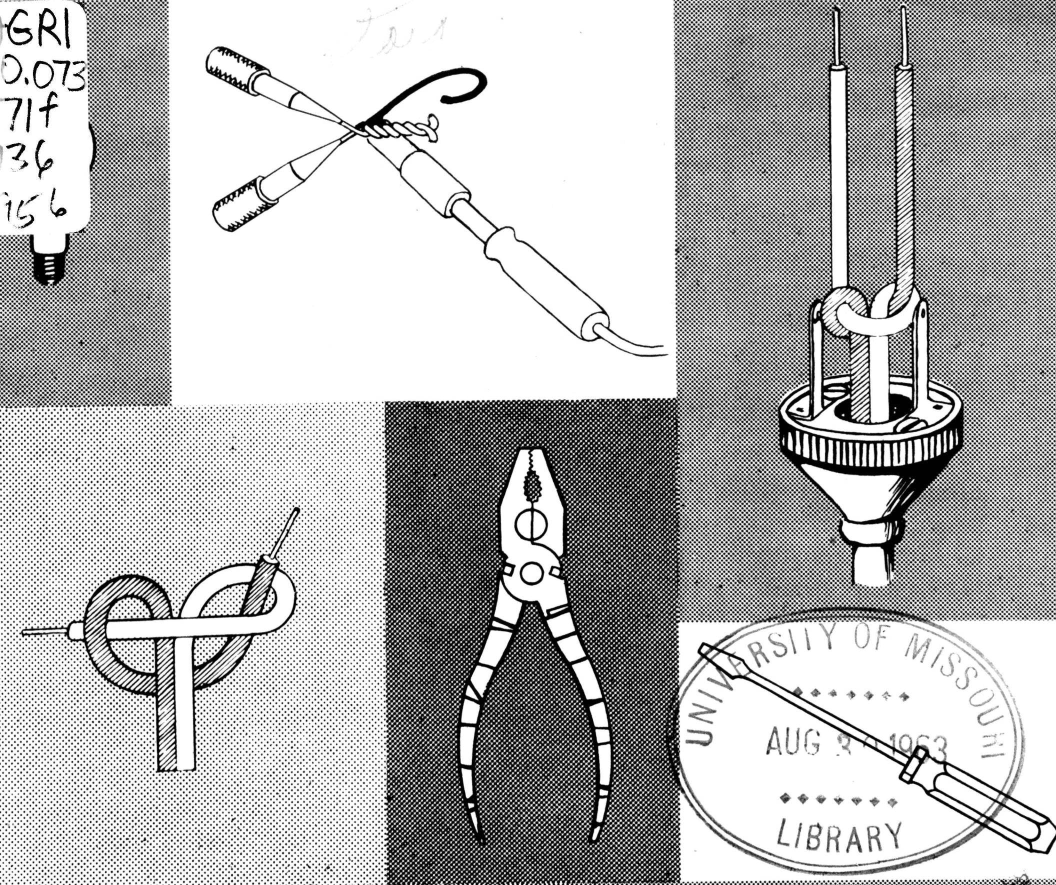
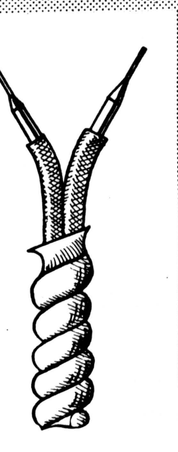


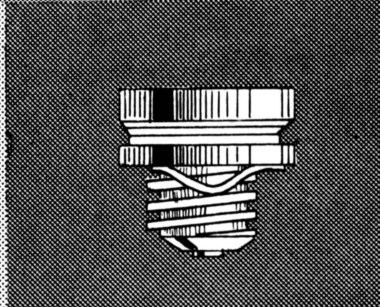


ELECTRICITY on the Farm

(A 4-H CLUB PROJECT)

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXTENSION SERVICE

4-H Circular 136 Columbia, Missouri May, 1956

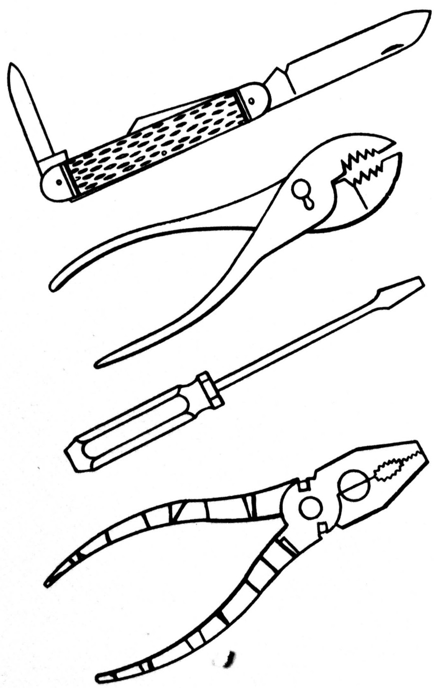


ELECTRICITY
on the Farm

C. E. STEVENS

TOOLS OF YOUR OWN

The electricity project will be more fun for you if you have your own tools. Then, with know how, you can make all sorts of repairs around the house. Here's a tip! Almost every home has an extra pair of pliers and a screwdriver around. Use these, if you can.



If there aren't any around for you to fix and use, you may have to buy new ones. If you do, it's smart to buy good ones. If you treat them right and know how to use them, they will last a long time.

Pocket Knife

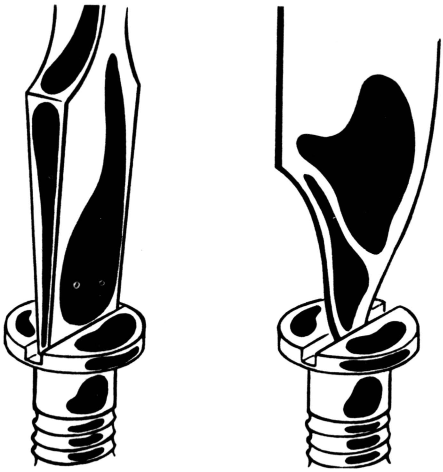
A good pocket knife is the handiest tool to have. It should be made of good steel with dividers between the blades. These dividers should be of a non-rusting metal such as brass, bronze, or stainless steel. The handles should be such that they will not chip or crack easily. They should be securely fastened to the knife.

You will probably find that a scout knife is good because it has other useful parts besides the cutting blades. Keep your knife dry, clean, sharp, and free from rust. Oil the joints from time to time.

A few safety rules for your pocket knife.

- Always cut away from you.
- Never throw your knife. You might break the blades or handles. You could hurt someone.

Acknowledgement: Much of the material in this circular was used by permission, or adapted from the following: *4-H Electric Project—More Power To You!,* University of California; *Illinois 4-H Club Electricity Manual and Record Book; 4-H Electric Project—Fun With Electricity.* Pennsylvania State University; *Farmstead Wiring Handbook,* Industry Committee on Interior Wiring Design; Better Light Better Sight Bureau.



Use screwdriver (left), not knife blade

- Never use a cutting blade for a screwdriver.
- As a good safety measure, keep the blades closed when you aren't using them.

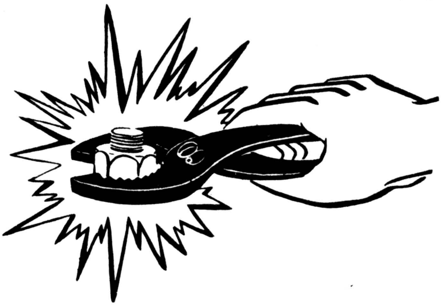
Pliers

A pair of common pliers will do nicely for this project. To make them safer for electrical work, wrap the handles with insulating tape. If you want to cut insulated wire, then you may decide to invest in electricians' pliers. The big difference between common pliers and electricians' pliers is that the electricians' pliers have wire cutters and insulated handles.

Pliers like all other tools should be kept clean. Usually you can clean them by wiping them with a clean rag. Put a drop of light oil on the joint every once in a while. Doing this will cut down on wear and prevent rusting, a vicious enemy of all tools.

Safety with pliers is simple.

- If you want your pliers to last and give you good service, don't use them as a hammer.
- Try not to use pliers on a hard surface. This dulls the teeth on pliers. Then pliers *lose their grip.*



- A good mechanic loses respect for a person when he see him loosening or tightening nuts with pliers. Always use wrenches on nuts—never use pliers.
- Never use pliers when any other tool will do the job.

Screwdrivers

Most folks don't know how to use a screwdriver, but don't you join their ranks. To start with, a screwdriver is built to withstand considerable twisting force. But it was not made to be used as a pry bar. If you use it this way

your screwdriver will become bent. Or you may break the blade. And a bent screwdriver is hard to keep in the screw slot.

Don't hammer on the end of a screwdriver. Chances are the handle will split and the screwdriver will be ruined.

