RURAL ELECTRIFICATION

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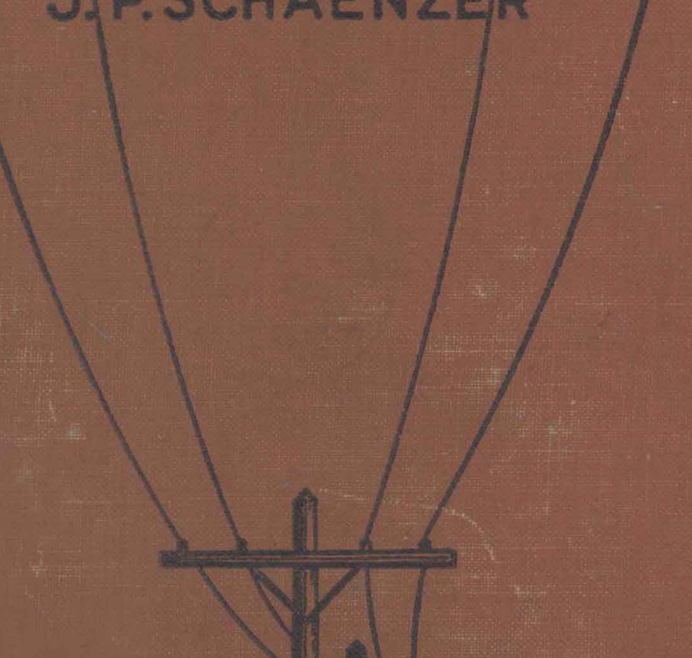

RURAL ELECTRIFICATION

By

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PREFACE

This book is dedicated especially to the vocational agriculture teachers of the high schools of America. It is hoped that it may also be of value to the Agricultural-Engineering and Home-Economics Departments of the State Colleges of Agriculture, farmers having or contemplating electric service, vocational schools, and the rural-service men of the electric utilities of the nation.

As practically no information has been published on this subject, it is the aim of the author to present it in a simple and concise manner. To save the time of the teacher, much attention has been given to presenting this material in the best teachable form. For this reason each chapter or lesson is divided into the following sections:

1. Class Discussion.
2. Equipment.
3. Demonstrations.
4. Practice and Problems.
5. Information.
6. Suggested Readings.

The class discussion consists of a series of questions, thought, and fact, which should be of help to both the students and the teacher. They also act as a guide to the study of the subject matter.

It may be impossible to obtain all of the equipment listed for each chapter. The suggested list, more or less ideal, is included, however, to save the teacher's time so that he may know without much effort what is needed and may have on hand as much of it as possible.

As far as possible, demonstrations of the equipment in operation are recommended. These may be conducted at the school shop, on farms, or by the local dealer of the equipment. Motion pictures are also available on many of the subjects presented in this textbook.

Practice and practical problems are included in each lesson. In order that the members of the class secure the greatest benefit, they should as individuals adopt some of the practices taught during the course on the home farm. With the exception of the faster and brighter students, it is not expected that all of them do all of the problems. In many cases, the problems may adapt themselves to the contract method of teaching if this is desired.

Basic information and illustrations needed to carry on this work are included. It has been the aim of the author to make this as practical as possible. Because of lack of space, it was impossible to include all of the many electrical applications to the household and farming. It is hoped that a study of the major ones may act as an inspiration to further investigation of this interesting and worth-while subject.

To supplement the information, each chapter is followed by a list of suggested readings to enable the student to draw upon outside sources of information. Few books have been written on this subject, but many bulletins and circulars have been published by the agricultural colleges of the United States. These should be gathered in advance of the time of studying each chapter.

The author is especially indebted to Dr. E. A. White and L. C. Prickett of the Committee on the Relation of Electricity to Agriculture, and to George W. Kable, National Rural Electric Project, for their valuable suggestions and numerous illustrations.

