# Wiring Houses for Electric Light

N. H. Schneider

THE KLAWITERS
16156 Alcima Avenue
Pacific Palisades, California

Making knot.

The knot made.

Connecting socket. Spare wire end to be cut off.

PLATE I.

# WIRING HOUSES

FOR THE

# ELECTRIC LIGHT

TOGETHER WITH

## SPECIAL REFERENCES TO LOW VOLTAGE BATTERY SYSTEMS

BY


**NORMAN H. SCHNEIDER**

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**SECOND EDITION REVISED AND ENLARGED**

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# PREFACE TO SECOND EDITION

A supply of electric current in the house for lighting, cooking, and for the operation of the labor-saving household appliances is no longer looked on as a luxury.

Electricity in the house is a necessity.

The wiring of the house therefore is a subject awakening vast interest and the second edition of this book has become necessary in order to keep abreast of the constantly arriving improvements in electrical work.

Although many farms and isolated dwellings are installing low voltage plants of their own, operated by a gasoline engine, there exists no reason why the wiring itself should not be as safe as that required for the higher voltage of the Public Service lines. Therefore, the directions in the succeeding pages are devoted to first class work only, and that suitable for all ordinary household voltages.

The rules of the National Board of Fire Underwriters have been freely consulted, an extensive digest with notes is given in a complete chapter of this edition.

In addition to practically all the information contained in the former edition, there has been added thirty-two new pages on conduit wiring and concentric wiring and a number of full-page plates.

Condulets and other fittings for conduit work have been described, together with BX armored cable and the handling of it.

Concentric wiring, a system of wiring much used abroad is treated on, several illustrations of the wire and the new line of fittings being developed by the General Electric Company being shown through the courtesy of the latter company.

There exists some opposition in the United States to this concentric wiring due solely to the fact that it is supposed to be a rival of the present systems, and its adoption to entail great losses to investments in tools and machinery devoted to the manufacture of the ordinary fittings. This is not logical.

Concentric wiring is an addition to the modern methods and has its field in the less pretentious dwellings. It is not likely to supplant any other form of wiring to any extent for years to come other than small circuits in open work or moulding.

It does, however, present a new additional line of convenient fittings to be likened to the condulet and BX lines.

The author wishes to thank the following for illustrations or information:

The Bryant Electric Mfg. Company and The H. T. Paiste Company for electric fittings. The Sprague Electric for illustrations of BX armored wire and multilets, the Crouse Hinds Company for illustrations of condulets, the Western Electric Company for illustrations from their book "Brightening up the Farm," and to the General Electric Company for illustrations and information on their new line of concentric wiring appliances.

Also he expresses his appreciation to Mr. R. S. Hale for information on concentric wiring, to Mr. John Deegan for reading manuscript and to Mr. Alfonso Ciani for the excellent photographs.

NORMAN H. SCHNEIDER.

Jersey City, N. J.

# CONTENTS

## CHAPTER I.

### Introduction.



## CHAPTER II.

### Planning the Wiring.



## CHAPTER III.

### Completing the Installation



## CHAPTER IV.

### Installing the Lights.

## CHAPTER V.

### Other Methods of Wiring.



## CHAPTER VI.

### Materials and Notes.



## CHAPTER VII.

### Conduit and Protected Wiring.



## CHAPTER VIII.

### Underwriters Rules and Notes.

# LIST OF ILLUSTRATIONS

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## LIST OF PLATES.

# CHAPTER I.

## Introduction.

Before light can be obtained from the incandescent lamp it must be placed in a suitable receptacle or socket and connected to wires leading from the battery.

The socket consists of a shell having insulated contacts of brass, into which the lamp screws and makes connection between its base and the contacts in the socket.

The wires having been attached to this socket convey the current through these contacts to the filament in the lamp and the filament becomes white hot, giving the desired illumination.

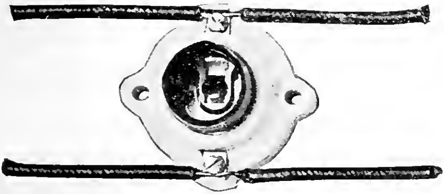
It is of vital importance that the wires carrying current shall not touch each other when bared or the current will flow through such point of contact and cause a short circuit which is a sudden rush of uncontrolled current.

Such a short circuit would very likely have disastrous results if not guarded against. This is done by covering the wires with a covering or insulation which prevents the passage of electricity. All metal parts which are to carry current are also insulated either by hard rubber, porcelain or by some other suitable means.

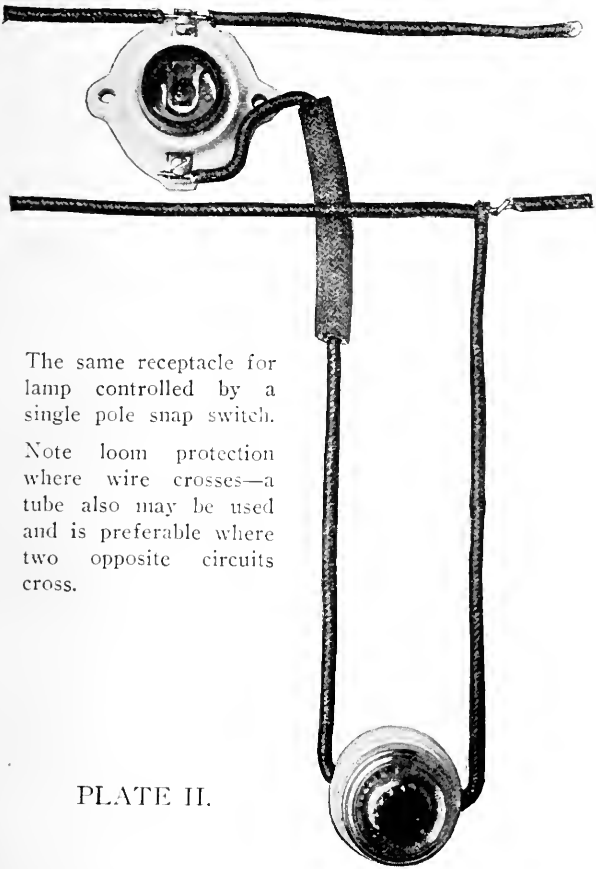
One of the simplest sockets to hold the lamp is shown in Fig. 1 having two short wires protruding from the upper part which are to be spliced or tapped on to the main wires of the circuit. The socket being of porcelain is especially adapted for use outdoors or in damp places. The wires may be of any length desired if specially ordered but usually they are a few inches in length. The copper wire is stranded giving greater flexibility and less likelihood of breaking off when the socket is swayed by the wind.


FIG. 1.

In attaching to the circuit wires, the socket wires are to be bared of insulation for about three inches, scraped bright and twisted on. A good plan is to divide the strands in each wire into two parts, bending them at right angles so as to form the letter T. Then each half is twisted around the circuit wire separately in opposite directions which ensures a good support for the socket and less liability of breaking at the point of connection.



Receptacle for lamp directly connected to circuit.



The same receptacle for lamp controlled by a single pole snap switch.

Note loom protection where wire crosses—a tube also may be used and is preferable where two opposite circuits cross.

PLATE II.

As stated elsewhere all such connections should be well soldered and taped.

Such an arrangement of a weatherproof socket tapped on to a wire is of use in its place, that is in damp locations, but for a dwelling house where something more convenient and ornamental is desired brass sockets are used as illustrated in Fig. 2. These having no permanent wires for ready connection like the weatherproof socket must be attached by means of other pieces of wire, or by flexible incandescent lamp cord.

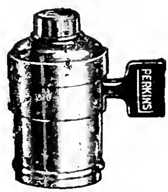



Fig. 2.

These brass sockets are provided with a key protruding from the side by means of which the current may be turned on or off as desired thus controlling the light. The key operates a switch in the socket, which switch is a device consisting of fixed and of movable contacts through which the current passes when the switch is turned on. Turning off the switch or key separates these contacts and the current can no longer pass until the key is again turned.

Switches are also made in a great variety for location in cases where it is desired to turn on or off the lights without reaching up to the socket. And sockets are made as in the weatherproof socket without keys or switches contained in them.

A combination of wires and lamps with their accessories is known as a circuit.

**Circuits.** The simplest practical circuit would consist of a pair of insulated wires leading from the battery to a key socket holding the lamp. The key of the socket being turned would either light or extinguish the lamp. The essential parts then of a circuit are the wires to carry the current, the socket or holder for the lamp and the switch or key to control the light. The wires would be insulated, that is, covered with some substance which is not a conductor of electricity to prevent a contact of the metallic portion of the wires and thereby a "short circuit."

In a simple circuit a few feet long the insulation on the wires would be deemed sufficient to protect the wires but where the wires are to be extended for a distance they would have to be supported on insulated supports.

The latter are of glass or porcelain, being generally called insulators, except the porcelain ones, to which the common name of "knobs" is usually given.

Other control of the light than by means of the key in the socket would probably be unnecessary.

Going a step farther a fuse would be added to prevent the copper wire becoming dangerously hot should an accidental short circuit or metallic contact be made. This fuse would be a piece of special lead alloy wire and would melt, opening the circuit when the current became too strong. Lead alloys are used because they melt at a lower temperature than copper without becoming hot enough to do damage before melting. Aluminum wire is also employed for fuses but principally in the high ranges of current. Other forms of fuses will be treated of in their place.

Then another light might be added or perhaps two by means of wires leading from the main wires. These circuits extending for considerable distances and being most probably permanent would be on insulators or otherwise safely supported.

The next improvement would be switches to control the lights and a main switch to cut off the battery from all connection with the wires. The main switch and the porcelain fuse block should be enclosed in an iron box or a wooden one lined with asbestos.

Elaborations will of course suggest themselves such as the installation of more lights, special means of control, fixtures and methods of running the wires to meet special requirements.

It is assumed that a house is ready for wiring and the details of the number, location and size of the lights have been decided upon.

While the scope of these pages is more particularly directed to the wiring for low voltage lighting from storage batteries, the methods described will be suitable for regular 110 volt installations. In the latter case the local rules affecting wiring should be consulted, and if insurance is to be carried, the insurance rules should be consulted. It is impossible to give in a book all the rules which are often different in each State and town. So far as possible all general rulings have been consulted in preparing these directions and the methods to be described are safe.

# CHAPTER II.

## WIRING A HOUSE.

Before starting to wire a house the plan or specifications should be decided upon showing the number and wattage of the lamps and the location of the lamp outlets. (It is customary to use the term outlet instead of lamp, as for, example, a house would be wired for ten outlets, not for ten lights).

The location of the switches should also be settled as well as the point of entrance for the service, that is where the wires from the electric light mains or battery shall come in.

If a small private plant it may be located in the cellar in which case the main switch or service switch will be in the cellar. But if the plant is located in an outhouse, then the wires must come in the same as those from an electric light company in most cases leading to insulators fastened to the walls at a height from the ground but may lead from there into the cellar if desired.

The exact location should be settled before wiring as all wires to the lighting circuits in the house must run to the service or main switch so that they may be more conveniently controlled.

**Material Required.** It will be better to read generally through the directions for wiring given here and then survey the job before attempting to figure out what material is required if the operator is inexpert. For this reason much of the description of material has been left to a later chapter and described separately. It then becomes a simple matter to measure with a rule the amount of wire wanted and the other supplies will be in proportion. Of course such things as sockets and switches depend upon the actual lighting requirements.

**Laying Out the Job.** Suppose it is desired to conceal the wiring in a finished frame house. The first thing is to lay out the outlets or points where the lights are to go and mark the walls or ceiling with a pencil cross at the spot, also marking in the location of switches if any.

Where outlets are required in the centre of a room the ceiling must be marked at the centre spot. This may be done in two ways. The width of the floor is first measured and the result divided in half, a long line than being penciled on the floor at this point, or a stick laid down at right angles to the width of the room. The length of the room is then measured and likewise halved, the place where the half length and the half width meet is the centre of the room. The center of the ceiling may be readily found by means of a plumb bob or a weight on a string held to the ceiling and shifted until the plumb bob hangs directly over the mark.

Where the string touches the ceiling marks the center.

Another and quicker method usually followed by the regular wireman is to procure a stick about half the width of the room in length and standing on a chair or step ladder shove one end of the stick against the wall near the ceiling and mark on the ceiling where the other end reaches. Then put it against the other side of the room near the ceiling and mark again in like manner. This is done four times when the four marks on the ceiling being all of equal distance from the walls can be used to get the exact centre by means of a foot rule.

The stick must be held straight each time parallel to the wall or the measurement will be off. Where rooms are of irregular shape the centre or location for the ceiling outlet may be decided arbitrarily. In the case of a bay window, the latter is not to be taken as included in the dimensions of the room, but is to be ignored.

A long thin bit about one quarter of an inch in diameter and say eighteen inches long is fastened in a brace and carefully driven up through the mark on the ceiling until it comes through the flooring of the upstairs room.

The little hole in the floor will show where to take up the board later on. It is very rare that the center of a floor will correspond with the centre of the ceiling right below it as the upstairs rooms are often laid out differently than those down stairs For this reason it would be very hard to locate the exact spot where the floor board should be removed or the pocket cut in order to get exactly over the ceiling outlet, unless this above method was pursued. The hole bored by the small bit is hardly noticeable in the flooring, except it be looked for.

Where a partition comes exactly over the bored hole, the skirting or mop board must be removed. This is best done by driving in the nails with a nail punch and then lifting off the mop board. If it is attempted to pry it off, it will be surely split and the plaster may come off in patches. But having driven in the nails there is nothing holding the board in place but the edges of the plaster and the fit with the floor.

Having drilled all the outlets and marked where the switches are to go, the next thing is to figure out the easiest and shortest route for the wires. This will not only save labor and mistakes when the work is under way but will enable a list to be made of the material needed.

Taking the case of a two story frame dwelling house with the service or battery plant in the cellar, the outlets on the first floor will be wired through holes or "pockets" cut temporarily in the floor above. The bed rooms may probably be wired from the attic which if not floored will facilitate the wiring operations.

In the first place look which way the floor joists lie and arrange to have as many of the circuits as possible run in the same direction to avoid boring holes transversely through the joists.

This is well illustrated in Fig. 3 which represents a portion of a floor with part of the boards cut away. The joists run in the direction of arrow *B* while the flooring runs like arrow *A*.

If the circuit is to run in the direction of arrow *A*, the joists must be bored and porcelain insulating

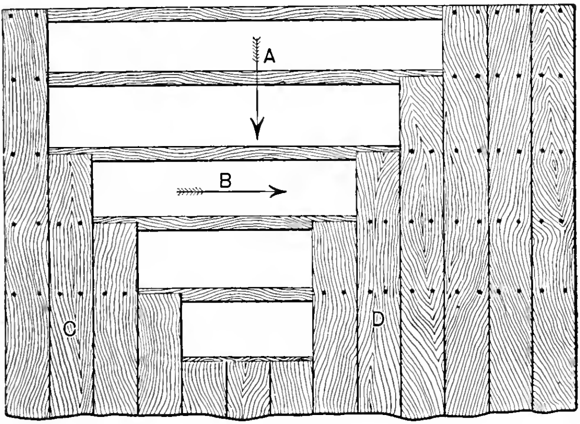



FIG. 3.

tubes inserted in the holes as will be described later. In order to bore the holes in every joist the entire board or two boards covering the route must be taken up.

But where the wires run in the direction of arrow *B* it is not necessary to bore any joists as the wires will lie between them, and the entire board need not be taken up but only a small portion as will be seen later.

**Wiring Plans.** In the following four plans are shown some typical arrangements of wiring. The

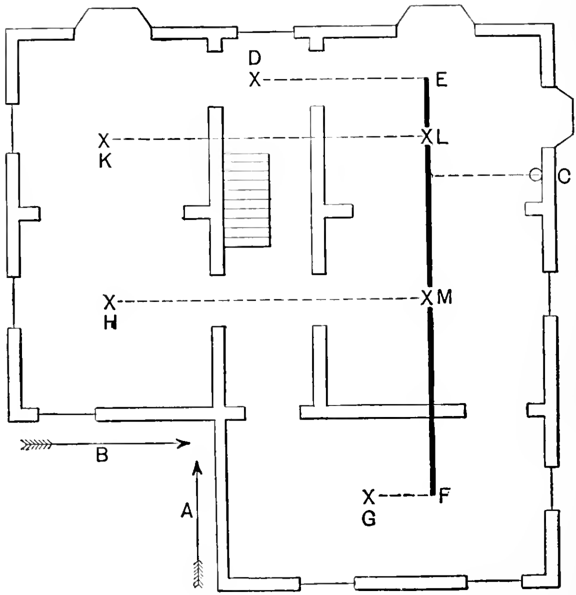



FIG. 4.

plans are those of the first floor and show the outlets of that floor, but the wiring is as it would appear when viewed from the second floor under which it is located.

In order not to complicate these plans no clothes closets, bathrooms or the usual details of house construction are shown. The idea is merely to show in a brief manner the direction which the wiring would take, the two wires being indicated by a single firm line or dotted line.

The arrows indicate the direction of the joists and floor boards, arrow *A* pointing in the direction of the floor boards and arrow *B* in the direction of the joists.

