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ELECTRICITY FOR THE FARM AND HOME

BY

FRANK KOESTER

Koester

VGC

IN THE GLOW OF AN ELECTRIC RADIATOR

Frontispiece

ELECTRICITY FOR THE FARM AND HOME

BY

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WITH AN INTRODUCTION
BY
THOMAS COMMERFORD MARTIN

ILLUSTRATED

New York
STURGIS & WALTON
COMPANY
1913

Set up and electrotyped. Published June, 1913

DEDICATED

TO

MY FRIEND

THOMAS COMMERFORD MARTIN

Author of the first American book on the Electric
Motor, 25 years ago, in which hopeful
reference is made to the subject
herein developed.

INTRODUCTION

BY THE GENERAL EDITOR

This is the day of the small book. There is much to be done. Time is short. Information is earnestly desired, but it is wanted in compact form, confined directly to the subject in view, authenticated by real knowledge, and, withal, gracefully delivered. It is to fulfil these conditions that the present series has been projected—to lend real assistance to those who are looking about for new tools and fresh ideas.

It is addressed especially to the man and woman at a distance from the libraries, exhibitions, and daily notes of progress, which are the main advantage, to a studious mind, of living in or near a large city. The editor has had in view, especially, the farmer and villager who is striving to make the life of himself and his family broader and brighter, as well as to increase his bank account; and it is therefore in the humane, rather than in a commercial direction, that the Library has been planned.

The average American little needs advice on the conduct of his farm or business; or, if he thinks he does, a large supply of such help in farming and trading as books and periodicals can give, is available to him. But many a man who is well to do and knows how to continue to make money, is ignorant how to spend it in a way to bring to himself, and confer upon his wife and children, those conveniences, comforts and niceties which alone make money worth acquiring and life worth living. He hardly realises that they are within his reach.

For suggestion and guidance in this direction there is a real call, to which this series is an answer. It proposes to tell its readers how they can make work easier, health more secure, and the home more enjoyable and tenacious of the whole family. No evil in American rural life is so great as the tendency of the young people to leave the farm and the village. The only way to overcome this evil is to make rural life less hard and sordid; more comfortable and attractive. It is to the solving of that problem that these books are addressed. Their central idea is to show how country life may be made richer in interest, broader in its activities and its outlook, and sweeter to the taste.

To this end men and women who have given each a lifetime of study and thought to his or her specialty, will contribute to the Library, and it is safe to promise that each volume will join with its eminently practical information a still more valuable stimulation of thought.

Ernest Ingersoll.

INTRODUCTION

BY

THOMAS COMMERFORD MARTIN

The fact is universally recognised that farming and country life in general have been improved in condition and made more profitable in the degree to which mechanical energy has been substituted in them for human and animal labour. The public at large has also benefitted from heavier crops, planted, raised, and gathered more cheaply.

This process is happily in greater expression to-day than ever; and to the resources utilised by the farmer in releasing himself and the land from mere brute toil is now added electricity, the most readily adaptable power of all. The new agency has been rendered chiefly available in country life by the development of water powers, and the extension of power circuits over large areas and remote districts, fed from these hydroelectric central stations. In some rare instances, the farmer is able to generate his own electricity.

Mr. Koester has been wise in his method and manner of telling the story of this modern innovation, from which seem likely to spring greater revolutions even than came in with the reaper and binder or the cotton gin. No one yet knows exactly how far the change may take us or what economic limitations of electricity in rural life are, in its usefulness for light, heat, pumping, and other services. But the first step in that direction, is obviously to study the conditions, learn the facts, and note actual applications, whether in America or in Europe. Mr. Koester has done this admirably, so that his work as a popular, accurate manual on the subject stands unique. What thousands of farmers are now doing in harnessing electricity for their service, instead of horses or mules, other thousands ought to be able to do; and that they will do it in the near future is more than hopeful. It is inevitable, and Mr. Koester points the way.

Mr. Koester has been wise in adding chapters that deal with the general utilisation of electricity in rural districts, of which there are a great many where service can be taken from distant city telephone exchanges or central stations, as well as from remote power plants. The farmer is not alone the beneficiary, but there is thus given the use of electricity in the home, while an immense stimulus is imparted of a profitable nature, tending to develop a residential population not involved directly in farming and helping to take "back to the soil," those who should never have left it.

ACKNOWLEDGMENTS

The author wishes to express his thanks to the "The Electrical Review and Western Electrician," "The Electrical World," "Electrical Record," "Popular Electricity Magazine" and "The Engineering Magazine" for the use of engravings which originally illustrated articles written by him on the various phases of agricultural electricity, and printed in those publications during the past eight years. Much credit is due them for their support and indorsement of the subject of adapting electric power to agriculture, and to their early recognition of its great importance to the public at large.

Although electric farming has now reached a high state of development, especially abroad, this is the first extended work on the subject. It will be found to cover the field in a comprehensive manner, and to contain illustrations of all the important apparatus. For some of these, previously published elsewhere, my thanks are due to the following concerns:

Siemens Schuckert Werke, Berlin; Allgemeine Electricitaets Gesellschaft, Berlin; Oerlikon, Oerlikon, Switzerland; Westinghouse Electric and Manufacturing Company, Pittsburg; General Electric Company, Schenectady, N. Y.; Simplex Electric Heating Company, Cambridge, Mass.; C. A. Sterlinger Company, Detroit; Rochester Railway & Light Company, Little Falls, N. Y., and The Pacific Gas & Electric Company, San Francisco.

I am particularly indebted to Mr. Thomas Commerford Martin, Secretary of the National Electric Light Association, for the great interest shown in the volume and many valuable suggestions offered.

F. K.

New York, April, 1913.

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BENEFITS OF AGRICULTURAL ELECTRICITY

THE ages of toil which agriculture has demanded of man and beast, the bondage of labour and the stupefying and soul-benumbing work of the tiller of the soil, so long unescapable, are yielding to the advance of modern science.

Agriculture is no longer to remain a practice of yokels but is to become an applied science, and the farmer with business ability no longer needs the supply of brawn and elbow-grease which was once his sole necessary equipment. With the changes now taking place, the man of brains and ability can find in the country every exercise for his talents that has attracted him in the past to the city; every opportunity for fortune and development; a healthier and a fuller life; and at the same time escape from the drudgery and the grinding toil that have made the farm a place to be abandoned to the less enterprising.

The greatest agent of agricultural progress is electricity. It is the great emancipator of the toiler. A motor of even diminutive size does the work of a man at far less expense, since the power developed by the human machine is the most expensive power which mankind ever utilises. And in supplanting labour electricity has a most profound effect upon agriculture, since agriculture demands great labour but very little skill. Electricity minimises the labour, and the farm hand, with the necessity of exercising but little skill, can direct the labours of large electrical units and accomplish amounts of work that would be utterly impracticable under ordinary conditions.

The importance of electrifying farms is not only of the first consequence to the farmer, but also to the city dweller, for the emancipation of labour means vastly increased and cheapened production of the necessities of life, and a consequent increase in the purchasing power of the labour of the dweller in the city.

In utilising electricity on the farm, however, it is necessary, since the farmer uses a great many and a great variety of implements and mechanical devices, that he should co-operate with the engineer, in order to take advantage of the skill and experience of the latter to replace the much sought-for and much needed manual labour, to cut down the number of draught animals, to make the farm produce more, and to make rural life more congenial and agreeable.

The use of electricity on our farms is sure to be greatly increased with the progress of that intensive cultivation which is becoming an acute national need, and the rural industries in general must look to the engineering profession for the best utilisation of our natural resources through the medium of electric energy. The present decade will be as notable for American farmers as was the past decade for the German farmers by its scientific agricultural development with the aid of electricity.

As a class, the farmer is a large user of power, but the sources from which he draws it are at present inefficient and uneconomical, compared with industrial standards in other lines. Of the 33,000,000 persons engaged in gainful occupations in the United States, not less than 10,000,000 devote their energies to agriculture. About 90 per cent. of the horses and mules in this country are also at work on the farms. The substitution of electric power for even a small proportion of the work of farm animals means a great national economy.

There is no form of energy which can supplant manual and animal labour, on the farm or country estate, as conveniently and cheaply as electricity; and it is far superior to steam or any internal-combustion engine. In fact there is no other agent which can supply all three necessities—light, heat and power—from the same source. Due to this fact, working hours on the farm and rural industries can be regulated, as are those in manufacturing and commercial industries; and life in rural communities can be made as attractive, if not more so, than that of the cities, where the struggle for existence is incessant, and the living accommodations, or what corresponds to home life, fall far short of the pleasant and healthful surroundings of the country residence.

The giant industries of the country are of recent origin and started in a humble way, but they now surpass any branch of agrarian pursuits. This is a condition readily accounted for, since the services of the trained engineer were used to advantage in building up the great manufacturing industries, while farming, though the oldest of industries, has been neglected even to the point of being abandoned in many places.

Up to the present time, especially in America, the aid of the technical man is seldom sought in solving the problems which arise in rural industries. Probably there is no better or more authoritative statement of the value of technically trained men as an aid in modern farming, than that made by Col. Theodore Roosevelt on August 23, 1910, at Ithaca, N. Y.:

"One reason why the great business men of to-day—the great industrial leaders—have gone ahead while the farmer has tended to lag behind, is that they are far more willing, and indeed eager, to profit by expert and technical knowledge, that can only come as a result of the highest education. From railways to factories no great industrial concern can nowadays be carried on, save by the aid of a swarm of men who have received a high technical education in chemistry, in engineering, in electricity, in one or more of scores of special subjects. The big business man, the big railway man, does not ask college-trained experts to tell him how to run his business, but he does ask numbers of them to give him expert advice and aid on some one point indispensable to his business. He finds this man usually in some graduate of a technical school or college in which he has been trained for his life-work.

"In just the same way the farmers should benefit by the advice of the technical men who have been trained in phases of the very work the farmer does. I am not now speaking of the man who has had an ordinary general training, whether in school or college. While there should undoubtedly be such a training as a foundation (the extent differing according to the kind of work each boy intends to do as a man), it is nevertheless true that our educational system should more and more be turned in the direction of educating men toward, and not away, from the farm and the shop.

"During the last half century we have begun to develop a system of agricultural education, at once practical and scientific, and we must go on developing it. But, after developing it, it must be used. The rich man who spends a fortune upon a fancy farm, with entire indifference to cost, does not do much good to farming, but, on the other hand, just as little is done by the working farmer who stolidly refuses to profit by the knowledge of the day; who treats any effort at improvement as absurd on its face, and refuses to countenance what he regards as newfangled ideas and contrivances, and jeers at all book farming."

In Europe, particularly in German-speaking countries, due to the harmonious co-operation of farmer and engineer, great progress has been made in the use of electricity as a servant on the farm, about the country residence, and in rural industries in general.

In order to obtain a clearer idea of the advantage of electricity over any other agent, and to show that electricity is the best medium for the farmer, the following facts are cited. There are thousands of steam and internal-combustion engines in use on our farms to-day, principally for replacing draught animals, and, of course, a proportionate number of farm hands; and they are used with machinery, such as ploughs and threshers and especially pumps. For operating small machinery such as is required in dairies, as cow-milkers, cream-separators, butter-kneaders, etc, an internal-combustion engine could not be as advantageously used as an electric motor, however, for the reason that the smallest commercial internal-combustion engine is about two horsepower, while the electric motor may be chosen in capacities of one-tenth of a horsepower and upwards to suit the machine to be operated. Further, no fuel is necessary, the only requirement being to turn on a switch to start the motor.

In fact practice has proven that farm machinery can advantageously be operated by electric motors. The machines usually operated on the farm are, ploughs, rollers, reapers, threshers, corn-grinders, corn-shellers, corn-shredders, fodder-cutters, wood-saws, pumps, horse and sheep clippers, and apparatus for unloading and hoisting hay, corn-stalks and similar products. Another great saving of labour in the use of electricity is in serving washing machinery, carpet-cleaners, sewing machines, fans, and appliances for cooking and for heating laundry irons, none of which could well be served by any agent other than electricity. In addition to its use for power, electric energy, which has to be supplied to the motors either from an outside source or from its own central plant, may be utilised for light and heat.

Where connection cannot be made with a local electric distributing company, the farmer should have his own electric generating station, which may be operated by water, steam, gas, gasoline, oil or windmill power. Where a stream runs through a farm or is in the neighbourhood, cheap power, both as regards the first cost and operating expenses, may be derived from this natural source.

In generating current by steam power, the cost per kilowatt-hour is comparatively high. Somewhat better results may be obtained with a gas-producer plant, which, instead of burning the coal in a steam boiler, and using the steam for driving the engine, slowly burns the coal in a producer, generating gas for operating the gas engine.

The gasoline, oil, and alcohol engines work on the same principle as the gas engine, as all are of the internal-combustion type. Great strides have been made in the last decade in this type of engine, so that to-day it operates with reliability and economy and requires but little attention.

Another source of energy for generation of electric current for farm and country residences, is the windmill. The early Dutch windmills were built with sweeps from 50 to 100 feet in diameter; but our modern American windmills have a sweep of only 12 to 18 feet, and generate more power than the early Dutch mills, with less attention.

All the above prime movers can be connected to electric generators by belt, gearing or couplings, and their control may be accomplished automatically, so that little attention is required.

The greatest amount of energy being used in the daytime, and the load for illumination being small and wanted principally in the evening, it is therefore not profitable to run the prime movers except during the day. The use of a storage battery is therefore of great service in supplying energy at periods of small demand, when the generators are shut down. In connection with the storage battery, and with the new development of the low-voltage Tungsten lamps, the cost and size, as well as the maintenance-expense, may be considerably reduced by proper engineering.

The main feature in which the great advantage of a farm operated by electricity lies is that the farmer himself has at all times under his direct control the entire supply of electric energy being used, whether obtained from some public-service corporation or supplied by his private plant.

A plan much adopted abroad, is to install a rural central station for the purpose of supplying a number of farms, local industries and country estates, with electric current. By establishing a rural central station, actuated by steam, water, gasoline, oil or gas, a great saving in the production of electric energy may be secured. In Germany to-day as many as 100 to 150 consumers are supplied with electric energy from a single one of the many stations.

Many of the German farmers carry on industries in connection with their farms, whereby they utilise their by-products; and this is the secret of the success of many well-to-do men. For instance, one rural central station system serves four grist mills with five motors, having a total capacity of 105 horsepower; one tile works with a 40-horsepower motor; one saw-mill with a 20-horsepower motor; four wheelwrights with motors consuming 16 horsepower; and many other industries such as cabinet-making, distilling, blacksmithing, bottling works, etc., which use motors of various capacities. There are also served by the system some 20 consumers for light only, having a total of 343 incandescent lamps and five arc lamps; one railway and freight station with 120 incandescent lamps; one club house with 72 lamps and six arc lights; and in addition to this two towns are supplied, having a total of 1,692 lamps.

From the above facts and figures, it is obvious that electricity can give a new stimulus to agriculture and farming, and at the same time open a new way by which the rural population can be induced to remain on the farm instead of flocking to the cities.

A very important feature is, that a few motors properly selected may be used to operate all of the machines on the farm, instead of having a steam or gasoline prime mover attached to each machine. In this feature lies a great advantage of electrically operated farm machinery. For instance, a motor may be placed on a low wheeled truck, and connected by means of a belt to a threshing machine, taking its electric supply from the mains by a flexible cable plugged into a suitable outlet. On the throwing of a switch, the motor starts and operates continuously without attention. After the threshing is completed, the motor may then be connected to the baling machine, which packs the straw into bales, while, if necessary, the motor may be used in loading the bales upon wagons by operating a hoist. At other times, the same motor may drive a water-pump, wood-saw, etc.

It is readily seen that the electric motor can be operated without the attention necessary for steam or gasoline prime movers, which have to be supplied with water and fuel. With all other prime movers, when placed in the barn or haymow, or beside some stack in a field, the risk from fire is a thousandfold greater than with an electric motor; in fact, an enclosed electric motor may be placed anywhere on the farm without such a risk, or the fear of an explosion.

The motors used on dairy appliances, and for the various household operations, are of such small size and weight that they may readily be carried around by one or two persons and applied to one machine or another wherever needed. Thus many farms can get along with one large and one small motor. As the various farm machines operate at different speeds, the motors are supplied with suitable regulating devices, so that the desired speeds may be obtained.

The great advantage of cold storage is not properly recognised to-day by farmers. By means of electrically operated cold-storage systems, butter, milk, eggs and other perishable goods may be saved from spoiling. In many cases, especially with fruit, a farmer is forced to let his product lie on the ground and rot, because the price offered does not pay the expense of picking, packing, and shipping to the commission merchant. A private cold-storage system would enable him to pick his fruit in season, when the market price was low, and store it until he received his own price.

For such purposes electric ice-making machines for refrigerating plants are preferable. The motor applied to this equipment can be arranged to start and stop automatically, and will keep the temperature in the cold-storage room within a few degrees of that desired.

For irrigation purposes, electric pumps are of great service, whether on a large or a small scale. As these pumps work only in certain seasons of the year, and at certain hours of the day, public-service corporations have recognised of late that they are a means of keeping up a uniform power-demand on the plant, and consequently energy for this purpose is offered at exceptionally low rates. The motor-driven pumps may be stationary or portable.

Large sums are yearly spent for irrigation purposes, waterways regulation and drainage systems, and, seemingly, in almost all cases, without due consideration of the possibilities of utilising the energy of the water for generating an electric current which might advantageously be used for farming or rural industries. Good examples on a large scale of such combination systems are found in Switzerland and Germany, where advantage is taken of all kinds of natural resources, and the proper husbanding of the same for the benefit of the public in general.

Electric ploughing has been carried on in Germany for some fifteen years, and great strides have been made, particularly in the last five years. Of the several systems employed, the one- and two-motor systems are most extensively used. In both these systems the plough is pulled across the field by a cable wound on a drum.

In the single-motor system, on one side of the field the motor is mounted on a self-propelled wagon, while on the other side is an anchor-wagon, which automatically travels forward, parallel with the motor-wagon, with each new furrow. The two-motor system has two motors, one on each of two self-propelled wagons, one of these replacing the anchor-wagon. The one motor system is lower in first cost, but the other can be more readily adapted to the cultivation of any form of field.

Electric ploughing has great advantages over that by gasoline or steam engines. With a steam plough, for instance, a great amount of coal and water must be taken to the field by teams and drivers which must be paid for. Electric ploughing can be carried on in practically every kind of weather, even in the winter, when steam-operated ploughs would freeze; and the electric plough can be used in soft or loamy soil where horses cannot work, and on hilly ground.

As far as the cost of electric ploughing is concerned, experience shows that it can be done cheaper per acre than by horses or steam. The field of electric ploughing of to-day is found principally in Germany. It is an established fact that American agricultural machinery in its wide practical application, is, in most respects, far superior to that of any foreign make; and should the domestic manufacturers devote themselves with the same skill to contriving apparatus for electric ploughing, it will be only a short time until our farmers recognise the advantages of the system. Electric ploughing is not confined to farms of large acreage, but may be carried on to good advantage on farms of small size.

The need of utilising farm-refuse for by-products is one that deserves the most thorough consideration. Our modern industries seek to make all possible utilisation of by-products, and in thousands of cases it has turned out that the by-product has proved more profitable than the original substance sought. Many of the products of the farm which are now allowed to go to waste, could be turned to good account by the use of electrically operated apparatus especially designed to turn into marketable goods such by-products as alcohol, sugar, starch, cider, etc. Further, the electric motor may be used in the blacksmith or carpenter shop, grist mill, wheelwright shop, in a briquetting and tile plant, etc., all furthering the advance of rural industry.

As potatoes lose value to a considerable amount in storage, thrifty German farmers in the last few years have installed some 3,000 drying systems, where the potatoes are washed, peeled and cut into dice, then dried and stored for future use, without the loss due to ordinary storage. By this process Germany saves $25,000,000 per year. To effect a further economy, the German farmers are installing, at present, drying systems for beet and potato leaves, which contain a great amount of nutriment for cattle. Through these installations it is calculated that a saving of $12,000,000 per year can be effected, while in previous years Germany was forced to buy $8,000,000 worth of cattle food from other countries.

An efficient lighting system is well recognised as being of as much importance in the country as in the city. Good lighting assists in fixing definite hours of labour, which is necessary to satisfy the demands of farm hands, and is of value to every one in the country as well as in the town. Better light secures greater efficiency and cleanliness; while fire risks are diminished and insurance rates are reduced. Electric lamps require no matches, burn without flame, consume no oxygen, and therefore do not vitiate the air of a room, and are unaffected by any change in weather conditions. Electric lighting is particularly of great service for stables and barns, where the use of lanterns has caused numerous fires and destroyed millions of dollars' worth of property. The country yard and field may be lighted, such lighting controlled from the residence. This feature is especially convenient when, in the autumn, harvesting is necessarily carried on after dusk in order to take advantage of weather conditions. In such cases, the field under harvest can be illuminated to advantage and work continued long after nigth-fall.

Electricity is a ready servant for cooking or heating. No heat is wasted, as in a coal or wood stove, all being concentrated in the one piece of apparatus being used. The cost of operating a small electric range is in many cases cheaper than burning wood or coal. Electric current may often be bought for 5 cents per kilowatt-hour, and as the average price of gas throughout the country is $1.20 per thousand cubic feet, the cost of electric cooking is the same as that done by a gas range, provided no heat is wasted by the gas range, which, however, is practically unavoidable. Electric cooking also means perfect cleanliness, for there is no soot or smoke, and as for convenience, all that is necessary is to turn a switch. In country residences, where during certain hours of the day only a little cooking is carried on, such as making coffee, boiling eggs, preparing toast or supplying heat to chafing dishes, all this is done electrically in a few minutes, even on the dining table itself.

The heating of flatirons by means of electricity has proven one of the greatest of boons to the household. The electric flatiron is so constructed that the current is supplied to the iron during use, and it therefore maintains its working temperature, does not overheat, causing accidental scorching of the work, and is kept ready at a minimum cost. As no stove is necessary, there is no constant change of irons; and no intense heat is radiated into the room to make the operation tiresome, as is so particularly the case in the summertime.

Other electrically operated heating appliances for household convenience are facial and scalp massage apparatus, foot-warmers, heating-pads and bed-warmers, radiators, etc., many of which are conveniently applied to hospitals and sick-rooms. Among appliances especially made for hospital use, are sterilisers, x-ray apparatus, cauteries, electric blankets, ozonisers, etc.

These by no means comprise the entire list of necessary and convenient household appliances which can be found to-day. New devices are appearing constantly, so that at the present time there is hardly a household or farm where electric energy, through the skill of the engineer, could not be made to supplant many of the laborious operations.

At the present time, fully ninety per cent. of all skilled labour comes under the supervision of the engineer, who has employed it and the various kinds of natural resources, to build up the gigantic industries which we have to-day. Our farmers should, in a similar way, take advantage of the electrical engineer's experience in the practice of developing and husbanding their natural resources through the medium of electric energy, and modernise and render more productive our agrarian industries, upon which not only our financial standing is dependent, but the general welfare of the country as a whole.

CHAPTER II

CENTRAL STATION SERVICE

Availability of Electricity.—Many farms both in the United States and abroad are served by lines from city or other electric stations, and in many of the states throughout this country the long-distance transmission lines of numerous hydro-electric plants pass through farming communities more or less populated. These systems are usually of high tension, varying from 13,000 to 60,000, or as high as 150,000 volts. These high voltages are not used directly in motors, but must be reduced by transformers to a suitable value, depending on the nature of the purpose to which the motor is to be applied. Likewise for use on farms and in country residences, a transformer must be had to furnish a supply of current at a low voltage value for local distribution.

Where large tracts are to be covered on a single farm, practice has proven that a voltage of about 13,000 is most suitable; intermediate stationary or portable transformers being used to step the voltage down to that desired on the motors of the ploughs, threshing machines, etc.

Charges.—Electric energy for a central-station service is usually sold on a sliding-scale principle, that is, the larger the consumption the lower the price per kilowatt-hour; again, the larger the consumption at a certain hour of the day, when the load on the central station is low, the cheaper is the current obtainable.

From the above, it might seem to some that this is an unjust method of making charges for power, because the smallest consumer bears the larger portion of the rates scheduled. But it must be borne in mind that material bought in bulk or large quantities is always obtained at a low cost, consequently the larger a consumer's load, the smaller the rate charged per horsepower per hour.

The average rate charged for electric energy varies from 5 to 15 cents per kilowatt-hour (1 kilowatt=1.34 horsepower). The *kilowatt* is the standard for measurement of electric energy. The amount of current consumed is registered by metres, supplied by power companies. As the rates charged for light and power are different, two metres are installed; one registers the energy consumed for lighting and the other for power. A third metre is sometimes installed, called a maximum-demand metre, which registers apart from the usual load any excessive current which may be drawn. An additional low rate of charge is made whenever a maximum-demand metre is installed, the rate being based on the reading of that metre alone.

Rural Central Station.—A practice much adopted abroad, particularly in Germany, where the government encourages electrically operated farms, is to install rural central stations for the purpose of supplying a number of farms, rural industries, country residences and estates with electric current. By establishing such a station, with either steam, water, oil or gas power, a great saving in the production of electric energy may be readily secured. Today in Germany often as high as 100 to 150 consumers are supplied with electric energy from a single rural central station such as have been installed in great numbers within the last fifteen years.

In northern Italy and throughout Switzer-

Fig. 1. Interior of the electric sub-station at a New York farm, showing motor-generator sets and switchboard.

land also, there is considerable use of the electric energy in agriculture and by small rural communities. A network of distributing lines has been formed, drawing energy from numerous and scattered sources of hydroelectric power which are, however, interconnected. The

Swiss and Italian land proprietors, and small farmers throughout western Europe, have taken in large numbers to the use of electric light and electric power.

An example of the extent to which a single rural central station may supply a farming community with electric energy is seen at Besswitz, Germany. The distributing system for the electricity is 145 miles long, the station being as near as possible at the centre of the network and the point most distant from it is 26 miles. The territory served with current is equivalent to 102,000 acres, of which 40,000 acres are cultivated with the plough. To the transmission system are connected 180 electric motors and about 5,000 electric lamps, with a total consumption of 1300 kilowatts or 1780 horsepower.

Another interesting instance is the distribution system of Lottin, Germany. Here a water-power of 300 horsepower is utilised, but during certain seasons of the year when the water is low, a steam generating set of 180 horsepower is put into service to keep up the supply. It is obvious that this aid can be pressed into service at any time should the demand exceed the capacity of the hydro-electric station. The distribution system is 82 miles long. The electric energy is used on 61 farms, including rural industries, and 5 villages, a total of 24,700 acres. Altogether 102 consumers are served, having some 150 motors with a total of 1500 horsepower, while 4850 incandescent lamps and 20 arc lamps comprise the lighting part of the load. During the year 1908, there were consumed 440,000 kilowatt-hours. There are 50 farms, with a varying acreage of from 60 to 1800 acres per farm, under cultivation by the plough, with a total of 275 horsepower in motors, 1200 incandescent lamps and 20 arc lamps. Of these farms twelve contain from 300 to 600 acres each and have 12 motors with a total capacity of 122 horsepower.

Central Station Service.—The purpose of central station companies is to deliver a product ready for use to a number of different users at a lower cost and with greater convenience and reliability than they could otherwise obtain it. That product is electricity, and it is to the interest of both the companies and the consumers to use as much electricity as possible, for wherever it can be applied it effects a saving, and the more of it used the cheaper will be its proportionate cost and the greater the satisfaction to all concerned.

One of the means whereby the farmer can get his electricity at a still lower rate, is to make his consumption as uniform as possible during the whole twenty-four hours. The cost of electricity is based on the cost of fuel or water-power, attendance, and the amount of money invested in the equipment, including generators and transmission system. It will be seen that if all the farmers on a line demand electricity during a few hours only of each day, larger and more expensive machinery must be installed to generate it than would be necessary if the demand for the same amount of electricity is spread over a longer part of the day.

