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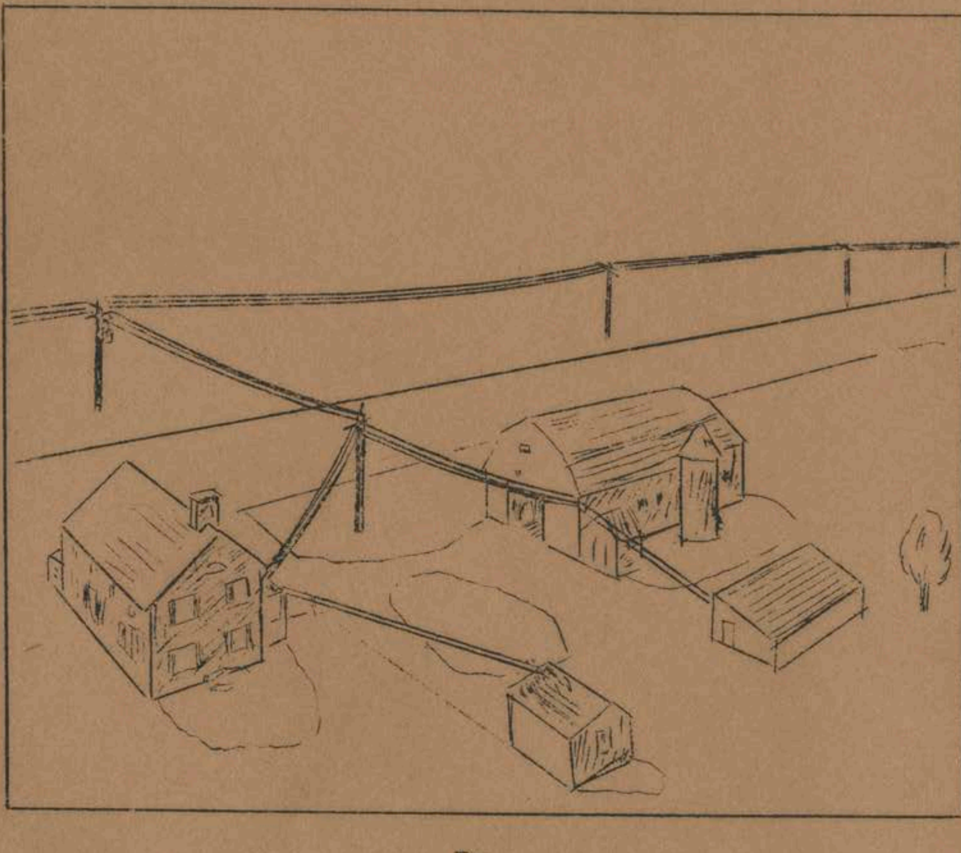
WIRING FOR ELECTRIC SERVICE



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WIRING FOR ELECTRIC SERVICE

It is important that the home and farm owner carefully plan the electric wiring layout on his property. His plans should not only take care of the immediate uses of electric service but possible future uses as well. It should be remembered that rural electrification has been attained only when the farmer uses electricity to an economical advantage, and this means the use of equipment in addition to lights. Even though not many uses are anticipated when service is first obtained, the trend of electric rates is downward and more equipment will be added in the future. Therefore, it will pay to plan for both immediate and future uses of electricity. This circular aims to assist the new customer in planning a safe, adequate, economical, and convenient wiring system.

NATIONAL ELECTRIC CODE

There has been worked out over a period of years what is known as the National Electric Code, which is simply a set of rules, regulations and practices by which farm wiring is done for the protection of the owner's property and family. Since there are no government regulations for wiring in rural districts, it is to the rural customer's advantage to see that his wiring conforms to the National Electric Code for his own safety and protection. He should be sure that the contractor doing the job is familiar with this code and should have an inspector check the work before the contractor is paid for his services.

WIRING SYSTEM REQUIREMENTS

The following brief discussion of requirements that the farm wiring system should meet will emphasize their importance and show their relation to each other:

Adequacy: The heart of the light, heat and power needs on the farm is the wiring system. Without adequate wiring facilities, full and economical value of the electric service cannot be realized. The wiring plan for each building should be carefully considered by the owner to see that the building is adequately served. Often additions are made to the contractor's work that are both unsafe and unsightly.