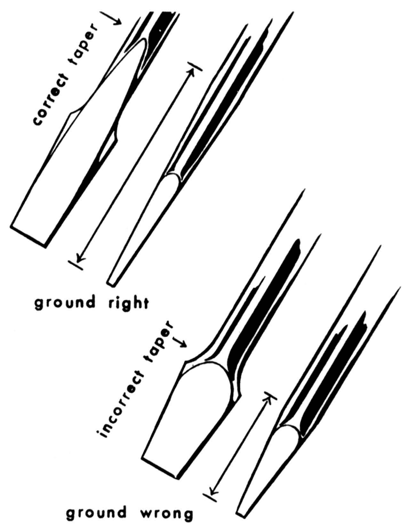
Don't use pliers on a screwdriver, either. Your tool will not be strong enough to take it.

As a final word of caution, never use your screwdriver to check high amperage on electrical equipment. It's dangerous!

Do's and Don'ts of Screwdriver Safety

Do

- Get a screwdriver that has an in-



sulated handle for your electricity work.
- Keep grease and oil off the end of the screwdriver when you use it.
- Hold your work in a vise or on a solid surface when you tighten or loosen a screw. If you hold it in your hand, the blade might slip and a screwdriver can puncture a hand!
- Use a screwdriver that fits the slot in the screw.
- Center the screwdriver in the slot or you might break off the corner of the blade.
- Keep your screwdriver vertical to the screwhead. If you let your screwdriver lean you won't get good turning action. And your tool might slip out of the screw slot.

Don't

- Use your screwdriver as a chisel or a pry bar.
- Hammer on the end of your screwdriver.

- Use pliers with your screwdriver.
- Use a screwdriver with a bent blade.

Remember

- Carrying a screwdriver around in your pocket is a dangerous habit.
- Work away from you, just as you do with your knife. Then if the screwdriver slips you won't get hurt.

SAFETY

Most of the time we think of electricity as a safe, reliable helper. That's the way it should be. As long as we handle it the right way and treat it with respect, electricity will work for us. Treat it badly, and electricity will repay us with serious accidents or fires.

Some rules to help you "play it safe:"

Know where the main switch box is and keep the space clear so you can reach the switch quickly in an emergency. Pull the main switch to cut off the current before you make any repairs.

Be sure you use the right fuse for the circuit. You may have heard of a person putting a penny under a blown fuse to turn the circuit on again. Don't you be so foolish.

Pull out an attachment plug by holding the plug instead of the cord.

Electricity is stubborn . . . it is always trying to get back into the ground. If you give electricity a wire to travel along, it will use the wire as a road until it comes to some path that will ground it. If that detour is you, there is trouble. So . . .

- Don't touch a bare wire or any metal that is touching a bare wire.
- Don't touch electrical fixtures, switches, or appliances when you are wet.
- Fly your kites somewhere away from overhead electrical wires or the string may carry the electricity through you to the ground.
- Don't climb power poles to see what's cooking—it might be you.

When you are through using the toaster, heater, or any other electrical appliance, turn off the electricity.

Run your extension cords in places that are out of the way, but not through doorways, under rugs, or over radiators. The heat and wear may break through the outside covering of the wire and cause a fire, or give someone a shock.

Men who have worked with electricity and are interested in safety have done two things to make electricity safer for you. First, they set up some standards to follow in wiring houses called the Electrical Safety Code. Be sure you know the code requirements when you do any wiring. Second, they designed a label, called the Underwriters' Laboratories label. When attached to a cord it means the cord has been tested and approved. It is usually a colored band around the cord, stamped with the letters UL. This approval means that a cord or wire is satisfactory for use under a given set of conditions. Also, when equipment has been tested and approved, the letters, UL, are stamped on it.

Last but not least, don't be confused by the term *low voltage.* In spite of its name, *low voltage is dangerous when handled carelessly.*

HOW DOES ELECTRICITY WORK?

When electricity flows through a wire it makes heat. The more electricity flows through a wire the more heat it makes. How much will flow through it depends among other things on the kind and size of wire (which determines its resistance) in the circuit and how many volts the source of power has.

A *circuit* is a complete path along which electricity can flow from the power source and back again. Electricity must pass through a complete circuit to do its work.

A *volt* is the measure of electrical pressure on the line, something like the pressure in a water system. The voltage on a circuit is usually fairly constant, such as the 115 volts on your house line.

An *ampere* is the measure of how much electricity or current is passing through a wire, something like the number of gallons of water per minute flowing through a water pipe.

An *ohm* is the measure of resistance to flow of electricity through the wire. It is like the friction in pipe lines. You measure resistance in *ohms per foot.* The resistance will depend on the length and size of the wire and the materials from which it is made.

Shortening the wire means less resistance and lets more amperes flow through.

Lengthening the wire means more resistance and fewer amperes.

Ohm, a German electrician, stated that one volt would force one ampere through a resistance of 1 ohm. Two volts would force two amperes through a resistance of 1 ohm. $\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$.

For electrical heating and lighting equipment the amperes that would flow through it could be figured if the resistance were known. If the resistance of a light bulb in your home is 68 ohms how many amperes would flow through it? $\text{Amperes} = \frac{115\ \text{Volts}}{68\ \text{Ohms}} = 1.7.$

Since the resistance of our heating and lighting equipment is not readily available the amperes that flow through them are usually figured from their watt rating.

A *watt* is a measure of the rate at which electricity works.

$$\text{Watts} = \text{Volts x Amperes}$$

From this the amperes that a 200-watt lamp uses could be figured:

$$200\ \text{Watts} = 115\ \text{Volts x Amperes}$$

$$\text{Amperes} = \frac{200}{115} = 1.7$$

The amperes that a 1000-watt electric iron uses could be figured the same way.

$$1000\ \text{Watts} = 115\ \text{Volts x Amperes}$$

$$\text{Amperes} = \frac{1000}{115} = 8.7$$

The amperes flowing through an electric motor cannot be figured from its wattage the same way as for heating and lighting equipment. The motor name plate will list the amperes it uses under full load. Suppose a motor uses 2.3 amperes. If the lamp, iron, and motor were plugged in at the same place the wire carrying the electricity to them would be carrying 1.7 amperes +8.7 amperes +2.3 amperes = 12.7 amperes. This is the way the number of appliances that can be safely put on any circuit can be figured.

A *kilowatt* (kw) is 1000 watts.

A *kilowatt hour* (kwh) is 1000 watts working for an hour. Ten 100-watt lamps used for an hour will take 1 kwh of electricity. One 100-watt lamp will use 1 kwh in 10 hours. About 1 kilowatt input to an electric motor gives 1 horsepower output.

PROTECTIVE DEVICES

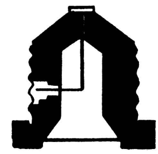
Electricity gives off heat when it flows through a wire. The amount of heat depends upon how much current is passing through the wire and the resistance of the wire. It is true that some wires in an electrical system, mainly those in certain appliances, are designed to produce heat. However, the wires that distribute electricity in your house or farm buildings are not intended to become hot.

They are of such a size and materials that they will not heat too much unless overloaded.

When an expert wires a house, he selects the size of wire according to the amount of electricity which he expects to be used at any one time and place in the house. Even then wiring in a house needs protection against overload and excessive heating. The most common protective device for wiring is the fuse. A fuse is simply a strip of metal having a low melting point. This strip burns in two when a current above that for which it is designed attempts to flow through it. For example, size 14 copper wire in house wiring carries safely 15 amperes of electricity without too much heating. So the electrical code specifies a 15-ampere fuse for protecting such a circuit.

You'll find fuses made in many different sizes to protect any size wire.

You probably have seen several types of fuses. Most common in the home

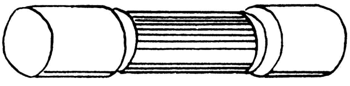


Plug fuse

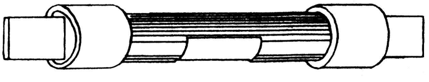
and on the farm is the plug fuse. This type fuse screws into a socket similar to a lamp socket.

Fuses

You can see the fuse link through a little window, making it easy to note when a fuse has "blown." When a fuse "blows" or burns out, the fuse link melts and may spatter. Therefore, all fuses are mounted in a sturdy case of some sort to control the spattering. Plug fuses are available in sizes up to 30 amperes.



