STANDARD WIRING
FOR
ELECTRIC LIGHT AND POWER

CUSHING.

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STANDARD WIRING

FOR

ELECTRIC LIGHT AND POWER

AS ADOPTED BY

THE FIRE UNDERWRITERS

OF THE UNITED STATES

IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE, WITH EXPLANATIONS, ILLUSTRATIONS AND TABLES NECESSARY FOR OUTSIDE AND INSIDE WIRING AND CONSTRUCTION FOR ALL SYSTEMS, TOGETHER WITH A SECTION ON HOUSE WIRING.

BY

H. C. CUSHING, JR.
Fellow Am. Inst. Elecl. Engrs.

WITH THE CO-OPERATION OF THE WIRING COMMITTEE OF THE COMMERCIAL SECTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION AND THE SOCIETY FOR ELECTRICAL DEVELOPMENT

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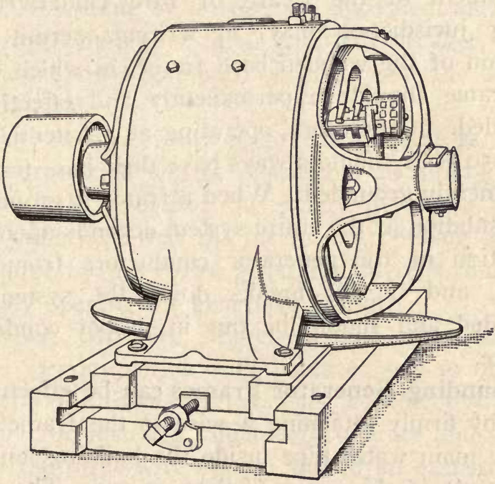
PREFACE

THE Author, with the collaboration of Mr. F. E. Cabot, Chairman of the Electrical Committee of the National Fire Protection Association, and with the Co-operation of the Wiring Committee of the Commercial Section of the National Electric Light Association, and the Society for Electrical Development, has made it his aim in compiling the following pages to set forth, as clearly as possible, the essential rules and requirements for safe and efficient exterior and interior wiring and construction for electric light, heat and power. The object of this book is to standardize, as much as possible, all work of this nature and to respectfully suggest to the Electrical Engineer, Architect, House-owner, Contractor and Wireman just what is required by Fire Underwriters' Inspectors throughout the United States.

THE GENERATOR

All generators, whether for central station or isolated lighting or power work, should be located in a dry place so situated that the surrounding atmosphere is cool. If the surrounding air is warm it reduces the safe carrying capacity of the machine, and is likely to allow such temperatures to rise in



Proper installation of dynamo or motor on filled wooden base frame.

the machine itself as to burn out either armature or field, or both. A generator should not be installed in any place where any hazardous process is carried on, nor in place where it would be exposed to inflammable gases or flying combustible materials, as the liability of occasional sparks from the commutator or brushes might cause more or less serious explosions.

Foundations. Wherever it is possible, generators should be raised or insulated above the surrounding floor on wooden base frames, which should be kept filled to prevent the absorption of moisture, and also kept clean and dry. When it is impracticable to insulate a generator on account of its great weight or any other reason, the Inspection Department of the Board of Fire Underwriters having jurisdiction may, in writing, permit the omission of the wooden base frame, in which case the frame should be permanently and effectively grounded. Generators operating at a potential of over 550 volts should always have their base frames permanently grounded. When a frame is grounded the insulation of the entire system depends upon the insulation of the generator conductors from the frame, and if this breaks down the system is grounded and should be put in proper condition at once.

Grounding Generator Frames can be effectually done by firmly attaching a wire to the frame and to any main water pipe inside the building, on the street side of the meter, if there is one. The wire should be securely fastened to the pipe by screwing a brass plug into the pipe and soldering the wire to this plug or by approved ground clamps. When the generator is direct driven an excellent ground is attained through the engine coupling and piping.

Wherever high voltage machines have their frames grounded a small board walk should be built around them and raised above the floor on porcelain or glass insulators, in order that the attendant may be protected from shock when adjusting brushes or working about the machine.

Accessibility. Sufficient space should be left on all sides of the generator, or motor, and especially at the commutator end, so that there may be ample room for removing armatures, commutators, or other parts at any time.

Circuit Breakers and Fuses. Every constant potential generator should be protected from excessive current by a fuse, or equivalent device of approved design, such as a circuit breaker. Such devices should be placed on or as near the dynamo as possible.

For two-wire, direct-current generators, single pole protection will be considered as satisfying the above rule, provided the safety device is located and connected that the means for opening same is actuated by the *entire* generator current thus completely opening the generator circuit.

When two-wire, direct-current generators are used in conjunction with balancer sets to obtain a neutral for three-wire systems, a protective device should be installed which will operate and disconnect the three-wire system should an excessive unbalancing of voltage occur. If a generator, not electrically driven, in a two-wire system has one terminal grounded, the circuit breaker above mentioned should be placed in the grounded lead.

For three-wire direct-current generators, either compound or shunt wound, a safety device should be placed in each armature lead of sufficient capacity and so arranged as to take care of the entire current from the armature.

The safety devices for this service should be a double-pole, double-coil overload circuit-breaker, or a four-pole circuit-breaker connected in the main and equalizer leads and tripped by means of two overload devices, one in each armature lead. The safety devices thus required should be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature from the system.

Fuses should never be used for this class of protection.

In general, generators should preferably have no exposed live parts and the leads should be well insulated and thoroughly protected against mechanical injury. This protection of the bare live parts against accidental contact would apply also to all exposed, uninsulated conductors outside of the generator and not on the switchboard.

Waterproof Covers, though not required, should be provided for every generator and motor and placed over each machine as soon as it is shut down. Negligence in this matter has caused many an armature or field coil to burn out, as only a few drops of water are necessary to cause a short circuit, when the machine is started up again, that might do many dollars' worth of damage, to say nothing of the inconvenience of having to shut off light or power when it is most needed, and for an indefinite length of time.

Name Plates. Every generator and motor should be provided with a name plate, giving the maker's name, the capacity in volts and amperes and normal speed in revolutions per minute. This will show exactly what the machine is designed for, and how it should be run.

Terminal blocks when used on generators should be made of *approved* non-combustible non-absorptive, insulating material, such as slate, marble or porcelain.

Wiring from Generators to switchboards and thence to outside lines should be in plain sight or readily accessible, and should be supported entirely throughout upon non-combustible insulators (such as glass or porcelain) and in no case should any wire come in contact with anything except these insulators, and the terminals upon the generators and switchboard. When it becomes necessary to run these wires through a wall or floor, the holes should be protected by some approved non-combustible insulating tube, such as glass or porcelain, and in every case the tube should be so fastened that it shall not slip or pull out. Sections of any conduit, whether armored or otherwise, that are chopped off for this purpose, should not be used. All wires for generator and switchboard work should be kept so far apart that there is no liability of their coming in contact with one another, nor of short circuit from metallic tools used about them. All wire used in this class of work should be the best quality of "rubber covered" (see page 76). Bus-bars on switchboards, may be made of bare metal so that additional circuits may be readily attached. They should have ample carrying capacity, so as not to heat with the maximum current likely to flow through them under natural conditions. (See "Capacity of Wire Table," page 91.) So much trouble in past years has arisen from faulty construction of switchboards, and the apparatus placed upon them, that strict requirements have been necessarily adopted by engineers as well as insurance inspectors, and the following suggestions are recommended by the latter; although it is advisable, when possible, that all wires from generators to switchboards be in plain sight and readily accessible, wires from generator to switchboard may, however, be placed in a conduit in the brick or cement pier on which the generator stands, provided that proper precautions are taken to protect them against moisture and to thoroughly insulate them from the pier or foundation. If lead-covered cable is used, no further protection will be required. If liable to moisture, however, cable with grounded lead sheath or grounded conduit should be used. A smooth runway is desired. If iron conduit is provided, double braided rubber-covered wire will be satisfactory. In wiring switchboards with regard to their ground detectors, voltmeters, pilot lights, potential transformers or other indicating instruments. Nothing smaller than No. 14 B. & S. gage "rubber covered" wire should be used, and no such circuit should carry over 660 watts. Such circuits should be protected by *approved* enclosed fuses. (See pp. 110-113.)

The Switchboard should be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material, and, like the generator, should be erected in a dry place and kept free from moisture. It is necessary that it should be accessible from all sides when the wiring is done on the back of the board, but may be placed against a brick, stone or cement wall when all wiring is on the face of the switchboard.

The board should be constructed wholly of non-combustible material and never built up to the ceiling; a space of three feet, at least, should separate the top of the board from the ceiling and at least eighteen inches should separate the wall from the instruments or connections, when the wiring is done on the back of the board. Wires with inflammable outer braiding, when brought close together, as frequently happens on switchboards, should each be surrounded with a tight, non-combustible covering.

Flame proofing should be stripped back on all cables a sufficient amount to give the necessary insulation distances for the voltage of the circuit on which the cable is used. Every instrument, switch or apparatus of any kind placed upon the switchboard should have its own non-combustible insulating base. This is required of every piece of apparatus connected in any way with any circuit. If it is found impossible to place the resistance box, rheostat, or regulator, which should, in every case, be made entirely of non-combustible material upon the switchboard, it should be placed at least one foot from combustible material or separated therefrom by a non-inflammable, non-absorptive insulating material. This will require the use of a slab or panel of non-combustible, non-absorptive insulating material such as slate, soapstone or marble, somewhat larger than the rheostat, which should be secured in position independently of the rheostat supports. Bolts for supporting the rheostat should be countersunk at least ⅛ inch below the surface at the back of the slab and the holes over the heads of the bolts filled with insulating material. For proper mechanical strength, the slab should be of a thickness consistent with the size and weight of the rheostat, and in no case to be less than ½ inch.

If resistance devices are installed in rooms where dust or combustible flyings would be liable to accumulate on them, they should be equipped with dust-proof face plates. Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided that they do not carry or control the main current nor constitute the regulating resistance of the device.

When so used, lamps should be mounted in porcelain receptacles upon non-combustible supports, and should be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated. They should in all cases be provided with a name-plate, which should be permanently attached beside the porcelain receptacle or receptacles and stamped with the candle-power and voltage of the lamp or lamps to be used in each receptacle.

Wherever insulated wire is used for connection between resistances and the contact device of a rheostat, the insulation should be "slow burning." (See page 77.) For large rheostats and similar resistances, where the contact devices are not mounted upon them, the connecting wires may be run together in groups so arranged that the maximum difference of potential between any two wires in any group shall not exceed 75 volts. Each group of wires should either be mounted on non-combustible, non-absorptive insulators giving at least ½ inch separation from surface wired over, or, where it is necessary to protect the wires from mechanical injury. Each group may be encased in approved flexible tubing and placed in approved conduit, the flexible tubing to extend at least 1 inch beyond the ends of the conduit. Special attention is again called to the fact that switchboards should not be built down to the floor, nor up to the ceiling, but a space of at least ten or twelve inches should be left between the floor and the board, and thirty-six inches between the ceiling and the board, when possible, in order to prevent possible fire from communicating from the switchboard to the ceiling, and also to prevent the forming of a partially concealed space very liable to be used for storage of rubbish and oily waste. Where floor is of brick, stone or concrete, the switchboard may go to the floor, but for cleanliness and safety space should always be provided when possible.

Lightning Arresters should be attached to each wire of every overhead circuit connected with the station.

It is recommended to all electric light and power companies that arrestors be connected at intervals over systems in such numbers and so located as to prevent ordinary discharges entering (over the wires) buildings connected to the lines (see p. 59.)

Arresters for Stations and Sub-stations should be located in readily accessible places away from combustible materials, and as near as practicable to the point where the wires enter the building.

Station arrestors are often placed in plain sight on the switchboard. The switchboard, however, does not necessarily afford the only location meeting these requirements. In fact, if the arresters can be located in a safe and accessible place away from the board, this should be done, for, in case the arrester should fail or be seriously damaged there would then be no chance of starting arcs on the board.

In all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines should be avoided as far as possible.

They should be connected with a thoroughly good and permanent ground connection by metallic strips or wires having a conductivity not less than that of a No. 6 B. & S. copper wire, and these should be run as nearly in a straight line as possible from the arresters to the earth connection.

Ground wires from lightning arresters should not be attached to gas-pipes within the buildings.

It is often desirable to introduce a choke coil in circuit between the arresters and the dynamo. In no case should the ground wire from a lightning arrester be put into iron pipes, as these would tend to impede the discharge.

Unless a good damp ground is used in connection with all lightning arresters, they are little better than useless. Ground connections should be of the most approved construction, and should be made where permanently damp earth can be conveniently reached. For a bank of arresters such as is commonly found in a power house, the following instructions will be found valuable: First, dig a hole six feet square directly under the arresters until permanently damp earth has been reached; second, cover the bottom of this hole with two feet of crushed coke or charcoal (about pea-size); third, over this lay 25 square feet of No. 16 copper plate; fourth, solder at least two ground wires, which should not be smaller than No. 4, securely across the entire surface of the ground plate; fifth, now cover the ground plate with two feet of crushed coke or charcoal; sixth, fill in the hole with earth, using running water to settle.

A practical and effective method of installing an outside line arrester is shown on page 59.

All lightning arresters should be mounted on non-combustible insulating bases, and be so constructed as not to maintain an arc after a discharge.

Testing of Insulation Resistance. All circuits except such as are permanently grounded, as described on pages 56 and 57, should be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground wires from detectors should not be attached to gas pipes within the building.

Where continuously indicating detectors are not used, the circuits should be tested at least once per day (see page 75), and preferably oftener.

Data obtained from all tests should be recorded and preserved for examination.

Fire Extinguishers. At least one, or more if the size of the installation demands it, good approved extinguisher should be in plain sight and readily accessible, one which is capable of extinguishing electrical fires or arcs without danger of transmitting a shock to the operator (see page 258.)

Storage or Secondary Batteries should be installed with as much care as generators, and in wiring to and from them the same precautions and rules should be adopted for safety and the prevention of leaks. The room in which they are placed should not only be kept dry, but exceptionally well ventilated, to carry off all fumes which are bound to arise. The insulators for the support of the secondary batteries should be glass or porcelain, as filled wood alone would not be approved. The use of any metal liable to corrosion should be avoided in cell connections of secondary batteries of the lead and sulphuric acid type.

Oily Waste should be kept in approved metal cans (made entirely of metal, with legs raising them at least three inches above the floor, and with self-closing covers) and removed daily.

Attendance. A competent man should always be kept on duty where generators are operating.

MOTORS.

The Installation of Motors. All motors when operating at a potential in excess of 550 volts should have no exposed live metal parts, and have their base frames permanently and effectively grounded.

When operating at a potential of 550 volts or less, their base frame should be permanently and effectively grounded wherever feasible. Where grounding of the frame is impracticable, special permission for its omission may be obtained, in writing, by the local insurance or city inspection department, in which case the frame should be permanently and effectively insulated. Wooden base frames used for this purpose and wooden floors which are depended upon for insulation where for any reason it is necessary to omit the base frames should be kept filled to prevent absorption of moisture and be kept clean and dry.

Motors operating at a potential of 550 volts or less should be wired with the same precautions as required by rules for inside wiring (see pages 89 to 96) for wires carrying a current of the same volume.

Motors operating at a potential between 550 and 3,500 volts should, except in central or sub-stations, be wired with approved multiple conductor, metal sheathed cable in approved metal conduit. All apparatus and wiring connected to the high tension circuit should be completely enclosed in substantial grounded metal shields or casings and the conduit should enter and be properly secured to such casings or to suitable terminal boxes screwed or bolted to the casings.

The insulation of the several conductors for high potential motors, where leaving the metal sheath of cables, should be thoroughly protected from moisture and mechanical injury. This may be accomplished by means of a pot head, see illustration on page 52, or some equivalent method. The conduit should be substantially bonded to the metal casings of all fittings and apparatus connected to the inside high tension circuit.

Where outside conductors directly enter the motor room special permission in writing should be obtained to install the wires for high potential motors according to the general rules for high potential systems. (See pages 159 to 160.)

Conductors carrying the current of only one motor should be designed to carry a current at least 25 per cent. greater than that for which the motor is rated. Where the conductors under this rule would be overfused in order to provide for the starting current, as in the case of many of the alternating current motors, the conductors should be of such size as to be properly protected by these larger fuses.

The current used in determining the size of the conductor carrying the current of only one varying (or variable) speed motor should be the percentage of the 30-minute current rating of the motor as given for the several classifications of service in the following table:

Classification of Service	Percentage of current rating of motor
Operating valves, raising or lowering rolls	200
Rolling tables	180
Hoists, rolls, ore and coal handling machines	150
Freight and passenger elevators, shop cranes, tool heads, pumps, etc.	120

Varying speed motors are motors in which the speed varies automatically with the load, decreasing when the load increases, and vice versa. It does not mean motors in which the speed is varied by the use of different windings or grouping of windings, or motors in which the speed is varied by external means, and in which, after adjusting to a certain speed, the speed remains practically constant.

Each motor with its starting device should be protected by a cut-out and controlled by a switch (see page 43), said switch plainly indicating whether "on" or "off." Small motors may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed 10 amperes and the total wattage of the circuit does not exceed 660. With motors of one-fourth horse power or less, on circuits where the voltage does not exceed 300, single pole switches may be used. Such switches, however, should never be used as service switches or circuits located in damp places, nor placed in the neutral wire of a three-wire system, except in the two-wire branch circuit supplying not more than 660 watts. The switch and rheostat should always be located within sight of the motor.

Where the circuit-breaking device on the motor-starting device disconnects all wires of the circuit, the switch may be omitted.

Overload-release devices on motor-starting devices will not be considered to take the place of the cut-out required for this class of work.

An automatic circuit-breaker disconnecting all wires of the circuit may serve as both switch and cut-out. (See page 44.)

Where a rubber-covered conductor, see page 76, carries the current of only one A. C. motor of a type requiring large starting current it may be protected by a fuse or an automatic circuit breaker without time limit device. The rated continuous current capacity of a time limit circuit breaker protecting a motor of the above type need not be greater than 125% of the motor current rating, providing the time limit device is capable of preventing the breaker opening during the starting period.

In most cases where A. C. motors of the above type are started by means of autostarters the current-carrying capacity of wires meeting the rule will not exceed the following percentages of the full load currents of the motors.

Rated full load current	Percentage
0- 30 amperes	250
31-100 "	200
Above 100 "	150

Rheostats should be so installed as to comply with *all* the suggestions on this subject given on pages 9 to 11.

Auto starters, unless equipped with tight casings enclosing all current-carrying parts, in all wet, dusty or linty places, should be enclosed in approved cut-out boxes or cabinets. Where there is any liability of short circuits across their exposed live parts being caused by accidental contacts, a railing should also be erected around them.

Motors should not be run in series-multiple or multiple-series, except on constant-potential systems.

When deemed necessary, motors should be enclosed in an *approved* case.

Such enclosures should be readily accessible, dust proof and sufficiently ventilated to prevent an excessive rise of temperature. Where practicable the sides should be made largely of glass, so that the motor may be always plainly visible.

The use of an enclosed type motor is recommended in dusty places, being preferable to wooden boxing.

All motors permanently located on wooden floors should be provided with suitable drip pans.

When motors are combined with ceiling fans, they should be hung from insulated hooks, or else there should be an insulator interposed between the motor and its support.

Every motor should be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

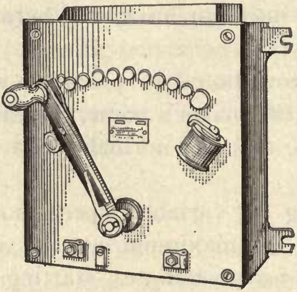
All varying (or variable) speed motors should be marked with the maximum current which they can safely carry for 30 minutes, starting cold.

Motor terminal blocks should be made of *approved* non-combustible, non-absorptive, insulating material such as slate, marble or porcelain.

Adjustable speed motors, if controlled by means of field regulation, should be so arranged and connected that they cannot be started under weakened field.

The use of soft rubber bushings to protect the lead wires coming through the frames of motors is permitted, except when installed where oils, grease, oily vapors or other substances known to have rapid deleterious effect on rubber are present in such quantities and in such proximity to motors as may cause such bushings to be liable to rapid destruction. In such cases hardwood properly filled, or preferably porcelain or micanite bushings should be used.

Starting and Stopping Motors (Direct Current) One rule at all times to be remembered in starting and stopping motors is, *switch first, rheostat last,* which means, in starting, *close the switch first,* and then gradually cut out all resistance as the motor speeds up. To stop the motor *open the switch first* and then cut in all the resistance of the rheostat



Motor Starting Rheostat or "Resistance Box" with No-Voltage Release. Slate front carries lever, contacts and release spool, mounted on a ventilated box of pressed steel which serves as a container for the resistance.

which is in series with the motor armature. When starting any new motor for the first time, see that the belt is removed from the pulley and the motor started with no load. Never keep the rheostat handle on any of its coils longer than a moment, as they are not designed to regulate the speed of the motor, but to prevent too large a flow of current into the armature before the latter has attained its full speed.

The illustration above shows a rheostat which is designed to automatically protect the armature of a motor. The contact arm is fitted with a spring which constantly tends to throw the arm on the "off-point" and open the circuit, but is prevented from so doing, while the motor is in operation, by the small electro-magnet, shown on the face of the rheostat, which consists of low resistance coil connected in series with the field winding of the motor. This magnet holds the contact arm of the rheostat in the position, allowing the maximum working current to flow through the armature while it is in operation.

If, for some reason or other, the current supplied to the motor be momentarily cut off, the speed of the armature generates a counter current which also tends to hold the arm in position as long as there is any motion to the motor armature, but as soon as the armature ceases to revolve all current ceases to flow through the electromagnet, thereby releasing the rheostat handle, which flies back to the "off" point, as shown in the illustration, and the motor armature is out of danger. Such a device is of great value where inexperienced men have to handle motors, and are unaware that the first thing to be done when a motor stops for any reason whatever is to open the circuit, and then cut in all the resistance in the rheostat to prevent too large an in-rush of current when the motor is started up again.

The Circuit Breaker for under and over loads is also a most valuable protection in such cases.

Motor Wiring Formulae—(Direct Current). To find the proper size of wire for direct-current motors proceed as follows:

e = voltage of motor.

d = single distance from generator to motor in feet.

v = volts loss in lines.

k = efficiency of motor. (See table below.)

10.8 = Resistance in ohms of a wire 1 ft long and .001 inch diameter. Then in size or wire circular mils (cm)

$$\text{c.m.} = \frac{\text{horsepower} \times 746 \times 2d \times 10.8}{e \times v \times k}$$

$$\text{or simplified cm} = \frac{\text{horsepower} \times d \times 16113.6}{e \times v \times k}$$

Compare the size of wire thus found with that allowed by the underwriters for full load current of motor, + 25%. If it be smaller it must be increased to at least that figure to be approved and the resulting lower line loss accepted. (See table, p. 91.)

THE AVERAGE MOTOR EFFICIENCY (K).

1 h.p. and under	75 per cent.
3 h.p. to 5 h.p.	80 per cent.
5 h.p. to 10 h.p.	85 to 90 per cent.
Over 10 h.p.	90 per cent.

The tables and examples worked out on pages 79 to 82 will give the desired results, in many cases of smaller installations without having to use the above direct current formulæ.

CURRENT REQUIRED BY MOTOR

(Direct Current.)

To find current required by a motor when the horse-power, efficiency and voltage are known, use the following formula:

Let C = current to be found.

H. P = horse-power of motor.

E = voltage of motor circuit.

K = efficiency of motor in per cent.

$$C = \frac{H. P. \times 746 \times 100}{E \times K}$$

The table of "amperes per motor" given on the following page, will, in many cases, prevent the necessity of working out the above formula.

By adding the volts indicated in the (page 25) table to the voltage of the lamp or motor, the result shows the voltage at the dynamo for losses indicated. Thus, 10 per cent. on 110 volt system is: 12.22 volts added to 110 equal 122.22, showing that the dynamo must generate 122.22 volts to take care of a 10 per cent. loss in the line (for A. C., see pp. 83-89).

SIZES OF FUSES, IN AMPERES, FOR MOTORS EQUIPPED WITH OVERLOAD STARTING RHEOSTATS.

Horsepower.	115 Volts.	230 Volts.	500 Volts.
0.5	8	4	2
1	15	8	4
2	30	15	7
3	40	20	10
4	50	25	12
5	60	30	15
7.5	90	45	20
10	115	60	25
15	175	90	40
20	225	115	50
25	300	150	60
30	350	175	75
35	400	200	90
40	450	225	100
50	600	300	125

AMPERES PER MOTOR.

H. P.	Per Cent. Eff.	Watts.	The Top Row Indicates Volts.									
			50	75	110	220	400	500	600	800	1000	1200
¾	75	746	14.9	9.95	6.78	3.39	1.87	1.49	1.24	.93	.746	.62
1½	75	1492	29.8	19.9	13.56	6.78	3.73	2.98	2.49	1.87	1.492	1.24
3	80	2797	55.9	37.3	25.4	12.7	6.99	5.59	4.66	3.50	2.797	2.33
5	80	4662	93.2	62.2	42.4	21.2	11.74	9.32	7.77	5.83	4.662	3.88
7½	90	6217	124.	82.9	56.5	28.3	15.54	12.43	10.38	7.77	6.217	5.18
10	90	8288	166.	111.	75.3	37.7	20.72	16.57	13.81	10.36	8.288	6.91
15	90	12433	249.	166.	113.	56.5	31.08	24.86	20.72	15.54	12.43	10.36
20	90	16578	332.	221.	151.	75.5	41.45	33.15	27.63	20.72	16.58	13.81
25	90	20722	414.	276.	188.	94.1	51.8	41.4	34.5	25.9	20.7	17.3
30	90	24866	497.	331.	226.	113.	62.2	49.7	41.4	31.	24.9	20.7
40	90	33155	663.	442.	301.	151.	82.9	66.3	55.3	41.4	33.2	27.6
50	90	41444	829.	553.	377.	189.	101.	82.9	69.	51.8	41.4	34.5
60	90	49733	995.	663.	452.	226.	124.	99.5	82.9	62.	49.7	41.4
70	90	58022	1160.	773.	527.	264.	145.	116.	96.7	72.5	58.	48.4
80	90	66310	1326.	884.	603.	303.	166.	133.	111.	82.9	66.3	55.3
90	90	74599	1492.	995.	678.	339.	187.	149.	124.	93.	74.6	62.
100	90	82888	1658.	1105.	754.	377.	207.	166.	138.	104.	82.9	69.
120	90	99467	1989.	1326.	904.	452.	249.	199.	166.	124.	99.	82.9
150	90	124333	2487.	1658.	1130.	565.	311.	249.	207.	155.	124.	104.

VOLTS LOST AT DIFFERENT PER CENT. DROP.

Termin'l Volts	52	104	110	120	240	550	1100	2200	6600	11000
% .5	.261	.523	.553	.603	1.21	2.76	5.53	11.06	33.17	55.28
1.	.525	1.05	1.11	1.21	2.42	5.56	11.11	22.22	66.67	111.11
1.5	.791	1.58	1.68	1.83	3.65	8.38	16.75	33.50	100.50	167.51
2.	1.06	2.12	2.24	2.45	4.90	11.22	22.45	44.90	132.65	224.48
2.5	1.33	2.67	2.82	3.08	6.15	14.10	28.21	56.41	169.23	282.05
3.	1.61	3.22	3.40	3.71	7.42	17.01	34.02	68.04	204.11	340.20
3.5	1.89	3.77	3.99	4.35	8.70	19.95	39.90	79.79	239.37	398.96
4.	2.17	4,33	4.58	5.00	10.00	22.92	45.83	91.67	275.00	458.33
5.	2.74	5.47	5.79	6.32	12:63	28.95	57.90	115.79	347.36	578.94
6.	3.32	6.70	7.02	7.66	15.32	35.11	70.21	140.42	421.27	702.12
7.	3.91	7.83	8.28	9.03	18.06	41.40	82.80	165.59	496.77	827.95
8.	4.52	9.04	9.57	10.43	20.87	47.83	95.65	191.30	573.90	956.52
9.	5.14	10.29	10.88	11.87	23.74	54.40	108.79	217.58	652.75	1087.91
10.	5.78	11.56	12.22	13.33	26.67	61.11	122.22	244.44	733.33	1222.21
11.	6.43	12.85	13.59	14.83	28.66	67.97	135,95	271.90	815.69	1359.49
12.	7.09	14.18	15.00	16.36	32.72	75.00	150.00	299.99	899.98	1499.96
13.	7.77	15.54	16.44	17.93	35.86	82.18	164.36	328.72	986.17	1643.62
14.	8.46	16.93	17.91	19.53	39.07	89.53	179.07	358.14	1074.41	1790.69
15.	9.17	18.35	19.41	21.18	42.35	97.06	194.12	388.23	1164.70	1941.17
20.	13.00	26.00	27.50	30.00	60.00	137.50	275.00	550.00	1650.00	2750.00
25.	17.33	34.67	36.67	40.00	80.00	183.33	366.66	733.33	2199.98	3666.63

DIRECT CURRENT GENERATORS AND MOTORS

General Information

Output—The output of a generator in watts may be obtained by multiplying the current in amperes by the e.m.f. in volts. To obtain the horse power, the product obtained in the first operation is divided by 746.

$$\text{Horsepower} = \frac{\text{Volts x Amperes}}{746}$$

See equivalent values, page 200.