Safety: The wires should be large enough to carry the intended load and fuses (safety valves in the wiring system) should be of the proper size to protect both the wiring and equipment. Too often the size wire used is so small that unsafe, large capacity fuses are used. The results are heating of the wire, poor voltage at the appliance and general dissatisfaction. For example, a No. 14 wire should carry only 15 amperes; therefore, if the circuit operates appliances pulling more than 15 amperes of current, and if a fuse larger than 15 ampere capacity is used, the wire becomes hot and the system is unsafe and inadequate.

Convenience: The wiring system should be planned so that it will be convenient. Many people have been content to wire a house so that the only outlet in a room is the ceiling light outlet. The light must be turned on and off by a pull chain in the center of the room. If a floor lamp, radio, or other appliance is wanted a double socket must be used at this same outlet and extension cords run to the other appliances. This makes both an unsightly, unsafe, and inconvenient arrangement. Convenience outlets should be placed along the walls, and the ceiling light should be controlled by a wall switch by the most frequently used door. Better still, the light can be controlled from two or more doors by using three-and four-way switches. These convenient features cost little extra when the complete job is done at first, and the economy comes from the time saved in doing the many house chores.

Economy: The terms adequacy and economy go hand in hand when referring to the wiring system. This is especially true when the farmer makes adequate provision in the beginning for all future uses. For example, the difference between the cost of No. 8 and No. 6 service wires may be only a few dollars when the job is first done; but if the smaller and cheaper wires are installed originally, it means that they must later be removed and replaced with the larger wires to operate some added appliance. This means spending money twice for the same wiring; whereas, if the larger wires had been installed at first, the system would have been adequate and money saved.

New developments in service entrance cables and switches now make it possible to do the job when first installed so correctly and adequately that it will serve all future needs and expensive replacements in the wiring are avoided.

DEFINITION OF ELECTRICAL TERMS

It is necessary to understand the meaning and relation to one another of several simple electrical terms in order to plan the wiring layout intelligently.

Volt -- The volt is the unit of electric "pressure" which causes electricity to flow over the wire. It is analogous to the term "pounds per square inch" when referring to the pressure of water in pipes.

Ampere -- The ampere is the unit or rate of flow of electric energy over a conductor or wire. It is analogous to the term "gallons per minute" when referring to the rate of flow of water in pipes.

Kilowatt -- A watt is a unit of electric power used, but it is so small that the common commercial unit of electric power is called the kilowatt which means 1000 watts. The number of kilowatts used over an electric circuit or wiring system is the product of the volts and amperes delivered, divided by 1000. (Allowance is made for another relation between the two, which need not be considered here.)

Therefore, it is evident that "high voltage power" lines can carry large amounts of energy with a relatively low flow of amperes and over comparatively small wires. The common voltages used on the farm are 115 and 230, which are comparatively low voltages, making comparatively larger wires necessary. This will be illustrated later in a problem.

Kilowatt-hour -- The kilowatt-hour is the unit of work done by one kilowatt of electric power over a period of one hour. It is by this unit that electricity is measured through the company meter and purchased by the customer.

Transformer -- The electrical instrument which is furnished by the service company for stepping down the high voltage on the company distribution line to the low (115 and 230) voltage usually used for farm appliances. The transformer should never be more than 1000 feet from the meter or distribution center and should be located as near the point where large appliances are to be used as possible.

Two-Wire Service -- When only one voltage is desired (usually 115 volts) for lights and small appliances in the home, only two wires are brought from the transformer.

Three-Wire Service -- When the customer desires to operate many lights, appliances or motors, it is desirable to have both 115 and 230 volts, making it necessary to bring three wires from the transformer to the distribution center. This type of service is always more desirable for farm customers.

DESIGNING THE FARM WIRING SYSTEM

Keeping in mind the general requirements for the farm wiring system already discussed, each wire must be large enough to meet two definite conditions satisfactorily. The wire must be large enough to carry the number of amperes required by the equipment on the circuit safely, and, since the resistance of the wire has a tendency to cause the voltage or pressure to drop when carried any distance, the wire must be large enough to keep this voltage drop less than 5% of the normal voltage of the circuit. Therefore, in designing the wiring system, it is necessary to determine the maximum number of amperes of electricity each circuit must carry at any one time, and the distance that the current must be carried.