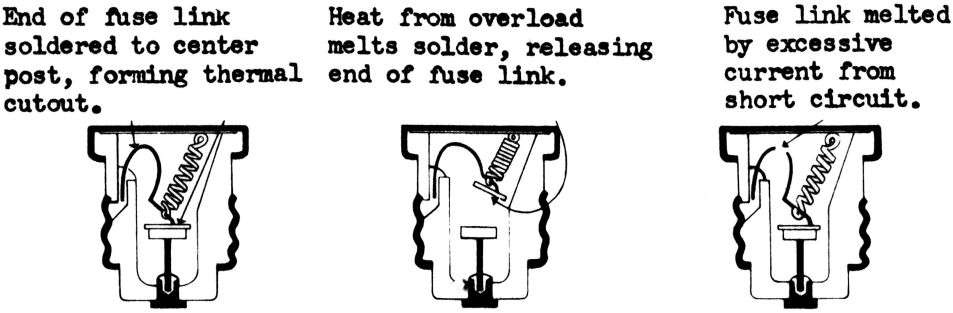
Ferrule type cartridge fuse



Knife blade type cartridge fuse

The cartridge fuse also is a common one. There are two types of these, one known as the ferrule type and the other, the knife blade type. The ferrule type is used up to 60 amperes and the knife blade type from 61 amperes up.

The sizes of these fuses vary so that it is not possible to interchange fuses varying too greatly in amperage. For



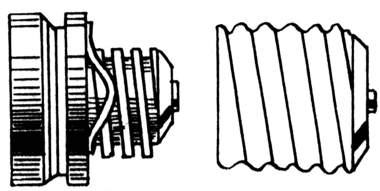
Time-delay fuse

instance, a 20-ampere fuse cannot be replaced with a 40-ampere fuse, although a 30-ampere fuse could be used. There is no visible means of telling when a cartridge fuse has blown. An indicator of some sort such as a test lamp must be used.

Some cartridge fuses have renewable fuse links so that when they "blow," a new fuse link may be put in without replacing the entire cartridge.

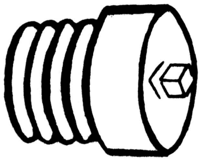
Time-Delay Fuses—Often a fuse blows because of a very short time current overload. For instance, you may have a circuit protected with a 25-ampere fuse on which a 1000-watt iron is "pulling" a current of about 9 amperes. If on the same circuit you start a motor, such as a washing machine motor, it will take up to 30 amperes when starting. This will cause a load of 39 amperes for a very short time but long enough to blow the fuse. Where you have motors or other equipment which require only very short overloads, a time-delay fuse serves well. The overload, operating for only a few seconds, will not be sufficient to cause the wiring to heat dangerously. However, if the overload continues for any length of time, usually a matter of a minute or less, the time-delay fuse will blow.

A time-delay fuse, like other plug fuses, has a fuse link which melts on extra heavy overloads. In addition, there is another connection in the bottom of the fuse, which melts when even a small overload continues. A spring pulls the connection apart. This type of fuse is sold under the trade name "Fusetron."



Left, fustat. Right, adapter.

Non-Tamperable Fuses—Since it is possible to replace a small fuse with a larger fuse in many cases, it is desirable to have fuses which cannot be interchanged. A fuse commonly called a "Fustat" is the most common of the nontamperable type. It makes use of an adapter which screws into the fuse socket and cannot be removed. The adapter will take fuses only of a given size or smaller, so that a larger fuse may not be substituted. Fustats are so arranged that placing a coin under them will not short them out. Check on availability of local supply before changing to this type of fuse.



Mini-breaker

Circuit Breakers

Circuit breakers do not burn out and need to be replaced. Some circuit breakers function like a time-delay fuse and will allow overloads for short periods of time. Hence when of the proper size they can be used to protect motors from overload or low voltage.

The Mini-Breaker is a small circuit breaker that can be used to replace a regular fuse.

A common fault of most fuses is that they can be shorted out. The common but very dangerous practice of putting a penny behind a plug fuse or placing a strip of copper along side a cartridge fuse completely removes the protection a fuse is designed to give. When a fuse "blows" it is a sign of a dangerous condition in the electrical system. After locating the trouble and correcting it, replace the fuse with a new one of the same size. Shorting out the fuse with a penny will mean that the next time an overload occurs, instead of blowing the fuse, the wiring will overheat and possibly cause a fire. Fuses are cheap, but houses are not.

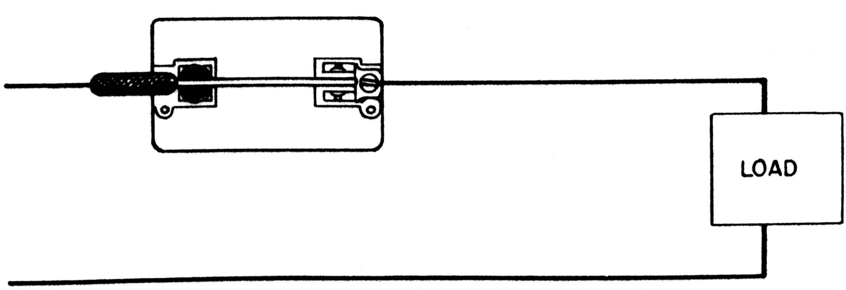
CONTROL DEVICES

You can consider control devices in two groups, those which operate by hand and those which operate automatically.

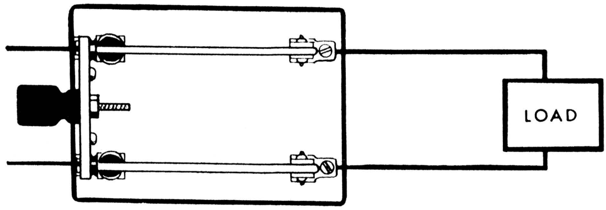
In electrical work, you'll hear the term "circuit" a great deal. A circuit is an electrical path from the source of electricity to the load and back to the source again. The load may be a lamp bulb or a toaster. The source may be the power company wires. In order for the lamp to burn, the circuit must be "closed" or continuous. The lamp may be turned off from any point along the circuit by breaking the wire. For this purpose, we use a "switch."

The simplest type of switch is a single blade knife switch. It has two contacts with a knife blade connecting them. By opening the blade, the wire is disconnected and the light will not burn.

For house wiring, the knife switch would look clumsy and be dangerous because of its open connections. In its place, a toggle switch is used. It may be mounted either in or on the wall.



Single pole knife blade switch with load



Double pole knife blade switch with load

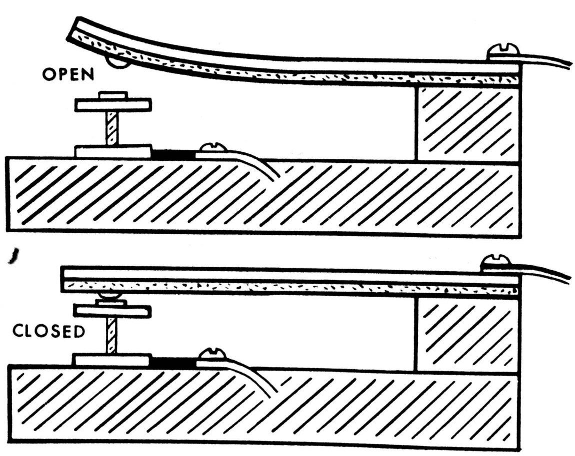
When recessed in the wall, only the handle shows. Surface mounted switches are enclosed in neat cases so that the insulated handle is the only exposed working part.

A toggle switch is small and compact and does the same thing a knife switch does, only in a safer manner. The mechanism in a toggle switch is spring operated to give a quick connection or disconnection, which reduces the flash or arc of electricity that may occur when a connection is made slowly.

Another type of switch is known as the double pole switch. Here both wires from the source pass through the switch and both are disconnected when the switch is open. It is the same as two single pole knife switches side by side. When open, this type of switch disconnects the load entirely from the source. With the single pole switch, one wire still connects directly from the source to the load.

Thermostats—Many heating appliances use switches which automatically open and close the circuit according to a temperature setting. Such an automatic control device is known as a thermostat. Most thermostats contain a single pole switch, which should be quick acting, that is, give a quick make or break when connecting or disconnecting a circuit. A sufficient change in temperature causes the control to work.

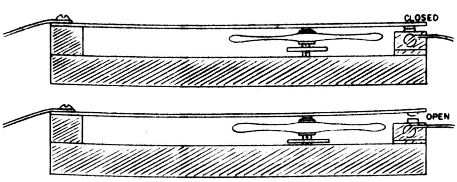
Bimetal Thermostat—Different metals have different rates of expansion



Bimetal thermostat

due to temperature. If thin strips of two metals having different heat expansion are fastened together and heated the strip will bend. By fastening one end of the strip, the other end can be made to move because of this bending action. The bimetal strip is in contact with the electrical contact at the breaker points. When the temperature increases, the bimetal bends causing the connection to be broken as is shown. When cooled it returns to its original position. This type thermostat serves on irons and other heating appliances where there is little space.

Ether Wafer Thermostat—Another type of thermostat often used has an ether filled bellows which can expand or contract. Within certain temperature limits, ether changes from a liquid to a gas and back again. As the temperature rises, the ether expands into gas and causes the bellows to enlarge. The bellows is so mounted that it makes and breaks the electrical contact as it expands and contracts. Most ether and bimetal thermostats are now used with a small quick acting microswitch. The movement of the thermostat causes the switch to go on and off. Thus there need be no electrical contact with the working parts of the thermostat, and the electrical parts all are enclosed. Ether wafer thermostats serve mainly for temperatures in the range of 50° to 120° F.



