical success, and is not confined to cities and towns.

Tests on the Individual Plants in the Laboratory

The following tests were made on the 1500 watt Kohler non-battery automatic plant in the laboratory.

This plant is peculiarly adapted to making tests on it, due to the absence of a storage battery as a source of current as is the case with the battery type of plants.

It may be advisable here to give the procedure observed in making the tests on this plant. A volt and ameter were connected in the circuit between the generator and the load. A thermometer was placed in the coils of the generator in order to get the generator temperature, one placed in the cooling water, and one near the plant for room temperatures. Readings were taken every 30 minutes throughout each test and the plant was allowed to warm up ten or fifteen minutes before any readings were made. The amount of gasoline used was arrived at by placing a filled gas tank on a pair of scales. This tank was connected with the carburetor by arubber tube. By this means the number of pounds of gasoline used could be determined.

From the above procedure the following table on test No. I, which was a light load test of 2 hours duration, was compiled.

See Next Page

TEST NO I.

Light Load Test - 50 Watts - 2 hours

		Generator			Engine			
Time	TEMP Room	Volts	Amps	Temp	R.P.M.	Fule-lbs	Temp Water	Remarks
10:05	54	124	0.6	55	1094	43.375	129	load - 1 60 w lam
10:35	53	123	0.6	69	1098	42.625	151	Water lost by expans.
11:05	54	122	0.6	76	1052	41.875	153	
11:35	55	121	0.6	80.5	1062	41.125	153.5	
12:05	59	121	0.6	82.	1114	40.437	154	Plant ran fine throut test.
AVerage	55	122.5	0.6	72.5	1084		148.1	

Average Watts 73.5

K.W. hours(total) .147

Gasoline used 2.0375 lbs.

Fuel used per K.W. hr 19.983 lbs.

Oil used 1/8 pt.

Water used 1/32 pt.

Fuel cost $.6394

Oil Cost(Consumed .0062

Replacement .0046

Total .6502

Time test was run 2-19-25

A.M.

From Tabel No I. it is seen that the total cost of this test to be about $.65. As it might seem without consideration that this 65 cents was the cost of running for two hours, but is the amount it will cost to produce one killowatt hour using a sixty watt lamp.

Test No. II Follows

(See Next Page)

Test No. II (Kohler)

One-quarter Load Test - 375 Watts - 2 hours

	GENERATOR					ENGINE		
Time	R.Temp	Volts	Amps.	Temp	R.P.M.	Fuel-lbs	W.Temp	Remarks
1:55	62	119	3.6	77	1048	40.062	151	Load - Lights
2:55	64	117	3.5	86	1104	39.3125	163	'
2:55	65	116	3.5	91	1096	38.375	164	'
3:25	66	116	3.5	94	1092	37.562	164	&
3:55	66.5	115	3.5	95	1038	36.75	164	'
Average	64.7	116.6	3.51	88.6	1076		161.2	

Average Watts 409.266

K.W.H (total) .8185 Fuel cost $.1295

Gasoline used 3.3125 lbs. Oil Cost (Consum) .0062

Fuel used per K.W. hr 4.0469 lbs. Replad. .0046

Oil used 1/8 pt. Total $ .1404

Water used 1/32 pt.

Time 2-19-25 P.M.

The same methods and procedure were followed in Test No. II as in No. I. This test was 375 watt load or about one-quarter load of the rated load of the plant.

This test shows that it costs about 14 cents to produce one K.W. hour.

TEST NO III

One-half Load Test - 750 Watts - 2 hours

Time	Room Temp	Generator Volts	Generator Amps	Generator Temp	Engine R.P.M.	Engine Fuel	Engine Water Temp	Remarks
9:15	48	119	7.75	57	1062	35.625	159	Load - Ligh
9:45	48	117	7.75	71	1040	34.5	159.5	
10:15	50	116	7.75	79	1040	33.437	162.	
10:45	53	115.8	7.75	84	1080	32.437	165.	
11:15	55	115	7.6	88	1046	31.375	166.	
Average	50.8	116.5	7.72	75.4	1053		162.3	

Average Watts	899.38	Cost	
K.W. hours (Total)	1.7987	Fuel	$.0756
Gasoline used	4.25 lbs.	Oil(Consump	.0062
Fuel used per K.W. hr	2.363 lbs.	Replac.	.0046
Oil used	1/8 pt.		$ .0865
Water "	1/32 pt.		

Test No. III was for one-half load or 750 watts. In this case it cost about 9 cents to produce one K.W. hour.

TEST NO IV. (Kohler)

Three-quarters Load Test - 1125 Watts - 2 hours

Time	Room Temp	Generator Volts	Amps.	Temp	R.P.M.	Engine Fuel	W.Temp	Remarks
1:25	62	115	10.4	79	1068	30.875	162	Load - Lights
1:55	65	114	10.3	93	1072	29.625	178	'
2:25	66	113	10.2	100	1066	28.5	&178	'
2:55	66	112.5	10.2	103	1044	27.25	177	'
3:25	66	112.5	10.2	104	1068	26.125	177	'
Average	65	113.4	10.26	95.8	1063		174.4	

Average Watts	1163.484		Cost
K.W. hours (total)	2.327	Fuel	$0.06532
Gasoline used	4.75 lbs.	Oil(Consumed)	.00625
Fuel used per K.W.Hr	2.0413	Replaced	.00467
Oil used	1/8 pt.	Total	$ .07624
Water used	1/32 pt.		