The heavy lines show where it is necessary to take up complete boards and to bore and tube the joists. The dotted lines show where the wires are run between the joists.

It is thus possible to see at a glance the best path for the wires.

The circle *C* is at the place where the wire from the service or main switch will come up in the wall to feed the circuit.

Consider first Fig. 4. The flooring will be taken up between points *E* and *F* in the manner to be described later.

The branch wires to outlets *D*, *K*, *H* and *G* will be joined or "tapped" on to the circuit between *E* and *F* and the wires to the service down the wall at *C* will be also tapped on. This tapping will only require pockets to be taken up at intervals possibly one at *D*, *K*, *H* and *G*, and one or two between *L* and *K* and between *M* and *H*. The point at *C* will probably be opened by removing a portion of the mop board or skirting.

In Fig. 5 is another layout of the same job where it will be noticed that there will be more boards to remove and more boring as shown by the heavy lines.

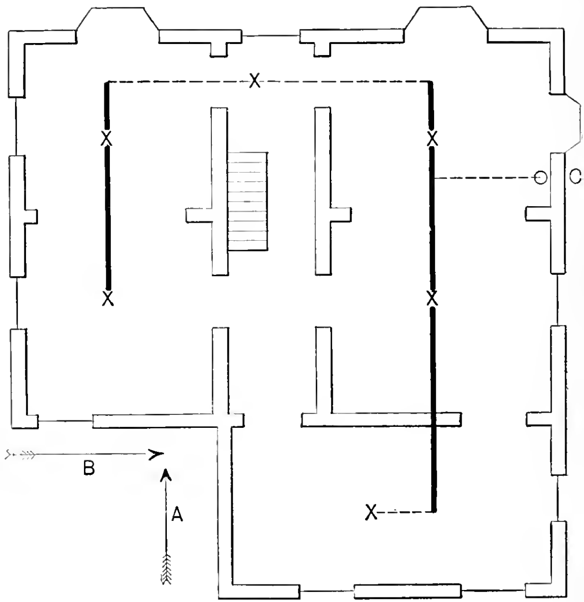



Fig. 5.

The labor is greater in this scheme and nothing is gained thereby.

In Fig. 6 is a plan of another house drawn in the same manner the boards running like arrow *A* and the joists like arrow *B*. Here the boring through the joists will take the direction of heavy lines, but the wires may be continued past outlet *D* and down in the wall to the cellar.

Outlets *E* and *F* and *G* will require branch wires run to them.

In Fig. 7 is another house plan where the wires run in a complete circuit from outlet *F* to outlet *D* and the service wires tapped on at *C* where they go down in the partition. If the partition is not handy the main wires may continue to the point *E* and there go to the service.

Each house presents its own conditions but a little study will disclose the best and most handy route for the wiring.

As the simplest of these circuits, the last one will be considered and the operations more particularly referred thereto although most of the directions given will be general in application.

**Pockets.** The first operation in wiring will be to open pockets at intervals in the floor or to remove floor boards in order to gain access to the space beneath.

The pockets will be spaced where the knobs are to come and above all outlets in the ceiling.

In order not to complicate the directions at this point, it will be better to read to the end of this chapter before actually cutting any flooring. In this way the exact points where the knobs are to come will be better understood.

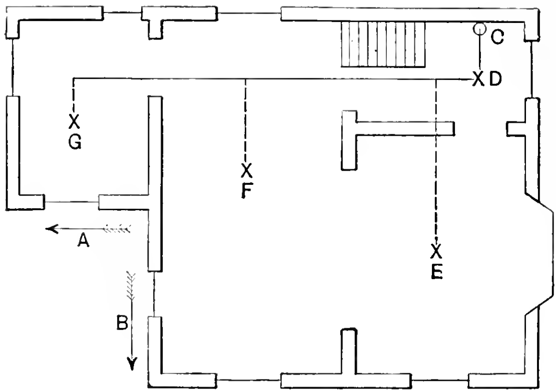



FIG. 6

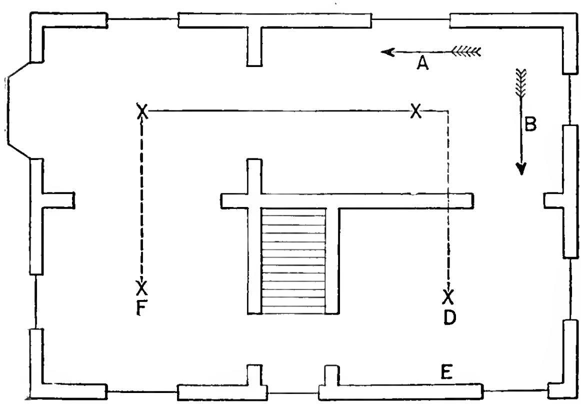



FIG. 7

The exact places where the ceiling outlet pockets are to be taken up will be found marked by the bit which was driven up through the ceiling, but the other points will have to be determined on surveying the route and will be determined by the distance between outlets as is explained in the paragraphs on knobs and their use.

The manner of opening a pocket in a matched wood floor is first to bore a one quarter inch hole for the keyhole saw through the joint between two

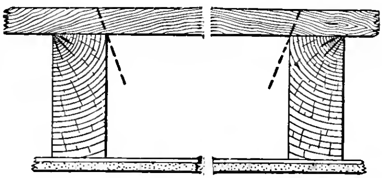


FIG. 8.

boards and as near the joist as possible. The joist may be located by the nails through the flooring.

If blind nailed bore a hole by guess after tapping the floor and locating as near to the joist by the dull sound. Then bend a short length of wire and inserting it through the hole fish around for the joist. A little practice will reveal to the touch the distance of the joist by the resistance to the bent wire.

Having bored the small hole, force in the end of a key hole saw and cut across the board at an angle as shown by the dotted lines in Fig. 8. This is to permit of the board being replaced neatly after the wiring is completed. Having sawed across the piece of board at both ends in a similar manner it may be pried out using a chisel as shown at *B* in Fig. 9. If it be a hard wood floor it is better to saw first down with the grain between the boards cutting off the tongue of the adjacent board as shown at *B*. This makes it easier to pry the

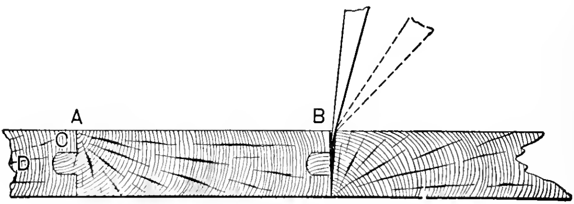



Fig. 9.

board up without splitting off the top tongue *C* of board *D* as would be the case if the chisel were bent down hard at *A*.

When taking up a complete board insert the chisel always on the side *B* and leave a second chisel in to act as a wedge when removing the first chisel to pry at a new place further along. Sometimes several flat wedges or chisels may be used in this manner or an assistant can be of service. Taking up the first board in every case is the hardest, a second adjacent board is easier to take up than the first. Always lay the pieces near the hole from which they are taken or mark them so that they may be put back again. The chisel used should be at least one inch broad and better if it is wider as the distribution of leverage will ensure lighter markings on the edges of the boards.

When all pockets are open and all necessary boards taken up, the boring and tubing of the holes through the joists may be undertaken.

**Boring and Tubing.** In boring the holes through the joists they should be located about two inches from the top of the joist. As they will be bored from above they will slant a trifle but this cannot be helped and will only require a little more wire and be harder to pull the wires through than if the holes could be bored straight and level.

These holes should be bored with an $^{11}/_{16}$ inch Ford bit or other single cutter bit so that they will accomodate tubes $^{9}/_{16}$ inches outside and $^{5}/_{16}$ inch hole. If a tighter fit is desired use $\frac{5}{8}$ inch bit. It is better to have the tubes fit tight as they will not slip out through jarring or when pulling the wires through them. The latter is usually done so that the pulling wire tends to pull the tube head into the hole and not the other way. The matter of bits is taken up in the later section on tools and material. There will be probably a lot of holes to bore but a clean sharp bit and application will finish the job.

In boring these joist holes an extension is a handy tool, this is a steel rod which fits into the brace and holds the bit lengthening the latter. These extensions may be bought of several convenient lengths.

The two holes for one circuit should not be closer

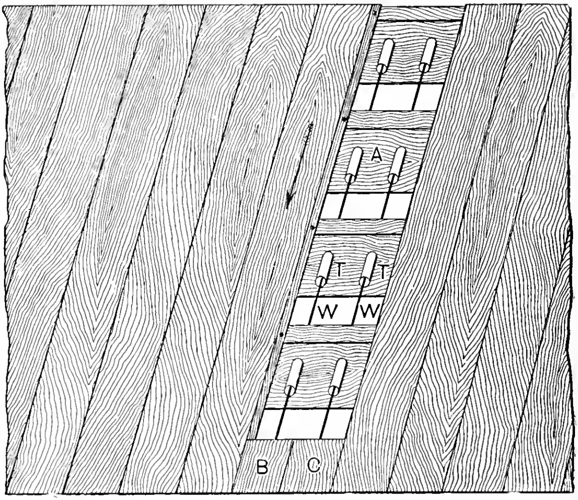



Fig. 10.

than five inches to one another and better if still further apart.

The appearance of a portion of the floor with the tubes and wires installed is shown in Fig. 10.

There being two wires it is necessary here to take up two boards in order to have room enough to work in. *A* is a joist, *T T* two tubes and *W W* two wires while *B* and *C* are the boards continuing those which have been taken up. The wires being pulled in the direction of the arrow pull the tubes into the holes the heads being on the side of the joists not shown. If pulled against the direction of the arrow there is a liability of pulling out the tubes. Of course it is a small job to push them back again but doing so means handling the wires after they have been stretched and this is not to be done more often than is necessary by one inexpert in wiring work.

Where two joists come together as where the end of one overlaps the end of another, a long tube must be used sufficiently long enough to pass completely through both joists. Details such as these will readily suggest themselves to the careful worker who studies the work as it progresses.

**Running the Circuits.** Having now bored all the holes and tubed those in the joists, place the knobs after which the actual running of the wires may be proceeded with.

**Nails and Nail-heads.** For fastening knobs to the wood work, screws may be used but stout wire nails are cheaper quicker and satisfactory.

In order to avoid hitting the porcelain with the hammer while driving the nail home, leather nail-heads are slipped on the nail. These are small washers of belt leather and lying under the head of the nail act as a cushion between the hammer and the porcelain. Leather nail-heads may be purchased from any electrical supply store or cut from a piece of old leather.

**Knobs and Their Use.** The form of porcelain insulator or knob used in this class of wiring is known as the No. 5 or 5½ and is described and shown in the section on materials. What are known as split knobs are also there described.

The general spacing between knobs along the joists is 4½ feet but will vary according to circumstances. The pockets intended for use in placing knobs between outlets are taken up in accordance with this spacing but may vary. Sometimes by extending this spacing a trifle only one knob is needed between two outlets and only one pocket is therefore required.

A study of this condition will save work and knobs but remember not to save labor and material to the detriment of the job. A portion of the floor showing three pockets with the knobs and wire installed is given in Fig. 11.

There is no attempt in these diagrams to give exact distances or measurements as the width of floor boards and other conditions vary.

**Wire.** The copper wire used in wiring inside the house must be rubber covered and protected by a cotton braid and of the size to be selected according to the data given elsewhere. This wire is suitable to use in moulding or concealed in the flooring when strung between porcelain knobs, or pulled in between walls having first been incased in some form of flexible tube such as Circular Loom or Flexduct.

It must not be used outdoors where it will be exposed to rain or snow but the so-called weatherproof wire with a braided covering used in its

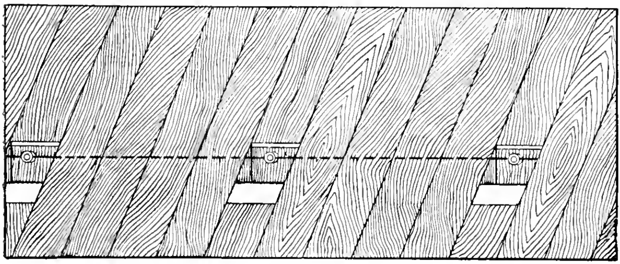


FIG. 11.

stead. Although the latter form of insulation is never as good as rubber yet outdoors it does not crack or rot. It is never run in wood mouldings but is always supported on knobs or glass insulators.

Details of wire are given in the section on materials.

The best method of handling the wire is to take the coil and divide it into two equal coils. This enables both sides of the circuit to be run practically at the same time.

For the present leave these two coils at the point where it is intended to drop the two service ends down in the wall to the service switch in the cellar.

Take two ends from each coil, or one at a time as preferred and with care so that they do not kink, start these ends under the floor through the nearest pocket and under the floor from pocket to pocket and through the tubes until the extreme end of the circuit is reached. Considering Fig. 7, the coils will be left at *D* (or at *E*) and the ends run under the floor past each outlet until outlet *F* is reached. Then making fast at *F*, the wires may be stretched and fastened to the knobs returning along the route until the other end of the circuit at *D* or *E* is reached, there being then the remainder of the wire lying in two coils.

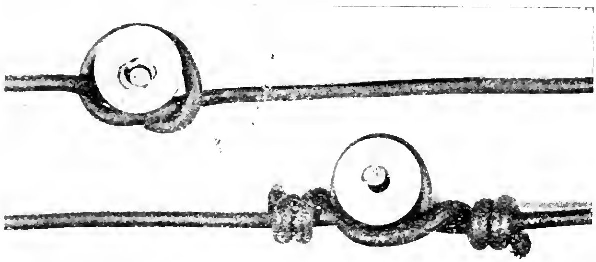
They will not be pulled down into the cellar at *E* yet but at a later time as will be seen farther on.

The ends at the farther ceiling outlets *F* may be left long enough to pass down through the ceiling hole and leave at least 8 inches for connection to the fixture.

On straight runs or when running one circuit it is a good plan to place all the knobs first then the wires can be pulled tight from the extreme end knob and fastened to the knobs as the circuit is followed.

The run will be past each outlet as far as possible but no outlet wires will be tapped on yet, this will be done when the entire length of wire has been fastened under the floor to the knobs.

**Making Fast.** When making fast from knob to knob the wire may either be given a turn around the intermediate knobs being held tight at the end knobs by a dead-end hitch or what is better be



Figs. 12 and 13.

hitched at each knob as shown in Fig. 12. This takes more wire and a little more practice but keeps the wire tight between all knobs instead of only between those to which it is dead-ended or hitched. The principal objection to these methods as against tie wires is that should the wire come off the knob the hitched or twisted part would slacken and allow the wire to touch the woodwork.

A good method is to fasten a few knobs on a board and practice the hitches and other methods of securing wires the advantages of the several methods will then be apparent and the practice useful when actually engaged in wiring up the house.

The method of tying a wire to a knob using tie wires is shown in Fig. 13 from a photograph. The tie wire is a separate piece about fifteen inches long and is first tied around the knob and main wire so as to secure the latter to the knob. The loose ends are then twisted around the main wire one end on each side of the knob. The hitch or tie is made by using the middle portion of the tie wire leaving two ends of about the same length.

Another method which is not so good is to merely wrap the tie wire around the main wire and the knob and twist on the ends. The hitch although taking more wire and more time is to be preferred in all cases.

Where a circuit ends at an outlet two methods may be pursued. The wires may be dead ended and short pieces for the outlet be tapped on, this makes a firm job but requires a soldered joint. Or the ends of the wire may be left long enough to reach down through the outlet after the wires have been stretched and made fast by means of the dead-end method elsewhere illustrated. The latter is the usual method where the wires can be ended near the outlet but sometimes it is not practicable to end them near the outlet.

Where two circuits cross each other or where one wire of a tap crosses the other main wire, a porcelain tube should be slipped over the crossing wire or wires as shown in Fig. 14. There should be placed two knobs each side of the crossed wires as shown in order to secure the crossing wire and the tubes. These knobs are often omitted and the tubes merely held fast to the wire upon which they are slipped by means of tape but the above is preferable.

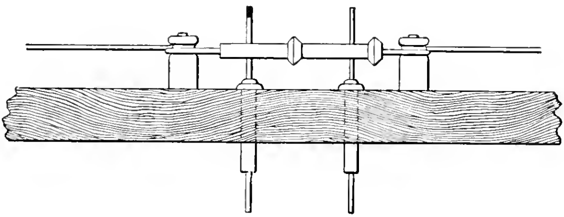


FIG. 14.

All branch or tap wires must be secured to a knob at the point where they are led off from the main circuit as at outlets, these knobs however need not be installed now but when making the taps.

**Joints.** The two joints used in electrical wiring are the splice and the tap. The splice as its name implies is used where two pieces of wire are to be joined together in the direction of their length. The tap is used where a branch wire is to be run off another wire at right angles to it.