Acknowledgment is due the following commercial companies and their representatives who spent considerable time in going over the subject matter for authenticity and furnished many photographs: American Saw Mill Machinery Co., Bryant Electric Co., Burton-Page Co., Crouse-Hinds Co., Dayton Pump & Manufacturing Co., Decatur Pump Co., Detroit Edison Co., Edison Lamp Works, Fitz Water Wheel Co., Freeman Manufacturing Co., Fuel-Power-Transportation Educational Foundation, Gehl Bros. Manufacting Co., General Cable Corporation, General Electric Co., Hamilton Beach Manufacturing Company, Hebco Aerolectric Sales Co., The Hoover Company, James Manufacturing Co., The Kohler Company, Lyon Electric Co., Malleable Iron Range Co., The Miller Co., National Electric Products Corporation, Oakes Manufacturing Co., Public Service Company of Northern Illinois, RCA Manufacturing Co., Inc., Stover Manufacturing & Engine Co., Trumbull Electric Manufacturing Co., Universal Milking Machine Co., Wellington J. Smith Co., Westinghouse Electric & Mfg. Co., Westinghouse Lamp Co., Wisconsin Power & Light Co., Wisconsin Valley Electric Co.; also to the following publications: *Electricity on the Farm, The Wisconsin Agriculturist,* Universities of California and Wisconsin Bulletins, and to the United States Geological Survey.

Credit is due Professor F. W. Duffee and other members of the Agricultural Engineering Department, University of Wisconsin; Professor M. A. Sharp, Agricultural Engineering Department, Iowa State College; Mr. L. M. Sasman, State Supervisor of Agricultural Education, Wisconsin; Dr. C. H. Lane, Messrs. J. A. Linke and the late A. P. Williams of the Federal Board for Vocational Education, Washington, D. C.; and members

of the agricultural education departments of a number of state agricultural colleges, for their many valuable suggestions and constructive criticisms. The author also wishes to express his appreciation to the vocational-agriculture instructors who tried out this material in their farm-mechanics classes before publication.

CONTENTS

Chapter I

ELECTRICITY, THE SILENT PARTNER

Class Discussion

1. Why are the farmers of the nation anxious to have electric service?

2. What has been the effect of mechanical power upon the habits and accomplishments of the people?

3. How does the amount of power machinery used in the United States compare with other countries and with the world?

4. When and where was the first electricity generated for commercial lighting purposes?

5. What progress has been made in the United States in the number of farms electrified during the past decade?

6. What number and per cent of the farms of your state and community are electrified?

7. In what ways can electricity be of service to the farmer and his wife?

Demonstration

1. Have the students make a trip to see the local generating stations, substations, transmission and distribution lines so as to get a general idea of the electrical industry.

Practice and Problems

1. Have the manager of the electric utility supply you with such information of the local electric business as:

a) Total generating capacity in horsepower.

b) Size of steam or water turbines or internal-combustion engines in horsepower.

c) Size of electric generators in horsepower.

d) Cost of the equipment.

e) Kilowatt-hours generated per year.

f) Kilowatt-hours sold per year.

g) Pounds of coal or other fuel required per kilowatt-hour of electricity generated.

h) Average kilowatt-hour consumption for each hour of the day.

i) Cost of transmission lines per mile.

j) Cost of distribution lines per mile.

2. Information on the development of the electrical industry may be obtained through the *Commerce Yearbook,* published each year by the United States Department of Commerce, Washington, D. C.

3. Make a survey of the number and per cent of farmers, by townships, having individual lighting plants, and those receiving central-station service. Students and township assessors may be able to give considerable information on the number of individual lighting plants, while the electric utilities serving the communities will be able to furnish the information on the number receiving central-station service. If this work is done annually, it will help to show the progress made in rural electrification locally.

4. Become acquainted with the accomplishments in electricity of such famous men as Thomas A. Edison, Charles P. Steinmetz, Benjamin Franklin, William Gilbert, Luigi Galvani, and others.

Information

Only a few years ago, the farm having electricity was talked of as the millionaire's plaything. It was a luxury. Only the man with money or the farmer having a farmstead adjacent to a city or small hamlet was able to have electric service. Today, conditions have changed. Electricity is considered a necessity and a sound investment for the farm. In fact, many find that with dispelling many hours of drudgery, accomplishing more per individual, and increasing the leisure of the family, it may also increase the annual farm income. Good lights and time-saving devices are a necessity on the farm where so much work must of necessity be done by artificial light.

Mr. M. C. Albright, Oakwood Farm, Athens, New York, in a radio talk over Station WGY, said, "Since replacing muscles with electric energy we find less need for rest and actually put in more hours of work, study, and recreation than before.

"Our children have more time for their studies, 4-H Club work, and play. The wife's work is more quickly and easily done and leaves her fit for work among her flowers, a game of bridge, or a bit of gossip now and then.

"I am able to give more attention to producing, not more, but more economically, and market more intelligently, have more time for Farm Bureau and community activities, play ball, tennis, and ride down hill with the youngsters, play barnyard golf with the neighbors, and occasionally have a day off for hunting and fishing.

