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Farm Lighting Systems

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Farm Lighting Systems

M. M. Jones

Abstract.—Three types of farm lighting systems are described; acetylene, individual electric, and the rural electric line. In order to determine the degree of satisfaction that each of these types is giving in actual use the Experiment Station questioned a large number of owners of such plants on farms throughout the State. The answers are summarized. This practical testimony is supplemented with detailed directions for the most efficient management of each type of plant. The cost of operation for each type is also reported.

There are many different kinds and types of modern lighting systems available for use on farms, and it is the purpose of this bulletin to describe and compare some of the most important of these and to relate briefly the experiences of a number of Missouri farmers who have used them. A farmer can better choose a system to meet his conditions and needs if he fully understands the advantages and disadvantages of the different types available and if he knows what results other farmers have had with these systems.

ACETYLENE SYSTEMS

An acetylene light plant generates a gas, known as acetylene, by the action of water on calcium carbide. Calcium carbide resembles crushed stone in appearance and is made in the electric furnace by fusing coke and limestone. It is shipped and sold in air-tight drums. Acetylene generators or light plants adapted to farm use consist essentially of a reservoir for water, into which carbide may be fed, a hopper for holding the carbide, an automatic feeding device for allowing the carbide to fall into the water as needed, and a gas drum to accumulate and hold the gas after it is generated. The acetylene is piped through ordinary gas pipe into the house or to wherever the light is wanted. The ends of the pipes are fitted with special burners, which allow the proper amount of air to mix with the acetylene to give the best light. No mantles are used on acetylene burners. The burners may be lighted with matches, but they may be equipped with friction spark lighters which are much more convenient and less dangerous. These lighters are cheap and are used on practically all late installations.

Acetylene makes one of the best artificial lights, even better than electricity, in the opinion of many. It gives a soft white light that is very easy on the eyes.

There are different types of generators, classified as to their location. Indoor types or types placed in basements or cellars, have been used quite extensively in the past, but there have been a few serious explosions caused by improper handling or faulty installation of these indoor plants. Consequently, the type most used now and the type to be recommended most generally is the outdoor type. The outdoor underground, or pit, generator is probably the best type for farm use. Being underground, there is no trouble encountered from freezing.

Sizes of Acetylene Generators.—The larger sizes of generators are most generally preferred by farmers because they require charging less often. Also, there is less danger from operation of large plants, because practically the only danger comes in recharging. There is practically no danger even then if the plant is refilled in daylight and no open flame is brought near the plant. The most popular size of plants installed by Missouri farmers in the last few years is the 200-pound size; that is, the plant that holds 200 pounds of carbide. Plants of this size, on the average farm, require charging only two or three times a year.

Installing Acetylene Plants.—An acetylene plant should be installed by an expert who understands it and who can install it to meet the requirements of

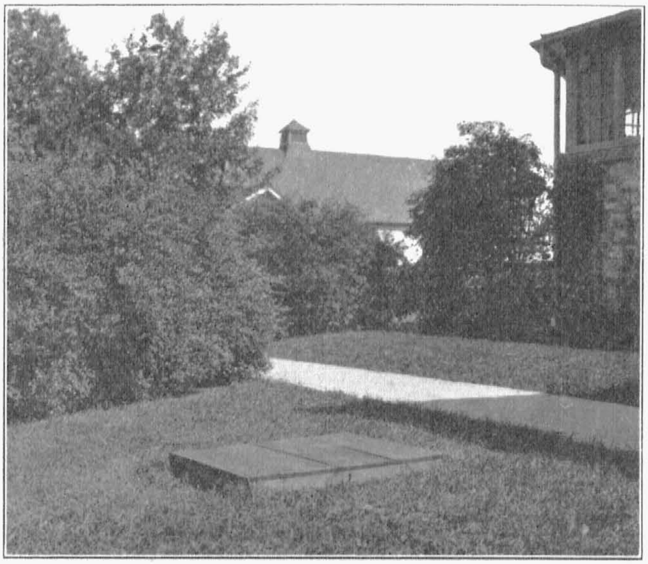

Fig. 1.—The out-door underground type is the most popular of the acetylene generators.

the National Fire Underwriters. Outdoor plants should not be placed closer than 10 feet to a building. The pipes into the house should be absolutely tight and should be thoroughly tested before making final connection to the generator. Leaks, even when slight, are a source of waste that make an appreciable difference in carbide costs.