There are two methods of making splices, by twisting the wires together and by using patent screw unions or Dossert joints. Taps are also made by twisting one wire on to the other or by Dossert taps. Furthermore there are several pieces of apparatus such as fuse blocks and cutouts

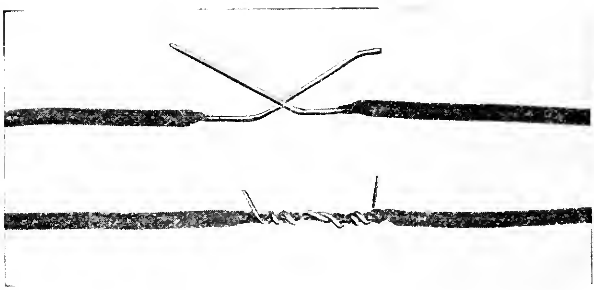
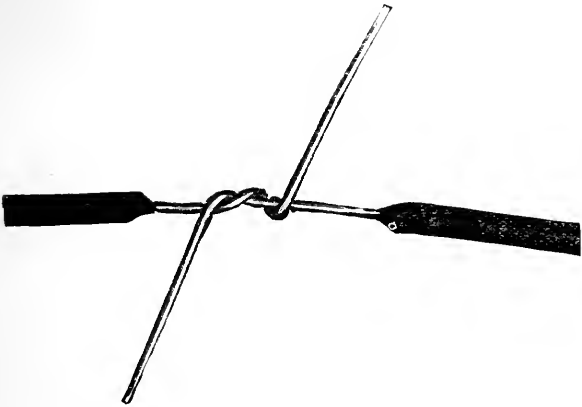


Fig. 15.

in which wires are joined through screw connections or under screwed lugs and several ingenious devices for special conditions.

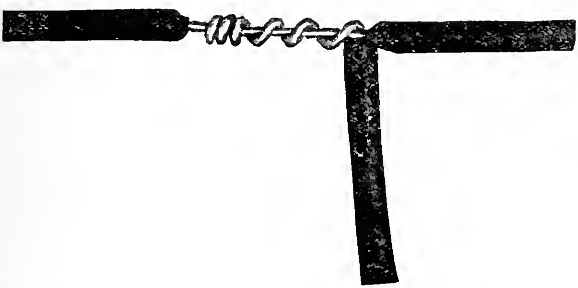
The first and simplest methods of twisting wires will be described here.

The illustrations showing splices and the methods of fastening wires have been made from photographs of the actual work making the operations clearer than could be done by drawings.



Making a splice joint.

The splice ready for soldering.



A tap ready for soldering.

PLATE III.

In Fig. 15 is the method of making a splice. The wire is bared of its insulation for three inches and the two pieces laid together and bent as shown. Then the two bare wires are twisted together the ends shown loose being either worked in with the pliers or cut off close. A method often pursued is to twist the wires tighter together each turn lying close up to its neighbor, but the looser twist gives a better means for applying the solder. With

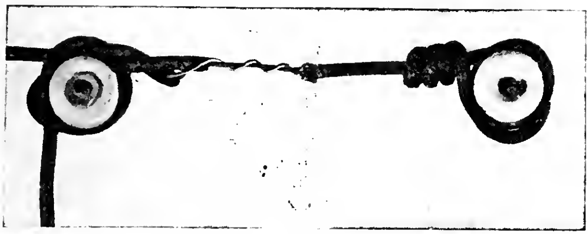


FIG. 16.

the close coiling the solder is liable not to penetrate the wire turns but where the turns are well apart it can enter more readily.

The method of making a tap is shown in Fig. 16 from a photograph. A knob is placed where the tap wire is to lead off from the main wire. The latter is then bared of its insulation a few inches from this knob and scraped bright.

The tap wire is also bared and scraped bright for three or four inches at its end and fastened around the knob so as to hold the main wire to the insulator. This is done by making a hitch with the tap wire while putting it in place. The loose end is wrapped around the insulated portion of the main wire and twisted around the bare spot as shown.

This method secures the main wire to the knob, secures the tap wire to the knob and to the main wire before it gets to the bare spot and takes all strain off the joint and the main wire. The hitch is not drawn tight in the illustration to better show the details of the operation.

In the same figure is illustrated the best method of making a dead-end. This is the end of this circuit and the end of the wire is hitched around the knob, then the loose end wrapped around the tight wire. This is better than merely giving the wire a turn or two around the knob and twisting up the ends.

**Soldering.** All joints made in wires which are to carry current should be soldered in order to make good electrical contact. Unsoldered joints are both dangerous and unreliable. In the first place unsoldered joints will corrode from dampness and by reducing the bare clean copper surface raise the resistance of the joint so that it may become heated. In the case of 110 volt installations the resistance of a poor joint might not be apparent in the light but where the voltage is low the resistance of the poor joint is a serious matter.

Poor joints are the cause of fires in many cases and it must be impressed here that all joints carrying current must be above reproach. *Remember that an unsoldered joint or any poor work in fact does not improve with time but becomes worse.*

As there will be a number of joints to solder in wiring up a house, it is best to leave them until as many as possible are ready for soldering. It is then a quick job to go from joint to joint and solder up. The soldering torch need not be lighted and extinguished more often than necessary.

The soldering torch used will depend upon what is available unless it is desired to buy one. If none is at hand a small alcohol torch or blowpipe may be bought for about a dollar and will answer all practical purposes. A flame that gives smoke will not do to solder with, alcohol or gasoline used in a proper torch are the best.*

Together with the lamp will be needed some wire solder or shoestring solder and some kind of flux. There are several good kinds on the market called generally " soldering paste " and any electrical or hardware store can supply them. So called soldering salts made of muriatic acid and zinc *should never be used* as unless the last trace has been washed off the joint it will surely corrode in time.

A small quantity of the paste should first be put on the joint which is then heated with the torch

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* *See* Thatcher, Simple Soldering both Hard and Soft.

flame and the solder held to it until it melts and runs thoroughly into all the crevices of the joint. If the wire is not hot and the solder run in well, the joint will be bad and surely cause trouble. Try the first job as soon as the solder is set and if it peels off either the paste was not sufficient or the wire was not hot enough. Soldering with a clean joint, good paste and a hot flame is by no means a difficult process.

**Taping.** After soldering the joint, or tap, it must be covered with an insulation equal to that removed for a weak spot of insulation at any point is bad.

A few inches of the rubber tape is cut off the roll and twisted tightly around the joint while it is hot. If it has cooled it should be again heated. It will be found that the heat will melt the rubber and it will adhere to the joint to which it is to be moulded with the fingers. Then the friction or adhesive tape is wound over the joint covering the wire entirely from a few inches back of the joint to an inch or so beyond it.

No bare spots may show at any place but all metal must be covered neatly with rubber tape and with friction tape.

**Ceiling Outlets.** In order to have a secure hold for the screws used in fastening up the fixtures, ceiling boards, *B*, Fig. 17 are placed at every ceiling outlet. A piece of $\frac{7}{8}$ board, soft pine preferably is cut just long enough to fit between the joists *J J* and about 6 inches wide. Wire nails are then driven part way through the board near the edge in a diagonal direction and the board laid in place so that its centre comes just over the small hole made by the bit. It is then nailed fast using great care not to hit it so that the plaster falls from the ceiling *C*.

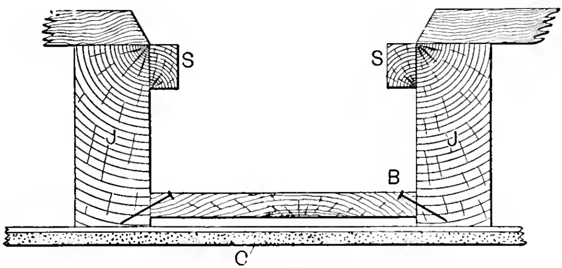



Fig. 17.

It is not hard to fix these ceiling boards if the nails are driven carefully and diagonally, using a nail not over one inch and a half or two inches long. A little experimenting first will show the correct way to nail the board, it is easy after the correct way is learned but pages of directions would not make it any clearer.

Having put ceiling boards in place at every outlet, go down stairs and with the bit used in boring for the tubes, bore up through the ceiling at the point where the small bit went through. Two holes must be bored but each diagonally upwards in such manner that they make two diagonal holes through the ceiling board but only one hole in the ceiling plaster below. The idea is that the two pieces of loom each covering one wire are to start down through practically separate holes in the ceiling board but to come together through one hole in the ceiling. This is shown in a later illustration (Fig. 25).

After studying this out it will be seen to be very simple as the loom is flexible and two ends can be flattened a trifle to come out through one 11/16 inch hole in the plaster. If the operator prefers he may bore one hole straight up and cut the board away to allow the two pieces of loom to pass through, or bore the ceiling hole first, then make a large hole in the ceiling board before nailing it in place. But the first method is the best and really the simplest.

It may be remarked here that the wires coming down through the ceiling outlets for the fixtures will be separate pieces cut to length and tapped on to the circuit separately except perhaps at the extreme end where enough may be allowed when tying to drop down at this one outlet.

After having installed the ceiling boards, pieces of lumber say one inch thick and two inches wide, are nailed on along the joist just below the opening as shown at *S S*. These pieces are to hold the pieces of flooring when the latter are relaid as is shown in a later illustration (Fig. 25).

**Looming the Wire.** Having now reached the coiled wire measure enough to reach clear down into the cellar and leave enough additional to reach the switchboard, then cut loom enough to cover the wires from the last knob upstairs to the entrance into the cellar and slip it on the wires. This of course applies to both wires of the circuit.

This loom or " circular loom " is a flexible insulating tube made in several varieties and called by various trade names. Circular loom and Flexduct are the two best known and are suitable for use here. They are costly however and measurements should be made before buying, the average cost being about 5 cents a foot or 10 cents for the two wires.

The wire is inserted in the tube and should be shoved in little by little taking a grip on the wire between the first finger and the thumb a few inches from the opening of the loom. At first the wire will slip in easily but after a while it may stick, when the loom should be shaken as a terrier shakes a rat. If an assistant holds the far end of the loom when feeding in long wires, he can shake it continually and the wire will slip in the more easily. The sizes of loom suitable for different wires are given in the section on materials.

**Wiring in Attics.** The wiring for the fixtures on the second floor will be done in the attic. Wiring in attics is done with consideration as to whether there is any possibility of the attic being used for other than a space between the roof and the ceiling. Where the attic is too small for other use and there is no possibility of persons entering it except for stringing wires, or where it cannot be used for storage purposes, as in many bungalows, the wiring may be installed on the floor beams without boring or tubing them but by running the wires on knobs. But where there is any possibility of the attic being used the wires should be installed by boring and tubing.

The installation of the wiring for the second floor then will probably be easier than that for the first floor as there will be less cutting of boards and perhaps none. The layout can be made easily as here will be no partitions to obstruct the view and the flooring if any will not be hard wood matched but plain boards.

The ends of this circuit may either be tapped on to the circuit on the floor below or what is better in a large house, run clear to the service and there connected to a separate cut-out or switch, details of which will be given in the section on service switches.

# CHAPTER III.

## Completing the Installation.

**Wiring to the Service Switch.** The service or main switch will in the majority of cases be in the cellar or lower part of the house. The ends of the circuit wires which have been measured, cut and protected by loom are now ready to be pulled down for attachment to this switch. This may be done now or after the outlet wires have been tapped on. Whatever will save time labor and going up and down stairs is worthy of consideration and will determine the time for each operation.

In frame houses there will be found a space between the lath and plaster of the walls and the outside boards of the house in which space the wires may be pulled down. Generally this space extends clear from the attic floor to the cellar ceiling and a lead weight called a mouse tied on a stout cord may be dropped clear down to the cellar from above. In some houses where the floor has been laid in continuous lengths the space will be blocked but removal of the mop board and the boring of a couple of holes will remedy this. A joist or "plate" will also be frequently found blocking the way and must be bored.

Having dropped the weight down in this space and secured the free end of the cord to the wires, the weight may be found down in the cellar probably resting on top of the cellar wall and the wires pulled down by its aid.

It is a hard job for a novice to pull wires down alone and an assistant is of service upstairs who can feed the loomed wires down and keep them from kinking while they are being pulled down. It is a peculiar fact that if there is a nail or any projection upstairs any where near the wires while they are being pulled down that they are almost sure to catch on it. The pull should be steady and careful as although the loomed wire will stand a considerable strain there is no need of using more force than necessary.

The wires having been pulled into the cellar are ready for attachment to the service switch.

Where the service is in the attic the weight is to be dropped down in the same manner and the wires pulled up. As this is a harder job, sometimes it is better to pull down a separate pair of wires and tap them on to the main circuit which is first dead-ended.

**The Service or Main Switch.** Where the battery plant and the switchboard are located in the house the circuit wires will probably be led directly to this switchboard and controlled from it by means of a switch or switches. But if the plant is in another building the wires leading from it will then run to a main or service switch located in the house to which likewise the house circuit wires will also connect.

Considering then that the battery or service wires are run in from outside it is best to install a service switch and fuse block. As also in the case of a large house the wiring will be divided into perhaps two or more circuits, there will be necessary more than one fuse block and if desired a switch to control each circuit. The service wires will run to the service switch and cut-out first. The best plan is to make up a box to hold the switches and fuse blocks.

The size of the box will depend upon what it is to hold of course but it must be large enough to hold all the apparatus with the switches either open or closed. It should be made from $\frac{7}{8}$ inch lumber and be not less than $3\frac{1}{2}$ inches deep, provided with a door which should be hinged from above so that the weight of the lid will always keep it closed. After having been well painted within and without with a good moisture repelling paint, it should be lined entirely on the inside with either sheet iron or sheet asbestos and the asbestos again painted. This will keep it dry and prevent any liability of fire from a blown fuse or from other causes. The holes through which the wires pass should be bushed with porcelain tubes, loom is sometimes used but is not suitable in damp places.

The usual form of main switch is known as a double pole, single throw, knife switch and of an ampere carrying capacity as required. Generally for a small house with a few lights this switch will be of 15 to 25 ampere capacity but a larger one is no detriment.

The fuse block or cut-out may be one with cartridge fuses or what is suitable for the low voltage circuits, with Edison screw plug fuses as in Fig. 18.

The wires from the battery should go to the fuse block or cut-out first and the house circuit wires to the switch. This allows the fuses to protect the entire circuit and the switch, if the switch should happen to be short circuited by accident, it having

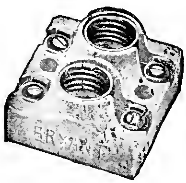


FIG. 18.

bare metal parts, the cut-out fuses would blow. But if the outside wires led first to the switch, a short circuit on the switch would not blow the fuses there but those at the battery if there were any. Note here and in all cases that a knife switch must be fastened *so that it opens downwards* and not upwards. This is so that it cannot drop shut after being left open.

In Fig. 19 is shown a diagram of a service switch and box where $C$ is the cut-out with its fuses and $S$ the switch. The wires from the source of electricity here come in at the top of the box and the house circuit wires leave from the bottom. This

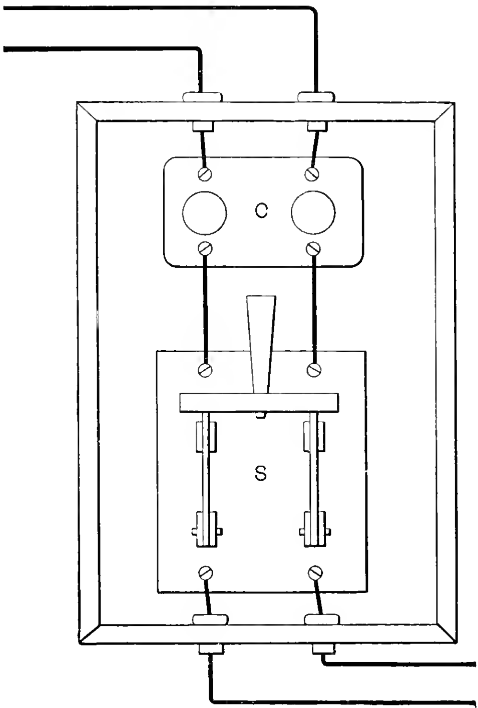



FIG. 19.

is the simplest arrangement of a cut-out and switch.

In Fig. 20 is another diagram where the house circuit wires and the service wires all lead out at the top. This is sometimes an advantage as the wires may be led away directly along the cellar ceiling beams.

A very convenient form of 25 ampere service switch for this class of work is that shown in Fig. 21.

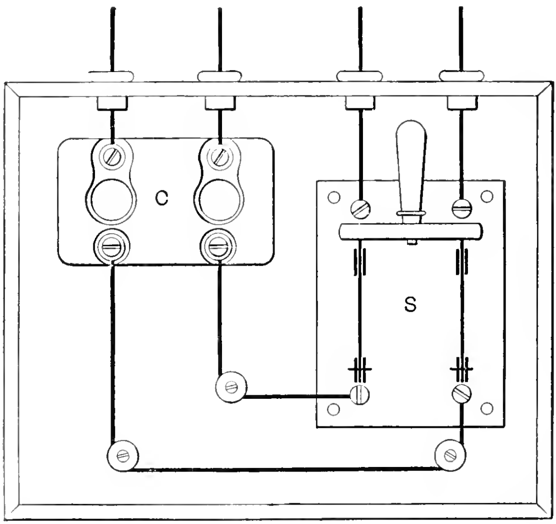



FIG. 20.

It is self-contained with both the switch and the cut-out and its fuses mounted on one base. This form of switch may be installed on an asbestos covered board, or even on a board painted with moisture repelling paint providing the location is not damp. But a cut-out box is easy to make, and is by far a safer and neater job, a lock and key

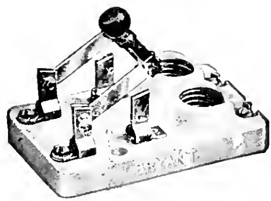


FIG. 21.