"Electricity for us is a real and proven farm relief."

Electricity, the Giant Energy[1]

"Within the memory of men now living, electricity has revolutionized the world. It has made possible, within a half century, greater progress than in all the years of history which preceded it and which science gives to the career of man on earth.

"Man has learned to harness, distribute, and utilize this magic power for day and night service throughout the civilized world. It is banishing darkness, has lightened the burden of the housewife and has become the silent partner of industry."

Your "Thirty Slaves"

"The Smithsonian Institution has figured that, if all our machinery operated by power should be taken away, it would require the services of 30 times as many hard-working slaves as we have population to duplicate the work done in America. In other words, the use of power and machinery gives to every man, woman, and child in our country the equivalent of 30 slaves, or the average family of five has 150 'slaves' working for it.

"Push a button and our home is illuminated as by the midday sun; an electric vacuum cleaner banishes dirt and dust; an electric washing machine and electric iron help with the housework; a fan gives cooling breezes, and an electric heater radiates warmth; an electric range cooks the family meal; an electric refrigerator makes ice; or the many other familiar labor-saving appliances are placed in action.

"Today electricity rings the doorbell; tows a ship through the Panama Canal; lifts a great bridge; milks the cows; chops or grinds feed on the farm; increases the production in factories by providing good lighting and ample power; lights homes and stores; even provides illumination for surgical operations in hospitals. It is ready to perform these tasks 24 hours of each day.

"Yet it is only a short time ago, less than 50 years, that the richest kings had none of these conveniences which make life easier and better for even the poorest Americans of the present time."

Beginning of the Electrical Industry

On September 4, 1882, the first central, steam-operated, electric generating station in the world was opened in New York City by Thomas A. Edison. It was known as the Pearl Street Station. It furnished 59 consumers in a small territory in downtown Manhattan with electricity

[1]Source: *Electricity — How It is Made and How Distributed,* 1928. Issued by Wisconsin Public Utility Information Bureau, Milwaukee, Wisconsin.

for lighting. The incandescent lamps were only one sixth as efficient and had one fourth the life of those used today.

On October 15 of the same year the first hydroelectric central station was placed in operation at Appleton, Wisconsin. It had a capacity of 250 16-candlepower incandescent lamps.

This started a new epoch in electricity, and the same principles of generating and distributing electricity were utilized then as are used today.

Growth in Rural Electrification

A few figures will help to show the trend of the acceptance of electricity on American farms. Both central-station service and the individual electric-lighting plant have played a very important part in electrifying the farms of the nation.

In 1923, the Committee on the Relation of Electricity to Agriculture reported 166,140 farms connected. A report by states, released as of September 30, 1936, shows the number connected to be 889,152. This is a gain of nearly 435 per cent (Chart 1).

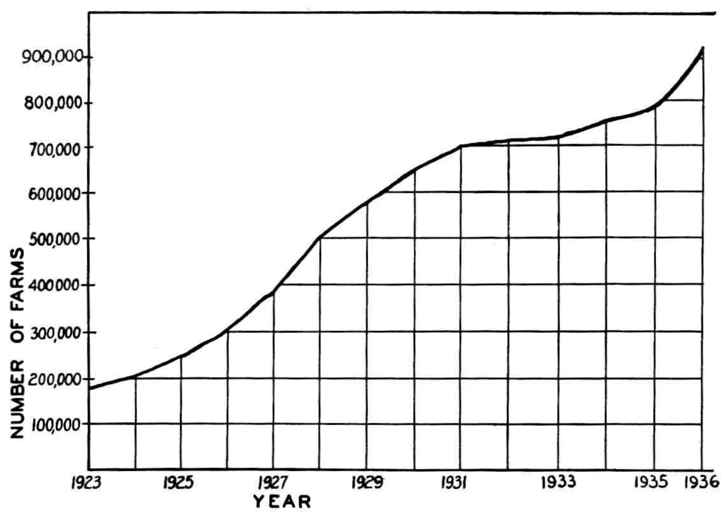

Chart I. Number of farms in the United States receiving central-station service.

The individual electric-lighting plant has been of great service in furnishing light and power to the farmers of the country. Detailed information by states on the number of farms receiving central-station service and using individual plants is shown in Table 1.

Why Farmers Use Electricity

Whenever electricity is put to use on the farm, it assists in raising the standard of living. People living on electrified farms are more contented because they have the conveniences of city life. Electricity is a dispeller of drudgery and makes more time available for recreation and leisure.