The farmer thus by using power for feed-chopping, meat-grinding, dairy purposes, wood-chopping, cooking, washing and general purposes during certain hours of the day, light for morning and evening, and in pumping water for the household and for irrigation at night, can, under the direction of the electric company, so consume his electricity that it may be generated at the lowest possible cost.

Fig. 2. Electric transformers in the farmyard.

Reducing First Cost of Electric Farming.—It is the custom of the central-station companies to deliver the electricity to the user's premises, where usually the user installs his own distributing system through his house, barns, etc., for the majority of farmers can afford to buy their own machinery, especially of the smaller sizes; but in the case of large installations a number of methods may be employed to obtain the benefits of such machinery without buying it outright, principally by means of co-operation with central-station concerns. Many such companies are only too willing to furnish electric motors and wire the farm premises, both for light and power, at a small yearly rental or on low instalment-payments. Thus the farmer may have the cost of machinery spread out over a number of years, and the saving effected in manual and animal labour would be far more than sufficient to pay for the investment; and thus he will not only own the equipment in the end, but all the time will have been making a good profit out of its use.

Central-station companies can readily sell bonds and obtain funds with which to supply their farmer clients with all the motors necessary. The credit of farmers is of the highest character, so that the companies would not only have a profit on the sale of the machinery but would be secure in the principal, and for many years would have a greatly increased demand for electricity which would never have existed if the farmer had been compelled to go into debt on his own account for his machinery.

Co-operative Methods.—On American farms at present, a certain degree of co-operation exists, as for example in the threshing of grain. Farmers growing small grain, such as wheat, oats, rye, barley, etc., after the grain is harvested, have a threshing machine outfit visit their fields where a day or so is spent in threshing the grain, the outfit then proceeding to the next farm. Such outfits are usually private business enterprises conducted by two or three farmers in a district, each with his own outfit. Essentially, however, it is a form of co-operation, and under American conditions probably the most effective form in which co-operation can be carried out, the small profits of the owner being a negligible factor compared with the convenience, and in fact, the necessity to the individual farmer of such an apparatus which is too expensive for his own private use unless he has a farm of enormous size.

The same principle can be readily applied in the case of large electrical machinery, such as for electric ploughing and threshing, wood-sawing and electric truckage of products in large quantities, and water-pumping for irrigation, as well as for such other purposes as may be found feasible.

If, as will be the case in many instances, no farmer takes up, as a private business venture, such utilisation of electrical machinery, it will be found perfectly feasible for a group of farmers to co-operate in its use and ownership, either in the form of a partnership, or as a society or corporation. Central stations could also interest themselves financially in such undertakings, which would be conducted not for profit but for mutual benefit.

One of the great advantages of central-station participation in such matters lies in the feature of maintenance and repairs. The central station would at all times have supervision over the machinery, and would have it inspected regularly and repaired without delay when out of order. The farmer being relieved of this responsibility would have every encouragement to adopt electrical machinery, and once made acquainted by practical experience with its great advantages he would find new and profitable uses for it.

Co-operation between central-station companies and farmers, and of groups of farmers, in whatever form it may be carried out, offers a great field for national enrichment. For the farmer to be fully equipped with every modern appliance will enable him to get from the soil the greatest source of national wealth, the biggest crops with the least expense. This means cheaper food and greater net incomes for everybody. No better way of reducing the cost of living can be found than this, and no better way of investing surplus capital devised.

The subject is one that deserves the most profound consideration of bankers and capitalists throughout the country and the particular attention of all electrical companies.

The matter may be taken up directly, as has been pointed out, by the central-station companies, through the issuance of bonds and the purchase of farm machinery with the proceeds. Separate farm equipment companies could be organised for the purpose of supplying farmers with implements, and such equipment companies could be financed by local bankers and business men, an important farm equipment company being organised in each locality.

Capital for Farming Operation.—One of the best forms of security in the money markets of the world is railroad equipment notes, and there can be no doubt that farm equipment notes would be just as desirable. It is, indeed, the duty of local capitalists and bankers to place their funds at the disposal of farmers, as such use of the money in the surrounding region reacts favourably upon local conditions. Large bankers in central cities could also find a profitable employment for millions of capital in the promotion of farm equipment companies on a large scale. Such companies could both manufacture as well as sell the farm machinery, and also be interested in, if not the proprietors of, central-station companies.

The capital of the country, owing to the formation of trusts, has largely been absorbed in manufacturing developments which, though possibly of greater immediate profit, have taken

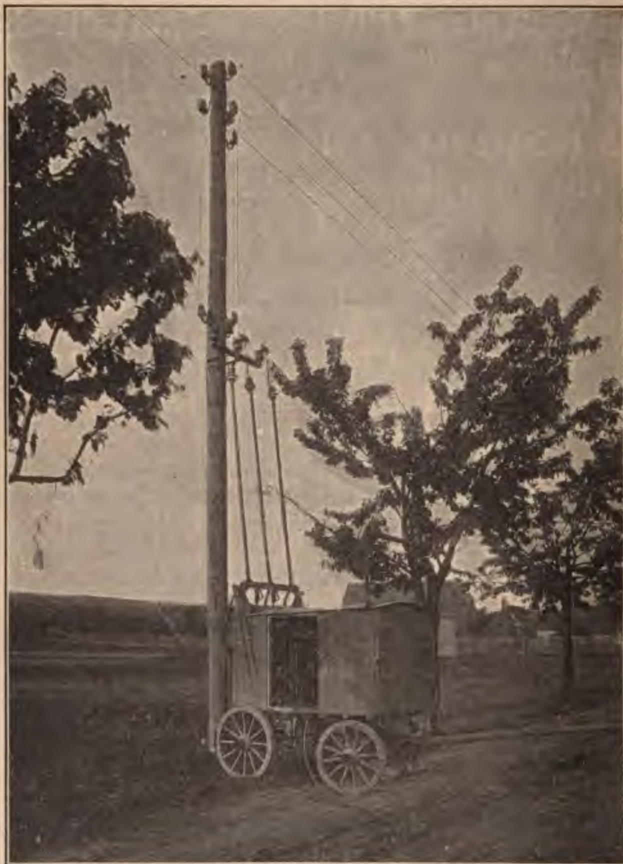

Fig. 3. Portable transformer much used on German farms for temporary large consumption of current, as in ploughing, threshing, etc. In this apparatus the current is drawn from a high tension transmission line and stepped down to a low voltage for motor use.

money away from rural investments. This has left agriculture neglected and incapable of keeping pace with other phases of progress, with the result that all forms of manufacturing are now sharply checked by the drag of the farm in the form of high prices of commodities, a condition which would never have arisen had farmers had ample capital placed at their disposal on terms as favourable as those granted to manufacturers.

Agriculture must now be given its proper encouragement, and enabled to contribute its share to the prosperity of the country, and this can be done in no way so well as by the expansion of the use of electricity on the farm. A most powerful element of stimulation will then be injected into the veins of the whole country and a new era of prosperity will ensue.

QUESTIONS

1. What is the usual voltage employed for the transmission systems of central station concerns?
2. What are the usual charges for electric current for central-station service?
3. What is a kilowatt-hour?
4. Why are two different rates charged, one for light and the other for power?
5. What is understood by a rural central station?
6. What is the purpose of the co-operation of central stations and farmers?
7. Would the farmer benefit in making use of central station service?

CHAPTER III

GENERATING ELECTRIC POWER

IT is generally recognised that central stations and public utility companies are the best sources of supply from which to draw electricity, owing to their reliability, "cheapness" and convenience. The advantage of using central-station service may be enumerated as follows:

- Smaller investment; no capital tied up in generating apparatus, fuel, supplies, etc.
- Reliability of supply; failure almost unknown.
- Any accident to a machine is confined to it and does not affect any other portion of the shop. In all other systems the machines are not thus independent.
- Availability of supply at any moment, day or night, and cost for power always in proportion to amount of work being done.
- Ample overload capacity.
- No delay from lack of power; power always ready.
- Good voltage regulation; lights steady and motor-speeds constant.
- Freedom to locate machinery anywhere within several miles of the farm building, and to relocate it at any time without reference to power supply.
- Ability to enlarge farm capacity at any time in order to keep pace with demands, without expensive changes in power plant.

Freedom from all expenses and annoyance chargeable to operation of power plant; this includes labour troubles, fuel shortage, break-downs, etc.

When the user, however, is located beyond the reach of the distributing lines of central-station companies, it is necessary to install an isolated plant to supply light, heat and power, and such a plant is a much more profitable investment than the installation of other kinds of power, such as individual gas, oil or steam engines, to operate the different farm machines. The great advantage of using electricity on the farm for light, heat and power, is amply demonstrated in other chapters.

Isolated Plants.—For the purpose of generating electricity in isolated plants, various forms of power are utilised, depending on the locality of the farm or country residence and the nature and source of the available fuel or water supply. The various methods of generating electricity will be discussed in the following order:

WATERPOWER PLANTS.
STEAMPOWER PLANTS.
INTERNAL-COMBUSTION ENGINE PLANTS.
WINDMILL POWER PLANTS.
ELECTRIC STORAGE BATTERIES.

THE WATERPOWER PLANT

Water Available.—In order to generate electric energy from waterpower, it is necessary to take advantage of a fall of water, and if a natural fall is not available, an artificial fall must be erected; and the higher the fall, the smaller the quantity of water necessary to obtain the desired capacity of the generating plant. It is not necessary that the waterfall be located on the premises or estate, for it may be many miles distant without affecting the result; yet for the sake of convenience, first cost and other kindred reasons, it is desirable to have the plant near at hand.

In many instances, where the stream runs through the property or in the neighbourhood, cheap power may be derived by building a dam across it, thus increasing the height of the water for driving a wheel or turbine. Where the stream is of more than ordinary size, part of the water may be deflected and led through concrete, wooden or steel conduits to the waterwheel. The water discharged from the wheel may, in many cases, be distributed for irrigating purposes, a factor of vital importance in all branches of agriculture, as will be discussed later on.

Water-Wheels.—One of the first essentials is to choose the right type of water-wheel. This depends on the height and volume of water available. For a high-head fall, a Pelton wheel, consisting of a steel disc with buckets mounted on the rim, gives best efficiency. The water is directed against the buckets, causing the wheel to run at high speed. For low-head falls, turbines of the different designs should be chosen to fit the particular cases at hand. A low-head turbine, as the name implies, is designed to use large quantities of water with a low fall. These turbines operate at low speed. There are, of course, many other factors to be considered from an engineering point of view, and much depends upon the ability of the engineer who is chosen to build the plant. With all water-wheels, proper regulating devices must be installed, so that the operation of the plant may be as automatic as possible, thus materially cutting down the operating expenses and doing away with constant attention. It is an easy matter to so equip a small waterpower plant that the entire plant can be started, controlled or stopped from the residence, or from any distant point on the farm, at any hour of the day or night.

Fig. 4. Hydroelectric generating plant on a large farm.

Generators.—The energy of a rotating water-wheel is converted into electricity by means of a dynamo or electric generator, driven either by a belt from the water-wheel or directly connected to its shaft. From the generator the energy is led over copper wires to the switchboard, from which it is distributed to the different places where it is needed, such as in the various power-motors and lights in the house, barn or garden.

The illustration (see opposite page) shows the exterior view of a waterpower plant on a large farm. This plant supplies current to operate all kinds of labour-saving devices and machinery.

The power-house was built by a farmer with up-to-date ideas. His farm had running through it a good sized stream. He conceived the idea of harnessing the water, converting the energy into electricity and using the current to operate his farm machinery. By engaging a competent engineer, he was enabled to get more horsepower than he figured. The engineer designed the proper kind of dam for the stream, and also the best type of house for the conditions at hand.

The most efficient water wheels and generators are best known to engineers, and unless one is well versed in engineering, he is likely to buy machines and apparatus which would not be suitable, because he would not be able to state the correct conditions for his needs. The farmer or any one else putting up a generating station, whether it be large or small, will not go astray by consulting a competent engineer.

Size of Equipment.—It requires close study to ascertain the proper size and most economical machines for the particular conditions. The work on the farm must be divided up so that all the heavy work of different kinds is not being done at the same time. For instance, if the total horsepower for all kinds of machinery amounted to thirty-five it would not be necpower-house is necessary. The starting and stopping of the water-wheel in this case is done from the residence by pulling a quarter-inch steel cable, running over sheaves on the pole-line carrying the copper wires; but this primitive device could better be replaced by an up-to-date method operated by pushing a button in the residence.

The current is used for lighting the residence, the barns and the grounds, and for actuating several electric motors. One 3-horsepower motor, by means of shafting, operates a churn, a cream-separator and laundry machinery; another 3-horsepower motor is installed in a dairy barn for operating milking-machines, while a large 15-horsepower motor is mounted on skids and transported from place to place as desired, for cutting and grinding feed, cutting ensilage, shelling corn, sawing wood and operating a grain elevator and a deep-well pump. The operating expenses of the plant are exceptionally low, amounting to but ten dollars per year, and the total equipment cost only $1200.

Another concrete example of the cost of a water-power plant for farm use, according to

The American Agriculturist, is found in Portage County, Ohio. A dam, 350 feet long, was constructed, of which 320 feet was built of earth, while the remainder was of concrete, so designed as to act as an overflow weir in time of freshets. The water-wheel works under a head of 10 feet, 8 inches, drives an electric generator at a speed of 1300 revolutions per minute, and is able to furnish electric current for 100 16-candlepower lamps, or their equivalent in the working of small motors. The machinery is placed in a small separate building, 12x14 ft., and little attention is required for it, except to start and stop the water-wheel, and to oil the wheel and the generator, which is done every two weeks. The cost of this installation was more than would be required for similar plants, because a long dam had to be constructed and a long transmission was necessary. A brief outline of the cost is as follows:

Dam excavation, etc.	$ 367
Flume	40
Power-house	50
Machinery	236
Transmission-line poles (cut on farm)	20
Copper wires	124
Home-wiring and fixtures	185
TOTAL	$1022

Waterpower Developments on Farms in the State of New York.—Waterpowers on small streams afford the means of bringing many elec-

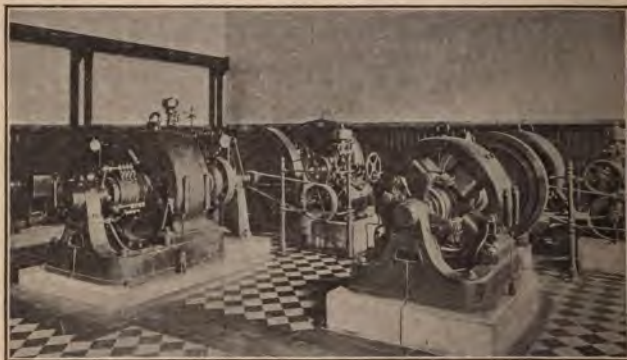

Fig 5. Interior of an hydroelectric generating plant at a large farm.

trical conveniences and labour-saving appliances to neighbouring farm homes. An interesting account of some of these farm-waterpower installations in New York State is contained in an illustrated report, "Water-Power for the Farm and Country Home," prepared by David R. Cooper, engineer-secretary for the New York State Water Supply Commission. After directing attention to the many small streams which might be harnessed to do useful work, the report enumerates the many uses heretofore mentioned for electrical energy on the farm, and in the buildings.

Examples of actual work done by electric power are given by Mr. Cooper, as follows:

A 6-hp.* motor will thresh 250 bu. of oats, grind 20 bu. of corn, grind 48 bu. of feed, grind and press 250 bu. of apples or saw seven cords of hard-oak stovewood an hour, in the last instance taxing the ability of four men to stack the wood in cords as fast as it is sawed. A 12-hp. motor driving a 50-in. circular saw will cut 4000 ft. of oak or 5000 ft. of poplar lumber in a day. A 10-hp. motor running a 16-in. ensilage cutter and blower will deliver ensilage into a 30-ft. silo at the rate of 7 tons per hour. A 1-hp. motor will supply water for ordinary farm-house use.

Actual installations described in the report yield the following data:

At Oneida.—The 100-acre farm of Mr. E. B. Miner, near Oriskany Falls, Oneida County, N. Y., is devoted to hop raising, mixed farming and dairying. The sons of the family studied engineering at college and, becoming convinced of the possible uses of the stream near their home, designed and built up the 17-hp. water-power plant and dam which now supplies the electricity for lighting the farm buildings and saves many chores. This timber-crib dam, 36 ft. long, raising the water four feet, is carried on

* Hp. = horsepower.

heavy concrete sills cast in a 2-ft.x1.5 ft. ditch dug across the stream bed. Above the crest of the dam is a row of 1-ft. flash-boards held erect by chains locked by pins which can be withdrawn by a capstan, dropping the boards in case of high water. There is also a supplementary 40-ft. spillway, with its crest a few inches higher than the main dam, helping to discharge heavy floods. From the dam a 60-ft. canal and forebay leads down-stream to the power-house, where a vertical-shaft 17-hp. turbine wheel is installed. A double-pulley arrangement increases the speed of the water-wheel's rotation to the 1100 r. p. m. (revolutions per minute) required by the 12.5-kilowatt belted generator at the far end of the 12 ft. x 16 ft. power-house.

Oriskany Creek, at the point utilised by Mr. Miner, drains 14 square miles, furnishing throughout nearly all the year the flow required to drive the water-power plant at full load under the available head of 6 ft. From the power-house to the farm buildings, 1700 ft. distant, an aluminum wire is carried on 20-

ft. poles set at 100 ft. intervals. The energy thus delivered is used to operate a circular saw, machine lathe and drill press, vacuum-cleaning system (used also for operating milking-machines in the twenty-five-stall cow-barn), a cream-separator, churn, grindstone, ventilating and cooling fans, electric iron, sewing-machine, egg-beater and water-pump. The house is also warmed by five electric heaters, maintaining an indoor temperature of 75 degrees when it is at zero outside. The water-wheel and generator run continuously night and day, and self-oiling attachments cause the plant to require little attention. Mr. Miner says the waterpower is worth to him several times its cost, which he does not state, but which engineers estimate to have been about $1800 complete for dam, power-house, line and equipment.

At Lake George.—Mr. Stephen Loines, of Brooklyn, has a summer home on the shore of Lake George, his property including a seven-acre pond at an elevation of 180 ft. above the lake. The outlet of this body of water is caught in a 6-inch spiral riveted pipe and conveyed 1600 ft. down a gulley to the little power-house, which contains a 10-hp. 24-inch impulse wheel, operating under a 165-ft. head. The 6.5-kw. generator delivers energy to a sixty-cell house-lighting battery; an eighty-four-cell battery for a 35-ft. cabin launch; a forty-eight-sell battery for a 20-ft. open launch, and a forty-cell battery for an electric roadster, all of which are in nearly continuous use five months in the year. Another development on the estate comprises a 2-inch pipe with a fall of 110 ft. in its 1200 ft. length, operating a 3-hp. impulse wheel used to drive a saw belted to a shaft. An unusual use of hydroelectric energy on the Loines estate is the operation of the roof of the private astronomical observatory just above the cottage. The dome roof is mounted on wheels and is moved by a 1.5-hp. motor.

At Lawyersville.—Mr. J. Van Wagenen, of Lawyersville, Schoharie County, N. Y., a practical and scientific farmer, utilises the 15-ft. head created by a disused saw-mill dam. His 5-hp. water-wheel is belted to a 3-kilowatt, 125-volt generator, the output of which is conveyed over 3700 ft. of pole-line to the houses of the owner and a neighbour. As it was undesirable to visit the plant half a mile away, night and morning, to stop and start the turbine, as well as inadvisable to waste water during the dry season by letting the plant run all the time, the turbine valve has been attached to a pull-wire extending to the bedroom window of a neighbour living 700 ft. distant. Pulling this wire at 5 A. M. starts the plant, and releasing it at night allows a counterweight to drop, turning off the water. For this service of starting and stopping the machine the neighbour gets his electric service free for his house and barn. The cost of maintenance of the plant has been trifling. The owner wired his house at a cost of $40 for material, doing the work himself. The plant cost a little over $500 (see below), the dam being already built and most of the installation work being done by the owner and at odd hours.

Dynamo, 3 kw. (second-hand)	$ 50.00
Water-wheel, 9 kw. (naked wheel)	55.00
Governor (new)	75.00
Wire (7,400 ft.)	210.00
Labour (installing wheel)	40.00
Fixtures (lamps and the like)	2[illegible].00
One small motor 2 hp. (new)	[illegible]0.00
TOTAL	$5[illegible].00

Such a water-plant Mr. Van Wagenen declares to be equivalent to a hired man's services, doing away with many chores and laborious duties about the place.

At Delhi.—Mr. J. T. McDonald has a farm near Delhi, N. Y., which is equipped with three water-wheels utilising the 15-ft. head created by a dam and 900 feet of raceway. A 25-hp. turbine runs a saw-mill and a feed mill; a 3-hp. wheel runs small saws and machine tools; and a 6-hp. wheel drives the electric generator. The turbine gate is opened and closed by a switch in the owner's house, while the field circuit and rheostat are brought to the same point, enabling the voltage to be regulated closely.

Mr. Frank Caspar, in Schoharie County, has a water-wheel driving a generator which lights a furniture factory, church, village street, and his own house. The plant is started and stopped by a pull-wire which opens a small valve admitting water pressure to a cylinder, the piston of which operates the gate.

In addition to a 36-inch impulse-wheel operating under a 210-ft. head and driving a saw-mill on the place of Mr. Arthur Cowee, near Berlin, N. Y., a smaller impulse-wheel is directly connected to a 3-kw. (kilowatt) generator supplying electricity to 160 lamps. The penstock for the main wheel is a 10-inch cast-iron pipe 1680 feet long.

At Chazy.—One of the largest farm waterpower installations in America is that at the "Heart's Delight" farm, of Mr. W. H. Miner. There are two waterpower sources for this. The smaller is a group of three small dams built across Tracy Brook to create storage reservoirs. From the lower of these a 44-inch penstock 670 ft. long carries the water to the powerhouse under a 19-ft. head. Here two turbines, of 30-kw. and 12.5-kw. capacity respectively, are installed, driving 220-volt direct-current generators. At the larger source a concrete dam is built across the Chazy River, and the water is led through a concrete penstock, 48x60 inches in section and 630 ft. long, to a second power-house, where a fall of 30 ft. is obtained. Here two turbines drive alternators, the effect of which is conducted to the farm buildings three miles distant. Hydraulic rams are also used for water-pumping on this farm. Twenty-five motors are installed for a great variety of purposes, for nearly every modern use of electricity is employed on this farm.

STEAM POWER PLANTS

One of the most widely used means of generating electricity is the steam engine. Steam for the purpose is produced in a boiler, by burning coal, oil, wood, refuse, etc., but in most cases coal is used, and that in grades of various qualities.

Coal is divided into two main classes, anthracite and bituminous; the former resembling carbon or coke, the latter pitch or bitumen. There are a number of degrees in the nature of these two qualities of coal, which are graded commercially as semi-anthracite, semi-bituminous, gas or cannel coal and lignite. Some of these coals are very soft, the most recent formations or lignites being the softest, while others are of a hard nature, and very often the classification is made of "hard" and "soft" coal in place of anthracite and bituminous. Anthracite coal is supposed to be the oldest and deepest coal formation in existence.

Engineers rate coal by heat units expressed in British thermal units (always abbreviated B. T. U.), and it should be bought on this basis, because a ton of one kind of coal may produce twice as much available power in a boiler as a like quantity of another grade. On the other hand, with certain kinds of boilers and grates, and possibly additional equipment, more power may be obtained from a lower grade or cheaper coal. It is from such conditions and probable combinations that the kind of coal to be used for the most economical operation is determined.

The user of coal must bear in mind that coal contains a certain percentage of moisture, volatile matter, fixed carbon, ashes and sulphur.

Storage of Coal.—Coal, particularly in large quantities, should be stored under a roof, as otherwise it loses much of its heat value, due to slow chemical changes which start as soon as the coal is mined and continue until it is burned. These losses are greatest with soft coal and greater in warm weather and in the tropics than in cool air. The losses are slight when the coal is fresh, but increase rapidly as it ages. Care must be exercised in the storing of coal to prevent spontaneous combustion, which is more troublesome with soft coal than with hard. The most obvious remedy is to provide proper ventilation, and to avoid storing it in high heaps.

Boiler Room.—The boiler room for a farm or country estate, from the point of view of safety, is best located in a separate house, yet in many instances, conditions warrant the use of the basement of the residence or barn. In any case, wherever the boiler may be placed, the coal-bin must be so located that the cost of handling the coal is a minimum. Along with the handling of the coal, the easy and economical removal of ashes must be arranged.

Engine Room.—The engine room is preferably located alongside the boiler room, separated from it by a partition wall. When this is not possible, the engine must not be placed too far from the boiler room, because then long steam pipes would have to be installed, which will cause the steam to condense in the pipes, even when it travels with high velocity. When large quantities of water, due to condensed steam, get into an engine there are possibilities of accidents. Of course there are instances where the engines cannot be separated from the boilers, as for example in the case of the portable engine mounted upon the boiler.

Size of Engines.—For plants of the size shown, it is the common practice to install two engines, so that on a light load one engine is running, and when the load is heavy both engines carry it. For instance, two 50-hp. engines are installed, and when the load increases above 50 hp. the single engine running will carry the over-load for some time. When the load passes 65-hp., however, both engines must be put into operation, and together might then be called upon to carry a load of up to 130-hp. for some time. In addition, by the adoption of the two-engine installation, repairs on one of the engines can readily be made without shutting down the entire plant.

Efficiency.—The problem involved in the construction of a steam-electric power-plant must necessarily be treated in conjunction with the cost of construction, operation and maintenance; as it is the ultimate aim to produce electricity at a minimum of expense. The efficiency of a steam-electric power-plant is low, ranging from 5 per cent. to 14 per cent. of the heat value of the coal. Fourteen per cent. is extremely economical and can only be secured by the best designed and equipped plant and by scientific operation. The average plant of recent construction operates with an efficiency of from 8 per cent. to 10 per cent.

The following table taken from the author's "Steam Electric Power Plants," shows the approximate loss per pound of coal in a well conducted, first class power plant. It will be noticed that the coal is assumed to have a heating value of 14,000 B. T. U., of which the equivalent of 12.8 per cent. or 1792 B. T. U. are delivered to the switch board.

APPROXIMATE LOSSES IN A WELL-CONDUCTED FIRST-CLASS POWER PLANT, PER POUND OF COAL

	Losses in B. T. U. and Percentages per pound of coal	
	14,000 B.T. U.	100%
Items		
Ashes	210	1.5
Radiation and leakage of boiler ..	560	4.
Radiation and leakage of flue ...	140	1.0
Gases through chimney	1960	14.
Blow-off and leakage	210	1.5
Radiation and leakage of piping .	210	1.5
Friction and leakage of engine ..	140	1.0
Rejected to condensers	8540	61.
Electrical loss	28	0.2
Required for all auxiliaries	910	6.5
Total	12908	92.2

Returned by Feed Water Heater 5 per cent. or 700 B. T. U. (British Thermal Units).

Delivered to the bus-bars $105 - 92.2 = 12.8$ per cent. or 1792 B. T. U.

Since the efficiency of a steam-electric power-plant is so low, every increase in economy, be it even a fraction of a per cent., should be looked after, and it will be to the advantage of the plant owner to consult an engineer who is expert on the subject. The exhaust steam of the engine or turbine, which usually is wasted, can be utilised for heating the feed for the cattle or heating water for general purposes on the farm, or it may be used for heating the residence in winter, or in making ice in summer.

INTERNAL-COMBUSTION ENGINE PLANTS

Where natural or illuminating gas is at hand, or in the neighbourhood, it can be made useful in operating an electric generator set. When not available, a gas may be generated or produced on the premises and used in driving an engine just the same as natural gas. Such installations often are slightly higher in cost at first than a steam plant, but the operating cost is less. Close calculations are necessary to determine which power may have the advantage.

Producer Gas.—The gas-producer plant consists of a producer, scrubber and a gas-tank. The producer is a furnace where the coal is burned at a low rate of combustion. With the hopper and magazine to the furnace properly filled, no attention is necessary for some time. The gas is slowly generated and led to a tank filled with coke, called a scrubber. Here the impurities of the gas are removed by passing through a spray of water playing on the coke. The gas is next led to a comparatively small tank or reservoir, which supplies the gas engine.