Windings—Depending upon the character of field winding employed, direct-current generators and motors are classified under one of the following three general groups.

1—Shunt wound
2—Series wound
3—Compound wound

See diagrams pages 43-47.

Shunt-Wound Generator—The field winding of a shunt-wound generator is composed of a large number of turns of wire or strap of comparatively high resistance, which is connected directly to the armature terminals, forming, in parallel with the main circuit, a shunt circuit through which only a small percentage of the total current flows.

The regulation characteristic of a shunt-wound machine is such that the voltage is a maximum at no load, and drops as the load increases unless regulated by the manipulation of a rheostat in the field circuit.

Series-Wound Generator—The field winding of a series-wound generator is composed of a heavy wire or strap connected in series with the armature and external circuit. With this type of machine the total current delivered flows through the field winding and the voltage varies directly with the load. The greater the load the higher the voltage. Generally, a slight load is required to make these machines pick up voltage.

Compound-Wound Generator — A compound-wound machine has both shunt and series winding. It may be generally assumed that the shunt field is so designed that on open circuit, the series field being idle, the machine will generate the desired line voltage. The result of applying load would, as noted under "Shunt Generator," tend to lower the terminal voltage; but it is here that the utility of the compound winding becomes apparent. The series coils reinforce the shunt field in direct proportion to the increase of load and thus hold the terminal voltage constant, balancing the drop due to increased copper loss and armature reaction at the heavier loads.

It is a difficult matter to design a machine for exact voltage under all conditions and for this reason additional hand regulation is provided in the form of a rheostat in the shunt-field circuit.

It is easily possible and quite generally desirable to have a compound-wound generator over-compounded, i. e., provided with a series field of sufficient strength to not only hold the voltage constant but increase it with increase of load. The over-compounding is customarily given as the percentage of the no-load terminal voltage which the increase in voltage from no load to full load represents. Thus a 9 per cent. over-compounded 230-volt generator will have a full-load voltage of approximately 250.

Shunt Motors—This is by far the most common type of winding, and is generally applied to motors designed for operating at constant speed under constant or varying loads. Nearly all commercial applications, particularly those of large capacity, require this type of motor. When necessary, considerable speed variation can usually be secured by means of a rheostat in the field circuit, increased resistance resulting in an increased speed.

Series Motors—Series motors are variable speed machines particularly adapted to a few special uses, such as railway and crane service, but are not extensively employed in the field of work to which this book is devoted. The characteristic features of a series motor are its great torque at starting and low running speeds.

Compound-Wound Motors—For some special classes of service, in which it is necessary to start under heavy load and later operate at approximately constant speed, a series winding is added to assist the shunt field at the low speed points.

As in the case of the compound generator, a compound motor combines the characteristics of both shunt and series motors. In most cases, however, the series winding has comparatively little effect except during the starting period.

Connections for Parallel Operation—Parallel operation of direct-current generators is effected in a comparatively easy manner if machines are of the same make and voltage or are designed with similar electrical characteristics. If they are shunt-wound machines, no connections other than main leads are required as the inherent regulation characteristics are such as to insure proper division of the load. If they are compound-wound machines, the addition of equalizer connections between the machine is required. See diagram page 46. If the generators have different compounding ratios, it will be necessary to change adjustments so that all machines have the same inherent regulation; i. e., with shunt field adjusted by rheostat for same voltage at no load, the compounding is such as to produce the same voltage on all at full load. The way to determine if all machines have the same regulation is to test them individually.

Equalizer—An equalizer, or equalizer connection, connects two or more generators operating in parallel at a point where the armature and series field leads join, thus placing the armatures in multiple and the series in multiple, in order that the load may be divided between the generators in proportion to their capacities.

The object of the equalizer, as the name implies, is to divide the total load between the machines according to their capacity. Consider, for example, two compound-wound machines operating in parallel without an equalizer. If, for some reason, there is a slight increase in speed of one machine, it would take more than its share of load; and the increased current flowing through the series field would strengthen the magnetism, raise the voltage, and cause the machine to take a still greater amount until it carried the entire load. When equalizers are used, the current flowing through each series coil is proportional to the resistance and is independent of the load on any machine; consequently an increase of voltage on one machine builds up the voltage of the other at the same time, so that the first machine cannot take all the load, but will continue to share it in proper proportion with the other generators.

OPERATION

General Rules—Leave all switches open when machine is not running. (See page 43.)

At all times keep the generator or motor clean and free from oil and dust, especially from copper or carbon dust. With high-voltage machines a small accumulation of dust on the windings may be the cause of serious burn-out.

Keep small pieces of iron and bolts and tools away from the frame. Any such fragment attracted to the pole of a field magnet may jam between the armature and pole and cause serious damage.

Occasionally give the machine a thorough inspection. The higher the voltage of the generator or motor, the oftener this should be done.

Starting Generators—See that the bearings are well supplied with oil and that the oil rings are free to turn. Inspect all connections for loose screws or wires.

Start slowly. See that the oil rings are revolving properly.

Turn in all resistance in the field rheostat, then bring the machine up to speed.

Adjust the rheostat for the normal voltage of the generator.

Throw on the load.

Causes of Insufficient Voltage—The following causes may prevent generators from developing their normal e. m. f. (electro motive force).

The speed of the generator may be below normal.

The switchboard instruments may be incorrect and the voltage may be higher than that indicated, or the current may be greater than is shown by the readings.

The series field may be reversed, or part of the shunt field reversed or short-circuited.

The brushes may be incorrectly set.

A part of the field rheostat or other unnecessary resistance may be in the field circuit.

Reversing Polarity—To change the polarity, if a generator keeps the same rotation, it is necessary to reverse the magnetism in the field circuit which is done by exciting the shunt field in the opposite direction.

Reversing Rotation—To change the rotation but not the polarity, it is necessary to reverse either the magnetism or the armature leads. The simplest method, and the one recommended, is to reverse the leads to the armature and the leads to the commutating-pole winding. In all commutating-pole machines, it must be borne in mind that the direction of current in the armature and commutating-pole windings always bear the same relation to each other, and, if the armature current is reversed for any reason, the commutating-pole coils must be reversed.

To Parallel—To throw a machine on the line in "parallel" with machines already operating.

Bring the machine up to normal speed.

With a voltmeter connected to its terminals, gradually bring up the voltage by cutting out resistance in the rheostat until approximately the voltage of the other machines is reached. Throw in equalizer switch. Adjust voltage, if necessary. Throw in main switches. Adjust rheostat till generator takes its proportion of the load. The proper voltage to obtain before throwing a generator in parallel with others can be found by trial. It may vary slightly from line voltage depending on local conditions, regulation, etc.

Excitation of D. C. Generators—When starting up, a generator may fail to excite itself. This may occur even when the generator operated perfectly during the preceding run. It will generally be found that this trouble is caused by a loose connection or break in the field circuit, by poor contact at the brushes due to a dirty commutator or perhaps to a fault in the rheostat, or incorrect position of brushes. Examine all connections; try a temporarily increased pressure on the brushes; look for a broken or burnt out resistance coil in the rheostat. An open circuit in the field winding may sometimes be traced with the aid of a magneto bell; but this is not an infallible test as some magnetos will not ring through a circuit of such high resistance as some field windings have even though it be intact. If no open circuit is found in the rheostat or in the field winding, the trouble is probably in the armature. But if it be found that nothing is wrong with the connections or the winding it may be necessary to excite the field from another generator or some other outside source.

A very simple means for getting a compound-wound machine to pick up is to short-circuit it through a fuse having approximately the current capacity of the generator. If sufficient current to melt this fuse is not generated, it is evident that there is something wrong with the armature, either a short-circuit or an open circuit. If, however, the fuse has blown, make one more attempt to get the machine to excite itself. If it does not pick up, it is evident that something is wrong with the shunt winding or connections.

If a new machine refuses to excite and the connections seem to be alright, reverse the connections; i. e. connect the wire which leads from the positive brush to the negative brush and the wire which leads from the negative brush to the positive brush. If this change of connections does no good, change back and locate the fault.

To Shut Down Generator—Reduce the load as much as possible by throwing in resistance with the field rheostat.

Throw off the load by opening the circuit-breaker, if one is used, otherwise open the feeder switches and finally the main generator switches.

Shut down the driving machine.

Wipe off all oil and dirt, clean the machine and put it in good order for the next run.

Starting Constant-Speed Motors, Shunt or Compound—See that bearings are well supplied with a good lubricating oil and that oil rings are free to turn. Inspect all connections for loose screws or wires.

Make sure that the lever arm of the starting box or controller is in the "off" position. (See p. 20.)

Close the main switch.

Close the field switch.

Move lever arm of starting box or controller to the running position, pausing long enough on each notch to allow the motor to come up to the speed of that notch.

If using a controller, throw the short-circuiting switch and move controller handle back to the starting position. If using a starting box, the lever arm should remain in the running position.

To Shut Down Constant-Speed Motors—Open the main switch or circuit-breaker. (See pp. 43-44.)

After the motor has come to rest, see that the lever arm of the starting box has returned to its original position.

Open the field switches.

Clean the machine thoroughly and put in order for next run.

Starting Adjustable-Speed Motors—Examine shunt-field rheostat and see that all resistance is cut out.

Follow all directions given under "Constant Speed Motors."

After motor is running on full-line voltage, gradually cut in resistance in the shunt-field rheostat until the motor is up to the desired speed.

To Shut Down Adjustable-Speed Motors—Gradually cut out the resistance in the shunt-field rheostat until the machine is running on a full field.

Follow directions given under "To Shut Down Constant Speed Motors."

Starting Series Motors—Follow same instructions as those given for "Starting Constant Speed Motors," except there is no field switch to close.

To Shut Down Series Motors—Open main switch.

Examine machine carefully; wipe off all dirt or oil, and put in good shape for next run.

Opening of Feeder Circuits—If a line fuse blows or a circuit-breaker opens, first open the switch corresponding to that line, and then replace the fuse and close the breaker. The switch may now be closed again. If the circuit opens the second time, there is something wrong on the line—probably a short-circuit—and this should be corrected at once.

If for any reason, such as a short-circuit or a heavy overload on the line, the circuit-breakers or switches hold an arc when opened, such an arc should be extinguished if possible by using dry sand, a supply of which should always be kept conveniently at hand. In case the arc cannot be extinguished in this manner, as a last resort, open the field circuit of the machine or shut the generator down entirely. When the arc forms on the machine or on the generator side of the breakers, a shut-down is generally imperative, but should not be made if it can possibly be avoided. (See "Pyrene," p. 258.)

Brushes—The ends of all brushes should be fitted to the commutator so that they make good contact over their entire bearing face. This can be most easily accomplished after the brushholders have been adjusted and the brushes inserted. Lift a set of brushes sufficiently to permit a sheet of sandpaper to be inserted. Draw the sandpaper in the direction of rotation under the brushes releasing the pressure as the paper is drawn back being careful to keep the ends of the paper as close to the commutator surface as possible and thus avoid rounding the edges of the brushes. It will be found by this means a satisfactory contact is quickly secured, each set of brushes being similarly treated in turn. If the brushes are copper plated, their edges should be slightly beveled, so that the copper does not come in contact with the commutator.

Commutator surface speeds of direct-current turbo-generators are somewhat higher than for standard machines of other types owing to their larger diameter. For this reason it is usually necessary to use a self-lubricating brush. Brushes in the market that have this characteristic are ordinarily of graphite nature and are weaker mechanically and hence more easily broken than the carbon brushes for lower-speed machines. They are also softer and reasonable care should be exercised in handling them when the machine is taken apart or assembled. Rough handling or carelessness will probably cause breakage.

With graphite brushes of good quality, no oil should be necessary for lubricating the commutator; and as a rule, oil will have a tendency to "gum" the surfaces of the brushes, unless used very sparingly.

Besides maintaining the brushes in the proper position, the following points should be observed:

Make frequent inspection to see that—

Brushes are not sticking in holders.

Pig tail shunts are properly attached to brushes and holders.

Tension is changed as brush wears.

Copper plating is cut back so it does not make contact with the commutator.

Worn-out brushes are replaced before they reach their limit of travel and break contact with the commutator.

Remove any free copper picked up by the face of the brush.

Commutator—The commutator is perhaps the most important feature of the whole machine in that it is most sensitive to abuse. Under normal conditions, it should require little attention beyond frequent inspection. The surface should always be kept smooth, and if, through extreme carelessness, neglect, or accident, it becomes badly roughened, the armature should be removed and the commutator turned down in an engine lathe. Sometimes with large machine it is more convenient to rig up a temporary trueing device, leaving the armature in its own bearings and running it slowly either as a shunt motor or from a separate belted motor. Ordinarily, unless in very bad condition, it may be dressed down with a piece of sandstone conveniently mounted in a device especially designed for this purpose.

Sometimes a little sandpapering is all that is necessary. **Emery cloth or paper should never be used for this purpose** on account of the continued abrasive action of the emery which becomes embedded in the copper bars and brushes. Even when sandpaper is used the brushes should be raised and the commutator wiped clean with a piece of canvas lubricated with a very small quantity of vaseline or oil. Cotton waste should never be used and an excess of lubricant must be avoided.

Under normal conditions the commutator should become dark and highly polished after a few weeks' operation, and so remain unchanged for years.

Trouble is sometimes experienced from the burning out of mica insulation between segments. This is most commonly caused by allowing the mica to become oil soaked or by the bars loosening and thus allowing foreign conducting material to work its way in between them. It is rarely, if ever, definitely traced to excessive voltage between bars. When this burning does occur it may be effectively stopped by scraping out the burned mica and filling the space with a solution of sodium silicate (water glass), or other suitable insulating cement.

Even with the most careful workmanship, high mica will sometimes develop and start sparking, which burns away the copper and aggravates the difficulty. By prompt action, serious damage can be prevented by cutting away the mica to a depth of one-thirty-second to one-sixteenth of an inch below the adjacent copper. A hack-saw blade held between suitable guides will serve the purpose of a cutter.

Bearings—Most machines have self-oiling bearings. The well should be filled to such a height that the rings will carry sufficient oil upon the shaft. If the bearings are too full oil will be thrown out along the shaft. The oil should be renewed about once in six months, or oftener if it becomes dirty and causes the bearings to heat. Bearing housings are usually supplied with outlet holes for overflow of the oil. The oil should be kept slightly below the level of the holes.

The bearings must be kept clean and free from grit. They should be frequently examined to see that the oil supply is properly maintained and that the oil rings do not stick. Use only the best quality of oil. New oil should be run through a strainer if it appears to contain any foreign substance. If the oil is used a second time, it should first be filtered and, if warm, allowed to cool.

Hot Box or warm bearing is probably due to one of the following causes:

Excessive belt tension.

Failure of the oil rings to revolve with the shaft.

Rough bearing surface.

Improper fitting of the journal boxes.

Bent shaft.

Use of poor grade of dirty oil.

Bolts in the bearing cap may be too tight.

End thrust, due to improper leveling. A bearing may become warm because of excessive pressure exerted by the shoulder of the shaft against the side of the bearing.

End thrust, due to the magnetic pull, rotating part being "sucked" into the field because it extends beyond the field poles further at one end than at the other.

Excessive side pull, because the rotating part is out of center.

If a bearing becomes hot, first feed heavy lubricant copiously, loosening the nuts on the bearing cap; and then, if the machine is belt-connected, slacken the belt. If relief is not afforded, shut down, keeping the machine running slowly until the shaft is cool, in order that the bearing may not "freeze." Renew the oil supply before starting again. A new machine should always be run at a slow speed for an hour or so in order to see that it operates properly. The bearings should be carefully watched to see that the oil rings are revolving and carry a plentiful supply of oil to the shaft.

Belts—The belt on a belt-connected machine should be tight enough to run slowly without slipping, but the tension should not be too great or the bearings will heat. Belts should run with the inside lapping, not against it, and the joints should be dressed smooth so that there will be no jarring as it passes over the pulley. The crowns of driving and driven pulleys should be alike as "wobbling" of belts is sometimes caused by pulleys having unlike crowns. If this is caused by bad joints, they should be broken and cemented over again. A wave motion or flapping is usually caused by slippage between the belt and pulley, resulting from grease spots, etc. It may, however, be a warning of an excessive overload. This fault may sometimes be corrected by increasing the tension, but a better remedy is to clean the belt. A back and forth movement on the pulley is caused by unequal stretching of the edges of the belt. If this does not cure itself shortly examine the joints. If they are evenly made and remain so, the belt is bad and should be discarded. See formula for belting, page 252.

Sparking at the brushes may be due to any one of the following causes:

The machine may be overloaded.

The brushes may not be set exactly at the point of commutation. A position can always be found where there is no perceptible sparking, and at this point the brushes should be set and secured.

The brushes may be wedged in the holders or have reached the end of their travel.

The brushes may not be fitted to the circumference of the commutator.

The brushes may not bear on the commutator with sufficient pressure.

The brushes may be burnt on the ends.

The commutator may be rough, if so, it should be smoothed off with sandpaper, *not emery cloth.*

A commutator bar may be loose or may project above the others.

The commutator may be dirty, oily or worn out.

The carbon brushes may be of an unsuitable grade.

The brushes may not be equally spaced around the periphery of the commutator.

Some brushes may have extra pressure and may be taking more than their share of the current.

High mica.

Vibration of the brushes.

These are the more common causes, but sparking may be due to an open circuit or loose connection in the armature. This trouble is indicated by a bright spark which appears to pass completely around the commutator, and may be recognized by the scarring of the commutator at the point of open circuit. If a lead from the armature winding to the commutator becomes loose or broken it will draw a bright spark as the break passes the brush position. This trouble can be readily located, as the insulation on each side of the disconnected bar will be more or less pitted.

The commutator should run smoothly and true, with a dark, glossy surface.

Heating of Field Coils—Heating of field coils may develop from any of the following causes:

Too low speed.

Too high voltage.

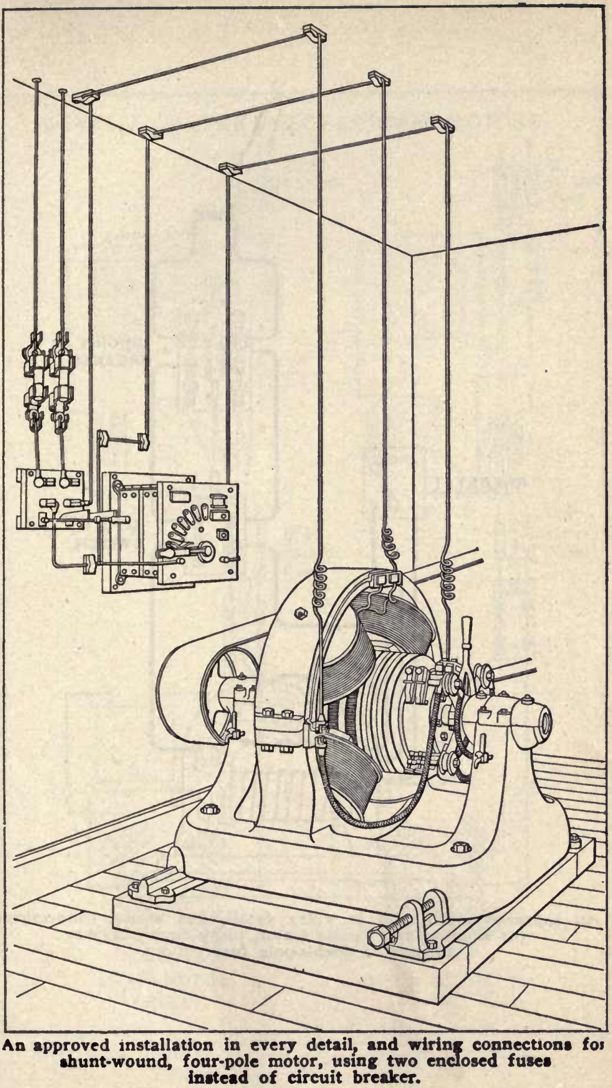
Too great forward or backward lead of brushes.

Partial short-circuit of one coil.

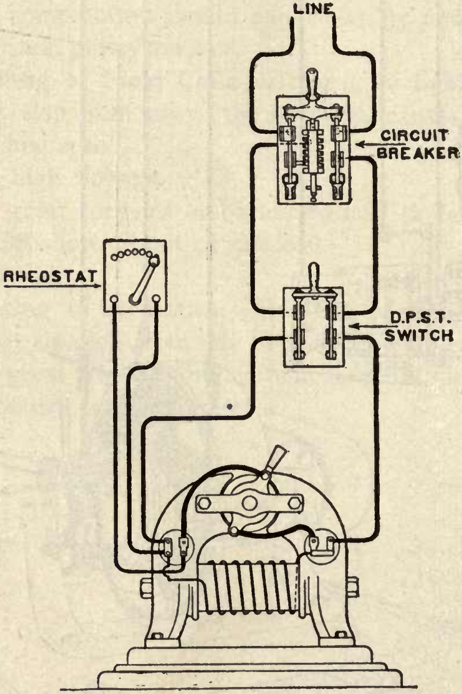
Overload.

Heating of Armature—Heating of the armature may develop from any of the following causes:

Too great a load. Short circuit in coils. Grounds on armature or commutator.

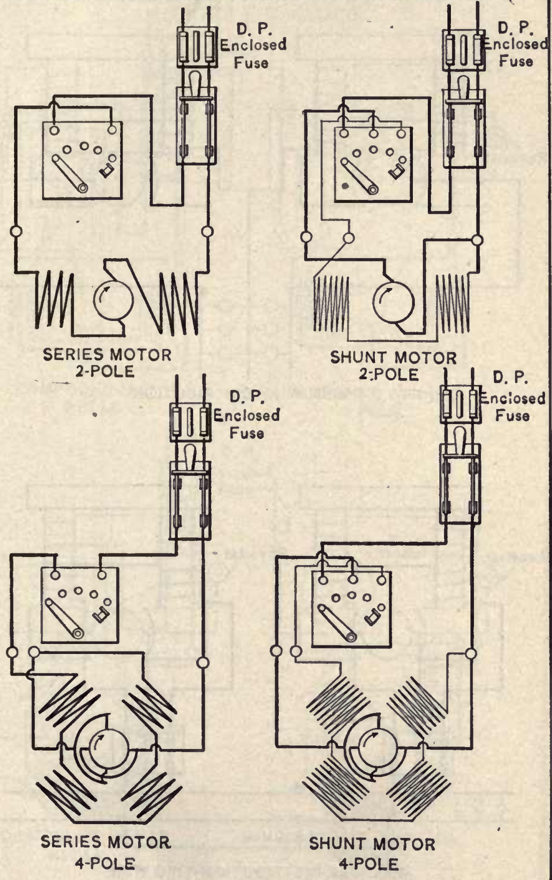


An approved installation in every detail, and wiring connections for shunt-wound, four-pole motor, using two enclosed fuses instead of circuit breaker.

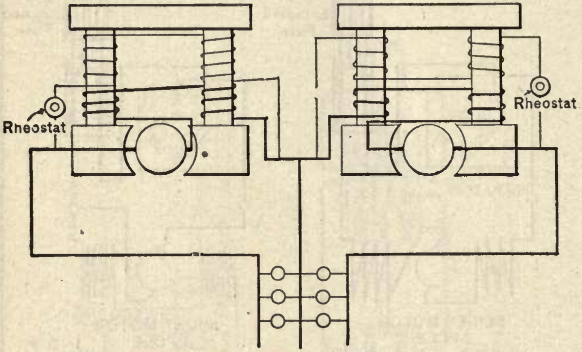


An approved installation in every detail, and wiring connections, for shunt-wound bipolar motor, using circuit breaker instead of double-pole fuse cut-out.

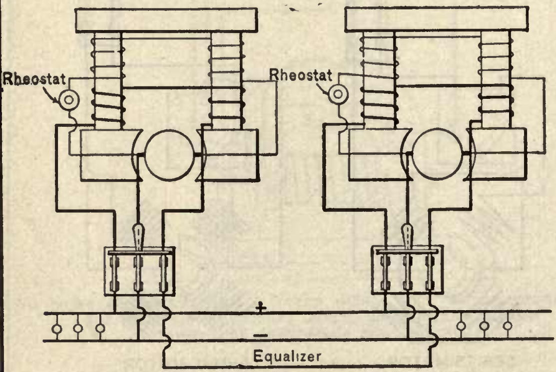
CONNECTIONS FOR DIRECT CURRENT MOTORS



CONNECTIONS FOR DIRECT CURRENT DYNAMOS.

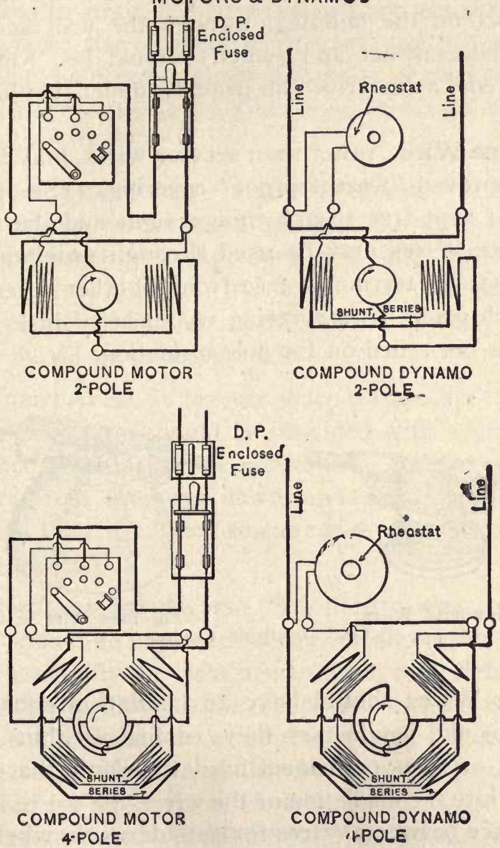


THREE WIRE DISTRIBUTION



MULTIPLE DISTRIBUTION-TWO WIRE

CONNECTIONS FOR DIRECT CURRENT MOTORS & DYNAMOS

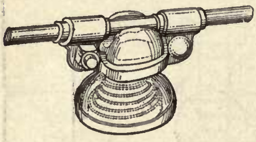


OUTSIDE WIRING AND CONSTRUCTION

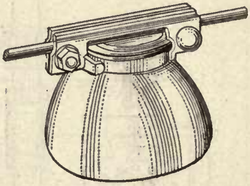
Service Wires (those leading from the outside support on the building, through the wall and to the main cut-out and switch) should be "Rubber Covered," as described on page 76, under that heading.

Line Wires, other than service wires, may have an approved "weatherproof" covering. (See page 78,) if kept free from awnings, signs and shutters.

Bare Wires may be used through uninhabited and isolated territories free from all other wires, as in such places wire covering would be of little use, as it is not relied on for pole insulation.



For Insulated Wires.



For Bare Wire or Cable.

Clark Insulator Clamps.

Tie Wires should have an insulation equal to that of the conductors they confine, within city limits, or some permanent insulated clamp that will not injure the insulation of the wires.

Space between Wires for outside work, whether for high or low tension, should be at least one foot, and care should be exercised to prevent any possibility of a cross connection by water. Wires should never come in contact with anything except their insulators. They may, however, be run in the form of multiple conductor cable or in conduit. When multiple conductor cables are used they should be secured to strain insulators spaced not less than one foot from any adjacent wood work and in turn secured to petticoat or strain insulators by strain wires.

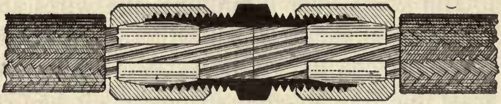
When conduit is used the conduit system should be waterproof.

Roof Structures. If it should become necessary to run wires over a building, the wires should be supported on racks which will raise them from 8 to 12 feet above flat roofs, as shown on page 53, or at least one foot above the ridge of pitched roofs, and should be strongly made.

Guard Arms. Whenever sharp corners are turned, each cross arm should be provided with a dead insulated guard arm, or guard iron, to prevent the wires from dropping down and creating trouble, should their insulating support give way. (See Fig. 2, page 74.)

Petticoat Insulators. (See illustrations on page 51) should be used exclusively for all outside work, and especially on cross arms, racks, roof structures and service blocks. Porcelain knobs, cleats or rubber hooks should never be used for this heavy outside work. In fact, rubber hooks are not now approved for any form of electric light or power work. Wires on exterior walls of buildings should be supported at least every fifteen feet and this distance should be even shorter if the wires are liable to be disturbed.