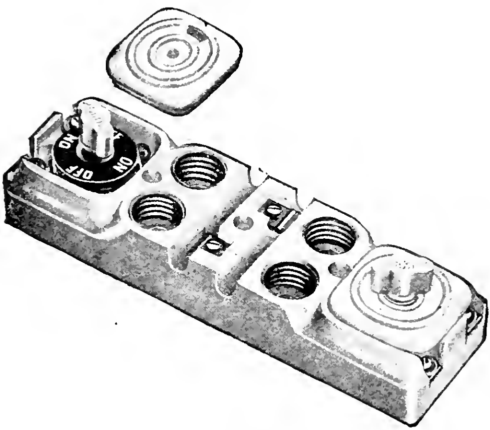


FIG. 22.

being added giving greater protection against any tampering with the main switch.

Where the house is a large one and it is best to divide the lights into several separate circuits each running to the cut-out box, the form of combined switch and cut-out shown in Fig. 22 is very suitable although for a cheaper job separate cut-outs and switches may be used. The arrange-

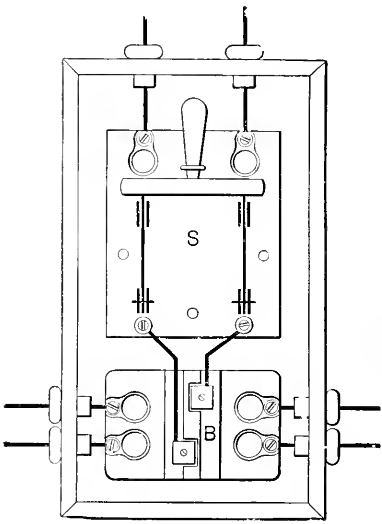



Fig. 23.

ment shown has snap switches but is also made with knife switches in a slightly different pattern. The one illustrated is neat enough to use where it is exposed should it be desired to put the switches controlling such separate circuits in a prominent place upstairs.

A service switch box made up with the self-contained switch before described is in Fig. 23. This box is arranged for two house circuits but more may be added as desired.

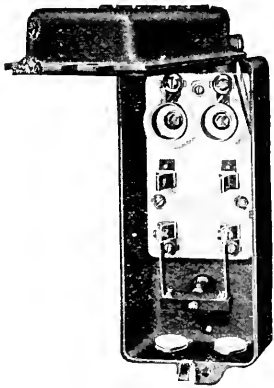


Fig. 24.

The form of service switch installed in an iron box shown in Fig. 24 is very convenient and ready for attachment to the wires. The switch is self-contained having plug fuses.

# CHAPTER IV.

## Installing Lights.

**The Outlet Wires.** The outlet wires may be tapped on now that the wires are in place and secured fast. Pieces of wire long enough to reach

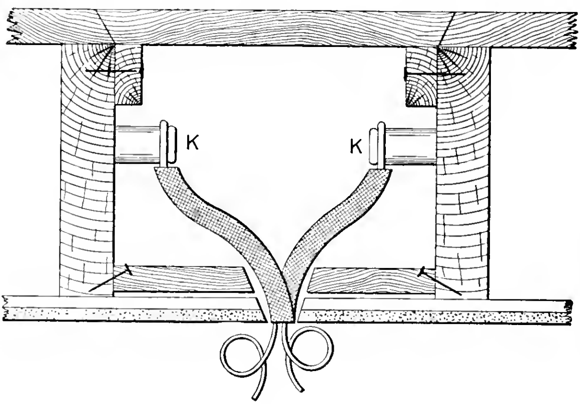



Fig. 25.

down through the outlet holes about eight inches and wrap around the knob and the main wire are cut off from the coil or odd short pieces are used. Before cutting them it will be well to fully under-stand how they are placed so that they may be cut to suit the location.

As in Fig. 25 the outlet wire is tied around the knob $K$, the short end bared and tapped on to the main wire and a piece of loom slipped on after which it is ready to be thrust down through the outlet hole. Tying it in this manner secures both the short piece and the main wire and takes the strain off the joint. *Leave the piece too long rather than short.* In cutting the outlet wire cut it long enough as it is easier to push up the slack from below or cut a piece off, than to splice a short wire.

**Installing the Lights.** Every joint having been soldered and taped and all wires in place the next operation is the last, that of connecting on the sockets or the fixtures. This is done after all wires are ready and the floor boards back in place, being generally a quick job.

Whether there will be regular fixtures or merely drop lights is a matter to be decided by the reader, but as the drop light is the cheaper and used very generally they will be next considered.

**Drop Lights.** In many places such as bathrooms, bedrooms and the kitchen, a drop light will suffice and save the cost of a fixture. Drop lights are made up in two ways, with fuses and without. The best plan is to make them up unfused and have the fuses in the cut-out box.

A drop light comprises three parts, the rosette, the cord and the socket, to which of course must be added the lamp. The rosette is the device by which the cord is attached to the main wires and also which supports the cord and lamp. It is of porcelain and has screws and lugs for attachment of the cord and the main wires, the fused rosettes being made in two readily separable parts.

The form of rosette shown in Fig. 26 is made to

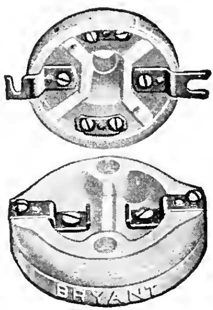



Fig. 26.

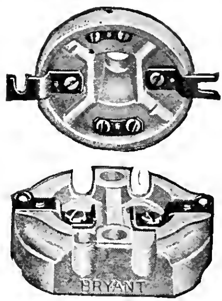



Fig. 27.

take a fuse and is used in concealed work where the wires come through the ceiling.

Another type for moulding work is shown in Fig. 27 and a cleat type used where the wires are run on cleats or otherwise exposed is shown in Fig. 28.

An unfused rosette is shown in Figs. 29. Making up rosettes is done the same way as with sockets in that a knot must be made in the cord to take the strain off the cord at the connecting clamps or screws.

**Making up a Drop Light.** The cord may be covered with cotton, silk or mohair as selected the twisted cotton covered being the kind most used. For low voltage lighting it is suitable but is not used in good work for regular 110 volt lighting. The sizes most used for single drop lights are No. 16

FIG. 28.

FIG. 29.

and No. 18 B. & S. The former will be better for low voltage work as its resistance per foot is less. For lengths of over 10 feet No. 14 should be employed.

The first operation is to measure the length of cord necessary so that the light will hang at the desired height. It should not be left too long as although there are plenty of cord adjusting devices for sale they all look unsightly.

Having cut the cord to the right length take a socket apart as in Fig. 30. Some sockets require that screws be loosened before the shell can be removed, others of more modern design are so made that a pressure on the shell near the point where it is slipped in the cap will loosen it so that it readily comes apart.

A hard rubber socket bushing is screwed into the hole in the cap to prevent the insulation of the cord becoming abraded.

Having separated the socket into its three parts

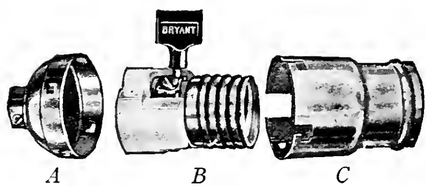



FIG. 30.

the cord may be untwisted for a few inches and the copper wires bared for about three-quarters of an inch on each part. The easiest way to do this is to lay the cord on the table and scrape off the cotton and rubber insulation. Then twist up the loose copper strands on both pieces so that they will not stray but lie neatly like a solid wire.

A knot is then made about an inch and a half from the end.

Loosen the screws on each side of the socket *B*

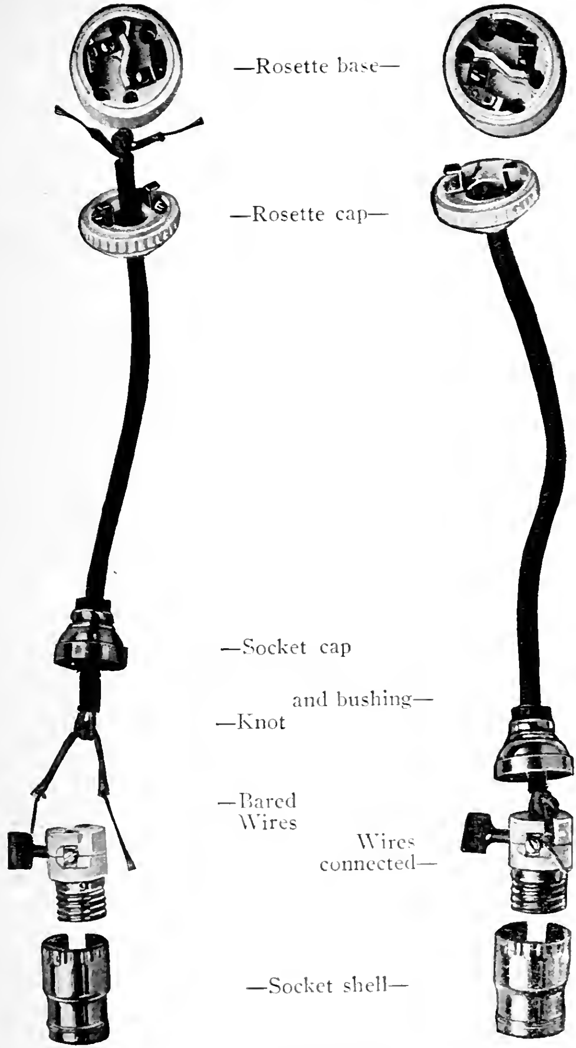

—Rosette base—
—Rosette cap—
—Socket cap
and bushing—
—Knot
—Bared
Wires
Wires
connected—
—Socket shell—

PLATE IV.

and twist the wires under them once around. Twist in the same direction as the screw will turn when being tightened so that the turning of the screw will not push out the wires.

Tighten up the screws and twist any loose ends around the wire above the screw.

Then slip the cap *A* over the other end of the cord and the shell *C* on to the lower part of the socket. Press them together and it will be found that the knot will take the strain off the screws inside by catching against the inside collar of the cap.

Great care must be taken that no loose strands of wire are left inside the socket or a short circuit will result, loose strands must be looked for before closing up the socket.

Having made up the socket take the rosette apart and thread the cord through the hole in the cap. The cord must be inserted bearing in mind that the cap will be head downward from the ceiling. The top end of cord is then untwisted and its ends bared as before, knotted and made fast under the screws in the rosette cap.

All the drop lights for a job may be made up and put up at one time if preferred which is the usual way on large jobs.

When ready to put up the drop light the wires in the ceiling are threaded through the holes in the rosette base and the latter screwed fast to the ceiling. Where ceiling boards have been installed screws long enough should be used so that

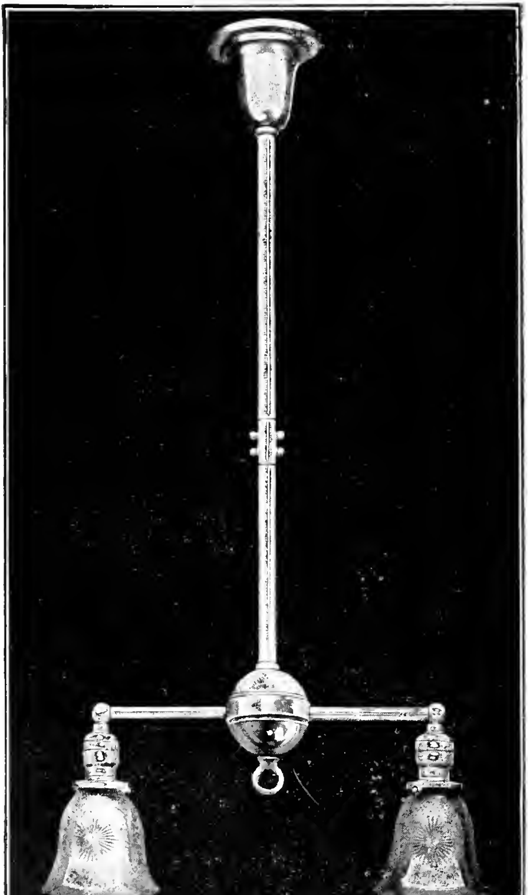


Fig. 31.

they penetrate it, a number 6 screw is heavy enough. The wires are then cut to length and scraped clean and fastened under the screw heads or lugs in the rosette base.

**Fixtures.** The selection of fixtures is a matter of taste. A simple design is shown in Fig. 31.

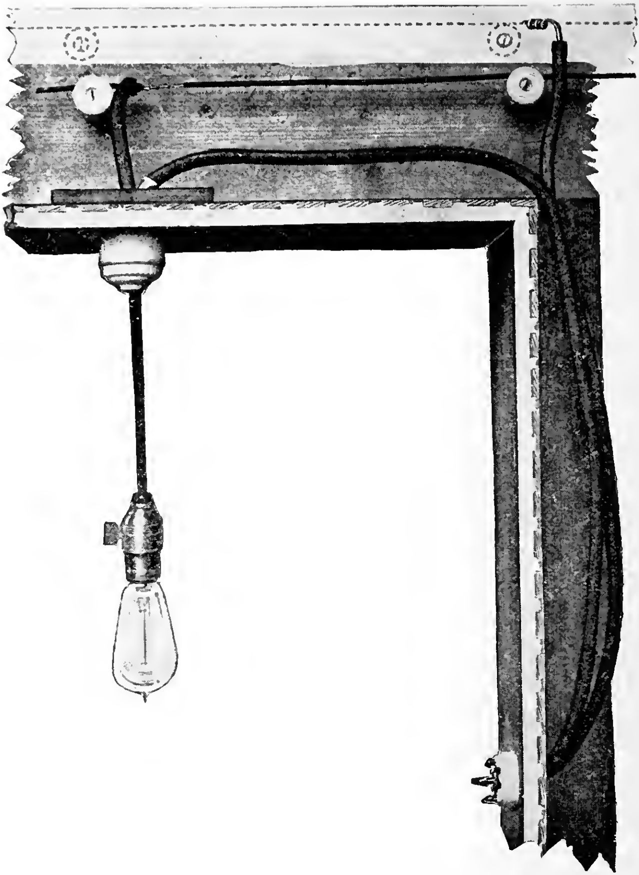
The recent introduction of high candlepower lamps with high intrinsic brilliancy has started a craze for what is termed indirect illumination, the light being reflected from the ceiling and the upper part of the walls, and not directly from the lamp.

This system is all very well where the expenditure of electricy is of little account, or where special effects are desired, but is out of place in the home where the cost of current is an item.

The underlying idea is that the direct light hurts the eyes, but no heed is taken of the fact that the straining from the poor quality of this reflected light is often worse.

Unless the candlepower of the light be very great, or there be many lights, the light reflected from the ordinary ceiling is almost always insufficient for reading, specially if the reader has any weakness of the sight, or has failing eyesight due to advancing years.

**Switches.** Switches are made in many styles and types to suit all conditions and will be treated of in their place. It is, however, most likely that



Section through ceiling and wall.

Fig. 32.—Wiring a drop light and single pole switch. Dotted line is second main wire.

there will be one or more single pole switches installed to control some of the lights and the operation of installing them will be next treated of. The simple form of single pole snap switch is shown in Fig. 33 without its cover, and may be procured in many finishes to suit the fixtures, the most used finish for general purposes being nickel plate.

**Switch Wires.** The running of switch wires where simple single pole switches are used to

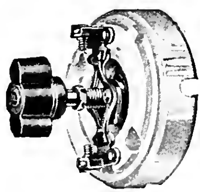


FIG. 33.

control a light from only one place as in Fig. 34 is as follows:

At the outlet in the ceiling or wherever the light is to be located, only one piece of wire *A* is brought down through the hole from the main circuit for the fixture.

Another piece of wire *B* is cut long enough to reach from the fixture up through the hole, fasten to the knob and run clear along the floor down to the switch outlet with enough left to make connection to the switch.

A third piece *C* is cut and run from the other side of the circuit at the outlet, that is from the main wire other than the one to which the outlet wire is connected. This second piece also runs clear down to the switch.

It will be seen then that the current passing down

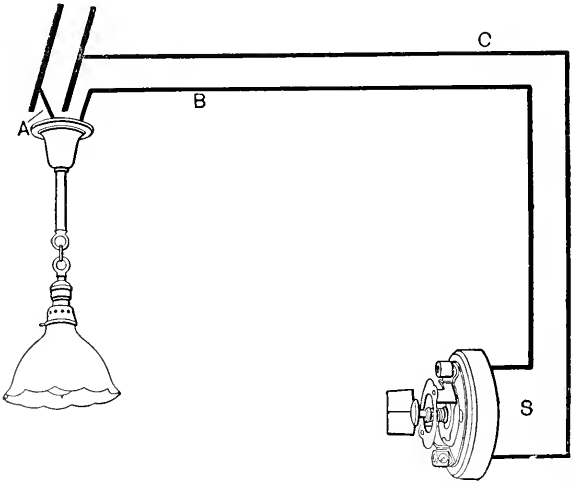



Fig. 34.

through the first short piece *A* through the fixture flows along the second length *B* through the switch and back to the circuit by the wire *C*.