Some of the advantages of a gas-producer

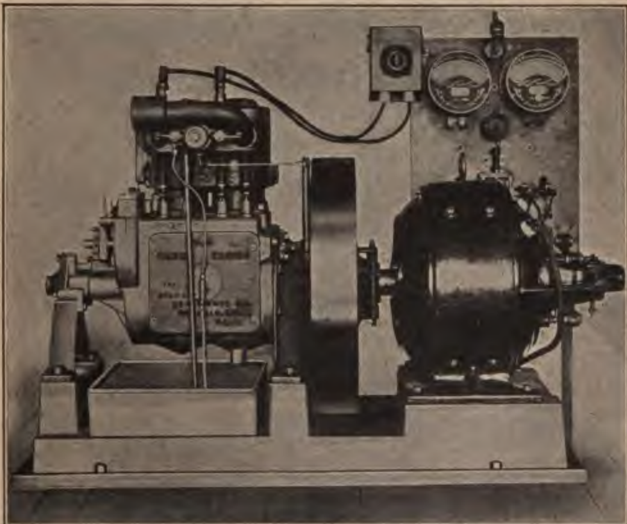

Fig. 6. A small electric generating outfit, consisting of a gasoline motor directly connected with an electric generator.

plant are: economy, simplicity of the machinery, safety in operation, low maintenance cost; no nuisance from smoke, and ease of starting and stopping.

Gas Engines.—A gas engine appears to be very similar to a steam engine, but has this difference, that the steam engine has steam expansion on both sides of the piston-head, while in the gas engine, the gas explosion takes place on one side of the piston-head only. The generator is usually directly connected (mounted on the shaft of the engine's fly-wheel), and in some instances it is driven by a belt from the engine's pulley.

In the producer-gas engine plant, a total efficiency of 15 to 17 per cent. and even higher is obtainable, through the proper selection of machinery making up the plant.

The producer plant can be operated on different kinds of fuel. Those in most common use are "pea" and "buckwheat" anthracite, lignite, foundry or gas-house coke (broken to small size), and in some cases, charcoal. The relative values of different coals can be approximately determined not only by chemical analysis, but by combustion in a coal calorimeter, or by actual trial in a gas producer. With the calorimeter test, the standard unit of heat is the British thermal unit (B. T. U.) defined as the amount of heat required to raise the temperature of one pound of pure water one degree (1°) Fahr. This is equivalent to 778 foot-pounds of energy, from which we find that 1 hp. is equivalent to 2545 B. T. U.'s per hour. The anthracite commonly used has a heat value of approximately 13,000 B. T. U.'s per pound.

The fuel consumption with some producer-gas plants does not exceed 1¼ pounds of pea-size anthracite per brake horsepower per hour, on test-runs at a rated load of 10 to 12 hours' duration. This is equivalent to 16,250 B. T. U.'s of heat supplied per brake horsepower per hour, and to a complete plant efficiency of $2545 \div 16250 = 15.7\%$.

A Gas-producer Plant.—An interesting example of a gas-producer installation is that on a De Kalb County farm in the northern part of Illinois. Here there is a gas engine and dynamo, and a pole-line distributing electricity to about 150 electric lamps, to various types of machinery in use about the farm, and to one small motor in the house. There is also a storage battery of 52 cells, so that electricity is available at night or other time when the plant may be shut down. The owner utilises the gas from his producer as fuel under the boiler of his steam-heating system in the house. Anthracite pea coal is used to charge the producer, and about two bushels per day are required. One hired man operates the plant, and he is enabled to give considerable time to other duties.

Gasoline and Alcohol Engines.—Inspired by the demand for a high state of perfection in this type of machinery for operating automobiles and launches, inventive genius and manufacturing skill have combined to produce gasoline engines fully equal to the best steam engines in reliability, and far excelling them in economy. For years gasoline engines have been built by various concerns to meet the exacting specifications and rigid tests of the United States Government.

This type of engine is of the general "internal-combustion" type, in which the fuel is fed into the engine in the form of a gas previously vaporised in a carbureter, then compressed in the engine and exploded by an electric spark.

Fuel Alcohol.—A very important substitute for gasoline or other fuels used at present, and particularly for the farm, is alcohol, which may be produced by the farmer himself from a variety of materials raised by him. Any of the starchy plants yields alcohol, as the southern cassava, sweet potatoes, white potatoes, and sugar beets. Corn cobs yield 11 gallons of alcohol to the ton, and sweet cornstalks 7 gallons. Many refuse plants may be used and also much unmarketable fruit and vegetable matter. Alcohol, as produced on the farm, is ready to supply light, heat and power when other sources of fuel fail. Many localities in the West suffer for fuel in winter, when storms are severe or railroad cars are scarce. Alcohol manufactured for such use will not be subject to a revenue tax. Potatoes which may be frozen, and of no use for other purposes, are for this purpose equal to good potatoes.

Petroleum Engines.—Instead of using gasoline for fuel, in localities where petroleum oil is more readily obtainable, many engines are designed to run efficiently on the heaviest and cheapest grade of petroleum. Even the Californian crude oils, containing a large percentage of asphaltum, may be employed without the slightest difficulty. On many occasions oils have been tested experimentally, which were too heavy to run from the can at ordinary temperatures, but which on being warmed up became liquid enough to handle and were found to be entirely satisfactory for fuel in an engine. The ordinary grades of crude oil produced by the various refineries as a by-product in the manufacture of kerosene and gasoline are well suited for use in this class of engine; and may be obtained in large quantities at the price of 3 to 5 cents per gallon, depending on the cost of transportation.

The operating expenses of these engines are exceptionally low, and the entire plant is a simple one. It consists of the engine, a small water-circulating system and a storage tank. When the engine is shut down, and the oil supply shut off, all expenses cease until ready to start again. The fuel oil is preferably run by gravity directly from the tank-car in which it is received into a storage tank, from which it is pumped into the engine itself. No refuse of any kind is produced in the operation of this engine. Robinson, in "Gas and Petroleum Engines," tabulates the results of various tests of a 25-hp. oil engine, and shows that the lowest oil consumption per actual or brake horsepower, is a trifle less than 3/4 lb., while the average is just one pound of oil. As the gallon of fuel oil weighs approximately 7 1/4 lbs., it will be readily seen that one horsepower per hour can be produced at a cost of 2 cents. This cost does not include overhead charges such as insurance, interest and depreciation of plant, labour, etc.

WINDMILL POWER PLANTS

Another source of energy for generating electric power is the windmill, which is extensively used throughout the country for pumping water and for other rural puposes. It is a machine which has been in use for some thousands of years to absorb the power of moving air and convert it into useful work. In the early part of the tenth century mills of the Dutch type were in general use throughout western Europe, and with the advancement of the art they have been steadily improved. The Dutch wheels were built from 50 to 100 ft. in diameter and produced from one to ten horsepower. They were used in Holland to operate the water-drainage lifts, for driving mill-stones, and for numerous other purposes requiring power. A few of these wheels were built in America, but the settlement of our great prairies developed a necessity for the use of a smaller wheel, the cost of which would be within the reach of the farmer and ranchman. It was found by various builders that a small wheel, 12 to 15 feet in diameter, filled with wooden slats, would give sufficient power and approximately the proper speed to operate such pumps as were commonly built for hand use.

About 40 years ago the American wheel was made safe and practical by grouping the slats or sails in sections which were pivoted under control of centrifugal governor-weights which altered the exposed surface of the slats, thereby preventing the wheel from running too fast in high winds. Another method of governing the speed of the wheel was by means of a side vane which was attached to a horizontal arm rigidly fixed to the head carrying the wheel, springs or weights being used to retain the wheel perpendicular to the main vane in light winds. High winds acting upon the side vane would turn the wheel slightly, thereby reducing its effective surface and preventing danger-producing speed.

A windmill should be able to run in a light wind; and it should swing easily on its turntable, to enable it to face up in such a light wind. The wheel itself should be at least 15 ft. above all houses, barns and trees, or any other wind obstruction within 400 ft.; in other words, the tower should be high enough to catch the lightest wind which may blow from any point of the compass, and at the same time it should be above eddies and changeable air currents. Fortunately, high winds occur more frequently during the winter months, when most of the grinding, feed-cutting, wood-sawing and other work requiring power is to be done. While a power windmill will do an astonishing amount of work in a moderate wind, the best results can be obtained in winds blowing from 25 to 35 miles per hour. With a 30-mile wind one man can scarcely shovel corn into a two-hole self-feed sheller fast enough to keep the hopper full, and three or four men will be kept busy to handle poles or cordwood and the resulting firewood while operating a wood-saw, while a man with the help of a boy can scarcely sack the feed-meal produced by a mechanically operated grinder.

Windmill Construction.—A power windmill which will not take care of and regulate itself in any wind less than a tornado is an unprofitable investment, as the owner cannot always take advantage of those high winds which really furnish the best power. It is therefore essential in order to obtain the best economy, to select a form designed to take advantage of the moderately high winds. One of the most widely known windmills is a machine built entirely of steel, and properly galvanised to protect it from all kinds of weather conditions. The following table shows the horsepower of such wheels in different wind velocities:

Size of Wheel	10 miles per hour	15 miles per hour	20 miles per hour	25 miles per hour	30 miles per hour	35 miles per hour
12-ft. .	.2	.67	1.6	3.12	5.4	8.5
16-ft. .	.36	1.21	2.9	5.5	8.5	15.3

In tests by Prof. F. H. King, of the University of Wisconsin, a 12-foot windmill of this type connected to a grinder for reducing corn to feed-meal produced the following results:

Wind velocity in miles, per hour	10.4	15.3	20.8	25.9	28.5	31.3
Meal ground per hour, in pounds	139.2	236.8	474.5	831	1005	1068

Oats and other light grains will feed slower than corn in proportion to their weight. Also, if exceedingly fine meal is to be made the quantity will be less in proportion to its fineness.

The 12-foot windmill will grind through the year on an average, 75 to 80 bushels of meal per day, and with proper attachments do all the pumping, feed-cutting, shelling and wood sawing for a large farm. The 14 and 16-ft. windmills are proportionately more powerful.

Electric Generating Equipment.—The windmill is readily and easily applicable to an electric generating set which should be equipped with the automatically regulating devices. Although the windmill plant regulates itself automatically to the speed of the wind, a valuable adjunct to it is a storage battery, which is fed automatically from a generator, and when fully charged is automatically cut out until needed, when it is again put into service, but this time giving up energy instead of storing it. The storage battery is a necessary feature with an electric generating set for any farm or residence.

ELECTRIC STORAGE BATTERIES

The principal function of a storage battery in small plants is the furnishing of current for a considerable period of time, as at night after a generator has been stopped. The operation of the battery consists of cycles of charge and discharge covering practically the capacity of the battery. The engine develops mechanical energy, which is transformed into electrical energy by the dynamo. The storage battery acts just like a water tank; it is a reservoir which stores this electrical energy to be drawn upon whenever needed, so that it is unnecessary to run the engine and dynamo continuously in order to have electric light at all hours of the day and night. Storage batteries may be charged each day, but larger batteries require charging only once in two or three days, and others still larger will store current for a week or more. Batteries require an engine to be run four to ten hours to charge them, the time depending upon how much electricity has previously been used from the battery.

Function and Service.—In plants for farms and country residences, the capacity of engine and generator must be sufficient for the maximum normal load; but during certain hours of each day no such amount of energy is required. This means a low degree of efficiency and high fuel costs. The installation of a storage battery corrects this condition by permitting the operation of the generator at the full or the most economical load and then shutting it down entirely, the battery providing the current for the balance of the time. When on special occasions an extra heavy load is required, the battery may be discharged in parallel with generator, and demands equal to the combined capacity of the battery and generator may be supplied. Also, the generating equipment may be stopped for adjustment or repair without interrupting the service, the battery being always available for unexpected demands for power.

Installation.—Storage batteries for light and power plants are usually installed either in glass jars, glass tanks or lead-lined wooden tanks. The cells of the small type are installed in glass jars resting on a bed of sand contained in a glass or wooden sand-tray, supported by four glass insulators under its corners. Cells of medium capacity are usually installed in tanks of pressed glass resting on insulators capped by small cushions of either lead or rubber to keep the hard surfaces out of contact. Lead-lined wooden tanks are often used for plants of medium size and always for those of large size. This type of cell is assembled at the place of installation. Cells which are not too heavy are generally installed on two-tier wooden racks in order to save floor space. The larger cells are set in one tier, the wooden stringers being supported by vitrified brick set upon the floor or by another set of glass insulators resting on vitrified tiles.

The number of cells is determined by the voltage of the system. Isolated plants of the various voltages require batteries of the number of cells, as follows:

Voltage of System	Number of Cells
110	60
115	64
125	70
220	120
230	126
250	138

The size of the individual cells needed is determined by the number of lamps, their candle-power and efficiency, and the length of time they must be supplied on one discharge.

Rating.—Storage batteries are rated in "ampere hours." This method defines their capacity, and is the product of the number of amperes of discharge multiplied by the number of hours such discharge can continue. The capacity at the eight-hour rate is considered the normal. As the ampere discharge is increased above this rate, the ampere-hour capacity decreases, as will be seen by the following example:

Rate, Hours	Amphere Discharge	Capacity Amphere-Hours
8	$12\frac{1}{2}$	100
5	$17\frac{1}{2}$	$87\frac{1}{2}$
3	25	75
1	50	50

Thus while $12\frac{1}{2}$ amperes may be obtained for eight hours (100 ampere-hours) if the discharge be made at 25 amperes it can be continued for but three hours (75 ampere-hours), the remaining capacity of the battery being, however, available at a lower rate. On discharge at less than the eight-hour rate, the capacity of the battery is slightly greater, but this need not be considered in ordinary calculation.

The size of a 110-volt battery can be approximately determined by the method outlined in the following example, the conditions being that the battery will be charged at any time during the day convenient to operate the generator, and that the battery will be able to furnish current for lamps according to the following schedule:

Time	No. of Lamps		Amperes	No. of Hours	Ampere-Hours
5 P. M. to 10 P. M.	Twenty	16 c. p.	10	5	50
10 P. M. to 6 A. M.	Two	8 c. p.	½	8	4
6 A. M. to 8 A. M.	Six	10 c. p.	3	2	6
					60

The last discharge-rate is three amperes, and there will be required a battery of sufficient size to furnish 60 ampere-hours at a three-ampere rate. This being less than the eight-hour rate a battery having a normal rating of 60 ampere-hours is required.

The above example shows a condition where the full normal capacity of the battery is used in carrying the load.

RURAL POWER DISTRIBUTION

Electric power distribution may be divided into high-tension and low-tension systems, the former used for long-distance transmission and the latter for local distribution. For high-tension lines alternating current is usually used, and for low-tension distribution, the direct or continuous current. Both systems are used with great success, and it cannot be said absolutely whether alternating or direct current is the more advantageous for rural distribution; it depends entirely on the conditions at hand.

Fig. 7. Electric power transmission system on a New York farm.

Direct Current.—In making comparisons between the two systems, the following points may be of interest: In direct-current transmission, the construction of the line is very simple, only two wires being required, which are strung on a single-pole line. The insulators are simple in construction and comparatively cheap, so that a high degree of reliability against a break-down of the line is assured. A direct current may be used as generated directly for power and lighting, and the power-motors of the various farm implements can be connected with the distribution system for lighting. Where large power-motors are connected to a direct-current lighting circuit, however, it is preferable to run a separate power-circuit, as otherwise in starting and stopping the motors fluctuation in a lighting-system may occur. Direct-current motors have a slightly higher efficiency; they are more compact in construction than the alternating-current motors, and they have a greater overload capacity.

The speed-regulating and starting devices of these motors, as well as the wiring system, are very much simpler and cheaper than those of the alternating-current motor system. As indicated, the direct-current transmission system should be used for long-distance transmission, as the current cannot be transformed without the medium of motor generators which are direct current transformers. The latter are far more expensive than the static transformers

Fig. 8. Portable transformer and field telephone connection.

used in connection with alternating current systems.

Alternating Current.—The advantage of the alternating current can best be realised when high voltage is applied. A distant waterpower can be economically utilised with this system, and the voltage can be stepped down to the pressure desired at the place of consumption. The transformers are, of course, extra items of expense, and owing to the power-factor of alternating-current generators larger generators and motors must be used than for equivalent direct-current machines. These machines are therefore slightly more expensive than direct-current ones of equal capacity, and the regulating device is more complicated and more expensive.

Owing to the additional equipment which is necessary in high-voltage alternating-current transmission systems, the efficiency is slightly less than in a direct-current system, but these disadvantages are outstripped by the possibility of transmitting an alternating current a long distance. For instance, in present practise, alternating current is being transmitted about 280 miles, while direct current seldom is transmitted more than 15 miles. By the use of alternating current, cheap fuel or waterpower at a distance may be utilised.

Portable Transformers.—In many instances current is wanted in a certain section of the field for a short time only, and to install a stationary transformer would be poor policy. To fill such an emergency, a portable transformer is used, mounted on wheels drawn by two horses, which can be placed in position in a short time, and then returned to the barn. A number of farmers can own such a portable transformer in common, and a large saving in first cost be thereby gained.

Transmission Lines.—A typical rural distribution high-tension line running through a field is illustrated (Fig. 8). The upper lines are used for transmitting electric power at high voltage while the two lower lines are for a telephone, so that communication between the operator of the farming machinery and the central station can readily be established. It will be noticed that on the pole in the foreground there is a device near the wires of the high-tension lines which is designed to protect the system against lightning. From this lightning-arrester, a wire leads into the ground by which the lightning is led to the ground. Such lightning-arresters are placed at intervals, thus reducing the damage possible from electrical discharges in storms.

QUESTIONS

1. Describe the various advantages of central-station service.
2. What are the sources of power for isolated plants?
3. What is a hydroelectric plant?
4. What should be the size of the equipment in relation to the power developed?
5. Describe the method of calculating the horsepower of a given water.
6. Give a description of a complete hydroelectric installation of an Illinois farmer.
7. Give some examples of waterpower developments on farms in the State of New York.
8. Describe the methods of generating steam.
9. How is coal rated?
10. How should coal be stored?
11. How should boiler and engine rooms be arranged?
12. What is the average efficiency of a well-designed steam-power plant?
13. What is an internal-combustion engine?
14. Describe the action of a gas engine.
15. What is producer-gas?
16. What is the average efficiency of a producer-gas plant?
17. What is an alcohol engine?
18. How could alcohol be produced at the farm?
19. What is an oil engine?
20. What is the cost of producing one hp.-hour, excluding overhead charges, at the engine shaft?
21. As this cost does not include losses in transmission and in motors, etc., would it be fair to compare this cost with the charges made by central-station concerns?
22. How may the wind be utilised to do farm work?
23. Describe the difference between the early Dutch and the modern American windmill.

24. How should the speed of a mill be regulated?
25. Give the horsepower of some windmills of a designated size and wind-velocity.
26. What should the electric equipment of a windmill-power plant consist of?
27. What is the purpose of storing electric energy?
28. Describe the installation of a storage-battery plant.
29. What is the rating of a storage-battery plant?
30. Describe the different systems of rural power distribution.
31. What are the advantages and disadvantages of alternating and direct-current systems?
32. What are the advantages of portable transformers?

Motor-driven centrifugal pump.

CHAPTER IV

ELECTRIC MOTOR APPLICATIONS

SMALL electric motors are revolutionising the methods of performing many of the operations of modern rural life. Almost any process that must be performed repeatedly with little or no variation can be done successfully and much more economically by a motor-driven mechanical device than by any other means. Electric motors in small sizes are rapidly passing from the class of luxuries into the class of necessities, and it is safe to say that within a few years these little labour-savers will be doing the larger part of the routine work on the farm as well as in the home, inn, shop, or factory of the town.

Convenience and Safety.—They may be located in almost any place where current is supplied for electric lights, and can be started and stopped as simply as turning light on or off, so that the machine operated may be placed here or there with sole reference to the convenience of the work to be done, the light, ventilation, etc., and with little regard to the source of power. An ordinary flexible lamp-cord with a connection-plug serves to conduct current for the smaller sizes of motor from any convenient lamp-socket, and the whole device can be moved about, even while working. Perfect safety to the operator, to the motor, and to the material being handled or the work being done, is assured. All conducting parts are effectually covered so that electric shock is practically impossible, and moving parts are so covered that clothing or material cannot be injured. They are so extremely simple that even the most inexperienced person can operate them successfully and safely.

Great Economy.—Economy is also a consideration in favour of small motor-operated devices, many of which, able to do more work than a full-grown person can do by hand, cost not over one cent per hour. Moreover, as current is taken only while the motor is operating, the expense stops when the machine does. The economy of space gained is sometimes an important matter. Motor-operated devices occupy minimum space, and the output of a farm can be materially increased by substituting them for older methods of driving, often in preference to enlarging the space.

The Electric Motor as a Household Servant.—In many a country home the small motor has solved the servant problem, either by making it possible to do without a servant, or by making the work so pleasant and agreeable that good servants are glad to remain indefinitely. Small motors do the hard work, such as turning the washing machine and wringer, moving the carpet-cleaner, floor-polisher, dish-washer, buffing and polishing wheels, etc. The sewing machine, for instance, a necessity in every household, and always so trying to the strength of many housekeepers, can be "run" with perfect satisfaction by a motor, and with practically no effort on the part of the operator except to guide the cloth. After having driven a machine by foot-power, and experienced the resulting feelings of weariness and possibly backache, what could be more agreeable than to have a motor do the work? The tiresome rocking motion of the treadle is no longer necessary; the motor takes all the drudgery, working quietly and tirelessly, for a minute, an hour, or the

Fig. 9. Portable general utility motor for domestic purposes.

whole day as desired,—and all at a surprisingly low cost. The control is perfect, much better than when operating by foot-power, and is easily learned. Pressing a button or turning a small switch starts the motor as easily as lighting or extinguishing an electric lamp.

Slight pressure on the toe of the treadle then starts the machine, and the speed depends entirely on the pressure applied, varying from a

Fig. 10. Motor-operated potato peeler on a farm.

few revolutions per minute to full speed. A single stitch can be taken or the machine can be run rapidly and then stopped almost instantly.

Motors are extensively used for driving washing and wringing machines. The presence of such motor-operated machines in the household is a very material aid in solving the servant question, since thus the more laborious and distasteful features of wash-day are eliminated. The operation is extremely simple and can be readily learned by any one. When the clothes are in the washer and the cover is in place, a turn of the switch starts the motor. No attention is required, and since no rubbing is necessary the clothes are not torn or injured. The power is easily transferred from the washer to the wringer, when the clothes can be fed through the rolls.

Thus small motors are demonstrating in a practical way the advantages of individual motor-drives for small machines, and are successfully operating thousands of labour-saving devices. The following is a partial list of machines which may be advantageously so driven, and for many of these services no other form of power could be used, and in no case could any other power compete successfully with the small motor.

Air Pump	Portable Motor Outfit
Water Pump	Hay Press
Churn	Thresher
Cream Separator	Ensilage Cutter
Cow Milker	Bone Cutter
Feed Cutter	Drier

Corn Sheller	Wood Surfacer
Shredder	Planer
Drill	Mangle
Horse Clipper	Elevator
Ice-Cream Freezer	Refrigerator
Ice Machine	Meat Grinder
Washing Machine	Lathe
Ironing Machine	Circular Saw
Sewing Machine	Band Saw
Vacuum Cleaner	Ice-Making Machine
Hay Hoist	Sprinkling System
Grist Mill	Plough
Husker	Truck

In selecting a motor to drive a given machine, great care should be used to choose one suitable to the particular purpose in view. It is evident that too large a motor will make the outfit unnecessarily expensive; on the contrary, if the motor is too small, failure will result. The motor must be of proper size and must be adapted to the work in order to produce the most satisfactory results.

Nearly all such machines may be operated by portable motors, so that one or two motors (preferably of two different sizes) will suffice to run a dozen or even more machines at once. To facilitate application, the motors, particularly those of small size, are placed on trucks or hand-carriages, and the latter arrangement makes it possible and convenient for the motors to be carried up and down stairs by two persons. Large motors, say above two-horse-

Fig. 11. Motor-operated dishwasher and exhaust fan in a farm kitchen.

power, are best placed on a small hand-truck, or on skids, and drawn from place to place by hand or by horses. With each motor goes a long flexible insulated copper cable and a plug, by which connection is readily made with the distribution system through outlets located at convenient places.

Group Drive.—Where it is possible to have several farming machines such as dairy apparatus, laundry machinery, blacksmith-shop

Fig. 12. An electrically operated dairy. Churn, butter machine and separator, operated from a common motor by means of counter, shaft and belts.

machinery, etc., in a single room, it is best to operate all of them from a shaft driven by a single motor. Leather belts are used to transmit the power from the driving shaft to the several machines and such a system as this is known as a "group drive."

The illustration (Fig. 12) on the opposite page gives a striking example of electrically operated machinery in a dairy of a large farm. The first thing noticeable is the use of the group drive. The motor and starter being on the floor are easily accessible and the shaft being on the ceiling is out of the way, while it also serves to give the belts their proper length. As the motor and shaft have a fixed speed, and the various machines require different speeds, it is only necessary to use pulleys of various sizes to get the correct speed on each machine. As the periods of operation of the machines differ, and as it is thus necessary to stop a single machine without shutting down the motor and thus stopping all machines, each machine has adjoining the driven pulley an idler pulley which turns loose on the machine or shaft. When the machine is to be stopped the belt is slipped on to the idler pulley and the machine comes to rest while the belt continues to run. Although the original machinery is installed by competent engineers, alterations are often desired later by the user to accommodate additional machines; and as it is necessary to calculate the size of pulleys and belts required to drive the additional machines the following data (see page 98) may be of assistance.

Belt Transmission.—A simple rule for ascertaining transmitting power of belting, without first computing speed per minute that it travels, is as follows: Multiply the diameter of the pulley in inches by its number of revolutions per minute, and this product by the width of the belt in inches. Divide the result by 3300 for single belting, or by 2100 for double belting, and the quotient will be the amount of horsepower that can be safely transmitted. The resistance of belts to slipping is independent of their breadth, consequently there is no advantage derived in increasing that dimension beyond what is necessary to enable the belt to resist the strain to which it is subject.

A leather belt will safely and continuously resist a strain of 350 lbs. per square inch of transverse section, and a section of .2 of a square inch will transmit the equivalent of 1 horsepower when running at a velocity of 800 feet per minute over a wooden drum, and .4 of a square inch will transmit a like power running over a turned cast-iron pulley.

Long belts are more effective than short ones.

A single belt, 1 inch wide, travelling at a velocity of 800 feet per minute will transmit 1 horsepower.

A double belt, that is a belt of two layers of leather, 1 inch wide, travelling 550 feet per minute, will transmit 1 horsepower.

When a double belt is long and runs over large pulleys, it may be calculated to do 1 horsepower of work at a speed of 400 feet per minute.

The upper side of the pulley should always carry the slack of the belt.

To throw a belt on to its pulleys properly after it has been laid off requires that it should always be laid first over the pulley that is not in motion, and then be thrown over the edge of the moving pulley to its face. A belt will transmit about 30 per cent. more power with a given tension when the grain (smooth side of the leather) is in contact with the pulley, than with the flesh side turned inward. The leather is also less liable to crack, as the structure on the flesh side is less dense, and the fibres

Fig. 13. Motor-driven pump, showing flexible cable between motor and permanent outlet of wiring system at wall.

more extensible. The adhesion of belts is greater on polished pulleys than on rough pulleys, and is about 50 per cent. greater on a leather-covered pulley than on a polished iron pulley. Belts should be kept soft and pliable by applying tallow occasionally, and neat's-foot or liver oil mixed with a little resin when they become hard and dry. Rubber belts should always be kept free from grease or animal oils. If they slip, moisten the inside of the belt with boiled linseed oil. Some fine chalk sprinkled on over the oil will help the belt.