Splicing of two pieces of wire or cable should be so done as to be mechanically and electrically secure without solder. They should then be soldered, unless made with some form of *approved* splicing device. This ruling applies to joints and splices in all classes of wiring. All joints whether soldered or made with an approved splicing device should be covered with an insulation equal to that of the conductors.



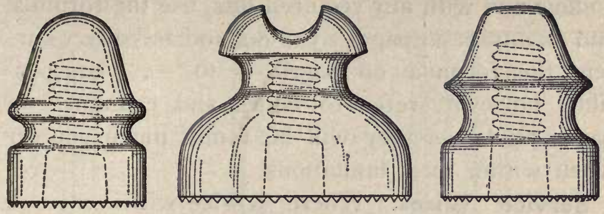
The Dossert Solderless Cable Connector approved for use on stranded wires and cables without the use of solder.

Tree Wiring. Whenever a line passes through the branches of trees, it should be properly supported by insulators, as shown on page 41, to prevent the chafing of the wire insulation and grounding the circuit.

The tree insulators shown on the opposite page have proved themselves to be practical and permanent insulators for all kinds of tree construction, allowing the free swaying of limbs without chafing the insulation of the wires.

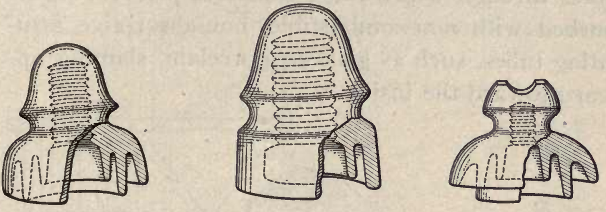
Service Blocks which are attached to buildings, should have at least two coats of waterproof paint to prevent the absorption of moisture.

Size of Wire. To find the required size of wire in circular mils for any alternating current system, to carry any required current any distance at any



Hemingray.

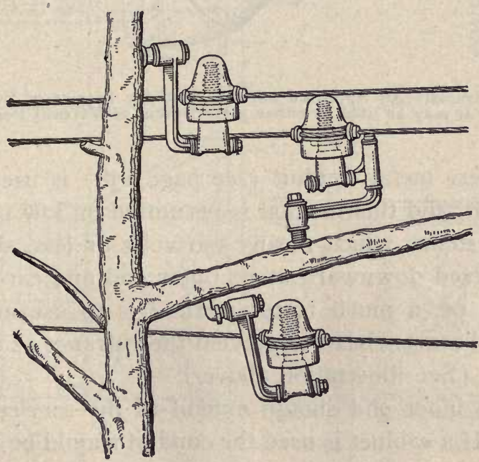
3000 Volts | 10000 Volts | 5000 Volts



Brookfield.

6000 Volts | 4000 Volts | 15000 Volts

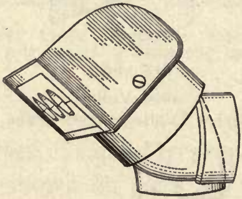
For Higher Voltages See Page 161.



Tree Insulators

voltage and with any required loss, use the formulæ and examples on pages 83 to 89, and for direct current the formulæ on pages — to —, when possible, however, refer to tables and examples on pages 79-82, as they will be found much simpler when within their limitations.

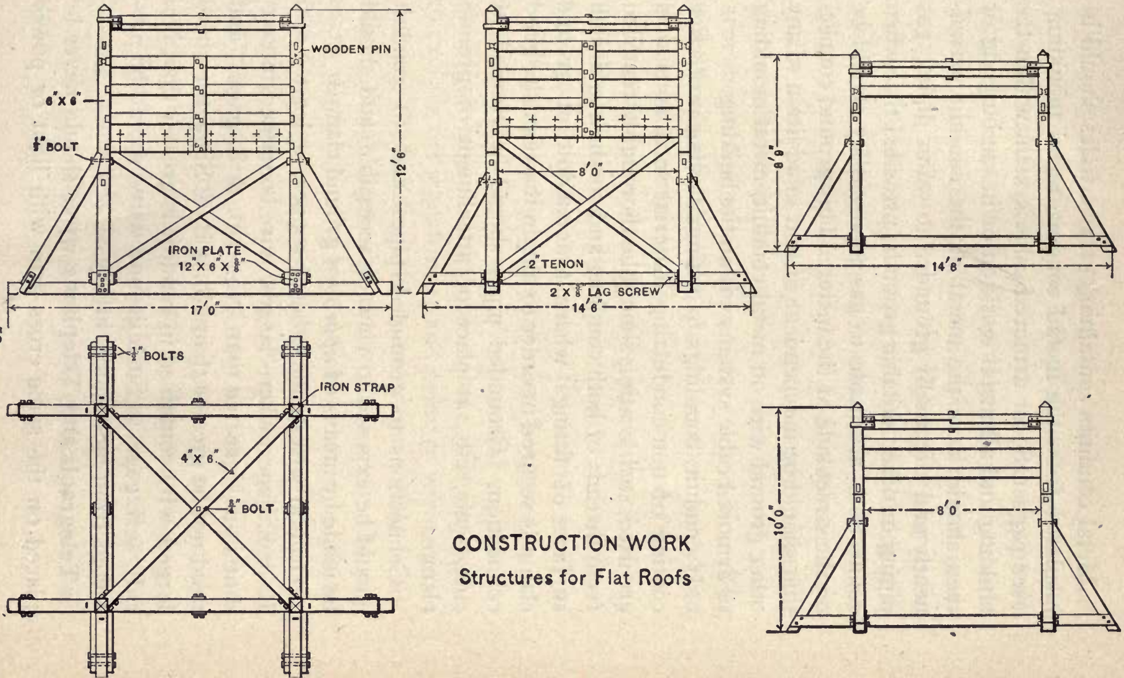
Service Wires. Where service wires enter a building they should have drip loops outside and the holes through which the conductors pass should be bushed with non-combustible, non-absorptive insulating tubes, such as glass or porcelain, slanting upward toward the inside.



G-V Universal—An Approved Service Head for Service or Entrance Wires. It may be used in either a Horizontal or Vertical Position.

Where metal conduit (see page 138) is used the conduit, and this method is permitted on low potential systems, which means 550 volts or less, should be curved downward at its outer end and carefully sealed or, a much better method is to use an approved service-head to prevent the entrance of moisture. (See illustration above.)

The inner end should extend to the service cutout. If a cabinet is used the conduit should be properly carried within the cabinet.



CONSTRUCTION WORK

Structures for Flat Roofs

Metal conduits containing service wires should be insulated from the metad conduit, metal moulding, (see page 128) or armored cable system within the building and all metal work on or in the building or they should 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 to gas piping, they should be on the street side of the meter. This ground connection should be independent of and in addition to any other ground wire on metal conduit, metal moulding or armored cable systems within the building.

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

Connections to grounded pipes and to conduit should be exposed to view or accessible, and should be made by means of *approved* ground clamps.

Ground wires should be of copper, at least No. 6 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.) Such ground wires should be protected from mechanical injury.

Telegraph and Telephone wires should never be placed on the same cross arm with light or power wires, especially when alternating currents are used, as trouble will arise from induction, unless expensive special construction, such as the transposing of the lighting circuits, be resorted to at regular intervals. Even under these conditions it is bad practice, as an accidental contact between the lighting or power circuit might result in starting a fire in the building to which the telephone line is connected. If, however, it is necessary to place telegraph and telephone wires on the same poles with lighting and power wires, the distance between the two inside pins of each cross arm should not be less than twenty-six inches. The metallic sheaths to cables should be thoroughly and permanently connected to earth every 500 feet.

Transformers should not be placed inside of any building excepting central stations or sub-stations, and should not be attached to the outside walls of buildings when the potential exceeds 550 volts, unless separated therefrom by substantial supports as shown on page 60. In cases where it is impossible to exclude the transformer and primary wiring from entering the building, the transformer should be located as near as possible to the point where the primary wires enter the building, and should be placed in a vault or room constructed of or lined with fire-resisting material, and should contain nothing but the transformers. It is, of course, the safest practice to place all transformers on poles away from the building that is to be wired, as illustrated on page 60. Special permission should always be secured, in writing, when it is desired to install transformers on or inside of buildings other than central or sub-stations.

Where transformers are to be connected to high-voltage circuits, it is necessary in many cases, for best protection to life and property, that the secondary system be permanently grounded, and provision should be made for it when the transformers are installed.

Grounding of Low-Potential Circuits. The grounding of low-potential circuits is only recommended when such circuits are so arranged that under normal conditions of service there will be no appreciable passage of current over the ground wire.

In Direct-Current 3-Wire Systems the neutral wire should, except in the case of private individual power or lighting plants where the primary voltage does not exceed 550, be grounded, and when grounded the following suggestions should be complied with:

1—They should be grounded at the central station on a metal plate buried in coke beneath permanent moisture level (see directions for securing good ground on pages 12 and 13), and also through all available underground water and gas pipe systems.

2—In underground systems the neutral wire should also be grounded at each distributing box through the box.

3—In overhead systems the neutral wire should grounded every 500 feet.

In Alternating-Current Secondary Systems. All transformer secondaries of distributing systems should be grounded, provided the maximum difference of potential between the grounded point and any other point in the circuit does not exceed 150 volts and may be grounded when the maximum difference of potential between the grounded point and any other point in the circuit exceeds 150 volts. The following suggestions, in either case, should be complied with:

1—The grounding should be made at the neutral point or wire, whenever a neutral point or wire is accessible.

2—When no neutral point or wire is accessible one side of the secondary circuit should be grounded.

3—The ground connection should be at the transformer or on the individual service and when transformers feed systems with a neutral wire, the neutral wire should also be grounded at least every 500 feet.

Ground Connections. When the ground connections are inside of any building, or the ground wire is inside of, or attached to any building (except central or sub-stantion) the ground wire should be of copper and have an approved rubber insulating covering for 600 volts (see page 76.)

The ground wire in direct-current 3-wire systems should not at central stations be smaller than the neutral wire and not smaller than No. 6 B. & S. gage elsewhere. The ground wire in alternating-current systems should never be less than No. 6 B. & S. gage.

On 3-phase systems, the ground wire should have a carrying capacity equal to that of any one of the three mains.

The ground wire should, except for central stations and transformer sub-stations, be kept outside of buildings as far as practicable, but may be directly attached to the building or pole by cleats or porcelain knobs. Staples should never be used. The wire should be carried in as nearly a straight line as practicable, avoiding kinks, coils and sharp bends, and should be protected when exposed to mechanical injury.

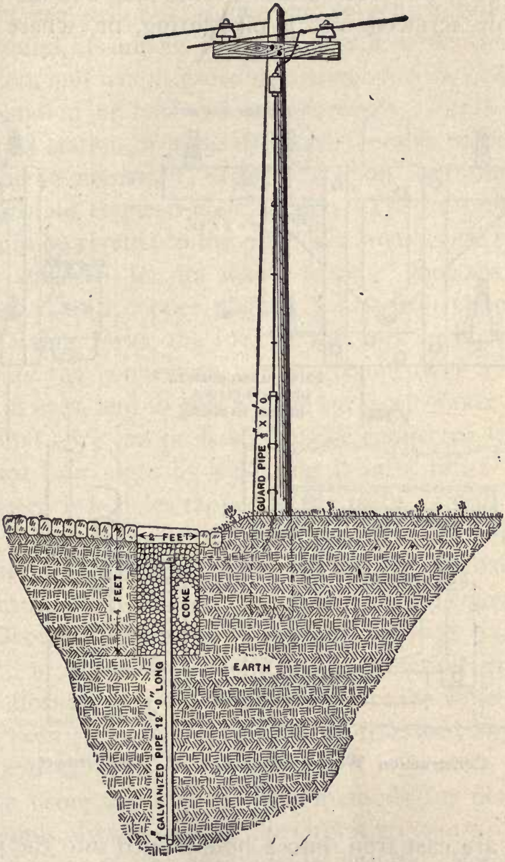
This protection can be secured by use of an approved moulding, and as a rule the ground wire on the outside of a building should be in moulding at all places where it is within seven feet from the ground. Conduit may be used for this purpose.

The ground connections for central stations, transformers, sub-stations, and banks of transformers should be made through metal plates buried in coke below permanent moisture level, and connection should also be made to all available underground piping systems, including the lead sheath of underground cables.

For individual transformers and building services, the ground connection may be made to water piping systems running into buildings. This connection may be made by carrying the ground wire into the cellar and connecting on the street side of meters, main cocks, etc.

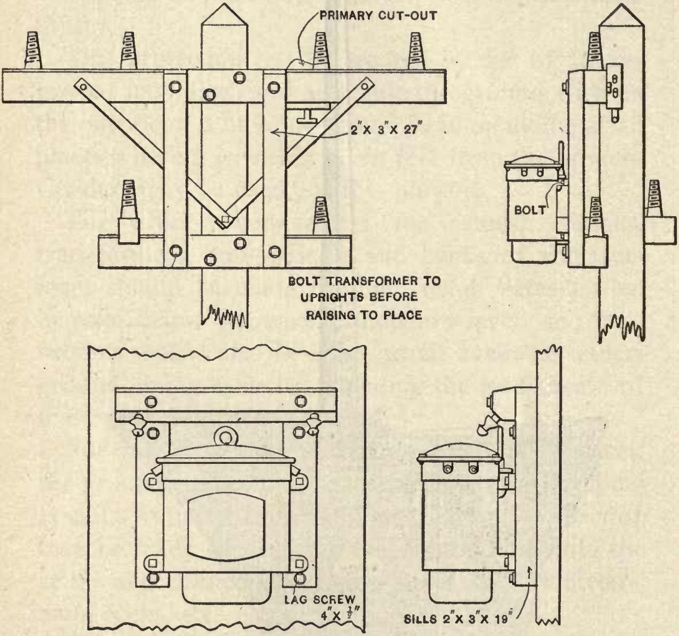
Where it is necessary to run the ground wire through any part of a building it should be protected by approved porcelain bushings through walls or partitions and should be run in approved moulding, or conduit, except that in basements it may be supported on porcelain.

In connecting a ground wire to a piping system, the wire should be sweated into a lug attached to an



Installation of Lightning Arrester on outside lines, showing method of obtaining a good "ground."

approved clamp, and the clamp firmly bolted to the water pipe after all rust and scale have been removed; or be soldered into a brass plug and the plug forcibly screwed into a pipe-fitting, or, where the



Construction Work—Installation of Transformers.

pipes are cast iron, into a hole tapped into the pipe itself. For large stations, where connecting to underground pipes with bell and spigot joints, it is well to connect to several lengths, as the pipe joints may be of rather high resistance.

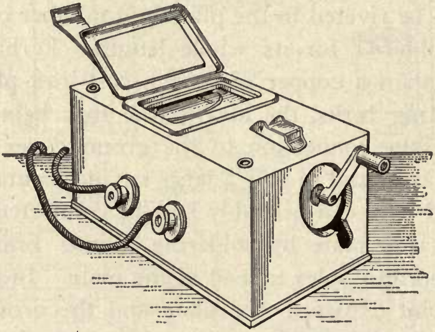
Where ground plates are used, a No. 16 Stubbs gage copper plate, about three by six feet in size, with about two feet of crushed coke or charcoal, about pea size, both under and over it, would make a ground of sufficient capacity for a moderate-sized station, and would probably answer for the ordinary sub-station or bank of transformers. For a large central station, a plate with considerable more area might be necessary, depending upon the other underground connections available. The ground wire should be riveted to the plate in a number of places, and soldered for its whole length. Perhaps even better than a copper plate is a cast-iron plate with projecting forks, the idea of the fork being to distribute the connection to the ground over a fairly broad area, and to give a large surface contact. The ground wire can probably best be connected to such a cast-iron plate by soldering it into brass plugs screwed into holes tapped in the plate. In all cases, the joint between the plate and the ground wire should be thoroughly protected against corrosion by painting it with waterproof paint or some equivalent.

Ground Detectors. The cuts on page 75 illustrate a few simple methods of detecting grounds on alternating and direct current circuits which have not been purposely grounded, as described on pages 56 and 57.

In using any one of these methods for detecting grounds always see that the circuit TO GROUND is left open after testing the outside circuits. Some central station men are in the habit of leaving the ground circuit closed on one side constantly in order that any ground that might occur on the other side may be instantly noticed. This, however, is bad practice, as it greatly reduces the insulation of the whole system. Test all circuits once a day.

MEASURING RESISTANCE

It is frequently necessary to know just what the insulation resistance of a line, or the wiring in a building, is in ohms.



The "Megger" for Measuring Resistance.

Heretofore such tests have been made with some form of portable testing set (Wheatstone Bridge), or by the voltmeter method; inconvenient calculations being necessary in either case.

Now, however, there is on the market a new instrument, called the Evershed Megger, by means of which conductor or insulation resistance can be measured as quickly and as accurately as voltage is measured with a voltmeter. A small hand generator is mounted in the case, so that no outside source of current is required.

Tests by the "Megger-method" are made as follows: Connect a wire from one side of the circuit to binding post of the Megger marked "Line," and with another piece of wire connect a water pipe to the "earth" binding post of the Megger. Turn the generator handle at one end of the Megger case, and the pointer of the instrument will instantly show the correct resistance—the scale being graduated in ohms.

As the generator voltage is usually 100 or 250 volts, there is the added advantage that tests by the "Megger-method" are practically made under working conditions.

Wire for Outside Use has, in most cases, a "weather-proof" (see page 78) insulation, except service wires, which should be "rubber covered" (see page 76). Any insulating covering for wires exposed to the weather on poles is in time rendered useless. The real insulation of the system is dependent upon the porcelain or glass insulators on which the wires are supported.

Constant-Potential Pole Line Circuits of over 5,000 volts should be given special care and attention as to their installation and location with respect to adjoining or near-by property or other outside wiring.

Accidental crosses between such lines and low-potential lines may allow the high-voltage current to enter buildings over a large section of adjoining country. Moreover, such high-voltage lines, if car ried close to buildings, hamper the work of firemen in case of fire in the building.

It is fully understood that it is impossible to frame rules which will cover all conceivable cases that may arise in construction work of such an extended and varied nature.

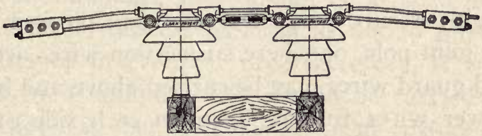
Every reasonable precaution, however, should be taken in arranging routes so as to avoid exposure to contacts with other electric circuits. On existing lines, where there is a liability to contact, the route should be changed by mutual agreement between the parties interested wherever possible.

Such lines should not approach other pole lines nearer than a distance equal to the height of the taller pole line, and such lines should not be on the same poles with other wires, except that signaling wires used by the company operating the high-pressure system, and which do not enter property other than that owned or occupied by such comany may be carried over the same poles.

When such lines must necessarily be carried near other pole lines, or where they should necessarily be carried on the same poles with other wires, extra precautions to reduce the liability of a breakdown to a minimum should be taken, such as the use of wires of ample mechanical strength, widely spaced cross arms, short spans, double or extra heavy cross arms (see page 74), extra heavy pins, insulators, and poles thoroughly supported. If carried on the same pole with other wires, the high-pressure wires should be carried at least three feet above the other wires.

Where such lines cross other lines, the poles of both lines should be of heavy and substantial construction.

Whenever it is feasible, end insulator guards should be placed on the cross arms of the upper line. If the high-pressure wires cross below the other lines, the wires of the upper line should be dead-ended at each end of the span to double-grooved, or to standard transposition insulators, and the line completed by loops.



Clark Protective Clamping Set for High Tension Crossings. This set is designed for use at crossings and at such other points as it is essential that the conductor be fastened to the insulator in a most efficient manner. It is approved by the larger Telephone, Railroad and Central Station Companies for use at their crossings.

One of the following forms of construction may be adopted:

The height and length of the cross-over span may be made such that the shortest distance between the lower cross-arms of the upper line and any wire of the lower line will be greater than the length of the cross-over span, so that a wire breaking near one of the upper pins would not be long enough to reach any wire of the lower line. The high-pressure wires should preferably be above the other wires, or

A joint pole may be erected at the crossing point, the high-pressure wires being supported on this pole at least three feet above the other wires. Mechanical guards or supports should then be provided, so that in case of the breaking of any upper wire, it will be impossible for it to come into contact with any of the lower wires.

Such liability of contact may be prevented by the use of suspension wires, similar to those employed for suspending aerial telephone cables, which will prevent the high-pressure wires from falling, in case they break. The suspension wire should be supported on high-potential insulators, should have ample mechanical strength, and should be carried over the high-pressure wires for one span on each side of the joint pole, or where suspension wires are not desired guard wires may be carried above and below the lower wires for one span on each side of the joint pole, and so spread that a falling high-pressure wire would be held out of contact with the lower wires. (See Clark method on page 65.)

Such guard wires should be supported on high-potential insulators, or should be grounded. When grounded, they should be of such size, and so connected and earthed that they can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction should be such that the guard wires will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

Whenever neither of the above methods is feasible, a screen of wire should be interposed between the lines at the cross-over. This screen should be supported on high tension insulators or grounded, and should be of such construction and strength as to prevent the upper wires from coming into contact with the lower ones.

If the screen is grounded each wire of the screen must be of such size and so connected and earthed that it can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction should be such that the wires of screen will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

When it is necessary to carry such high-voltage lines near buildings, they should be at such height and distance from the building as not to interfere with firemen in event of fire; therefore, if within 25 feet of a building, they should be carried at a height not less than that of the front cornice, and the height should be greater than that of the cornice, as the wires come nearer to the building.

It is evident that when the roof of the building continues nearly in line with the walls, as in Mansard roofs, the height and distance of the line should be reckoned from some part of the roof instead of from the cornice.

POLES FOR LIGHT AND POWER WIRES

It is very essential to a proper installation that the poles receive due consideration, a fact that is too often overlooked.

In selecting the style of pole necessary for a certain class of work, the conditions and circumstances should be considered. They may be arranged in three classes, the size of wire they are to carry being one of the important regulating circumstances.

First Class. Alternating-current plants for lighting small towns. Main line of poles should consist of poles of from 30 to 35 feet with 6-inch tops. These are strong enough for all the weight that is placed upon them. No pole less than 30 feet with 6-inch top should be placed on a corner for lamps. The height of trees, of course, will have to be considered in many cases.

Second Class. All poles should have at least 6½-inch tops, and wherever the cross arms are placed on a pole at different angles, the pole should be even thicker at its top.

Third Class. Where heavy wire, such as No. 00, is used for feeder wire, the poles should be at least 7-inch tops. Where mains are run on the same pole line the strain is somewhat lessened.

Cull Poles. The question as to what is a cull pole is something on which many authorities differ. Of course, if specifications call for a certain-sized pole, parties supplying the poles should be compelled to send the sizes called for. All poles that are smaller at the top than the sizes agreed upon, show signs of dry rot, large knots and bumps, have more than one bend, or have a sweep of over twelve inches, should certainly be classed as cull poles. Specifications for electric light and power work should be, and in many cases are, much more severe than those required by telegraph lines. A cull pole, one of good material, is the best thing for a guy stub, and is frequently used for this purpose. A cedar pole is always preferable to any other, owing to the fact that it is very light in comparison to other timber, and is strong, durable, and very long lived.

Pole Setting. In erecting poles, it seems to be the universal opinion of the best posted construction men that a pole should be set at least five feet in the ground, and six inches additional for every five feet additional length above thirty-five feet. Also additional depths on corners. Wherever there is much moisture in the ground, it is of much value to paint or smear the butt ends of the pole with pitch or tar, allowing this to extend about two feet above the level of the ground. This protects the pole from rot at the base. The weakest part of the pole is just where it enters the ground. Never set poles further than 125 feet apart; spacing not over 110 feet is good practice.

Pole Holes should be dug large enough so that the butt of the pole can be dropped straight in without any forcing, and when the pole is in position only one shovel should be used, to fill in, the earth being thoroughly tamped down with iron tampers at every step until the hole is completely filled with solidly packed earth. Where the ground is too soft for proper tamping, a grouting composed of one part of Portland cement to two parts of sand mixed with broken stone may be used to make an artificial foundation.

Painting. When poles are to be painted, a dark olive green color should be chosen, in order that they may be as inconspicuous as possible. One coat of paint should be applied before pole is set, and one after pole is set. Tops should be pointed and thoroughly painted to shed water.

All poles 35 feet long and over are usually loaded on two cars.

For chestnut poles add 50 per cent. to weights as given in the following table:

CEDAR POLES FOR ELECTRIC LIGHT WORK.

SIZE.	Average weight, pounds each.	No. of Poles to a Car	SIZE.	Average weight, pounds each.	No. of Poles to a Car
25-ft., 5-inch top	200	150	35-ft., 7-inch top	650	90
25 " 5½ " "	225	130	40 " 6 " "	800	80
25 " 6 " "	250	100	40 " 7 " "	900	75
28 " 7 " "	400	80	45 " 6 " "	900	70
30 " 5 " "	300	110	45 " 7 " "	1000	65
30 " 6 " "	350	90	50 " 6 " "	1200	55
30 " 7 " "	420	75	55 " 6 " "	1400	45
35 " 6 " "	550	100			

Cross Arms. The distance from the top of the pole to the cross arm should be equal to the diameter of pole at the top. All cross arms should be well painted with one coat of paint before placing, and must be of standard size.

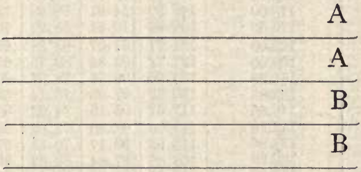
Cross arms of four or more pins should be braced, using one or two braces as occasion demands. Cross arms on one pole should face those on the next, thereby making the cross arms on every other pole face in one direction. All wooden pins should have their shanks dipped in paint and should be driven into the cross arm while the paint is wet. The upper part of the pin should also be painted. Put double arms on the pole where feeder wire end. (See page 74.)

Guard Irons. Guard irons should be placed at all angles in lines and on break arms. (See p. 74.)

Steps. All junction and lamp poles should be stepped so that the distance between steps on the same side of the pole will not be over 36 inches. Poles carrying transformers should also be stepped.

Guys. All poles at angles in the line should be properly guyed, using No. 4 B. & S. galvanized iron wire, or two No. 8 wires twisted. All junction poles should also be guyed.

For high tension lines, double or triple petticoat or suspension insulators are recommended. (See cuts on page 51 and 161.)



Primary Wires on Poles. When running more than one alternating current, single-phase primary circuit upon the same line of poles the wires of each circuit should be run parallel and on adjacent pins, as shown opposite, so as to avoid any fluctuation in the lamps due to induction. The lines lettered A and A are for circuit No. 1, and B and B for circuit No. 2, etc.