**Pulling down Switch Wires.** To cut the loom for the switch outlets measure the distance from the switch outlet to the ceiling which should be the same for all switch outlets on the first floor. Then allow enough for the thickness of the ceiling or beam under the floor, and also be sure that the loom will reach in one piece from the outlet to the knob at the point where the switch wire leaves the joist to run down the wall. Then slip the switch wires into the loom and pull through the ends, bare the copper for a few inches and twist the ends together ready for attachment to the fish line.

The switch outlet having been cut in the wall through the lath and plaster the mouse is dropped down from above pulling the string along with it all but the loop end which is tied tightly to the twisted end of the switch wires.

A piece of hooked wire is then run in the outlet hole down-stairs and the fish line pulled through. Pulling on the line soon brings out the twisted ends of the switch wires, if they stick, they must be helped from above, it is very helpful here to have an assistant who can guide the wires down. The twisted ends are then loosed from the fish line and left for connection to the switch later on.

**Hall Lights.** It is often very convenient to locate a light in a hallway for instance so that by means of two switches it can be controlled from two places. A person desiring to go down-stairs at night can then light the lamp in the down-stairs hall before descending, by means of the switch up-stairs; and then after having descended can extinguish the lamp from the switch down-stairs. Or it may be lighted from down-stairs and extin-

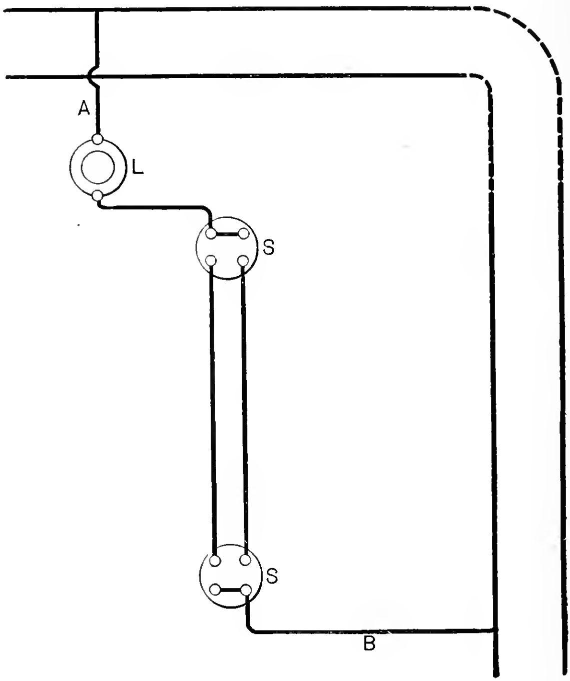



FIG. 35.

guished from up-stairs. Either switch will light or extinguish the lamp.

The wiring for this arrangement is not complicated but needs two special switches called "three way switches."

A diagram of the wiring is in Fig. 35. The rosette of the hall light *L* is connected on one side *A* to the circuit as shown and the other side of the rosette is connected to the single binding post on the switch *S* up-stairs. This binding post is quite easily distinguished as it is strapped to another which has no hole and screw for a wire. The same binding post on the switch down-stairs is connected *B* to the circuit but not to the same side of the circuit as the top switch rosette wire. Then two wires are run, one between each of the two remaining binding posts of the switches as shown.

Where there is an available circuit both up-stairs and down-stairs or the same circuits runs near each switch as shown, the wires may be attached to each taking care that they go to different sides of the circuit. But where there is no circuit down-stairs the lower switch wire must be run upstairs and tapped on to the same circuit as the rosette.

A study of the illustration will make this clearer than pages of explanation. It really is very simple.

What happens is as follows: When the button of one switch is turned it connects one live wire to *one* of the two switch-wires and the current flows along through the second switch and out through the lamp to the other live wire lighting the lamp. Now if the second switch is turned, it changes the lamp wire to the other switch-wire and the lamp goes out.

# CHAPTER V.

## Other Methods of Wiring.

**Open Work or Cleat Work.** Where appearance is no object the wires may be run on knobs or held by cleats on the ceiling or walls of the room. In the case of barns, outhouses and even in cellars this class of wiring may suffice. But it is not neat and even moulding work is better and more symmetrical.

The general directions for open work are not much different than for running wires between the floors except that cleats holding two wires may be used. The wire should be rubber covered and stretched tight between the knobs or cleats. Wires must be kept apart at all times and a generous use of knobs or cleats is recommended to that end.

Where a long run of open work is to be made, the two extreme ends of the circuit should be stretched tight first, that is of course on a straight run such as the whole length of a hallway or cellar. The end knobs or cleats being in place it is easier to put up the intermediate ones straight.

In general wires should be supported by cleats or knobs at least at every 4½ feet but often it is better to space them closer.

This class of work is a little hard for the beginner as the wires must be stretched tight in order to look neat. An assistant would be of use to help stretch the wire and hold it tight while it is being cleated and the screws driven home.

When the circuit turns at an angle the wires may be fastened as in Fig. 36 which shows the arrangement of the cleats although where the wire is stiff enough the middle cleat may be dispensed

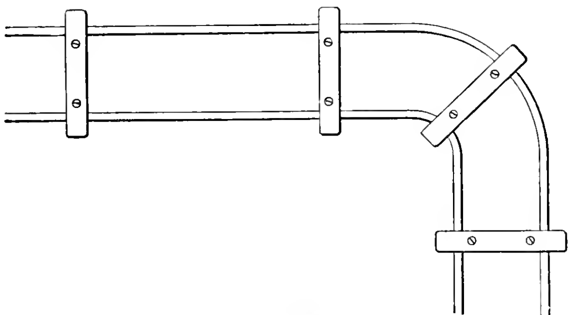


Fig. 36.

with. The cleats used are porcelain and come in pairs, some being interchangeable top and bottom.

This class of work should not be installed outdoors or where it is damp. The wiring of damp places is best done on knobs, and outdoors, except under cover, on glass insulators.

Where money is less an object than time or labor, loom may be used throughout dispensing with knobs almost entirely. Pockets are opened only at the outlets and at a few other places such as where the wires run down in the walls. The wire then being encased in loom for its entire length is pulled under the floors for the entire distance being left without loom at the outlets for a short space in order to make fast to the knob. Knobs are used at the outlets of course to secure the wires for the lights and the switches.

A snake wire of steel is useful to pull the loomed wires from outlet to outlet. This snake wire is of flat steel and one end being bent to prevent it catching in projections beneath the floor it is pushed under the floor boards and as it reaches an outlet the wires made fast at its other end are pulled along by its aid.

In some types of house construction there will be found a space between the joists and the plaster allowing the wires to be fished without boring the joists. Otherwise the joists must be bored and tubed as usual.

**Wiring in Wooden Moulding.** In buildings where it is not desired to wire on the plans described the wires are run in wooden moulding fastened to the ceilings or to the walls. This moulding consists of two parts, the backing which is a flat strip having grooves cut in it for the wires to lie in, and the capping, a thin lath which is nailed over the wires to hold them in place and to conceal them.

This moulding should be painted with a moisture repelling paint inside and out and the wire used must be rubber covered.

*Under no circumstances should this moulding be used outdoors or in damp places.*

In wiring with moulding, the backing is first nailed in place, the wire laid in the grooves and held temporarily in place by brads which are removed when the capping is nailed on. It is better to use screws instead of nails to fasten the capping as it may then be the easier removed when necessary. Whether nails or screws be used, they are to be driven through the central rib of the backing and not through the bottom of the grooves. It is best to plan so that there are no splices in the wires, but have them continuous throughout.

When taps are necessary they may be made as usual, by twisting the tap wires on and soldering them but a better plan is to use one of the tap devices described later on.

When the circuit turns at an angle, the moulding should be neatly cut and mitred as in a picture frame. This class of work is one where the mechanical skill of the operator becomes apparent as it is really joiners work and the neat fitting of the pieces in their place and the straightness with which the moulding is run are very noticeable. A great amount of ingenuity and taste may be displayed in the manner with which the work is done and a job of moulding may be either an eyesore or an ornament. Sometimes it is nice to continue the moulding beyond where the wires stop in order to gain symmetry of design.

Although it is often quicker to use moulding all the way, switch wires may be often pulled down inside the walls in loom and out at the switch outlet.

**Moulding Taps.** Where a tap is to be taken off a run of moulding one of the tap wires will

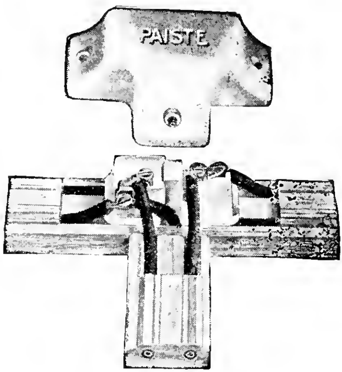



Fig. 37.

naturally cross the main wires and the moulding. The crossing tap wire is led out through a slot cut in the main wire moulding capping and crosses outside this capping which is thus interposed between the wires and keeps them apart. The other tap wire is led out of a slot cut in the outside wall of the main moulding and into the groove of the tap moulding.

A neater and better plan is to use the tap device shown in Fig. 37 which is made by the H. T. Paiste Co. of Philadelphia. It can be bought at almost any electrical supply store and is simple in attachment the illustration showing sufficiently well its application.

Where two circuits have to cross each other, a cross over device made by the same company is used as illustrated in Fig. 38.

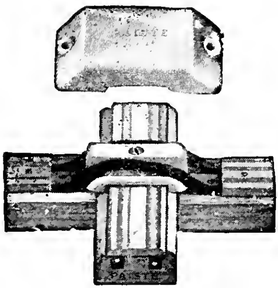


FIG. 38.

The moulding of the crossing wires is butted up to the main run of moulding, a piece of capping cut from the latter and the device installed as in the illustration. This interposes a solid base of porcelain between the two circuits.

**Wall Moulding Method.** One of the slowest and hardest jobs in wiring houses is the boring of innumerable holes through the floor joists to accommodate the circuit wires which run through them. In a house of six or eight rooms there may easily be a hundred of these holes and the boring of a hundred $\frac{11}{16}$ inch holes through floor joists with a brace and bit is no light task. Then the tubes must be inserted and the wires pulled through all of which may be saved if the operator is skillful and there is no objection to moulding on the side walls. This moulding may be of a special kind resembling picture moulding or it may be the regular electric wire wooden moulding as desired.

In this side wall moulding method the wires that otherwise would run through the holes in the joists up-stairs are run in moulding on the side walls down-stairs.

For example the main circuit that would run from the front of a house to the rear necessitating boring and tubing the whole distance may be run in moulding on the wall of the room below as shown by the heavy dotted line in Fig. 39. It may not run as straight as by the other plan but will only require a few feet more wire.

Taps for ceiling outlets *H*, *K*, *D*, *L* and *M* are taken off and fished up-stairs in loom then run as usual between the joists.

The number of pockets is also very much reduced and it is probable that there will be no need to take up an entire board anywhere.

The outlet at *G* can be run in moulding on the ceiling being fed by wires coming through tubed holes in the wall of the next room.

Where no picture moulding has been installed this special moulding or the regular kind is run

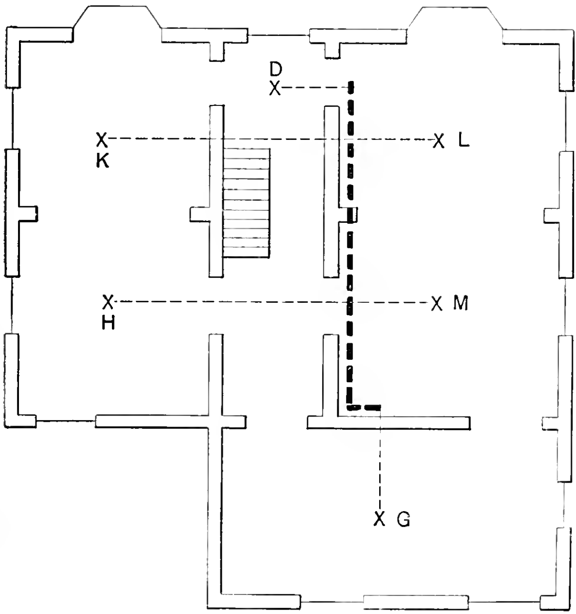



FIG. 39.

about 10 or 12 inches below the ceiling or to suit personal taste and the wall paper border.

As in the case of kitchen outlet *G* at partitions between two rooms the partition wall is bored and the wires pulled through in loom or tubes then continued on to the end of the circuit.

The ends for attachment to the cut-out box down-

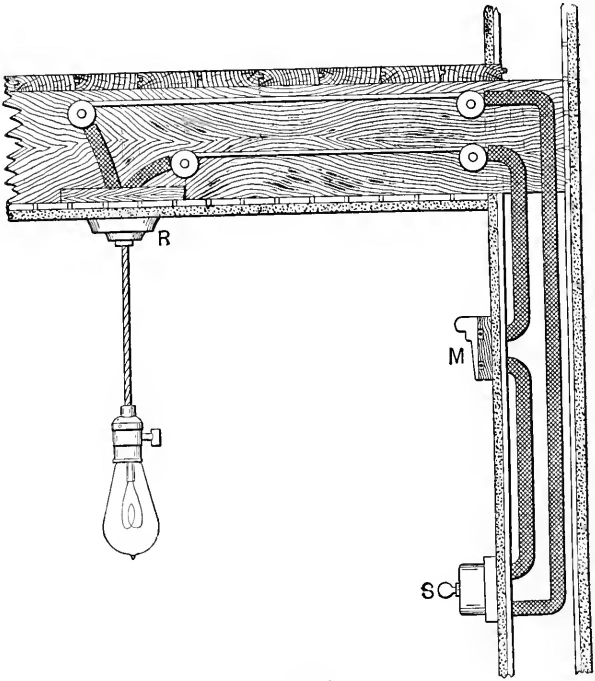



Fig. 40.

stairs or to the main switch are encased in loom and pulled up or down inside the walls, according as the service is up-stairs or down-stairs.

Taps running to ceiling outlets are to be run between the joists to a point as nearly above the moulding as possible then holes being bored through both moulding and wall the ends of these taps may be fished down and through them and soldered on to the wire in the moulding.

In the case of the live wire running from the main wires to a switch, this is easily pulled down to the outlet from a point in the moulding directly above it. Of course it should be loomed first. This makes a shorter run than in the ordinary method as the switch live wire may be taken from a near point right above it perhaps, whereas in the other method it has to run generally clear to the ceiling outlet. The wiring of a switch is clearly shown in Fig. 40 where *R* is the rosette, *M* the wall moulding and *S* the switch on the wall.

There is no practical difficulty about this system of wiring except that incurred by the appearance of the moulding or on account of the down-stairs wall running irregularly. It puts the wires where they may be tapped on for additional lights or wall brackets in a more accessible position.

**Outdoor Service.** When the battery is to be located in a separate building the wires leading to the house from the battery switchboard must be properly put up so as to withstand all weather conditions.

In the first case the wire must be weatherproof, triple braid the weights and sizes being given in Table 1. Sizes larger than No. 12 B. & S. should be stranded as they are then easier to handle and less liable to fracture when bent.

The insulators will be of glass and mounted on pins or brackets of wood or iron as may be decided.

Porcelain knobs should not be used to carry main wires where they will be exposed to rain or snow. In fact it is better to use glass insulators exclusively outdoors except of course where running a line for a light on the porch or in a similar case.

Before running an outdoor line, the route should be first surveyed. It should be run in as straight a direction to economize wire and must be supported at frequent intervals to allow for the weight of snow which accumulates on wires in the winter, and for the strain of heavy winds. In running long outdoor lines it is customary to allow at least a pole at each 125 feet but in the present case it will be better to keep well within this distance.

Although the wire itself may be exposed to the weather when properly supported on insulators, it is necessary to guard against rain running along it and entering the house by way of the entrance holes. This not only would damage the wall but would seriously endanger the insulation at the point of entrance. This contingency is guarded against by fastening the wires below the entrance

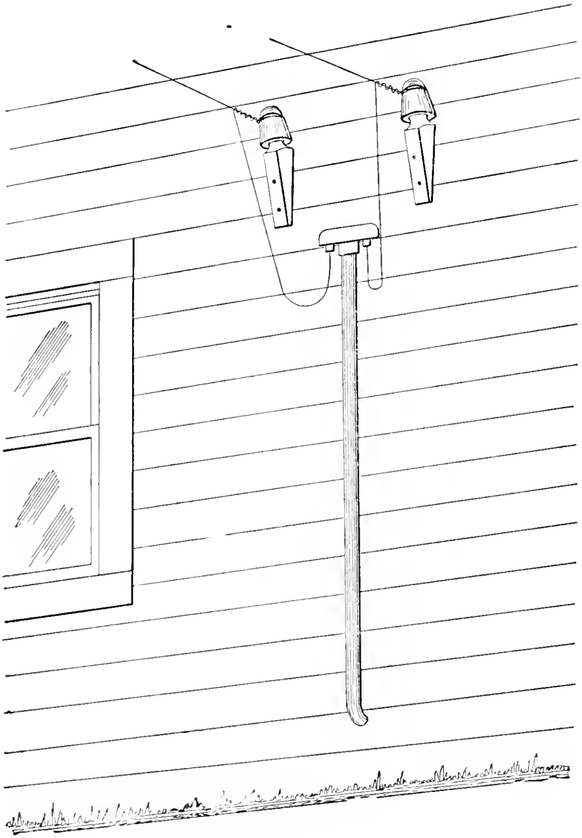


Fig. 41.

holes, giving them a loop from which the water can drip or by a combination of both.