(Note) The water & oil used was measured at the end of this test and the amts. used divided by 4. Four tests of equal duration.

Test No. IV was run with the plant under a load of three quarters or 1125 watts. This test shows only a little decrease in cost per K.W. hr. over test No. III. In fact there seemed to be about only one cent difference.

Test No. V (Kohler

RATED LOAD TEST - 1500 WATTS - 8 hours

Time	Room Temp	Generator Volts	Generator Amps	Generator Temp	Generator R.P.M.	Engine Fuel	Engine Water Temp	Remarks
9:15	46	110.0	14.25	71	1015	54.750	166	
9:45	50	109.9	14.2	82	1019	53.375	167.5	
10:15	52	109.5	14.0	88	1036	52.000	170.	
10:45	54	109.3	13.9	92	1026	50.562	173	
11:15	56	109.5	13.9	95	1034	49.25	175	
11:45	57	109.5	13.9	97	1026	47.875	176	
12:15	59.5	109.2	13.75	99	1038	46.500	177.5	
12:45	62	109.0	13.75m	102	1032	45.187	179.	
1:15	62.5	108.8	13.75	103	1048	43.812	180	
1:45	64	108.8	13.75	104	1042	42.500	180.5	
2:15	65	108.7	13.75	105.5	1046	41.125	182.5	
2:45	66	108.7	13.75	106.5	1030	39.750	183.	
3:15	66.5	108.7	13.75	106.7	1030	38.437	183	
3:45	67.5	108.8	13.75	107.8	1026	37.062	183.5	
4:15	67,	108.7	13.75	108.	1036	35.750	183.	
4:45	65	108.5	13.7	107.7	1040	34.437	182.7	
5:15	64	108.5	13.7	106.5	1046	33.062	181.5	
Average	60.2	107.2	13.38	98.9				

(See Next Page)

Test No. V continued (Kohler)

Average Watts 1511.43

K.W. hrs.(total) 12.0915

Gasoline used 21.6875 lbs.

Fuel used per K.W. hr 1.7936 lbs.

Oil used 1/4 pt.

Water " 1 pt.

Cost per K.W. Hr.

Fuel $0.05739

Oil(Consumed) 0.00625

Replaced 0.00467

Total cost $ 0.06831
per K.W.Hr.

Note - Oil consumed is possibly low due to the fact that the oil was measured at room temperature when the sump was filled and at crank case temperature when drained. The plant operated very well throughout this test but it had slight tendency to slow up at times.

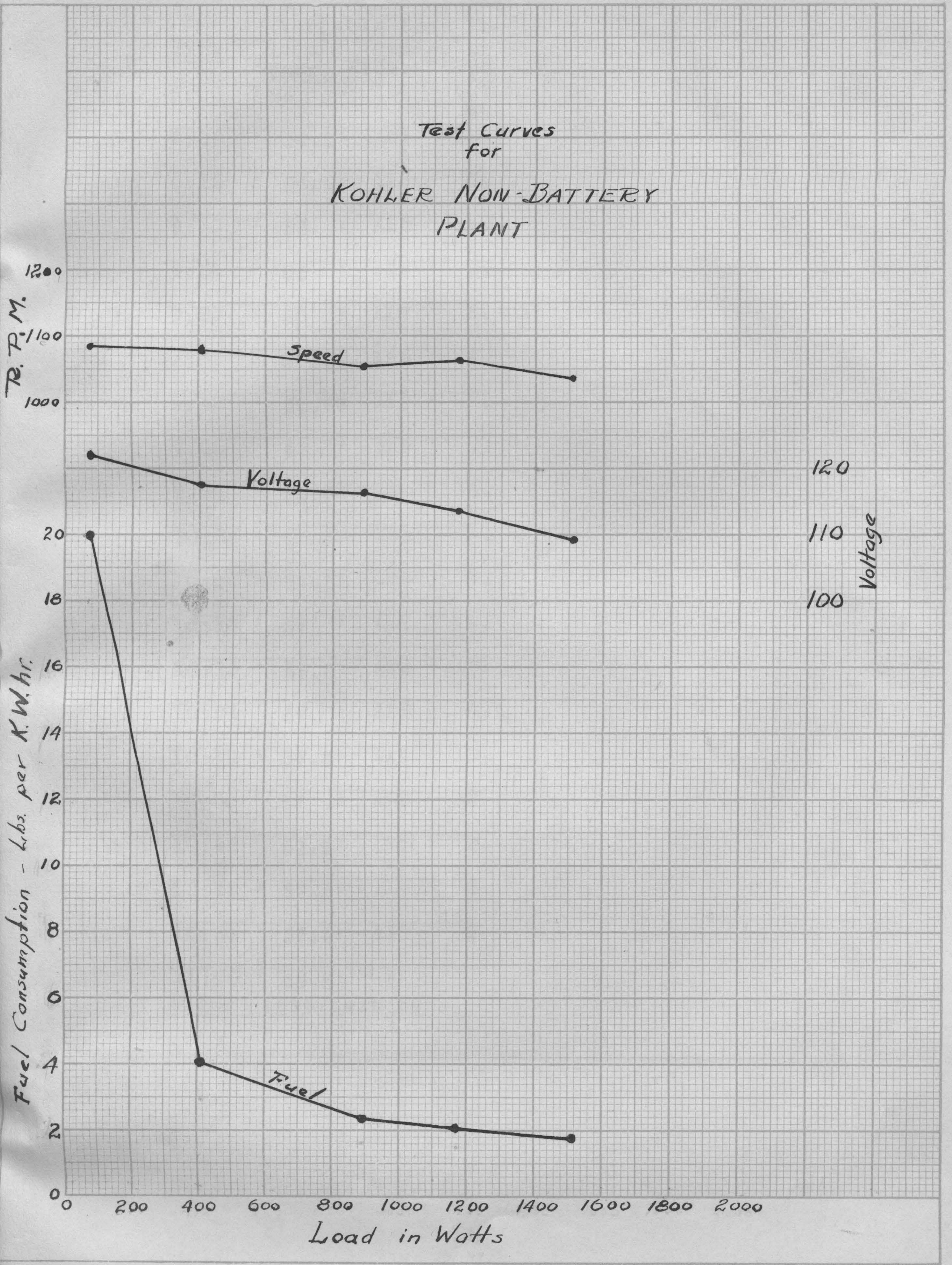
Test No. V. was of eight hours length with plant operating under full load or 1500 watts. The average wattage output was a little over the rated capacity of the plant. This speaks well for the plant.