POLE LINE DATA

Gauge No. B. & S.		4-0	3-0	2-0	1-0	1	2
Diam. Bare wire, in Thousandths		.460	.40964	.3648	.3249	.2893	.2576
Ohms Res. B. wire at 75° per mile		.2622	.33	.4164	.5252	.6642	.8337
Wt. (lbs.) per 1,000 ft. Triple B..		775	630	490	400	306	268
Wt. " " Mile " "..		4092	3326	2587	2112	1616	1415
Poles per Mile	Dist. bet. Poles—Ft.	Approximate Wt. of Weatherproof Wire between Poles					
20	264.00	210.73	171.31	133.24	108.78	83.21	72.87
21	251.40	200.66	163.14	126.87	103.58	77.24	69.39
22	240.10	191.64	155.81	121.17	98.91	75.67	66.27
23	229.56	183.24	148.96	115.85	94.57	72.36	63.36
24	220.00	175.60	142.76	111.03	90.64	69.34	60.72
25	211.20	168.59	137.04	106.58	87.01	66.56	58.29
26	203.07	162.07	131.76	102.48	83.65	64.00	56.05
27	195.55	156.10	126.90	98.69	80.56	61.64	53.97
28	188.55	150.46	122.35	95.16	77.68	59.43	52.05
29	182.09	145.34	118.16	91.89	75.01	57.39	50.26
30	176.00	140.50	114.21	88.83	72.51	55.47	48.58
31	170.30	135.92	110.51	85.95	70.16	53.67	47.00
32	165.00	131.71	107.07	83.28	67.98	52.01	45.55
33	160.00	127.72	103.82	80.75	65.92	50.43	44.16
34	155.29	123.96	100.76	78.37	63.98	48.94	42.86
35	150.85	120.38	97.89	76.14	62.15	47.55	41.64
36	146.66	117.07	95.15	74.02	60.43	46.23	40.48
37	142.70	113.90	92.60	72.02	58.79	44.98	39.39
38	138.96	110.93	90.17	70.13	57.25	43.88	38.36
39	135.38	108.05	87.84	68.33	55.77	42.67	37.37
40	132.00	105.37	85.65	66.62	54.38	41 61	36.43
41	128.78	102.79	83 56	64.99	53.05	40.59	35.54
42	125.71	100.35	81.58	63.44	51.79	39.62	34.70
43	122.79	98.01	79.68	61.97	50.59	38.70	33.89
44	120.00	95.79	77.87	60.56	49.47	37.82	33.12
45	117.33	93.66	76.15	59.21	48.38	36.98	32.38
46	114.78	91.61	74.48	57.93	47.27	36.18	31.68
47	112.34	89.67	72.89	56.70	46.28	35.40	31.01
48	110.00	87.80	71.38	55.52	45.32	34.67	30.36
49	107.75	86.01	69.92	54.38	44.39	33.96	29.74
50	105.60	84.30	68.53	53 29	43.50	33.28	29.15
51	103.52	82.63	67.18	52.24	42.65	32.63	28.57
52	101.53	81.04	65.89	51.24	41.83	32.00	28.02
53	99.64	79.54	64.65	50.29	41.05	31.40	27.50
54	97.77	78.04	63.44	49.34	40.28	30.82	26.98
55	96.00	76.63	65.29	48.45	39.55	30.25	26.50

POLE LINE DATA—*Continued.*

Gauge No. B. & S.		No. 3	No. 4	No. 5	No. 6.	No. 7	No. 8
Diam. Bare Wire, Thousandths		.2294	.2043	.1819	.1620	.1442	.1285
Res. B. Wire, per mile at 75°		1.058	1.333	1.6748	2.114	2.673	3.387
Wt. 1,000 ft. Triple Braid		210	164	145	112		78
Wt. Mile " "		1109	866	766	591		412
Poles Per Mile	Distance Between Poles —Feet	Approximate Wt. of Weatherproof Wire between Poles					
20	264.00	57.10	44.59	39.43	30.45	......	21.21
21	251.40	54.38	42.46	37.54	29.00	......	20.20
22	240.10	51.93	40.55	35.86	27.70	......	18.29
23	229.56	49.65	38.77	34.28	26.48	......	18.44
24	220.00	47.59	37.16	32.86	25.38	......	17.67
25	211.20	45.68	35.68	31.54	24.36	......	16.97
26	203.07	43.92	34.30	30.33	23.42	......	16.32
27	195.55	42.29	33.03	29.21	22.56	......	15.71
28	188.55	40.78	31.85	28.16	21.75	......	15.15
29	182.09	39.39	30.76	27.19	21.00	......	14.63
30	176.00	38.07	29.73	26.29	20.30	......	14.14
31	170.30	36.83	28.77	25.43	19.64	.....	13.68
32	165.00	35.69	27.87	24.64	19.03	......	13 26
33	160.00	34.61	27.03	23.90	18.46	......	12.85
34	155.29	33.59	26.23	23.19	17.91	......	12.47
35	150.85	32.63	25.48	22.53	17.40	......	12.12
36	146.66	31.72	24.78	21.90	16.92	......	11.78
37	142.70	30.87	24.10	21.31	16.46	......	11.46
38	138.96	30.06	23.47	20.76	16.03	......	11.16
39	135.38	29.28	22.86	20.22	15.62	......	10.88
40	132.00	28.55	22.30	19.71	15.23	......	10.64
41	128.78	27.85	21.75	19.23	14.85	......	10.31
42	125.71	27.19	21.24	18.78	14.50	......	10.10
43	122.79	26.56	20.74	18.34	14.17	......	9.86
44	120.00	25.96	20.27	17.92	13.84	......	9.64
45	117.33	25.38	19.82	17.52	13.53	......	9.43
46	114.78	24.83	19.39	17.14	13.24	......	9.22
47	112.34	24.30	18.98	16.78	12.96	......	9.02
48	110.00	23.79	18.58	16.43	12.69	......	8.84
49	107.75	23.31	18.20	16.09	12.43	......	8.66
50	105.60	22.84	17.84	15.77	12.18	......	8.48
51	103.52	22.39	17.49	15.46	11.95	......	8.32
52	101.53	21.96	17.15	15.16	11.71	......	8.16
53	99.64	21.55	16.83	14.88	11.49	......	8.00
54	97.77	21.15	16.51	14.60	11.28	......	7.85
55	96.00	20.76	16.21	14 34	11.07	......	7.71

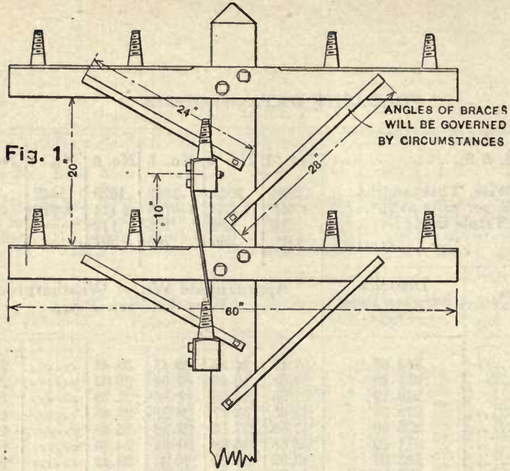


Fig. 1.

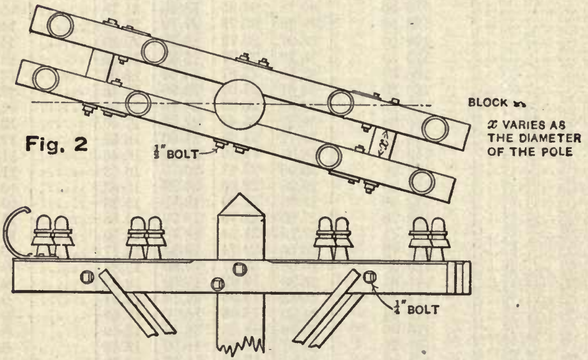


Fig. 2

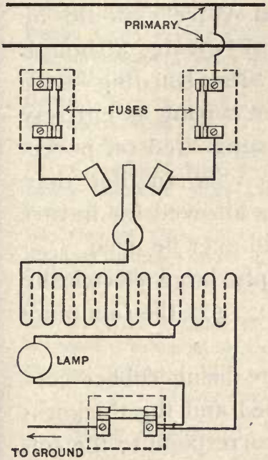
CONSTRUCTION WORK

Position of Cross-Arms when Turning Corners

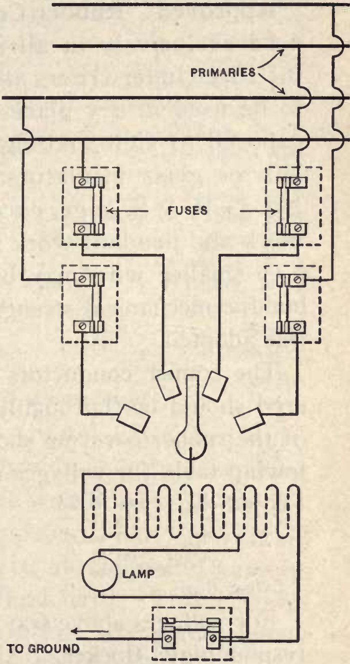
When running a heavy line where it is necessary to use two cross arms fastened as shown in Fig. 2. If lines are not heavy, only one cross arm will be necessary. In case lines cross the street diagonally, the arms where the wires leave and those to which they run are both set at an angle. When turning an abrupt corner, only one arm is turned. The above cannot be used where feeders tap into double branches. In such cases the method as given in Fig. 1 is used.

CONNECTIONS
OF
GROUND DETECTORS

ALTERNATING GROUND DETECTOR FOR ONE CIRCUIT

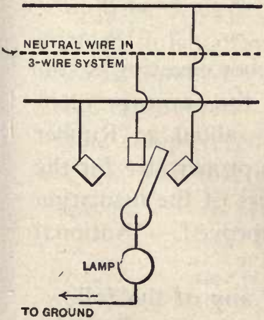


ALTERNATING GROUND DETECTOR FOR TWO CIRCUITS



IF THE LAMP BURNS A GROUND IS INDICATED ON THE OPPOSITE SIDE OF THE CIRCUIT FROM THAT TO WHICH THE SWITCH IS CONNECTED

DIRECT CURRENT GROUND DETECTOR



INSIDE WIRING

General rules for all systems and voltages for light, power and heat, when protected by service cut-out switch.

Approved "Rubber-Covered Wire" should be used exclusively in all interior wiring, although the Fire Underwriters allow "Slow Burning" wire to be used in dry places when wiring is entirely exposed to view and rigidly supported on porcelain or glass insulators. No wire smaller than No. 14 B. & S. gage, except as allowed for fixture work and pendant work should ever be used.

A smaller wire may be amply large electrically but for mechanical strength No. 14 is the minimum size adopted.

The copper conductors before being rubber covered should be thoroughly tinned and the thickness of the rubber covering should correspond to the following table for voltages up to 600:

From No.	14 to No.	8	inclusive,	3/64	inch
" "	7 to "	2	"	1/16	"
" "	1 to "	0000	"	5/64	"
	Over 0000 to "	500000 c. m.	"	3/32	"
	525000 to "	1000000 c. m.	"	7/64	"
Larger than	"	1000000 c. m.	"	1/8	"

For voltages above 600 the rubber covering is correspondingly thicker. All that the average contractor and wireman need know about a "Rubber Covered" wire is that it is of the proper size for the current it is to carry, the thickness of the insulation for the voltage and that it is approved.—"National Electrical Code Standard."

Consult your supply dealer or any of the following manufacturers who will furnish the proper insulation for the voltage required.

The list of Manufactturers of Approved "Rubber-Covered, Slow-Burning and Weatherproof Wire.

American Electrical Works....................Providence, R. I.
American Steel & Wire Co....................Worcester, Mass.
Atlantic Insulated Wire & Cable Co................New York.
Bishop Gutta Percha Co..............................New York.
Detroit Insulated Wire Co........................Detroit, Mich.
Electric Cable Co............................Bridgeport, Conn.
General Electric Co........................Schenectady, N. Y.
Habirshaw Wire Co.............................Yonkers, N. Y.
Indiana Rubber & Insulated Wire Co............Jonesboro, Ind.
Kerite Insulated Wire & Cable Co...................New York.
Lowell Insulated Wire Co.........................Lowell, Mass.
National India Rubber Co...........................New York.
The Okonite Co......................................New York.
Phillips Insulated Wire Co....................Pawtucket, R. I.
Roebling's Sons Co., John A....................Trenton, N. J.
Rome Wire Co.......................................Rome, N. Y.
Simplex Wire & Cable Co..............................Boston.
Standard Underground Cable Co......................Pittsburg.
Chicago Insulated Wire & Mfg. Co....................Chicago.
(*Slow-Burning and Weatherproof.*)

"Slow-Burning" Wire should have an insulation consisting of three braids of cotton or other thread with the interstices well filled with insulating and fire-proofing compound. The outer braid should be designed to resist abrasion and have its surface finished smooth and hard. This class of wire is especially useful in hot, dry places where "rubber covered" wires would perish.

The complete covering should be of a thickness not less than that given in the following table:

From No.	14 to No.	8	inclusive,	3/64	inch
" "	7 to "	2	"	1/16	"
" "	1 to "	0000	"	5/64	"
	0000 to "	500000 c. m.	"	3/32	"
	525000 to "	1000000 c. m.	"	7/64	"
Larger than	"	1000000 c. m.	"	1/8	"

"Weatherproof" Wire is for out-door use, where moisture is certain and where fireproof qualities are not so essential. It should have a covering of at least three braids thoroughly impregnated with a dense moisture repellent. The thickness of its insulation should correspond to that of "Slow Burning" wire.

Carrying Capacity of Wires. The table on page 91 gives the safe carrying capacity of wires from No. 18 B. & S. to cables of 2,000,000 circular mils. No wires smaller than No. 14 should be used except for fixture wiring and pendant cords. For fixtures as small as No. 18 may be used.

Tie Wires should have an insulation equal to that of the conductors they confine.

All wires of the size of No. 8 B. & S. gage or larger when used in connection with knobs should be securely tied thereto with tie wires having equal insulation.

Solid porcelain knobs should be used at the end of runs where circuits are terminated. Split knobs or cleats should be used for conductors smaller than No. 8 B. & S. gage, except at the end of runs.

All knobs or cleats should be fastened by screws or nails of generous length. If nails are used they should be long enough to penetrate the woodwork not less than one-half the length of the knob and fully the thickness of the cleat. Washers should be used with both screws and nails to prevent injury to the knobs or cleats.

Splicing should be done so as to make the wires mechanically and electrically secure without solder; then they should be soldered to insure preservation from corrosion and consequent heating from poor contact. Then thoroughly taped.

All joints in wires and cables should be soldered and then thoroughly taped, unless made with some form of *approved* splicing device such as Dossert joints. (See page 50.) This ruling applies to joints and splices in all classes of wiring.

Stranded Wires, except flexible cords, should have their tips soldered before being fastened under clamps or binding screws. Both solid and stranded wires having a conductivity greater than No. 8 B. & S. gage should be soldered into lugs for all terminal connection unless Dossert lugs are used.

Wiring Table for Direct Current. The following examples show the method of using the table on page 81.

1.—What size of wire should we use to run 50 25-watt Mazda lamps, of 110 volts, a distance of 150 feet to the center of distribution with the loss of 2 volts? First multiply the amperes, which will be 22.75 (50-25 watt 110-v. lamps take 11.35 amperes, see table on page 166) by the distance, 150 feet, which will equal 1702 ampere feet. Then refer to the columns headed "Actual Volts Lost," and as we are to have only a loss of two volts look down the column headed 2 until you come to the nearest corresponding number to 1702 and we find that 1542 is the nearest number. Put your pencil on the number 1542 and follow that horizontal column to the left until you come to the vertical column headed "Size B. & S." and you find that a No. 8 B. & S. wire will be the proper size to use in this case.

2. What size wire should we use to carry cur-

rent for a motor that requires 30 amperes and 220 volts, and is situated 200 feet from the distributing pole, the "drop" in volts not to exceed 2 per cent.? First multiply 30 amperes by 200 feet, as we did in the first example, and we get 6000 ampere feet. Now look at the upper left hand corner of the table and you will see a vertical column headed "Volts." Go down this column until you come to 220 and follow the horizontal column to the right until you come to the figure 1.8 which is the nearest we can come to a 2 per cent. loss without a greater loss or "drop." Place your pencil on a figure 1.8 and follow down the vertical column of figures until you come to the nearest corresponding figure to 6000, which we find to be 6200. Then with your pencil on this figure follow the horizontal column to the left and we find that a No. 5 B. & S. wire is a proper size to use for the above conditions.

3. Supposing we have occasion to inspect a piece of wiring, and find a dynamo operating 50-25 watt 110-volt Mazda lamps at a distance of 150 feet, and our wire gauge shows that wire in use is a No. 12 B. & S., at what loss, or "drop," are these lamps being operated? First multiply the amperes, which will be 11.35 (50-25 watt 110-volt Mazda lamps take 11.35 amperes (see table on page 166), by the distance, 150 feet and we get 1702 ampere feet. As we find in use a No. 12 B. & S. wire we look for the vertical column headed "Size B. & S." and follow it down until we come to 12. With our pencil on the figure 12 we travel along the horizontal line to the right until we come to the nearest corresponding number to 1702, which we find to be 1830. Then starting at

WIRING TABLE FOR LIGHT AND POWER,

Two Wire D. C. and Single Phase, A. C., and Four Wire Two Phase A. C.

Multiply current in amperes for D. C. and single phase, or amperes per phase (when Two Phase Four Wire) by single distance in feet and refer to the nearest corresponding number under column of Actual Volts lost, to find wire size.

Volts.	Percentage of Loss.													
2000	1.2	1.1	1.0	0.75	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05
1000	2.4	2.2	2.0	1.5	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
500	4.8	4.3	3.9	2.9	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2
220	10.3	9.3	8.3	6.5	4.4	3.9	3.5	3.1	2.7	2.2	1.8	1.4	0.9	0.45
110	18.5	17.0	15.4	12.0	8.4	7.6	6.8	6.0	5.2	4.4	3.5	2.7	1.8	0.9
52								11.8	10.3	8.8	7.1	5.5	3.7	1.9

Carrying Capacity *Amperes	Size. B. & S.	Actual Volts Lost.													
		25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	247000	222300	197600	148200	98800	88920	79040	69160	59280	49400	39520	29640	19760	9880
175	000	196000	176400	156800	117600	78400	70560	62720	54880	47040	39200	31360	23520	15680	7840
150	00	155375	139837	124300	93225	62150	55935	49720	43505	37290	31075	24860	18645	12430	6215
125	0	123250	110925	98600	73950	49300	44370	39440	34510	29580	24650	19720	14790	9860	4930
100	1	97750	87975	78200	58650	39100	35190	31280	27370	23460	19550	15640	11730	7820	3910
90	2	77500	69750	62000	46500	31000	27900	24800	21700	18600	15500	12400	9300	6200	3100
80	3	61500	55350	49200	36900	24600	22140	19680	17220	14760	12300	9840	7380	4920	2460
70	4	48750	43875	39000	29250	19500	17550	15600	13650	11700	9750	7800	5850	3900	1950
55	5	38750	34875	31000	23250	15500	13950	12400	10850	9300	7750	6200	4650	3100	1550
50	6	30750	27675	24600	18450	12300	11070	9840	8610	7380	6150	4920	3690	2460	1230
35	8	19275	17347	15420	11565	7710	6939	6168	5397	4626	3855	3084	2313	1542	771
25	10	12125	10912	9700	7275	4850	4365	3880	3395	2910	2425	1940	1455	970	485
20	12	7625	6862	6100	4575	3050	2745	2440	2135	1830	1525	1220	915	610	305
15	14	4800	4320	3840	2880	1920	1728	1536	1344	1152	960	768	576	384	192

Note:—In case a larger loss than any given in the table is required, proceed as follows: Divide the ampere feet by 10 and then refer to column of Actual Volts Lost divided by 10, from which we find the size wire as before. For examples worked out to illustrate the use of the above table see pages 79-82.

* Rubber insulation. For carrying capacity of weatherproof insulated wires. See table on page 91, fourth column.

this number we travel up the vertical column and we find a loss of about 6 actual volts, or at a 5 per cent. loss, which would greatly reduce the candle-power or brilliancy of the lamps. A larger wire should, therefore, be used.

A convenient type of pocket wire gauge, one-half actual size, for measuring wire from No. 18 to No. 000 B. & S. gauge. On the front is given the safe carrying capacity of copper wires in amperes, and on the reverse side the approximate decimal equivalent of the various sizes of wires.

Wiring Calculations for Alternating Current. When figuring wire sizes for Alternating Current, except in cases of long distances, the following methods of calculating should be used.

As compared with the circular mileage of each conductor of a two wire system, that of each conductor of other systems, transmitting same power with the same distance, volts lost, and lamp voltage is, for:—

3 wire, single phase..............25.0%
4 wire, single phase..............11.1%
4 wire, two phase.................50.0%
3 wire, two phase.................50.0% with
middle wire ....75 %
4 wire, three phase, with neutral..16.6%
3 wire, three phase...............50.0%

All wires of each system; except 3 wire two phase; considered of same size.

We will now take an example in each system and show how to calculate the wire size.

Three Phase, Three Wire. What size wire should we use to run 1-220 volt, 30 horsepower induction motor; and light 102-220 volt, 60 watt mazda lamps; a distance of 400 feet to the center of distribution with the loss of 7 volts?

Let us refer to the table on page 84. Here we see that the amperes per phase (same as amperes per terminal) of a 3 phase, 220 volt, 30 H.P. motor is 81. We must calculate the amperes per phase for the lamps by using this formula:—

$$\text{Amperes} = \frac{\text{total watts of lamps}}{1.73 \times \text{volts}}$$

APPROXIMATE AMPERES PER TERMINAL FOR ALTERNATING CURRENT INDUCTION MOTORS.

For determining capacity of fuses, setting of circuit breakers, and sizes of wires in connection with tables on pages 23 and 24.

H.P. of Motor	110 Volts			220 Volts			440 Volts			550 V.	1100 V.	2200 V.
	1 Phase	2 Phase	3 Phase	1 Phase	2 Phase	3 Phase	1 Phase	2 Phase	3 Phase	3 Phase	3 Phase	3 Phase
½	6.6	3.3	3.7	3.4	1.7	1.8	1.8	.9	1			
1	12	6	6.5	6	3	3.2	3	1.5	1.6			
2	21	10.5	12	19	5	6	5.2	2.6	3	2.5		
3	30	15	17	15	7.5	9	7.5	3.8	4.5	3.5		
5	54	27	30	26	13	15	13	6.5	7.5	6		
7½				40	20	22	20	10	11	9		
10				50	25	29	25	12.5	14	11		
15				71	35	41	36	18	20	16		
20				98	48	55	49	24	27	22		
25				110	54	62	56	27	31	25		
30				150	70	81		35	40	32	16	8
40				198	95	109		47	54	44	21	11
50				230	110	127		55	64	52	27	18
75					165	192		83	96	77	39	20
100					215	248		108	124	100	50	25
150					320	366		160	183	147	80	40
200					410	475		205	237	192	98	49
250					515	590		250	290	237	125	62
300					600	700		300	350	285	150	74

If the motor to be used does not come under **this** table the amperes per phase can easily be obtained from the manufacturer.

This table allows for Power Factor and efficiency, and no further calculations are necessary.

WIRING TABLE FOR LIGHT AND POWER—THREE PHASE, THREE WIRE.

For Three Phase, Four Wire, See Page 88.

Multiply current in amperes per phase by single distanceand refer to the nearest number under column of Actual Volts Lost, to find size of wire.

B. & S. Carrying Capacity *Amperes	Size	Actual Volts Lost. 25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
210	0000	286000	256000	227000	171000	114000	102000	91100	80000	68200	57000	45700	34200	22700	11400
177	000	266000	204000	181500	135200	90500	81500	72200	63200	54300	45200	36200	27200	18150	9050
150	00	179200	161300	144000	107000	71800	64300	57200	50200	42800	35800	28700	21600	14400	7180
127	0	142000	128000	113000	85200	57000	51200	45500	39800	34200	28300	22750	17090	11300	5700
107	1	110000	101500	905000	67700	45200	40500	36000	31600	27100	22600	18050	13540	9050	4520
90	2	89500	80800	71800	53700	35800	32300	28700	25000	21400	17900	14300	10800	7180	3580
76	3	71200	64000	56800	42650	28300	25500	22700	19900	17000	14200	11200	8520	5680	2830
65	4	55700	50700	45000	33700	22500	20250	18000	15760	13500	11200	9000	6750	4500	2250
54	5	44700	40200	35800	26800	17900	16100	14300	12360	10600	8950	7150	5370	3580	1790
46	6	35600	31800	28300	21300	14200	12700	11300	9900	8520	7100	5680	4270	2830	1420
33	8	22200	20000	17800	13330	8900	8000	7120	6220	5320	4450	3550	2660	1780	890
24	10	13950	12600	11000	8400	5590	5030	4480	3920	3360	2800	2240	1680	1100	559
17	12	8800	7910	7040	5285	3525	3170	2820	2470	2120	1760	1408	1040	704	352
12	14	5530	4980	4330	3330	2220	1993	1768	1552	1324	1110	886	664	433	222
6	16	3480	3140	2780	2090	1398	1255	1100	978	838	700	558	418	278	140

* Rubber covered, for weatherproof insulated wires, see page 81, fourth column.

In this case there are 102-60 watt lamps to be burned at 220 volts, therefore the

$$\text{Amperes per phase for lamps} = \frac{102 \times 60}{1.73 \times 220} = 16$$

Adding this to the 81 amperes for the motor we have $81 + 16 = 97$ for the total amperes per phase. Now let us look at the wiring table for three phase three wire circuits on page 85. It says at the top of this page "multiply current in amperes per phase by single distance (in feet) and refer to the nearest number under column of Actual Volts Lost, to find size of wire." Following these directions:—

$97 \times 400 = 38{,}800$; under column of 7 volts lost, the nearest number is 39,800, and following horizontally to the left, under column headed "Size B. & S." we find that No. 0 wire is our size, and since the allowable carrying capacity is 127 amperes, this size is permissible.

Two Phase, Three Wire. What size wire should we use to run 50-40 watt Mazda lamps and 1-10 H.P. induction motor, 220 volt service, a distance of 100 feet from the center of distribution, with a loss of 3 volts? There will be 25 lamps per phase and from the table on page 166 we find that the current taken by a 40 watt, 220 volt Mazda lamp is .1818 amperes; 25 of these lamps take $25 \times .1818 = 9.09$ amperes. Referring to the table on page 84 we note that the amperes per phase of a 10 H.P., 220 volt, 2 phase motor is 25. This, then, gives us a total of $25 + 9.09 = 34.09$ amperes per phase.

WIRING TABLE FOR LIGHT AND POWER—TWO PHASE, THREE WIRE.

For Two Phase, Four Wires, See Page 81

Multiply current in amperes per phase by single distance and refer to the nearest number under column of Actual Volts Lost to find size of wire.

Capacity Carrying *Amperes Outside Wires	Size B. & S. Outside Wires	Size B. & S. Middle Wire	Actual Volts Lost. 25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	300000C.M.	247000	222300	197600	148200	98800	88920	79040	69160	59280	49400	39520	29640	19760	9880
175	000	250000C.M.	196000	176400	156800	117600	78400	70560	62720	54880	47040	39200	31360	23520	15680	7840
150	00	0000	155375	139837	124300	93225	62150	55935	49720	43505	37290	31075	24860	18645	12430	6215
125	0	000	123250	110925	98600	73950	49300	44370	39440	34510	29580	24650	19720	14790	9860	4930
100	1	00	97750	97975	78200	58650	39100	35190	31280	27370	23460	19550	15640	11730	7820	3910
90	2	0	77500	69750	62000	46500	31000	27900	24800	21700	18600	15500	12400	9300	6200	3100
80	3	1	61500	55350	49200	36900	24600	22140	19680	17220	14760	12300	9840	7380	4920	2460
70	4	2	48750	43875	39000	29250	19500	17550	15600	13650	11700	9750	7800	5850	3900	1950
55	5	3	38750	34875	31000	23250	15500	13950	12400	10850	9300	7750	6200	4650	3100	1550
50	6	4	30750	27675	24600	18450	12300	11070	9840	8610	7380	6150	4920	3690	2460	1230
35	8	6	19275	17347	15420	11565	7710	6939	6168	5397	4626	3855	3084	2313	1542	771
25	10	8	12125	10912	9700	7275	4850	4365	3880	3395	2910	2425	1940	1455	970	485
20	12	10	7625	6862	6100	4575	3050	2745	2440	2135	1830	1525	1220	915	610	305
15	14	12	4800	4320	3840	2880	1920	1728	1536	1344	1152	960	768	576	384	192

NOTE.—In case a larger loss than any given in the table is required, proceed as follows:—Divide the ampere feet by 10 and then refer to column of Actual Volts Lost divided by 10, from which we find the size wire as before. For examples worked out to illustrate the use of the above table see page 75.

* Rubber insulation. For carrying capacity of weatherproof insulated wires. See page 81.

Turning to page 85 and following the directions given at the top of the table there given:—

$$34.09 \times 100 = 3409;$$

under the column of 3 volts loss, we find opposite the nearest number (3690) that we are to use No. 6 wire for the two outside lines and No. 4 wire for the middle one.

Two Phase, Four Wire. For this system of wiring calculate the amperes per phase the same as for 2 phase, three wire, and use the table on page 81 to find the size of wire. In the above problem under 2 phase, three wire, if we were to run a 2 phase, four wire service, we would use No. 6 wire for each line.

Three Phase, Four Wire, With Neutral. This system is very little used and therefore no table is given, but the sizes can be calculated in this way:— Calculate the circular mils necessary for a two wire system of the same total wattage, distance, volts lost and applied voltage and take as size for each wire 16.1%. For example, a system using a total of 10,000 watt, at 220 volts, 500 feet, and 10 volt drop, circular mils for two wire system =

$$\frac{10.8 \times 2 \times 500 \times 45.5}{10}$$

(formula given on page 239) = 49,000. 16.1% of this is 49,000 × .161 = 8,170. From table on page 85 we find that the nearest size (larger) is No. 10 wire, therefore we must use four wires of this size.

Single Phase, Two Wire. Calculate for this the same as for two wire D. C., using the table on page

81. In the case of motors, obtain the amperes required from table on page 84.

Single Phase, Three Wire. Calculate the size necessary for a two wire system of same power, voltage, volts lost, and distance, and take three wires of one-quarter the size thus calculated for this system. The same general method as given above under Three Phase, Four Wire.

Single Phase, Four Wire. Calculate the size necessary for a two wire system of same power, voltage, volts lost, and distance, and take 11.1% of the result for each wire in this system. The same general method as given above under Three Phase, Four Wire.

Installation of Wires (general suggestions for inside work.) All wiring, when not enclosed in approved conduit, moulding or armored cable, should be kept free from contact with gas, water or other metallic piping, or any other conductors or conducting material which they may cross, by some continuous and firmly fixed non-conductor, creating a separation of at least two inches, and in wet places should be arranged so that an air space will be left between conductors and pipes in crossing, and the former should be run in such a way that they cannot come in contact with the pipe accidentally. Where one wire crosses another wire the best and usual means of separating them is by a porcelain tube on one of the wires. The tubing should be prevented from moving out of place either by a cleat or knob on each end, or by taping it.