Size of Belts.—In calculating the length of a belt, add the diameter of the two pulleys together, multiply by $3\frac{1}{8}$, divide the product by 2, add to the quotient twice the distance between the centre of the shafts, and the product will be the required length.

For example, to ascertain the length of a belt for a twelve-inch pulley and a six-inch pulley, on shafting 5 feet and 3 inches between centres: Add the diameters of the pulleys together $(12 + 6 = 18$ inches$)$; multiply 18 by $3\frac{1}{8} =$

$$\frac{18}{1} \times \frac{25}{8} = \frac{450}{8} = 56\frac{1}{4} \text{ inches.}$$

Divide $56\frac{1}{4}$ by $2 = 28\frac{1}{8}$; add to the quotient $28\frac{1}{8}$ inches, twice the distance between the centre of shafts $(10' - 6'')$ equals 12 feet $10\frac{1}{8}$ inches, the required length.

This is only a rough rule, and in ordering a belt it is a good policy to add from five to ten per cent., which may be cut off when the belt is put in place. It is also a good rule, when there is plenty of room, to place the machinery so that the distance from centre to centre of shaft is twenty times the width of the belt.

The horsepower of any belt equals its velocity in feet per minute, multiplied by its width and divided by 800 for single and 550 for double belts.

Size of Pulleys.—Rules for determining size and speed of pulleys or gears are as follows:

(The driving pulley is called the *driver,* and the driven pulley the *driven.* If the number of teeth in gears is used instead of diameter, in these calculations, number of teeth must be substituted wherever diameter occurs).

To determine the diameter of the driver, the diameter of the driven and its revolutions, and also the revolutions of driver being given:

$$\frac{\text{Diameter of driven} \times \text{revolutions of driven}}{\text{Revolutions of driver}} = \text{Diameter of driver}$$

To determine the diameter of the driven, the revolutions of the driven and diameter and revolutions of the driver being given:

$$\frac{\text{Diameter of driver} \times \text{revolutions of driver}}{\text{Revolutions of driven}} = \text{Diameter of driven}$$

To determine the revolutions of the driver, the diameter and revolutions of the driven, and the diameter of the driver being given:

$$\frac{\text{Diameter of driven} \times \text{revolutions of driven}}{\text{Diameter of driver}} = \text{Revolution of driver.}$$

To determine the revolutions of the driven, the diameter and revolutions of the driver, and diameter of the driven being given:

$$\frac{\text{Diameter of driver} \times \text{revolutions of driver}}{\text{Diameter of driven}} = \text{Revolution of driven.}$$

Portable Motors.—Electric motors required for threshing and other heavy machinery, are larger and heavier than the small motors. As

Fig. 14. Hay cutter operated by portable motor, equipped with three different sizes of pulleys, suitable for different speeds of driven machinery.

the large threshing and other machines are located in various parts of the farm, the motors and starters are placed in wagons and hauled to the grounds by horses. The motors are placed in a closed carriage, the pulley end of the shaft projecting through the side of the carriage. The belt is readily applied to the motor and threshing or other machines to be driven. A flexible cable is easily connected to a convenient plug of the wiring system at the barn, or on a pole in the field.

As with ordinary threshing and other machines which are shifted from one farm to another, a motor mounted on such a truck may be sent from farm to farm, thus saving expense. A village or group of farmers may own a single such machine in common or a progressive farmer may own one and rent it out. The following tables give the horsepower required to operate various machines:

FARM MACHINERY

Thresher	5	Hp.
Cow Milker	½	"
Grindstone	¼	"
Grist Mill	15 to 30	"
Refrigerator	5 to 25	"
Pump	½ to 25	"

HAY PRESS

14″ x 18″	Bale Chamber ..	Capacity,	12	tons	per	day.	3	Hp.
16″ x 18″	" ..	"	14	"	"	"	4	"
17″ x 22″	" ..	"	16	"	"	"	6	"
14″ x 18″	" ..	"	10	"	"	"	2	"
16″ x 18″	" ..	"	10	"	"	"	2	"
17″ x 22″	" ..	"	12	"	"	"	3	"

Makes a bale of approximately 120 lbs.

FEED GRINDER

8″ large or small make . . .	Capacity,	8 bu. per hr.	4 Hp.
16″ ” ” ” ” . . .	”	36 ” ” ”	10 ”

Machine runs at 75 r. p. m. for each H.P.

10″	Capacity,	15 bu. per hr.	6 Hp.
10″	”	50 ” ” ”	15 ”

HUSKER

6 roll.	Capacity,	all that one man can carry	15 Hp.
Two 6 roll.	”	300 to 400 bu. per hour	12 ”
4 roll.	”	175 ” 250 ” ” ”	8 ”
2 roll.	”	100 ” 200 ” ” ”	4 ”

COMBINATION CHURN AND BUTTER-MAKER

Capacity	
50 Gals.	1 Hp.
100 ”	1 ”
200 ”	2 ”
300 ”	2 ”

PASTEURIZER

600 lbs. . . . . 2 Hp.

CREAM SEPARATOR

Capacity,	350	gal. of milk per hr.	½ Hp.
”	450	” ” ” ” ”	½ ”
”	650	” ” ” ” ”	½ ”
”	850	” ” ” ” ”	1 ”
”	1000	” ” ” ” ”	1 ”

QUESTIONS

1. What are the advantages of using electric motors for operating farm machinery?
2. Is it safe to use an electric motor in the barn?
3. Where can electric motors be applied?
4. What are the different kinds of machinery to be operated on the farm?
5. Describe the group-drive method.
6. Calculate the size of belt for a motor of given horsepower.
7. What are the proper speeds of single and double belts?
8. Calculate the size proper of pulleys under given conditions.
9. What benefits are to be derived from a portable motor?

CHAPTER V

COST OF ELECTRIC OPERATIONS

IN order to give in concrete form, an estimate of the amount of electric energy necessary on a farm, the following figures from a 100-acre farm are given. It is assumed that two-thirds of the products are of a stalk nature, and that the live stock of the farm includes three horses, ten cows, fifteen swine, etc. The figures are not fictitious, but are an average, taken from the actual experience of a number of farms. It is also assumed that electric energy for power purposes is five cents per kilowatt-hour, which is a reasonable figure for current used for power only, when purchased from a public-service corporation.

Pumping Water.—The water-pump is the most necessary part of the farm equipment, and in nearly every case is the first thing to be operated by electrical energy. The average water consumed on a 100-acre farm is as follows: for the house per head per day, 5 to 6 gallons; for cattle from 12 to 15 gallons per

Fig. 15. Small portable motor.

head; for swine or sheep 1 to 2½ gallons. For pumping 1,000 gallons to a tank elevated 35 ft., the power necessary is about ⅛ kwh., at a cost of 5 cents, so that the yearly average energy for 3 horses, 10 head of cattle, and 15 swine is about $4.

Threshing.—For a threshing machine of the smaller size, capable in ten hours of threshing, cleaning and sacking, ready for the market, 80 to 200 bushels, 3 to 5 electric horsepower are required. For machines of from 160 to 240

Fig. 16. Portable motor and controller operating thresher.

bushels capacity 5 to 7 horsepower are necessary; and for 300 to 800 bushels, from 10 to 20 horsepower are required.

The energy required for the various products to be threshed and cleaned, per 100 bushels is, for rye, 25; wheat 22; oats 19; barley 21 kilowatt-hours, or on the average, 22 kwh., costing $1.10, which is at the rate of 1.1 cents per bushel. If hay-baling machines are attached to the thresher from 4 to 6 additional horsepower are required.

Fodder Preparation.—Fodder cutters, varying from 1 to 2 horsepower consume per 100 lbs. of fodder 1-80 kwh. costing 1-16 cent a cut, and as 10 head of cattle consume per year 60,000 lbs. of cut beet, etc., the total yearly cost for the energy used to operate the fodder machines is 50 cents per head.

One of the by-products of cotton-seed or linseed-oil mills is sold as meal or as cake, and to break it up a special machine is needed. Such a machine often has a capacity of 2000 to 3000 lbs. per hour. The average food per head of cattle is 2 to 3 lbs. per day, which amounts, for 10 head, to about 9000 lbs. per year. The cost of electric energy for operating this machine is 25 cents a year per head.

As the cattle are fed from 2 to 3 lbs. of crushed grain per day per head, and as there are 10 altogether in the 100-acre supposition, a motor-driven grain-crusher is needed capable of crushing some 9000 lbs. per year. This could be prepared at one operation by a large mill, but for the purpose at hand, a motor varying from 3 to 5 horsepower, according to the size of the mill employed, will do the work con-

Fig. 17. Butter churn operated by direct geared motor.

veniently. To grind 100 lbs. costs 3 cents for the energy consumed, or for the 9000 lbs., $2.70 per year.

Cream Separating and Churning.—For running the cream separator, a small motor, about ¼ hp., can separate 300 quarts of milk per hour, consuming .3 kwh., at an expense of 1½ cents. As the average production for 10 cows is about 30,000 qts. per year, the yearly cost for operating the separator is $1.50.

A churn for 300 quarts of milk, assuming average conditions, requires from ¼ to ½ hp., as also does the butter-kneader, and the cost is negligible.

Vacuum Cleaners.—A comparison of the costs of vacuum cleaning with a large and a small machine will serve to illustrate the importance of proper selection and arrangement of apparatus so that the overhead charges will not prove disadvantageous. A portable vacuum-cleaning machine operated by a ¼-hp.-motor, costing complete $125, is used by one woman for 260 hours per year, cleaning 208,000 square feet of surface. It cleans 500 square feet of surface in 30 minutes. The cost including everything is $43.19 for the year. A large vacuum-cleaning machine, operated by a 3-hp.-motor, costing $1365 and capable of cleaning 14 rooms, or 2500 square feet of surface, in 1 hour and 53 minutes, is used twice weekly. It carries a 26.5-inch vacuum, which is piped throughout the house, with a controlling rheostat on every floor. The vacuum in use is about 10.5 inches. The apparatus is used 156 hours, cleaning 260,000 square feet of surface and requiring the time of one woman. The total cost is $248 per year, or 9½ cents per 100 square feet of surface cleaned.

In the small machine the cost of cleaning is but 2 cents per 100 square feet of surface cleaned. This fact is due to the cost of installation, the larger machine costing eleven times as much as the smaller. Thus the depreciation is $136.50 per year and interest $81.90, a total of $218.40, compared to $20 for the smaller machine. In this instance the depreciation estimate is quite high for the stationary equipment of the large machine, since a considerable part of the installation consists of piping which will last for many years.

To get the best results from the installation of electrical machines, it is thus necessary to exercise judgment as to the machines and the method of installation. The farmer is too apt to overlook the overhead charges and consider the cost as simply the amount of the running expense. The same tendency is seen in many waterpower plants, both large and small, in which unnecessarily large turbines and equipment are installed, so that when depreciation

Fig. 18. View in farm laundry showing motor-operated washing machine and centrifugal dryer.

and interest are figured, although the water costs nothing, the power costs more than it would if taken from a steam plant using purchased fuel.

Washing Machine.—A washing-machine, including wringer, operated by a ¼-hp. motor, costing complete $165, is used 260 hours a year, or some five hours a week. As other work can be done by the woman operating it, her time amounts to but 65 hours during the year. The machine turns out three washes an hour, and the total expense of the whole 780 washes is $35.41. This includes all labour, power and every expense, including overhead charges, and the same applies to the figures for the following machines.

Horse Groomer.—A horse-groomer costing $75, operated by a 1-hp. motor, cleans four horses in 36 minutes. It is used 328.5 hours during the year, or 2190 groomings, and requires the services of but one man. The cost amounts to $72.93 or 3½ cents per horse per grooming.

Cream Separator and Churn.—A cream-separator having a capacity of 1350 pounds per hour is operated by a 1½-hp. motor, and costs $350 complete. It is used 183 hours during the year, separating 237,900 pounds of milk at a cost of $88, or 3.7 cents per 100 pounds.

A butter churn having a volume of 300 gallons and a capacity of 100 gallons per churning, operated by a 2-hp. motor costs $118.50. It is operated 88 hours a year, churning 15,000 pounds of butter at a cost of $36.60 or two-tenths of a cent a pound. This includes churning, washing and working the butter ready for packing.

Meat Grinder and Stuffer.—The plant for making sausage consists of a grinder, a mixer and a stuffer. The grinder has a capacity of 750 pounds an hour and costs $71. It is operated by a 4-hp. motor costing $145, a total equipment-cost of $216. It is used 80 hours a year and grinds 60,000 pounds of sausage at a cost of $60, with one operative, a cost of one-tenth of a cent a pound.

A sausage-stuffer complete, costing $229.56, stuffs 116 pounds an hour with two operatives. It is used 517 hours a year, stuffing 60,000 pounds at a cost of $226 or 37-100 cents a pound, which with the grinding makes the manufacture of the sausage cost slightly less than half a cent a pound, ready for boxing.

Hay Hoist.—The hay-hoisting motor is one of 10-hp. and costs \$163; in addition, the rigging costs \$105. The barn is 300 feet in length and the hay has to be raised 25 feet and distributed on either side an average of 75 feet. A load of 2450 pounds is hoisted and placed

Fig. 19. Domestic electrically operated ice-cream freezer.

in position in 13 minutes. The overhead charge is \$42.88 a year, and the cost of placing a single load of one ton is 2½ cents for power and 10 cents for labour, in addition to the overhead charge.

Root Cutter.—A root-cutter with a capacity of 6 tons of turnips an hour costs \$26.30, and is operated by a 2-hp. motor costing \$86. It is used 52 hours a year, principally during the winter months, cutting 300 tons of beets and turnips at a cost of $35.94 or 11.9 cents a ton.

Milling.—The milling plant is provided with several machines operated by a 25-hp. motor in

Fig. 20. Motor-operated separator.

another building. The oat-rolling machine has a capacity of 111 bushels of rolled oats an hour, is used mostly during the winter and rolls about 40,000 bushels of oats a year. The labour and power cost is four-tenths of a cent a bushel. A grist mill, operated by the 25-hp. motor when the oat-roller is not in use, has a capacity of

70 bushels of cracked corn an hour. It uses $\frac{1}{4}$ more power than the oat-roller. A corn-cracking machine, for supplying cracked corn to the grist mill is operated by the same motor, and the power used is practically the same. In the same plant are also corn-shelling, corn-grinding and fine-corn-grinding machines, similarly operated from the same motor. The plant is thus very complete, and grinds some 16,000 bushels of corn a year in addition to the 40,000 bushels of rolled oats. Such a plant is, of course, far too large for the average farm, and is large enough for the ordinary requirements of a whole countryside. A farmer with an advantageous power-site could readily co-operate with his neighbours in the establishment of such a plant.

Fodder Cutter.—A fodder-cutter, having a capacity of 3 tons an hour of dry fodder, costs \$128.10 and is operated by a 10-hp. motor costing \$118.50. The outfit is used 88.70 hours a year, and will cut 180 tons of fodder at a cost of \$54.85, with one operative, a ton cost of 30 cents a ton.

QUESTIONS

1. What does it cost to pump 1000 gallons of water to a height of 35 feet, assuming that one kilowatt-hour costs 10 cents?
2. What is the horsepower required to thresh 80 to 200 bushels of wheat?
3. What is the horsepower required for fodder-cutters?
4. Does not the capacity of the motor depend on the size of the machine to be operated?
5. What is the cost of operating various types of vacuum-cleaners, assuming 5 cents per kwh. as the cost of current?
6. Calculate the cost of operating milling plants, assuming 5 cents per kwh. as the cost of current.

Electric heating pad.

CHAPTER VI

MANUFACTURE OF FARM BY-PRODUCTS

THE farmers in a community may combine and erect a co-operative electric plant for taking the surplus of vegetables, fruit and other plants, and converting it into various forms of by-products. Where the central station is operated by steam or gas, the drying of leaves of beets and potatoes for cattle food, and the drying of potatoes, as later described, may be conveniently carried on. Many of the products of the farm which are now allowed to go to waste, could thus be turned to good account, and made into marketable goods.

Sugar.—Nearly all fruit is rich in sugar, varying in contents from 5 to 10 per cent. Of the common fruits, the grape yields the largest percentage of sugar. The normal wine-grape contains from 16 to 30 per cent., with an average of 20 per cent. The two most important plants for yielding sugar, are the sugar-cane and sugar-beet. The Louisiana sugar-cane con-

Fig. 21. Fruit press operated by stationary motor to make farm by-products.

tains 19 to 40 per cent. of sugar, while sugar-beets yield from 12 to 18 per cent. of sugar. Sorghum contains in the stalk, at the time the seed is matured and the starch hardened, from

8 to 15 per cent. of sugar, and Indian corn contains from 8 to 15 per cent. according to the report of the U. S. Department of Agriculture.

Cider.—In packing fruit for market, such as apples, grapes, etc., only sound fruit is selected, that which is in any way bruised or in the first stages of decay, being thrown out. Instead of allowing this refuse to go to waste, it may, by the use of electric-operated presses, or stills, be turned into cider or grape-juice. The pomace which remains may be used as fertiliser for the soil. The amount of electric energy needed to operate the machine necessary for such purposes is less than 5 horsepower.

Starch.—Farm products from which starch may be obtained as a by-product are the potato and cassava. The American potato contains 15 to 20 per cent. of starch, which in turn may be converted into alcohol. In many instances potatoes are accidentally exposed to severe cold frosts, or are frozen in storage, and thus rendered worthless. In Europe potatoes in such condition are made to yield a considerable percentage of alcohol of high strength. This especially is a common practice in Germany.

Cattle Food.—Recent German reports, in stating facts on electrically operated farms, show that since the engineer has worked in harmony with the farmer a number of plants have been installed for drying the leaves of the potato and the beet, to be used as food for cattle, because they are high in protein or fat-producing elements. The records show that 24 million tons of green leaves are utilised for drying yearly, giving about 6 million tons of preserved food stuff having a value of nearly $12,000,000. The annual yield of potatoes in Germany amounts to some 50 million tons; which when put into bins for storage shrink in value about 10 per cent., with a loss of approximately $25,000,000.

By-Products from Potatoes.—In these days of rising values of all meat products there is a demand for a manufactured product which will aid materially in decreasing the cost of cattle raising, and this is particularly true where stock raisers are largely dependent upon fodder transported from a distance.

The potato crop of 1912 was the greatest in the history of the United States, aggregating

401,000,000 bushels for white potatoes alone. It is estimated that approximately 36,000,000

Fig. 22. Grist mill machinery on a New York farm, operated by portable motor.

bushels of that year's crop were furnished by Michigan, 28,000,000 bushels by Minnesota and 32,000,000 by Wisconsin.

Within the last ten years numerous plants have been installed throughout Germany to utilise a vast amount of potatoes for making potato flakes, potato cakes, dried potatoes and potato flour. In 1901, when the crop of the country reached the enormous total of 53,682,010 short tons, efforts were made to discover practical and economical methods of preserving potatoes so that the surplus could be stored and utilised in supplying future demands. Prizes were offered and a number of processes were submitted, in the more important of which the potatoes are dried by steam, forming what are called "kartoffelflocken," or potato flakes, which can be used for feeding stock, for distilling alcohol, for making starch, and for other purposes for which potatoes are used, or they can be ground and bolted for human consumption.

According to the U. S. Daily Consular Report, there are 436 plants established in Germany for drying potatoes with an estimated production annually of 110,230 to 165,345 short tons, or 3,674,000 to 5,511,500 bushels. Of the above plants, 350 are for the production of potato flakes, and in 86 plants the potatoes are cut in dice or slices and then dried. Of the 327 plants in operation during the season of 1910-11, besides potatoes 13 dried grain, 11 dried the leaves of sugar-beets, and 20 dried other agricultural products; 181 of the plants worked day-and-night shifts of 12 hours each. The 417,641 tons of potatoes used by the 327 drying plants in 1910-11 equalled 15,345,659 bushels of 60 pounds each. The following is a brief description of some of the principal systems in operation in Germany and which could advantageously be introduced into the United States and Canada.

Potato Flakes.—In one process for the production of flakes, the raw potatoes are washed in such a washing machine as is commonly used in distilleries or starch factories, and then conveyed by an elevator to a steamer erected over the drying apparatus, where they are cooked by means of low pressure steam, as if the potatoes were to be used for feeding stock. The drying apparatus proper consists of two smooth, hollow, cast-iron revolving drums, about 4 feet long and 2 feet in diameter, each with a clearance of about 0.039 inch. The drums are supported upon a cast-iron framework, on the top of which there is an iron hopper fitted at the bottom with emasculators, or crushers. The drums are heated by steam of 5.5 to 6 atmospheres led through a pipe passing through their axes. The interior of the drums are ridged longitudinally. Condensed water is taken from the drums by two small pipes and returned to the boilers.

The potatoes after being steamed are allowed to fall by gravity into the hoppers and through the crushers, where they are reduced to pulp, and in this shape are forced on to the drying drums which turn in opposite directions at five revolutions a minute. The heat drives off the moisture of the potato pulp, leaving a firm mass that is scraped off by means of knives set parallel to the main axes of the drums. The dried mass falls into a spiral transporter fitted with revolving arms, where it is broken into flakes and conveyed to the packing room.

In another system for producing potato flakes the potatoes are washed, then thoroughly steamed, after which they are passed between two rollers heated to 284° F.; the thoroughly crushed and dried substance in the shape of small flakes is then removed from the rollers by stationary knife blades and passed through a cooling funnel, after which it is ready for use or storing. A third system consists of washing potatoes, then after crushing them into a cold pulp, the matter is passed into a gas or steam-heated drum for drying purposes; when thoroughly dry it is spread for cooling and then ground into flour.

There are many other systems but the above will suffice to show the fundamental principles for manufacturing potato flakes and potato flour.

The price of potato flakes varies from 14 to 16 pfennigs (3.3 to 3.8 cents) per kilo (2.2 pounds). The estimated cost of the production of the flakes is 6.30 marks ($1.50) per 50 kilos (110.2 pounds).

Potato Flour.—In the production of potato flour the flakes are ground and bolted. There are but few concerns that manufacture the flour, each having its own process. The flour is a yellowish-white product, rich in carbohydrates. According to experiments made by the "Institut für Gärungs-Gewerbe" (Institute for the Fermentation Industry) in Berlin, the principal constituents of the flour are: Water, 10.69 per cent.; protein, 6.59 per cent.; fatty sub-

Fig. 23. Electric-operated grain mill on a large farm. A single motor drives a group of machines.

stances, 0.23 per cent.; and ashes, 2.58 per cent. This flour is used principally by bakers for adding to rye and wheat flour in making bread. The proportion for wheat bread is 5 to 10 per cent. of the ground potato flour, and for rye bread the amount can be increased to 15 per cent. It is claimed that the addition of potato flour to rye or wheat flour gives bread a good flavour, makes it more digestible, and keeps it fresh for a comparatively long time. This flour is also used to a slight extent in thickening soups and sauces. It is known to the trade as "Walzmehl" "Kartoffel Walzmehl," "Patent Walzmehl" and "Fiddichower Walzmehl." The prices vary according to the potato crop and the quality, and range from $4.76 to $7.14 per 100 kilos (220.46 pounds).

Miscellaneous By-Products.—There are many vegetables and plants grown on the farm which can be converted into one form of by-product or another, and especially into alcohol. There is over twenty per cent. of starch in the South Carolina sweet potato, for example, and as high as 2600 lbs. of starch per acre has been produced. The average yield of sweet potatoes per acre is of course much less than in the South Carolina case, where heavy fertilisation was practised. On plots to which fertiliser was not added, the yield was about 8000 lbs. of sweet potatoes an acre, yielding in round numbers, about 1900 lbs. of starch. The quantity of sugar in the 8000 lbs. was about 350 lbs., which makes about 1250 lbs. of fermentable matter. This can be turned into industrial alcohol yielding about 160 gallons of 95 per cent. proof.

QUESTIONS

1. What by-products are to be obtained on the farm by m of electric power?
2. What was the potato crop of the United States in 1
3. What are the by-products from potatoes?
4. What are potato flakes?
5. What is potato flour?
6. What are the principal sources of industrial alcohol?
7. What is the percentage of sugar in various fruits?
8. What is understood by "the co-operative system" in nection with farm by-products?

Electric stove.

CHAPTER VII

PRESERVATION OF FARM PRODUCTS

NEARLY every farmer can make use of a cold-storage plant, to keep meat in proper condition, and to prevent butter, milk, eggs and other perishable goods from spoiling. The greatest benefit of such cold storage for the farmer lies in the fact that he is not forced to ship his goods immediately to market, for he can preserve them until the market prices advance. In many cases, especially with fruit, the farmer is forced to let his product lie on the ground and rot, because the price offered does not pay the expenses of picking, packing and shipping his goods to the commission merchants. A cold-storage plant would enable him to pick fruit in the proper season, and keep it until the price becomes profitable.

Cold Storage of Fruit.—Some kinds of fruit are better adapted to storing in cold temperatures than others, and are in active demand through a longer season. Winter apples and

Fig. 24. Motor-operated ammonia pumps (chain connected) in ice-making plant on a New York farm.

pears can be kept in good condition for long periods in cold storage, and a large part of the late apple and pear crops is now so held annually to insure a supply of these fruits in good condition throughout the winter and spring months. On the other hand, berries and other small fruits are not stored to nearly so great an extent, on account of their highly perishable nature.

The storage of small fruits is a problem somewhat different from that of the more durable fruits. Winter apples and pears are usually too hard and immature when stored to be fit for immediate consumption. Cold storage insures the safe keeping of these fruits, and under proper management brings out their finest flavour and quality. The fruits ripen slowly in the low temperature of the storage house, acids diminish, the starch changes to sugar if the transformation is not already completed when the fruit is stored, and the fine flavour and aroma of the fruit are developed.

Small fruits held in cold storage are placed there to protect them temporarily from decay until they can be placed in the hands of the consumer. Shipments of small fruits are frequently delayed in transit and reach their destination too late for the early morning market. There is often little opportunity of disposing of them until the following morning, or in case of the late arrival coming on Saturday the fruit can not be sold until the following Monday morning. Without artificial refrigeration, the fruit would deteriorate rapidly, and in

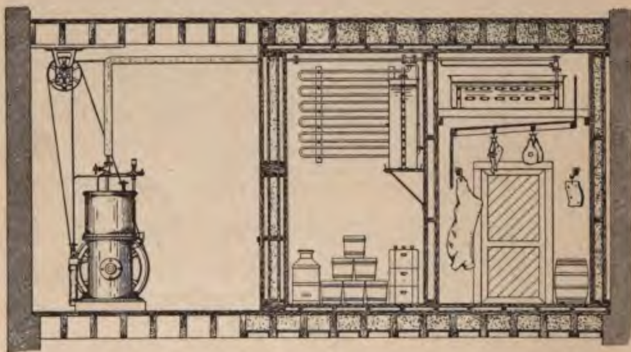

Fig. 25. Electric-operated refrigerating plant for farms, butchers, restaurants, etc. The surrounding brine tanks will keep the boxes cold during the time the machine is not running.

many cases would become worthless before it could be sold. Advantage is often taken of an overstocked market for the cold storage of considerable quantities of small fruits when there is a reasonable prospect of a stronger demand and better prices within two or three days.

A Combination Plant.—Where the steam-electric plant is of considerable size, supplying a number of farms with electric energy, it is an economical proposition to utilise the exhaust steam for making ice. For instance in a small plant of 100-horsepower operating 12 hours per day, with the steam consumption of the engines at 20 lbs. per horsepower-hour, some 6 tons of ice daily can be made as a by-product and distributed among the farmers supplied with electricity. In the installation of an apparatus using the exhaust steam for ice-making, the services of a competent engineer in the planning and installation is a wise investment, for considerable experience is necessary to get all the component parts fitted so that a harmonious and economical operation results. Once installed, the apparatus can be attended to as easily as any farm machinery, as it does not require constant attention.