Recharging the Plant.—To recharge a plant, the sludge or residue which is a solution of lime and water, has to be drawn off, and replaced with clean water, and the carbide hopper refilled with carbide. Recharging should be done in strict accordance with the instructions furnished by the manufacturer of the plant and only by daylight. The residue, which is lime, can be used effectively for whitewashing chicken houses, nests, roosts, fruit trees, etc. By some owners of acetylene plants, the chore of recharging is considered its greatest disadvantage. The time required for recharging, as reported by 46 Missouri farmers owning acetylene plants, ranges from ½ hour to 5 hours. The average time is 1¾ hours. The time for recharging will, of course, depend upon the size of the plant and the ease of getting the sludge away from the plant and the clean water to it.

Reports of Owners of Acetylene Plants.—In order to determine how satisfactorily acetylene lighting systems are working in actual use, the cost of operation, etc., the agricultural engineering department of the Missouri Agricultural Experiment Station sent questionnaires to several owners of such systems in the State. Summary I gives facts reported in the replies.

Summary I.—Reports from Farmers Using Acetylene Plants

1. Number of questionnaires returned....................54.

2. Ages of plants reported.

Age, Yrs.	No. of plants
1	12
2	6
3	7
4	3
5	0
6	0
7	3
8	3
9	1
10	5
11	2
12	4
13	1
14	4
15	1
16	1
No Ans.	2
Ave. Age	6.3

3. Size of plants reported.

Carbide capacity (lbs.)	No. of plants
25	1
35	1
50	9
100	18
200	17
300	1
No Ans.	7

4. Location of plants.

Location	No. of Plants
In basement or cellar	10
Outdoors above ground	11
Outdoors under ground	21
No answer	2

5. Satisfactory

Yes	42
No	8
No Ans.	4

6. Kind of lighting system, if getting new one

Acetylene	36
Electric	6
Kerosene lamps	1
Gasoline lamps	1
Undecided	10

All but six stated that they would not be without a lighting system of some kind.

7. Cost of operation for one year (1923 or 1924).

Carbide	
Average of 43 reports	$22.05
Least reported	5.50
Most reported	45.55

Repairs

Only four out of 54 reported any repairs, and these averaged $4.44 for the four, or $0.33 for the 54 plants.

8. Number of times plant is charged per year, average of 41 reports, 3.6 times, or once in about 14 to 15 weeks.

9. Time required to recharge plant once.

Average of 46 answers	1¾ hrs.
Minimum reported	½ hr.
Maximum reported	5 hrs.
No answer, 8	

10. Number of burners in house

Average of 52 answers	12.58
Minimum reported	4
Maximum reported	20

11. Number of the 54 reporting who use burners in barn or other buildings ..19

Average number of burners in barns and other buildings	2.63
Minimum reported	1
Maximum reported	8

12. Number of the 54 reporting who use acetylene appliances

Iron, (2-4 hrs. per week)	16
Stove, (cooking)	12

13. Cost of plant, piping, and fixtures, Average of 44 replies $270.78
Cost of piping and fixtures alone, Average of 25 replies 78.15

Conclusions with Reference to Acetylene Plants.—By far the large majority of the owners replying to this questionnaire are satisfied and well pleased with the performance of their plants. The greatest objections reported are (1) time and trouble of recharging, (2) high cost, and (3) cannot be used for power.

Practically all of those reporting inconvenience in recharging have either old plants or plants located indoors.

The cost of light is not high compared to electric lights, and, considering the amount of light given, is very little, if any, higher than light from kerosene lamps.

The acetylene system of lighting can be highly recommended where something better than portable kerosene or gasoline lamps is wanted, and where electric lights cannot be afforded. The initial cost is not excessive, and the yearly cost for carbide is not high, averaging $22.05 for 43 Missouri farmers. An acetylene plant has a long life and needs very few repairs. Many plants 12 to 15 years old are still giving good service. Many of these older plants have been replaced by new ones simply because the new models are somewhat safer and more easily cared for, and not because the old ones were worn out.

ELECTRIC LIGHTING SYSTEMS

Electricity is generally preferred, not because it gives any better light than acetylene, but because it gives a light practically as good and in addition can be used to operate small motors, fans, sweepers, washing machines, etc., and, if the plant is large enough, large motors, too. Electricity is safe when the wiring is properly done; it is convenient; and it gives excellent light with no open flame.