The cost per K.W. hour is less than in test No. IV being less than seven cents.

The most outstanding feature of these five tests was the gradual decrease in cost per K. W. hr. as the load increased. In other words the plant can be operated cheaper under full load than on a light load. Therefore, it is not the best economy to operate on a light load but get the most out of this type of plant when it is operating.

The following curve which is a summary of tests No. I, II, III, IV and V brings out this point very forcibly as the fuel consumed per K. W. hour is the limiting factor in the cost.

(Curve - next page)


Test Curves
for
KOHLER NON-BATTERY
PLANT
R. P. M.
1200
1100
1000
Speed
Voltage
120
110
100
Voltage
Fuel Consumption - Lbs. per K.W. hr.
20
18
16
14
12
10
8
6
4
2
0
Fuel
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Load in Watts

TEST NO. VI

Variable Load Test - 6 minute runs - 2 hours

Time	Room Temp	Generator Volts	Generator Amps	Engine Temp	R.P.M.	Fuel	Water Temp	Load	Remarks
9:00	54	114	6.75	76	1049	43.562	155	Lights(740 w)	Plant slowed by load; Amps 20, Volts 50
9:06	54.5	107	13.5	77	1044	43.312	162	Lights(") & Delco*	
9:12	54.5	116	8.1	80	1058	43.000	171	Delco	
9:18	55	115	11.	81	1056	42.812	170	Delco &Grinder**	Amps to 16; Volts to 80
9:24	55	118	2.1	82	1062	42.562	171	Grinder &(60W)lamp	
9:30	55	117	2.1	82	1087	42.437	166	Lights(180 w)	
9:36	55.5	116	4.	82.5	1061	42.250	161	Lights(180w)¼HP Motor	Amps to 11; Volts to 110
9:42	55.5	117	.75	83.	1074	42.125	161.5	Lights(60w)	Volts to 120
9:48	55	115	7.75	82.5	1025	41.937	158	Lights(60w)&Delco	Amps to 21; Volts to 50
9:54	55.5	105	14.	85.	1019	41.687	166	Lights(615W)Delco & ¼HP Motor	Amps to 16; Volts to 100
10:00	56.5	115	6.1	89	1069	41.500	177	Lights(615W)	Volts to 121
10:06	57.5	114	8.5	88.5	1071	41.250	171.5	Lights(615w)&1/6 HP M	Amps to 12; Volts to 105
10:12	57	116	2.5	89.	1064	41.000	171	Lights(60W)& ditto	Volts to 122
10:18	56.5	110	10.	88.5	1050	40.812	165	Lights(60w)1/6HP M & Delco	Amps to 205; Volts to 51
10:24	57	115	7.5	90.	1056	40.625	170	Lights(60W) & Delco	
10:30	57.5	110	10.	90.	1046	40.437	172	Lights(300W)& Delco	
10:36	57	108	12.	91.5	1044	40.250	175	Lights(300W)Del&Grind	Amps to 21; Volts to 75
10:42	57.5	115	3.5	93.	1055	40.000	178	Lights(300W)	Volts to 125
10:48	57.5	116	2.2	92.	1067	39.812	171	Lights(180W)	
10:54	57.5	117	1.1	91.5	1072	39.687	164	Lights(60W)	
11:00	58.5			90		39.500	160.5		

NOTE: (see next page)

Note: Governor handled engine speed with very little variation except upon addition of record load.