Refrigeration Plants.—People are becoming more and more alive to the superiority of refrigerating machines, popularly called "ice machines," for producing the cooling effects for which natural ice is now employed. Such a machine can be used to make ice, which will be more solid and will last longer than the natural product. It can and should be made from water of known purity, so as to make it absolutely hygienic. More often, however, it is simpler and more economical to let the machine itself do the cooling that ice was formerly em-

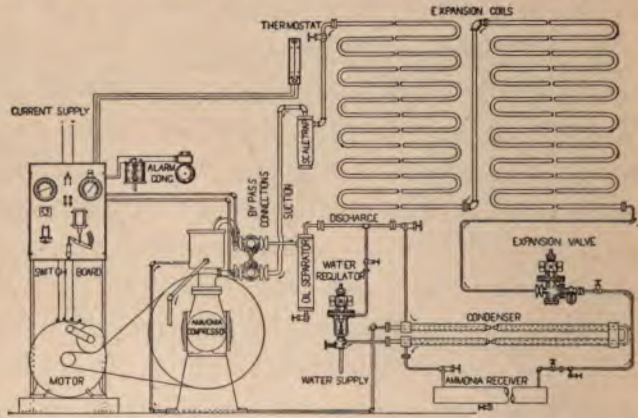

Fig. 26. Diagram of general arrangement of complete refrigerating system.

ployed to do, equipping it, if desired, with auxiliary appliances to make ice in small quantities, as for drinking water or for making ice-cream. By mechanical refrigeration, boxes and chilling-rooms are given a dry, clean coldness that, even when above the freezing point, preserves their perishable contents much longer than is possible with ice placed in an overhead bunker or used in any other manner. Each compartment is given the temperature especially adapted to its particular contents. And if freezing temperatures are desired for the long storage of butter, poultry, fruit and other articles, a refrigerating machine is a practical medium.

Sometimes the machine is made to chill brine, which is then pumped into lines of piping, arranged along the top or sides of the room to be cooled—and this is known as the "brine system." A simpler method, and usually the preferable, is the "direct expansion system," in which anhydrous liquid ammonia passes directly into the pipe lines, called "expansion coils," and as it vaporises takes up the heat from the chilling room, fresh-water tank, or other place that is to be kept cold. In either system, where a room is to be refrigerated, the piping is placed behind non-conducting shields, so as to insure a proper circulation of the cold air.

Principle of Refrigeration.—This principle of physics, that the vaporising of a liquid will take heat from surrounding objects, is at the basis of nearly all of the present-day commercial machines, and, for practical purposes, anhydrous ammonia, usually designated simply as "ammonia," is the best refrigerating agent. (This is not to be confused with the common aqua ammonia, which is ammonia gas in solution with water; if, however, the gas is driven off by heating the solution and is then cooled under sufficient pressure, anhydrous liquid ammonia is obtained). If one pound of anhydrous liquid ammonia is allowed to pass from a small orifice in the vessel containing it into pipe lines, where it expands to a gas, it will in vaporising take up enough heat through the walls of the piping to lower the temperature of rather more than 500 lbs. of water one degree, or in other words to absorb over 500 B. T. U. But after having done this work, the ammonia, now in a gaseous form, has exhausted its capacity of absorbing heat until it has again been made dense by compression, and has been cooled by passing through pipes in contact with flowing water, such as is drawn from street mains, so as to bring it back to liquid form.

Where electricity is available on a country estate, an electric motor is readily applicable to a refrigerating plant, which is nothing more than an ammonia compressor, generating a cold temperature as low as is necessary. Such a generating set needs

Fig. 27. Electric refrigerator.

to operate only for a few hours, twice a day, to keep a constant temperature in the cold-storage room. When the temperature rises, the machine automatically starts and operates until the set temperature is reached, when it automatically stops. The greatest variation in temperature is thus not more than five degrees. The advantage of this refrigerating system is, that all the moisture in the air collects on the pipes as frost, leaving the air practically dry, while, with the use of ice, the air is more or less moist, and such an air is not best for keeping some kinds of fruit and vegetables for a considerable length of time.

QUESTIONS

1. Why is cold storage of advantage to the farmer?
2. What are the advantages of using a refrigeration plant instead of solid ice in preserving farm products?
3. What are the principles of refrigeration?
4. How may the refrigeration plant be operated automatically?

Parts of combination electric cooker.

CHAPTER VIII

TRANSPORTATION OF FARM PRODUCTS

THE problem of transportation on a farm of any size is a factor of great importance, especially in unsettled weather, when the products have to be hurried under cover. For thousands of years transportation has been dependent on the physical exertion of man or some animal, but to-day machinery is ready to do the work, and the self-propelled electric vehicle has filled the gap.

Methods.—In considering any method of transportation, there are three things to be considered: The road, the load and the vehicle. In transportation other than on tracks, the road must be accepted as it exists. In commercial work the load must be accepted as it is received and must be delivered as ordered. These two factors of transportation are the same, no matter what method is employed. Hills, bad roads, frequent stops and starts, long routes or heavy loads, are equal in the demand made on animals or machines of any kind. The third factor, the

Fig. 28. A 3½ ton electric truck carrying 617 bundles of wheat. Electric vehicles carry three times the load of horse-drawn vehicles and dispense with one farm hand.

vehicle, is the only one with which the solution of transportation problems can be made easier. Just as the electric street car has solved the problems for passenger transportation in cities, so has the electrically driven wagon opened the way to a simple freight and delivery system.

The electric vehicle for trucking and delivery is purely a mechanical proposition. It is a machine. Like other machines, it can be built to do a given amount of work in a definite time at a certain cost under any known conditions. The safely carried load in pounds or tons is the basis of its mechanical design and construction. The specified speed with full load on a hard level determines how much power will be required. The specified duration of continuous operation at full load on a hard level determines the amount of energy that must be stored in its battery at one time, and fixes the size of the battery. The power and speed required determine the size of the motor and the gear ratios, while the total weight affects the tire design.

Cost.—Accurate engineering can be applied to the problems of transportation with greater satisfaction with electric vehicles than with any other type. Electrical measuring instruments reveal, and record if necessary, the condition and performance of storage batteries and electric motors. The cost of producing electricity is a known quantity, and the amount necessary to charge a battery is measurable. The amount of electricity delivered to an electric motor by the battery is a known quantity, or can be measured. The performance of an electric motor is accurately specified for any conditions. Its efficiency is easily determined.

The work of moving a ton a mile per hour on a hard level road is expended in starting it from rest and in overcoming the resistance of the road, the tires, the bearings, the electrical circuits and the air. If the road is not hard or not level of course more work will be required to overcome its resistance or to move the load up a grade. If it is necessary to start often from rest more work must be done than for continuous motion.

The Question of Value.—The cost of doing this work depends on the amount of energy expended and the cost per unit of power.

An electric vehicle cannot be used profitably where it is not needed. Where the work to be done is less than half the ability of the machine, proper value may not be derived from the investment. There are also localities where operating conditions prevent a satisfactory return for investment. But in thousands of cases the owner of a few horse-drawn delivery wagons, a couple of trucks or two or three heavy drays, can profit at once by replacing them with one or more electric vehicles. His work will be done quicker, his stable may be smaller and his expense will be much less for a given service. Where a large number of vehicles are used the advantage of electricity becomes more apparent and the efficiency of the service is improved still more.

An example of the utilisation of electric trucks for rural transportation purposes may be cited—that of the nursery of the Brown Brothers, about four miles from the business section of Rochester, N. Y. During the shipping season, the firm employs a 3½-ton electric truck for delivering trees and shrubs to the depot; the truck returning with fertilisers and supplies for the nursery. During the harvest season, the same truck is utilised in harvesting the hay and wheat. In one of the accompanying illustrations the truck is shown with a load of 617 bundles of wheat, which after being

Fig. 29. Electric motor with controller operating hay hoist on a New York farm.

threshed yielded 45 bushels. The regular two-horse load is 260 bundles. Where the time-element in getting the wheat to the thresher, due to variable conditions of the weather, is so important, one can readily perceive how progressive farmers may find it profitable to avail themselves of modern appliances.

The price paid for an electric vehicle does not necessarily determine its full value to the owner, for this value depends on the use to which it will be subjected, and, of course, upon its constructive features. There are many farmers who desire a pleasure vehicle, and who do not have sufficient produce to handle to warrant the purchase of an electric truck for transportation purposes only. They should choose a type which is suitable both for light trucking and pleasure. To suit country-road conditions, such a vehicle should have high wheels and solid rubber tires.

Industrial Railroads.—A more extensive system of transportation for farms of more than ordinary size, is an industrial railway, consisting in essential features of a narrow-gauge track, a copper electrical conductor strung some 12 feet above the tracks, and an electric locomotive. The electric current is sent to the locomotive over the copper wire, and returned to the generator through the tracks. The electric locomotive is somewhat similar to the ordi-

Fig. 30. Electric railway for handling farm products on a farm in Germany.

nary trolley car, on a smaller scale, and is capable of hauling the number of cars suited to its size.

The accompanying illustration shows a transportation system which once employed horses to haul the cars over the rails. Within three years the total yearly haulage of the new electric system has increased many fold. The ease with which farm products can be loaded, transported and unloaded in the places desired is obvious. In most instances the tracks can be laid into the storehouse or barn; a train-load of products can be brought right in, and the locomotive sent back with empty cars for another load.

Electric Hoists.—For loading and unloading the farm products at the barn, small motor-operated hoists are used to lessen the labour. With a single lift, a whole load of hay, wheat or straw, can be taken from the wagon and placed in the loft. With manual labour, usually three to four men are often required to unload a load of hay, while with an electric hoist, one man can do the same work, in a fraction of the time. The cost for electric energy is almost negligible, when compared with the number of hands required for manual labour.

QUESTIONS

1. How may the problems of transportation of farm products be solved by means of electric truckage?
2. What are the advantages of electric vehicles?
3. Would electric haulage by means of narrow-gauge tracks and locomotives be of advantage on large farms?
4. What may be accomplished with electric hoists for unloading farm products?

CHAPTER IX

ELECTRIC PLOUGHING

PLOUGHING is the father of industries, the indispensable primary operation upon which civilisation has depended from the earliest ages, and the plough is thus the most useful and necessary implement which has ever been designed by mankind for his own advancement. Without the plough agriculture is impossible, and without agriculture no industry can exist. Yet in spite of all the progress which has been made in mechanical arts, and in the sciences, the plough of to-day remains the same in principle as the plough of dozens of centuries ago. The furrow is still turned in the old way, and modern science has added nothing in principle to the plough except different means of drawing it across the field.

Farmers in Germany, where during the past 15 years the steam plough has been used to a great extent, have made increasing use of the electrically operated plough, which is now far beyond the experimental stage, and is in many respects superior to that drawn by steam or gasoline tractors, saving both time and money.

The Single-Motor Plough.—There are in Germany in successful operation, two different systems, known as the single-motor and double-motor systems. In both methods a plough is pulled across a field by means of a cable wound on a drum. The single-motor system utilises one motor-wagon and a so-called anchor-wagon, while the double-motor system has two motor-wagons. In the case of the single motor an endless cable runs around the drum of the motor-wagon which is placed on one side of the field, and thence around the sheave of the anchor-wagon on the other side of the field. The plough is pulled back and forth between the two wagons, one man operating the motor and another the plough.

After the plough has covered a course across the field, a man tips the plough so that another set of ploughshares is ready to turn furrows in the opposite direction. The motion of the drum on the motor-wagon is reversed and the plough is pulled back across the field. By a certain device on each wagon, both the motor-wagon and the anchor-wagon advance after the

Fig. 31. Motor wagon of single-motor plough system.

plough has traversed the field in one direction, just enough to start the plough on a new set of furrows. As it is necessary that the anchor-wagon remain in a fixed position while the plough is travelling, the rims of its wheels are provided with large flanges, which, by the pull of the plough cable, are forced into the ground, holding it firmly in place. (See Fig. 32).

The Double-Motor Plough.—The two-motor plough system consists of two motor-wagons, and the plough is pulled back and forth between them by a single cable. As seen in the illustration (Fig. 33), the plough and each wagon has an operator, so that three men are necessary to this system. The wheels of the motor-wagon have broad rims to give a large bearing, thus aiding the machine to travel over soft ground. The rims of one pair of wheels are provided with ribs so that locomotion over any kind of ground is readily accomplished, while the rims of the other pair of wheels are provided, as in the single-motor plough, with large flanges set at right angles to the pull of the plough-cable. This arrangement gives an anchorage when the cable becomes taut.

The plough is so designed that it can turn furrows in both directions. When it has reached the limit of travel in one direction, it is tilted in the reverse and is ready to plough on the return travel. One set of ploughshares is always in the ground. By equipping the plough with a number of shares, a number of furrows may be turned at the same time.

The motor-wagon is provided with a reel of cable which is paid out as the machine advances. One end of the cable is plugged in at a portable transformer and the other end is connected to

Fig. 32. Anchor wagon of single-motor plough system.

the motor of the winding wagon. The cable is flexible and well insulated, and can be laid on the surface of the ground without any danger.

Speed of Electric Ploughing.—It may be of interest to give some facts and figures regarding the speed of an electrically operated plough. The test figures given were taken in the early development of the system at Albrechshausen, Germany, in May, 1900. The length of the furrows were 1200 feet, and the plough was made to accommodate four ploughshares, so that the width of the ground turned was 3½ feet. The speed of the plough was approximately 200 feet per minute. As the tilting of the plough required 45 seconds at each end of the travel, this means that ¾ of an acre were turned per hour. The furrows were 9 inches deep, and the power required at the station was 40 horsepower.

To-day electric ploughs are much more efficient, and turn as much as two to three acres per hour, depending upon the depth of the furrow. When our American manufacturers of farm machinery, who lead the world in their branch, take up the subject, these results will no doubt soon be exceeded.

The following are figures derived from actual practice showing average conditions in the field, and are not of an experimental nature.

In a twelve-hour day, with an 8¾-inch deep furrow, 27 acres were ploughed, at an average current-consumption of 19.2 kilowatt-hours per acre. In a twelve-hour day, with a

10¾-inch deep furrow, 23.1 acres were ploughed at an average current-consumption of 23.2 kilowatt-hours per acre. In the same length of time, with a 14½-inch deep furrow, 20.4 acres were turned at an average electric consumption of 33.6 kilowatt-hours per acre.

Cost of Electric Ploughing.—The following table is derived from the foregoing data, and shows the costs of electric ploughing under various conditions. The electricity is figured on the basis of three cents per kilowatt-hour, which is fair for such a purpose. Three men are required for operating the plough, and their combined wages are figured at 45 cents per hour. Furrows are 8¾, 10¾-inch and 14½ inches in depth and the latter is made up of an 8½-inch upper cut and a 6-inch lower or subsoil cut.

COST OF ELECTRIC PLOUGHING

Depth of furrows in inches	8¾	10¾	14½
Acres per hour	2.25	1.92	1.70
Minutes per acre	27.	31.	35.
Kilowatt-hours per acre	19.2	23.2	336.
Cost of Electricity per acre in cents	57.6	69.6	100.8
Wages per acre for three men in cents	20.	24.9	27.9
Total cost of ploughing per acre in cents	77.6	94.5	128.7

It will be noticed from the foregoing that the cost of electric ploughing varies directly with

Fig. 33. Electrically operated double-motor plough system in action on a farm in Germany. On each side of the field a motor is stationed, the plough and attached harrow, being drawn back and forth between them.

the depth of the furrow. The speed of the electric plough can be easily varied according to the depth of the furrow. It is customary to run more rapidly than with other kinds of ploughs, which has the additional advantage of pulverising the ground more thoroughly than when the plough is drawn slowly. The average speed of a 80-hp. to 120-hp. plough, with four shares for nine-inch furrows, including time lost in tilting the plough at the ends of the furrows, is 1.16 metres per second or 315 feet per minute. This is at a speed of about 3½ miles per hour, which is considerably better than a fast walk. This is the average of a twelve-hour day and might be readily continued twenty-four hours a day with an extra shift of men, and the use of electric lights such as are seen abroad in threshing in the field, etc.

It is often wondered why German farms are more productive per acre than American farms. One of the reasons is the depth of the furrows ploughed, which, when the ploughing is done by horses, is likely to be very much less than with the electric plough. By a proper rotation and selection of crops, and by the time saved between the harvest of one crop and the sowing of the next, largely effected by the speediness of the electric plough, the German farmer reaps with its aid two crops a year on much of his land, harvesting on an average 2600 acres of crops annually from 1600 acres of land.

There are in the German Empire some 60,000,000 acres under cultivation. There are some 282,000 farms ranging from 50 to 250 acres, 21,000 farms ranging from 250 to 1200 acres and 4180 farms of more than 1200 acres each. The electric plough is available for use on farms of all sizes, but as it is somewhat expensive in first cost, it is utilised only on very large sized farms, except where rented out by an owner or purchased in common by a group of small farmers.

Comparative Costs of Electric and Steam Ploughs.—A one-motor, 80-hp. to 120-hp. plough-system costs about $8000, while a two-motor plough-system costs about $11,000. A steam plough of the same capacity is more expensive, costing from $14,000 to $15,000. It will be seen that those farms which can afford a steam or gasoline tractor-plough, could be equipped much more cheaply with electric ploughs.

Overhead and operating charges, such as repairs, maintenance, fuel (either coal or gasoline), continuous transportation of fuel by means of teams to the tractor in the field, the cost of having such teams in readiness and the loss of their services when needed for other farm work delaying the planting of a new crop, and danger of fire and explosion at the tractor itself, or where the fuel is stored with increased insurance costs, all go to make the steam or gasoline plough much less desirable than the electric plough; indeed, any single item is sufficient to throw the balance in favour of the latter.

The electric plough, however, it may be fairly stated, has the disadvantage of not being self-propelled from the storage barn to the field. It could, however, readily be made self-propelled by having a trolley wire of a simple nature run from the barn to the field, similar to the trackless-trolley system; and this could be suspended from the poles of the general transmission system.

Advantages of Electric Ploughing.—Other advantages of the electric plough are that it is lighter in weight than a steam or gasoline tractor-plough, more readily operated on soft ground, as well as more readily conveyed over bad roads and light bridges; more applicable for use on hilly ground, where the steam plough cannot work on account of the drainage of water in its boiler away from the fire box; and better adapted for use in all sorts of weather, especially during cold snaps when the steam plough would freeze up overnight. The electric plough requires fewer operatives and less arduous labour, and altogether its advantages are so great that it is unfair to the other ploughing systems to compare them with it.

In the development of electric farming in Germany, an entirely new conception of agriculture has arisen, and one which must be taken into consideration in order to understand the progress which has been effected.

Co-operative Electric Ploughing.—The new conception of agriculture is that it is a manufacturing industry of a more or less co-operative nature. The German farmer does not isolate himself and conduct his operations as such operations have been conducted for centuries, but he constantly seeks and receives the benefit of the advice of both the Government

Fig. 34. Electric ploughing in Germany, showing single-motor plough system in action.

and the distributing electrical companies, as to how to co-operate with his neighbour, and how such co-operation can be made to pay.

In addition to the smaller farmers, who to so large an extent act in unison, the managers of large estates also conduct their operations on the principle of manufacturing industries; at every turn, the most modern and efficient machinery is utilised, and electricity is employed.

Proposed System for Electric Ploughs.—In order to remove the harvest as rapidly as possible and thus prepare the way for the second ploughing, which must be quickly done in order to obtain two crops in a single season, many farms are provided with inexpensive electric-haulage systems. Such a system consists of a track of light rails, about 20 inches apart, secured to cross-ties, laid directly on the ground with little or no grading. An electrical conductor suspended about twelve feet high, feeds a small electric locomotive. Such a track costs very little, and when laid in sections can readily be taken up and stored or laid to another field as needed. An early development of agriculture will be the placing of inexpensive but permanent tracks over fields in parallel rows, five hundred to a thousand feet apart, to be used both for the speedy removal of crops, and for the windlass-wagons of electric ploughs. The distance between the tracks would depend, of course, on the size, shape and lay of the land.

QUESTIONS

1. How is electric ploughing accomplished?
2. State the different methods of electric ploughing.

3. What is the difference between a one-motor and two-motor plough-system?
4. Describe the construction of the plough proper.
5. Describe a single or one-motor plough-system.
6. Describe a double or two-motor plough-system.
7. Describe an anchor-wagon.
8. How many men are required to operate a single-motor plough-system?
9. How many men are required to operate a double-motor plough-system?
10. Describe an electrically operated plough with a track system.
11. Describe the advantages of the latter system.
12. What is the speed of an electrically operated plough?
13. What is the cost of electric ploughing per acre with furrows $8\frac{3}{4}$, $10\frac{3}{4}$ and $14\frac{1}{2}$ inches deep?
14. What is the first cost of a single-motor plough-system?
15. What is the first cost of a double-motor plough-system?
16. Could the first cost of an electric plough be reduced if our large domestic manufacturing concerns built them?

Electric Broiler.

CHAPTER X

DIVERSE APPLICATIONS OF ELECTRICITY

In addition to the more important uses of electricity in the principal farming operations, there is a wide variety of applications of electricity to minor operations, by which it proves of the greatest utility and convenience, relieving the farmer of many tasks of the most irksome nature, and thus at a very slight expense adding greatly to the pleasantness of rural life.

Among such uses the following are especially interesting:

Domestic Water Supply.—For pumping water for domestic purposes two systems are now in use, known respectively as the open tank and the pressure-tank system. In the former, a tank large enough to hold about one day's supply for domestic purposes should be used. This can be placed either on a hill or on a tower sufficiently elevated to get the desired pressure. The usual city pressure ranges between forty and fifty pounds per square inch. To get a pressure of forty pounds per square inch will require a tower nearly ninety feet high. As this is quite expensive, a tank is usually put but little higher than the upper floor, and in some cases in the attic, giving a pressure of possibly fifteen pounds per square inch. With this pressure the water flows very slowly from the taps on the upper floor and is practically worthless in case of fire. It is therefore preferable to use the pressure system when a hill is not available on which to place the tank. When an open tank is used it is possible to put in a float connected to a switch, which will start the motor when the water has reached a predetermined low level and stop it when the tank is full.

Pressure Tank.—In the pressure system the pump delivers water into a closed air-tight tank which can be placed in the basement or in any other convenient place. As the tank becomes filled the air becomes compressed in the top. When the tank is half full the air pressure is fifteen pounds, and when three-quarters full forty-five pounds. This pressure, when a faucet is opened, forces the water out with a velocity dependent upon the pressure in the tank and the difference in level between the tank and the faucet. Let us suppose that a faucet thirty-five feet above the tank is open; then the water will flow until the pressure, due to the static head, equals the pressure in the tank, which is about fifteen pounds. This means that the tank will still be half full. To obviate this air is forced into the tank either by a differential plunger, small compressor or otherwise, so that the pressure at any given fulness of the tank will be increased. Thus, instead of the pressure being fifteen pounds when the tank is half full, it will be thirty pounds, so that the tank can be emptied from a faucet thirty-five feet above the tank level. An automatic pressure-switch can be installed that will start or stop the motor, keeping the pressure always within a given range of a few pounds.

Attention is called to the small size of the pump and motor that can be used with either of these systems. By reducing the size the first cost of the outfit, including the tank, is cut down in a marked degree. As the starting and stopping of the motor are done automatically and the outfit requires no additional attention, the motor may be run continuously. Where the outfit is not automatic, attention is such an item in its operation as to preclude the use of anything but a large pump so that the necessary water may be pumped in a few hours.

Automatic System—A newer and more efficient system for supplying water for domestic purposes is that in which a specially designed pump is automatically controlled in such a way that no tank is necessary. Thus a large expense and all danger of flooding is obviated. The pressure throughout the system may be uniformly regulated as desired. This system is probably the best of all.

Electrically Operated Milking Machines.—The history of cow-milking machines dates back over a century. Besides the United States, Australia and New Zealand are the two most prominent countries where real work along this line has been done, and at the present day these countries are second in the use of such machinery.

Professor Oscar Erf, an authority on the subject, states:

" . . . The labour saved under practical conditions has been conservatively estimated to range from 30 to 40 per cent. Hence, more responsible men can be employed and higher wages paid. . . . By the use of a milking machine the objectionable part of hand milking is greatly eliminated. The uncomfortable part of milking is the position in which the milker must place himselm. The continuous opening and closing of the fingers becomes tiresome. In the summertime it is exceedingly warm work and in winter it is cold, and in fly-time it is very disagreeable. By the use of the machine,

Fig. 35. Motor-operated (belt-connected) vacuum pump and milking outfit. The motor is mounted on the wall.

all of these objectionable features are eliminated. . . . Machine milking is cleaner than hand milking. . . . In all cases milk taken from the milking machine remained sweet for a longer time, varying from one hour to ten hours longer than that obtained by hand milking. . . . We have found that milking machines, if the vacuum is normal and the teat cups fit well, are more comfortable to the cow than hand milking. Some cows can be milked by milking machines that as a rule cannot be milked by hand. . . .

"A milking machine will milk cows as thoroughly as the average milker. Some cows give more milk when milked with a machine than when milked by hand. To reach the highest degree of success cows should be selected and bred to respond to machine milking. If this factor is taken into consideration, machine milking will be equally as successful as the best hand milking. . . ."

Professor Lane, describing experiments he carried out on milking machines, states that:

"One good careful man or woman can operate four machines milking eight cows simultaneously, and an additional hand can not only carry away the milk, but can assist in manipulating the cows' udders. The operating expense of the machines is comparatively small."

One man has milked 60 cows on more than one occasion, the time required being two hours. If, however, we include the time of the extra man, the saving in time is reduced to one-half, or 58.45 minutes per day for the 10 cows. These figures furnish sufficient proof for the statement that the machines are time-savers.

Naturally the large dairyman will be the first to adopt the cow-milker, for the reason that his equipment will cost him less per cow than the small dairyman. Again, the large dairyman has more at stake and has to depend entirely upon the hired men to do the work. If they fail him the large dairyman is much more independent, and could himself milk a herd of 50 cows without assistance. However, there seems to be no good reason why a dairyman with a herd of even 10 or 12 cows could not use a machine with profit.

Milking Devices.—One of the successful milking devices consists of two parts, one being the milk can or receptacle, and the second the machine. The milking-machine consists of a cover which fits air-tight on the receptacle by means of a small rubber casket. Mounted on the cover is a frame, a pair of vacuum-pumps and a pair of double valves. The pumps are operated through a crank-shaft by a small electric motor of 1/6 hp. Operatively connected with the crank-shaft is a drive which puts the double valves into motion. On one side of the frame is a small vacuum-gauge which indicates the degree of vacuum created in the can. Beneath the vacuum-gauge is a needle-valve by means of which the degree of vacuum desired to milk the cows can be exactly regulated. The double valve is equipped with a stopcock on which is fastened a rubber tubing about 3½ feet in length, a transparent and flexible connection with shut-off clippers to a pair of teat-cups carrying pneumatic cushions.

While excellent results have been obtained with cow-milkers, yet in many cases, through

Fig. 36. Milking with electrically operated vacuum machines.

carelessness in operation, the results have not been so encouraging; and before going into the subject extensively, it should be thoroughly investigated. It is much more successful with some cows than with others, owing perhaps to the individual idiosyncrasies of the animals; and some farmers having careful helpers are more fortunate in their use of mechanical milkers than others whose work is done by careless persons.

Fig. 37. Electrically operated vacuum stock-cleaning machines.

Vacuum-Cleaners.—The principle of cleaning by suction was the direct outgrowth of the coming into use of compressed air, and has been employed on a large scale for a number of years in planing mills and wood-working establishments for removing sawdust and shavings.

Its use in homes, stables, etc., is comparatively new.

Four distinct types of vacuum-cleaning machines are in general use: (1) fan type, (2) diaphragm-pump type, (3) rotary-pump type, (4) reciprocating-pump type, all made in a variety of sizes and forms designed for portable, semi-portable and stationary service.

Construction of Vacuum Cleaners.—The essential features of any vacuum-cleaner are its inlet, a dust-catcher, a motor-driven pump or fan, and an exhaust. To the inlet is connected the hose through which the dust-laden air passes. The dust-catcher in the smaller machines is usually a cloth or felt bag, often concealed in a metal chamber. The motor-driven pump or fan produces the vacuum or suction, and the exhaust merely disposes of the dust-free air, which may often be used for blowing purposes, using the same hose ordinarily attached to the inlet. It is obvious that these various essential parts can be arranged in many ways and the result is machines that differ widely in appearance.