The greatest hindrance to a wider use of electricity is the lack of a cheap source of electric current.

Individual Electric Plants.—There are many small electric plants that are satisfactory for farm use. Thousands of these are giving satisfactory service on farms today. They are somewhat expensive to install and the upkeep cost is rather high, especially if the plant is not well cared for. Most individual farm plants are not large enough to operate motors larger than ½ horsepower, ¼ horsepower generally being the maximum size recommended.

The 32-*Volt Battery Plant* is the type of individual plant that is most widely used. It consists of a gasoline or kerosene engine, an electric generator a switch and instrument board, and a storage battery. The plant is operated to charge the battery, and then the battery will furnish current for lights when the engine and generator are not running. The plant is operated from one to three times per week on the average farm, depending on the size of the battery and the amount of electricity used. It is customary to operate the plant whenever heavy electric loads are used, such as operating an electric iron.

The 32-volt plant is very satisfactory for lighting, and for operating household appliances, such as fans, sweepers, washing machines, churns, etc., but is not well adapted for operating motors over ½ H. P., and it is not economical to operate motors of this size a great deal. Another disadvantage is that current cannot be easily transmitted very far from the plant, usually not over 300 or 400 feet. Houses and barns wired for 32-volt service must be wired with larger wire than if 110-volt service is to be used. No. 12 wire is commonly used for 32-volt and No. 14 for 110-volt service. Even larger wire than No. 12 should be used to those outlets where electric irons or the larger motors are to be attached. Another slight disadvantage is that 32-volt lamps and appliances are not quite as easily obtained in some places as 110-volt lamps and appliances.

The 110-Volt Battery Plant is sometimes used where the current must be transmitted over 400 or 500 feet and where a larger capacity plant is needed. The 110-volt plant is very similar to the 32-volt plant, except the generator is wound for 110 volts instead of 32 and the battery is composed of 56 cells instead of 16. The meters on the switchboard are, of course, made for 110 volts instead of 32.

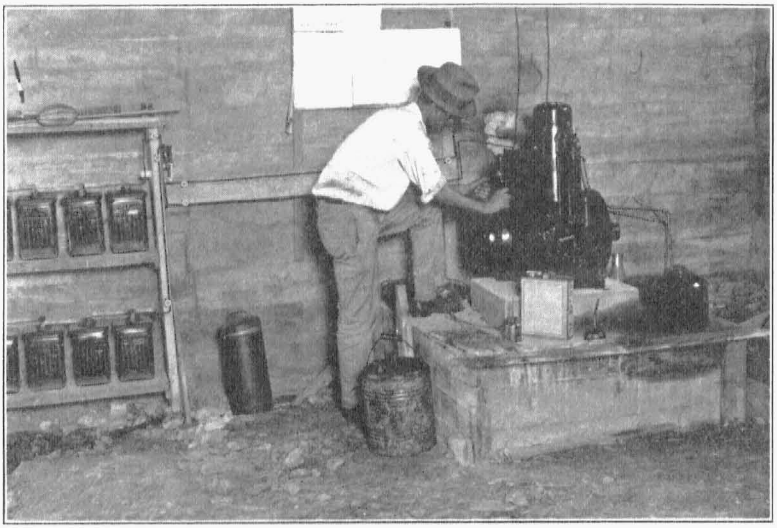

Fig. 2.—The light plant brings modern conveniences and comforts to thousands of farm homes.

The 110-volt battery plant is not used extensively on account of the extra battery cost, both initial and upkeep. For batteries of like capacities a 110-volt battery costs about twice as much as a 32-volt battery, and, of course, there being a larger number of cells, the upkeep cost will be higher.

The Non-Battery Plant has been developed to eliminate the expenses of buying and maintaining a large battery. The non-battery plant consists of an engine-driven generator that must be run whenever lights or appliances are used. Most of these plants are automatic and are equipped with a small automobile type of storage battery for cranking or starting the plant. The automatic plants are controlled by a control panel or box which causes the plant to start automatically when a light or appliance is turned on anywhere, and to stop when the last light or appliance is turned off. The current used by the lights or appliances comes direct from the generator and is not stored in batteries. The non-automatic plants are very similar, except the operator must go to the plant to start it. The plant is then allowed to run as long as electricity is to be used. Stopping buttons may be placed at convenient points in the house or barn to save going to the plant to stop it.