Ether wafer thermostat

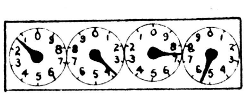
MEASURING WATTAGE

The electric meter indicates the number of kilowatt hours used throughout the wiring system. Starting with the right dial, it counts the units; when this hand has made a complete revolution, the next one to the left has moved over to 1, indicating that 10 kwh have been used; and so on, just like the hands on a clock, except that there are four dials instead of one.

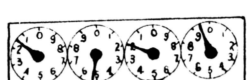
When reading a meter the number that is read is the one that has just been passed which is always the smaller one of the two between which the hand may be.

The kilowatt hours used in a month are determined by the difference between the readings at the beginning and end of each month. Most late meters are constructed so that they can be read direct just as you would read the mileage on a car.

For purposes of checking the load on a motor or other electrical equipment, count the rate of disk revolutions on the meter when the equipment is operating. The power company can tell



Meter dial beginning of month - 1 3 7 5 kwh



Meter dial end of month - 1 5 1 9 kwh

The difference in these readings is 144, the number of kwh used.

Meter dials

you the "disk constant" for the meter, and in that way you can calculate the load and the relative output of the equipment.

If, for example, you want to know how much current the electric water pump is drawing, first see that every other piece of electrical equipment is turned off, so that the electric meter which measures energy coming into the farm is recording only the amount of current being used by the water pump.

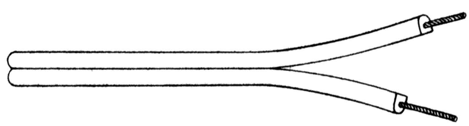
Next, go to the meter and count the number of revolutions the meter disk makes in one minute's time. Multiplying this figure by 60, you will have the number of revolutions the meter makes in one hour's time. Then by referring to the name plate on the meter, or by asking your power company or co-operative, you can find out how many watt-hours go through the meter when the disk has revolved once. Multiply this figure by the number of revolutions the meter disk would make in an hour to find the watt-hours per hour, which is merely the watts the appliance is drawing. For example, checking water pump: meter disk constant is found to be ⅓; counting by watch, meter disk turns 14 times in 1 minute, which is 840 times in 60 minutes, or 1 hour; multiplying by ⅓ (disk constant), the total is 280 watt-hours per hour, which is an average of 280 watts going into the motor on this water pump.

If you cannot find this constant, a close estimate can be obtained by comparing the rate of revolutions of the disk made by a water pump or other piece of electric equipment with a 100-watt bulb. If the equipment makes the disk turn 17 revolutions per minute and the 100-watt bulb causes it to turn 6 times per minute, then the wattage of the equipment is $^{17}/_{6}$ x 100 or 280, approximately.

SOME COMMON ELECTRICIAL CORDS

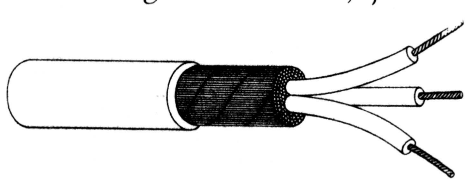
To make equipment convenient and movable it needs to be connected by means of a connecting cord. These are more apt to be damaged than the wiring in the house so they require more attention to keep them in good repair.

Light duty rubber or plastic covered cord is commonly used for appliances using small amounts of electric power such as clocks, radios, and



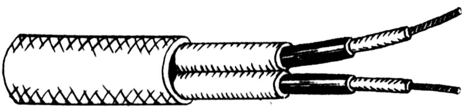
lamps. The conductors are covered with cotton braid to keep the rubber from sticking then enclosed in a solid mass of rubber or plastic. Five hundred watts is the maximum load for this cord.

Heavy duty rubber covered cord may have two or three insulated wires twisted together. Cotton, jute or



twisted paper fills it out to make it round. A cotton braid is sometimes added to help the cord hold its shape and then a tough rubber covering is molded over the outside. It comes in larger sizes than the light duty cord and can be used for motors, washing machines, trouble lamps, vacuum cleaners, or wherever it will receive hard usage.

Heating appliance cord has asbestos insulation that provides extra protection from heat. The asbestos protects the rubber insulation and the cotton pad protects the asbestos from



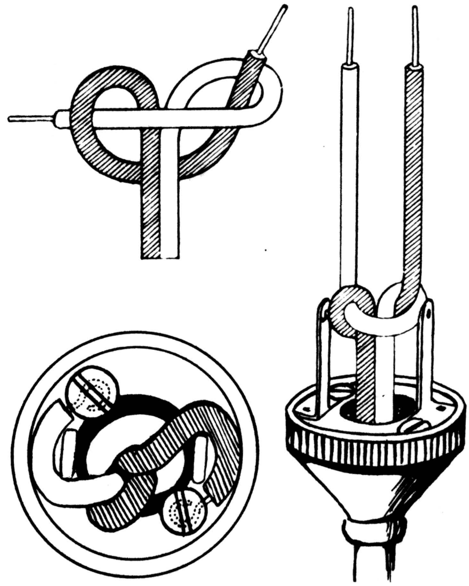
mechanical damage. This type of cord is used on heating appliances such as irons, toasters, heaters and so forth.

HOW TO ATTACH A PLUG TO A CORD

One of the most useful things you can learn about electric wiring is how to attach a plug to a cord.

Follow these steps:

1. Pull the cord through the plug.
2. Cut off the outer insulation (if any) from three inches of the end of the cord. Use your knife, but don't cut the wire insulation or the wire.
3. Remove one-half inch of insulation from each wire with your knife. Twist the strands to the right.
4. Tie an Underwriters' knot in the end of the cord. This knot was designed by the same folks who put the labels on cords which have been tested for safety. The knot goes inside the plug to take the strain off the wires. The picture shows how to tie it.
5. Push the knot into the plug.



Attaching a plug to a cord

6. Bring the loose ends of the wires around behind the contact prongs and connect them under the binding screws. Be sure to wrap the cord wires around the screws in the same direction as you tighten the binding screws. Be careful to see that there are no "whiskers" of wire that may cause a short.
(If there isn't room in a plug for the Underwriters' knot, use a simple overhand knot.)

SOME TYPES OF ELECTRICAL WIRE

Good wiring is as important to the success of your electricity project as veins and blood are to your health. If your veins didn't work properly, no blood would get to the parts of your body and you would't be you very long. The same is true of the wires in an electrical system. With the wrong wires you won't have enough electricity. Without enough electricity — no work from your machines, your tools or lights.

Pay attention then to the wires you use. Find the right wire with the right insulation for the job. Flexible wires for portable extension cords. Weatherproof wires for outside wiring. Heavy wires for high voltage, and so on. Know the job you want to do and choose the best wire for the job.

Wire sizes

Wires come in sizes from "0" and "00," etc. to "40" or so. The larger the number the smaller the wire. Number 14 is the smallest wire you can use for permanent 115-volt wiring.

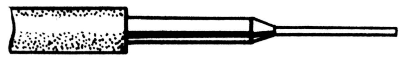
Number 16 and 18 wires are used for the portable cords on most low-voltage household fixtures—your floor and wall lamps and your radios. Wire sizes 20 to 40 are used inside electrical devices.

Service entrance cables on your farm and in your home are the larger wires—number 4, 6, or 8. These, and the still larger wires such as the 0, 00, 000, etc., are usually stranded to make them more flexible. (Sometimes these numbers are written like this, 1/0, 2/0, 3/0 etc.)

Types of Wire

Rubber or Plastic Covered Wire. You may have noticed that most wires have some sort of rubber or plastic insulation. But only one particular type is known as rubber covered wire. This, or plastic covered wire, is the kind you will use for most interior wiring jobs.

A copper wire is tinned to keep the



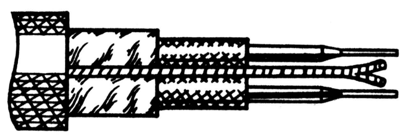
Rubber covered wire

Plastic covered wire

rubber or plastic insulating layer from sticking to it. A protective braid, treated to be resistant to fire and moisture, covers the rubber on the rubber covered wire. A wax coating on this braid makes it easier to pull through conduit.

Type R is the most common grade of rubber covered wire.

Non-Metallic Sheathed Cable. Look closely at this cable and you will see that it is made of two or more rubber or plastic covered wires with a paper tape spiral wrapped over them, and over the spiral a cotton braid cover.



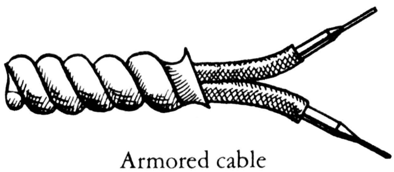
Non-metallic sheathed cable

The spaces between the wires and the outer cover are filled with jute cord. The outer cover has been treated specially to make it fire and water-proof.