The following tables show the number of amperes of current that various size motors require and the number of amperes of current that various size and type wires will carry safely.

No. 1

Current Rating for Small Motors

H.P.	110 volt	220 Volt
1/6	3.3 Amp.	1.7 Amp.
1/4	4.0 "	2.0 "
1/2	7.5 " *	3.7 "
3/4	10.0 "	5.0 "
1	12.5 "	6.1 "
2	24.0 "	12.0 "
3	34.0 "	17.0 "
5	55.0 "	28.0 "

*Use 230 Volt Service for larger than 1/2 H.P.

No. 2

Current Carrying Capacity for Wires

Wire Size	Rubber Covered	Weather Proof
No. 14	15 Amp.	20 Amp.
" 12	20 "	25 "
" 10	25 "	30 "
" 8	35 "	50 "
" 6	50 "	70 "
" 4	70 "	90 "
" 2	90 "	125 "
" 1	100 "	150 "

The name plate on practically all electrical equipment except motors shows the number of watts of power the appliance will require and also the voltage of the power necessary to operate the appliance. To determine the number of amperes of electricity that the appliance will require, divide the watts by the voltage. For example, assume that an electric water heater has a name plate listing of 2000 watts to be operated on 220 volts. Then the ampere requirements will be approximately 10 amperes, and the wire must be large enough to carry this amount of current. Motor name plates usually show the ampere rating and the voltage, which can be read directly.

For determining the proper size wiring for a certain length circuit to assure a voltage drop of less than 5% of normal, the following table can be referred to:

No. 3

LOAD--DISTANCE TABLE

for 5% VOLTAGE DROP SINGLE PHASE

Wire Size	14	12	10	8	6	4	2	1	0
Amp.	Wire Length for 115 Volt or Distance for 230 Volt in Feet								
3	757	1202	1915	3040	4840	7690			
5	454	722	1148	1826	2900	4615	7340	9250	
10	227	361	574	913	1450	2307	3670	4620	5830
15	151	241	383	608	967	1537	2445	3080	3883
20	113	180	287	456	725	1152	1834	2310	2910
25	91	144	230	365	581	922	1463	1850	2332
30		120	191	304	484	762	1223	1542	1942
35			164	260	414	658	1046	1320	1664
40				228	363	577	917	1157	1458
45				206	323	514	816	1030	1298
50				182	290	461	734	925	1166
60				152	242	384	612	771	971
70					207	330	523	660	834
80					182	288	459	579	730
90						257	417	515	649
100						231	367	462	583
125							293	370	466
150							244	308	388
175								264	333
200									291

The following simple layout of farm buildings and electric equipment at the house and barn will illustrate how to use the current carrying capacity table, No. 2, and the voltage drop table, No. 3, in determining the proper size wires.

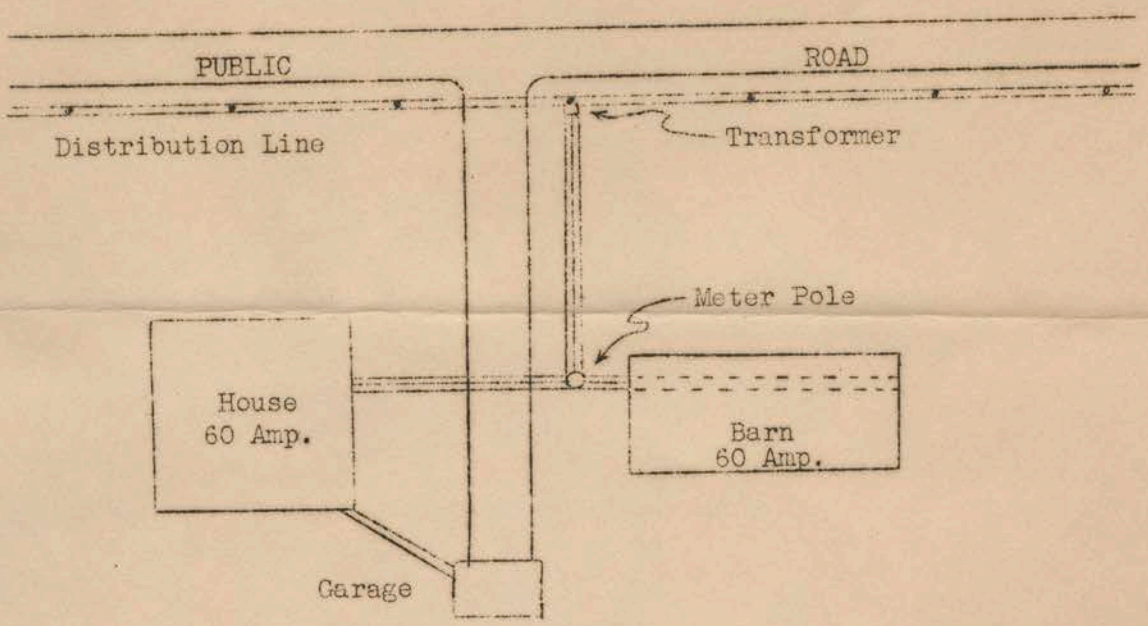
Assume that there is a possibility of installing the following equipment at the house and barn, either immediately or in the future. An adequate wiring system would be determined this way:

Distance from transformer to meter is 200 feet; from meter to end of barn is 150 feet and from meter to house is 200 feet.

House	Watts	Volts	Amps.
Lights	800	110	7
Refrigerator	1/4 HP	110	4
Appliances	800	110	7
Range	7000	220	31
Water heater	2000	220	10
Total			59

Barn	Watts	Volts	Amps.
Lights	400	110	4
5 HP motor			28*
Total			32

*Motor will pull about 60 amp.to start



Typical Farm Wiring Layout

Table No. 1 shows that #6 wire will be required to carry the current of 59 amperes safely from the meter pole to the house. Checking for voltage drop, we find that table No. 3 shows that at 220 v. the #6 wire will carry 60 amp. 242 ft. and keep the voltage within 5% of normal. Therefore, the service to the house will be two #6 wires for the 220 volts and one No. 8 for the grounded neutral. The service entrance for the house should contain a 60 amp. capacity three pole switch to control this service.

Follow the same procedure in determining the size wires to the barn. This should be checked for 60 amp. of current also, because the motor will require that much power when it starts, although the normal running requirement is only

28 amps. Since this is the case, #6 wires will be necessary here, because this size wire is necessary to carry 60 amp., although #8 would be satisfactory as far as the voltage drop is concerned. Then this service would contain two #6 wires for the 220 volt power and one #14 for the neutral, since the barn lights (on 110 volts) will demand only 4 amps. A three pole 60 amp. switch will also be used in the service entrance at the barn.

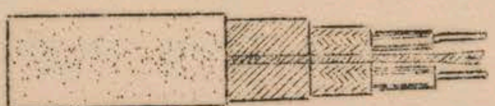
The utility providing the service will determine the size wire to run from the transformer on its line to the meter pole, based on the customer's total demand and use of the equipment. Usually the first span is furnished by the utility at no expense to the customer; however, this policy varies with different companies. On most farms, the arrangement of buildings is such that it is usually better to locate the meter on a pole at a central location and run service wires from this pole to the various buildings, as in the above example. In this way, economies can usually be effected in wiring by reducing the distance from the meter to the various buildings, thereby allowing smaller wire to be used.

In purchasing all materials such as wires, cables, switches, fuses, etc., see that the materials have the underwriters' stamp of inspection and approval. This will guarantee the materials to be first grade and accurate in rating and design.

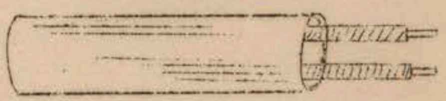
The method of mounting the service entrance switch and the entrance wiring at the meter or buildings should conform with the standards set up by the company providing this service and approved by their inspector. All outside wires should be either uninsulated or weather-proof insulated. All wiring in "conduit" should be rubber covered.

INSIDE WIRING

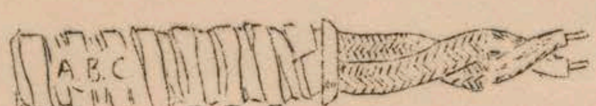
There are three general types of wiring used in circuits inside buildings: (1) "knob and tube" or open wiring; (2) cables, either "armored" or "non-metallic" sheathed with wires protected inside the metallic or non-metallic covering", (3) conduit wiring with rubber covered wires run inside of smooth pipe which may be either "rigid" or "thin wall" tubing.