The same method may be adopted where wires pass close to iron pipes, beams, etc., or, where the wires are above the pipes, as is generally the case, ample protection can frequently be secured by supporting the wires with a porcelain cleat placed as nearly above the pipe as possible.

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. No smaller size than No. 14 B. & S. gauge should ever be used for any lighting or power work, not that it may not be electrically large enough but on account of its mechanical weakness and liability to be stretched or broken in the ordinary course of usage. Smaller wire may be used for fixture work, if provided with approved rubber insulation.

Wires should never be laid in or come in contact with plaster, cement or any finish, and should never be fastened by staples, even temporarily, but always supported on porcelain or glass insulators or cleats which will separate the wires at least one-half inch from the surface wired over and keep the wires not less than two and one-half inches apart. This style of wiring is intended for low voltage systems (550 volts or less), and when it is all open work and in dry places, rubber covered wire is not necessary as "Slow Burning" wire may be used. Wires should not be fished between floors, walls or partitions or in concealed places.

Twin wires should never be used, except in metal conduits; they are always unsafe for light or power circuits on account of the short distance between them.

CARRYING CAPACITIES AND DIMENSIONS OF WIRES AND CABLES.

As adopted by the National Board of Fire Underwriters of the United States.

For further dimensions of bare and insulated wires, see Index.

Gauge No. B. & S.	Diameter Mils	Area Circular Mils	No. Amperes Weatherproof Insulation	No. Amperes Rubber Covered	Ohms Per 1000 Ft. (68° F.)	Lbs. Per 1000 Feet Bare	Feet Per Lb. Bare
18.....	40	1 624	5	3	6.385	4.9	203.40
16.....	51	2 583	10	6	4.016	7.8	127.90
14.....	64	4 107	20	15	2.525	12.4	80.44
12.....	81	6 530	25	20	1.588	19.7	50.59
10.....	102	10 380	30	25	.999	31.4	31.82
8.....	128	16 510	50	35	.628	49.9	20.01
6.....	162	26 250	70	50	.395	79.4	12.58
5.....	182	33 100	80	55	.313	100.2	9.98
4.....	204	41 740	90	70	.248	126.4	7.91
3.....	229	52 630	100	80	.197	159.3	6.27
2.....	258	66 370	125	90	.156	200.9	4.97
1.....	289	83 690	150	100	.124	253.3	3.94
0.....	325	105 500	200	125	.098	319.5	3.13
00.....	365	133 100	225	150	.077	402.8	2.48
000.....	410	167 800	275	175	.062	507.9	1.96
0000.....	460	211 600	325	225	.049	640.9	1.56
Cables...	450	200 000	300	200	.0532	800	For weights of insulated wires, see pages 205-209.
" ...	630	300 000	400	275	.0335	932	
" ...	727	400 000	500	325	.0251	1242	
" ...	814	500 000	600	400	.0201	1553	
" ...	892	600 000	680	450	.0166	1863	
" ...	964	700 000	760	500	.0143	2174	
" ...	1030	800 000	840	550	.0125	2474	
" ...	1092	900 000	920	600	.0111	2795	
" ...	1152	1 000 000	1000	650	.0100	3106	
" ...	1209	1 100 000	1080	690	.0091	3416	
" ...	1263	1 200 000	1150	730	.0083	3727	
" ...	1314	1 300 000	1220	770	.0076	4038	
" ...	1364	1 400 000	1290	810	.0071	4348	
" ...	1413	1 500 000	1360	850	.0066	4658	
" ...	1459	1 600 000	1430	890	.0062	4968	
" ...	1504	1 700 000	1490	930	.0058	5278	
" ...	1548	1 800 000	1550	970	.0055	5588	
" ...	1572	1 900 000	1610	1010	.0052	5898	
" ...	1630	2 000 000	1670	1050	.0050	6208	

The lower current carrying limit (fifth column) is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation.

The carrying capacity of Nos. 18 and 16 B. & S. gauge wire is given, but no smaller than No. 14 should be used for general wiring purposes. Insulated aluminum wire 84% of the carrying capacity of the above figures.

TENSILE STRENGTH OF COPPER WIRE.

Numbers, B. & S. G.	Breaking weight, Pounds.		Numbers, B. & S. G.	Breaking weight. Pounds.	
	Hard-drawn.	An-nealed.		Hard-drawn.	An-nealed
0 000	8 310	5 650	9	616	349
000	6 580	4 480	10	489	277
00	5 226	3 553	11	388	219
0	4 558	2 818	12	307	174
1	3 746	2 234	13	244	138
2	3 127	1 772	14	193	109
3	2 480	1 405	15	153	87
4	1 967	1 114	16	133	69
5	1 559	883	17	97	55
6	1 237	700	18	77	43
7	980	555	19	61	34
8	778	440	20	48	27

The strength of soft copper wire varies from 32,000 to 36,000 pounds per square inch, and of hard copper wire from 45,000 to 68,000 pounds per square inch, according to the degree of hardness.

EQUIVALENT CROSS SECTIONS OF WIRES.

Brown & Sharp Gauge.

0000	2— 0	4— 3	8— 6	16— 9	32—12	64—15	128—18
000	2— 1	4— 4	8— 7	16—10	32—13	64—16	....
00	2— 2	4— 5	8— 8	16—11	32—14	64—17	1 and 3
0	2— 3	4— 6	8— 9	16—12	32—15	64—18	2 " 4
1	2— 4	4— 7	8—10	16—13	32—16	......	3 " 5
2	2— 5	4— 8	8—11	16—14	32—17	......	4 " 6
3	2— 6	4— 9	8—12	16—15	32—18	......	5 " 7
4	2— 7	4—10	8—13	16—16	......	......	6 " 8
5	2— 8	4—11	8—14	16—17	......	......	7 " 9
6	2— 9	4—12	8—15	16-18	......	.....	8 " 10
7	2—10	4—13	8—16	......	......	......	9 " 11
8	2—11	4—14	8—17	......	......	......	10 " 12
9	2—12	4—15	8—18	......	......	......	11 " 13
10	2-13	4—16	.....	......	......	......	12 " 14
11	2—14	4—17	.....	......	......	......	13 " 15
12	2—15	4—18	.....	......	......	......	14 " 16
13	2—16	.....	.....	......	......	......	15 " 17
14	2—17	.....	.....	......	......	......	16 " 18
15	2—18	.....	.....	......	......	......	....

All wiring should be protected on side walls from mechanical injury. This may be done by putting a substantial boxing about the wires, allowing an air space of one inch around the conductors and closed at the top (the wire passing through bushed holes) and the boxing extending about five feet above the floor. Sections of metal conduit may be used (the wire being protected by approved flexible tubing), and in most cases this practice is preferable. All bushings should be made of non-combustible, non-absorptive insulating material such as glass or porcelain and should be used wherever wires go through walls, floors, timbers or partitions. They should 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 the wire should be protected by a continuous length of *approved* flexible tubing extending one inch from each end of the pipe or conduit or far enough to keep the wire absolutely out of contact with the pipe.

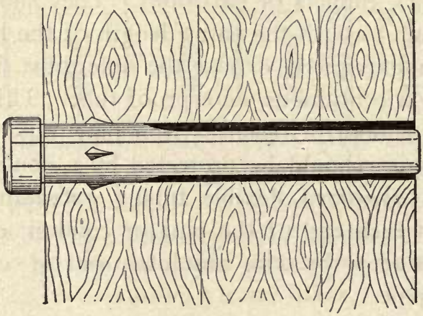
If iron pipes, conduits, or metal mouldings are used with alternating currents, the two or more wires of the circuit should always be placed in the same conduit.

When crossing floor timbers in cellars or in rooms where they might be exposed to injury, wires should be attached, by their insulating supports, to the under side of wooden strips not less than one-half inch in thickness and not less than three inches wide.

When wires are run immediately under roofs, or in proximity to water tanks or pipes they will be considered as exposed to moisture and care should be taken as described on pages 99 and 152.

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, see page 138, or armored cables. See page 135.

In three wire (not three-phase) systems, the neutral should be of sufficient capacity to carry the maximum current to which it may be subjected.



Porcelain Insulating Tube for partition and walls.

Underground Conductors. All underground conductors should be protected against moisture and mechanical injury where brought into a building, and all combustible material should be kept from the immediate vicinity.

They should not be so arranged as to shunt the current through a building around any catch-box.

Where underground service enters building through tubes, the tubes should be tightly closed at outlets with asphaltum or other non-conductor, to prevent gases from entering the building through such channels.

No underground service from a subway to a building, and no service from a private generating plant should supply more than one building, except by special permission, unless the conductors are properly protected by fuses and are carried outside all the buildings but the one served. Conductors in conduit or duct under two inches of concrete under a building, or buried back of two inches of concrete or brick within a wall are considered as lying outside of the building. These suggestions do not apply to factory yards and factory buidings under single occupancy or management.

Switches, Cut-outs and Circuit-Breakers

On constant potential circuits, all service switches and all switches controlling circuits supplying current to motors or heating devices, and all fuses should 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, should 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 should have the poles and trip coils so arranged as to afford complete protection against overloads and short circuits. In two or three-phase three-wire circuits and two-phase four-wire circuits there should be a trip-coil in each of two phases, and in four-wire three-phase circuits there should be a trip-coil in each phase. If a circuit breaker is also used in place of the switch it should be so arranged that no one pole can be opened manually without disconnecting all the wires.

This, of course, does not apply to the grounded circuit of street railway systems.

They should 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 should be enclosed in approved dust-proof cabinets with self-closing doors, except oil switches and circuit breakers which have dust-tight casings.

Cabinets and cut-out boxes should be of metal when used with metal conduit, armored cable or metal moulding systems. (See page 126.)

They should also, when exposed to dampness, be enclosed in a moisture-proof box. The cover of the box should be so made that no moisture which may collect on the top or sides of the box can enter it.

Time switches, sign flashers and similar appliances should be of approved design and enclosed in *approved* cabinets. See page 122.

Series Arc Lamp Wiring. All wiring in buildings for constant current series arc lighting should be with approved rubber covered wire and the circuit arranged to enter and leave the building through an approved double contact service switch, which means a switch, mounted on a non-combustible, non-absorptive insulating base, capable of closing the main circuit and disconnecting the branch wires when turned "off"; this switch should be so constructed that it will be automatic in action, not stopping between points when started, and must prevent an arc between points under all circumstances, and should indicate, upon inspection, whether the current be "on" or "off." Such a switch is necessary to cut the high voltage current completely out of the building by firemen in case of fire or when it becomes necessary to make any changes in the lamps or wiring. It should be in a non-combustible case.

This class of wiring should never be concealed or encased except when required by the Electrical Inspector, and should always be rigidly supported on porcelain or glass insulators which will separate the wiring at least one inch from the surface wired over, and should be kept at least eight inches from each other. Except within the structure of lamps, or hanger-boards or in cut-out boxes or such fixtures when a less distance is necessary. This class of wiring should, on side walls, be protected from mechanical injury by a substantial boxing, retaining an air space of at least one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than seven feet from the floor. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires should be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness. Instead of the running-boards, guard strips on each side of and close to the wires will be sufficient. These strips to be not less than seven-eighths of an inch in thickness and at least as high as the insulators.

Except on joisted ceiling, a strip one-half of an inch thick is not considered sufficiently stiff and strong. For spans of say eight or ten feet, where there is but little vibration, one-inch stock is generally sufficiently stiff; but where the span is longer than this or there is considerable vibration, still heavier stock should be used.

Series arc lamps, now rapidly going out of use, being replaced by gas filled high efficiency mazda or tungsten lamps, should be isolated from inflammable material, and should be provided at all times with a glass globe surrounding the arc, and securely fastened upon a closed base. Broken or cracked globes should not be used.

They should be provided with a wire netting (having a mesh not exceeding one and one-fourth inches) around the globe, and an *approved* spark arrester when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks of carbon or melted copper. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

Outside arc lamps should be suspended at least eight feet above sidewalks. Inside arc lamps should be placed out of reach or suitably protected.

Arc lamps, when used in places where they are exposed to flyings or easily inflammable material, should have the carbons enclosed completely in a tight globe in such manner as to avoid the necessity for spark arresters.

"Enclosed arc" lamps, having tight inner globes, may be used in such places.

Series Incandescent Lamp Wiring

The same suggestions given for the wiring for series arc lamps should apply to this class of work as well. Each series incandescent lamp should be provided with its own automatic cut-out. Each lamp should be suspended from a hanger-board by a rigid tube.

In no way should they come in contact with, or be connected to, gas fixtures. No electro-magnetic device for switches and no multiple-series or series-multiple systems of lighting should be used.

Special Wiring for damp places such as breweries, packing houses, stables, dye houses, paper or pulp mills, or buildings specially liable to moisture or acid or other fumes liable to injure the wires or their insulation, except where used for pendants should always be done with approved rubber covered or weather-proof wire, and rigidly supported on porcelain or glass insulators which separate the wires at least one inch from the surface wired over and must be kept apart at least two and one-half inches for voltages up to 300 and four inches apart for higher voltages. The wire in such damp places should contain no splices as it is almost impossible to tape a splice that will prevent acid fumes from getting at the copper surface.

Automatic Cut-Outs—Fuses and Circuit Breakers

On constant potential systems the general rules, for all voltages, require that a circuit-breaker or fuse be placed on all service wires, either overhead or underground, in the nearest accessible place to the point where they enter the building and inside the walls, and arranged to cut off the entire current from the building. Departure from this rule may be authorized only under special permission in writing.

Where the switch required on all service wires is inside the building, the cut-out (circuit-breaker or fuse) should be placed so as to protect it, unless the switch is of the knife-blade type and is enclosed in an *approved* box or cabinet, under which condition the switch may be placed between the source of the supply and the cut-out. It is always safer, however, to place the cut-out between the source of supply and the service switch.

Cut-outs should never be placed in any permanently grounded service wire.

In risks having private plants, the yard wires running from building to building are not considered as service wires, so that cut-outs would not be required where the wires enter buildings, provided that the next fuse back is small enough to properly protect the wires inside the building in question.

Cut-outs should be placed at every point where a change is made in the size of wire [unless the cut-out in the larger wire will protect the smaller (see current carrying capacity of wires page 91)].

Cut-outs should not be placed in any permanently grounded wire. They should be in plain sight, or enclosed in an *approved* cabinet, and readily accessible. They should not be placed in the canopies or shells of fixtures.

Link fuses (see pages 105-107) may be used only when mounted on *approved* bases which, except on switchboards should be mounted in *approved* cut-out boxes, or cabinets. A space of at least two inches should be provided between the open-link fuses and metal, or metal lined walls or metal, metal lined or glass paneled doors of cabinet or cut-out boxes.

Cut-outs should be so placed that no set of small motors, small heating devices or incandescent lamps, whether grouped on one fixture or on several fixtures or pendants (nor more than 16 medium size or 25 candelabra size sockets or lamp receptacles) requiring more than 660 watts, will be dependent upon one cut-out.

By special permission, in cases where wiring equal in size and insulation to No. 14 B. & S. gage *approved* rubber-covered wire is carried direct into keyless sockets or receptables, and where the location of socets and receptacles is such as to render unlikely the attachment of flexible cords thereto, the circuits may be so arranged that not more than 1,320 watts (or thirty-two sockets or receptacles) will be dependent upon the final cut-out.

Except for signs and outline lights sockets and lamp receptacles will be considered as requiring not less than 40 watts each, if of the medium size, or 25 watts each if of candelabra size.

Receptacles (see page 150) for attachment plugs (see page 114) rated at not over 660 watts each may be connected to ordinary branch circuits, and when so installed will be considered as requiring not less than 40 watts. Heating and other appliances rated not over 660 watts each may be connected to such receptacles only when the normal load in use on the circuit at any time will not exceed 660 watts. A cut-out should be provided for each receptacle rated above 660 watts.

All branches or taps from any three-wire system which are directly connected to lamp sockets or other translating devices, should be run as two-wire circuits if the fuses are omitted in the neutral or if the difference of potential between the two outside wires is over 250 volts, and both wires of such branch or tap circuits should be protected by proper fuses. (See page 110.)

The above should also apply to motors, except that small motors may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed 10 amperes.

When 1,320 watts are dependent upon one fusible cut-out, as is allowed in outline lighting, signs and large chandeliers, the fuses may be in accordance with the following table:

125 volts or less	20 amperes
126 to 250 volts	10 amperes

Fused rosettes (see page 153) may be used only for open work in large mills. *Approved* link fused rosettes may be used at a voltage of not over 125 and *approved* enclosed fused rosettes at a voltage of not over 250, the fuse in the rosette not to exceed 3 amperes, and a fuse of over 25 amperes should not be used in the branch circuit.

The rated capacity of fuses (see pp. 112 and 113) should not exceed the allowable carrying capacity of the wire as given in the table on page 91. Circuit breakers should not be set more than 30 per cent.

above allowable carrying capacity of the wire, unless a fusible cut-out is also installed on the circuit. Where a rubber-covered conductor carries the current of only one A. C. motor of a type requiring large starting current, it may be protected by a fuse or an automatic circuit breaker. The rated continuous current capacity of a time limit circuit breaker protecting a motor of the above type need not be greater than 125 per cent. of the motor current rating, provided the time limit device is capable of preventing the breaker opening during the starting period.

In the great majority of cases where A. C. motors of the above type are started by means of autostarters the current-carrying capacity of wires meeting the rule will not exceed the following percentages of the full load currents of the motors,—

Rated full load current	Percentage
0- 30 amperes	250
31-100 "	200
Above 100 "	150

For the protection of wires having safe carrying capacities exceeding the rated capacity of the largest *approved* enclosed type fuses, *approved* enclosed fuses, see pages 108-113), arranged in multiple, may be used, provided as few fuses as possible are used and the fuses are of equal capacity, and provided the cut-out terminals are mounted on a single continuous pair of substantial bus bars. The total capacity of the fuses should not exceed the safe carrying capacity of the wires. This does not apply to motor circuits.

Fixture wire or flexible cord, see page 149, of No.

18 B. & S. gage will be considered as properly protected by 10 ampere fuses.

Each conductor of motor circuits, except on main switchboard or when otherwise subject to competent supervision, should be protected by an *approved* fuse, whether automatic overload circuit breakers are installed or not (see page 45.) Single phase motors may have one side protected by an *approved* automatic overload circuit breaker only, if the other side is protected by an *approved* fuse.

Circuit breakers will be approved for circuits having a maximum capacity greater than that for which approved enclosed fuses are rated. (See page 44.)

Circuit Breakers. All circuit breakers, for voltages of 550 or less, should be mounted on non-combustible, non-absorptive, insulating bases, such as slate or marble. Bases with an area of over twenty-five square inches should have at least four supporting screws. Holes for the supporting screws should be so located or countersunk that there will be at least one-half of an inch space measured over the surface between the head of the screw or washer and the nearest live metal part, and in all cases when between parts of opposite polarity should be countersunk.

They should be plainly marked with the name of the maker and the current and voltage for which they are designed.

Cut-Outs. All small safety devices which, under this heading, mean fuses of the open link or enclosed or cartridge type, should be supported on bass of non-combustible, non-absorptive, insulating material.

Cut-outs should be of the enclosed type, when not arranged in *approved* cabinets, so as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

Cut-outs should operate successfully on short-circuits, under the most severe conditions with which they are liable to meet in practice, at 25 per cent. above their rated voltage, and for link fuse cut-outs with fuses rated at 50 per cent. above the current for which the cut-out is designed, and for enclosed fuse cut-outs with the largest fuses for which the cut-out is designed.

With link fuse cut-outs there is always the possibility of a larger fuse being put into the cut-out than it was designed for, which is not true of approved enclosed fuse cut-outs. Again the voltage in most plants can, under some conditions, rise considerably above the normal. The need of some margin, as a factor of safety to prevent the cut-outs from being ruined in ordinary service, is therefore evident.

The most severe service which can be required of a cut-out in practice is to open a "dead short-circuit," with only one fuse blowing.

Every enclosed fuse should be marked where it will be plainly visible when installed with the name of the maker, and current and voltage for which it is designed.

Link Fuse Cut-Outs.– The following suggestions are intended to cover open link fuses mounted on slate or marble bases, including switchboards, tablet-boards and single fuse-blocks. They do not apply to the ordinary porcelain cut-out blocks, enclosed fuses, or any special or covered type of fuse. When tablet-boards or single fuse-blocks with such open link fuses on them are used in general wiring, they should be enclosed in cabinet boxes made to meet the requirements. This is necessary, because a severe flash may occur when such fuses melt, so that they would be dangerous if exposed in the neighborhood of any combustible material.

Such cut-outs should be mounted on bases made of strong non-combustible, non-absorptive, insulating material. The design of the base should be such that considering the material used, the base will withstand the most severe conditions liable to be met in practice. Bases with an area of over twenty-five square inches should have at least four supporting screws. Holes for supporting screws should be kept outside of the area included by the outside edges of the fuse terminals, and should be so located or countersunk that there will be at least one-half of an inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part.

The following spacings should be attended to for this class of fuses:

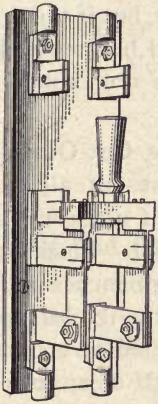
	Minimum Separation of Nearest Metal Parts of Opposite Polarity.	Minimum Break-Distance.
Not over 125 Volts:		
10 amperes or less...	¾ inch	¾ inch
11-100 amperes......	1 "	¾ "
101-300 "	1 "	1 "
301-1,000 "	1¼ "	1¼ "

Not over 250 Volts:

10 amperes or less...	1½ inch	1¼ inch
11-100 amperes......	1¾ "	1¼ "
101-300 "	2 "	1½ "
301-1,000 "	2½ "	2 "

The link fuses used in this class of cut-out, should all have contact surfaces or tips of copper, or other hard metal, and securely soldered to the fuse wire.

Switches. All service wires, either overhead or underground, should be controlled by a service switch in the nearest readily accessible place to the



An Approved Double Pole Knife Switch, Showing Terminals for Approved Enclosed Fuses. Always install so that the handle will be *up* when circuit is closed.

point where the wires enter the building, and arranged to cut off the entire current.

Service cut-out and switch should be arranged to cut off current from all devices including meters.

Service switches should indicate plainly whether they are open or closed.

In risks having private plants the yard wires running from building to building are not considered as service wires, so that switches would not be required in each building if there are other switches conveniently located on the mains or if the generators are near at hand.

All switches should be placed in dry, accessible places, and be grouped as far as possible. All knife switches should be so placed that gravity will not tend to close them. (See cut p. 107.) Double-throw knife switches should be mounted so that the throw will be horizontal, but if the throw be vertical a locking device should be provided so constructed as to insure the blades remaining in the open position when so set.

Enclosed-Fuse Cut-Outs—Plug and Cartridge Type. The bases of all enclosed fuse cut-outs should be made of non-combustible, non-absorptive, insulating material. Blocks with an area of over twenty-five square inches must have at least four supporting screws. Holes for supporting screws should be so located or countersunk that there will be at least one-half of an inch space, measured over the surface, between the screw-head or washer and the nearest live metal part, and in all cases where between parts of opposite polarity should be countersunk.

Except for sealable service and meter cut-outs, terminals should be either the Edison plug, spring clip or knife blade type, to take the corresponding standard enclosed fuses.

All enclosed fuse cut-outs should be classified as regards both current and voltage as given in the following table, and should be so designed that the bases of one class cannot be used with fuses of another class rated for a higher current or voltage.

STANDARD PLUG OR CARTRIDGE CUT-OUTS

Not over 250 Volts:		*Not over 600 Volts:*	
0-30 amperes.		0-30 amperes.	
31-60	"	31-60	"
61-100	"	61-100	"
101-200	"	101-200	"
201-400		201-400	"
401-600	"		

Sealable Service and Meter Cut-Outs.

Not over 250 Volts:		*Not over 600 Volts:*	
0-30 amperes.		0-30 amperes.	
31-60	"	31-60	"
61-100	"	61-100	"
101-200	"	101-200	"

Enclosed Fuses—Plug and Cartridge Type

Plugs, commonly known as Edison Fuse Plugs, should not be used to protect circuits of over 30 amperes at 125 volts. This, of course, includes any circuit of a three-wire 125-250 volt system with grounded neutral. The large size Edison Plug is designed for circuits between 31 and 60 amperes at 250 volts.

Enclosed Fuses (Cartridge Type)

Should be so constructed that with the surrounding atmosphere at a temperature of 75 degrees Fahrenheit they will carry indefinitely a current 10 per cent. greater than that at which they are rated, and and at a current 25 per cent greater than the rating, they will open the circuit without reaching a temperature which will injure the fuse tube or terminals of the fuse block. With a current 50 per cent. greater than the rating and at room temperature of 75 degrees Fahrenheit the fuses starting cold, should blow with the time specified below:

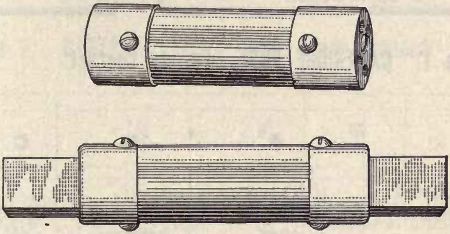
0-30	amperes	1 minute
31-60	"	2 minutes
61-100	"	4 "
101-200	"	6 "
201-400	"	12 "
401-600	"	15 "

They should be marked where it will be plainly visible, with the name, trade-mark of the maker, the voltage and current for which the fuse is designed, and the words "National Electrical Code Standard." Each fuse has a label, the color of which is green for 250-volt fuses and red for 600-volt fuses.

No enclosed fuses should ever be refilled by the user but should be returned to their makers, who will refill them at a nominal cost, and in strict accordance with their ratings.

There are no "Renewable" or "Refillable" enclosed or cartridge fuses, so-called, approved by the National Board of Fire Underwriters, or appear in the list of Electrical Fittings published by the National Board of Fire Underwriters.

Following is a list of makers of approved enclosed or cartridge fuses: Bryant Electric Co.. "Bryant"; Chicago Fuse Mfg. Co., "Union"; Detroit Fuse & Mfg. Co., "Arkless"; D. & W. Fuse Co., "D. & W."; General Electric Co., "G. E."; Johns-Pratt Co., "Noark" (H. W. Johns-Manville Co., sole agents); Westinghouse Elec. & Mfg. Co., "Westinghouse."



Cartridge Fuses—Ferrule and Knife Blade Contacts.

For dimensions of National Electrical Code Standard fuses see two following pages.

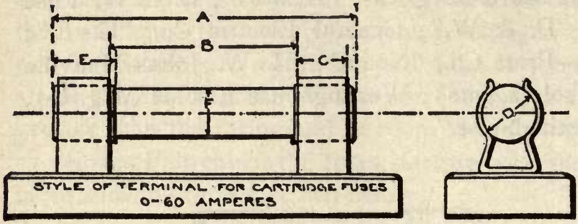
All switches should be so wired that blades will be "dead" when switch is open.

Up to 250 volts and thirty amperes, *approved indicating snap switches* are suggested in preference to knife switches on lighting circuits.

Single pole switches should never be used as service switches nor for the control of outdoor signs or circuits located in damp places, nor placed in the neutral wire of a three-wire system, except in the two-wire branch, or tap circuit supplying not more than 660 watts.

Three-way switches are considered as single pole switches.

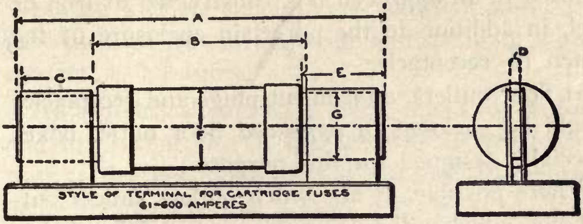
Table of Dimensions of the Standard Cartridge



Form 1. CARTRIDGE FUSE—Ferrule Contact.

Voltage.	Rated Capacity. Amperes.		A Length over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches.
0-250	0-30	Form 1	2	1	$\frac{1}{2}$
	31-60		3	$1\frac{3}{4}$	$\frac{5}{8}$
	61-100	Form 2	$5\frac{7}{8}$	4	$\frac{7}{8}$
	101-200		$7\frac{1}{8}$	$4\frac{1}{2}$	$1\frac{1}{4}$
	201-400		$8\frac{5}{8}$	5	$1\frac{3}{4}$
	401-600		$10\frac{3}{8}$	6	$2\frac{1}{8}$
251-600	0-30	Form 1	5	4	$\frac{1}{2}$
	31-60		$5\frac{1}{2}$	$4\frac{1}{4}$	$\frac{5}{8}$
	61-100	Form 2	$7\frac{7}{8}$	6	$\frac{7}{8}$
	101-200		$9\frac{5}{8}$		$1\frac{1}{4}$
	201-400		$11\frac{5}{8}$	8 7	$1\frac{3}{4}$

National Electrical Code Enclosed Fuse.