Some common trade names for these cables are Romex, Braidex and Loomex.

Armored Cable. Another cable you'll see frequently is "BX." It has two or more rubber covered wires wrapped with a spiral of tough kraft paper. Around this is an outer cover of continuous, interlocked spiral casing of steel.

Lead-Covered Cable. Rubber covered cables, such as non-metallic



Armored cable

Type RW wire

sheathed cable and armored cable can be used only in reasonably dry places. Where the cable might get wet, choose one with lead covering over the usual insulation. The cable is then protected by conduit, spirally wound steel, or some other strong cover.

However, you should remember when planning your work that wiring with lead-covered cables is relatively expensive.

Type RW Wire. You can use type RW wire, too, in damp places, since the wire has a special water-resistant rubber cover. However, it must be protected by conduit and it can't be buried in the ground without additional covering.

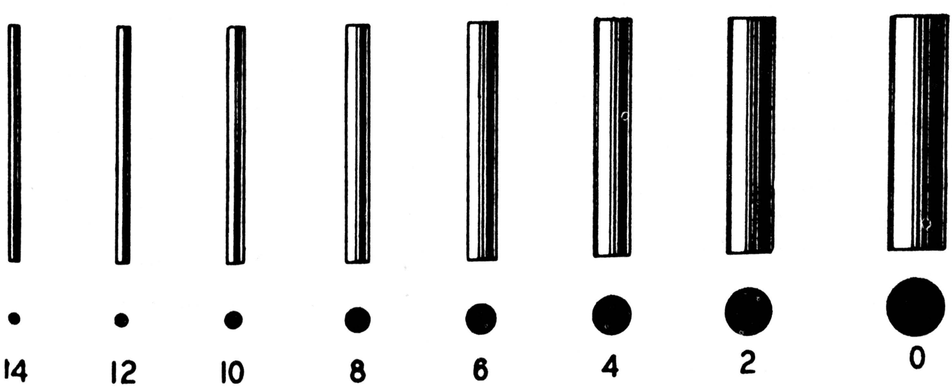
Underground Service Entrance Cable. Underground service entrance cable is like type RW wire. Its insulation is even more protection against dampness. It has a tough outer cover of special rubber which makes it extremely strong.

Weatherproof Wire. The requirements for outside wiring—conditions of the job, location, and shelter —call for types of wire altogether different from indoor wiring.

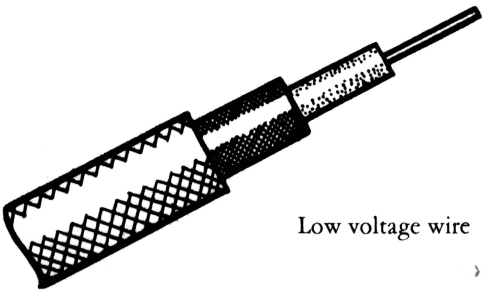
Outside wiring can be placed high off the ground, out of harm's way; the wires can be well separated. They don't need the kind of protection wires lying side by side in conduit do. But outside wiring does have to be protected from rain, wind, and snow. That's why we use a special weatherproof wire for such jobs.

The copper wire core of weatherproof wire is covered with two or three separate cotton braids which are saturated with weatherproofing material. An outer covering of flake mica makes it cleaner to work with. It is best never to handle this wire with the current on.

Low-Voltage Wire. Low-voltage



Approximate sizes of copper wire



Low voltage wire

wires are used for such equipment as doorbells, telephones and furnace controls. Its insulation consists usually of only two layers of parafined cotton. It is a small wire, so use it for 30 volts or less.

Methods of Wiring

Rigid Conduit. Conduit looks like water pipe but is different. It has to be rust-proof and the inside must be smooth. Regular conduit has threaded ends for making connections. You can bend conduit around corners but you have to do so before you run the wire through. Wires are reached at connection boxes.

Electrical Metal Tubing. "Thin wall tubing" is another name for electrical metal tubing. It is much the same as rigid conduit except that it is thinner and connections are made with clamp couplings and connectors.

Electrical metal tubing and rigid conduit are usually best for use in damp surroundings or exposed areas because they offer more protection. But be sure of good grounds.

Non-Metallic Sheathed Cable. You can use this cable in almost any dry place. It is light, easy to handle, and inexpensive. You can staple it to studding joists or other protected parts of a frame building.

Armored Cable. Unless an electrical code tells you not to, you can use armored cable in just about the same places as non-metallic sheathed cable. It shouldn't be used in barns or other buildings where corrosive fumes are present.

Knob and Tube Wiring. In the past, most interiors were wired in this way, and even today it is permitted by electrical codes. But many local authorities have decided against its use.

In knob and tube wiring, rubber-covered wire is mounted on porcelain insulators and, where extra protection is needed, the wires are run through porcelain insulating tubes. Different kinds of insulators are used—knobs, tubes and cleats. Knobs and tubes carry only one wire each. Cleats can carry more if you have enough space between the wires. Where wires are too close together, "loom" is added as protection. "Loom" is a heavy fiber sleeve which slips over the wire.

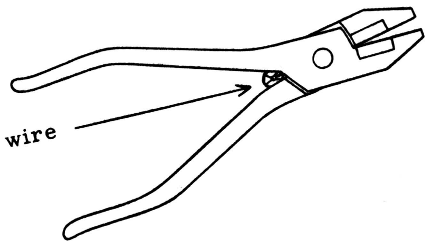
SPLICING ELECTRICAL WIRES

When two or more electrical wires are joined this connection is called a splice.

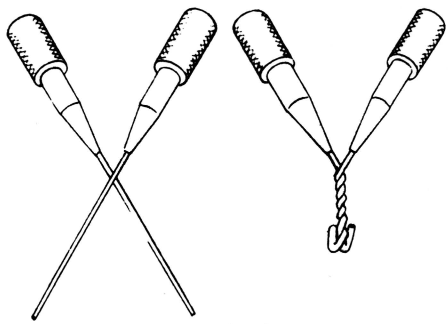
Splices must be strong so they will not loosen and must make good electrical contact so they will not heat. The following things must be done to make a good splice: remove the insulation, fasten the wires together, solder the connection (unless using solderless connectors), and apply insulation.

Remove the Insulation

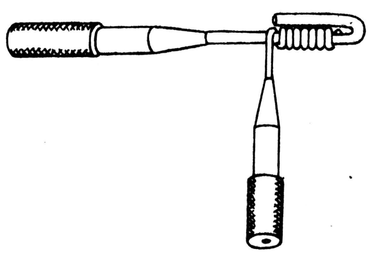
There are two ways to remove the insulation from wire. 1.) Use electrician's pliers and place the wire between



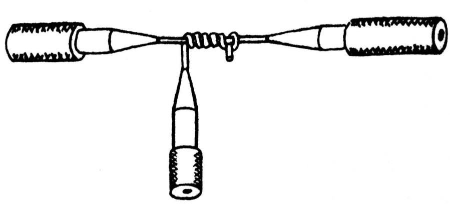
Crushing the insulation



Pigtail splice

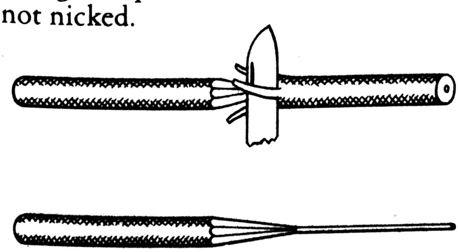


End tap splice



Center tap splice

the handles of the pliers up close to the jaws. Crush the insulation and then strip it from the wire with the plier jaws. Scrape the wire with a knife blade if it needs cleaning. 2.) Use a knife and cut off the insulation as if a pencil were being sharpened. Be sure the wire is not nicked.



Removing insulation with knife

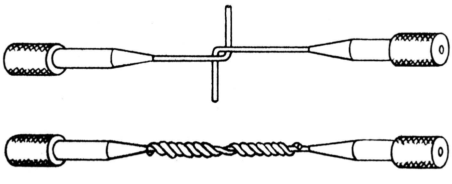
Splicing

Where there will be no strain on the wires, such as connections made in junction boxes or lighting fixtures, use the pigtail splice. Remove about 1½ inches of insulation from the end of each wire. Put them together and twist with pliers. Bend the ends over so the sharp ends will not puncture the insulation.

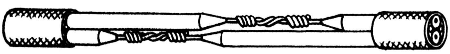
The pigtail splice is hard to make if the two wires are different sizes or one is stranded. In that case, make an end tap splice. Remove about 2 inches of insulation from the end of each wire. Wrap the small or stranded wire around the large wire. Clamp the end of the large wire over the twisted wire.

When a wire is to be connected to a continuous one, make a center tap splice. Remove 1½ inches of insulation from the continuous wire and 2½ inches from the wire to be attached. Wrap the single wire around the continuous one.