The entrance holes must be bushed with porcelain tubes which are made for this purpose with a curve, which curve is to be turned downwards.

In regular 110 volt work, an iron pipe about 10 feet long is bent at its lower end so that it will enter the cellar, equipped with a proper bushing at the top and the wires pulled through. After this it is fastened up upright against the outside wall. Fig. 41. Two insulators on iron brackets are located at each side of the pipe at the top which should be at least 10 feet from the ground depending upon whether wagons are liable to pass near it and the angle with which the wires come down to enter it. The service wires leading from the battery or plant being then fastened to the insulators may be led in to the cut-out box or service switch.

It is generally easier to make up the pipe with two wires long enough to reach from the service switch up the pipe and leave enough free ends to connect to the wires coming from the plant.

Where suitable bushings are not used to close the end of the pipe outdoors, it should be filled with tape and a few wooden wedges driven in to keep out dampness. The wires, however, must be guarded against any possible cutting on the edges of the pipe. Bushings such as described are cheaper in the long run.

Where the wires come down from a pole set back

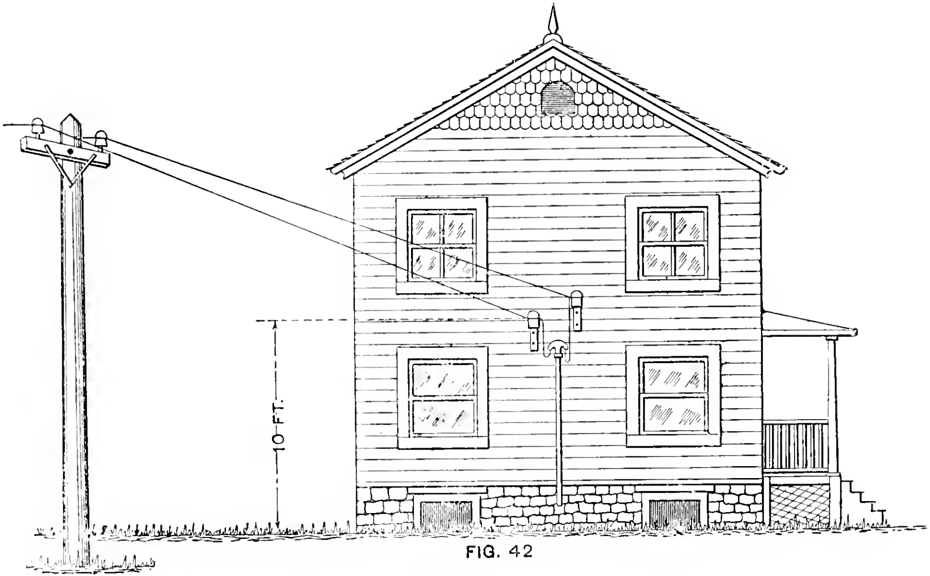


FIG. 42

of the house, one insulator will be mounted above the other so as to keep the wires apart as in Fig. 42.

Where the service wires come in up-stairs in the attic for example the pipe is dispensed with and insulators and tubes used. This method requires the use of a ladder unless the entrance can be located near a window.

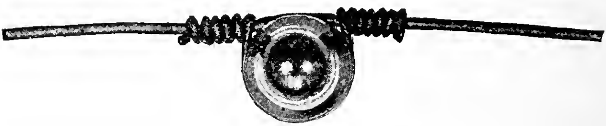


FIG. 43.—How to tie a wire onto a glass insulator.

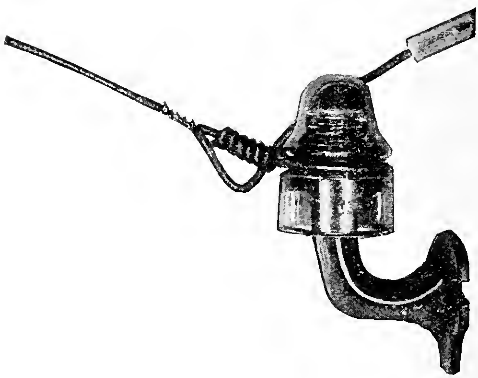


FIG. 44.—Dead ending a wire on a glass insulator and iron bracket—showing drip loop and inclined porcelain tube.

# CHAPTER VI.

## Notes on Materials.

**Estimating the Material Required.** To estimate the material required a careful survey must be made of the job after having digested the wiring directions already given.

The number of porcelain tubes will depend upon the number of joists and the wires running through them to which is to be added about 25% for use in odd places. Often from 150 to 200 will be required in a frame house of 7 or 8 rooms wired on the concealed knob and tube plan.

Knobs may be estimated at about 1 to each 3 feet of wire needed which allowance should be sufficient for most jobs.

The wire itself may be figured by measuring the route to be followed but a generous allowance should be made for ties or twisting around the knobs and also for the irregular manner in which it will run through the tubes in the joists. As wire is useful to have on hand allow 50% more than the estimate. This applies to small jobs, large jobs may be calculated to close figures and the wire bought in stock coils.

Flexible conduit or loom being somewhat ex pensive can be estimated somewhat closer if sufficient measurements are made. There will be two lengths for each single pole switch reaching from the switch to the space between the floor joists. This will average 12 feet per switch in rooms of ordinary height. For ceiling outlets short pieces a foot or less in length will suffice. From the circuit up-stairs to the cellar ceiling (or the attic floor) in the case of the service will be easy of measurement.

A roll of friction tape and one of rubber tape will be sufficient for quite a large job.

Other supplies such as nails or screws will be easy to figure.

**Material Required in Wiring.** No. 5 porcelain knobs for No. 12 or No. 14 wire have a groove $\frac{5}{16}$ inch wide to hold the wire, measure $1\frac{1}{4}$ inch from the top to the surface upon which the insulator is fastened and have a $\frac{1}{4}$ inch hole for the nail or screw. No. $5\frac{1}{2}$ porcelain knobs are similar except that they hold the wire higher from the surface wired over being $1\frac{9}{16}$ inches high.

Porcelain tubes should be unglazed and will vary in length according to circumstances. But in general for floor joists and most other woodwork in the house they may be 3 to 4 inches long measuring under the head. For places where two joists come together they should be probably 6 inches long. The inside diameter for wires not larger than No. 12 B. & S. should be $\frac{5}{16}$ inch and the outside diameter $^9/_{16}$ inch. A tube $\frac{3}{8}$ inch inside and $^{11}/_{16}$ inch outside is preferable for No. 12 B. & S. wire, as it will be easier to pull through a lot of tubes when in the joists.

**Split Knobs.** Split knobs are porcelain insulators made in two pieces the wire being held tightly between the upper and lower portions when the screw through the center of the knob is tightened. Nails and nail heads should not be used with split knobs. For the latter reason it is very hard work to use split knobs under a floor and in similar places as there is not often enough room to handle a screw driver. Moreover there is a greater liability for one inexpert to insufficiently tighten the screw and the wire will be loose. And the breakage is liable to be greater.

In the solid knob method if the knob is not abolutely immovable on the joist it will at any rate hold the wire as the latter is not dependent upon the centre nail or screw. But with split knobs the screw has to perform the double function of holding the wire and holding the knob.

For wiring in exposed places where the screw driver can be used readily, split knobs are preferable as they make a neat job and the screw being the easier driven allows no excuse for loose wires.

**Screws and Nails.** Screws for switches and rosettes will be generally Flat Head Bright wood screws, No. 6 and from 1 inch to 2 inches in length, according to whether they are to be used in ceiling boards or only in lath and plaster.

Where screws are used for the knobs they should be also Flat Head Bright wood screws. For No. 5 and No. $5\frac{1}{2}$, $1\frac{3}{4}$ inch and 2 inch No. 8 are suitable although 2 and $2\frac{1}{4}$ give a firmer hold.

Wire nails are suitable for knobs, using nail heads as mentioned before.

Screws and not nails are needed where wooden moulding is run on plaster ceilings as nails will not hold.

**Moulding.** The wooden moulding ordinarily used in wiring is made of hard wood and painted with moisture repelling paint or varnish. The back as well as the grooves should be painted or varnished and the whole outside may be painted any desired color after being installed on the wall or ceiling.

The size for No. 12 to No. 14 wire is No. A-2 and has grooves $\frac{7}{32}$ inch wide. For Nos. 8 and 10 wire the size is No. B-1 with grooves $\frac{5}{16}$ inch wide. The size of the grooves should be specified in ordering special mouldings or the number of the wire given.

**Bits.** Bits used in boring holes for tubes or outlets will of course follow the size of the hole desired. If neat holes are desired use double cutter bits, if a lot of holes are needed such as under the floor and through the joists the work is much easier with single cutter bits such as the Ford bit.

Tubes really should fit tight but it is the general rule to use a bit a trifle larger than the tube and depend upon the fact that there is no motion to the wire to make the tube stay in place. For a loose fit use an $\frac{11}{16}$ inch bit for tubes with an outside diameter of $\frac{9}{16}$ inch and a $\frac{3}{4}$ inch bit for tubes with an outside diameter of $\frac{11}{16}$. The $\frac{11}{16}$ inch bit will also be suitable for the outlets and the $\frac{1}{4}$ inch loom.

In locating the first holes in the ceiling for marking outlets a $\frac{1}{4}$ inch Syracuse bit is best, and may be as long as convenient one 18 inches long being most generally useful.

**Tape.** The real insulating tape is a rubber compound and must be put on with heat. It is best applied immediately after soldering a joint when it will adhere best but the joint may of course be heated later on and the tape applied. This rubber tape should not be confounded with the sticky or friction tapes. These are used merely to cover the rubber tape and protect it although often wrongly used for insulation.

*The insulation at a joint should be at least as good as that on the wire itself.*

Taped joints outdoors should be painted with P. & B. paint which is a rubber compound and not an asphaltum mixture. Failing genuine P. & B. a good grade of asphaltum paint is better than nothing.

TABLE 1.

COPPER WIRE PROPERTIES.

| No. B. & S. gauge | Circular mils | Weatherproof insulation Lbs. per thousand feet | Weatherproof insulation Carrying capacity amperes | Rubber insulation Carrying capacity |
|---|---|---|---|---|
| 00 | 133,325 | 522 | 220 | 150 |
| 0 | 105,625 | 425 | 185 | 127 |
| 1 | 83,694 | 328 | 156 | 107 |
| 2 | 66,373 | 270 | 131 | 90 |
| 4 | 41,742 | 170 | 92 | 65 |
| 6 | 26,250 | 115 | 65 | 46 |
| 8 | 16,509 | 78 | 46 | 33 |
| 10 | 10,381 | 53 | 32 | 24 |
| 12 | 6,530 | 35 | 23 | 17 |
| 14 | 4,107 | 25 | 16 | 12 |
| 16 | 2,583 | 16 | 8 | 6 |
| 18 | 1,624 | 12 | 5 | 3 |

**Figuring the Size of Wire.** The size of wire used depends upon the amount of current to be carried and the distance it will travel.

Although a good conductor of electricity, copper presents some resistance. A wire that would carry 5 amperes without loss would not be suitable for 10 amperes if both currents were to travel the same distance. The results of resistance will be shown in a dimming of the lights. Moreover, if the wire be too small for the current carried it will get dangerously hot. Fuses will be used to take care of this excess current when it arises from a short circuit but for normal conditions the wire should be figured large enough.

The safe carrying capacity of copper wire is shown in the Table I. The lower limits for rubber covered wire is due to the fact that such wire is generally used enclosed where the heating would be more pronounced and also because rubber deteriorates more than the weatherproof wire insulation on being heated.

Although the carrying capacity will determine the safe size of the wire, it will not ensure its being large enough to carry the current without a loss. In low voltage lighting this loss must be considered, as for example a loss of 3 volts would be worse on a circuit of 30 volts and affect the lights more than would the same loss on a wire where the voltage was 110, being a greater proportion.

The resistance of a foot of copper wire one circular mil or one circular thousandth of an inch in area is about 11 ohms.

It is a fundamental rule of electricity that the voltage expended in carrying a given current a given distance depends upon the resistance in the circuit. It would actually need an expenditure of 11 volts to cause one ampere to pass through this circular mil foot of wire. Therefore supposing the voltage of the plant was 30, there would only be 19 volts left for the lamp.

Of course a wire so small would never be used, it would burn up with the current but it is used as an illustration.

In order therefore to have the wire of the right area it must have the proper number of circular mils which is determined by a simple calculation. Referring to Table I No. 12 B. & S. has an area of 6530 circular mils so it is clear that a foot of this would only expend 1/6530 of the 11 volts for the same one ampere for its area having been increased would have correspondingly reduced the resistance.

Applying these facts to a simple arithmetical formula gives a rule to calculate the size of wire for any current and any distance.

Take the entire length of the wire, both sides of the circuit *L*. Multiply this in feet by the amperes *A* to be carried and then multiply the result by 11, or the ohms in a mil foot of copper wire. The answer will give the size of wire in circular mils to carry the current the required distance, and a reference to Table I will show the numerical size of wire needed. This allows a loss of one volt. If more or less loss is allowed divide the above answer by the loss allowable.

For example, suppose 10 amperes is to be carried 200 feet and one volt loss allowed. Then the entire wire length will be 400 feet and 400 times 10 times 11 equals 44,000 circular mils. The nearest size of wire in the table is No. 4 B. & S. with 41,742.

Another example, 12 amperes a distance of 240 feet with a loss of 2 volts. In this case perhaps the voltage at the battery in a distant building is 32, and 30 is required at the lamps. Then the entire wire length will be 480 feet and the multiplying together of 12,480 and 11 equals 63,360. This divided by 2 equals 31,680. The nearest in the table is again No. 4. A number 5 wire is made, but the extra area is an advantage.

As a formula the rule would be stated as follows.

$$\frac{L \times A \times 11}{\text{volts loss}} = \text{Area in circular mils.}$$

These rules apply to all voltages. For example, in the last calculation, the loss would be 2 volts, whether the line voltage was 32,110, or even 220 volts. But the percentage would of course be different, and therefore the effect on the light would vary. A loss of 2 volts in 32, would be worse than a loss of 2 volts in a circuit of 110 volts.

The formula gives the actual volts loss for a given number of amperes, a given distance and a wire of a given diameter. It is evident that with a higher voltage the current through the same resistance would be greater, but increasing the current in the wire would naturally increase the figure corresponding to the amperes in the formula.

Where it is desired to get the loss in a given size of wire, substitute the circular mils for the loss in the formula.

$$\frac{L \times A \times 11}{\text{CM.}} = \text{Loss in volts.}$$

Example, find the loss in a wire 31,680 circular mils, carrying 12 amperes a distance of 240 feet single wire, or 480 feet actual. Then 480 multiplied by 12 multiplied by 11 equals 63,360. This divided by the circular mils, or 31,680 equals 2 volts.

# CHAPTER VII.

## Conduit or Protected Wiring.

The safest and most substantial methods of wiring are those in which the conductors are protected by metal tape (armored cable), enclosed in iron pipe (conduit), and which make use of iron boxes to enclose all joints, switches or receptacles.

It is no more difficult to install these systems of wiring than to install the open work or knob and tube systems described previously. In fact in many ways it is easier. The first cost is greater and the cutting and threading of soft iron pipe or the cutting of the armored cables perhaps requires more physical labor. The pipe or the armored cable however may be laid with less labor and in shorter time, thus restoring the balance.

There exists no doubt of the greater safety and general superiority of iron pipe or armored conduit wiring systems over knob and tube work.

They are as fireproof and damage-proof as any system can be.

**Armored Cables.** There are several makes of armored cables on the market, sold under the trade names of "Flex Steel"—BX, etc. All the illustrations here are of work done with BX.

In the BX flexible steel armored cable, the wire conductors are insulated separately and then the two insulated conductors are held together by further insulation.

Outside of these insulated conductors is wound spirally, a convex and a concave shaped metal strip, hot galvanized with zinc, and also a strip of moisture repelling material laid between the metal strips so as to keep out all moisture.

BX may be had with one, two, or three conductors and in all the usual wire sizes.

These armored cables may be run practically anywhere except of course under water or where they would be subjected to the continuous action of excessive dampness or chemical fumes. Where likely to be exposed to moisture a lead covering is placed between the outer braid of the conductors and the armor.

The main requirements as laid down in the National Electrical Code of the National Board of Fire Underwriters require:

(a) That the cable be continuous from outlet to outlet—which means that whereever a splice becomes necessary it is to be made in an approved metal box.

(b) That the armor of the cable must properly enter and be secured to all fittings, which is done by clamps elsewhere shown.

(c) That the cable be mechanically secured in position, usually done by means of metal pipe straps.

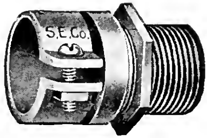
The code also requires that the metal armor be permanently and effectually grounded to water piping, or to other suitable ground connection.