Many individuals have proved to their own satisfaction that they can do three hours of chores in two hours when the barn is adequately lighted with electric lights as compared with doing this same work with a lantern. This is true also in the farm home where the housewife is able to do her work faster and better when good lights are available. In a survey covering 215 farms in the State of New York,[2] it was found that an average of 40 days of labor per farm per year could be saved by the proper application of electricity. In 267 homes of the same state a saving of 26 days per year resulted from its use.

If time is saved, naturally labor is saved also. The user of electric power is enabled to be relieved of such work as pumping and carrying water, milking cows, separating the cream, washing the clothes, grinding the feed, and many others. It is the most dependable and handiest power that the world has ever known.

Electricity, in many cases, is the most economical power that can be used for the operation of many household appliances and farm equipment. Records were kept on the cost of operating a washing machine and ironer for a period of three years on an Electro-test farm near Oconomowoc, Wisconsin. The average cost per month was $1.09. If this same work had been done by a laundress, it would have cost $6 per week. A farmer living near Whitewater, Wisconsin, does his own grain grinding and thereby saves $56 per year. In addition, he is relieved of the double handling of the grain and ground feed.

The use of electrical equipment may help to cut the costs of production, increase the output, and so increase the income. Many farmers, for instance, use electricity to light their poultry houses during the winter months, so as to increase the length of the feeding day. This increases egg production and hence also the poultry profits.

Summarizing, electricity on the farm provides safe light for every task, eliminates eyestrain, and reduces the amount of time required to do the housework and chores. Running water is made possible for cooking, the laundry, bath, and livestock. The installation of wiring and electrical equipment on the farm increases the value of the farm and home. Farm folks having the conveniences made possible through electricity are more

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[2]Cornell, *Farm Economics,* No. 51.

TABLE I. Number of Farms by States Receiving Central-Station Service* September 30, 1936, and Those Having Farm Electric Plants** April 1, 1930.

State or Division	Electric Lighted Farm Homes High Line	Electric Lighted Farm Homes Farm Plants
Total United States	889,152	249,342
Maine	14,857	1,854
New Hampshire	11,900	996
Vermont	8,205	1,054
Massachusetts	20,912	2,057
Rhode Island	2,780	241
Connecticut	18,339	1,200
Total New England	76,993	7,402
New York	68,060	10,272
New Jersey	15,405	2,459
Pennsylvania	54,765	10,357
Total Middle Atlantic	138,230	23,088
Ohio	59,750	16,377
Indiana	31,392	11,579
Illinois	33,759	15,206
Michigan	60,257	8,895
Wisconsin	42,552	14,815
Total East North Central	227,710	66,872
Minnesota	14,244	10,740
Iowa	33,816	19,976
Missouri	19,726	7,568
North Dakota	2,051	4,426
South Dakota	2,958	6,465
Nebraska	10,783	13,276
Kansas	14,766	10,372
Total West North Central	98,344	72,823
Delaware	1,869	441
Maryland	8,468	2,856
District of Columbia	62	13
Virginia	17,446	4,579
West Virginia	7,959	2,471
North Carolina	12,934	6,022
South Carolina	5,309	2,962
Georgia	7,432	3,895
Florida	7,704	2,143
Total South Atlantic	69,183	25,382

*Edison Electric Institute, New York City. **Estimated from the United States Census.

State or Division	Electric Lighted Farm Homes High Line	Electric Lighted Farm Homes Farm Plants
Kentucky	9,125	4,581
Tennessee	12,922	3,182
Alabama	14,109	1,343
Mississippi	3,622	2,305
Total East South Central	39,778	11,411
Arkansas	4,228	2,196
Louisiana	3,902	2,225
Oklahoma	6,338	3,913
Texas	16,194	12,299
Total West South Central	30,662	20,633
Montana	3,230	1,536
Idaho	16,308	1,353
Wyoming	577	677
Colorado	7,657	2,845
New Mexico	2,000	556
Arizona	6,000	228
Utah	18,198	1,224
Nevada	993	236
Total Mountain	54,963	8,655
Washington	41,122	3,800
Oregon	20,002	2,704
California	92,165	6,572
Total Pacific	153,289	13,076

contented and willing to live on the farm. Reducing the drudgery in the home preserves the strength of the housewife, and the many conveniences benefit every member of the family. Electricity also makes it easier to obtain and retain hired help. As it is the cheapest power available, it cuts the power cost for many jobs on the farm. The cost of service is usually small when compared with the benefits, conveniences, and comforts derived from it.