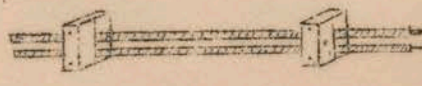
Non-metallic Sheathed Cable



Conduit



Armored Cable



Knob and Tube Wiring

Illustrations of Types of Wiring Materials

The Standard Handbook for Electrical Engineers shows the following relative costs of the various types of wiring (materials and labor):

Knob and tube	100%
Non-metallic sheathed cable	125%
Armored cable	133%
Thin wall tubing conduit	180%
Rigid conduit	190%

The type to be selected for a building will depend somewhat on the type, construction and use of the building. However, the National Electric Code recommends either of the first two, preferably the second, for such buildings as barns, sheds and outbuildings, because of its economy and safety from shock hazards. In fact, because of these reasons, the non-metallic sheathed cable is highly desirable for all farm wiring. Porcelain outlet and junction boxes are available for use with this cable to complete the "non-metallic" system. The armored cable is widely used for houses and buildings where there are no ammonia or acid fumes and the air is free from dampness. In such cases, the conduit type is considered the best; however, there is some doubt that the extra expense is warranted where economy must rule. In such cases, either of the first two types are considered satisfactory.

FUSES AND PROTECTIVE SWITCHES

The fuse is usually referred to as the "pop-off" or safety valve in a circuit. No fuse of a higher ampere rating than the current carrying capacity of the wire should be inserted in the circuit. Table No. 2 should be referred to in checking the maximum size fuse to use. The fuse not only protects the wiring in case of a short circuit or faulty appliances, but also protects the appliance or motor from serious damage by breaking the circuit in case of trouble causing excessive overloads. Certain types of switches have been developed to be used in place of fuses. They are called "no-fuse" breakers, "thermal" breakers, etc. and simply open the circuit, which must be reclosed manually. The advantage in them over fuses is that they do not need to be replaced but merely "reset".

The control switches with thermal overload devices built in are desirable for farm motors because the motors are frequently overloaded. It is much easier and quicker to reset the overload device than to replace a fuse and there is no temptation to use fuses too large for the wiring. This type switch costs slightly more than the fuse type but is probably more economical in the end and is more satisfactory to use.

OUTLETS

There are three types of outlets in the wiring system: (1) the "light outlet", (2) the "switch outlet", and (3) the power or "convenience outlet".

The desirability of convenience in the wiring system has already been discussed and the practice of using the "light outlet" for all three uses has been condemned. In addition to this practice being both unsightly and unhandy, it limits the service the appliances can give. Usually drop cords to the "light outlet" are of #18 wire, and this is too small to carry the necessary amount of current. Therefore, the practice that will satisfy all requirements requires wall switches and plenty of convenience outlets around the baseboard. It is good practice to use what is known as "duplex convenience outlets", which provide two points for connecting or plugging in appliances instead of one.

It is very desirable to plan the light and switch outlets on a separate circuit from the convenience outlets, because motors on appliances draw much current when starting and if on the lighting circuit, will sometimes dim the lights. Also, in case a fuse is blown by some faulty appliance, the lights will not be affected. This plan is easy to follow; furthermore, the National Electric Code says there should not be more than 12 outlets per circuit.

In planning the wiring system for the house, it is desirable to use #12 wires instead of #14, especially for the convenience or power outlet circuit. This will assure better operation of appliances and eliminate the possibility of overloading the circuit with small appliances. Wiring is usually contracted for on the basis of the number of outlets. The price usually varies from $2.00 to $3.00 per outlet, depending on the type of wiring and local conditions.

POINTS TO REMEMBER IN CONTRACTING FOR WIRING

1. Make a sketch of the building layout showing all buildings where service is desired and the possible load at each building.

2. Sketch the floor plan of each building and locate all outlets.

3. Indicate the type of outlets and all wire sizes on the sketches.

4. Have contractors bid on the job based on the plans outlined in the sketches.

5. Make sure that the contractor who gets the job is licensed and complies with the requirements of the National Electric Code in his work.

6. Have the completed job inspected by an underwriters' inspector before paying the contractor. Be sure the job meets all requirements, including those called for in the original sketches.

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