*Delco - 110 volt, 750 watt Delco Light Plant motored with spark plug removed.

** Grinder - 1/2 H.P. high speed motor.

Note: No starting devices used with motors.

Note: The volts, amperes, and R.P.M. readings were taken at the middle of each run and recorded under the time of the beginning of that particular load run.

Note: Water and oil used not measured.

Test No. VI was a variable Load test. This test was run primarily to observe the action of the plant under variable loads. Throughout this test the governor seemed to operate perfectly. The loads were charged suddenly which would be a severe test on the governor.

(See next page for Test VII)

TEST NO VII (Kohler)

Start and Run Test - Variable Load - 12 minute test runs with 15 minute intervals - total running time 2 hours.

Run		Room	Time	GENERATOR				ENGINE	Water	
No	Time	Temp	Start	Volts	Amps	Temp	R.P.M.	Fuel	Temp	Load
	1:15	61	8 sec	120	1.5	80	1062	48.687	164	Lights
1	1:27	63						48.312	162	
	1:42	62	4 sec	117	3.75	84	1052	48.250	154	Lights
2	1:54	63.5						47.937	165	
	2:09	63.5	4 sec	116	5.5	86	1049	47.937	161	Lights
3	2:21	64.75						47.500	169	
	2:36	64.5	4 sec	115	6.75	87	1033	47.500	164	Lights
4	2:48	64.5						47.062	171	
	3:03	64.5	9 sec	114	8	88	1037	47.062	164	Lights &
5	3:15	64.5						46.625	174	$\frac{1}{4}$ HP Motor
	3:30	64	11sec	113	9.9	92	1035	46.625	167	Lights & $\frac{1}{4}$
6	3:42	65.5						46.125	178	&1/6HP Motors
	3:53	65.5	10sec	113	9.5	94	1048	46.125	175	Lights, $\frac{1}{4}$ &
7	4:05	65						45.687	177	$\frac{1}{2}$ HP Motors
	4:20	64.5	5 sec	110	11	94	1046	45.687	171	Light, $\frac{1}{4}$, 1/6
8	4:32	65						45.187	178	& $\frac{1}{2}$ HP Motors
	4:47	64.5	70sec	100	15.2	99	979	45.187	169	Lights, 1/6, $\frac{1}{4}$
9	4:59	65						44.562	181	$\frac{1}{2}$ HPMotors&Del*
	5:14	63.5	10sec	121	1.5	94	1079	44.562	170	$\frac{1}{2}$ H.P.Motor
10	5:26	63						44.250	163	

REMARKS: Run No. 1 Warming up run from 12:40 to 1:00
" " 2 Carburetor overflowed during interval following 1st run
" " 7 110 v. relay orced slightly. Run started 4 min. too soon
" " 8 Slight orcing at 110 v relay.
" " 9 Relay 1st closed, etc. (see ~~next page~~ bottom page)
" " 10 Readings as relay closed. Volts 70, amperes 12.

*Delco - 110 volt, 750 watt Delco Light Plant motored with spark plug removed.

Relay first closed 10 sec. after closing line switch, then orced for 60 sec. while engine gained speed. The voltage varied from 30 at the beginning to 103 at end, while the amerpage dropped from 23 to 14.75

Note: The volts, amperes and R.P.M. readings were taken at the middle of each run and recorded under the time of the beginning of that particular load run.

"Time to Start" is the time from the closing of the line switch to the final closing of the line switch.

During this test no change is starting battery was perceptible. The change rate was 0.9 amperes, specific gravity 1300, and the average cell temperature 59 degree F.

Water and oil not measured.

No starting devices used on any motor or load in this test.

Test No VII was the start and run test. This test was primarily a test of the automatic starting mechanism of the plant. The plant behaved well on this test as the notes and explanations show.

(Test No VIII - next page)

Test No VIII (Kohler)

Cranking Test - Engine warm and cold

Engine warm - test made immediately after Test No VII

Amperes to break engine	--------------	38
" " crank "	--------------	10
Cranking speed	--------------	326 R.P.M.
Cooling Water Temp.	---------------	162 degrees
Room Temp.	--------------	63 "

ENGINE COLD - Test made three hours and fifteen min. after first cranking test.