Where a splice is needed that is as strong as the original wire, such as for spans between poles, use the Western



Western Union splice



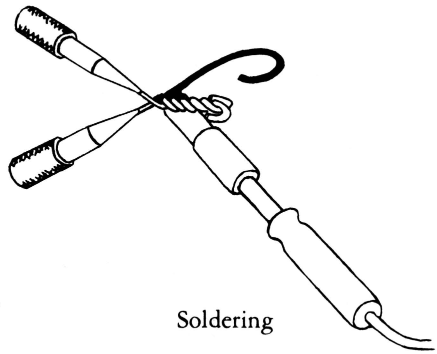
Western Union splices —staggered

Union splice. Remove about 4 inches of insulation from the end of each wire and place them together. Bend each wire at right angles about an inch from the insulation. Hold the wires and twist them in opposite directions. This can be done easily by holding the center of the splice with pliers and wrapping both free ends making sure that the turns of wire are close together and tight.

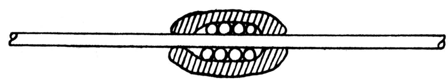
It is best never to splice extension cords. If you must splice, use the Western Union splice but stagger the splices so each one is at a different place. This reduces the danger of a short circuit and makes the splices less bulky. Each splice must be taped separately.

Solder

Solder is used to give a good electrical connection. The hot splice is covered with hot, melted solder which is a combination of lead and tin. A flux must be used to make the solder stick. Rosin is the proper flux for electrical work with copper wires. Solder with a rosin flux core, called rosin-core, is the most convenient type to use. A soldering iron or torch is used to supply heat for



Soldering



Hot solder applied to cold wire

Hot solder applied to hot wire

applying the solder. (A soldering "iron" actually is made of copper.)

When using a torch be careful not to burn the insulation. If the wires are hot enough to melt the solder it will flow into the splice and fill up all the spaces.

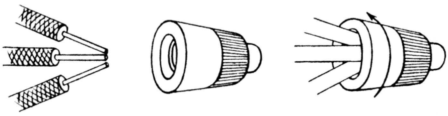
When hot solder is applied to cold wire, it will not fill up the spaces.

When hot solder is applied to hot wire a good connection is made.

Having the solder or wire too hot is just as bad as not having it hot enough. Experience is necessary to get it right.

A soldering iron should be kept clean and in good shape. If solder will not stick, the surface may need to be smoothed up first and reshaped with an old file.

Solderless connectors will fasten wires together without solder. They can be used only when there is to be no strain on the joint afterward. To



Solderless connector

make this splice, strip only enough insulation from the ends of the wires so no bare wires are exposed when the connector is on. If one wire is smaller than the others strip a little more off it and let it stick out a little past the other wires. Screw on the connector.

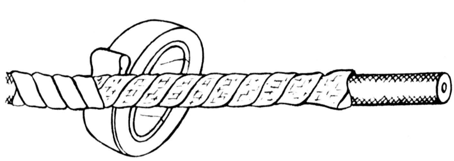
Solderless connectors are only for inside use. If used in a junction box no tape is necessary. Some types are made of metal and need taping.

Tape

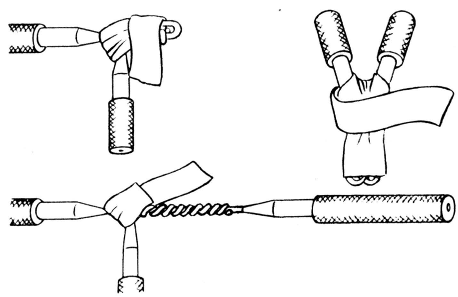
After the splice has been soldered insulation must be applied. Use rubber tape first, wrapping spirally with the turns overlapping slightly. This should be wrapped from end to end until it is as thick as the original rubber. Stretch the tape so it will stick together to keep out dirt and moisture.

Then use friction tape to replace the tough outer braid on the wire. Two layers are usually sufficient.

Rubber taping



Friction taping



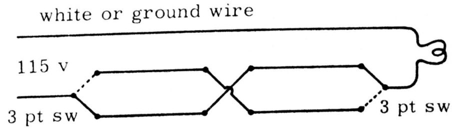
Taping

If weatherproof wire, which has no rubber insulation, is used no rubber tape is needed. Just put on enough layers of friction tape to replace the original insulation. To be sure to get all wires covered when taping the other types of splices, follow the methods shown in these pictures.

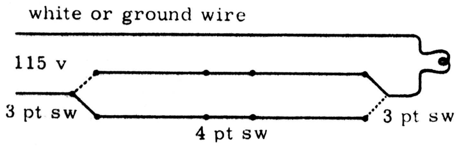
THREE AND FOUR POINT SWITCHES

It is easier to understand the action of 3 and 4-point switches after you have made a diagram. Here you will see that two 3-point switches (at either end) take the place of a single-pole switch. Where you want more than two switches for operating a single circuit, 4-point switches may be added, as many as you want. But these 4-point switches must be *between* the 3-point switches in the circuit.

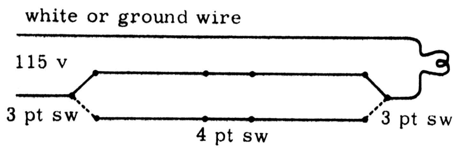
Here you can trace the solid line through and see that the circuit is completed. The light should be "on."



Here the 3-point switches have not been turned but the 4-point switch has been used to turn the circuit "off."



Here one of the 3-point switches has been used to turn the circuit "on", again. You can again trace the solid line through from one end to the other of the circuit.



Low Voltage Switches

A low voltage system is frequently cheaper especially where long runs of wire or many switches are needed. Because it operates on just 24 volts and does not carry the current used by the light or appliance expensive wire is not needed.

LET'S TAKE A LOOK AT LIGHT

Light is a form of energy. That statement doesn't help us very much unless we know something about energy. Probably you do, but it is good to remind yourself of what we mean by energy. Energy is called "the capacity for performing work." You might call it power or force. But remember, it can be either force at work, or force that is stored up and can be changed into work. As one example, you have energy stored in your muscles and nerves. Also, there is energy stored in coal, oil, wood, electricity, and in many other common forms.

Also, you know that the sun is considered the source of all the energy on earth. The sun constantly sends forth energy in all directions, and we call that radiant energy. Heat and light are parts of that radiant energy coming from the sun; and, as you know, light travels at a rate of about 186,000 miles per second.

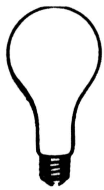
We have nothing else in our common experience that travels at the tremendous speed of this radiant energy from the sun, so the meaning of the figure is hard to grasp. However, a comparison like this may make that terrific speed a little easier to realize.

It takes light a little more than eight minutes to travel the 92,000,000 miles from the sun to the earth. It would take a jet airplane flying at 600 miles per hour almost 18 years to cover the same distance.

When you strike a match, what happens? The match "lights" and you see the flame. The wood of the match burns. Actually, what you see happening is the release or transfer of energy stored in the match. The friction of rubbing the match against the striking surface causes the match to burst into flame. The energy is released in the form of heat and light.

A transfer of energy can be made from fire or flame to material that does not burn in the ordinary sense. You know, for instance, that metals can be heated until they glow—first a dull red, then bright red, then yellow, and finally almost white. The heated metal throws off both heat and light.

In a similar way we get light from



MODERN INCANDESCENT LAMP

the light bulb so familiar to you. It is called an incandescent lamp or bulb. It is easier to understand and remember when you know that it comes from a Latin word meaning "to become red-hot."

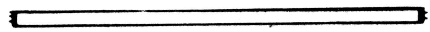
Light From Electric Current

Instead of a flame, we use electricity to produce this light. We pass an electric current through the tiny wire (filament) in the bulb. This causes the wire to glow, just like the heated steel in the blast furnaces of a steel mill. Again, this results in the creation of both light and heat. To say it more accurately, the electric energy is changed into energy taking the form of light and heat. We then use the light to see.

You may wonder why the filament wire glows with light when the current flows through it. The reason is this: There is resistance in the wire, the wire resists the passage of the current.

The wire purposely is made very small. Thus, when the current is turned on, it is like trying to force a large stream of water through a small rubber hose. Much of the electrical energy is turned into light and heat.

Now what about the long tubes used in fluorescent lighting? How do they work? To understand that, you must have some knowledge of the science called electronics. That, of course, is



STANDARD FLUORESCENT LAMP

part of the study of atoms and of how they act. No doubt you have already learned a good deal about this subject, and you know that electrons are parts of atoms. In any case, you will be able to grasp the main ideas in the following brief explanation of fluorescent lighting.

The long glass tube is called a fluorescent lamp. It contains two electrodes —one at each end of the tube. These are very small coils of wire. The tube also contains a tiny drop of mercury and a small amount of argon gas.