Form 2. CARTRIDGE FUSE—Knife Blade Contact.

D	E	F	G	
Dia. of Ferrules or Thickness of Terminal Blades. Inches.	Min. Length of Ferrules or of Terminal Blades Outside of Tube. Inches.	Dia. of Tube. Inches.	Width of Terminal Blades. Inches.	Rated Capacity. Amperes
9/16	1/2	1/2	Form 1	0-30
13/16	5/8	3/4		31-60
1/8	1	1	3/4 Form 2	61-100
13/16	1 3/8	1 1/2	1 1/8	101-200
1/4	1 7/8	2	1 5/8	201-400
1/4	2 1/4	2 1/2	2	401-600
13/16	1/2	3/4	Form 1	0-30
1 1/16	5/8	1		31-60
1/8	1	1 1/4	3/4 Form 2	61-100
3/16	1 3/8	1 3/4	1 1/8	101-200
1/4	1 7/8	2 1/2	1 5/8	201-400

Where flush switches or receptacles are used, whether with conduit systems or not, they should be enclosed in an *approved* box constructed of iron or steel, in addition to the porcelain enclosure of the switch or receptacle.

At floor outlets, attachment plugs and receptacles should be enclosed in *approved* floor outlet boxes especially designed for this purpose.

Where possible, at all switch outlets, unless outlet boxes which will give proper support for switches are used, a seven-eighths inch block should be fastened between studs or floor timbers flush with back of lathing to hold tubing and to support switches. When this cannot be done, wooden base blocks, not less than three-fourths inch in thickness, securely screwed to lathing, or *approved* fittings designed for the service, should be provided for switches.

Sub-bases of non-combustible, non-absorptive, insulating material, which will separate the wires at least ene-half inch from the surface wired over, should be installed under all snap switches used in exposed knob and cleat work. Sub-bases should also be used in moulding work, but they may be made of hardwood or they may be omitted if the switch is especially designed and approved for mounting directly on the moulding.

Knife Switches should be mounted on non-combustible, non-absorptive, insulating bases such as slate, marble or porcelain.

Hinges of knife switches should not be used to carry current unless they are equipped with spring washers, held by lock-nuts or pins, or their equivalent, so arranged that a firm and secure connection will be maintained at all positions of the switch blades.

Spring washers should be of sufficient strength to take up any wear in the hinge and maintain a good contact at all times.

All switches should have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about one square inch for every seventy-five amperes.

They should be plainly marked where it can be read, when the switch is installed, with the name of the maker and the current and the voltage for which the switch is designed.

Switches designed for 250-volt D. C. or 500-volt A. C. circuits, without fuses on the switch base, should be marked 250 V., D. C., 500 V., A. C. When 250-volt fuse terminals are mounted on the switch base the marking of the switch should be 250 V., D. C. and A. C. When 600-volt fuse terminals are mounted on the switch base the terminals should be spaced for 600-volt fuses and the switches marked 500 volts A. C.

Triple pole switches designed with 125-volt spacings between adjacent blades should be marked 125 volts and may be used on three-wire D. C. or single phase systems having not more than 125 volts between adjacent wires and not more than 250 volts between the two outside wires.

When designed with 250-volt spacings between adjacent blades triple pole switches must be marked 250 volts and may be used on three-wire D. C. or single phase systems having not more than 250 volts between adjacent wires and not more than 500 volts between the two outside wires.

It is not necessary to give all the dimensions and spacings required on knife switches. All the wireman wants to know is that it is of approved make with the maker's name and the current and voltage plainly marked on the switch.

Electric Heaters. Each heater of more than six (6) amperes or 660 watts capacity should be protected by a cut-out, and controlled by a switch or plug connector plainly indicating whether "on" or "off" and located within sight of the heater. Heaters of six (6) amperes or 660 watts capacity or less, may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed ten (10) amperes, or may be connected individually to lighting circuits when the normal load in use on the circuit at any time will not exceed 660 watts.

Flexible conductors for smoothing irons and sad irons, and for all devices requiring over 250 watts, must have an *approved* insulation at least one-sixty-fourth inch thick, a braided covering of asbestos one-thirty-second inch thick and of special quality, and outer braid one-sixty-fourth inch thick enclosing either all the conductors as a whole or each conductor separately.

With portable heating devices, *approved* plug connectors should be used, so arranged that the plug may be pulled out to open the circuit without leaving any live parts so exposed as to render likely accidental contact therewith. The connector may be located at either end of the flexible conductor or inserted in the conductor itself.

Smoothing irons, sad irons and other heating devices that are intended to be applied to combustible articles, should be provided with *approved* stands.

Stationary heaters, such as radiators, ranges, plate warmers, etc., should be so located as to furnish ample protection between the device and surrounding combustible material.

Every heater should be provided with a name-plate, giving the maker's name and the normal capacity in volts and amperes, or in volts and watts.

LOW-POTENTIAL SYSTEMS

Any circuit attached to any transforming device, machine, or combination of machines, which develops a difference of potential between any two wires or between any wire and the ground of not over 550 volts, is considered as a low-potential circuit. The primary circuit should not exceed a potential of 3,500 volts, unless the primary wires are installed in accordance with the suggestions given on pages 63-67 for lines of over 5,000 volts, or are underground. For 550 volt motor equipments a margin of ten per cent. above the 550 volt limit will be allowed at the generator or transformer.

All wires, on low-potential systems, should, when entering cabinets, cut-out boxes or junction boxes, except where they are in conduit, armored cable or metal molding, be protected by non-combustible, non-absorptive, insulating bushings, which fit tightly the holes in the box or cabinet and are well secured in place. The wires should completely fill the holes in the bushings, so as to keep out dust, tape being used to build up the wires if necessary. For concealed knob and tube work, or for open work in dry places, *approved* flexible tubing, see page 134, will be accepted in lieu of bushings, providing it extends from the last porcelain support into a wooden cabinet, or is secured to a metal cabinet, cut-out box, junction or switchbox by an *approved* fitting.

No wiring should be laid in plaster, cement or similar finish, and should never be fastened with staples nor should it be fished for any great distance, and only in places where the inspector can satisfy himself that the rules have been complied with.

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

All wires, 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, see page 138,or armored cable, see page 135, or be attached by their insulating supports to the under side of a wodden 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 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 should extend not less than seven feet from the floor and should consist of substantial boxing, retaining an air space of at least one inch around the conductors, closed at the top (the wires passing through bushed holes) or *approved* metal conduit or pipe of equivalent strength.

When metal conduit or pipe is used, the insulation of each wire should be reinforced by *approved* flexible tubing extending from the insulator next below the pipe to the one next above it, and the wire is approved for conduit use, see page 129. The two or more wires of a circuit *each* with its flexible tubing (when required), if carrying alternating current *must* be placed within the same pipe, to avoid trouble from induction.

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.

When wires are run in unfinished attics, or roof spaces they 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 should not be run on knobs on upper edge of joists.

For open work in dry places all wires should be rigidly supported on 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 should 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.

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

In damp places, or buildings specially subject to moisture or to acid or other fumes liable to injure the wires should have rubber insulation to protect them against water and protection against corrosive vapors, either weatherproof or rubber insulation should be used and they should be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one inch from the surface wired over, and must be kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

The same rigid supporting should be given such wiring as described on the preceding page.

Snap Switches

All flush, push-button, door, fixture and other snap switches used on constant-potential systems should have their current-carrying parts mounted on non-combustible, non-absorptive, insulating bases, such as slate or porcelain, and the holes for supporting screws should be countersunk not less than one-eighth of an inch. There should in no case be less than three-sixty-fourths of an inch space between supporting screws and current-carrying parts.

Sub-bases should be so designed as to separate the wires at least one-half inch from the surface wired over and be of a non-combustible, non-absorptive, insulating material, except for use with wooden moulding, where they may be of hard wood.

All snap switches should have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load.

All such switches should "make" and "break" with a quick snap, and should not stop when motion has once been imparted by the button or handle.

No exposed parts of any styles of snap switch should be in electrical connection with the circuit and every such switch should be plainly marked with the name or trade-mark of the maker and the current and voltage for which the switch is designed.

On flush switches these markings are sometimes placed on the sub-plate. On surface switches with covers constructed of porcelain or other moulded insulating material the marking is frequently on the inside of the cover. On all other types they should be placed on the *front* of the cap, cover or plate.

Switches which indicate whether the current is "on" or "off" are recommended.

Cabinets and Cut-Out Boxes. When cabinets intended for enclosing feeder and circuit branch panelboards and similar devices they may be designed for either surface or flush mounting and are usually provided with removable frames or matts, trims, etc., in which the swinging doors are hung; when for the enclosure of apparatus connected within the cabinet to the wires of more than four circuits they should have a back wiring space or one or more side wiring spaces, side gutters or wiring compartments unless the wires leave the cabinet directly opposite their terminal connections. When intended for installation out-of-doors they should be of the "weatherproof" pattern.

Cut-out-boxes are intended for enclosing single devices or combinations of devices connected within the cut-out box to the wires of not more than four circuits and usually are designed for surface mounting having swinging doors or covers secured directly to the wall of the box. When intended for installation out-of-doors they also should be of the "weatherproof" pattern.

The construction of all cabinets and cut-out boxes should be such as to insure ample strength and rigidity.

The spacing within cabinets and cut-out boxes should be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of cabinets or cut-out boxes and current-carrying parts of devices and apparatus mounted within them as follows:

Cabinets and cut-out boxes should be deep enough to allow the doors to be closed when 30-ampere branch circuit panelboard switches having spool or composition handles or when switches of combination cut-outs are in any position, and when other single throw switches are thrown open as far as their construction and installation will permit.

Outlet, Junction and Flush Switch Boxes should be of pressed steel having wall thickness not less than .078 inch or of cast metal having wall thickness not less than one-eighth inch, and should be well galvanized, enameled or otherwise properly coated, inside and out, to prevent oxidation.

All such boxes should be plainly marked, where it may readily be seen when installed, with the name or trade-mark of the manufacturer, and should be arranged to secure in position the conduit or flexible tubing protecting the wire.

Switch and outlet boxes should be so arranged that they can be securely fastened in place independently of the support afforded by the conduit piping, except that when entirely exposed, *approved* boxes, which are threaded so as to be firmly supported by screwing on to the conduit, may be used.

Switch and receptacle boxes should completely enclose the switch or receptacle on sides and back, and should provide a thoroughly substantial support for it. Boxes for floor outlets should be designed to completely enclose the receptacle and attachment plugs, if any, to protect them from mechanical injury and to exclude moisture.

Covers for outlet boxes if made of metal should be equal in thickness to that specified for the walls of the box. Covers may also be made of porcelain or other approved material, but should be of such form and thickness as to afford suitable protection and strength.

Panel Boards. In the relative arrangement of fuses and switches, the fuses may be placed between the bus-bars and the switches, or between the switches and the circuits. When the branch switches are between the fuses and bus-bars, the connections should be so arranged that the blades will be dead when the switches are open.

When there are exposed live metal parts on the back of board, a space of at least one-half inch should be provided between such live metal parts and the cabinet in which the board is mounted. All panelboards should be marked where the marking can be plainly seen when installed, with the name or trade-mark of the manufacturer and the maximum capacity in amperes and the voltage for which the board is designed.

For a really permanent and high class installation of a distributing centre, the following specifications are recommended:

Panel boards should be made as per the Underwriters Laboratory Label Service Specifications for Panel Boards and have label attached.

The panel boards should be natural black oiled finish slate ⅞ inch thick and equipped on face of panel, with such switches, fuse connections, bus bars and other apparatus as follows, all exposed metal parts should be copper, polished and wherever not used for contact should be lacquered. All fuse connections for mains and sub-feeders should be for National Electrical Code Standard cartridge fuses, and all fuse connections for circuit branches should be for 30 amperes (N. C. cartridge fuses) (Edison plug fuses). Each panel board should be equipped with main switch and main fuse connection. Main fuse connection and main switch and bus bar should be of an ampere capacity equal to the number of circuit branches multiplied by 3 ampere for the 3-wire system, and by 6 ampere for the 2-wire system, *plus* the full ampere capacity of any sub-feeder connections. Each panel board should be equipepd with D. P. circuit branches for the number of circuits shown on wiring plans, and 2 branches in addition for extra circuits. Each circuit branch should be equipped with D. P. fuse connection (connected to bus bar) and a D. P. (30 amp. knife) (10 amp. snap) (10 amp. push button) switch. All switches, either knife, snap or push button, should be protected by the fuses.

Cabinets should be made as per the Underwriters' Laboratory Label Service Specification for Cabinets and have label attached.

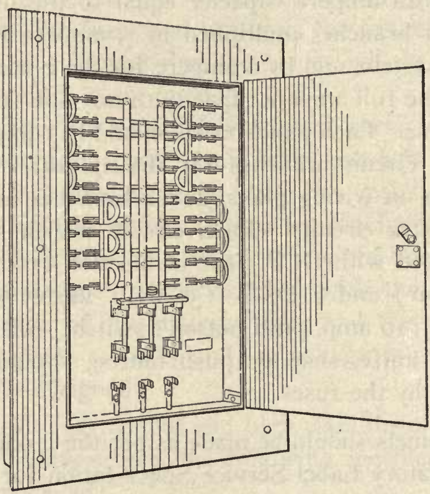
Boxes—Cabinet boxes should be made of all steel, of the gutter type and arranged for mounting flush into walls or partitions. The boxes should be formed from one piece of sheet steel, having flanged corners securely fastened with not less than 2 rivets and with ¾ inch flange turned in at front edges, and when panel is not over 24 inches wide should have gutters as follows:

For panels not over 30 inches high, not less than 3 inch gutter.

For panels over 30 inches and not over 50 inches high, not less than 3½ inch gutter.

For panels over 50 inches and not over 76 inches high, not less than 4 inch gutter.

Barriers—Cabinets are to be equipped with



Cabinet and Panelboard Complete.
For approved makes see page 269.

gutter barriers made in 4 sections of ½ inch black oiled slate, of the proper width to allow necessary space between panel board and front.

Fronts—Fronts should be made from one piece of sheet steel and for cabinets with 3 inch gutters should be not less than No. 12, and for all larger cabinets not less than No. 10.

Moulding Work (Wooden and Metal). All wiring in moulding, either wooden or metal (see page 128) should be done with approved rubber covered wire and should be in continuous lengths from outlet to outlet, or from fitting to fitting, no joints or taps should be made in moulding. Where branch taps are necessary in moulding work *approved* fittings for this purpose should be used.

No class of moulding work should ever be done in damp places or in concealed locations or when the difference of potential between any two wires in the same system exceeds 300 volts. When electrical construction is being carried out in metal moulding these mouldings may extend through walls and partitions if the moulding and capping are in continuous lengths where passing through the walls and partitions. Not more than four No. 14 B. & S. gage rubber covered wires, and no single circuit of more than 1,320 watts should ever be used in metal moulding.

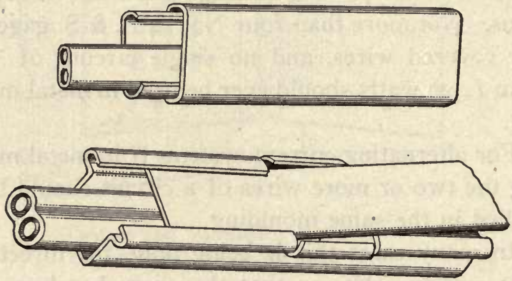
For alternating current systems if in metal moulding the two or more wires of a circuit should be installed in the same moulding.

In many cases this is being done for direct current systems also, so that they may be changed to alternating systems at any time, induction troubles preventing such a change if the wires are in separate metal mouldings.

Wooden Mouldings. They should have, both outside and inside, at least two coats of waterproof material, or be impregnated with a moisture repellent, should be made in two pieces, a backing, and a capping, and should afford suitable protection from abrasion. They should be so constructed as to thoroughly encase the wire, be provided with a tongue not less than one-half inch in thickness between the conductors, and have exterior walls which under grooves should not be less than three-eighths inch in thickness, and on the sides not less than one-fourth inch in thickness and made of hard wood.

Metal Mouldings. Each length of metal moulding should have its maker's name or trade-mark stamped in the metal. (For Installation, see p. 146.)

All metal moulding should be constructed of iron or steel with backing at least .050 inch in thickness,



Samples of Approved Metal Moulding.
For approved makes see page 268.

and with capping not less than .040 inch in thickness, and so constructed that when in place the raceway will be entirely closed. It should be thoroughly galvanized or coated with an *approved* rust preventive both inside and out to prevent oxidation.

Elbows, couplings and all other similar fittings should be constructed of at least the same thickness and quality, of metal as the moulding itself, and so designed that they will both electrically and mechanically secure the different sections together and maintain the continuity of the raceway. The interior surfaces should be free from burrs or sharp corners which might cause abrasion of the wire coverings, and at all outlets be so arranged that the conductors cannot come in contact with the edges of the metal, either of capping or backing.

Metal mouldings should be used for exposed work only and should be so constructed as to form an open raceway to be closed by the capping or cover after the wires are laid in.

Conduit Work. All wires for this class of work should have an *approvel* rubber insulating covering, and within the conduit tubing should be without splices or taps. Such wires should be double braided for twin, twisted pair or multiple conductor cables and for all single conductors of No. 6 B. & S. gage and larger.

Slow burning insulation (see page 77) may, however be used in permanently dry locations where excessive temperatures are present. No wires should ever be drawn in conduits until all mechanical work on the building has been, as far as possible, completed.

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

No. 14 to 0 inclusive every 100 feet.

No. 00 to 0000 inclusive every 80 feet.

Above 0000 to 350,000 C. M. inclusive every 60 feet.

Above 350,000 C. M. to 500,000 C. M. inclusive every 50 feet.

About 500,000 C. M. to 750,000 C. M. inclusive every 40 feet.

Above 750,000 C. M. every 35 feet.

The following methods of supporting cables are recommended:

Approved clamping devices constructed of or employing insulating wedges inserted in the ends of conduits.

Junction boxes (see page 123) may be inserted in the conduit system at the required intervals, in which insulating supports of *approved* type should be installed and secured in a satisfactory manner so as to withstand the weight of the conductors attached thereto, the boxes to be provided with proper covers.

Cables may be supported in *approved* junction boxes on two or more insulating supports so placed that the conductors will be deflected at an angle of not less than 90 degrees, and carried a distance of not less than twice the diameter of the cable from its verticle position. Cables so suspended may be additionally secured to these insulations by tie wires.

For alternating systems the two or more wires of a circuit should be drawn in the same metal conduit. It is advisable, whenever possible, to do the same thing when wiring metal conduit for direct current, as suggested for metal moulding, so that at any time a change might be made from direct to alternating current the necessity of rewiring the conduits would be avoided.

A single conduit should not contain more than four two-wire, or three-wire circuits of the same system, and should never contain circuits of different systems.

Concealed "Knob and Tube" Work. All wiring of this class should be done with approved rubber covered wire and should be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least one inch from the surface wired over. When possible, this class of wiring should be run singly on separate timbers, or studding, and kept at least five inches apart.

Such wiring should 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. (See page 94.) Wires passing through cross timbers in plastered partitions should 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 should be shortened.

At distributing centers, outlets or switches where space is limited, and the five-inch separation cannot be maintained, each wire should be separately encased in a continuous length of *approved* flexible tubing. (See page 134.)

When it is impracticable, in this class of work, 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 should be installed with *approved* metal conduit, or *approved* armored cable (see p. 135) 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 lengths from porcelain support to porcelain support, from porcelain support to outlet, or from outlet to outlet.

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

All wires, in knob and tube work, at all outlets, except where conduit is used, should be protectel by *approved* flexible tubing, extending in continuous lengths from the last porcelain support to at least one inch beyond the outlet. In the case of combination gas and electric outlets the tubes on the wires should extend at least flush with the outlet ends of gas caps, and if box or plate is used, gas pipes should be securely fastened into the outlet box of plate to secure good electrical connection.

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

In the best practice *approved* outlet boxes or plates are installed at all outlets, and the wires to be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support into the box.

Porcelain knobs, tubes, . cleats and bushings should have the manufacturer's name, initials or trade-mark stamped in the porcelain.

Tubes and Bushings should be straight and free from rough projections and with their ends and interiors smooth and rounded.

Cleats should hold the wires firmly in place without injury to the covering. All cleats for voltages up to 300 should separate the wires one-half inch from the surface wired over and two and one-half inches from each other.

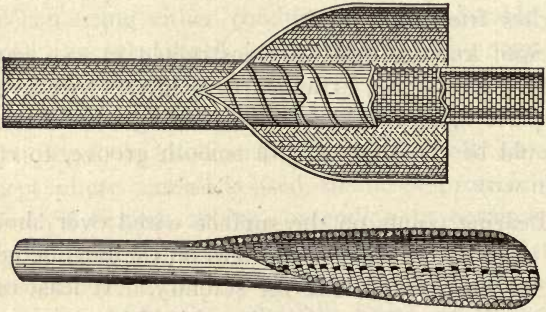
Split knobs should be constructed in two parts, a base and a cap, arranged to hold the wire firmly in place without injury to its covering. Solid knobs should be constructed with smooth groove, to contain wire.

Bearing points on the surface wired over should be made by a ring or by ridges on the outside edge of the base, to provide for stability. At least one-fourth inch surface separation should be maintained between the supporting screw or nail and the conductor, and the knob should be so constructed that the supporting screw or nail cannot come in contact with the conductor. For wires larger than No. 4 B. & S. gage, split knobs (or single wire cleats) should be so constructed as to require the use of two supporting screws. Knobs should separate the wire at least one inch from the surface wired over.

Flexible Tubing. Should have a sufficiently smooth interior surface to allow the ready introduction of the wire and be constructed of or treated with materials which will serve as moisture repellents.

The tube should be so designed that it will withstand all the abrasion likely to be met with in practice and the linings, if any, should not be removable in lengths of over three feet.

The one-fourth inch tube should be so flexible that it will not crack or break when bent in a circle with six-inch radius at 50 degrees Fahrenheit, and



Samples of Approved Flexible (Non-Metallic) Tubing.
For Approved Makes see page 268.

the covering should be thoroughly saturated with a dense moisture-proof compound. Other sizes must be as well made and none should convey fire on the application of a flame to the exterior of the tube when held in a vertical position.

All flexible tubing should be sufficiently tough and tenacious to withstand severe tension without injury.

It should have a distinctive marking the entire length of the tube, so that it may be readily identified.

Armored Cables. When wiring is done with armored cable, the cables should be continuous from outlet to outlet or to junction boxes or cabinets, and the armor of the cable should properly enter and be secured.

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 panelboard, as the case may be.

Armored cables should be equipped at every outlet with an *approved* outlet box, as recommended in conduit work.

For concealed work in walls and ceilings composed of plaster on wooden joist or stud construction, outlet boxes and also cut-out cabinets should 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 should be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or of the cut-out cabinet. On wooden walls or ceilings, outlet boxes and cut-out cabinets should be so installed that the front edge will either be flush with the finished surface or project therefrom. This need 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 outlet box can not be installed, these appliances may be omitted provided the armored cable is firmly and rigidly secured in place.

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

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

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, such coating should be thoroughly removed from the 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 should be cleaned of rust, scale, etc., at place of attachment of ground clamp.

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

Ground wires should 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 the largest wire contained in cable is greater than No. 0 B. & S. gage).

When armored cables are 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 should have a lead covering placed between the outer braid of the conductors and the steel armor.

This lead covering is not necessary when the cable is run against brick walls or laid in ordinary plaster walls unless same are continuously damp.

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

Junction boxes should always be installed in such a manner as to be accessible.

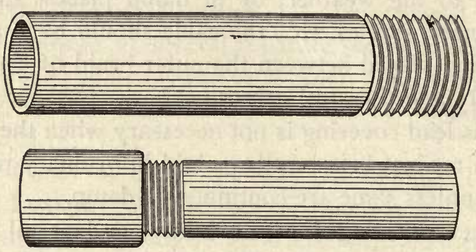
For alternating current systems armored cable should have the two or more conductors of the circuit enclosed in one metal armor.

All bends should 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 should not be less than one and a half inches.

The conductors in armored cable should be rubber covered.

Interior Conduits. Conduit smaller than one-half inch electrical trade size should never be used.

A conduit installation should be continuous from outlet to outlet or to junction boxes or cabinets, and the conduit should properly enter, and be secured to all fittings and the entire system mechanically secured in position and free from burs.



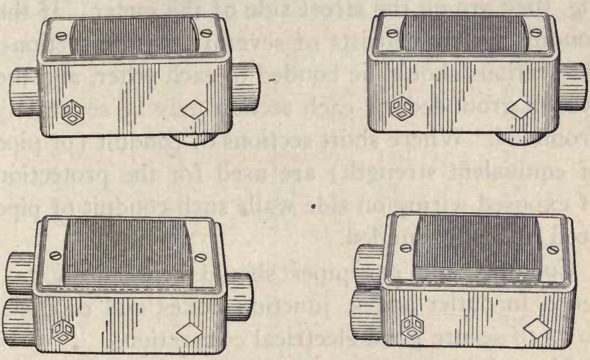
Samples of Rigid Interior Conduit with Coupling.
For Approved Makes See Page 268.

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

Every conduit installation should be completely finished before wires are drawn in.

Conduit systems should be equipped at every outlet with an *approved* outlet box. 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 should be used, such as "Condulets."

For concealed work in walls and ceilings composed of plaster on wooden joist or stud construction, outlet boxes and also cut-out cabinets should 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 should be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or the cut-out cabinet. On wooden walls or



"Condulet" bodies for flush switches and receptacles. There are hundreds of styles of "Condulets" for various interior condulet outlets. **See "Condulets" page 268.**

ceilings, outlet boxes or plates and cut-out cabinets should be so installed that the front edge will either be flush with the finished surface or project therefrom. This is not necessary in 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 an outlet box can not be installed, these appliances may be omitted, providing the conduit ends are bushed and secured.

Metal conduits where they enter junction boxes, and at all other outlets, should be provided with *approved* bushings or fastening plates fitted so as to protect wire from abrasion.

In all conduit systems the metal of the conduit should be permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connections are made to gas piping, they are on the street side of the meter. If the conduit system consists of several separate sections, the sections should be bonded to each other, and the system grounded, or each section may be separately grounded. Where short sections of conduit (or pipe of equivalent strength) are used for the protection of exposed wiring on side walls such conduit or pipe need not be grounded.

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

If conduit, couplings, outlet boxes, junction boxes, cabinets or fittings, having protective coating of non-conducting material, such as enamel, such coating must be thoroughly removed from threads of both couplings and conduit, and such surfaces of boxes, cabinets and fittings where the conduit of ground clamp is secured in order to obtain the requisite good connection. Grounded pipes should be cleaned of rust, scale, etc., at place of attachment of ground clamp. (See page 123.)

Connections to grounded pipes and to conduit should be exposed to view or accessible, and be made by means of *approved* ground clamps.

Ground wires must be of copper, at least No. 10

SIZE OF CONDUITS FOR THE INSTALLATION OF WIRES AND CABLES.
NUMBER OF CONDUCTORS IN SYSTEM.

Size B & S.	One conductor in a conduit. Size conduit, in. Electrical Trade Size	Two conductors in a conduit. Size conduit, in. Electrical Trade Size	Three conductors in a conduit. Size conduit, in. Electrical Trade Size	Four conductors in a conduit, Size conduit, in. Electrical Trade Size
14	½	½	½	¾
12	½	¾	½	¾
10	½	¾	¾	1
8	½	1	1	1
6	½	1	1¼	1¼
5	¾	1¼	1¼	1¼
4	¾	1¼	1¼	1½
3	¾	1¼	1¼	1½
2	¾	1¼	1½	1½
1	¾	1½	2	2
00	1	1½	2	2
00	1	2	2	2½
000	1	2	2	2½
0000	1¼	2	2½	2½
CM				
200000	1¼	2	2½	2½
250000	1¼	2½	2½	3
300000	1¼	2½	2½	3
400000	1¼	3	3	3½
500000	1½	3	3	3½
600000	1½	3	3½	
700000	2	3½	3½	
800000	2	3½	4	
900000	2	3½	4	
1000000	2	4	4	
1250000	2½	4½	4½	
1500000	2½	4½	5	
1750000	3	5	5	
2000000	3	5	6	

TWIN CONDUCTOR.

14	½	¾	1	1
12	½	¾	1	1¼
10	¾	1	1¼	1¼

3 CONDUCTOR CONVERTIBLE SYSTEM.

Size of Conductors		Size Conduit, in.
2-conductor Size B. & S.	1-conductor Size B. & S.	Electrical Trade Size
14	10	¾
12	8	¾
10	6	1
8	4	1
6	2	1¼
5	1	1¼
4	0	1½
3	00	1½
2	000	
1	0000	1½
		2
0	250000	2
00	350000	2½
000	400000	2½
0000	550000	3
250000	600000	3
300000	800000	3
400000	1000000	3½
500000	1250000	4
600000	1500000	4
700000	1750000	4½
800000	2000000	4½

SINGLE CONDUCTOR COMBINATION.