The main advantage of non-battery plants is the saving in battery expense. Also taking the current direct from the generator instead of a battery may effect some saving, especially when a large load is on the plant. Storage batteries have low efficiencies and only 60% to 75% of the energy used in charging them can be drawn out and used. On the other hand, the non-battery type of plant is inefficient when operated at low loads, and this, to a certain degree, offsets the gain in efficiency by the use of no storage batteries.

The automatic control of an automatic plant is necessarily somewhat complicated and may sometimes cause trouble. In case of engine or generator trouble on a non-battery plant, there is no way to have light; while with a battery plant the battery may furnish light a few nights until repairs can be made.

The Wind Electric Plant is newer and has not been used extensively. Such a plant consists of a special type of windmill with an electric generator built into the head, a storage battery, and a switch and instrument board.

The main advantage of this type of plant is that it is operated by the wind, which is free. The initial cost, however, is somewhat high. A larger battery is required than on the average engine-driven plant in order to store electricity for periods of calm or low wind. Therefore, the battery cost is somewhat higher.

Since there are so few of these plants in use, it is not possible to make statements regarding the satisfaction they give.

Hydro-Electric Plants are practical where there is a stream of sufficient size and velocity and where the cost of developing a site is not prohibitive. Hydro-electric plants consist of a water wheel or turbine, a generator, and a switch and instrument board. It is usually necessary to build a dam of some kind. The cost of operation of a hydro-electric plant is very very low, but the initial cost is generally much higher than the cost of an engine-driven plant of the same size, because of the expense of building a dam and developing the power site.

In determining the practicability of developing a water power site, one must first make an estimate of the power which the stream can develop, and then make an estimate of the cost of building the dam and buying and installing the equipment. The services of a competent engineer should be secured before building a hydro-electric plant.

A water-power plant usually cannot be purchased already set up and ready to run, and although a farmer can do most of the work of installing the equipment, he should get the advice of an engineer regarding the type of equipment to buy*.

Reports of Owners of Individual Electric Plants.—In order to get first-hand information on the satisfaction given by farm electric plants, and to obtain figures on cost of operation, etc. questionnaires were sent to several Missouri farmers who own such plants.

Summary II is a tabulation of the information received.

Summary II.—Reports from Farmers Using Individual Electric Plants

1. Number of questionnaires returned..144

*For further information on water power plants, see Farmers' Bulletin 1430, U. S. Department of Agriculture.

2. Type of Plant

32-Volt battery plant	135
No answer	7

3. Size of Generator

1500-watt	7
1200 "	1
1000 "	15
850 "	18
750 "	32
600 "	10
No answer	58

Average size of generator, 860 Watts.

4. Battery Capacity

225-ampere hour	2
180 " "	8
160 " "	41
120 " "	4
90 " "	8
80 " "	19
60 " "	2
No answer	60

Average capacity of battery 134 ampere-hours.

5. Age of Plant

Age, Yrs.	1	2	3	4	5	6	7	8	9	11	No Ans.
No.	17	12	17	15	29	31	12	3	1	1	6

Average age (138 plants) 4.24 years.

6. Number of Times without Lights.

	0	1	2	3	5	6	Several	No
No. of Reports	80	23	14	7	2	3	4	7

Average number of times without light since installing plant (4.24 years ago), 137 replies, 1.02.

7. Battery Renewals

21 owners reported that their batteries had been replaced with new ones.

Age of Battery when Replaced, Yrs.	Number
3	3
4	7
5	1
6	5
7	4
10	1

Average age when replaced 5.2 years.

8. Cost of operation for one year (1923)

Fuel and oil, average of 107 reports $17.87

Where fuel and oil costs were reported separately, 94 reported an average of $13.90 for fuel and 91 reported an average of $3.75 for oil.

Repair Parts, average of 107 reports $6.34

Of the 107 farmers reporting, 46 had no repair expense during theyear. (This does not include cost of new batteries where new ones were bought)

Labor

Repairing—38 reported an average of 9.38 hours per year spent in repairing.

9.38 hours at 25c $2.35

Care in operating—73 reported an average of 40 minutes per week (or28 hours per year) required to care for the plants.