Suggested Readings

1. Latest United States Department of Commerce Yearbooks.
2. *Study of Electric Light and Power Service,* Chapters I, VIII, IX, and pages 50–52. Fuel-Power-Transportation Educational Foundation, 1116 Beggs Building, Columbus, Ohio.
3. Ohio Bulletin No. 96, "Using Electricity on Ohio Farms."
4. Nebraska Bulletin No. 289, "Use of Electricity on Nebraska Farms, 1920 to 1934."
5. Oklahoma Bulletin No. 207, "Rural Electrification in Oklahoma."
6. Idaho Bulletin No. 180, "Rural Electrification Development in Idaho."

Chapter II

HOW ELECTRICITY IS MADE AND DISTRIBUTED

Class Discussion

1. What are the most common sources of power used to generate electricity?

2. Why has finely crushed coal, known as "powdered fuel" become such a popular fuel for steam generating plants?

3. How is an electric current produced and delivered to the customer?

4. How does direct current differ from alternating current?

5. Why is it not possible to connect a customer directly to a transmission line?

6. What is the function of the distribution line?

7. Why are transformers necessary in the transmission of electricity from the generating station to the consumer?

8. Why are transformers of different sizes necessary?

9. What metals are good conductors of electricity?

10. What materials are poor conductors or insulators?

11. Upon what factors does the resistance of an electrical conductor depend?

12. Define the following electrical terms:

a) Ampere	*d*) Kilowatt
b) Volt	*e*) Kilowatt-hour
c) Watt	*f*) Electric horsepower

13. What is the amount of heat available in each kilowatt-hour of electric energy used for such purposes as baking, cooking, and heating water?

Equipment

Borrow from the physics department such apparatus as permanent magnets, iron filings, dry cells, iron nails, wire, compass, and any other equipment suitable for simple experiments in magnetism and electricity.

Demonstration

1. Place magnets in iron filings and show that the magnetism is concentrated at the poles.

2. Place a piece of paper or glass over different combinations of magnets, sprinkle iron filings on this, tap the paper or glass gently, and note the position of the filings. What does this show?

3. Make a temporary magnet by winding insulated wire around an iron nail and connect the two ends of the wire to a dry cell.

4. Connect the two ends of the wire of the temporary magnet. Place the wire over a compass. Bring a magnet over the coil of wire wound around the nail, and note the deflection of the compass needle.

5. Connect pieces of various diameters of copper and iron wire to the two poles of a dry cell and then pass the wire over a compass. What is the difference in the amount of current flowing in the different wires?

6. What is the effect upon an electric bell connected to a dry cell when a long iron wire is used as compared with a short one? Demonstrate also for wires of different sizes and materials.

7. Demonstrate the operation of simple motors and any other electrical apparatus which may be of interest and value to the students.

Practice and Problems

1. To heat an electric iron an electric current of 6 amperes at 110 volts is needed. How many watts does the iron use?

2. An electric motor is used to operate a washing machine. It uses 275 watts at 110 volts. What is the flow of the electrical energy in amperes?

3. An electric dairy water heater uses 1,760 watts at 8 amperes. What is the voltage of the electric current?

4. The kilowatt is equal to how many electric horsepower?

5. For how many hours can each of the following be operated on one kilowatt-hour of electrical energy?

a) 50-watt lamp.

b) A percolator using 4 amperes at 110 volts.

c) A ¼-horsepower electric motor having a 60-per-cent efficiency used on a household refrigerator.

d) If all are operated simultaneously, during what time will a kilowatt-hour of energy be used?

6. *a*) A 10-gallon water heater is equipped with a 2-kilowatt electric heating element. How long will it take to heat the water from 60 to 180 deg. F., if the heater is 100 per cent efficient?

b) If the heater is 80 per cent efficient?

7. Become acquainted with the accomplishments in electricity of such famous men as Alexandro Volta, H. C. Oersted, A. M. Ampere, G. S. Ohm, Sir Humphrey Davy, Charles Wheatstone, Michael Faraday, Joseph Henry, Z. T. Gramme, J. C. Maxwell, Lord Kelvin, Samuel F. B. Morse, and Alexander Graham Bell.

Information

In order to generate electricity, it is necessary to have available such power as water (Fig. 1), heat, chemical energy, or wind. Falling water