NOTE—Where special permission has been secured to use more than four two-wire, or three three-wire circuits in a single circuit, the following table to apply:

No. of Wires	Size Conduit, in. Electrical Trade Size
3 No. 14 R.C. solid	½
5 No. 14 R.C. solid	¾
10 No. 14 R.C. solid	1
18 No. 14 R.C. solid	1¼
24 No. 14 R.C. solid	1½
40 No. 14 R.C. solid	2
74 No. 14 R.C. solid	2½
90 No. 14 R.C. solid	3

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).

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

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

Metal Conduits. Each length of metal conduit should have the maker's name or initials stamped in the metal that inspectors can readily see it.

Rigid Metal Conduit. The tube used in the manufacture of the conduit should be of mild steel; and should be of sufficiently true circular section to admit of cutting true, clean threads; it should be very closely the same in wall thickness at all points.

All surfaces of the tube should be protected against corrosion by one of the following or some other approved methods.

Enamel Conduit. The enamel coating on either the inside or the outside surface of the finished conduit should not soften at ordinary temperatures; it should have an even and smooth appearance and should be of a uniform quality at all points of the length of the tube.

Conduits With Metallic Coating. The metallic coating on either the inside or the outside surface of the finished conduit should not soften at ordinary temperatures, and should be of uniform quality at all points of the length of the tube.

If the interior surface is not given a metallic protective coating it should be coated with an *approved* enamel.

Elbows, bends and similar fittings must be made of full-weight material, such as is specified for the conduit proper, and must be treated, coated, threaded, etc., in every way corresponding to the conduit so far as they apply.

Threads upon conduits, couplings, elbows and bends should be full and clean cut. Their pitch and form should conform to the Briggs' standard for pipe threads.

If threads are cut after the protective coatings are applied they should be treated to prevent corrosion taking place before the conduit is actually installed.

The number of threads of the threaded portion should be in accordance with the following table:

Electrical Trade size. Inches.	Number of threads per inch.
1/4	18
3/8	18
1/2	14
3/4	14
1	11 1/2
1 1/4	11 1/2
1 1/2	11 1/2
2	11 1/2
2 1/2	8
3	8
3 1/2	8

Conduit Threads (Continued)

Elec. Trade Size inches.	No. Threads per inch.
4	8
4½	8
5	8
6	8

The finished conduit as shipped should be in ten-foot lengths, with each end reamed and threaded. For each length at least one coupling must be furnished. The finished conduit with coupling should not weigh less than is given in the following table:

Electrical Trade size inches.	Minimum weight of finished conduit ten, 10-foot lengths with couplings. Pounds.
¼	38.5
⅜	51.5
½	79.0
¾	105
1	153
1¾	201
1½	249
2	334
2½	527
3	690
3½	831
4	982
4½	1150
5	1344
6	1770

Flexible Conduits should be so flexible that the conduit may be bent in a curve, the inner edge of which has a radius equal to that specified in the following table, without opening up the tube at any point.

Electrical Trade Size Inches	Internal Diameter Inches	Thickness of Strip Inches	Weight in Pounds per 100 ft. Single Strip	Weight in Pounds per 100 ft. Double Strip	Radius of Curvatures Inches
5/16	5/16	.025	17¾	20½	2¼
⅜	⅜	.034	29	33½	2½
½	⅝	.040	54	62	3½
¾	13/16	.040	68	78½	4½
1	1	.055	108	129½	5
1¼	1¼	.055	132	158	5½
1½	1½	.060	171	205	6
2	2	.060	224	269	8
2½	2½	.060	277	332	10½

If of steel the metal should be thoroughly galvanized or coated with an approved rust preventive.

Metal Mouldings. An installation of metal mouldings (see p. 128) should be continuous from outlet to outlet, to junction boxes, or *approved* fittings designed especially for use with metal mouldings, and should at all outlets be provided with *approved* terminal fittings which will protect the insulation of conductors from abrasion, unless such protection is afforded by the construction of the boxes or fittings.

Such mouldings where passing through a floor should be carried through an iron pipe extending from the ceiling below to a point five feet above the floor, which will serve as an additional mechanical protection and exclude the presence of moisture often prevalent in such locations.

Where the mechanical strength of the moulding itself is adequate, the protecting piping from the ceiling below need extend only to a point three inches above the flooring.

Where such mouldings pass through a partition the iron pipe required for passing through floors may be omitted and the moulding passed directly through, providing the partition is dry and the moulding is in a continuous length with no joint or coupling within the partition.

The backing of all metal moulding should be secured in position by screws or bolts, the heads of which should be flush with the metal.

The metal of moulding should be permanently and effectually grounded to water piping, gas piping, or other suitable grounds, provided that when connections are made to gas piping, as in the case of metal conduit, they should be on the street side of the meter. If the metal moulding system consists of several separate sections, the sections should be bonded to each other and the system grounded, or each section may be separately grounded.

Metal mouldings and gas pipes should be securely fastened to outlet boxes, junction boxes and cabinets, so as to secure a good electrical connection. Moulding should be so installed that adjacent lengths of moulding will be mechanically and electrically secured at all points.

If metal moulding, couplings, outlet boxes, junction boxes, cabinets or fittings having protective coating of non-conducting material such as enamel, such coating should be thoroughly removed from the couplings of the metal mouldings, and from the surfaces of boxes, cabinets and fittings, where the metal moulding or ground clamp is secured in order to obtain the requisite good connection.

Connection to grounded pipes and to metal mouldings should be made by means of *approved* ground clamps, and the ground wires should be copper, at least No. 10 B. & S. gage.

As the two or more wires of an alternating current circuit are required to be placed in a single iron conduit, to prevent induction trouble, so must similar circuits be placed in single metal moulding.

Fixtures. All electric light fixtures supported at outlets in metal conduit, armored cable, or metal moulding systems, or from gas piping or any grounded metal work, or when installed on metal walls or ceilings, or on plaster walls or ceilings containing metal lath, or on walls or ceilings in fireproof buildings, should be insulated from such supports by *approved* insulating joints (see page 151) placed as close as possible to the ceiling or walls.

Gas pipes should be protected above the insulating joint by *approved* insulating tubing, and where outlet tubes are used they should be of sufficient length to extend below the insulating joint, and should be so secured that they will not be pushed back when the canopy is put in place.

In connection with insulating joints fixture canopies of metal should be thoroughly and permanently insulated from metal walls or ceilings, or from plaster walls or ceilings on metal lathing, and from outlet boxes.

Canopy insulators (see page 151) should be securely fastened in place, so as to separate the canopies thoroughly and permanently from the surface and outlet boxes from which they are designed to be insulated.

For fixtures which are not attached to gas pipes or conduit unless outlet boxes or other *approved* fittings which will give proper support for fixtures are used, a seven-eighths inch block should be fastened between studs or floor timbers flush with the back of lathing to hold tubing and to support fixtures. When this cannot be done, wooden base blocks, not less than three-quarter inch in thickness, securely screwed to lathing, should be provided.

Fixtures having so-called flat canopies, tops or backs, should not be used except where outlet boxes are installed, and for out-door use they should be of water-tight construction.

Fixture wires (see p. 104), should be not smaller than No. 18 B. & S. gage, and should have an *approved* rubber insulating covering.

In wiring certain design of show-case fixtures, ceiling bulls-eyes and similar appliances in which the wiring is exposed to temperatures in excess of 120 degrees Fahrenheit from the heat of the lamps. *approved* slow-burning wire shoud be used.

Supply conductors, and especially the splices to fixture wires, should be kept clear of the grounded part of gas pipes, and, where shells or outlet boxes are used, they should be made sufficiently large.

When fixtures are wired on the outside the conductors should be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixtures.

Fixtures thus wired should not be used in show windows or in the immediate vicinity of especially inflammable stuff.

Chain fixtures should be wired with flexible conductors.

Wires of different systems should never be contained in or attached to the same fixture, and under no circumstances should there be a difference of potential of more than 300 volts between wires contained in or attached to the same fixtures.

Fixture Wires, which may be either solid or stranded conductor, should never be smaller than No. 18 B. & S. gage (no wire smaller than No. 14 B. & S. gage should be used in any work outside of fixtures) and should conform to the following table for the wiring of fixtures:

B. & S. Gage.	Ampere Capacity. Rubber Insulation.	Slow-burning Insulation.
18	3	5
16	6	10
14	15	20
12	20	25

Conductors used in wiring fixtures should be of *approved* fixture wire, approved flexible cord or *approved* rubber-covered wire, excepting that *approved* slow-burning wire.

All electrical fittings (including insulating joints, sockets, receptacles, switches, attachment plugs, etc.) should be of *approved* types.

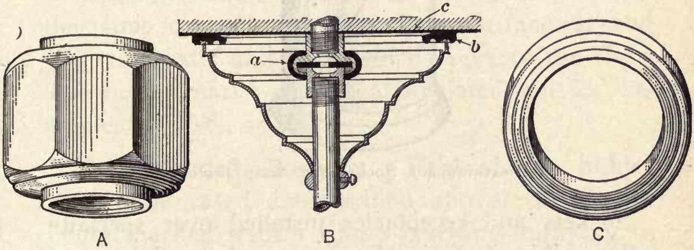
Canopy Insulators should be of *approved* types. They should be securely fastened in place so as to separate the canopies thoroughly and permanently from the surfaces and outlet boxes from which they are designel to be insulated.

Each fixture (after wiring and assembly) should be tested with a magneto which will ring through a resistance of at least 50,000 ohms and show no short circuits between conductors or contacts between conductors and metal parts of fixtures.

Each fixture should be marked with the manufacturer's name or trade-mark.

Insulating Joints. All a wireman needs to know about an insulating joint is that it is officially approved and bears the maker's name or trade-mark.

The same is true of Canopy Insulators.

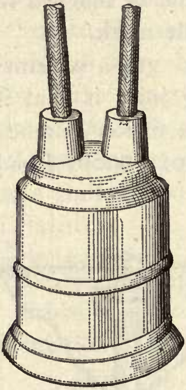


A Macallen Insulating Joint. B Macallen Canopy and Insulating Joint in Position. C Macallen Canopy Insulator.

Sockets. In rooms where inflammable gases may exist the incandescent lamp and socket should be enclosed in a vapor-tight globe, and supported on a pipe-hanger, wired with *approved* rubber-covered wire soldered directly to the circuit.

In damp or wet places, or where exposed to corrosive vapors, weatherproof sockets especially approved for the location should be used. Unless made up on fixtures they should be hung by separate *stranded* rubber-covered wires not smaller than No. 14 B. & S. gage, which should preferably be twisted together when the pendant is over three feet long.

These wires should be soldered direct to the circuit wires but supported independently of them.



Weatherproof Socket for damp places.

Sockets and receptacles installed over specially inflammable stuff or where exposed to flyings of combustible material, should be of the keyless type, and unless individual switches are provided, should be installed at least seven and one-half feet above the floor, or should be so located or guarded that the lamps cannot be readily backed out by hand.

When the socket is not attached to a fixture, the inlet if threaded should be not less than three-eight inch pipe size, and should be provided with an *approved* insulating bushing.

Sockets and Lamp Receptacles. Lamp holding devices are classified according to the diameters of the lamp bases. One-half inch are known as Candelabra, one inch as Medium, and one and a half inch as Mogul Bases and are rated as in the following table:

Nominal	Diam.	Key. Watts	Key. Volts.	Key. Max. amp. at any voltage	Keyless Watts.	Keyless Volts.	Keyless Max. amp. at any voltage
Candelabra	½ in	75	125	¾	75	125	1
Medium	1 "	250	250	2½	600	250	6
	(a)	660	250	6	660	660	
Mogul	1½ in				1500	250	
					1500	600	

All sockets and receptacles should be marked with the name or trade-mark of the manufacturer and with the watts and volts which apply to the class. The rating marks may be abbreviated, as, for example, "250 W., 250 V."

Double-ended Sockets. Each lamp holder should be rated as specified above, the device being marked with a single marking applying to each end.

All sockets, not attached to fixtures, if with threaded inlet, should be provided with a strong insulating bushing.

Rosettes for ceiling work, both fused and fuseless, should have all their current-carrying parts mounted on porcelain, be plainly marked where it may readily be seen after the rosette has been installed, with the name or trade-mark of the manufacturer, and the rating in amperes and volts. Fuseless rosettes are rated 3 amperes, 250 volts; fused rosettes with link fuses, not over 2 amperes, 135 volts.

Flexible Cord. Where the difference of potential between the two wires is over 300 volts, flexible cord should not be used, nor should flexible cord be used as a support for clusters. It should be used only for pendants, wiring of fixtures, portable lamps or motors, portable heating apparatus or other portable devices.

For all portable work, including those pendants which are liable to be moved about sufficiently to come in contact with surrounding objects, flexible wires and cables especially designed to withstand this severe service should be used.

When necessary to prevent portable lamps from coming in contact with inflammable materials, or to protect them from breakage, they should be surrounded with a substantial guard.

Unless provided with *approved* metal armor, flexible cord should not be used in show windows or in show cases.

Flexible cord should be protected by insulating bushings where the cord enters a lamp socket.

It should be so connected to all fittings that strain is taken from the joints and binding screws.

When passing through covers of outlet boxes it should be protected by *approved* bushings especially designed for this purpose.

Arc Lamps on Constant-Potential Circuits. Where arc lamps may be installed, although now rapidly being displaced by mazda or tungsten lamps, (see p. 166), a cut-out for each lamp or each series of lamps should be provided.

The branch conductors should have a carrying capacity about fifty per cent. in excess of the normal current required by the lamp.

They should be furnished with only such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat. Incandescent lamps, however, should not be used for this purpose.

All such arc lamps should be supplied with globes and protected by spark arresters and wire netting around the globe.

Outside arc lamps should be suspended at least eight feet above sidewalks. Inside arc lamps should be placed out of reach or suitably protected.

Lamps when arranged to be raised or lowered, either for carboning or other purposes, should be connected up with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 B. & S. gage.

Economy and compensator coils for arc lamps should be mounted on non-combustible, non-absorptive, insulating supports, such as glass or porcelain, allowing an air space of at least one inch between frame and support, and should in general be treated as sources of heat.

Vapor Lamps. Enclosed Mercury Vapor Lamps. Lamps of this kind (see page 167) should have cut-out for each lamp or series of lamps except when contained in single frame and lighted by a single operation, in which case not more than five lamps should be dependent upon single cut-out.

They should only be furnished with such resistances as regulators as are enclosed in non-combustible cases, such resistances to be treated as sources of heat. In locations where these resistances or regulators are subject to flyings of lint or combustible material, all openings through cases must be protected by fine wire gauze.

Gas Filled Incandescent Lamps. Mazda or tungsten gas filled lamps (see p. 166) should be so grouped that not more than 660 watts (nor more than 16 sockets or receptacles) should be dependent on one cut-out except that in cases where wiring equal in size to No. 14 B. & S. gage is carried directly into keyless sockets or receptacles, the location of which is such as to render unlikely the attachment of flexible cords thereto, the circuits should be so arranged that not more than 1,320 watts (or 32 sockets or receptacles) will be dependent on the final cut-out. Where a single socket or receptacle is used on a circuit the limitation of watts on the final cut-out should be the maximum capacity for which such socket or receptacle is approved.

Gas filled lamps should not be used in show windows or in other locations where inflammable material is liable to come in contact with lamp equipment except where used in connection with fixtures where temperature of any exposed portion of same does not exceed 200 degrees Fahr.

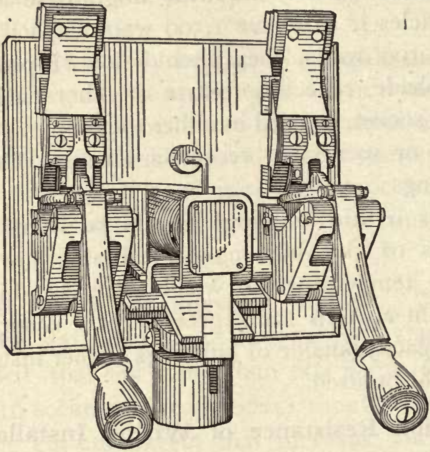
They should not be used in connection with medium-base sockets or receptacles if of above 200 watts nominal capacity nor with Mogul base sockets or receptacles if of above 1,500 watts capacity. If of about 100 watts, they should not, if provided with a shade, reflector, fixture or other enclosure above the socket, be used in either medium or Mogul base type or sockets or receptacles having fibre or paper linings.

Fixtures within buildings should be wired with conductors of slow-burning or asbestos covering where the temperature to which wire is subjected at any point exceeds 120 degrees Fahr. Where fixtures are placed outside of buildings rubber insulated wire should be used.

Insulation Resistance of Wiring Installation. The complete installation in any building should have a resistance between conductors and between conductors and ground not less than that given in the following table:

Up to	5	amperes	4,000,000	ohms
"	10	"	2,000,000	"
"	25	"	800,000	"
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	50,000	"
"	800	"	25,000	"
"	1,000	"	12,500	"

The test should be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only one-



Circuit Breaker.

The New I-T-E Circuit Breaker with Time Limit Feature.

For Approved Makes See page 268.

half of the resistances specified in the table will be necessary.

TRANSFORMERS

Oil Transformers. No transformers of this class should be placed inside of any building except central stations and sub-stations.

Air cooled transformers should not be placed inside of any building excepting central stations or sub-stations, if the highest voltage of either primary or secondary exceeds 550 volts, and with the exception of bell ringing and other signalling transformers, be so mounted that the case will be at a distance of at least one foot from combustible material or separated therefrom by non-combustible, non-absorptive, insulating material, such as slate, marble or soapstone. This will require the use of a slab or panel somewhat larger than the transformer.

Decorative Lighting Systems. Decorative Lighting, by which is meant temporary work, should be done with an approved system, such as the Elblight system, and the potential between the wires of any circuit should not be over 150 volts and also provided that no group of lamps requiring more than 1,320 watts shall be dependent on one cut-out.

HIGH POTENTIAL SYSTEMS

550 TO 3,500 VOLTS

Any circuit attached to any machine or combination of machines which develops a difference of potential between any two wires of over 550 volts and less than 3,500 volts, is considered as a high-potential circuit, and as coming under this class, unless an approved transforming device is used, which cuts the difference of potential down to 550 volts or less. For 550 volt motor equipments a margin of ten per cent. above the 550 volt limit at the generator or transformer is permissible without coming under high-potential systems.

All wires for high-potential systems should have an *approved* rubber-insulating covering, and should be always in plain sight, and never encased.

Such wires should be rigidly supported on glass or porcelain insulators, which raise the wire at least one inch from the surface wired over, and should be kept at least eight inches apart.

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least about every four and one-half feet. If the wires are liable to be disturbed the distance between supports should 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 ten inches and run from timber to timber, not breaking around, and may be supported at each timber only.

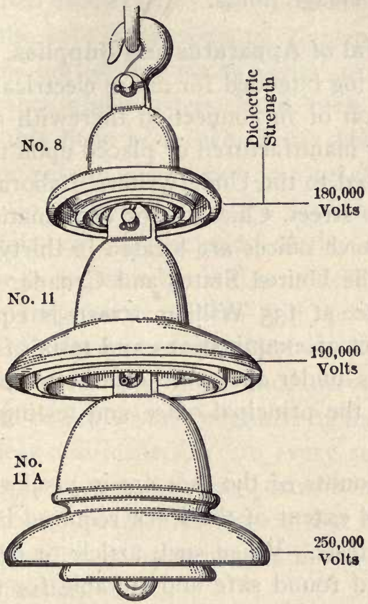
This class of wiring should be protected on side walls from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes) and extending not less than seven feet from the floor. When crossing floor timbers, in cellars, or in rooms where they might be exposed to injury, wire should be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

EXTRA-HIGH POTENTIAL SYSTEMS

Over 3,500 Volts.

Any circuit attached to any machine or combination of machines which develops a difference of potential, between any two wires, of over 3,500 volts, is considered as an extra-high-potential circuit, and as coming under this class, unless an approved transforming device is used, which cuts the difference of potential down to 3,500 volts or less.

Primary wires carrying over 3,500 volts should



Fred M. Locke.

Suspension Insulators for Extra High Voltages.

Insulators for other voltages see page 51.

never be brought into or over buildings, except power stations and sub-stations.

The secondary wires should be installed under the suggestions given in the preceding section for high-potential system when their immediate primary wires carry a current at a potential of over 3,500 volts, unless the primary wires are installed in accordance with the suggestions given for the construction of constant potential lines of over 5,000 volts as shown on page 63, or are entirely underground, within city, town and village limits.

Approval of Apparatus and Supplies. Every article or fitting intended for use in electrical wiring or construction or in connection therewith should, before being manufactured or placed upon the market, be submitted to the Underwriters' Laboratories, 207 East Ohio street, Chicago, for examination and report. Branch offices are located in thirty-two other cities of the United States and Canada. The New York office, at 135 William street, is equipped for the conduct of examinations and tests of all electrical devices under the same conditions as those afforded at the principal office and testing station in Chicago.

The amounts of the fees are in proportion to the nature and extent of the work required in examinations and tests. When such article or device is approved and found safe and suitable for the use intended, it is placed on the List of Electrical Fittings issued semi-annually by the Underwriters' Laboratories, for use in accordance with the rules and requirements of the National Electrical Code as given in the foregoing pages of this book.

When buying electrical supplies of any description make sure that they have been approved, or that their use will be permitted. If there is any question about it, make your supply dealer, or the manufacturer give you a guarantee that they will be approved by the Fire Underwriters' Inspector if installed in accordance with the rules and requirements of the National Electrical Code.

Electrical Inspection. The principal points regarding the safe installation of dynamos, motors, heaters and outside and inside wiring, as required by the insurance underwriters, have been briefly set forth in this little book, which has been compiled simply for reference and not as a teacher—a book designed to settle most of the doubtful questions which might arise in the mind of the engineer or contractor as to just what will be considered safe by insurance inspectors. There will probably arise questions which cannot be settled by reference to the suggestions herein contained, and, therefore, a great deal has to be left to the judgment of the constructing engineer and inspector. In every such case the Inspection Department having jurisdiction should be consulted with perfect assurance that nothing unreasonable will ever be demanded in the way of special construction.

Every piece of wiring or electrical construction work, whether open or concealed, should be inspected, and *notice*, therefore, *should always be sent by the contractor or engineer to the board having jurisdiction immediately upon completion of any work.* Negligence in this matter has frequently caused floors to be torn up when doubtful work has been suspected, and at the cost to the contractor.

LIGHT AND ILLUMINATION

Light and Illumination are two distinctly different things. Light is the raw product with which we work. It is produced in many ways that differ greatly in quantity and quality. By the application of light itself, or combined with various reflecting, refracting, absorbing or diffusing equipment, illumination is obtained as a result. The general principles of light should be clearly understood, that illumination may be intelligently brought about.

Light. Light is radiant energy. It varies in color, intensity and direction.

Candle Power is the Unit of Intensity of Light and is measured by comparison with a definite specified standard. The ordinary method of rating an incandescent lamp is *Mean Horizontal Candle Power.* It is the average intensity of light given out by the lamp in a horizontal direction when the lamp is hanging vertical. This does not give a true value of the candle power of the lamp, as few incandescent lamps radiate the same amount of light in other directions than the horizontal. The *Mean Spherical Candle Power* of a lamp is the average intensity of light in all directions about the lamp. It is usually less than the Mean Horizontal Candle Power, depending upon the characteristics of the individual lamp. If the Mean Horizontal Candle Power is known, the Mean Spherical Candle Power can be approximated by multiplying by what is called the *Reduction Factor* of the lamp; of the standard Mazda "B" lamp this Reduction Factor is about .78; with a gas-filled Mazda "C" lamp, the Reduction Factor is about .90. Both Candle Power terms refer only to average intensity of light, but do not give the measurement of a total quantity of light from a lamp.

The Unit of Quantity of light in one *Lumen.* The total quantity of light from a lamp is 12.57 times its Mean Spherical Candle Power. The efficiency of the lamp is expressed in terms of a quantity of light produced in lumens and the power input. This gives a rating according to Lumens per Watt.

Method of Producing Light. The three most common methods of producing light commercially, are Arc Lamps, Vapor Lamps and Incandescent Lamps. The first two are widely used for certain classes of work and to cover special conditions. The Incandescent Lamp, however, is the most common and easiest used, on account of the great variety of sizes and forms available.

Incandescent Lamps are produced in the following classes:

Carbon Filament, burning in vacuum.
Metalized Filament, burning in vacuum.
Tantalum Filament, burning in vacuum.
Tungsten Filament, burning in vacuum.
Tungsten Filament, burning in inert gas.

The first three classes of lamps are rapidly being superseded by the last two classes. The Tantalum Lamp was a great step in advance over the Carbon Filament and Metalized Filament, but the Tungsten Filament or Mazda Lamp followed so closely that little progress was made. It has practically been eliminated from the market.

Illumination is the result of application of light, with light itself, or with equipment to assist in the

MAZDA B LAMPS (VACUUM)

Volts	Watts	C. P.	W. P.C.	Amps.	Hot Res.
110	10	7.7	1.30	0.0909	1210.0
"	15	13.0	1.15	0.1363	807.0
"	20	18.2	1.10	0.1818	605.0
"	25	23.8	1.05	0.227	484.0
"	40	38.8	1.03	0.364	302.5
"	60	60.0	1.00	0.546	201.7
"	100	105.0	.95	0.909	121.0
"	150	150.0	1.00	1.363	80.7
"	250	263.0	.95	2.272	48.4

Volts	Watts	C. P.	W. P. C.	Amps.	Hot Res.
220	25	19.2	1.20	0.1136	1936.0
"	40	33.3	1.12	0.1818	1210.0
"	60	50.0	1.10	0.273	807.0
"	100	90.9	1.00	0.455	484.0
"	150	143.0	1.00	0.682	322.6
"	250	250.0	.95	1.136	193.6

MAZDA C LAMPS (GAS FILLED)

Volts	Watts	Total Lumens	Watts per Spherical Candle	Amps.	Hot Res.
110	200	2795	.90	1.82	60.5
	100	1257	1.00	0.909	121.0
"	300	4600	.82	2.73	40.3
"	400	6130	.82	3.64	30.3
"	500	8060	.78	4.55	24.2
"	750	12740	.74	6.82	16.1
"	1000	17960	.70	9.09	12.1

Volts	Watts	Total Lumens	Watts per Sph. C. P.	Amps.	Hot Res.
220	200	2514	1.00	0.909	242.0
"	300	4100	.92	1.36	161.2
"	400	5590	.90	1.82	121.2
"	500	7395	.85	2.27	96.8
"	750	11500	.82	3.41	64.5
"	1000	16120	.78	4.55	48.4

For comparative sizes see page 169.

distribution, direction and diffusion of light. The Unit of Intensity of Illumination is *One Foot Can-*

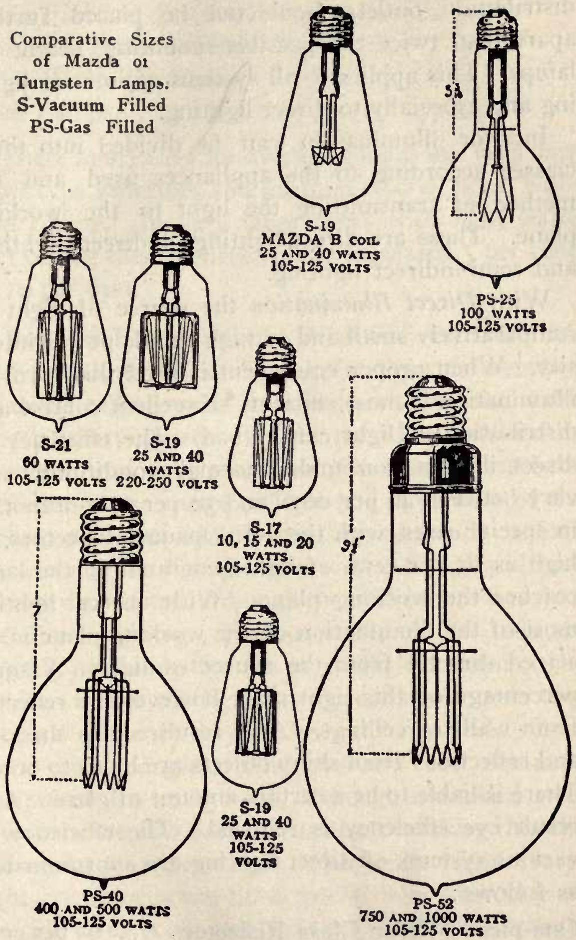
% Change in Voltage	% C. P. Mazda B (Vacuum)	% Watts Mazda B (Vacuum)	% C. P. Mazda C (Gas Filled)	% Watts Mazda C (Gas Filled)
Increase 10	39.3	16.3	36.3	15.9
9	35.0	14.6	32.3	14.3
8	30.7	12.9	28.4	12.7
7	26.6	11.3	24.6	11.2
6	22.6	9.7	20.8	9.5
5	18.6	8.0	17.2	7.9
4	14.7	6.4	13.6	6.2
3	10.9	4.8	10.1	4.7
2	7.2	3.2	6.6	3.1
1	3.6	1.6	3.3	1.6
Normal	0	0	0	0
Decrease 1	3.5	1.6	3.3	1.6
2	6.9	3.1	6.4	3.0
3	10.2	4.7	9.5	4.6
4	13.4	6.2	12.5	6.0
5	16.6	7.8	15.5	6.5
6	19.7	9.3	18.2	9.0
7	22.7	10.9	21.0	10.4
8	25.6	12.4	23.8	12.0
9	28.5	13.9	26.4	13.3
10	31.3	15.4	29.0	15.0

COOPER HEWITT LAMP UNITS—DIRECT CURRENT

Type	Watts	Length of Tubes, ins.	Candle Power	Watts per Candle
H	192	21″	300	.64
Double H.............	385	2-21″ ea.	600	.64
K	385	45″	700	.55
P	385	50″	800	.48
ALTERNATING CURRENT (60-cycle, 95-125 volts)				
F	365	50″	800	.46
Power Factor 85%.				
COOPER HEWITT QUARTZ LAMP—DIRECT CURRENT				
Y for 110 volts.......	418	1¼″	1000	.40
Z for 220 volts.......	725	4″	2400	.30

dle. This is the amount of light falling on a surface of one square foot area, every part of which is a distance of one foot from a source of light of one candle power. The quantity of light falling upon this surface under these conditions is one Lumen, thus the application of one Lumen of light to an area of one square foot will produce a resulting illumination of one foot candle. An approximate idea of this intensity of illumination can be obtained by hanging a 25-W Mazda "B" Lamp in a vertical position, then the light falling upon the vertical surface, held about four feet ten and a half inches away from this lamp, will result in illumination intensity of one foot candle.