28 hrs. at 25c $7.00

Total for Year $33.56

9. Original Cost

Cost of plants installed complete with wiring and fixtures, average of 130 reports $648.86

From the 104 reports the average cost for wiring and fixtures was found to be $142.13

10. Appliances Used.

Appliances	Percentage	Number out of 144
Iron	67.3	97
Washing Machine	41.6	60
Sweeper	33.3	48
Water Pump	16.6	24
Fan	8.3	12
Cream Separator	7.6	11
Utility Motor	6.2	9
Radio	1.3	2
Heating Pad	.69	1
Milking Machine	.69	1
Grindstone	.69	1
Refrigerator	.69	1
Battery charger	.69	1

11. Advantages and Disadvantages.

The greatest disadvantages of individual electric plants reported were: (1) expense, (2) trouble and time required to care for plant, and (3) inability of plant to operate large motors.

The advantages enumerated most often by those answering the questionnaire were (1) convenience, (2) safety, (3) good lights, (4) power for household appliances and (5) time and labor saved in doing chores.

RURAL ELECTRIC LINES

A rural electric line is the ideal source of electricity for the farm whenever the farm is not so far from the line or central or substation as to make the cost of the transmission line too great, and when the rates are reasonable and good service is furnished by the power company. Wherever it is possible for a farmer to get service from a power line, he can practically always get his electricity as cheaply as he could generate it himself, generally even more cheaply, and he is free from the trouble of caring for a plant. He can also use larger motors—up to any reasonable size—by installing suitable transformers. The reason more farmers cannot be served by transmission lines is that the cost of the line is high, and the expense of building the line is not justified unless the farmers are close together (two or three to a mile) or unless the farmers use large amounts of electricity.

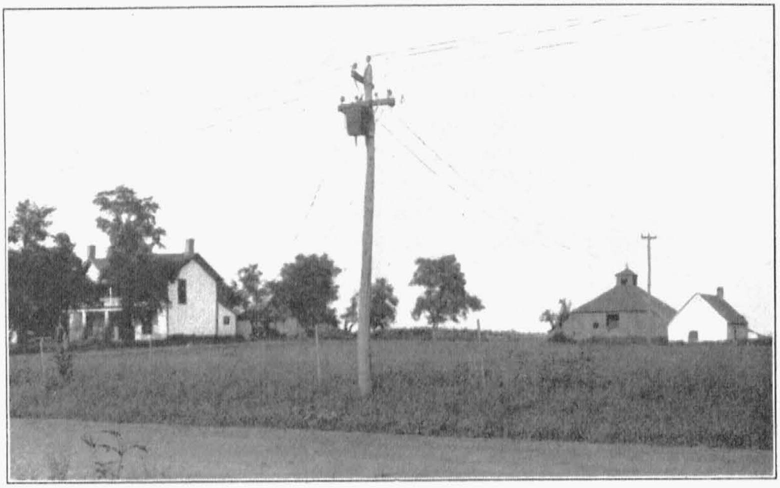

Fig. 3.—Service from a transmission line is generally more satisfactory than from an individual plant.

Why Rural Rates Must Be Higher than City Rates.—When a company invests money in transmission lines or any other equipment, it must have a reasonable return from the investment. The amount of money invested in transmission line and related equipment per customer is much higher in the country than in the city. There are also greater losses in transmission. In other words, it costs more to deliver electric energy to a farm out in the country than to a city dwelling nearer generating plant or substation. Where farmers live close together and a large number use the same line, the cost per farmer, of course, is proportionally less. Also, where farmers have use for a large amount of electricity, the rates per kilowatthour can be lower than where only small amounts are used.

The question is sometimes raised as to why a farmer cannot have his wires attached to an existing high tension line which runs between cities or towns. If the voltage of the transmission line is too high, a very expensive transformer would be required to reduce the voltage down so that it could be used safely inside a building. The cost of such a transformer and auxilliary equipment may be so high that it would not be justified except for a small village or for feeding a line of lower voltage which in turn could supply several farmers.

Reports of Farmers with Transmission Line Service.—A brief survey was made of 93 Missouri farms which get electric service from light and power companies. The objects of this survey were to determine what uses, besides lighting, farmers are successfully making of electricity, the cost of electric service, the amount of energy used, and the advantages and disadvantages of this type of service

Summary III.—Summary of Results of Survey of Farms Using Electric Service from Power Companies

1. Number of farms surveyed..93
2. Number owned, 82; number rented................................11
3. Average size of family 4.25
4. Average lighting load in dwelling house.........................577 watts
5. Number who use electric lights in other buildings........43
6. Average lighting load in other buildings........................234 watts
7. Electrical appliances used:

Appliances	Number out of the 93	Percentage
Irons	72	77.4
Sweepers	26	27.9
Washing Machines	26	27.9
Toasters	3	3.22
Sewing Machines	3	3.22
Fan	1	1.07
Grill	1	1.07

8. Motors used: Number of farms using electric motors, 21. One farmer uses 3 motors; four use 2 motors each; and fifteen use 1 each.
   Twenty motors were used on water pumps; 2 on milking machines; 4 on cream separators; and 1 on a bottle washer. Motor sizes ranged from 1/8 H. P. to 3 H. P. No farmer had a separate transformer for his motor load, however, and only two had special power rates.
9. Other power used: Of the 93 farms surveyed, 18 used tractors; 32 used one gas engine each; 6, two engines each; 2, three engines each; and 1 used four engines. Forty-two used windmills.
10. Different methods of getting rural electric service: A few farmers were supplied with electric service by the extension of city lines; a few are allowed to attach to existing lines between towns; some organized companies and built their own lines, and then buy energy wholesale from power companies or municipal plants; and others are supplied from lines built into the country by power companies.
    Various systems are used by farmer companies. Two farmer stock companies built their own lines. They buy energy wholesale and retail it to the users. Each party getting service from the line is required to buya share of stock and to buy his own transformer and secondary line which connects to the company line.

11. Cost of establishing electric service: The cost of building the lines, buying the transformers, making connections, etc. varied from nothing to $1000 per farmer, depending upon the distance from a source of power, the type of line built, etc. In one or two instances, farmers were served from existing extensions of city lines on the same basis as city customers. Various practices exist regarding the connection charges.

12. Rates: Various systems of rates were found in use. On one line fed by a municipal plant, the farmers were charged 40 per cent more than the city customers to take care of the extra line and the transformer losses. This line was built by the city but was paid for by the farmers using it. In another case, the energy fed into the line was paid for as metered by a master meter, and each customer having his own meter, the line losses were pro-rated according to the amount each used and the transformer losses were pro-rated according to the size of a transformer used.
In other instances, a given rate (14 cents per KwHr.) was charged for the energy used, with a $2.00 per month minimum where the farmers owned their own line and a $4.00 minimum where the company owned the line. In another case, the rate was 7 cents per KwHr. plus a charge of $2.50 per month.

13. Amount and cost of energy used: It was not possible to get figures on the amount and cost of energy used for all farms. Seventy-eight averaged 20.13 KwHrs. per month over a period of 12 months. The average cost of energy was $3.22 per month for the 78 customers. The average rate was, therefore, 16 cents per Kwhr.

14. Satisfaction: Of the 93 farmers eighty-eight were well satisfied with the service they were getting. The only complaints were high prices. It is true that electricity costs more than kerosene lamps, but in almost every case studied, the farmer was getting electricity cheaper than he could generate it himself with an individual light plant.

15. Length of service: On the farms surveyed, the length of service ranged from 1 to 12 years, the average being 4.18 years.

16. Time saved in doing chores: Seventy-five of the farmers estimated they saved from 5 minutes to one hour per day in doing chores by using electricity instead of lamps and lanterns. The average of the 75 estimates was 25 minutes.

17. Customers per mile: Data were obtained from nine different companies supplying electric service to the farms surveyed. The total mileage of lines serving farmer customers was found to be 130, and the number of farmer customers, 325. This gives an average of 2½ customers per mile. The average number of customers per mile ranged from 1.1 for one company to 5 for another.

18. Transformer Sizes: Various sizes of transformers were found in use. In one case, 7 parties were on one 2-Kva. transformer. On another line, each party had a 1-Kva. transformer. Several cases were found where 2 or 3

parties were supplied from one transformer, the size of which varied from 1-Kva. to 3-Kva. depending upon the connected load. This practice is desirable where the farmsteads are near enough together. Several ½-Kva. transformers were found in use.

19. Line voltage: The voltage of most of the lines supplying the farmers interviewed was either 2300 or 6600. In a few cases near city limits, 110-volt secondaries were extended and in a few cases, 132000-volt lines were used.

COSTS OF OPERATING FARM LIGHT PLANTS

Non-Battery Automatic Plant.—Several tests were run on an automatic non-battery type of light plant to determine the fuel cost at different loads. The chart (Fig. 1) shows how the fuel cost per hour of operation varies for different loads on the plant. It will be noted that the cost is practically the same (slightly more than 3 cents per hour) for loads between 100 and 250 watts. This means that if the plant is operated at all, it might as well be supplying 200 to 250 watts.