The smaller vacuum-cleaning devices are in-tended for portable use close to the operator, while the larger stationary outfits are generally placed in the basement of the house or stable, the building being piped so that a hose can be coupled to the suction pipe, usually placed near the floor in the various rooms or compartments.

A large variety of cleaning tools are employed, any one of which can be connected directly to the end of the hose, making the device suitable for many varieties of cleaning, such as for cleaning carpets, heavy rugs, tapestries, hard-wood floors, walls, books standing in the shelves, clothes on the individual, etc.

Electric Fans.—Good ventilation is as essential to comfort as good illumination, especially where many persons congregate, as in stores, restaurants, theatres, clubs, etc. Such places would have scant patronage, particularly during the summer months, were they not provided with artificial ventilation by the modern electric fans.

The small cost of operating well-designed fan-motors makes them a paying investment in the office or factory, for wherever the ease of employés may be increased by comfortable surroundings and cooling breezes the result is increased quantity and better quality of work. The home should certainly be as comfortable as the office, and when it is considered that an electric fan-motor, suitable for the home, costs less to operate than one standard incandescent lamp, that is, from one-fourth to one-half of a cent per hour, it is evident that the proper ventilation of the various rooms during the hot weather is easily within the reach of the most modestly appointed home.

Electric Fans in Winter.—Most users of electris fans store them as soon as the cool weather sets in, evidently assuming the fans to be useful only for making them comfortable during the warm days and nights; but a study of the indoor air will show that the fan really can serve a greater variety of useful purposes in the average room during the winter than during the summer. Indeed, the refreshing effect produced by the use of fans during warm weather is due only in part to the cooling of the skin, the rest of the action being explained by the diffusing of the air so as to distribute the carbon dioxid and other products of exhalation. This dissemination of the products of breathing can be accomplished just as effectively in winter as in summer by a forced circulation, and even in somewhat underheated rooms it will have a refreshing effect on the occupants if so placed that injurious cold drafts are not set in motion.

In the average steam-heated room, the ordinary convection currents of air are too slow to create an even temperature, so that it is quite common to have the immediate vicinity of a radiator overheated while the opposite side of the room is far below the normal. In such cases it is easy to use an electric fan to intermingle the air-strata and thereby distribute the heat more evenly. This is usually done by setting the fan on the floor and letting it blow the air towards the radiator, a simple expedient which should be more generally used in sick rooms where patients are so often uncomfortably cold, although within a few feet of hot radiators.

Electric Fans in Stores.—In stores the uneven distribution of heat is not apt to be so bothersome as in residences, but the coating of window panes with a film of frost or of moisture interferes seriously with the business-drawing powers of the store windows. As this

Fig. 38. Shearing sheep by electric power.

coating forms only because the glass is so much colder than the air in the store, the remedy consists in simply blowing a current of hot air against the window glass long enough to warm and dry it. While this same frosting or dimming of the window panes in a home is not objectionable from a commercial standpoint, it is serious in other ways, as the moisture thus deposited must be taken from the air of the room which is thereby robbed of a part of its healthful humidity, hence any method of redistributing the moisture through the air of the room will improve its healthfulness. Here, as in stores, the deposit on the windows is soon removed by letting the fan blow against the lower panes, for which purpose the fan may need to be placed on a chair or table. Most users of steam or hot-water radiators know that the use of water-pans in the arid rooms is ineffective, largely for the reason that the air moves over the surface of the water at a very slow rate. The forced circulation of this air by a fan, allowing more of it to absorb moisture, will increase the humidity of the air in the room. At present even our hospitals are paying too little attention to this important question of humidity.

Ozonisers to Purify Air.—The air of the "piney woods" has a soothing and pleasant effect on the lungs. The turpentine contained in the pine produces and sets free in the air small quantities of ozone, and the volatile oil of pine, which gives the fragrant and aromatic odour, also has the power of accumulating ozone. Nature constantly vitalises out-door air by sunshine, winds, rain, snow and electrical discharges. The peculiar fresh, invigorating, pure and wholesome air after a thunderstorm is due to the ozone produced by the electrical discharges.

Ozone is a colourless gas with a pungent odour, like that of chlorin, formed variously, as by the passage of electricity through the air. It is regarded as another form of oxygen, containing three atoms in the molecule, and is an extremely powerful agent in causing a compound to unite with oxygen chemically. It is both an antiseptic and a deodoriser, having the great advantage over all other disinfectants that it both destroys deleterious matter and imparts to the atmosphere properties which make it purer, healthier and more invigorating. When inhaled, ozone fills the blood with oxygen—oxidises it—and causes it to circulate more quickly. It also increases the oxyhæmoglobin in the blood, stimulates the appetite, and assists in producing sleep.

Oxygen is a colourless, tasteless and odourless gas element, the most abundant and most important yet discovered. The weight of the oxygen of the globe exceeds that of all other elements combined. It forms by weight about 3-4 of the animal, 4-5 of the vegetable, and 1-2 of the mineral worlds, 1-5 by volume of the atmosphere, and 8-9 by weight of water. Its inhalation by human beings and animals is essential to life; hence it was formerly called vital air. Pure air is 21 per cent. oxygen, 78 nitrogen and 1 per cent. argon, with variable quantities of aqueous vapour, carbon dioxid, ammonia, ozone, acid compounds of nitrogen and sulphur and small amounts of many other gases. Its oxygen is not only essential to animal heat and life, but is also a source of power, light and electricity. The use of air that has been contaminated ever so little from any source is injurious. With feeble patients it may be the deciding factor against recovery. Air which has been inhaled and exhaled is charged with poisonous waste,—carbon dioxid, broken-down cells, water vapour, disease-germs and its oxygen is much reduced. Such exhaled air is a real poison.

The ozoniser is an ozone-producing apparatus for purifying the air of dwellings, offices, and public buildings. It is run by electricity. By merely turning a button one is able to produce in the bedroom, office or workshop all the life-sustaining powers of fresh mountain air. At the ordinary temperature of the living-rooms, large quantities of ozone are produced, the foul air is revitalised and filled with pure life-sustaining atmospheric ozone. The electricity can be taken from the ordinary house wire in the same manner as for lighting, and costs no more than a single lamp.

What the Ozoniser Does.—The ozoniser imitates the action of the lightning on the outdoor air, and diffuses a constant supply of pure ozone, thus destroying germs and dangerous floating matter in the atmosphere. It makes the air of the apartments as fresh and pleasant to breathe as a breeze from the pine forests. No chemicals are used in the apparatus. No foreign matter is introduced into the natural air. Silent discharges of electricity restore free ozone to the atmosphere. If you cannot keep your windows and doors open to let in the necessary oxygen and carry out the poisonous gases, because you cannot stand the draft, the ozoniser will give you better air than that outside.

The Ozoniser in Refrigerating Chambers.—The necessity of keeping up a pure supply of air in refrigerating chambers, in order to keep the provisions stored therein, in a fresh condition is imperative, and for this purpose ozone is invaluable. The oxygen contained in such air must not be allowed to fall below a certain degree and the undue saturation of the air with the emanations of the provisions stored therein must be prevented. The latter precaution is of particular importance, because such emanations tend to favour the development of bacteria, which act detrimentally on the provisions. The preventive measures generally taken against this evil, consist in allowing a certain amount of fresh air from the outside to enter the refrigerating chamber from time to time, and to mix with the air confined there. But this necessary proceeding has the disadvantage of requiring an increased manufacture of cold air, because the yearly average temperature of the air outside is higher than the air in the refrigerating chamber, thus requiring greater cooling than the air circulating in the chamber, and secondly because the outside air contains much moisture and deposits much aqueous vapour.

The great advantage for using ozone for this purpose consists in its property of purifying enclosed air, by destroying the above-mentioned emanations, provided that the air thus treated is kept in constant circulation. The electric current consumed per apparatus for 100 cubic metres of air per hour amounts (without counting the fan) to 30 watts only. The air of the refrigerating chambers is always regenerated by the aid of these ozonators in the same proportion as it is conducted to the chambers, and therefore the drawing in of the outside fresh air with its attendant disadvantages becomes quite superfluous.

The degree of concentration of the ozonised air is of importance for the success of the process. Too great a quantity of ozone acts detrimentally, whereas too small a quantity of the same would not produce the desired effect. Experiments have proved that the lowest limit for the amount of ozone is 0.05 milligram, and the highest limit 5.5 milligrams per cubic metre. The requisite amount of the ozone is regulated according to the circumstances. Every trace of an unpleasant smell in meat-cooling and pickling (salting) houses, etc., disappears with the use of ozone.

Felling Trees by Electricity.—The forests have been long immune from inroads of electric progress, for it has not seemed feasible to change the historic methods of felling trees.

The woodman's axe still resounds through the forests, though every wasted chip now means the loss of timber much more valuable than

Fig. 39. Apparatus for felling trees by electricity.

formerly. To imitate the effective stroke of the axe which strikes from continually changing directions would require a complicated mechanism and one liable to serious damage if a tree should fall upon it. The same breakage-risk would be met in any attempt to drive a saw by electricity, as is found to be the case in the steam-actuated tree-felling saws made for colonial use by English manufacturers. Besides, a sweep of a power-driven saw like that of the ordinary double-handed saw of common practice requires considerable space, thus prohibiting the use of any such instrument until one or more trees have been chopped down wherever they are closely bunched. The steam-driven tree saw also requires a crew of men for operation, besides a team for moving the plant about the forest. The fact that these steam saws are proving economical, in spite of such difficulties, shows that power-cutting is needed, and that there ought to be a field for a tree-feller with fewer handicaps.

Aside from chopping and sawing, a third method of tree-felling consists in burning through the base of the trunk. To do this with a bonfire is at once slow, wasteful of timber and likely to cause a forest conflagration. Burning experiments were made a few years ago with a high-resistance wire heated by electricity and looped around a tree so as to burn its way through. This proved too frail and costly for practice, though the trials showed that by such means a tree could be cut much closer to the ground than otherwise.

Cutting by the Friction Wire.—More recently, as described in *The Electrical World* of Feb. 2, 1911, a German inventor, Hugo Gantke, has perfected another method of cutting timber by the use of a hot wire. The heat in this case is supplied not by the passage of a current of electricity, but by the friction of the wire on the tree itself. For this purpose a steel wire is looped tightly around the tree and pulled back and forth about 1500 times a minute by an electric motor. The cutting wire itself need only be a little longer than half the circumference of the tree, being coupled to a steel strand cable which leads to the motor, thereby allowing the latter to be placed 100 ft. or even 150 ft. away. The cut can easily be started close to the earth (or, if desired, a trifle below the surface) so that, instead of the usual stumps which interfere with the transportation of the timber, no obstructions are left above the ground. This lowering of the cutting adds to the length of the log a foot or two of the wide-spreading base, thereby enlarging the average diameter from which the lumber feet in the log are figured. With the hot-wire method no wedging is needed as in sawing, and the end of the log is charred so that it can be marked with crayons. The carbon coating also protects the cut ends against the action of the weather if the log is left lying on the ground for a time. Consequently it is fairly claimed for the new method that it increases the amount of lumber obtained, avoids the expense of stump pulling, decreases the cost of transporting the logs, and reduces the amount of rotting if the timber is not promptly moved.

Considerations of Cost.—The labour-cost varies with the size and hardness of the timber. Experiments have indicated that the time required for cutting trees of a given size increases with the hardness of the wood in about the same ratio for the hot-wire method as for a double-ended saw in the hands of a skilled workman, the ratio being about 3.3 minutes for German linden or ironwood and 1.8 minutes for beech or oak, in proportion to every minute needed for cutting pine of the same diameter. However, the required time does not increase nearly as fast for the friction-wire method as for hand-sawing with an increase in diameter of the same wood. Thus the cutting-time for Scotch fir (which cuts about six per cent. faster than pine) is as follows:

Diameter of fir, inches	7.6	12	19.2
Minutes for hand sawing	1.5	4	12
Minutes for hot-wire cutting	0.7	1.8	4.5

For beech, similar tests showed this comparison:

Diameter of beech, inches	7.6	12	19.2	30
Minutes for hand sawing	2.7	6.9	18.9	120
Minutes for hot-wire cutting	1.3	3.4	8.5	20.8

In these comparisons it must be remembered that the hand sawing required two men and for fair-sized trees a third at the wedges, while the hot-wire method needs but one man, even on the largest trees. This, minus rests, which even experienced men take between cuts, means that the real difference in output per man would be tremendously in favour of the hot-wire method. For large trees it would appear from figures lately published in *The Timber Trades Journal,* of London, that the steam-driven tree-saws will do even faster work per tree, but they require four men and a span of horses, besides leaving the objectionable stumps.

Electric Incubators.—The advantages of the

Fig. 40. Electric heated and regulated hover.

use of electricity for incubating and brooding eggs and chickens are many; briefly: economy in use, labour included; convenience in location of incubator; absence of fumes and gases; perfect distribution of heat in the egg-chamber; simplicity and accuracy of regulation.

Tests have demonstrated that it costs about one-half more to operate an incubator of any given size by electricity at the usual rates per current, than it does by the use of kerosene oil,—when no account is taken of the labour saved. When electricity is used the labour item is practically nothing. There is no lamp to be cleaned and filled, no wick to be trimmed, no dirt, no waste, and the machine can be located where it will be most convenient for the caretaker. An electrically heated incubator, being entirely free from odour and gases, can be operated in a living room where the temperature averages above 70 degrees, and therefore comparatively little electric current is required to create and maintain a hatching temperature of 103 degrees in the egg-chamber.

An electrically operated incubator or brooder has another advantage over a lamp-heated machine; which is in the fact that in the electric incubator the heat (or current) is "cut out" as soon as the temperature in the egg-chamber reaches 103 degrees, and thereupon all expense stops instantly, whereas when the regulator on a lamp-machine opens the damper above the lamp-flame, the consumption of oil continues, the surplus heat being discharged into the apartment in which the machine is located. Electric incubators are undoubtedly superior to the other forms.

QUESTIONS

1. What is the open-tank pumping system?
2. What is the pressure-tank pumping system?
3. What are the advantages of using electrically operated milking devices?
4. What are the disadvantages?
5. Describe the operation of milking devices.
6. Describe the construction and operation of vacuum-cleaners.
7. What are the advantages of using a vacuum-cleaner?
8. Describe the usefulness of electric fans.
9. What is ozone?
10. What is pure air?
11. Where should the ozoniser be installed?
12. What are the benefits of using ozonisers in refrigeration?
13. Describe an electric machine for felling trees.
14. What is the time consumed for felling trees of a given size?
15. Describe the Gantke tree-feller.
16. What are the advantages of electrically heated incubators?

Combined toaster and griddle.

CHAPTER XI

ELECTRIC HEATING

Electric heating dates back at least to the year 1800, when Sir Humphry Davy first produced the carbon arc by means of primary batteries. From that time little was done to further the use of electricity for heating, but during the last years of the 19th century the cost of producing electric power began to be reduced to such an extent as to make it available for certain heating purposes where cost was not of the utmost importance. Within the last five years an enormous development has taken place in its use, so that to-day there are comparatively few industrial processes which cannot afford to use it in some way or another.

Efficiency of Electric Heating.—It is possible to obtain 100 per cent. efficiency from the conversion of electric current into heat, but in spite of this fact, for such purposes as heating of buildings it is still far from a commercial commodity when compared with other heat sources. Some figures taken from *The Electrical Record* of June, 1910, will illustrate this:

One kilowatt-hour will produce 3412 B. T. U., whereas one pound of good coal will produce 14,000 B. T. U., so that 4 kilowatt-hours are about the equivalent of one pound of coal, which, at present commercial rates, places a very onerous burden on the use of electricity for such purposes. On the other hand it is highly serviceable for some uses on account of its great convenience, cleanliness and adaptability.

Electric heating may be divided into two classes, domestic and industrial. In the former we find the heating of utensils, such as toasters, coffee-percolators, milk-warmers, etc., as well as flatirons, heating-pads and similar sick-room necessities.

Preparing Breakfast.—Coffee is generally regarded as the most important item of a breakfast. Electricity will prepare this in a few minutes at a cost of about 1 cent. Toast enough for the family is made in from 10 to 15 minutes at an equal cost, and eggs are boiled at a cost of 1½ cents. Or, if a heartier breakfast is required, 20 or 30 minutes will prepare any one of a hundred simple eatables on the chafing dish at a cost not to exceed 2 cents.

Fig. 41. Preparing breakfast by electricity.

Thus 4 cents a day, or $1.20 a month, will get the family through some of the most trying hours of the day, without any particular trouble or inconvenience to any one. No one has to get up and go down to build the kitchen fire, or do any of the many things which are usually necessary in getting the family started for the day.

Electric Ironing.—Ironing day comes once a week, and here again electricity makes its appearance. With an electrically heated flatiron

Fig. 42. Electric dining-room set.

the ironing is done not only at a distinct saving in time and steps over former methods, but whenever it is most convenient. The week's wash may be ironed at a cost of perhaps 20 cents, or another 80 cents per month, bringing the total bill up to $2 per month.

Preparing Afternoon Tea.—On many other occasions electricity may also be put to work, getting the afternoon tea in 8 to 10 minutes at a cost of less than 1 cent, cooking a chafing-dish supper at a cost of from 3 to 4 cents; and, in case of sickness, the heating-pad supersedes the old-fashioned hot-water bottle, furnishing the invalid with constant, even warmth all night at a cost of 2 cents.

For the Bath.—Besides these smaller and frequently used articles, there is another class of electric heating which is very intermittent in its use, but none the less welcome. A 2-kw. radiator, turned on for 20 minutes or so in the early morning, will render a bath-room comfortable at a cost of 8 cents. A portable plate-warmer will keep some one's dinner hot for an hour for 3 cents without drying it up or running the chance of ruining the dishes in an oven.

Electric Cooking.—The application of electricity to cooking is a most interesting one. For light meals, like the breakfast described above, it is very inexpensive. Many a meal can be had with a disc-stove, or perhaps two, and a few detachable utensils, at an expense of from 3 to 10 cents, depending on the menu. Two small disc-stoves have long sufficed to get breakfast for one man and his wife, who take the rest of their meals out. On rising a cereal is put on and is cooked by the time they are ready for it. Eggs are then boiled, poached or fried, on one stove while the coffee is made on the other, and finally each partner makes toast on the stove-top while the breakfast is being eaten.

An electric waffle-iron may be used on the table or in the kitchen, as occasion warrants. Waffles made in this way are much lighter than those made over a fire, owing to the fact that they are cooked on both sides at once. The even distribution of heat over the entire surface insures a perfect brown, and about one-fourth less batter is necessary. The cost will not, on the average, exceed 3-10 of a cent per waffle.

With an electric broiler there are no gas or charcoal fumes to affect the nourishing qualities of the food; and the placing of the meat directly upon the heated surface so sears the outside that practically none of the juice escapes. While the current consumption is considerable, 1¼-kilowatts on the smaller sizes in a few minutes will broil an ordinary steak at a cost of 3¼ cents. Fish and chops will be cooked even more quickly, at a cost of 3 cents or less for a family of four or five.

Griddles for frying pancakes, etc., and kettles for doughnuts, croquettes, and other things which are cooked in deep fat, may be operated at a cost of 8 or 9 cents per hour.

Family Cooking.—To do the entire cooking for a family on a competitive cost basis with gas or coal is a different matter. All the above prices have been figured at about the average lighting-rate of 10 cents per kilowatt-hour, but an electric kitchen range demands, and in many cases receives, a better rate. Current consumption varies greatly with the scale of living, but will average 1 or 1½ kilowatt-hours per person per day.

To attain these results some care must be used. Maid and mistress must learn that current may be wasted by carelessly leaving the oven, stove or broiler turned on. Practically all apparatus of this kind is provided with controlling switches which regulate the intensity of the heat. An article put on to boil will take, say, 500 watts for 15 minutes to bring it to the boiling point, but 125 watts will keep it simmering. Bread is baked by perhaps 30 minutes' use of a maximum amount to heat up the oven, then 15 minutes on the medium, and the completion of the baking without the

Fig. 43. Electric baking and cooking.

use of any current at all, a total energy expenditure of 1 kilowatt-hour.

The clock has an important position in the electric kitchen. After once timing a perfect cake, it can be repeated indefinitely with unvarying success, and the "slow fire" and the "hot fire" terrors of the young housewife disappear.

In many families the mistress does the cooking. With electricity she finds most of the old drudgery gone. The heat, smoke and dirt have disappeared with the wood-box, the coal-scuttle and the ash-can, and the time and labour saved for other things more than compensate for the additional expense.

Keeping a range clean is a very simple matter. The heating element itself requires practically no attention save an occasional wiping with a damp cloth, as the utensil protects it while in use. The broiler may be treated in the same way when still fairly warm. Aside from the heaters there are no surfaces where drippings can lodge and burn, for the rest of the range always remains cool.

In hotels and institutions, large electric ranges and grills are frequently installed. The former find them especially convenient as occupying less room than the coal range, being cleaner and more convenient. Hospitals find that not only is the cooking more sanitary, but all the conditions surrounding it are so improved that from the standpoint of health alone an electric range is very well worth while.

In summer, when the heat of the ordinary kitchen is to be dreaded, an electric oven may be running on the maximum with no perceptible radiation 2 feet away, and windows may be

Fig. 44. Electric waffle irons.

wide open, for there is no flame to be affected by the wind.

Of more recent growth are the applications of electric heating on a larger scale. The laundry presents a good example, but here care must be taken to provide the right equipment or the installation may be a failure through no fault of the apparatus. As the work is done faster and more continuously than in the home, the wattage must be greater, and, as a consequence, a laundry running idle quickly increases greatly in temperature.

Heating Water.—To what extent water-heating by electricity is practical depends entirely upon conditions. Anything like instantaneous water-heating is almost out of the question on account of the large amount of current necessary, but small amounts of hot water may be obtained with a small installation, provided time be taken. A rough and handy rule is that 300 watt-hours will raise 10 gallons of water 10 degrees, but this may vary considerably with radiation, and 300 watts in a cold bath-tub would be almost entirely dissipated owing to the great capacity of the tub itself for absorbing the seat.

Therefore the proper and adequate heat insulation of any container of water-heaters is very important. An electric boiler may be useful and at a 4 cent rate, which is not uncommon for this purpose, and with an initial water-temperature of 50° F., such a boiler will furnish 100 gallons of water per day at 110° F., a warm bath temperature, for 60 cents, or 6-10 of a cent per gallon. The heating element consists of coils of tubing within the boilers, and these are removable.

A CENT'S WORTH OF ELECTRICITY, AT 10 CTS. PER KW-HR.

Will keep a 6-lb. electric flat-iron hot for 15 min.
Will make four cups of coffee in an electric coffee percolator.
Will keep an 8-in. disc stove hot for 7 min., or long enough to cook a steak.
Will operate a luminous radiator for 8 min.
Will bring to a boil two quarts of water.
Will make a Welsh rarebit in an electric chafing-dish.
Will operate a 7-in. frying pan for 12 min.
Will operate an electric griddle for 8 min.
Will run the electric broiler for 6 min.
Will keep the foot-warmer hot for a quarter of an hour.
Will heat an electric curling-iron once a day for two weeks.

Miscellaneous Uses.—Baking ovens may be had in various capacities up to 100 or more loaves per day. These ovens may be accurately timed to produce the best results, and the heaters so disposed that the bread is evenly baked.

The purely commercial uses of electrical heating are numerous and rapidly growing. Many types of shoe machinery are now equipped and factories making clothing, overalls, shirts, and even lace curtains, use electric flatirons. Bookbinders' tools, rubber vulcanisers, branding irons, embossing presses, matrix driers, hair driers—all are successfully heated by electricity.

Doctors and dentists use electric sterilisers, electric ovens for sterilising bandages, and electric cautery needles and knives for operations.

Wood workers use electric glue pots, metal workers soldering irons, and bankers and ex-

Fig. 45. Electric iron.

press companies electric sealing-wax pots. The field is constantly broadening.

These details of heating are only an outline of the subject. The art has grown enormously during the last five years, and to-day there are hundreds of different devices for domestic purposes, ranging from curling irons to complete cooking ranges, eliminating an untold amount of danger. Electric household devices are not only for the residences of the wealthy but also for the cottages and apartments of the less fortunate, where they are of vastly greater service and importance, because in such homes servants are not commonly employed.

Heating of Rooms.—One of the manifold uses to which electric heat is applied is the artificial heating of air in buildings on a comparatively small scale. While this method of obtaining artificial warmth has not yet reached a state of perfection permitting it to be economically applied to the heating of the air of large buildings, yet the convenience arising from the facility with which the electric current can be led to the heater, the comparatively small size and portability of the latter, the readiness with which the current can be turned on and off, the safety of the apparatus, its freedom from fumes and dirt, and the ease with which it can be managed, are being more and more appreciated and their use is rapidly increasing.

The subject of heating and ventilating rooms is a very broad one, and is affected by so many different conditions that no steadfast rule can be laid. Some of the ever-varying conditions are:

Sizes of the rooms or buildings.
Amount of exposed wall surface.
Thickness of walls.

Amount of exposed glass surface.
Whether the glass surface is single or double.
Building material used, as wood, brick, etc.
Temperature desired.
Minimum outside temperature.
Number of times air is changed per hour.

As these conditions are frequently not known,

Fig. 46. Electric range.

it is safe to figure that it requires one watt-hour to raise the temperature of one cubic foot of air about 200 degrees F.

In addition to raising the temperature of the air to the desired degree, the loss of heat through conduction and ventilation must be taken into consideration. Electric energy supplied at the rate of one watt will raise the temperature of a cubic foot of air at the rate of 0.0556 degrees F. per second, or approximately 3.3 degrees per minute.

The power required to keep the temperature at a given degree can be roughly estimated by assuming the number of cubic feet of air which are required per minute for ventilation, multiplying this by the number of degrees which the temperature must be raised and then dividing the product by 3.3, which gives the number of watts necessary to maintain the temperature. For example, assume a room 15 by 15 ft. and 10 ft. high, in which the air is changed three times an hour, and the temperature to be maintained 30 deg. above the outside. The volume of the room=15 × 15 × 10=2250 cu. ft.

$$\frac{2250}{20} = 112.5 \text{ cu. ft. per min.}$$

$$112.5 \times \frac{30}{3.3} = 1020 \text{ watts necessary to supply ventilation loss.}$$

To begin with, the air of the room must be raised 30 deg. This will require

$$2250 \times \frac{30}{200} = 370 \text{ watt-hours.}$$

Therefore the total energy used during the first hour will be 1.020 + 0.370 = 1.390 kw.hr., and during the succeeding hours it will be 1.020 kw.hr. per hour. It will be noticed that by far the largest part of the energy is used in supplying the loss due to ventilation.

The amount of power for electrically heating a room depends greatly upon the amount of glass surface in the room as well as upon the draughts and admission of cold air. An empirical rule, commonly employed, is to figure from $1\frac{1}{2}$ to 2 watts per cubic foot of space to be heated.

According to European authorities, if a sitting-room with a content of 100 cubic metres is to be heated to 17 degrees centigrade, while the temperature of the outside is 3 deg. cent., the engineer estimates that 3500 kilogram calories are required per hour. With electric heating this means a consumption of 4 kw.hr. for every hour, while with coal fuel about 3 kilograms of coal are required per hour. Experience has shown that for every degree Cent. difference between the lowest outside temperature and the desired inside temperature, and for every cubic metre of space to be heated, 1 to 1.5 watts of electric power are required. As an approximate average, 1.2 watts may be assumed. For instance, if the outside temperature is 10 deg. Cent. below, and a sitting-room of 50 cubic metres is to be heated to 18 deg. Cent., the difference of temperature is 28 deg. Cent. Hence 1680 to 1800 watts are required, while the time in which the desired temperature is obtained varies from one to three hours, varying of course, according to whether the neighbouring rooms are heated or not.