When the electric current is turned on, the electrodes are heated, just like the wire in an incandescent bulb. However, they are so made that they do not become as bright as the filament wire in the bulb. They are heated just enough—and just long enough—to start giving off a flow of electrons. At the same time, the mercury in the tube is changed into vapor. This mercury vapor and the argon gas provide a path for the flow of electric current through the tube. Once this has started, the filament wires of the electrodes need not be heated any longer. So they are taken out of the electric circuit automatically.

The electrons are speeding along through the tube at a terrific rate of speed—about 1000 miles per second. When one of them hits an atom of mercury vapor, it knocks some of the mercury electrons out of position. But these mercury electrons are parts of a mercury atom. They are held together by atomic force. When they are knocked out of position for a fraction of a second, they come bouncing back again. In doing so, they release some energy. (It takes less than a millionth of a second for this to happen.)

Why do these mercury electrons release energy? It took energy to knock them out of position and they simply release that energy on coming back to position. It is like throwing a lump of soil straight up in the air. It takes energy to throw it. That energy is released by the lump when it strikes the ground again. Only in this case the energy is released in the form of heat (although the amount is so small you can't feel it) while in the case of the mercury electron it is released in the form of ultra violet radiation.

You probably know that this is another of the many forms of energy given off by the sun. Now it happens that ultraviolet radiation is invisible. Here we have had all this action of electrons dashing around "bopping" each other, and still no light!

The answer lies in another feature of the long glass tube. The inside of the tube is coated with a thin film of materials called phosphors. These phosphors are minerals and chemicals. They have a quality known as fluorescence. That simply means that when they receive ultraviolet radiation, they give off visible light. In other words, the invisible ultraviolet energy is changed into another form of energy—light.

There are five main steps, then, in the production of light in a fluorescent tube:

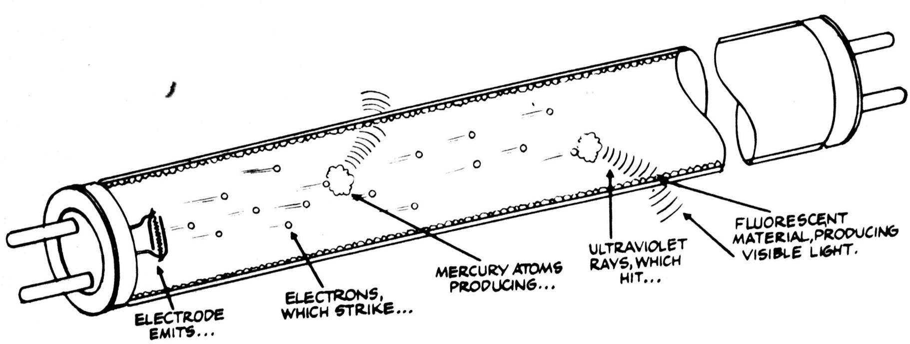
1. Electric current heats the electrodes and causes electrons to start flowing.
2. Electrons flow through the mercury vapor and argon gas.
3. Mercury vapor electrons are hit by the free electrons flowing through the tube.
4. As the mercury vapor electrons snap back into place, they give off energy in the form of ultraviolet radiation.
5. The ultraviolet rays falling on the phosphor coating are changed into visible light.

It takes quite a little while to explain this process, but it happens in the twinkling of an eye. Remember, the electrons are flowing at a speed of 1000 miles per second.

MAGNETISM MAKES MOTORS MOVE

Did you know that a motor and the north pole have something in common? That something is magnetism.

We use compasses to point out the direction north. They depend on mag-



netism to do their work. Here's how.

Magnets have two poles. One end is north and one end is south. This is true whether the magnet is a bar or horseshoe in shape. Poles that are alike repel each other; unlike poles attract. This attraction is called magnetic force.

Permanent magnets, like the earth, have the north and south poles always in the same places. A compass needle is really a small permanent magnet. Its south pole is attracted to the earth's north pole. Thus, unless disturbed by another magnet, a compass needle always points to magnetic north.

Electromagnets

You can build an electromagnet by winding a coil of wire around a piece of soft iron called the core. By passing an electric current through the wire you can magnetize the core. It then has a north and south pole, just like the permanent magnet. The more turns of wire on the coil the stronger the electromagnet will be. However if hard or tool steel is used for the core instead of soft iron the steel may be permanently magnetized.

One advantage of an electromagnet is that you can reverse its polarity. Here is another. As soon as the electric current is turned off, the core loses its magnetism and then has no north or south pole. Another advantage is that its polarity can be reversed. If the direction of the electric current is reversed the position of the north and the south pole reverses. This action is used in making electric motors run.

ELECTRIC MOTORS

What's Good About an Electric Motor

It's safe . . . an electric motor has few moving parts and is easy to cover.

It's easy and cheap to maintain . . . you have no fuel or radiator problems, no oil to change, and it will not freeze.

It's quiet . . . an electric motor is quieter than other types of power.

It has a long life . . . should last 25 years or longer.

It's portable . . . easy to move from one job to another.

It's inexpensive to run . . . a ¼ horsepower motor will do the job of one man for about five cents a day.

What Kinds Are There?

All electric motors operate because of the magic of magnetism. They may be built to operate at a certain speed for a given load and they will keep operating at that speed unless you pile more work on them than they can handle. Some motors are made to operate at two or three different speeds, and some will operate at almost any speed.

You will find four types of motors in general use on the farm and in your home. They are:

Split phase
Capacitor
Repulsion start-induction run
Universal

The first three on the list run as induction motors. (You will learn more about this later.) The difference in these first three is the way in which they are started. Electric motors need a "push" to get them started and the names of these motors indicate how the push is applied.

The *split phase* motor will not start a very big load. You find it mostly on small machines or where the machine does not start under load. It is limited to ½ horsepower.

Capacitor-start motors can start loads about twice as large as the split-phase motor. They come in popular sizes from ¼ to 7½ horsepower.

Repulsion-start motors are the best motors for real heavy duty and come in regular sizes up to 10 horsepower.

The *universal* motor is so named because it will work on either alternating current or direct current if the voltage is right. It will start a fairly heavy load and has a wide range of speeds. Many small motors around the farm are this type. They are usually on small appliances, however, because they are not very efficient and cost extra to run.

Another motor used on farms is the *3-phase motor*. It is used particularly for heavy jobs of three horsepower or more. You can use them only where 3-phase electrical service is available.

How To Care for a Motor

You do not have to do much to keep an electric motor running well. However, a few things are important.

Keep motor clean. Do not let dust and dirt accumulate in the coils. If it does, the motor may overheat and wear out faster than it should. Keep the outside wiped off. If the windings on the inside become dirty, clean them with carbon tetrachloride. Use a suction vacuum cleaner to suck the dirt off the inside parts of a motor.

Keep motor dry. If you are planning to use it in a wet place, install a splash-proof motor. If the motor has been flooded with water, clean and dry it thoroughly, then have it tested for short circuits before you use it again.

Lubricate. All motors need some lubrication. Sometimes the factory does it "for life" and you don't have to worry. For motors that do need oiling, apply two or three drops often rather than a lot of oil less often. Oiling a motor is largely a matter of common sense. As a general rule, use S.A.E. 10 oil in motors of ½ horsepower or less, and S.A.E. 20 oil on larger motors.

For safety's sake, oil the motor when it is not running.

Protect Motor from Overload

Motor protection is somewhat like fire insurance. Most people never have a fire, but they carry fire insurance to protect themselves against the one chance in hundreds of a heavy loss. Similarly, adequate motor protection should be provided, especially on automatic equipment that operates when you are not around.

Regular fuses are inserted in the fuse boxes to protect the circuit wires. They will not protect motors, because the starting current is 3 to 8 times normal operating current. A ¼ hp motor may draw 30 amperes of current to start, but draw only 5 amperes while running at full load. Therefore, this motor circuit would need a 30-ampere fuse to start the motor, but would then permit the motor to run with 6 times the rated current before it would "blow out" and break the circuit. This would burn out the motor. Special fusing is needed to protect them.

A dual element fuse of the proper size with a time delay feature will protect a motor.