The chart also shows how the fuel cost per kilowatthour varies with the load on the plant. The cost is very high for low loads, being about $1.00 per Kwhr. for a 25-watt load; but drops rapidly as the load is increased to a little more than 10 cents at a 300-watt load and reaches a minimum of about 7 cents for loads from 600 to 800 watts. These figures represent fuel costs only and not any other items of cost. Oil consumption as estimated from the tests on the automatic plant is about 4 gallons per year. It is very difficult to determine the probable oil consumption of a light plant engine by short laboratory tests, because of the variation in oil consumption of engines of the same type, and because of the difference in length of time between oil changings as practiced by different users of plants.

Battery Plant.—Laboratory tests have been conducted on three typical battery type farm light plants over a period of three years by the agricultural engineering department of the Missouri Agricultural Experiment Station. The object of these tests were principally (1) to determine the fuel and oil costs of operating such plants, and (2) to determine the efficiency of the batteries. These tests were conducted by charging the batteries, keeping accurate measure of the fuel and oil required by the engine to do the charging and of the electric energy used in charging the batteries and then discharging the batteries and measuring the output. The batteries were discharged in eight hours.

From these tests it was found that the plants used about 2 pounds of fuel (approximately three-tenths of a gallon) for each Kwhr. of energy put into the batteries. It was found that those plants operating on kerosene used about the same quantity of fuel as those using gasoline.

In these tests the engines used an average of 0.11 of a pint of oil for each Kwhr. of energy delivered to the battery. Although, as stated previously, it is difficult to determine probable oil consumption from laboratory tests, this value is probably a fair average of what might be expected from an engine in actual use on a farm.

It was found that 56 per cent of the Kwhrs. of energy put into the batteries could be drawn out and used, and that 72 per cent of the ampere-hours input could be drawn out. These efficiencies are probably lower than they would be if the plants were in actual use on an average farm, because in the tests the batteries were discharged continuously and at higher rates than they would normally have been on the average farm.

Figuring gasoline at 20 cents per gallon, kerosene at 15 cents per gallon, and lubricating oil at 80 cents per gallon, the following table gives an estimate of the fuel and oil cost of electricity from the battery type of plant. The battery efficiency used in determining the fuel and oil cost of energy taken from the battery, is 65 per cent.

ESTIMATED FUEL AND OIL COSTS PER KWHR, BATTERY TYPE FARM PLANT

	Gasoline	Kerosene
Fuel cost—(2 lbs. per Kwhr)	6.45c	4.44c
Oil cost—(15/100 pt. per Kwhr. with Kerosene) (10/100 pt. per Kwhr. with gasoline).	1.00	1.50
Fuel and oil cost per Kwhr. when current is taken direct from generator	7.45	5.94
Fuel and oil cost per Kwhr. when current is taken from battery	11.46	9.14

Other Items of Cost.—It should be remembered that the fuel and oil cost is only a part of the total cost of electricity from an individual plant; and it should be remembered also that a plant operated under very favorable conditions (engine kept in good repair and well lubricated, battery not overloaded, engine operated when a heavy load is on plant, etc), might produce electric energy at a lower cost than indicated in the table, and that a plant operated under unfavorable conditions would not produce electricity as cheaply.

The cost of energy will vary somewhat with the amount used direct from the generator and the amount used from the battery while the generator is not running, because not all the energy stored in a battery can be taken out again an used.

Total Yearly Costs.—On the basis of the fuel and oil costs as determined by laboratory tests and on the basis of reports of a number of light plant users regarding the length of battery life, time and labor in caring for plants, repair costs, etc., the following estimates of yearly cost are made.