QUESTIONS

1. For how long a time have electric heaters been in use?
2. What is one kilowatt-hour expressed in heat units?
3. Describe the various electric heating appliances for domestic use.
4. Give examples of cost-figures for electric heating.
5. Give examples of cost-figures for electric cooking.
6. Give comparative cost-figures of heating by gas and electricity.
7. Give comparative cost-figures of cooking by gas and electricity.
8. Can large rooms advantageously be heated by electricity?
9. Give the calculation to ascertain the watt-hours required for heating rooms.

CHAPTER XII

ELECTRIC LIGHTING

THERE are few subjects which demand more attention than the illumination of the home, as the proper lighting of a house adds very much to both its comfort and its appearance. Illumination has gone through many stages of development. The earliest forms of lighting, the pine torch, the candle, and the kerosene lamp, bear a marked contrast to the modern electric light.

With the introduction of electricity came the greatest step in advance. The use of matches and the consequent fire-risk, the annoyances of filling and caring for lamps, the breakage of chimneys and parts, the prevalence of smoke and disagreeable odours, the vitiation of the air, inseparable from both oil and gas lights, have all been eliminated by electric lights.

However, as is usually the case with the introduction of improved appliances, the cost of apparatus for generating electricity and the large amount of it required for lighting a home,

Fig. 47. Electrically lighted stable.

limited its earlier use either to those who could afford the expense of installing and maintaining a large and elaborate plant, or to those who lived within reach of a public service electric-lighting station.

The Incandescent Lamps.—The tungsten lamp has made it possible to obtain the same amount of illumination formerly afforded by the carbon filament lamp with one-third of the electricity. This lamp will wear longer than the old style lamp and maintains its full brilliancy during the greater part of its life. It is also less sensitive to the variations in pressures of electricity, and therefore its use requires less complicated and expensive apparatus.

The reduction in the amount of electrical energy required per tungsten lamp has brought about a proportionate reduction in the cost of generating and storing electricity, so that now the many advantages to be gained from the various uses of electricity are within reach of all those of very moderate means. The country resident or farmer, situated beyond the reach of a public electric-lighting station, is now able at very small expense to install and operate his own lighting plant.

The need of an efficient lighting system for farms has long been recognised as of great importance for the country. With better light greater efficiency and cleanliness is secured al around, fire risk is diminished and insurance rates are reduced. Small electric lamps in closets and in dark corners, in cellar or attic, are very convenient. These small electric lights take the place of oil lamps or candles, whose light is unsatisfactory, and the use of which is inconvenient and dangerous.

Electric illumination is the superior method for the lighting of stables and barns. The use of lanterns in and about barns and similar places has been the cause of numberless fires and the destruction of millions of dollars' worth of property, as it is seldom that the country house has available apparatus for successfully fighting fires. Electric lamps require no matches, and burn without flame, consume no oxygen and therefore do not vitiate the air of the room. They are turned off by a simple switch placed in any convenient part of the house. The electric system is not affected by extremely cold weather, as is the case with gas.

Having electric current on the farm for operating the various machines, it is but natural that advantage should be taken for the utilisation of the current for lighting the house, barns and outbuildings, yard and grounds. In the following discussion, the scheme and method of lighting the various rooms, buildings and yards will be treated separately. Two different methods of lighting will come under consideration, the incandescent lamp and the arc light; the former for small spaces such as rooms, stairways, etc., the latter for large areas, such as the interior of barns and sheds, and for yard lighting.

Arc Lamps.—An important use for the arc light in modern farming is found in the illumination of the field during the time of harvest. Threshing can be continued long after nightfall by locating an arc-lamp or two in the vicinity of the threshing machine. The advantage of threshing after dusk is very apparent and the arc lamp is a simple and convenient solution of such a situation. Winds do not affect the operation or the intensity of light given out. The general adoption of the flame arc-lamp for the lighting of streets, barn-yards and large interiors, and the growth in the number of installations for this class of service during the few years since the lamp was first introduced in

America, are due to its superiority when compared with other lighting units. It is now generally conceded that this is the most efficient illuminant yet developed, and that the penetrating quality of the brilliant golden yellow light is such that even under the most adverse conditions, such as those imposed by fog or smoke, it provides a highly satisfactory illumination.

Exterior Lighting.—Arc-lamps are suspended from poles, brackets on buildings, or even from cables strung between buildings. For illuminating a threshing field, a portable pole can easily be erected on the threshing machine itself, or on the motor-wagon accompanying the thresher. Such a pole may be either of wood or sections of pipe, screwed together and of sufficient length to support the lamp high enough in the air so that the most economical area is lighted.

For lighting a large interior by arc-lamps, small lamps are made with the mechanism compact and the light given out very intense. The selection of such lamps must be left to the engineer having charge of the installation.

Interior Lighting.—As previously stated, for interior lighting incandescent bulbs, with either the old carbon filament or the new tungsten style, are used. The introduction of the new metal filament incandescent lamp has produced results of a far-reaching and most revolutionary character in the lighting industry. To its many advantages of convenience, safety, adaptability, portability, low maintenance-cost, cleanliness and reliability, the metal filament has added a three-fold improvement in efficiency which definitely establishes the incandescent lamp as the ideal illuminant, and ensures it a supreme position in the lighting field.

The first metal filament lamp, the tantalum, with its efficiency of 2 watts per candle, was closely followed by the tungsten lamp with an efficiency of 1¼ watts per candle. The tungsten lamp (also called Mazda) gives the high efficiency of 1 to 1¼ watts per candle, and represents the highest attainment in this direction.

Electricity can now compete with gas and other illuminants on an equal basis of cost, thus opening a field for new business of almost unlimited extent. A more liberal use of light (larger lamps and longer hours of service) is

Fig. 48. Electric threshing by electric light. View taken on an autumn night, during the early days of electric farming in Germany.

possible without excessive cost, thus improving the load-factor of the central station. A much better quality of light is secured, a light that is not only superior in brilliancy and intensity, but more attractive in colour and better suited for general illumination.

While the tungsten or Mazda lamp thus advances the art of lighting, it also maintains the simplicity of installation and operation of the ordinary incandescent lamp. It is available in small or large units having equal efficiency; it has no moving parts, is applicable to all classes of service, whether direct or alternating current of any frequency, and, most important of all, it involves no heavy investment.

The surprising increase in efficiency is given by the filament and is due to two causes: first, the fact that, due to selective radiation, the filament gives more light at the same temperature than the carbon filament; second, that the filament of the tungsten lamp can stand a much higher temperature than the carbon filament. A much higher degree of incandescence is thus obtained, and a much greater volume of light per unit of energy is produced, as shown by the remarkable efficiency of 1 to 1¼ watts per candle.

Example of Lighting Rural Residence.—For lighting farm residences and country homes in general, by the incandescent-lamp system, the following outlines from a bulletin issued by the University of Illinois, are of interest:

Since the living-room is the one in which most of leisure time of the family is spent, it should therefore be well lighted. First of all there must be a light for reading purposes. Since the family is likely to be large, several persons will often want to read at the same time, so a considerable area should be well illuminated. The ordinary table electric reading-lamp would be very satisfactory for one or two persons to read by if the room were otherwise generally illuminated. In the ordinary farm home, however, the lamp that furnishes light for reading is usually required to furnish a general illumination for the room. This a table lamp will not do. Accordingly, a three-light fixture is provided. In this fixture the middle socket points directly downward, and is equipped with a prismatic glass reflector. This will concentrate the light under the chandelier for reading purposes, and at the same time give a moderate illumination of the walls and ceiling. Thus, the single reading lamp becomes sufficient for ordinary occasions. When a more general illumination is desired, the middle lamp is turned out and the two outside lamps are used. These two lamps are provided with prismatic reflecting globes. Since the reflecting globes will prevent the dazzling direct rays from the filament from reaching the eyes of a person in the room, unfrosted lamps may be used. The middle lamp, however, may be seen from positions close under the chandelier. Hence a frosted lamp should be used here. The fixture should be hung so that the lamps are about six and one-half feet from the floor.

A dining-room requires a strong illumination over the table and a soft pleasing light over the walls and ceiling. This can be obtained by two lamps placed in prismatic bowl-reflectors hung at a height of six feet from the floor. These reflectors will distribute the light well to the edges of the table, while the ceiling and walls will be sufficiently lighted to make the room seem cheerful, but not brilliant. Frosted-tip lamps should be used. A single unfrosted lamp placed in a glass reflector will amply light the hall. It should be hung about eight feet from the floor.

The kitchen has such an important place in the life of the farm house-wife, that it should be well illuminated. This can be adequately done by a single lamp in a pendant fixture hanging rather high in the middle of the room, and provided with opal bell-reflector. Over the stove and table where it is most needed, there is an adjustable bracket-fixture with an opal bell-reflector and a frosted-tip lamp.

One lamp placed inside of a prismatic reflecting ball is used for lighting the porch. This is placed in front of the door and directly on the ceiling. The upper fluted portion of the ball throws the light downward where it is needed. The lower portion is frosted in order to soften the glare of the filament.

The lights in the cellar are equipped with the flat enamelled metal reflectors, and are placed on the ceiling.

For each bedroom a bracket fixture carrying one frosted light in an opal bell-reflector is provided, and placed high enough to furnish a good light by which to dress beneath it. An eight-candlepower carbon lamp is placed in three of the closets. These are simple drop lights suspended about 6½ feet from the floor, and no extra length of cord should be provided, or the lamp may be hung upon a hook in contact with clothing. Then, if the lamp is accidentally left lighted, a fire is almost sure to follow. Simple, single-light pendant fixtures are provided for the second floor hall and the bathroom. These are equipped with opal bell-reflectors and are hung about seven and one-half feet from the floor. The lamps should be frosted.

The following table is a summary of the number and distribution of the lights of an ordinary country residence; and also shows the number of lamp-hours per twenty-four hours.

Dining Room: Two lights, on during breakfast and supper	
5:00—6:30 a. m.	6 lamp hours
5:30—7:00 p. m.	
Living Room: Three lights, on only after supper.	
7:00—10:30 p. m.	10½ lamp hours
Kitchen: Two lights, on morning and evening.	
5:00—7:30 a. m.	10 lamp hours
5:00—7:30 p. m.	
Front Hall: One light	
8:00—10:30 p. m.	2½ lamp hours
Front Porch: One light	
7:30—9:00 p. m.	1½ lamp hours
Rear Hall: One light	
5:00—6:00 a. m.	2½ lamp hours
6:00—7:30 p. m.	
Bedrooms: Two lights	
5:00—5:30 a. m.	2½ lamp hours
9:00—9:30 p. m.	
One light	
10:30—11:00 p. m.	
Total	35½ lamp hours

Tungsten or Mazda lamps ordinarily installed in residences are of 25-watt or 40-watt size. Using the 25-watt size, the daily cost of 35½ lamp-hours would amount to 14½ cents a day or $4.35 a month and with the 40-watt size, the cost would be 18¾ cents a day or $5.62 a month.

Effect of Wall Colour.—In using lights, several factors of great importance must be taken into consideration, in addition to the placing of the lamps in the best positions and the use of certain forms of globes, and these factors are the colours of the shades, the colour of the wall-paper and the effect of the combination on the eyesight.

The colour of the wall-paper increases or decreases the volume of light in a room in proportion to its reflecting properties. In a room coated with white paper, a large part of the light that strikes the wall is reflected back into the room while, when a chocolate colour is used, only a small part is reflected; the white-papered room will be more than three times as effectively illuminated as the other. Papers arranged according to their colours reflect light and add to the illumination of a room in the following order, expressed in terms of illuminating value:

White	3.33
Chrome Yellow	2.63
Orange	2.00
Plain Pine Wood	1.82
Yellow Paper	1.67
Light Pink Paper	1.56
Yellow Paint	1.25
Emerald Green Paper	1.22
Dark Brown Paper	1.15
Vermilion Paper	1.14
Blue-Green Paper	1.14
Cobalt Blue Paper	1.14
Deep Chocolate Paper	1.04

Effect of Globe and Shade Colour.—The colours of the globes and shades have a greater effect upon illumination than the colour of the walls, as will be seen from the following tables. The absorption of light in clear glass globes is very low, while in cobalt-blue globes practically all the light is absorbed, as appears from the subjoined list.

Colour of Glass	Per cent.
Clear Glass	5 to 10
Light Sand-blasted	10 to 20
Alabaster	10 to 20
Canary-coloured	15 to 20
Light Blue	15 to 25
Heavy Blue	15 to 30
Ribbed Glass	15 to 30
Opaline Glass	15 to 40
Ground Glass	20 to 30
Medium Opalescent	25 to 40
Heavy Opalescent	30 to 60
Flame Glass	30 to 60
Signal Green	80 to 90
Ruby Glass	85 to 90
Cobalt Blue	90 to 95

While to produce the greatest amount of lighting white walls and clear glass globes are requisite, it must be remembered that a high illumination may affect the eyes most unfavourably. Conservation of the eyesight is quite as important as conservation of electric energy and certain principles should be observed. Light should be so shaded that the rays are not reflected into the eyes as a glare. The direct rays of the incandescent filament should not strike the eye. Light coming in large quantities from an unusual direction should be avoided. An example of this is seen in the effects of foot-lights and spot-lights on the eyes of actors. Both too much and too little light should be avoided. Sources of light which produce streaks, and sharp contrasts, as between a brilliantly lighted desk and the remainder of the room in darkness, should be avoided.

In a well-lighted room, the lighting should be such that it attracts no attention to itself, either from being too intense or too dim, just as a well-dressed man is one so garbed that his clothing attracts no attention on its own account.

QUESTIONS

1. What are the advantages of electric lighting?
2. Describe the old and new types of incandescent lamps.
3. Where should an arc-lamp be used?
4. Describe interior lighting systems.
5. Describe exterior lighting systems.
6. Describe an example of rural residence lighting.
7. What is the effect of wall colour in illuminating a room?
8. What is the effect of colour in lamp shades?
9. What is the most efficient colour for wall and lamp shades?

CHAPTER XIII

THE TELEPHONE IN RURAL COMMUNITIES

THE farmer of to-day, whenever he is thoroughly convinced that a certain tool or piece of machinery will do his work better, do more of it, or increase his income, isn't very long in becoming the owner of that tool or machine. That this attitude has proven beneficial to himself and to his calling is demonstrated by the wonderful strides agriculture has taken, and the improved methods employed on the average farm. But he must be convinced. He is a careful, prudent man, not quick to jump at conclusions.

The first thought that must have come to the minds of a majority of farmers upon the advent of the rural telephone line was, "Of what good to the farmer is the telephone?" This was a very natural question.

Some farmers argued that they had gotten along so far in life without the telephone, why not the rest of their days? This same argument, if carried out, would have kept hundreds of other improvements, now considered absolute necessities, off the farm, and would thus have greatly retarded the march of agricultural progress.

Because a man might walk from New York to Chicago is no reason why it would not be cheaper and more sensible to ride, as well as being quicker and easier. Thousands of farmers, however, were quick to recognise the value of the telephone to the rural resident. They foresaw the improved conditions that its adoption would bring to them and their families, and the consequence is that the building of farm lines, which began a long time ago, is going on at a livelier rate than ever to-day. No one questions the statement that time is money, and very few will question the statement that as a time-saver the telephone has no equal. Time is an important item on the farm. The need of a telephone connection is far more urgent to the farmer than to the city man. Every errand means a long trip to town or to the neighbours, involving a loss at every step. Lost time means lost money and lost opportunity.

Suppose in the rush of the busy season, when every hour is precious, a piece of machinery breaks down. What is the result? To get repairs means a trip to town; lost time; perhaps a wasted crop. With the telephone at hand, the new part may be ordered in a moment and be on its way by rural delivery before the "boy" could saddle his pony and get started after it, often reducing the delay from a day to an hour.

The product of the average farm in the United States is worth $850 but the progressive business farmer who uses the most improved implements and machinery produces 50 to 100 per cent. more than the average. There are only about 200 good working days in a year on the farm, therefore every day counts. When a corn field is getting weedy, a day's work with the cultivator will make a difference of $25 in the value of the crop. When a field of wheat is ripe, the delay of a day may cost more.

The successful farmer has to consider all these things and he cannot afford the time to run errands when nature is calling him to the fields. Help on the farm is scarce, and is more difficult to find each year. The farmer must help himself by using everything which will save labour and make his time go farthest, and a man with the most modern equipment can do as much as two or three men with old, out-of-date methods.

A Time Saver.—The farmer with the telephone not only saves time which he can devote to his fields, but if he needs a man for a few weeks or a few days, the telephone gives him the inside track in finding some one. If he has a fence to build or some other odd job that he cannot take the time to do, a moment at the telephone will discover some one in a near-by village or town who will be glad to do the job. While it is getting harder and harder to find men who will work for a year on a farm, the telephone makes it easy to get transient help just when you need it without losing or hunting for it.

In a hundred other ways the telephone saves time and helps to keep things going, thus swelling the profits for the year. It saves the hard-worked farm-horses many a drive when they need the rest. When stock gets sick the farmer can call the veterinary quickly and thus perhaps save the most valuable of his animals. When the threshers are in the neighbourhood he can step to the telephone and make the needed arrangement for "change" of work, hire extra help for haying or harvesting, order provisions down town, get market reports, and save time in a thousand different ways.

"A friend in need is a friend indeed," and perhaps the greatest service the telephone can render is in the time of sickness. Medical attention can be summoned, more than half the time saved,—in many instances a precious life. When accidents happen or a fire breaks out, the telephone affords assistance that could be obtained in no other way, and one such service may easily repay its cost many hundred times over.

Before hauling produce to town, the farmer can know just what the dealer is paying; he doesn't have to go it blind, and take the dealer's prices or haul his stuff back home. He knows that he has the advantage. He is in a position to buy when prices are down and sell when prices are up.

As a Business Getter.—The telephone is the connecting link between city, town and country. In a social sense alone it is worth all it costs. News of the neighbourhood flashes across the wires before it gets cold. It helps to keep the boys and girls contented at home. They are no longer isolated from the society of other young folks, and farm-life is not the dry drudgery of the non-telephone times. The farmer thus owes it to his family to have a telephone installed. Many times he is away from home and his wife and children are in peril of the encroachments of tramps and other offensive characters, but by means of the telephone, they can immediately summon assistance, which could not be obtained in any other way.

Petty thieving can be often detected and information sent speeding of news of any outrageous conduct through the neighbourhood. Pilfering has almost entirely disappeared where telephones are in general use.

The advantages of the telephone on the farm are so numerous and valuable that it is difficult to appreciate them at their real worth. With its advent comes new companionship, new life, new possibility, new relations and attachments for the old farm, by both the young and old. Lonesomeness is banished by the privileges of city life being added through the telephone, and the influx of country folks to the city has been changed to an exodus from city to farming communities, even to a much greater degree than people who have not investigated realise.

The advantages of the farm telephone cannot be overestimated, because their practical utility is unlimited, and where installed, they are never taken out. The farmer cannot keep house without one, after once learning the convenience, time-saving and money-saving features.

Telephone Lines.—A metallic telephone circuit consists of two wires on a single set of poles, one for the outgoing current and one for the return current. Metallic circuits are always preferable to grounded lines, as the service is superior, being free from noise caused by earth-currents, and the liability of damage to apparatus by lightning is much less.

Where several metallic circuits are run on the same set of poles, they should be transposed, that is, the wires of circuits should be crossed and recrossed, which is done to prevent cross-talk between the different circuits. Cross-talk may be explained as follows: When two telephones are in use, the subscribers on all the other lines on that set of poles can hear the conversation going on, although there may be no metallic connections, and if the lines are run for a considerable distance on the same set of poles, this cross-talk would be so strong as to be objectionable. No definite rule can be given for this crossing and recrossing, as different schemes are required for various numbers of lines on a one-pole route.

A grounded line consists of one wire on the poles and using earth for the return path of the current. Grounded lines prove quite satisfactory where there are no trolley wires, electric light circuit or telegraph wires running very close to the line. If such conditions as these are encountered, a grounded line will pick up so much noise from the other lines as to make it almost impossible to hear distinctly, but this can be overcome by running a metallic circuit.

Where a great many lines are run on the same set of poles, and where a ground-return will not be satisfactory, a common return wire is sometimes used. This style of construction was at one time of very common practice with telephone exchanges. It consists in running several wires on the same set of poles and using one larger wire for the common return. In the common return line, only one ground is made, this being located at the central office, and it is important that an extra good grounding should be made. Of course the number of instruments that are to be used on a line determines to a large extent which is the most practical kind to build, a metallic grounded or common return line.

After the conditions are known and the kind of line decided upon, the first thing that becomes necessary in the building of a line is its proper location. This is usually accomplished by starting from an initial point and measuring off distances where poles are to be set, locating them by stakes as nearly as possible to the measurements. The line should be built as straight as possible, avoiding sharp turns and angles.

Telephone Poles.—Cedar or chestnut poles are the best. Poles should be peeled and the top end roofed so that the water will run off instead of collecting at the top and decaying the pole. The length and size of the pole depends entirely upon the kind of a line that is to be built. It is not well to use poles with less than 5-inch tops, and 6 inches is a better size. The average length of poles is 25 feet. In some instances, where no roads have to be crossed, and where one wire is to be carried, 20-foot poles can be used. For a line with one or two wires at least 30 poles should be used per mile, for four or more wires, 35 poles to the mile; the more poles used the shorter the stretches of wire, and the less liable is the wire to break.

Brackets.—Brackets are usually made of oak and are given two coats of metallic paint. They have a thread on the upper end to which is fastened the glass insulator, of a type especially adapted to telephone work. Where only one or two wires are to be carried on the poles, brackets serve the purpose very satisfactorily.

They should be at least 18 inches apart. The upper bracket should be 8 inches from the top of the pole, and the other 20 inches below it on the opposite side. The bracket should be nailed to the pole with one 50-penny and one 20-penny nail.

Cross Arms.—Where three or more wires are to be run on the same pole cross-arms should be used. They are made of sawed yellow pine painted with two good coats of metallic paint, and are of a length to accommodate from two to ten pins. The size of the arm used for telephone work is 2¾x3¾ inches, bored for 1¼ inch pins.

The proper way to attach the cross-arms to the pole is to cut a recess about 1½ inches deep, 10 inches from the top, and of such width as to cause a tight fit of the arm; then fasten with a machine bolt, through the arm and the pole, with a nut and washer on the opposite side of the pole. Two lag screws can be used for this purpose, but they are not quite as good. The arm may be further strengthened by two iron "cross-arm braces." These usually consist of straight flat galvanised iron bars 1¼ inches wide by ¼ inch thick, varying in length from 20 to 28 inches. Holes are usually punched in one end for the reception of ½-inch lag screws, and in the other end for ⅜-inch carriage bolts. On straight lines, where the distances between the poles are equal, the cross-arm should be placed on alternating sides of the pole. On curves, the cross-arm should be placed on the poles so that the strain of the wire will pull it against the pole; then the strain of the wire is on the pole instead of the bolts. On curves and corners, the wire should be tied to the side of the insulators away from the strain. The quickest way to erect a line is to do all the work on the poles, such as attaching brackets or cross-arms, before the poles are set into the holes.

Lightning Protection.—Every tenth pole should be equipped with a lightning rod, made of No. 9 or No. 10 wire, stapled on the side of the pole and attached every two feet by ½ inch galvanised iron staples. The rod should be extended to the top of the pole and have two turns under the bottom end of the pole.

Setting Poles.—Twenty-five-foot poles should be set at least 4½ feet in depth, and on curves six inches or a foot deeper. The hole should be large enough to admit the pole without hewing or cutting, and to permit free use of the tamping and digging bar. The refilled earth should be thoroughly tamped, as it will greatly lessen any trouble from poles pulling away when placed under strain. The soil should be firmly packed around the poles to a height of at least 12 inches above the ground. Every corner pole and every pole not in line should be guyed before the wire is stretched, or else the line will not stand up properly and will always be giving more or less trouble. The guying can be done by a brace-pole, or by running a No. 6 or No. 9 wire from the top of the pole to an anchor which should be set in the ground some four feet, or by running a guy-wire from the top of the pole to a suitable guy stub. Single guys to anchor should be used whenever possible and set in the line of the resultant strain from the line wires. When it becomes necessary to raise the guy-strand to a sufficient height to clear obstacles or cross the highway, guy-stubs should be used. The poles should not be guyed to fences or trees, as the former are not permanent, and the swaying of the trees will break the wire.

Telephone Wire.—No. 12 B. S. galvanised iron telephone wire is the proper wire to use for the telephone circuits. It will give the most satisfactory results, and is by far the cheapest in the end. It should be stretched tight, leaving not more than 10 inches sag between the poles. The wire clamp consists of a clamp which has an automatic arrangement whereby the wire is automatically gripped when a strain is exerted on the pulley-blocks to which the clamp may be fastened. The clamp releases automatically as soon as the strain on it is released. Iron or steel fence wire may be used, but it is very hard, or high in resistance, and therefore cuts down the talking efficiency, and not being so well galvanised, rusts in a short time. Its cost per pound is somewhat cheaper than galvanised wire, but the fact that it takes a greater number of pounds of wire to reach a mile than the No. 12 B. S. galvanised iron telephone wire makes the total cost greater. For example, No. 10 steel fence wire costs 3½ cents per pound, and one mile weighs 260 pounds. This brings the cost per mile to $9.10. The No. 12 B. S. galvanised iron telephone wire costs 4⅛ cents per pound, and there are 165 pounds to a mile, making the cost $6.80 per mile.

Insulation.—The insulation of the telephone line means its isolation from anything that would tend to conduct the electricity direct to earth instead of passing through the telephones in such proportionate quantities as it should. The insulation of the telephone line should, of course, be as good as it is possible to make it. Telephone lines must not be allowed to touch or come in contact with tree tops, for the limbs and leaves would tend to ground the lines, and the swaying of the trees might, in some cases, break the wire. Where telephone lines run through wooded sections, it is well to trim off the tops of all the trees.

Making Connections.—To make connections place the telephone on the wall as near the outside line wire as possible. Rubber-covered, weather-proof copper wire should be used to run from the telephone to the line wire and to the ground. In damp places rubber-covered wire should also be used. In single-wire grounded circuits, avoid making the ground-wire extending from the instrument to the ground any longer than is absolutely necessary, as any unnecessary turns in it have a tendency to cut down the efficiency of the line, since thus an additional amount of resistance is introduced. Either single-conductor or double-conductor, rubber-covered, weather-proof copper wire is the most durable and satisfactory to run from the instrument to the line wires. Always take the covering from the wire where it goes under the binding posts and scrape the wire bright and clean. The wire leading from the telephone line to the telephone instrument should extend from the nearest pole to a porcelain knob, fastened to the outside of the house near where the telephone is mounted. If the nearest pole to the house should be over 100 feet away, it is advisable to run this line to an oak bracket with pony glass insulator instead of to the porcelain knob. Insulated saddle staples should be used to fasten the wires to the walls of the house.

Ground Connections.—The most common practice of making ground connection is to take a sharp iron rod seven feet long by half an inch in diameter, having a hole about three inches from the top end, and drive the rod into the earth in some damp place so that enough of the rod sticks out of the ground to attach the ground wire, which is done by inserting the wire through the hole near the top and making several turns around the rod and then soldering carefully. Care should be taken to drive the rod into the earth in a place where the earth is damp continually, and not for a few months in the year. The difficulty in driving this rod can greatly be overcome by making a hollow in the ground, filling it with water and letting it stand for a while. Do not try to use a piece of iron wire for ground, as it will not prove satisfactory. Another good method of making a ground is to solder a copper wire to a copper plate, dig a hole about six feet deep in some damp place, place the plate in the bottom, cover with charcoal, empty in a few pails of water and cover with earth. Too much attention cannot be given to this matter of making ground which, if slighted, will cause the strongest and best telephone made to give no better results than a much weaker telephone on a system having good ground.