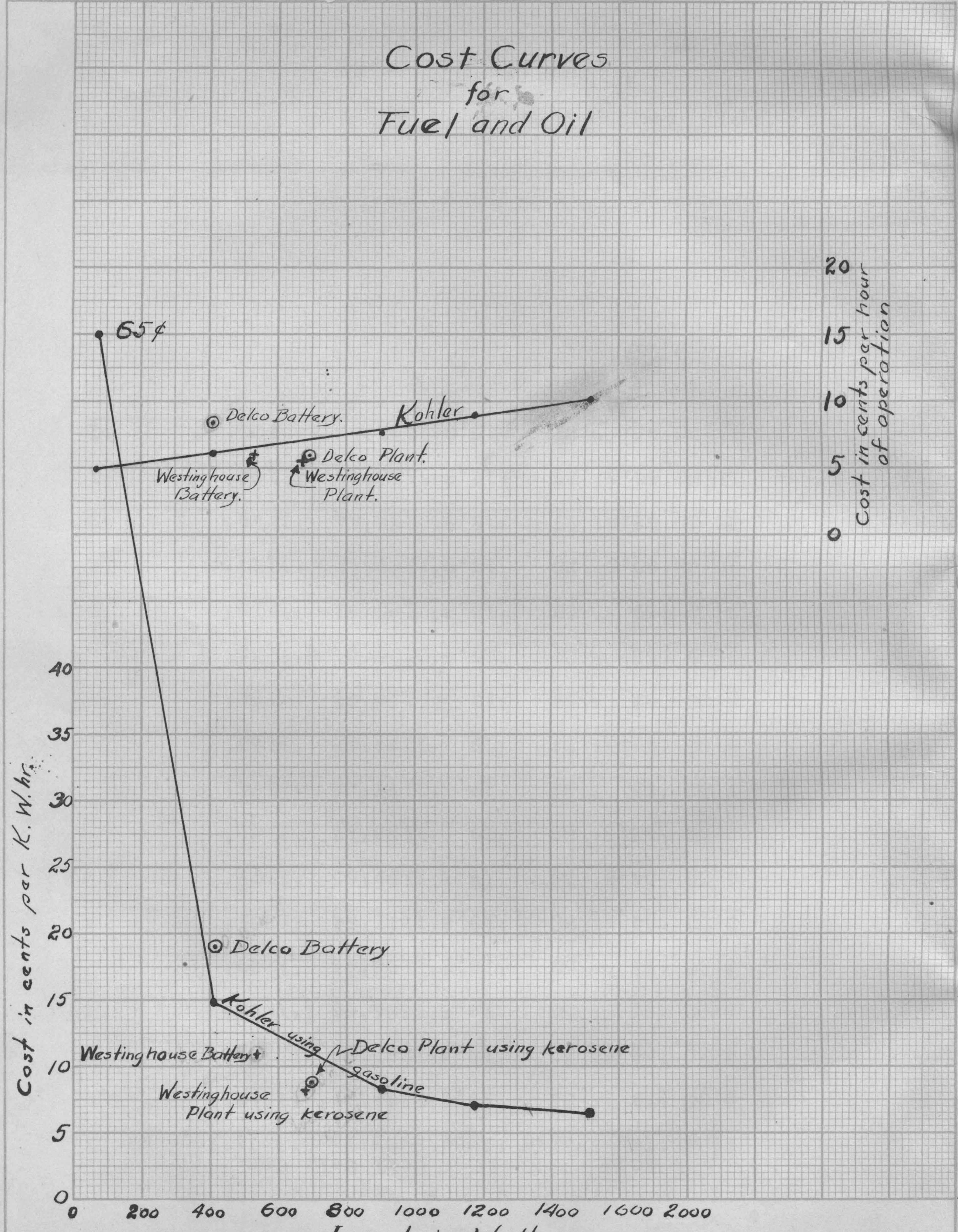
Amperes to break Engine	--------------	50
" " crank "	--------------	17
Cranking speed	--------------	222 R.P.M.
Cooling Water Temp	--------------	77 degrees
Room Temp	--------------	50 "

TEST NO VIII was a test to determine how much electricity was taken from starting battery when the engine was warm and cold.

The next test was run on the Westinghouse Electric Light Plant Type E - Model 60. This plant is of the battery type.

The following tables I and II with the summary of these tables give about all the necessary information and results connected with this test.

It will be seen that it cost about 10 cents per K.W. hr. with an output from the battery of over 500 watts. This will average about the same as the Kohler plant as this load is between test No II and III of that plant.



Cost Curves
for
Fuel and Oil
65¢
Delco Battery.
Kohler
Westinghouse Battery.
Delco Plant.
Westinghouse Plant.
20
15
10
5
0
Cost in cents per hour of operation
40
35
30
25
20
15
10
5
0
Cost in cents per K.W.hr.
Delco Battery
Kohler using gasoline
Delco Plant using kerosene
Westinghouse Battery +
Westinghouse Plant using kerosene
0
200
400
600
800
1000
1200
1400
1600
2000
Load in Watts

Table I - Eight Hour Discharge Test (Westinghouse)