Circuit- breaker switches will also

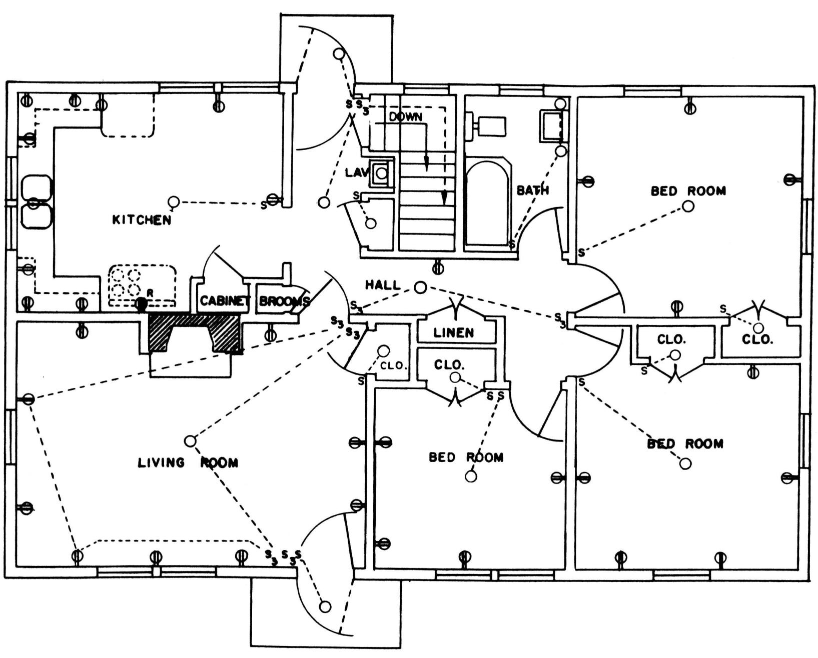
protect a motor. A small heating element corresponding to the size of the motor heats a bimetalic strip under over-loaded conditions. This trips the switch and breaks the circuit. The switch must then be reset before the motor will operate. Some of the more expensive motors have thermal overload protection built in the motor frame. These also operate from a bimetalic strip and can be reset automatically or manually, depending on the type.

PLAN FOR WIRING THE FARM HOME

In most instances the farm home should be wired by a competent wiring contractor. Occasionally, however, a member of the family has the time and knowledge that with some study he can wire the house or outbuildings. In either case the finished job should be inspected by a power supplier inspector before the current is turned on.

Before any wiring is done draw the floor plan of the house or building. This plan should be roughly to scale of ¼ inch or ½ inch equalling one foot. On this plan show the location of all switches, convenience outlets, light fixtures, etc., similar to the sketch shown.

The following tables may be used as an additional guide in the wiring diagram.



Farm home

SUMMARY OF RESIDENTIAL OUTLET LOCATIONS

This table is given for quick reference and is necessarily condensed.

Space	Lighting Outlets	Type of Circuit	Convenience Outlets	Type of Circuit	Special-Purpose Outlets	Type of Circuit
Living Room Farm Office	General illumination wall-switch controlled.	Gen.	No point at wall line more than 6 feet from an outlet; outlet in mantel shelf. Two or more outlets switch controlled.	Gen.	1 for room air conditioner	Ind.
Dining Areas	1 outlet, wall-switch controlled.	Gen.	No point at wall line more than 6 feet from an outlet.	App.		
Kitchen	General illumination plus light over sink, wall-switch controlled. Work-area lighting.	Gen.	1 for every 4 feet of kitchen work-surface frontage. 1 at refrigerator location. 1 at table space.	App.	1 for range. 1 for clock. 1 for fan. 1 for dishwasher-waste disposal unit (if plumbing facilities are installed).	Ind. Gen. Gen. Ind.
Laundry	General illumination; wall-switch controlled. Work-area lighting.	Gen.	1 outlet, at least.	App.	1 for washer 1 for hand iron or ironer. 1 for clothes dryer. 1 for water heater.	Ind. App. Ind. Ind.
Bedrooms	General illumination; wall-switch controlled.	Gen.	No point at wall line more than 6 feet from an outlet. Outlet on each side, and within 6 feet of center line of each bed location.	Gen.	1 for room air conditioner.	Ind.
Bathrooms, Lavatories	Good illumination of face at mirror essential; wall-switch controlled.	Gen.	1 near mirror.	Gen.	1 for built-in space heater. 1 for built-in fan, wall-switch controlled.	Ind. Gen.
Recreation Room	General illumination; wall-switch controlled.	Gen.	No point at wall line more than 6 feet from an outlet; outlet in mantel shelf.	Gen.		

Hall	General illumination; wall-switch controlled.	Gen.	1 for each 15 feet of hallway. Halls over 25 sq ft at least one outlet.	Gen.		
Stairways	Outlets for adequate illumination of each stair flight. Multiple control at head & foot of stairway.	Gen.	1 at intermediate landings.	Gen.		
Closets	1 outlet	Gen.				
Exterior Entrances	1 or more outlets; wall-switch controlled.	Gen.	1 preferably near front entrance.	Gen.		
Porches	Outlet for area greater than 75 sq ft; wall-switch controlled.	Gen.	1 for each 15 feet of wall bordering porch.	Gen.		
Terraces and Patios	General illumination; wall-switch controlled.	Gen.	1 for each 15 feet of wall bordering terrace or patio.	Gen.		
Basement and Utility Space	General illumination of work areas, equipment, and stairways.	Gen.	2 outlets, one at work-bench location.	Gen.	1 for electrical equipment in connection with furnace 1 for freezer.	Ind. Ind.
Accessible Attics	1 outlet, wall-switch controlled. 1 for each enclosed space.	Gen.	1 for general use	Gen.	1 for cooling fan, with switch control.	Ind.
Garage	1 for one or two car garage, wall-switch controlled. 1 for exterior lighting, multiple-switch controlled if garage is detached from house.	Gen.	1 for one or two car garage.	Gen.	If food freezer, work bench or automatic door opener is planned, provide appropriate outlets.	Ind.

Notes on Preceding Table

Gen.-Outlets supplied by General-Purpose Circuits.
App.-Outlets supplied by Appliance Circuits.
Ind.-Outlets supplied by Individual-Equipment Circuits.
A convenience outlet to be at least of the duplex type (two or more plug-in positions), except as otherwise specified.

All spaces for which wall-switch controls are required, and which have more than one entrance, to be equipped with multiple-switch control at each principal entrance. If this requirement would result in the placing of switches controlling the same light within 10 feet of each other, one of the switch locations may be eliminated.

GRAPHICAL ELECTRICAL SYMBOLS FOR FARMSTEAD WIRING PLANS

These symbols have been extracted or adapted from American Standards Association Standard ASA Z32.9-1943, wherever possible. Adaptations and new symbols included in this list have been proposed for inclusion in the next revision of that standard.

General Outlets

- Lighting Outlet
- Ceiling Lighting Outlet for recessed fixture (Outline shows shape of fixture.)
- Continuous Wireway for Fluorescent Lighting on ceiling, in coves, cornices, etc. (Extend rectangle to show length of installation.)
- L — Lighting Outlet with Lamp Holder
- L PS — Lighting Outlet with Lamp Holder and Pull Switch
- F — Fan Outlet
- J — Junction Box
- D — Drop-Cord Equipped Outlet
- C — Clock Outlet

To indicate wall installation of above outlets, place circle near wall and connect with line as shown for clock outlet.

Convenience Outlets

- Duplex Convenience Outlet
- 3 — Triplex Convenience Outlet (Substitute other numbers for other variations in number of plug positions, such as 1 for single convenience outlet).
- Duplex Convenience Outlet — Split Wired
- GR — Duplex Convenience Outlet for Grounding-Type Plugs
- WP — Weatherproof Convenience Outlet
- X" — Multi-Outlet Assembly (Extend arrows to limits of installation. Use appropriate symbol to indicate type of outlet. Also indicate spacing of outlets as X inches.)
- S — Combination Switch and Convenience Outlet
- R — Combination Radio and Convenience Outlet
- Floor Outlet
- R — Range Outlet
- DW — Special-Purpose Outlet. Use subscript letters to indicate function. DW-Dishwasher, CD-Clothes Dryer, etc.

Switch Outlets

- S — Single-Pole Switch
- S_3 — Three-Point Switch
- S_4 — Four-Point Switch
- S_D — Automatic Door Switch

Switch Outlets (continued)

- S_P — Switch and Pilot Light
- S_{WP} — Weatherproof Switch
- S_2 — Double-Pole Switch

Low-Voltage and Remote-Control Switching Systems

- S — Switch for Low-Voltage Relay Systems
- MS — Master Switch for Low-Voltage Relay Systems
- R — Relay-Equipped Lighting Outlet
- Low-Voltage Relay System Wiring

Auxiliary Systems

- Push Button
- Buzzer
- Bell
- Combination Bell-Buzzer
- CH — Chime
- Annunciator
- D — Electric Door Opener
- Interconnection Box
- T — Bell-Ringing Transformer
- Outside Telephone
- Interconnecting Telephone
- R — Radio Outlet
- TV — Television Outlet

Miscellaneous

- a,b — Special Outlets. Any standard symbol given above may be used with the addition of subscript letters to designate some special variation of standard equipment for a particular architectural plan. When so used, the variation should be explained in the Key of Symbols and, if necessary, in the specifications.
- Feeder
- Branch Circuit
- Branch Circuit, Concealed in Floor
- Switch Leg Indication. Connects outlets with control points.
- Service Entrance Equipment
- Distribution Panel for Feeders and/or Branch Circuits

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J. W. BURCH, Director, Agricultural Extension Service