The entire conduit or armored cable constituting the wiring system of one building must have its iron pipe or armor effectually grounded. This is usually done by seeing that good connection is made at all breaks in the lines, such as at junction or switch boxes, and that a ground wire clamp is properly secured to the conduit and to an adjacent water pipe.

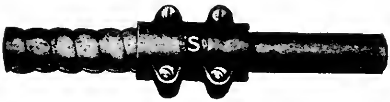
Where a gas pipe is used, the ground connection must be on the street side of the meter.

Where there is no gas or water pipe, an artificial ground is made consisting of a sheet of copper with a copper wire soldered to it, and buried in the ground where there is continuous moisture.

The idea is that there shall be a first class path along the armor into the earth for any electricity that hits the armor. It is self evident then that rusty joints, poorly made connections and even only one break in the continuity of the ground connection will utterly destroy the value.



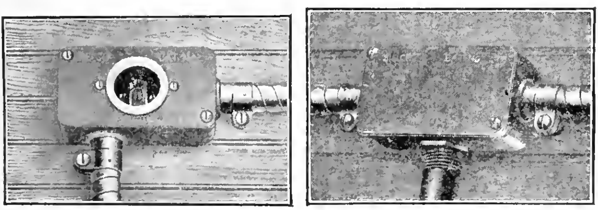

Malleable Iron Panel Box Connector.



Combination Coupling Joining Flexible Conduit to Rigid Conduit.

Stamped Steel Panel Box Connector and Locknut on BX.


Sprague BX Steel Armored Conductors.



Showing How Panel Box Connectors are Used with BX and Rigid Conduit. Also Two Multilets.

PLATE V.

Although it may be true that where the voltage is low, as in the low voltage home lighting plants, there is less danger than where it is higher, it is better to wire as if for 110 volts even if 32 are only going to be used.

Good wiring is good insurance in itself.

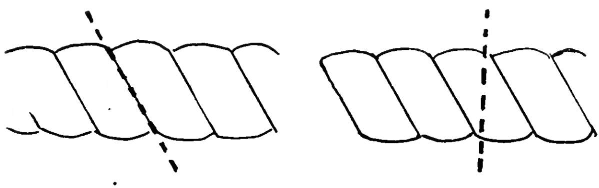
**Installing Armored Cables.** The actual installing of BX or other cable is by no means complicated. It may be pulled under the floors or down in the walls wherever desired.

The securing of the BX to the joists or beams is done with pipe straps which may be nailed or screwed fast, gripping the cable so that it cannot shift. In no case is the strain of a wire or cable to come directly upon a screw terminal, such as in a socket or on a switch. The cable is always made fast before the wires are connected.

At all places where a tap, joint or splice is to be made or a switch, socket or receptacle is to be attached, an approved iron box must be used. This is to still farther carry out the idea of protecting the appliances against breakage and preventing accidental contact with bare metal carrying current. Examples of details are shown in the illustrations.

The end of the BX is stripped of its armor and the two inside wires separated (but not bared of their own insulation) for 6 inches or so dependent upon the distance between where they enter the box and the connection screw.

In cutting BX and all similar armored wires, the saw cuts must be made across the metal tape as shown in the second figure, never in a groove as in the first figure. Otherwise, the saw will jam and break. Care must always be taken not to saw beyond the metal tapes and into the insulation. A little practice will help. Having sawed the first metal tape, it may be bent back and broken off with the pliers and the second tape also removed. Then, the braid and insulation protecting the two inside insulated wires are



Wrong way to cut BX cable. Right way to cut BX cable.

FIG. 45.

cut away. Do not cut off any of the insulation of the two inside wires until finally making the connection or splice.

There are cutting tools made for stripping armored cable, which are a great help.

The end being now ready, a malleable iron panel box connector is slipped over the armor (the free ends of the cable projecting from the threaded end), and the clamp collar tightened. The threaded end is now thrust through one of the holes in the iron box and a lock nut screwed on to draw the connector up tight.

This is where a sheet iron box is used, having discs of metal or knockouts closing the holes around the box sides. These knockouts are driven out by a hammer blow wherever entrance is desired.

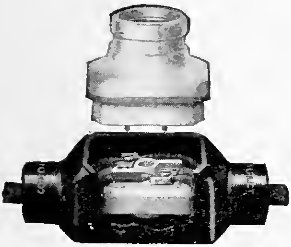
Cast iron boxes or condulets have threaded nipples, in which case the threaded end of the panel box connector is screwed in tight first, and then the wire and armor are inserted and clamped.

The clamping of the armor in this manner not only secures it, but by making a good connection between the iron armor and the iron box, insures that the ground circuit will be unbroken at that point.

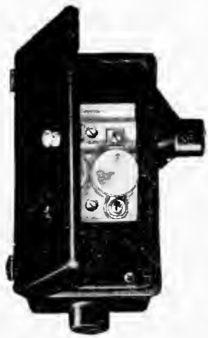
These operations are really not complicated. A study of the illustrations and, wherever possible, a look at some actual armored cable wiring will give the instruction necessary.

**Conduit Wiring in Pipe.** Iron pipe or rigid conduit work is the safest form of wiring in that when properly installed, the wire is protected by a rigid iron pipe against moisture, gases and mechanical injury. The iron pipe or conduit is coated either with black varnish or in the more modern forms by a coating of zinc. Either coating admits of the pipe being bent without flaking off, which would quickly permit rust and consequent destruction of the pipe, the zinc coating

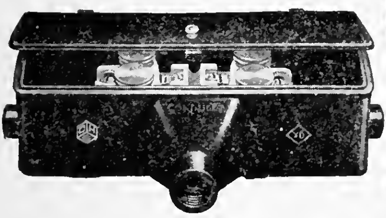
Condulet Type YC with cover sealed, showing Plug Fuse Cut-out.



Type J
Norbitt Conduletto Receptacle with Shade Holder Groove.



Type YL
With Plug Fuse Cut-out.



Condulet Type YD
With Plug Fuse Cut-out.

Type YS with Cartridge Fuse Cut-out.

PLATE VI.

being preferable. Rigid conduit is installed complete with all the iron boxes to contain the switches, receptacles and other appliances, before the wire is drawn in. For this reason it admits of changes, a wire being easily removed or replaced without in any way disturbing the pipe. The installing of iron conduit and the iron boxes is merely a mechanical operation involving the cutting and threading of pipe and the setting of the fittings. The conduit itself is fastened up by pipe straps. Condulets, as they are generally termed, are metal fittings of almost every conceivable kind made to screw on the pipe. Examples are shown in the illustration. They include tees with porcelain bushings through which the wires emerge, elbows, splice boxes, iron switch boxes, receptacle boxes, and cutout boxes. Where sheet iron boxes are used, the threaded conduit is held in holes in them by locknuts and bushings. In the condulets locknuts are not necessary as threaded lugs or nipples form part of the box itself. It will be evident that wire ends coming out of the end of an iron pipe would be liable to injury on the sharp edges. To prevent this injury the pipe is reamed out and bushings with rounded edges used. Sharp edges in the pipe are always to be avoided. Even when two pipes are joined together with couplings the pipes are reamed out and drawn together by the coupling. Wherever possible, the switches, receptacles or cutouts are installed in iron boxes forming part of the pipe system, the pipe entering these boxes and being secured thereto. But where it becomes necessary to lead off a pair of wires or a flexible cord a fitting made to screw on the pipe is necessary.

A system of iron conduit, just like the armor of a flexible armored wire or BX for example, must be a continuous metallic structure. This is to insure the proper grounding of the system, and is insured by carefully scraping paint or rust off all threads so that at all junctions there is a perfect metal to metal contact. Bends in the system are obtained in two ways, by bending the pipe or by using fittings, an example of the latter being shown in the full page illustration of a switch and ceiling light installation. In order to prevent strain on the wire when being pulled in, only four quarter bends are allowed by the code in any one run. Where more bends become necessary, a drawing in box must be used between each four bends so that the wire has only this maximum between its point of entry and where the pulling strain is applied.

**Concentric Wiring.** A system of wiring much used abroad for several years is that known as concentric wiring. The wire itself from which the name is derived is duplex, the conductors being made up together. The inner wire conductor is insulated in the regular manner, but outside of this insulation a spiral or tape of copper or alloy is wrapped, forming the second conductor.

This outer conductor is not insulated on the outside but is bare. The outer conductor is however thoroughly grounded and therefore there being no difference of potential (Voltage) between this bare conductor and the ground, no danger ensues.

The grounding must be well performed and a continuous contact must be assured at all joints or boxes. These contacts are not made with solder but with clamp sleeves.

Special fittings, sockets, switches, etc., are required as it is evident that the mode of construction of the two conductors would not admit of the ordinary kind being used.

The General Elecric Company, some of whose fittings for concentric wiring are shown here, furnish a bare concentric wire with the outer conductor or sheath of tinned sheet copper, folded longitudinally around the inner insulated wire, with a full lap. This tin sheath is then soldered where it laps, making it continuous electrically and mechanically, and at the same time gas tight and water tight.

It will be noted on referring to the illustrations that there is a clamp which fits over and makes the contact with the sheath, and a screw connector for the inner wire. This is most clearly shown in the view of the back of the receptacle.


Concentric Wire, Outer Conductor Partly Cut and Bent Out.

Wheel Bending Tool.


No. 171445
Switch and Plug Cut-out, 3 Wire to 2 Wire.


No. 171463
Key Receptacle.

No. 171456.
Sub-base for Receptacle.

PLATE VII.

Owing to the impracticability of making taps or splices by twisting together wires, various fittings have been designed for these purposes.

The No. 171446 Junction Box for example is used where a tap or a switch leg is to be taken off a circuit, the main wire passing through the center of the block.

The No. 171448 inside junction box is used where the service or main wire runs up or down in the angle of a wall which in this form of wiring is the most logical place for a riser. This box located in the upper angle of the corner, takes the wire from above or below and distributes both ways along the walls of the room.

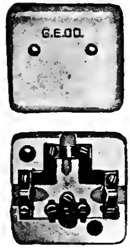
Switch No. 171445 is for a three wire service to the top screws in ordinary wire, the two circuits of concentric wire joining to the connecting clamp on each side of the lower part of the switch.

A ground wire is run from the middle lower connection, which through the transverse clamp, effectually grounds the sheaths of both the right and left hand circuits.

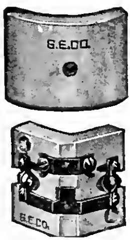
The wire is bent to fit corners with a special grooved roller tool shown in the illustration. In the method of installation most in vogue this concentric wire is merely strapped to the walls or supports with metal straps and screws.

Where the wire passes through the floor or partitions it is protected by iron pipe, otherwise it is not covered in any way.

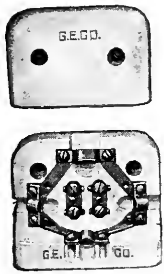

No. 171447.
Four Way Branch
Junction Box.




No. 171446.
Three Way Branch
Junction Box.

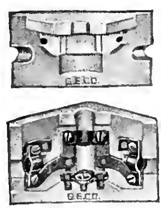



No. 171449
Outside corner
Junction Box.




No. 171450.
Snap Switch
Junction Box.


No. 171452
Sub-base for
S. P. Snap Switch.




No. 171448.
Inside Corner
Junction Box.

PLATE VIII.

It will be seen then that concentric wiring is simple. Its cost of construction would approximate the cheaper kinds of open work, but at greater safety and speed of installation.

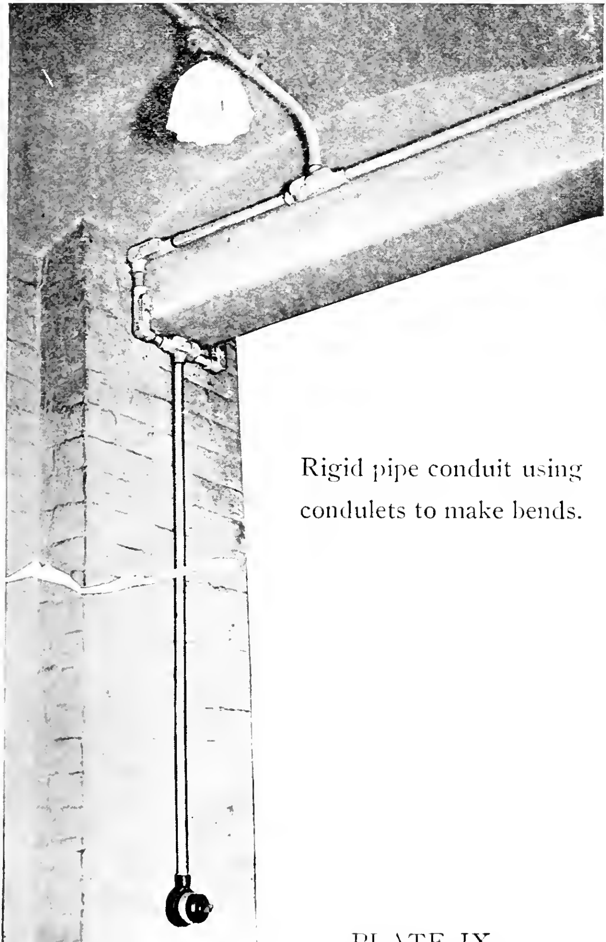
The safety of this form of wiring is evident. Owing to the perfect ground connection, the bare outer wire may be touched with impunity. If the ground is broken at any point the current would fail as the continuity of the circuit would also be broken.

Current is brought to the meter in the usual way, the concentric wire being usually installed for the actual house circuits alone.

Concentric wiring will be widely introduced into the United States in the course of time.

It is a logical and well tried system of house wiring for inexpensive, safe installations, and although it may not entirely supplant the present cumbersome methods, it will find a wide field of application in the electric wiring of moderate sized homes and business places.

For some time to come, however, the immense investment in the older form of wires, sockets, and fittings in general, and the tools or plant necessary to make them, will necessitate time for readjustment before concentric wiring becomes general.



Rigid pipe conduit using condulets to make bends.

PLATE IX.

## CHAPTER VIII.

### The National Code.

This Code comprises over 200 pages detailing how electrical wiring should be done to be safe. It should be studied and followed by everyone doing electrical wiring.

It may be obtained from the National Board Headquarters in most large cities, being furnished free to interested parties.

The following extracts will assist the operator in the installation of inside wiring for not exceeding 250 volts.

Under the head of General Suggestions the National Board of Fire Underwriters in the National Electrical Code make the following valuable recommendations:

"In all electrical work, conductors, however well insulated, should always be treated as bare, to the end that under no conditions, existing or likely to exist, can a ground or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to the minimum.

In all wiring special attention should be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of conductors, and securing and attaching of fittings, are specially conducive to security and efficiency, and are strongly advised.

In laying out an installation, except for constant current systems, every reasonable effort should be made to secure distribution centers located in easily accessible places, at which points the cut-outs and switches controlling the several branch circuits can be grouped for convenience and safety of operation. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

The use of wire-ways for rendering concealed wiring permanently accessible is most heartily endorsed and recommended; and this method of accessible concealed construction is advised for general use."

Class C.

## INSIDE WORK

*(Including All Work for Light, Power and Heat Protected by Service Cut-out and Switch.)*

### General Rules.

**16. Wires.**

*a.* Must not be of smaller size than No. 14 B. & S. gage, except as allowed for fixture work and pendant cord.

**This is not only on account of carrying capacity, but also for mechanical strength.**

*b.* Conductors of size No. 8 B. & S. gage or over used in connection with solid knobs must be securely tied thereto. If wires are used for tying they must have an insulation of the same type as the conductors they confine. Solid knobs or strain insulators must be used for all wires at the end of runs where conductors are terminated. Split knobs or cleats must be used for the support of conductors smaller than No. 8 B. & S. gage, except at the end of runs.

Knobs or cleats which are arranged to grip the wire, must be fastened by either screws or nails. If nails are used, they must be long enough to penetrate the woodwork not less than one-half the length of the knob and fully the thickness of the cleat, and must be provided with washers which will prevent under reasonable usage, injury to the knobs or cleats.

**Leather nail heads are pieces of leather on nail just below head to take impact of hammer.**

**Splice should be open to allow solder to penetrate. See a previous page.**

*c.* Must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered unless made with some form of *approved* splicing device, and covered with an insulation equal to that on the conductors.

Stranded wires (except in flexible cords) must be soldered before being fastened under clamps or binding screws, and whether stranded or solid, when they have a conductivity greater than that of No. 8 B. & S. gage they must be soldered into lugs for all terminal connections, except where an *approved* solderless terminal connector is used.

*d.* Must be separated from contact with walls, floors, timbers or partitions through which they may pass by non-combustible, non-absorptive, insulating tubes, such as glass or porcelain, except at outlets where approved flexible tubing is required.

Bushings must be long enough to bush the entire length of the hole in one continuous piece, or else the hole must first be bushed by a continuous waterproof tube. This tube may be a conductor, such as iron pipe, but in that case an insulating bushing must be pushed into each end of it, extending far enough to keep the wire absolutely out of contact with the pipe.