Time	Room Temp	Volts	Amps	Cell SpGr	Cell Temp	Cor. SpGr	Remarks	Cadmium Readings Volts Pos.	Neg.	Cell Voltage
4:00	59	32	19.6	1244	67	1243		2.1	.2	1.92
4:30	55.5	30	19.3	1253	65	1231		2.1	.2	1.93
5:00	55	30	19.2	1224	65	1222		2.1	.2	1.92
5:30	55	30	19.2	1222	64	1220		2.1	.2	1.92
6:00	54	30	19.2	1211	64	1209		2.09	.2	1.90
6:30	54.5	30	19.2	1199	63	1197		2.08	.22	1.90
7:00	53.5	30	19	1188	62	1185		2.09	.22	1.89
7:30	55	29	19	1177	62	1174	T	2.07	.22	1.89
8:00	54.9	29	19	1166	62	1163		2.06	.23	1.85
8:30	53	29	19	1155	62	1152		2.06	.22	1.86
9:00	55	29	18.8	1138	61.5	1135		2.04	.22	1.84
9:30	59	28	18.8	1128	61	1125		2.05	.22	1.85
10:00	60.5	28	18.8	1122	61	1119		2.05	.23	1.80
10:30	62.5	27	18.2	1112	64	1116		2.00	.24	1.76
11:00	64.5	25	17.8	1116	66.5	1105		1.97	.25	1.74
11:30	65	21	15.8	1111	66.5	1100		1.95	.245	1.70

TABLE II - Eight Hour Charge Test (West 1)

	Time	Room Temp	Volts	Amps	Specific Gravity SpGr Read.	Cell Temp	Cor Spec	Remarks
Discharge	6:45	60	20	15.5	1150	60	1147	
0	7:15	60	36.5	26.5	1150	60	1147	
1	7:45	60.5	37	25	1150	62	1147	
2	8:15	60.5	37	24.8	1150	62.8	1147	
3	8:45	60.5	37	23.6	1150	62	1147	
4	9:15	60.5	37	23	1150	64	1148	
5	9:45	60.5	37	22.5	1150	64	1148	
6	10:15	61	37	21	1150	66	1149	
7	10:45	61	37	21	1150	66	1149	
8	11:15	61	37	20	1150	66.9	1149	
9	11:45	61	38	18.9	1150	66.1	1149	
10	12:15	61	39	17.1	1150	62.1	1149	
11	12:45	62.5	39	15.1	1170	66.1	1149	
12	1:15	61	40	12	1180	67	1179	
13	1:45	60.5	40	9	1181	63	1179	Gasing
14	2:15	60	40	8	1190	63	1189	"
15	2:45	60	40	7	1200	67	1199	"
16	3:15	60	40	6.9	1244	68.1	1244	"

Note: See following page 47' for other half of this Table

Other half of Table II - Eight Hour Charge Test - (West 1) 47'

Cadmium V Pos.	Neg.	Cell Volt	Generator Temp	Remarks	Engine R.P.M.	Temp	Fuel
1.9	10	1.7	63				Pounds
2.31	10	2.23	68		1107	110	31.437
2.31	09	2.23	80		1096	90	30.000
2.31	10	2.23	81.5		1105	85	29.125
2.31	10	2.23	81.6		1112	86	28.187
2.32	09	2.23	81.6		1138	86.3	27.375
2.33	08	2.25	82		1129	86.3	26.312
2.34	07	2.27	82		1108	86.4	25.312
2.35	06	2.29	81		1115	86.5	24.562
2.37	05	2.31	82.4		1099	82	23.375
2.37	05	2.34	81		1124	82	22.312 + 30#
2.38	02	2.36	79.5		1137	85	51.125
2.39	02	2.43	79		1150	94	50.187
2.40	09	2.49	79		1150	126	49.187
2.41	10	2.51	77		1149	110	48.250
2.41	12	2.51	77		1175	119	47.250
2.41	11	2.53	77		1153	110	46.187
2.41	11	2.53			1112	110	45.125

Summary of Tables I and II

Charge:

Average speed of engine and generator	1127.6 R.P.M.
" voltage	38.15
" amperage	17.73
" watts	676.4
Watt Hours	5411.2
Kilo " "	5.4112

Weight of fuel per gal	6.6 lbs	
" " " used in Test	16.312 lbs	or 2.47 gal.
Kilo Watt Hours per gallon	2.19	
Gallons per K. W. Hour	.45	
Cost of fuel	$ 0.15 per gal	
Cost of fuel per K.W. hr.	$ 0.068	
Lubricating oil used	0.07 gal.	
Cost of oil consumed(@80¢gal)	$ 0.05	
Cost of replacing oil (1 gal every 400hrs	$0.016	
Cost of oil per K.W. hr	$ 0.0133	
Total cost per K.W. hr for fuel and oil	$ 0.0813	
Total cost of oil consumed in test	$ 0.4399	

Discharge:

Average amperes	18.74
" volts	28.56

Charging: Watts input 38.15 x 17.73 - 676.4 W

Discharging " output 18.74 x 28.56 - 535.21

$$\frac{535.21}{676.4} - 74.18\% \text{ Watt hour efficiency}$$

$$\text{Total cost} - \frac{.0813}{7418} = \$0.1096 \text{ per K.W. hour}$$

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Test No III on the Westinghouse plant was to find the comparative cost of using gasoline and kerosene to recharge the battery. It was found that kerosene was about half as expensive as gasoline.

The engine temperature was much higher in the use of gasoline as shown by this table.