ESTIMATED COSTS OF VARIOUS SYSTEMS

ESTIMATED YEARLY COST OF BATTERY TYPE FARM ELECTRIC PLANT
(Assuming a consumption of 20 Kwhrs. per month)

Interest on Investment (6% on half of original investment of $450 for plant and $75 for wiring and fixtures)	$15.75
Depreciation	
Battery, $200 at 20% (Useful life of 5 years)	40.00
Engine and generator, $250 at 10% (Useful life of 10 years)	25.00
Wiring and Fixtures, $75 at 4% (Useful life of 25 years)	3.00
Operating Cost	
Fuel and Oil, 240 Kwhrs at 11.46 (gasoline)	27.50
or 240 Kwhrs at 9.14 (kerosene)	(21.94)
Repair Parts, (average repairs on 107 plants)	6.34
Labor at 25 cents per hour	
Repairing, 10 hours.	2.50
Care and Operation, (40 min. per wk.—avg. of 73 plants)	8.66
Total, if gasoline is used	$128.75
if kerosene is used	123.19

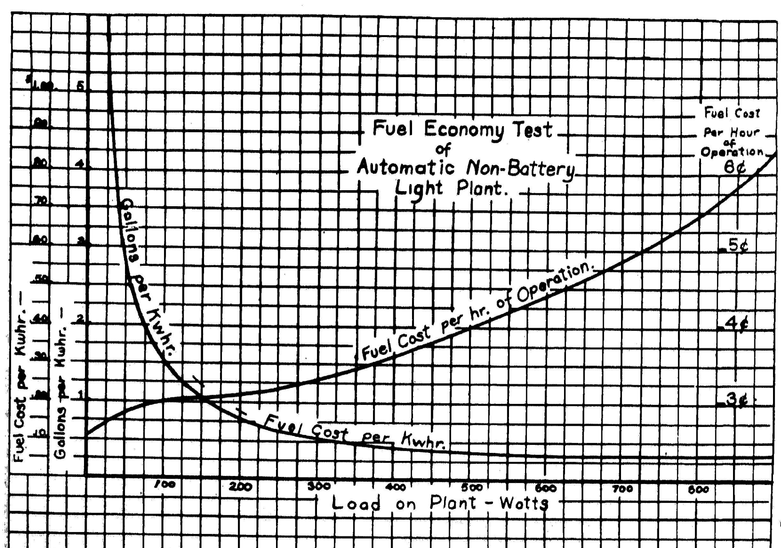

Fig. 4.—Results of fuel tests on automatic non-battery plant.

ESTIMATED YEARLY COST OF NON-BATTERY FARM ELECTRIC PLANT

(Assuming that plant is operated on average of 4 hrs. per day, at an average (fuel cost of 3¼ cents per hr.)

Interest on Investment	$12.75
(6% on half of original investment of $350 for the plant and $75 for wiring and fixtures)	
Depreciation	
Plant, $350 at 10%	35.00
(Useful life of 10 yrs.)	
Wiring and Fixtures, $75 at 4%	3.00
(Useful life of 25 yrs.)..	
Operating Cost	
Fuel, 4 hrs. per day at 3¼c per hr.	47.45
Oil, 4 gallons per yr. at 80c	3.20
Repair parts (estimate)	10.00
Labor at 25c per hour	
Repairing, 10 hrs. (estimate)	2.50
Care and operation, 10 hrs. (estimate)	2.50
Total	$116.40

In using either of the above estimates of yearly cost to determine the probable cost of a particular proposed light plant installation, the various items of cost should be checked item by item and where the assumptions made in the estimates, such as cost of plant, price of fuel, hours of operation per day, Kwhrs. used per month, etc., do not fit the individual case under consideration, corresponding changes should be made in the estimate of cost for the particular case. Although the above estimates may be considered average, the cost of different individual plants may vary widely from the average. In an attempt to reduce the cost of owning and operating a light plant to the minimum, one should center his effort on the larger items. For instance, with a battery type of plant, battery depreciation is a large item. Proper care and attention to the battery will increase its life, and, therefore, decrease the item of depreciation. In the case of the non-battery plant, the fuel cost is the largest item. Therefore, it would pay to keep the engine in first class operating condition so that it would use no more fuel than absolutely necessary.

The following is an estimate of the yearly cost of operation of an acetylene light plant. The items of operating cost are the averages taken from 54 replies to questionnaires sent to a number of acetylene plant owners in Missouri.

ESTIMATED YEARLY COST OF ACETYLENE SYSTEMS

Interest on Investment	$10.65
(6% on ½ original investment, assuming original investment of $280 for plant and $75 for piping and fixtures)	
Depreciation	
Plant, $280 at 8%	22.40
(Useful life of 12 years)	
Piping and fixture $75 at 4%	3.00
(Useful life of 25 years)	
Operating Cost	
Carbide (average for 44 plants)	22.05
Repairs (average for 54 plants)	.33
Labor recharging plant, 1¾ hrs. 3.6 times per year at 25c per hr.	1.58
Total	$60.01