Inspection.—Telephones not subject to regular inspection by an experienced man, should be equipped with dry batteries, as they require no attention during their life, are cleaner and do not freeze except under rare conditions. They cannot be re-charged. They will last six months to one year and a half, all depending upon the work the instrument is required to perform. When exhausted, they are replaced by new batteries, installed by the owner of the telephone without any difficulty.

Wet batteries need careful attention. They should not be more than three-fourths full of solution after the zinc and carbon are placed in the jar. Do not use any more sal ammoniac than will dissolve in the water placed in the glass jar. While the sal ammoniac is being poured into the water, stir the solution briskly with a stick. When it refuses to dissolve, no greater strength of solution may be obtained. The use of more sal ammoniac is detrimental to the solution, and a waste of material. If the outside of the jar and the tops of the zinc and carbon become wet with the solution, wipe them dry with a cloth. Do not leave them wet, as it will corrode the connections. Periodically, a small amount of salts may be dissolved in the solution which keeps the batteries up to their highest efficiency. As in the case of the dry cells, the life depends upon the amount of the work the battery has to perform. All party line batteries should always be connected in series, that is, a carbon of one battery should be connected to the zinc of the other.

All that is necessary for lightning protection is to provide an easy path for atmospheric electricity to reach the ground. This consists of two blocks of carbon with a strip of mica between them. In a metallic bridging line, the line wires are connected to the outside posts and the ground wire is connected to the middle posts. These carbons are separated by a strip of mica which prevents the ordinary telephone currents from escaping, which would make a short circuit, but which affords practically no resistance to a discharge of lightning which passes through it into the ground. After a storm is over it is often found that dust has collected between the blocks of carbon. This would allow an ordinary telephone current to pass through, making an easier path than the telephone. The carbon block should therefore, be slipped out and wiped off thoroughly. Additional protection may be furnished by using a carbon and fuse arrester on metallic grounded circuits. These are usually placed on the inside wall where the wires enter the house. On some farm lines a knife switch is placed in the line wire above the telephone, so that the telephone can be cut off from the circuit entirely during an electric storm. The only objection to the use of this switch is that if one forgets to close it after a storm the telephone will not work and no one can call you—in fact, if it is not properly connected, it would put the entire line out of service.

QUESTIONS

1. What are the advantages of telephones in rural districts?
2. Why is the telephone necessary?
3. What are the earnings of the average farm?
4. How can the farmer increase his business?
5. Describe the telephone system.
6. Describe the construction of the telephone installation, such as poles, conductors, ground wire, etc.
7. Describe the method of inspection.

Electric Curling Iron Heater.

CHAPTER XIV

ELECTRIC POWER IN IRRIGATION

By the help of a suitable electrically driven pump, water for irrigation may be raised to practically any desired height. As this water is best distributed during the night, the pumps may operate at this time to advantage, because the usual day load has then fallen off. By this means a more even power-load is put upon the distributing system at a time when it can be readily carried. The public companies sell power at an especially low rate for irrigation purposes in order to induce a large consumption.

The Gravity System.—Large sums are yearly spent for irrigation purposes, and also on waterways regulation, but in nearly every case without consideration of a combination system, wherein electric power could advantageously be generated. In irrigation, the water-level of the river is usually raised, in order to get sufficient head so that the water to the fields can be distributed by gravity, and the head in most instances is sufficient to operate the necessary machines for the generation of electric energy, which might advantageously be used for farming purposes and rural industries when the water was not needed.

The same practice applies to river regulation. There are a number of examples in Switzerland, and more particularly in Germany, where large central stations are enabled by proper engineering to utilise the energy of a river. Advantage can also be taken of the flow of water in drainage canals by installing power plants at suitable intervals.

Amount of Water Required.—The acreage which may be watered by any given supply varies greatly in different localities and for different crops. Fields in some regions need only one flooding each summer, while in the most unfavourable places water must be supplied at least once per week. Shallow soil, over clay or hardpan, holds its water too near the surface, permitting rapid evaporation. Loose, sandy subsoil permits the water to sink or to pass to other substrata, slightly benefiting adjacent fields to the detriment of the field irrigator.

Fig. 49. Motor-operated pump for irrigation.

Deep sandy loam soil, with clay or hardpan subsoil, gives the best returns for a given amount of water.

The crop itself in an irrigated field absorbs very little water, but to enable this small supply to be constantly available to the plants, a liberal supply must be furnished to replace that which is lost by surface evaporation. To replace surface evaporation, three to seven gallons per minute are required for each acre in semi-arid regions, and from fifteen to twenty gallons per minute per acre in the arid regions. Surfaces covered with alfalfa or similar dense growth require less water than crops planted in rows with bare ground between, unless as a result of cultivation a layer of loose earth several inches deep covers the surface and lessens the evaporative effect of the atmosphere.

Alfalfa south of the fortieth degree of latitude, and red clover north, are the most profitable forage and hay crops on irrigated farms. Both require a liberal supply of water the first year, less the second, and very little thereafter; consequently when the first field is a year old another may be planted, and so on until the acreage will take up the entire water supply. Fields well flooded in winter will need less water in the spring and summer, and a much larger area may be irrigated with a given amount of water than if spring and summer flooding alone is practised.

Motor-driven pumps are preferably located in small houses, scattered over the field to be irrigated. They may lift the water directly into elevated reservoirs, or preferably pump the water directly into trenches.

Water Distribution.—Where the fields can be levelled off, embanked, and main or feeder ditches run on the embankment above the level of the fields, the flooding system may be used. As not less than three inches of water should be run at once, the field should be divided into plots having four times the area of the reservoir for each available foot of its depth.

Furrow irrigation on small plantations seems to be the favourite system. Furrows are run between rows five to fifteen feet apart. If the field is not level, run the furrows in such direction as to keep each furrow nearly on a level throughout its length. When the main ditch is flooded, the bank opposite each furrow is broken down, allowing the furrows to fill successively. In orchards, the furrows are made in circles six or eight feet in diameter, around each tree. This brings the water well over the roots, but not against the trunk of the tree, which is harmful. The small circular ditches may be fed by main ditches between every alternate row. Where great economy of water is needed, large tiles are sunk into the ground near each tree, or twelve or sixteen feet apart in a vegetable garden, the water being led into these tiles by means of a ditch or hose. This system conducts the water well below the surface, preventing much of the loss by evaporation.

The source of water supply may be either surface water from the streams, or may be ground water, secured by sinking wells.

Motor-Driven Pumps.—Irrigation by gravity systems can, of course, be accomplished only in those favoured localities which have a natural source of water-supply at a level higher than the tract under cultivation. Such locations have long ago been appropriated, so that extensions are dependent upon some source of power for pumping. Long-distance transmission-lines, carrying power from the mountain streams and waterfalls over the intervening dry plains to the growing cities and towns of Colorado, Nevada, California, Oregon, Washington and Idaho, have made possible the use of electric motors for the operation of pumps for irrigation purposes in those States. In fact, the ease and economy with which electricity can be transmitted over wide areas and used to drive motors, make electric pumping in many cases preferable to the gravity system. The pumps can be in comparatively small units, each supplying a local area. The distributing ditches may be small, thus leaving a maximum area for crops, and the water-supply to each area is always under perfect control. There is thus a minimum danger of broken ditches and flooded crops, such as sometimes occurs with large ditches.

The sage-brush-covered plains of these states, when properly cultivated and flooded with water, produce the wonderful grapes, melons, peaches, cherries, apples, strawberries, etc., which are now a common sight in the markets of this country. Land which less than a decade ago could be purchased for from fifty cents to two dollars an acre in the valley of the Columbia, is now held at $150 an acre for alfalfa hay land, producing three crops a year and averaging four to nine tons an acre at $10 per ton. Irrigation has brought these lands before investors, large and small, from all parts of the country, and where ten years ago individuals held vast areas of this cheap land, the rising values have now reversed such conditions, and division and sub-division is constantly going on. Intensive cultivation is the secret of successful irrigation to the man of moderate desires, and with the same amount of attention and care bestowed upon the land, ten to twenty acres or even less of good irrigated land will produce more than larger areas in the East, particularly when devoted to the raising of fruits.

The results obtained by this intensive method of the cultivation of small unit areas of land, have been the greatest factor in opening up the various tracts of irrigable lands in the Pacific Coast States. Organised companies have taken up tracts of land in units from 160 to 6000 acres and have divided them into small tracts of 5, 10, 20 and 40 acres each and sold them to homeseekers, with water rights at prices ranging from $100 to $600 per acre, the land being in its original prairie form but with the water delivered thereto.

Irrigation by Electric Power.—A concrete example of an operating company in the upper Columbia River Valley, as described in *The Electric Journal,* February, 1911, may be of interest. This company has taken a 160-acre unit of sage-brush land, platted it into five- and ten-acre tracts and supplied it with water under a pressure system.

The pumping station consists of a 40-hp. three-phase, 60-cycle, 2300-volt, shunt-wound, secondary induction motor, directly connected to two $3\frac{1}{2}$-inch and one 5-inch centrifugal pumps. These pumps are so arranged that they may be run in single, multiple or series stages to supply water for the different heads to be pumped against. They perform the following duty:

250 gallons per minute to a head of 190 feet, all three pumps in series;

500 gallons per minute to a head of 160 feet, two small pumps in parallel pumping into the large unit;

750 gallons per minute to a head of 110 feet, the arrangement being the same as with 160 feet head but the pumps operating on reduced head and picking up more water.

500 gallons per minute to a head of 55 feet, the five-inch pump working alone as a single step pump.

The main discharge from the pumping is a 12-inch double-riveted flanged steel pipe 1700 feet long. The lateral system is made up of galvanised sheet steel pipe of various diameters, branching from the main discharge line and having at intervals one-inch stand-pipes about two feet long, with valves which feed the water into the small ditches. The loss of water by evaporation is thus minimised, and by means of the stand-pipes the irrigator is enabled to

Fig. 50. Sprinkling system on farm supplied by a motor-operated pump with remote control.

control the flow as he works on the distributing ditches.

This system proves more economical to the holder of the small five- or ten-acre tract than would obtain if he had to purchase an individual pumping-equipment for this land, for the Power and Land Company carries the necessary investment for the electric-substation, pumping stations and water-distributing system, and although the farmer pays more for an acre of his land under these conditions, the terms of sale are such as to make it less of a financial burden than would be the individual unit pumping plant.

In this particular case, assuming a load-factor of 80 per cent. on the pumping plant on 24-hour service, the average station-load would be about 32 horsepower. It would thus be easy to keep the mechanical equipment in good running condition, even though the full load of 40 horsepower might be carried at times for short intervals. Basing the power-bill at $7 per month per horsepower on the maximum demand, the charge would be $280 per month as a possible maximum, or $1.75 per acre per month for each 160 acres affected. The water could thus be delivered at a maximum cost of $17.50 per month for a ten-acre tract from a central pumping plant, where an individual plant of, say, a 3 horsepower unit, would require a monthly charge at a higher rate, besides the maintenance, attention and cash investment.

These figures, of course, are rough, as the cost of power differs materially in different localities, but they indicate in a general way the advantage secured by the small owner in getting his water from a central station as contrasted with putting in the small individual unit. The tendency is increasing, therefore, towards the installation of larger pumping-units to supply sub-divided tracts of land, both on account of the economy in stepdown-transforming stations in larger units, and for the reason that where power is purchased the large sizes of pumping-equipment offer more opportunities to make the installation along good engineering lines, and to build the station and equip it with machinery of high class manufacture, reliability and efficiency.

The hydroelectric transmission companies are naturally assisting in this movement, as the irrigation projects through the country traversed by these trunk-lines form a natural and very desirable market for power. Many of the larger projects have substantial impounding reservoirs which catch the tail-water from their stations at a higher elevation than the irrigated valley, and from which the water is distributed under pressure to the towns, orchards and fields below. Such a reservoir is a part of the system of the Improvement Company at Clarkston, Washington, which distributes water for irrigating purposes under gravity pressure to a considerable area surrounding these cities. At the same time, by carrying the first part of their 48-inch wood-stave pipe-line around the hills at a considerable altitude, a head of 475 feet is made available for their 3000 horsepower hydroelectric generating station, located on Asotin Creek, six miles above the town. Power is thus made available for lights and industrial uses and also for pumping water for irrigation purposes where it is difficult to supply gravity pressure. The water in the main flume is at a sufficient pressure when it reaches the town of Clarkston to furnish a head of 250 feet to a 400-kw. generating-station located just above the town. The tail-water from this station is impounded in a reservoir for gravity irrigation on the lower levels, water being taken from the main flume at the higher levels. This company has in all seven miles of 48-inch, four miles of 40-inch, two miles of 36-inch, and one mile of 30-inch pipe line. The two hydro-electric power stations, operating in conjunction with a 500-kw. steam-turbine auxiliary station, furnish power to the towns of Lewiston, Clarkston, Asotin, Genessee and Moscow, through a total of over 50 miles of transmission line at 45,000 volts.

The alfalfa range of about thirty miles in the Eden Orchard Tracts was sage-brush land four years ago at $20 per acre. When the water was put on the land two years later, it immediately became worth $100 per acre.

Irrigation has produced these changes, and electricity has become the principal factor in developing and making accessible these vast arid tracts, which are becoming rapidly transformed into gardens, orchards, towns and cities, with inter-connecting interurban systems, electric lights and telephones and all modern conveniences.

California in very recent years has made enormous strides agriculturally, due largely to electric irrigation systems. The largest company in this field and one of the largest of its kind in the world is the Pacific Gas and Electric Company, operating in central California. It has developed this branch of engineering to a high degree, and has installed great numbers of electric irrigation plants which are supplied by its service lines. This company's reports contain interesting drawings and views of some of its installations and indicate the character of the service it performs.

Pumping Plants.—The type of pumping plant

Fig. 51. Pumping plant of Snake River Irrigation Company's plant, southern Idaho. This plant irrigates approximately 15,000 acres. The equipment consists of one 30, two 20 and two 16-inch centrifugal pumps, lifting the water 57, 108 and 145 feet, respectively. Another pumping plant of this company irrigates 48,000 acres.

most generally installed is a centrifugal pump directly connected to an electric motor and set in a pit near the water-level. Centrifugal pumps are built in two styles, vertical and horizontal, each to meet certain conditions. A good centrifugal pump will draw water as far as a plunger pump, or about twenty-eight feet, but will operate with much less power when set near the water-level. For this reason pits are usually dug with the floor at or near the level of the water in the well when the pump is not running. These pits may be lined with concrete or boarded with redwood. The pit is covered by a house, frequently built with a wood frame and with sides and roof of corrugated iron.

An important feature in drilling a well is developing the water supply. When the perforated casing is landed in the water-bearing strata, or the casing punctured, whichever method is used, it is important that the largest reservoir possible be formed in the water zones. This is done by pumping out the sand and gravel around the pipe. If done carefully, a large saucer-shaped cavity, with the casing passing through its centre, is formed. If not carefully done, the upper strata may cave and greatly reduce, or entirely prevent, the water flow. Where a well has been properly developed it will make but little sand afterward, thus reducing wear on the pump and making sand pumping unnecessary. The pit for a horizontal pump should be large enough when finished to allow at least two feet between any of the machinery and the wall. At one side of the pump enough space should be allowed to remove either pump or motor from the base.

Centrifugal Pumps.—As a centrifugal pump will not throw water until the casing is full of water, or, in other words, will not prime itself, some means must be provided for doing this. A small hand-pump is usually installed for this work. If a foot-valve is used, priming may be done by pouring water down the discharge-pipe. If a check-valve is installed, a priming-pump must be used. The proper place to connect a priming-pump is at the highest part of the pump-casing. One of the most common faults in starting a pump is its becoming "air bound." Be sure every bit of air can be pumped out of the casing and suction-pipe by the priming-pump.

Vertical pumps are usually installed where the ground water is so far below the surface that the expense of sinking a pit for a horizontal pump would be prohibitive. Instead of a pit, a shaft large enough to pass the pump is sunk, and the pump is installed at the bottom with the motor at the surface. A timber frame-work is built in the bottom of the pit and a vertical frame extends from top to bottom, carrying pump and shafting. At the top a frame is built to carry a pulley or a vertical motor. Spreader-bars should be spaced every ten feet on the vertical frame, and vertical bearings attached to these for keeping the shaft in line. Great care must be taken that this shaft is kept in perfect alignment.

If the total head exceeds forty feet a check-valve must be used. For lower heads a foot-valve is suitable. It is a good plan to use suction and discharge pipes one size larger than the pump openings. A flared reducing fitting should be used to keep friction losses low.

QUESTIONS

1. What are the advantages of electric power in irrigation?
2. What is a gravity-system in irrigation?
3. How is the water distributed?
4. Describe the application of motor-driven pumps.
5. How much water approximately is required for proper irrigation under different conditions?
6. What type of pumps are best adapted for irrigation?
7. How should the pumps be installed?

CHAPTER XV

ELECTRIC STIMULATION OF VEGETATION

THE possibility of increasing crops by electrical stimulation is a fascinating subject and one which has occupied the attention of scientists since it was discovered that seeds subjected to electrical stimulation germinated earlier than untreated seeds. Tests have been made at various experimental studios here and abroad, showing that both electric illumination, and currents passed through the soil, increase the rapidity of growth and also improve crops. The action of the electrical current in either case seems to be somewhat analogous to that of a tonic in the human body. The extent to which the electric currents may be so utilised will depend in each case upon the character of the farm, the surrounding conditions and the weather. The principal process by which electrical energy forces the growth of vegetation consists in producing ozone and nitrate compounds and forcing them into the capillary tubes of the plants, when the electrical energy passes from a conductor to the ground.

Applying Electric Current.—The method of applying electrical energy to force vegetation is in general accordance with the following system. A netting or a system of copper wire is supported over the area under cultivation, from poles about 10 feet high driven into the ground at regular intervals. To insure good results, small barbs are woven into the net or copper wire with points projecting downwards. One of the feed-wires from the machine furnishing the electrical energy is connected to the net or overhead wires; the other is connected to a conductor imbedded in the earth below the overhead net.

When the machine is put in action, an electrical current goes over the net and then passes out of the barbed points through the air into the ground. In passing through the air, the current causes ozone and nitrous compounds in gaseous state to be formed which are carried into the ground. The current passes through the soil and back to the earth conductor. Being an alternating current, the reverse action then takes place, the current flowing from the earth conductor to the net overhead. In doing so, the chemical compounds formed on the previous passage, are now forced up into the capillary system of the plants and into the sap of the plant. This action corresponds to a tonic and increases the growth of the stems, leaves, buds, etc. The quality of the plant itself is improved.

This action of passing into and out of the system completes or makes what is known as a cycle. The frequency or rapidity with which these changes take place must be very high, 500 to 600 per second; and the pressure of the current must be from 200,000 to 250,000 volts. A large machine does not necessarily mean a large amount of energy, for it is possible to combine a number of small parts to form a compact yet powerful machine, suitable for the purpose.

Another system is that of putting up arc-lamps in the region cultivated, thus furnishing artificial sunlight, and bringing plants to maturity in less time than without the lamps.

What has been done in this branch of the engineering art, has principally been in European countries. The results show that electric energy does have an advantageous influence on vegetation, but as yet it has not reached the stage of commercial availability. To cite a prominent experiment of what has been done with electrical air-current, that conducted by Dr. Pringsheim in the fields near Breslau, Germany, in the summer of 1902, is of note.

The experimental field covered about 1200 sq. ft. The machine used was driven by a motor fed from a storage battery, and the results in per cent. of the effect of the influence upon the increased growth of the plans under experiment were: Strawberries 50; carrots 13; potatoes averaging 21; barley averaging 10; oats averaging 22.

Experiments conducted in Burham, England, proved that the conditions of the air and soil affect the action of electric influence in vegetation very greatly. The presence of moisture plays an important part; a well-watered field seeming to have, in the majority of cases, an advantage over one with little or no water. For a number of different plants, with watered ground, the percentage of crop increase was for sugar beets 40; potatoes 31; rye grass 129; while for unwatered ground the increase was 40, 49, 65 and 97 respectively. The tests were conducted at the same time so that weather conditions were alike for each test.

Recent Progress.—In recent times the subject of conservation of natural resources has been sharply forced upon the attention of the public, and of scientists, and investigators of the Department of Agriculture have been carrying on experiments to determine how best to increase the output of the farm. Engineers and

Fig. 52. Melons grown by the aid of electricity.

students have carefully analysed the practicability of electric forcing with the result that its great advantages have been generally recognised.

In *The Electrical Review and Western Electrician*, of November 11, 1911, F. L. Cook in an article on "The Growth of Plants by Means of Electricity," reported:

> "A series of investigations has just been completed in one of the large greenhouses of a suburb of the city of Chicago which should prove of great import to those interested in the development of the soil and its products. This work is being carried on by Richard Gloede, a prominent landscape gardener of Evanston. His building is fitted with every facility for making accurate and reliable tests as to the action of growing plants under the stimulus of electricity." . . .
>
> "The distribution of the electricity on this experimental acre is by means of a network of wires 2 ft. to 3 ft. apart mounted at a height of about 8 ft. above the ground. On this plot were planted a great variety of vegetables, including Indian corn, popcorn, tomatoes, cantaloupes, cucumbers, eggplant, lettuce, radishes, onions, peppers, cauliflower, cabbage, carrots, etc. Although planted late, these vegetables came through a severe drought much better than similar unelectrified plants and reached maturity in a period much less than the usual time. The current was turned on the plot only from two to six hours daily, morning and evening, during hot, dry weather, although for longer periods when the air was moist. The energy consumption was almost negligible, it appears, for, although no indicating instruments were used, the electricity bills averaged only $2 to $3 per month during the treatment of the acre.
>
> "As an example of the superior growing power of plants when subject to electrification, even newly laid sod along pathways through the acre plot was found to thrive and grow green, while the old rooted grass at other parts of the grounds was burned badly by drought."

Sir Oliver Lodge has recently contributed important advances to the science of electric stimulation of vegetation, and it is now recognized commercially. The cost of an installation sufficient to cover 300 acres is about $7,500. The action has the same effect as sunshine. Plants are always taking electricity from the air and the apparatus only supplies them with more. It is worked from spring until the end of summer.

The use of electric current for stimulation of plant growth promises to be highly profitable both for the farmer and for the central station, as surplus electricity can be sold for the purpose at a very low rate, as such usage enables the establishment of a uniform load factor throughout the day.

Air Nitrate.—Of the great triumphs of modern electric-chemistry, the reduction of the nitrogen of the air to a commercial product, the creation of a fertiliser for the field out of the air that blows across it, is one of the most notable that has ever been achieved. It is far reaching in effect and appeals to the imagination as few discoveries have ever done.

The great value of the discovery is realised but little by the general public; but it may be understood when the fact is known that the natural supply of nitrate, or saltpetre, is near the point of exhaustion. Nitric acid is one of the fundamentals in the arts, and nitrate is the principal fertiliser of the world, while saltpetre is an indispensable element of explosives. Besides these, there are a great number of important uses of nitrate, such as in the form of ammonia, etc., and a synthetic source of supply is therefore of enormous importance.

The Problem of Fertilising.—One of the greatest problems of the present time is to increase the fertility of the soil. The growing crops are constantly extracting from the soil three chemical substances, nitrogen, potassium, and phosphoric acid, and it is necessary that they should be replaced in a form available for plant life. The nitrate thus far fed to the soil has come entirely from manures or of late years from deposits of nitrate of soda taken from South America, and from sulphate of ammonia recovered as a by-product when coal-gas is made. The output of Chili saltpetre, or nitrate of soda, is at the rate of 1,500,000 tons per annum, and it has doubled in the last fifteen years, while 500,000 tons of sulphate of ammonia are produced annually. Owing to its high cost and scarcity, the demand is very much less than would be the case for a cheaper fertiliser.

What the proper use of a fertiliser means may be seen by a comparison of American yields on recently virgin soil with German yields on a soil under cultivation for centuries before America was discovered. Germany averages 31½ bushels of wheat per acre to 13 in America, rye 29 to 16, oats 51 to 25, and potatoes 158 to 83. If American farmers should increase their yields to the German averages, it would mean a doubling of the gross output of our products. Yet Germany was formerly but little if any in advance of America. The intelligent selection of seed and free use of fertilisers has made the change. As much as 2650 pounds of potash salts and manure are used per acre in Germany on cultivated lands, while but 311 pounds are used in the United States. The German farmer practically uses his land as a mechanism for transforming fertiliser into products.

Importance of Air Nitrate.—The production of nitrates from the air assures inexhaustible supplies of a highly necessary substance, since the air contains about 80 per cent. of nitrogen; and in addition it affords a means of more completely utilising our waterpowers by transforming their surplus energy into soil fertility.

The original inventor of the electro-chemical process for manufacturing nitrate fertilisers and other chemical productions from the air was Professor Birkeland, a Norwegian. After

Professor Birkeland had made his discovery, some nine or ten years ago, he associated himself with Mr. S. Eyde, an experienced engineer. They organised a stock-company, with a capital of $134,000 and built their first plant at Notodden, in Telemarken, some 70 miles from Christiania.

The process, briefly stated, is to pass air through an enormous electrical flame, of about 75 inches width, which heats the air to 3000 degrees Celsius, and the gases are then cooled and passed over lime in water, resulting in calcium nitrate, which is sold in granular form like salt.

The company later consolidated with a German concern, which had added improvements, and there are now several branch companies, with a capital of over $16,000,000 whose annual production will soon reach 80,000 tons.

Two German chemists, Adolph Frank and Nikodemus Caro, of the technical staff of the Siemens-Halske Co., a great electrical firm, have discovered an entirely different process of extracting nitrate from the air. They combine coke and lime at 3000 degrees Centigrade, resulting in a substance that has a great affinity for nitrogen, and draws it directly from the air. This is known as the cyanamid process and is a strong competitor of the Birkeland-Eyde process. Cyanamid sells at $55 to $60 a ton at present. Tests by 37 governmental stations in Europe show its superior value to Chili saltpetre as a fertiliser. It is also easier to handle in its commercial form, being less liable to liquify or to cake. Six companies are already manufacturing it in Europe, turning out 167,000 tons annually, and other companies are beginning. A plant has been erected on the Canadian side of Niagara Falls, and others are projected in Japan, Mexico and elsewhere.

An American Waste of Opportunity.—The United States has $70,000,000 invested in fertiliser factories of various kinds. Chilian saltpetre to the value of $75,000,000 annually, at 2½ times its former price, is exported by Chili, $15,000,000 worth of which comes to the United States. While, with almost criminal carelessness, we disregard our own resources, and allow phosphate rock to be exported in large quantities, our imports of fertiliser of various kinds are $17,000,000 in excess of our exports annually. The whole of this amount could be saved by the erection of hydroelectric plants to utilise our vast wasted waterpower and to manufacture air nitrates.

Fig. 53. Office of a nursery, showing flowers electrically forced.

The opportunity of the United States in this respect is unusual, since we have 30,000,000 hp. in waterpower running to waste. If properly utilised by means of storage, economically constructed and properly designed plants, following the latest European practice, this would amount to from 150,000,000 to 200,000,000 horsepower. A steam horsepower per year costs $20, so that a waste of power of $4,000,000,000 is occurring annually.

Promotion of the Air Nitrate Industry.—The manufacture of air nitrate is of course an exacting engineering and manufacturing proposition. It has been neglected in the United States through the demands of other manufactures for capital. Large land owners and bankers in agricultural regions should co-operate and advance the capital necessary for such undertakings. They would not only profit directly in the manufacture of air nitrate, but would have the further benefit of greatly increased yields and profits from the land of their regions. The farmer should help himself in this respect and not wait on the slow progress of the distant city banker.

QUESTIONS

1. What are the principles of electrically stimulating vegetation?
2. How is the electric current applied?
3. How can the growth of vegetation be stimulated by means of electric lights?

4. Describe the experiments of Dr. Pringsheim.
5. Describe the experiment conducted at Burham, Eng.
6. What is the yield per acre on German farms as compared with American farms?
7. How much potash-salts is used on German farms as compared with American farms?
8. What is air nitrate?
9. Describe the Birkeland-Eyde process.
10. Describe the Frank-Caro process.
11. How would the manufacture of air-nitrates affect farm products?

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