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(see next page)

TABLE III TEST ON DISCHARGE (West 1)

Time	Room Temp	Volts	Amps	Gen Temp	R.P.M.	Engine Temp	Fuel	Remarks
				Kerosene				
12:15	74.8	36	24.1	76.3	1101	44	44.000	
12:45	76	36	23.5	77	1107	90	43.250	
1:15	74	36	22.8	88	1106	90	42.125	
1:45	74	36	22.8	89	1107	98	41.125	
2:15	74	36	22.2	88.5	1101	95	40.125	
2:45	73	36	21.8	87.7	1111	83	39.125	
3:15	72	36	21.7	87.5	1101	68	38.187	
3:45	70	37	21.1	85.5	1114	64	37.125	
4:15	69	37	21.1	85	1107	64	36.312	
				GASOLINE				
4:30	66.5	37	21.5	85.5	1107	64	32.937	
5:00	64.2	37	20	82.9	1106	183	31.125	
5:30	62.6	37	19	79	1109	223	30.312	
6:00	62	37	17	74.9	1101	223	29.250	
6:30	59.8	40	15	71.5	1139	220	28.312	
7:00	58	40	10.5	69	1168	202	27.375	
7:30	56	40	8.9	76	1151	210	26.562	
8:00	56	40	8.0	74.5	1153	199	25.562	
8:30	52.1	40	7.8	72	1131	182	25.000	

Summary of Table III

Recharge

Kerosene:

4 Hours

K.W. hours	=	3.236
Total Kero. used	=	1.17 gallons
Cost of " "		$0.1755
Cost per K.W. hr		$0.054

Gasoline:

4 hours

K.W. hours	=	2.198
Gasoline used	=	1.27 gallons
Cost of gas used		$ 0.254
Cost per K.W. hr.		$ 0.116

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The following test was made on the Delco Plant, 1¼ K.W., model - 1278.

This test was conducted in the same manner as that on the Westinghouse Plant.

The summary of tables I and II shows that the total cost is about 19 cents per K.W. hr with an average wattage output of 411. This cost is much higher than either the Kohler or the Westinghouse.

Table III shows that kerosene is cheaper than gasoline for recharging purposes.

TABLE I Eight Hr. Charge Test (Delco)

Time	Room Temp	Volt	Amps	SpGr Read	Cell Temp	Cor SpGr	Volt	Remarks
				Specific Gravity Readings (Pilot Cell only)				
4:30	51	35	29	1150	42.5	1141	2.2	
5:00	54	37	23	1150	46	1142	2.2	
5:30	54	37	21	1150	48	1127	2.2	
6:00	54	37	20.5	1150	50	1143.4	2.22	
6:30	54	37.5	20.25	1150	51.5	1143.9	2.25	
7:00	54	38	19.5	1160	51	1153.4	2.25	
7;30	54				54	1144.7	2.15	
8:15	54	39	21.25	1150	55	1145	2.27	
8:45	54	40	19	1150	55	1145	2.3	
9:15	53	40	16.5	1160	56	1155.3	2.35	
9:45	53	40	15	1175	57	1165.7	2.9	
10:15	53	41	19	1180	58	1176	2.5	
10:45	53	42	13.5	1180	58	1176	2.53	
11:15	53	42.5	13.5	1190	60	1186.7	2.55	
11:45	53	42.5	13.25	1190	61	1187	2.55	
12:15	52	42	13	1200	61	1197	2.55	
12:45	51.5	42.5	12.75	1225	62	1222.3	2.58	
1:15	51	43	12.5	1250	63	1247.7	2.6	

Note - See Next page(52')for other half of this Table.

Summary of Eight Hour Charge Test

Average speed of Engine & Generator	-		1236 R.P.M.
" volts	-		39.76
" amperes	-		17.5
" watts	-		695.8
Ampere hours	-		140
Watt hours	-		5566.4
Kilo Watt hours	-		5.57
Weight of fuel per gal.	-		6.562 lbs.
" " " used in run	-		18.750 lbs.
Amt. of fuel in gals.	-		2.85
K.W. H. per gal	-		1.95
Gal. per K.W.H.	-		.51
Cost of fuel used	-	$	.43
Cost of oil used	-		.05
Total cost of run	-	$	.48
Cost of fuel per K.W.H.	-	$	.077
Total cost per K.W.H.	-	$	.086

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Pilot CELL ONLY

	Time	Room Temp	Volt	Amp	Cell Temp	SpGr Read	Cor SpGr	Volt	Cadmium Pos	Cadmium Neg
0	1:15	64	30	20.66	53	1250	1244.3	2.0	2.26	.2
1	1:45	69	30	20.25	54	1225	1219.7	2.0	2.16	.16
2	2:15	68.5	30	20.25	55	1200	1195	1.96	2.15	.18
3	2:45	68.5	29	20.25	56	1175	1170.3	1.95	2.14	.18
4	3:15	68.5	29	20.25	57	1175	1170.7	1.95	2.12	.2
5	3:45	67	29	20	58	1175	1171	1.93	2.12	.19
6	4:15	65	29	20	60	1175	1171.7	1.9	2.1	.2
7	4:45	63	28	19.75	60.25	1175	1171.7	1.9	2.1	.2
8	5:15	61.5	28	19.7	61	1175	1172	1.8	2.05	.2
9	5:45	60	27.5	19.5	62	1175	1172.3	1.85	2.06	.25
10	6:15	59	25	19	62	1165	1162.3	1.8	2.0	.25
11	6:45	59	23	18	62	1160	1157.3	1.75	2.0	.27
12	7:15	59	20	16.75	62	1150	1147.3	1.7	2.0	.3

Remarks: 12 - 50 Watt Lamps used for this test.