*e.* Where not enclosed in approved conduit, moulding or armored cable and where liable to come in contact with gas, water, or other metallic piping or other conducting material, must be separated therefrom by some continuous and firmly fixed non-conductor creating a permanent separation. Must not come nearer than two (2) inches to any other electric lighting, power or signaling wire, not enclosed as above, without being permanently separated therefrom by some continuous and firmly-fixed non-conductor. The non-conductor used as a separator must be in addition to the regular insulation on the wires. Where tubes are used, they must be securely fastened at the ends to prevent them from moving along the wire.

**Note.—This applies to wires not in conduit or armored cable. Conduit work is cheaper in the long run.**

Deviations from this rule may, when necessary, be allowed by special permission.

*f.* Must be so placed in wet places that an air space will be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact with the pipe accidentally. Wires should be run over, rather than under, pipes upon which moisture is likely to gather or which, by leaking, might cause trouble on a circuit.

*g.* The installation of electrical conductors in moulding, or on insulators, in elevator shafts will not be approved, but conductors may be installed in such shafts if encased in approved metal conduits, or armored cables.

**18. Table of Allowable Carrying Capacities of Wires.**

*a.* The following table, showing the allowable carrying capacity of copper wires and cables of ninety-eight per cent conductivity, according to the standard adopted by

**18. Allowable Carrying Capacities of Wires—continued.**
the American Institute of Electrical Engineers, must be followed in placing interior conductors.

For insulated aluminum wire the safe carrying capacity is eighty-four per cent of that given in the following tables for copper wire with the same kind of insulation.

| B. & S. G. | Table A Rubber Insulation Amperes | Table B Other Insulations Amperes | Circular Mils |
|---|---|---|---|
| 18 | 3 | 5 | 1,624 |
| 16 | 6 | 10 | 2,583 |
| 14 | 15 | 20 | 4,107 |
| 12 | 20 | 25 | 6,530 |
| 10 | 25 | 30 | 10,380 |
| 8 | 35 | 50 | 16,510 |
| 6 | 50 | 70 | 26,250 |
| 5 | 55 | 80 | 33,100 |
| 4 | 70 | 90 | 41,740 |
| 3 | 80 | 100 | 52,630 |
| 2 | 90 | 125 | 66,370 |
| 1 | 100 | 150 | 83,690 |
| 0 | 125 | 200 | 105,500 |
| 00 | 150 | 225 | 133,100 |
| 000 | 175 | 275 | 167,800 |
| 0000 | 225 | 325 | 211,600 |
| Circular Mils | | | |
| 200,000 | 200 | 300 | |
| 300,000 | 275 | 400 | |
| 400,000 | 325 | 500 | |
| 500,000 | 400 | 600 | |
| 600,000 | 450 | 680 | |
| 700,000 | 500 | 760 | |
| 800,000 | 550 | 840 | |
| 900,000 | 600 | 920 | |
| 1,000,000 | 650 | 1,000 | |
| 1,100,000 | 690 | 1,080 | |
| 1,200,000 | 730 | 1,150 | |
| 1,300,000 | 770 | 1,220 | |
| 1,400,000 | 810 | 1,290 | |
| 1,500,000 | 850 | 1,360 | |
| 1,600,000 | 890 | 1,430 | |
| 1,700,000 | 930 | 1,490 | |
| 1,800,000 | 970 | 1,550 | |
| 1,900,000 | 1,010 | 1,610 | |
| 2,000,000 | 1,050 | 1,670 | |

**19. Switches, Cut-outs, Circuit-Breakers, Etc.**

*a.* On constant potential circuits, all service switches and all switches controlling circuits supplying current to motors or heating devices, and all fuses, unless otherwise provided, must be so arranged that the fuses will protect and the opening of the switch will disconnect all of the wires; that is, in the two-wire system the two wires, and the three-wire system the three wires, must be protected by the fuses and disconnected by the operation of the switch.

When installed without other automatic overload protective devices automatic overload circuit breakers must have the poles and trip coils so arranged as to afford complete protection against overloads and short circuits, and if also used in place of the switch must be so arranged that no one pole can be opened manually without disconnecting all the wires.

*b.* Must not be placed where exposed to mechanical injury nor in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust or to flyings of combustible material.

Where the occupancy of a building is such that switches, cut-outs, etc., cannot be located so as not to be exposed as above, they must be enclosed in approved dust-proof cabinets with self-closing doors, except oil switches and circuit breakers which have dust-tight casings.

*c.* Must, when exposed to dampness, either be enclosed in a moisture-proof box or mounted on porcelain knobs. The cover of the box must be so made that no moisture which may collect on the top or sides of the box can enter it.

**23. Automatic Cut-outs.**

*c.* Must be in plain sight, or enclosed in an *approved* cabinet, and readily accessible. They must not be placed in the canopies or shells of fixtures.

Link fuses may be used only when mounted on *approved* bases and must be enclosed in dust-tight, fire-proofed cabinets, except on switchboards.

*d.* Must be so placed that no set of........ incandescent lamps, whether grouped on one fixture or on several fixtures or pendants (nor more than 16 sockets or receptacles) requiring more than 660 watts, will be dependent upon one cut-out.

There are exceptions allowed individually for particular cases.

*e.* The rated capacity of fuses must not exceed the allowable carrying capacity of the wire as given in No. 18......

**The idea of a fuse is primarily to protect the wiring wherein the greatest fire danger exists.**

Fixture wire or flexible cord of No. 18 B. & S. gage, will be considered as properly protected by 10 ampere fuses.

**This is a miximum and does not mean that a lower fuse may not be used.**

For circuits having a maximum capacity greater than that for which enclosed fuses are approved circuit breakers alone will be approved.

**26. Wires.**

## General Rules.

*a.* Where entering cabinets must be protected by approved bushings, which fit tightly the holes in the box and are well secured in place. The wires should completely fill the holes in the bushings so as to keep out the dust, tape being used to build up the wires if necessary. On concealed knob and tube work approved flexible tubing will be accepted in lieu of bushings, provided it shall extend from the last porcelain support into the cabinet.

*b.* Must not be laid in plaster, cement or similar finish, and must never be fastened with staples.

*c.* Must not be fished—*pulled down in walls or under flooring*—for any great distance, and only in places where the inspector can satisfy himself that the rules have been complied with.

*d.* Twin wires must never be used, except in conduits, or where flexible conductors are necessary.

*e.* Must, where exposed to mechanical injury, be suitably protected. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires must be installed in approved conduit or armored cable or be attached by their insulating supports to the under side of a wooden strip, not less than one-half inch in thickness, and not less than three inches in width. Instead of the running boards, guard strips on each side of and close to the wires will be accepted. These strips to be not less than seven-eighths of an inch in thickness and at least as high as the insulators.

Protection on side walls must extend not less than seven feet from the floor and must consist of substantial boxing, retaining an air space of one inch around the conductors.

closed at the top (the wires passing through bushed holes) or *approved* metal conduit pipe of equivalent strength.

When metal conduit or pipe is used, the insulation of each wire must be reinforced by *approved* flexible tubing extending from the insulator next below the pipe to the one next above it.

**This acts as a non-shiftable extra insulation through the metal pipe.**

The two or more wires of a circuit *each* with its flexible tubing (when required), if carrying alternating current *must*, or if direct current, *may* be placed within the same pipe.

**Here the flexible tubing is merely extra insulation. In all cases it is preferable to put both wires of a circuit in the same metal conduit. It must be done when alternating current is used on account of the danger of the iron pipes heating if two were used. This refers to metal conduit only.**

In damp places the wooden boxing may be preferable because of the precautions which would be necessary to secure proper insulation if the pipe were used. With this exception, however, iron piping is considered preferable to the wooden boxing, and its use is strongly urged. It is especially suitable for the protection of wires near belts, pulleys, etc.

*f*. When run in unfinished attics, or roof spaces, will be considered as concealed, and when run in close proximity to water tanks or pipes, will be considered as exposed to moisture.

In unfinished attics, or roof spaces, wires are considered as exposed to mechanical injury, and must not be run on knobs on upper edge of joints.

## Special Rules.

### For Open Work.

*In dry places.*

*g*. Must have an *approved* rubber slow-burning weather-proof, or slow-burning insulation.

*h*. Must be rigidly supported in non-combustible, non-absorptive insulators, which will separate the wires from each other and from the surface wired over in accordance with the following table:

| Voltage. | Distance from Surface. | Distance between Wires. |
|---|---|---|
| 0 to 300 | ½ inch | 2½ inch |
| 301 to 550 | 1 inch | 4 inch |

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports must be shortened In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about six inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

Must not be "dead-ended" at a rosette, socket or receptacle unless the last support is within twelve inches of the same.

### For Moulding Work (Wooden and Metal).

**Note.—Wooden moulding is practically obsolete and not allowed in most places.**

*Metal* mouldings must not be used for circuits requiring more than 1,320 watts of energy.

### For Conduit Work.

*n.* Must have an *approved* rubber insulating covering (Type Letter R. D.), and must within the conduit tubing be without splices or taps.

*o.* Must not be drawn in until all mechanical work on the building has been, as far as possible, completed.

Conductors in vertical conduit risers must be supported within the conduit system in accordance with the following table:

No. 14 to 0 every 100 feet.
No. 00 to 0000 every 80 feet.
0000 to 350,000 C. M. every 60 feet.
350,000 C. M. to 500,000 C. M. every 50 feet.
500,000 C. M. to 750,000 C. M. every 40 feet.
750,000 C. M. every 35 feet.

### For Concealed "Knob and Tube" Work.

*q.* Must have an *approved* rubber insulating covering.

*r.* Must be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least one inch from the surface wired over. Should preferably be run singly on separate timbers, or studding, and must be kept at least five inches apart.

Must be separated from contact with the walls, floor timbers and partitions through which they may pass by non-combustible, non-absorptive, insulating tubes, such as glass or porcelain. Wires passing through cross timbers in plastered partitions must be protected by an additional tube extending at least four inches above the timber.

Rigid supporting requires, under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed the distance between supports must be shortened.

At distributing centers, outlets or switches where space is limited and the five-inch separation cannot be maintained, each wire must be separately encased in a continuous length of approved flexible tubing.

*s.* When in a concealed knob and tube system, it is impracticable to place the whole of a circuit on non-combustible supports of glass or porcelain, that portion of the circuit which cannot be so supported must be installed with *approved* metal conduit, or *approved* armored cable, except that if the difference of potential between the wires is not over 300 volts, and if the wires are not exposed to moisture, they may be fished if separately encased in *approved* flexible tubing, extending in continuous legths from porcelain support to porcelain support, from porcelain support to outlet, or from outlet to outlet.

*t.*.When using either conduit or armored cable in mixed concealed knob and tube work, the requirements for conduit work or armored cable work must be complied with as the case may be.

*u.* Must at all outlets, except where conduit is used, be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support to at least one inch beyond the outlet........

When the surface at any outlet is broken, it must be repaired so as to leave no holes or open spaces at such outlet.

### For Fixture Work.

*v.* Must be not smaller than No. 18 B. & S. gage, and must have an approved rubber insulating covering.

## 27. Armored Cables.

*a*. Must be continuous from outlet to outlet or to junction boxes or cabinets, and the armor of the cable must properly enter and be secured to all fittings, and the entire system must be mechanically secured in position.

In case of service connections and main runs, this involves running such armored cable continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be.

*b*. Must be equipped at every outlet with an *approved* outlet box or plate, as required in conduit work.

For concealed work in walls and ceilings composed of plaster on wooden joist or stud construction, outlet boxes or plates and also cut-out cabinets must be so installed that the front edge will not be more than one-fourth inch back of the finished surface of the plaster, and if this surface is broken or incomplete it shall be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or plate or of the cut-out cabinet. On wooden walls or ceilings, outlet boxes or plates and cut-out cabinets must be so installed that the front edge will either be flush with the finished surface or project therefrom. This will not apply to concealed work in walls or ceilings composed of concrete, tile or other non-combustible material.

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted by special permission, provided the armored cable is firmly and rigidly secured in place.

*c*. Must have the metal armor of cables permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connections are made to gas piping, they must be on the street side of the meter. If the armored cable system consists of several separate sections, the sections must be bonded to each other, and the system grounded, or each section may be separately grounded, as required above.

The armor of cables and gas pipes must be securely fastened in outlet boxes, junction boxes and cabinets, so as to secure good electrical connection.

**The clamp connectors illustrated elsewhere take care of this.**

**27. Armored Cables—continued.**

If armor of cables and metal of couplings, outlet boxes, junction boxes, cabinets or fittings having protective coating of non-conducting material, such as enamel are used, such coating must be thoroughly removed from threads of both couplings and the armor of cables, and from surfaces of the boxes, cabinets and fittings where the armor of cables or ground clamp is secured in order to obtain the requisite good connection. Grounded pipes must be cleaned of rust, scale, etc., at place of attachment of ground clamp.

Connections to grounded pipes and to armor of cables must be exposed to view or readily accessible, and must be made by means of approved ground clamps.

Ground wires must be of copper, at least No. 10 B. & S. gage (where largest wire contained in cable is not greater than No. 0 B. & S. gage), and need not be greater than No. 4 B. & S. gage (where largest wire contained in cable is greater than No. 0 B. & S. gage). They shall be protected from mechanical injury.

The ground for the armored cable system is not to be considered as a ground for a secondary system.

*d.* When installed in so-called fireproof buildings in course of construction or afterwards if exposed to moisture, or where it is exposed to the weather, or in damp places, such as breweries, stables, etc., the cable must have a lead covering placed between the outer braid of the conductors and the steel armor.

The lead covering is not to be required when the cable is run against brick walls or laid in ordinary plaster walls unless same are continuously damp.

*e.* Where entering junction boxes, and at all other outlets, etc., must be provided with *approved* terminal fittings which will protect the insulation of the conductors from abrasion, unless such junction or outlet boxes are specially designed and approved for use with the cable.

*f.* Junction boxes must always be installed in such a manner as to be accessible.

*g.* For alternating current systems must have the two or more conductors of the circuit enclosed in one metal armor.

*h.* All bends must be so made that the armor of the cable will not be injured. The radius of the curve of the inner edge of any bend not to be less than 1½ inches.

## 28. Interior Conduits.

*a.* No conduit smaller than one-half inch electrical trade size shall be used.

*b.* Must be continuous from outlet to outlet or to junction boxes or cabinets, and the conduit must properly enter, and be secured to all fittings and the entire system must be mechanically secured in position.

In case of service connections, and main runs, this involves running each conduit continuously into a main cutout cabinet or gutter surrounding the panel board, as the case may be.

Departure from this rule may be authorized in case of underground services by special permission.

*c.* Must be first installed as a complete conduit system, without the conductors.

*d.* Must be equipped at every outlet with an *approved* outlet box or plate. At exposed ends of conduit (but not at fixture outlets) where wires pass from the conduit system without splice, joint or tap, an approved fitting having separately bushed holes for each conductor must be used. Departure from this rule may be authorized by special permission.

Outlet plates must not be used where it is practicable to install outlet boxes. . . .

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted, providing the conduit ends are bushed and secured.

It is suggested that outlet boxes and fittings having conductive coatings be used in order to secure better electrical contact at all points throughout the conduit system.

**This refers to the zinc coated conduit as being better than enameled conduit.**

*e.* Metal conduits where they enter junction boxes, and at all other outlets, etc., must be provided with *approved* bushings or fastening plates fitted so as to protect wire from abrasion, except when such protection is obtained by the use of *approved* nipples, properly fitted in boxes or devices.

*f.* Must have the metal of the conduit permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connections are made

**28. Interior Conduits—continued.**

to gas piping, they must be on the street side of the meter. If the conduit system consists of several separate sections, the sections must be bonded to each other, and the system grounded, or each section may be separately grounded, as required above. Where short sections of conduit (or pipe of equivalent strength) are used for the protection of exposed wiring on side walls, and such conduit or pipe and wiring is installed as required by No. 26 *c*, the conduit or pipe need not be grounded.

Conduits and gas pipes must be securely fastened in outlet boxes, junction boxes and cabinets, so as to secure good electrical connections.

**Taken care of by lock nuts and bushings or by condulets where the pipe is held by a threaded nipple.**

If conduit, couplings, outlet boxes, junction boxes, cabinets or fittings, having protective coating of non-conducting material such as enamel are used, such coating must be thoroughly removed from threads of both couplings and conduit, and such surfaces of boxes, cabinets and fittings where the conduit or ground clamp is secured in order to obtain the requisite good connection. Grounded pipes must be cleaned of rust, scale, etc., at place of attachment of ground clamp.

Connections to grounded pipes and to conduit must be exposed to view or readily accessible, and must be made by means of approved ground clamps

Ground wires must be of copper, at least No. 10 B. & S. gage (where largest wire contained in conduit is not greater than No. 0 B. & S. gage), and need not be greater than No. 4 B. & S. gage (where largest wire contained in conduit is greater than No. 0 B. & S. gage). They shall be protected from mechanical injury.

The ground on the conduit system is not to be considered as a ground for a secondary system (see No. 15).

*g*. Junction boxes must always be installed in such a manner as to be accessible.

*h*. All elbows or bends must be so made that the conduit will not be injured. The radius of the curve of the inner edge of any elbow not to be less than three and one-half inches. Must have not more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlets not being counted.