Battery discharged at normal rating.

Summary on Discharge Test

Average volts	27.5		
" amperes	14.95		
" watts	411.125		
Ampere hours	119.6		
Watts	2466.75		
Total Cost per K.W.H. from Battery	$\frac{.086}{.437}$	-	$.19
Watt hour efficiency	$\frac{2431.6}{5566.4}$	=	43.7%

TABLE III RECHARGE TEST DELCO

Kerosene

Pilot CELL ALONE

Time	Room Temp	Volt	Amp	SpGr Read	Cell Temp	Cor	Volt	Remarks
0 1:55	66	37	25.5	1150	50	1143	32.25	
1 2.25	69.5	37	21.5	1155	54	1149.7	2.2	
2 2.55	70	36	20	1155	57	1150.7	2.2	
3 3.25	71	36	19	1150	60	1146.7	2.18	
4 3.55	71.25	36	18.5	1150	62	1147.3	2.2	
5 4.25	70.5	36	18	1150	63	1147.1	2.21	
6 4:55	69	38	17.75	1152	65	1151.3	2.25	
7 5:25	69	37.5	17.5	1155	66	1153.7	2.25	
8 5:55	69	38	16.75	1160	67.5	1159	2.26	
GASOLINE								
0 6:00	69	37.5	18	1160	68	1159	2.26	
1 6:30	70	37.5	15	1160	69	1159.7	2.26	
2 7:00	70.5	38	14	1160	69	1159.7	2.3	
3 7:30	70.5	38.5	13.75	1160	70	1160	2.33	
4 8:00	70	40	12.5	1170	72	1170.7	2.37	
5 8:30	70	40	12.25	1180	72	1180.7	2.45	
6 9:00	69m	41	11.5	1200	73	1201	2.5	
7 9:30	69	41	11.5	1205	74	1206.3	2.5	
8 10:00	69	42	11.5	1225	76	1227	2.52	

Note: SEE PAGE 56' (following) for other half of this table.

TABLE III RECHARGE TEST CONTINUED DELCO 56'

Cadmium		Generator		Cool	Engine		
Pos	Neg.	Temp	Remarks	Temp	R.P.M.	Fuel	Remarks
				Kerosene			
2.35	.1	65		136	1220	18.875	
2.25	.1	70		158	1231	17.625	
2.27	.1	76		157	1244	16.500	
2.25	.09	76		152	1223	15.312	
2.26	.08	77		148	1221	14.750	
2.29	.08	76		143	1214	13.562	
2.3	.08	72		140	1226	12.312	
2.3	.07	75		140	1228	10.500	Total Fuel used
2.3	.07	75		140	1232	9.437	used 9,437 lbs.
				Gasoline			
2.3	.07	77		136	1238	20.562	
2.33	.07	76		148	1236	19.250	
2.35	.06	75		148	1224	17.875	
2.36	.05	75		142	1229	16.625	
2.37	.0.0	75		140	1225	15.312	
2.4	.05	75		146	1220	14.062	
2.4	-.1	74		141	1238	12.750	
2.45	-.1	74		138	1237	11.500	Total Fuel used
2.45	-.1	74		138	1249	10.250	10.312 lbs.

The foregoing tests on the individual lighting plants in the laboratory show that there is comparatively little difference between them in the operating costs, and that this is a very satisfactory way of obtaining good lights and small conveniences in the farm home.

Summary and Conclusions

A consideration of the results of this study seems to indicate that not enough is yet known regarding the exact fundamental requirements with regard to the more important processes of farming, to justify the immediate and premiscuous electrification of large rural areas. There must be a more thorough and definite knowledge of the requirements both from an agricultural and engineering standpoint. In other words there must be fundamental research on the agricultural processes and then developmental research on the machinery required to perform the processes to the best advantage.

Nevertheless it is shown that enough is known on the subject to demand serious consideration of general rural electrification.

The greatest problem at present in doing any rural electrification is the cost to the farmer and electrical company. The solution of this problem of serving the farmer at a price he can afford and yet be profitable to the power company is the education of the farmer into a more extensive use of electricity. In other words build up his total electrical load.

This study shows the unusual satisfaction of the farmer with the individual lighting plants; his realization of the benefits to be derived from electricity on the farm.

The mechanical perfection and efficiency of the individual plants are demonstrated by the test on these plants.

Therefore it seems only a matter of time before the problem of rural electrification will be solved. The demand has been created so the supply will be forthcoming, which will put rural electrification beyond the experimental and suggestive stages, and bring its usefulness and comfort to isolated rural districts.

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