The source of light is very seldom such that the light radiated will result in illumination where it is desired, or is it possible to place the source of light where good results would be obtained. It is therefore necessary to use various types of equipment to re-direct the light where it is desired and in such a manner that it will be most useful. The equipment may reflect, refract or diffuse the light, or may combine these, but the result produced, namely the illumination, should be such that best results would be obtained for the conditions. In planning illumination the following general principles of good illumination should be kept in mind. The amount of illumination should be sufficient for the requirements of the surface lighted. The intensity of illumination should be fairly uniform. The lamps should be so placed that they will give the above results and also so that they will not be in direct range of vision under normal conditions. The equipment used with the lamps should be such that the eye is protected from a direct view of the filament under all normal conditions. When practical, extreme contrast between



Comparative Sizes of Mazda or Tungsten Lamps.
S-Vacuum Filled
PS-Gas Filled

sources of light and immediate surroundings should be avoided. In order to obtain proper results as to distribution, outlets should not be placed further apart than twice the possible mounting height of lamps. This applies to all systems of interior lighting and especially to direct lighting.

Interior illumination can be divided into three classes according to the appliances used and the method of transmitting the light to the working plane. These are direct lighting, indirect lighting, and semi-indirect lighting.

With *Direct Illumination* the source of light is comparatively small and of high candle power intensity. When proper equipment is used this form of illumination is most efficient. Excellent control and distribution of light can be had. The efficiency of direct illumination under normal conditions, will vary between 40 per cent. and 50 per cent, although in special cases, with the best Opaque Reflectors, as high as 65 per cent. of light generated by the lamp reaches the working plane. With direct lighting most of the illumination on the working plane is received directly from the source of light. A small percentage of this light may, however, be reflected from walls or ceilings. As a result, sharp shadows and reflections from shiny objects are liable to occur. There is liable to be a certain amount of glare. As a result eye efficiency is reduced. The efficiency of various systems of direct lighting are approximately as follows:

One-piece Mirror Glass Reflector.....	65 per cent.
Clear Prismatic Reflectors	55 "
Heavy Density Opal Reflectors........	45 "

Aluminized Metal Reflectors	45	per cent.
Medium Density Opal Reflectors	40	"
Satin Finished Prismatic Reflectors	40	"
Porcelain Enameled Steel Reflectors	40	"
Opal Enclosing Globes	35	"
Bare Lamps	28	"

These figures are for average conditions, with deep bowl type reflectors and medium colored floor, walls and ceiling. In very large areas with light walls, and ceiling these figures will be increased 5 per cent. to 10 per cent.

Indirect Illumination. With indirect illumination practically all of the useful light is received from the ceiling and a small amount from the walls. The primary source of light may be contained in bowl fixtures, cornices, floor pedestals or brackets. The secondary source of light is a large area of the ceiling, the foot candle intensity of which is low. As a result the light is very well diffused and uniformly distributed, although the efficiency is less than the direct lighting. For successful results it is absolutely necessary that the most efficient reflectors be used to throw the light on the ceiling in ordr that the total efficiency may be the highest possible. One-piece mirrored glass reflectors are the standard equipment for such work, although enameled steel reflectors are also used. It is also necessary that the ceiling be of a very light color, either light ivory, light cream or white being preferable. The color of the side walls is not so important, although most satisfactory results are obtained with medium color on the side walls, especially up to eight or ten feet from the floor. Under these conditions and with mirrored glass reflectors efficiency will vary between 28 and 39 per cent.

Indirect Illumination is especially desirable where sharp shadows, reflections from shiny objects or glaring light sources are found to be annoying. The actual eye efficiency is highest under this method of artificial illumination. There is less eye strain and eye fatigue than with direct lighting or semi-indirect lighting where the efficiency is high. In planning installations of indirect illumination, the manufacturer's data, which is easily available, should be followed closely.

Semi-Indirect Lighting. Semi-indirect illumination is generally considered as lighting by means of lamps placed in opalescent glass bowls. These vary greatly in density and amount of transmitted light through the bowl, so that many of them, especially those showing the highest efficiency, are quite the same as direct lighting with enclosing diffusion globes. General engineering practice has set a standard that requires less than 50 per cent. of resulting illumination to be received direct from the bowl, or source of light, in order to be classed with semi-indirect illumination. The efficiency of this method of lighting will vary between 30 and 40 per cent, depending upon the density and shape of the bowls and color of walls and ceiling. With this method of lighting the harsh effects of direct illumination are greatly reduced, the shadows are not so intense and because of the amount of light reflected from the ceiling, there is a better diffsion. There is slightly less eye strain and fatigue than with direct illumination, but the advantage is not so great as with indirect lighting.

The efficiency figures given above refer to the amount of light received at the working plane, as compared with the amount of light generated within the lamps. The working plane is normally the average desk or counter height, thirty or thirty-six inches from the floor. Knowing the quantity of light or total lumens generated by the lamps, and the efficiency of the system of lighting, the average lumens received on the working plane can be estimated. One lumen per square foot results in illumination of one foot candle. On the other hand, if the desired illumination on the working plane is known, and also the efficiency of the proposed system of lighting, the total lumens necessary at the lamps can be estimated and from this the number and size of lamps determined. The following table shows the required illumination for various classes of service. These are average figures and will vary according to individual requirements.

Illumination Required for Various Classes of Service

Service	Foot Candles.
Armory	2-3
Auditorium	1-3
Automobile, Garage	2-3
Automobile, Showroom	4-6
Ball Room	2-3

Required Illumination (Continued)

Service.	Foot Candles.
Bank	3-4
Billboard	5-15
Billiard Room, General	1-2
Billiard Room, Table	5-8
Bowling Alley, Pins	4-0
Bowling Alley, Alley	1-0
Barber Shops*	3-5
Cafe	2-4
Cars, Street	2-3
Court, Tennis	5-8
Court, Handball	5-8
Church	1-3
Corridor	0.5-1.5
Court Room	2-4
Desk*	4-6
Draughting Room*	7-10
Gymnasium	1-3
Hospital, Operating Table	12-18
Hospital, Ward	1-2
Hotel, Dining Room	1-4
Hotel, Guest Room	1.5-2
Hotel, Lobby	2-4
Hotel, Writing Room	2-4
Library, Reading Room*	3-4
Library, Stack Room	1.5-2
Lunch Room	2-4
Market	2-4
Moving Picture*	0.5-1.5
Museum	2-4
Office*	4-5
Power House	2-3

Required Illumination (Continued)

Service.	Foot Candles.
Residence	1-2
Restaurant	2-5
School*	3-4
Show Window	10-40
Stock Room	0.5-2
Store, Clothing	4-7
Store, Drug	4-6
Store, Dry Goods	3-6
Store, Furniture	2-3
Store, Grocery	3-5
Store, Jewelry	4-7
Store, Shoe	3-5
Store, Tobacco	3-5
Theatre	1-3
Warehouse	0.5-2
Wharf	0.5-1.5

* Some form of Semi-indirect or Totally Indirect lighting particularly desirable.

Show Window Lighting. This special field of lighting requires attention especially fitting its conditions. The sources of light should always be hidden from view. They should be located in the front of the window close to the glass and should be mounted either at the ceiling of the window or from the transom bar. Special reflectors are received giving a distribution of light particularly adapted to flooding the window with strong illumination, but preventing light being wasted through the window on the sidewalk or on the top of the window. Individual reflectors are best equipment for this work, the most efficient being one-piece mirrored glass reflectors, followed closely by special prismatic glass reflectors. In general, lamps used for show window lighting should be either 60-W or 100-W Mazda "B" Lamps, or 100-W Mazda "C" Lamps. Most standard equipment is for use with these lamps. Under special conditions for very small windows or limited space, tubular lamps or special small lamps may be used. The number of lamps required for show window lighting can be estimated from usual practice, which varies between five and ten watts per square foot for floor area in the window. Windows with dark trimmings and dark goods on display require more light than those in which light colors predominate.

The following formulæ will be of assistance in calculating illumination:

C.P. = Candle Power.
M.H.C.P. = Mean Horizonal Candle Power.
M.S.C.P. = Mean Spherical Candle Power.
R.F. = Reduction Factor (Expressed as decimal).
W. = Energy in Watts.
L. = Total Lumens.
L(e) = Lumens effective at working plane.
L per W = Lumens per Watt (Measure of Lamp Efficiency.)
W per CP = Watts per Candle Power.
Ft.Cd. = Illumination (lumens per square foot).
W = C.P. × (W per C.P.)

$$\text{W. per C.P.} = \frac{W}{\text{C.P.}}$$

$$\text{Candle Power of a lamp—(M.H.C.P.)} = \frac{W}{\text{W. per C.P.}}$$

M.S.C.P. = M.H.C.P. × R.F.

Lumens of Lamp = W × (Lumens per W.)

Lumens of Lamp = M.S.C.P. × 12.57 = M.H.C.P. × R.F. × 12.57.

$$\text{Efficiency of Lamp} = \text{Lumens per Watt} = \frac{L}{W}$$

Total Lumens available = L. per W. × W × No. of Lamps.

L(e) = L × Efficiency of Lighting System.

$$\text{Ft. Cd.} = \frac{L(e)}{\text{Sq. Ft.}} = \frac{L \times \text{Eff. of System}}{\text{Sq. Ft. (Area to be lighted)}}$$

L(e) = Ft. Cd. × Sq. Ft.

Efficiency of Lighting System

$$= \frac{L(e)}{L} = \frac{\text{Ft.Cd.} \times \text{Sq.Ft.}}{\text{Total lumens of lamps}}$$

$$= \frac{\text{Ft. Cd.} \times \text{Sq. Ft.}}{\text{M.S.C.P.} \times 12.57 \times \text{No. Lamps.}}$$

HOUSE WIRING.

Special Suggestions and Recommendations to the House Owner, Architect, Contractor and Wireman, with the co-operation of the Wiring Committee of the Commercial Section of the National Electric Light Association and the Society for Electrical Development, in Accordance with the Rules and Requirements of the National Board of Fire Underwriters.

Obtaining Service.

In every case where the electric wires have not been introduced into a house, it is necessary to consult the central station as to the terms on which service can be obtained.

When the wires are not even on the street it will always be necessary for the central station to make an extension, involving additional mains, as the electric wires in the street are called, and usually additional poles for overhead wires, or digging for conduits for underground wires.

It may be noted here that the current for trolley service is not suitable for house lighting, nor is such service allowed by the insurance interests in any part of the country.

No one but the central station representative can determine the cost of making an extension, and all that can be said in this general treatise is that sometimes the central station will extend its wires without any guarantee, on the chance that the new business will be profitable. In other cases the prospective customer is asked to guarantee a definite income for a term of years, or to make a deposit towards the cost of the extension, to be returned out of the income; or in extreme cases, even to pay the whole cost. Each case has to be considered separately; but in this country a somewhat general rule is to make extensions when the annual income, either estimated or guaranteed, is equal to about half the cost of the additional investment, or cost of the extension beyond the point to which the lines have been already built.

In regard to whether the service is overhead or underground, this usually depends on the character of the neighborhood, dense city districts being supplied underground, and suburban or country districts overhead.

If in a district where the wires are underground, the central station extends the mains along the street, and usually branches from the mains to the lot line without further charge for the branch. Sometimes the street construction is such that the house service comes from the wire directly opposite. In other cases there are manholes in the street at convenient intervals, and the wires run directly from such manhole to the house.

Sometimes a charge is made by the central station for the whole of the branch to the house, but more usually there is no charge for the work in the public streets, and often the wire is carried free to the house wall, especially if the house is close to the street. If, however, there is a wide lawn a charge is often made, running from 75 cents to $1.50 per foot, according to circumstances. In the case of new houses it is often convenient to use the same trench or conduits for the telephone wires also, and sometimes even for the water pipe.

As the central station will always either do this underground work itself or furnish definite and complete specifications, no further reference need be made to it here.

In the case of overhead wires questions about the extension of the central station wires in the street come up. The householder should appreciate that overhead wires are installed only in districts where the cost of underground is prohibitive, so that if the central station cannot obtain the right to set the necessary poles in such districts it may not be able to extend the wires at all.

When the necessary poles are near enough the central station will usually run the wires from the pole to the house without further charge.

In other cases, as when the house sets far back, or when for some special reason the wires have to enter the house in the rear, it may be necessary to set poles on the private property, for which work the central station will frequently make a charge, which should run from say $10 to $50, about $25 for each pole together with the wire, cross arms, insulators, etc.

Of course, when the customer is willing to pay for it, the central station will run its wires down the pole into the ground and supply the house by an underground service, even in overhead districts.

The Code rules governing outside work for both overhead and underground are as follows:;

a. Line wires must have an approved weather-proof or rubber insulating covering (see p. 78).

That portion of the service wires between the main cut-out and switch and the first support from the cut-out or switch on outside of the building must have an approved rubber insulating covering, but from the above-mentioned support to the line, except when run in conduit, may have an approved weatherproof insulating covering if kept free from awnings, swinging signs, shutters, etc.

b. Line wires must be so placed that moisture cannot form a cross connection between them; must be not less than one foot apart except when in conduit or in the form of multiple conductor cable; must not be in contact with any substance other than their insulating supports. Multiple conductor cables must be secured to strain insulators spaced not less than one foot from any adjacent woodwork and in turn secured to petticoat or strain insulators by strain wires.

For conduit work, wires must be placed so as to conform to rules for unlined conduit except that conduit system must be waterproof. *(see p. 129).*

c. Must be at least eight feet above the highest point of flat roofs *(see p. 53)* *and at least one foot above the ridge of pitched roofs over which they pass or to which they are attached and roof structures must be substantially constructed. Wherever feasible, wires crossing buildings should be supported on poles independent of the buildings.*

d. Must, where exposed to the weather, be provided with petticoat insulators of glass or porcelain (see pp. 51 and 161); porcelain knobs or cleats and rubber hooks will not be approved. Wires on the exterior walls of buildings must be supported *at least every fifteen feet, the distance between supports to be shortened if wires are liable to be disturbed.*

Where not exposed to the weather, low potential wires may be supported on glass or porcelain knobs which will separate the wires at least one inch from the surface wired over, supports to be placed at least every four and one-half feet.

e. Must be so spliced or joined as to be both mechanically and electrically secure without solder (see p. 50). The joints must then be soldered, to insure preservation, and covered with an insulation equal to that on the conductors.

All joints must be soldered, unless made with some form of approved splicing device (see p. 50).

f. Must, where they enter buildings, have drip loops outside, and the holes through which the conductors pass must be bushed with non-combustible, non-absorptive, insulating tubes slanting upward toward the inside.

For low-potential systems the service wires may be brought into buildings through a single iron conduit. The conduit to be equipped with an approved service-head (see pp. 52 and 54). The inner end must extend to the service cut-out, and if a cabinet is required by the Code must properly enter the cabinet. Metal conduits containing service wires must be insulated from the metal conduit, metal moulding, or armored cable system within the building and all metal work on or in the building or they must have the metal of the conduit permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connec-

tions are made to gas piping, they must be on the street side of the meter. This ground connection to be independent of and in addition to any other ground wire on metal conduit, metal moulding or armored cable systems within the building.

If conduit, couplings 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 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 accessible, and must be made by means of approved ground clamps.

Ground wires must be of copper, at least No. 6 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.

g. Electric light and power wires must not be placed on the same cross-arm with telegraph, telephone or similar wires, and when placed on the same pole with such wires the distance between the two inside pins of each cross-arm must not be less than twenty-six inches.

h. The metallic sheaths of cables must be permanently and effectively connected to "earth" approximately every 500 feet (see pp. 56-60).

Although not specified in the Code, bare wires are sometimes used, especially through uninhabited and isolated territories, free from other wires.

Bare wire is also used for high tension lines, the theory being that only the insulators and not the covering are relied on for pole insulation. Hence, where there is no danger of other wires or trees coming near them, bare wire is satisfactory. If there are other wires or trees near, and the tension is below say 5000, then weatherproof insulation saves enough trouble from crosses with other wires, branches, etc., to be worth the cost. When, however, the voltage is above 5000, the protection of the covering is so slight as not to be worth while.

It should be noted that wires should be kept well clear of trees, as branches may blow onto the wires and cause trouble, even if clear of the wires in calm weather.

Also, many companies consider it undesirable to attach wires to trees, but prefer to set independent poles, even at an added expense, on the ground that in the long run the cost is less. Where tree wiring may be necessary, suggestions are illustrated on page 51.

Guard arms should be placed on all corner poles (see pages 49 and 74).

This, however, applies more often to poles on street corners rather than from pole to house.

In alternating current systems the wires in the street are usually of high voltage (2000 to 4000 volts) and a transformer is used for transforming the voltage to 110 or 220 volts.

The rule governing transformer installation is given on pages 55 and 158.

Current Supply.

Art. 1: In designing a house wiring installation, it is necessary to know whether the current is direct or alternating and the voltage of the supply service. If alternating it is also necessary to know the phase and cycle.

In some large cities direct current is used and also in places where owners have private generating plants. In most of the intermediate and smaller cities, however, and in practically all suburban districts, the supply is from alternating current.

In practically all residences, except very large ones with large individual motors, the alternating current is delivered in what is known as single phase, requiring but one transformer, and this condition is assumed throughout this section of the book.

The transformer for supplying a residence is generally located on a pole (see p. 60), or in an underground vault, near, or inside, the building and the transformer is designed with two or three wires, according to the system used, coming from it on the house or service side.

The Code rule is as follows:

Transformers must not be placed inside of buildings without special permission.

Must be located as near as possible to the point at which the primary wires enter the building.

Must be placed in an enclosure constructed of fire-resisting material; the enclosure to be used only for this purpose, and to be kept securely locked, *and access to the same allowed only to responsible parties.*

The transformer case must be permanently and effectually grounded, and the enclosure in which the transformers are placed must be practically air-tight, except that it must be thoroughly ventilated to the outdoor air, if possible through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

In equipments with not more than fifty lights and outlets many lighting companies deliver the current, from the transformer to the building, on a two-wire system at about 110 volts and without the use of the third or neutral wire.

Voltage.

Art. 2: With the three-wire system the voltage between the two outside wires is generally about 220 volts and the voltage between the neutral (middle) wire and either outside wire is about 110 volts. The 110-volt outlets, for lights and small appliances are placed on two-wire branch circuits, balanced on each side of this neutral wire. Larger appliances are often wound for 220 volts and connected across the outside or 220-volt circuit.

For these larger power appliances and motors 220-volt apparatus is used for the purpose of reducing the size of the wires supplying them. Small heating appliances where considerable heat must be generated are almost universally made for 110 volts.

Bell and telephone systems require but low voltage (4-6 volts) and small currents and therefore are seldom dangerous from a fire standpoint, when kept away from contact with light and power wiring. This portion of the installation is not inspected by insurance representatives, except to see that the wires do not come in contact at any point with electric lighting or power circuits, from which they must be kept entirely separate.

Service Feeders.

Art. 3: In most of the larger cities the feed wires come directly into the cellar underground and in many cases where the wires are overhead on poles, the owner prefers to have the wires brought into the house underground from the nearest pole, although in this case, the owner must pay for the underground portion of the work.

Where the lighting companies' pole on the highway is not over sixty or seventy feet (60′ or 70′) from the residence, the service company will generally bring its service wires overhead to the house without charge and in such cases it is good practice to have the house wiring carried through the cellar wall to the outside of the house and then rise in a rigid iron conduit to meet the overhead wiring, the end of the conduit being turned over or fitted with an appliance such as a service head or pot-head which will prevent the entrance of water (see p. 52).

At this point, insulators are placed on the side of the house to take the strain of the wires from the pole to the house, and then a loop is made, connecting to the wires in the conduit arranged so that the wires come out of the conduit at a downward angle to prevent rain water from running along the wires into the conduit.

Main Switch and Meters.

Art. 4: The service switch (see pp. 107 and 114) for cutting off the entire electrical supply of the house, and the meters usually furnished and installed by the lighting company, should be located at some accessible point as in the cellar close to where the wires come through the wall. This makes it unnecessary for the meter reader, who comes once a month, to go through the main living portion of the residence.

Where a different rate is charged for different classes of service there should be a different meter for each class. Many service companies make different rates for light, for power and for heating, cooking and refrigeration. Most companies will furnish and connect 3-wire meters for power and cooking, etc., as well as for light, so that both 110-volt and 220-volt apparatus may be used on the same meter by balancing on each side of the neutral wire, as explained in Art. 2. The service company should be consulted as to meter arrangements.

Current Costs.

Art. 5: The costs given below for operating various appliances are based on the ratio common with many companies throughout the United States, viz:

Lighting, 10c. per kilowatt-hour.

Power, 8c. per kilowatt-hour.

Heating, cooking and refrigeration, 5c. per kilowatt-hour.

Rates varying from the above, as in some localities they are based on a sliding scale according to the minimum demand, will cause a like change in the operating costs. Electricity is sold at so much per kilowatt-hour. A kilowatt means 1000 watts (see pp. 236 and 240).

A kilowatt-hour is the equivalent of 1000 watts continually consumed for one hour (see p. 241). Watts (see pp. 236 and 240) are the product of the volts by the amperes. Thus, 40 25-watt Mazda or Tungsten lamps (each giving about 24 candle-power) all continuously in use for one hour, or one such lamp burning for 40 hours would in either case consume one kilowatt-hour and cost about 10c. at the above rate (see Lamp Data, p. 166).

For cooking, current at 3c. per kilowatt-hour is about the equivalent of artificial gas at 90c.

Grounding.

Art. 6: In two-wire system (see Art. 1), one side of the service switch and in the three-wire system, the neutral (middle) of the service switch (in both cases on the incoming side), should be grounded by means of a copper wire to the water supply pipe on the supply side of the water meter.

By grounding is meant a solid, permanent connection to the earth or ground by means of connection to water pipes, or plates buried in the ground (see pp. 56-61). The result is that if either outside the house or in it anyone touches this neutral or grounded wire, as at a lamp socket, and also touches or makes connection with the ground, as through a gas pipe or radiator, there is no difference of potential, while if either the positive or negative wire is touched only, the system potential, as 120 or 240 volts, is felt, and is considered perfectly safe while pressures above 300 become dangerous.

Without a ground connection, it is possible, in case of an accident in the street or during a thunderstorm, for almost any pressure to get on the wires. If this happens they are still safe so long as no connection is made by a person between the wires, and no ground connection made at all. If after such dangerous pressure gets on the wires a ground connection is made somewhere by accident, still nothing happens, but then if a person touch the ungrounded wire and connect to ground, as through a radiator, etc., he gets the full pressure.

On the other hand, with a ground connection made intentionally, whenever any dangerous pressure gets on the wires it immediately flows to the ground, when contact is made, through any lamp socket, motor, or current-using devices on the system, and blows the fuses before any harm can be done.

The result is that a ground connection, while making it possible for any person easily to get the normal voltage, makes it impossible for him to get any more.

Where the wiring of the house is in conduit, the conduit system should be continuous or electrically connected by means of wires, and the conduit system also grounded in the cellar to the water pipe, in the same manner as described above for service switches. The two ground wires should be separate, although they may connect to the same water pipe.

House Mains.

Art. 7: From the service equipment the supply wires, called the mains, should be carried to the central distributing points (known as cut-out or panel equipments), there being one such main for each class of equipment that is separately metered (see Art. 4). These mains are carried to all panel equipments controlling the class of appliance which the mains are intended to supply. The branch circuits which run to light and power outlets and to the various appliances radiating from these panel equipments, should be located in central and accessible positions. (To find the proper size of wires for carrying any current any distance for any number of lamps, or their equivalent, at any loss of voltage, see table and examples on pages 79 to 82.)

Distributing Panels.

Art. 8: In residence work it is good practice to place the distributing panels in cellars, servants' halls or corridors (not in clothes closets) so that workmen can get to them when necessary without disturbing the occupants of the house, and where possible dirty shoes and hands will do the least damage. The necessity, however, does not often occur in well designed and installed systems.

These panel equipments may consist of groups of porcelain cut-outs and fuses or porcelain base knife switches and fuses. In the best class of work knife switches and enclosed fuses are mounted directly in two vertical rows on polished slate or marble panels and cross connected by metal straps to polished copper bus-bars rising up the middle of the panel. These bus-bars are fitted at their ends with lugs to which the mains connect. The cut-outs or panel are surrounded with slate edgings containing openings through which the circuit wires pass to connect to the branch switches. The slate frame thus formed is mounted in a metal box with from three to four inches (3″ to 4″) space around the slate, thus forming a gutter in which the circuit wires can be carried from the ends of the conduits terminating in the metal box, to the various switches. If a wooden door is used it should be lined with slate and any wood trim which covers the gutter and overlaps the joint between the box and wall should be lined on the under surface covering gutter with metal. Where metal doors and trims are used only the slate door lining is required. These trims are usually from 24 to 28 inches wide and of varying lengths to suit the number of circuits.

Each panel circuit or switch should be numbered by means of a metal stamp on the bus-bars opposite the switch and a directory sheet should be placed on the inside of the door giving the number of each switch and the number and location of the lights controlled. There should be a separate double pole cut-out or switch and fuses for each circuit consuming 660 watts or less in the case of lamps or small power and heating devices; and a similar cut-out and switch for each outlet for motor, etc., where the capacity is greater than 300 or 350 watts (see Art. 9), (see illustrations, pp. 43-47).

Where more than one main feeds a panel in bus-bar construction, the bus-bars are cut into the required number of sections and each section carried out between switches to the edge of the panel that the main wires may be joined to the bus-bar ends just inside the slate edge and without the necessity of having the wires cross the panel.

To limit the necessity of cutting away too much of walls, floors and supports, where circuit conduits come together, the number of circuits at any panel box should be limited to ten or twelve by placing as many boxes at separate locations as may be necessary to supply the residence. Where the construction will permit, however, as many as eighteen to twenty-four circuits may be grouped at a single panel equipment without undue size.

Branch Circuits.

Art. 9: The rules of the Fire Underwriters allow 660 watts distributed at sixteen sockets on each 2-wire lighting circuit. It is recommended, however, that the number of sockets be limited to twelve or thirteen on a circuit, as this does not greatly affect the cost of the work and will permit the use of No. 14 wire for practically all such branch circuits without undue loss in voltage and without appreciable variation in voltage between outlets on the same circuit under any condition of use. (See Carrying Capacity of Wires, p. 91.)

Branch circuits for single phase power are also two-wire and vary in size depending on the horsepower of the motor or the watts of the appliance connected. (See p. 81.)

In wiring for small motors from ½ H.P. to 1 H.P. branch circuits should be No. 14 wire for 220-

volt motors and No. 12 wire for 110-volt motors. These sizes are made necessary because of the large inrush of current at the moment of starting the motor. For either appliances where there are no moving parts (such as electric soldering iron) the size of the wires vary with the watts consumed, but in no case may such wires be smaller than No. 14 Brown and Sharp gauge (see p. 91, 5th column). Where heating devices are of small capacity (as glue pot and soldering iron in basement workshop) two or more may be placed on one circuit. Where the wattage of a single appliance is 350 watts or more, it is better to carry a separate circuit to each such appliance.

The branch circuits to electric cooking ranges are generally three-wire; the size depending on the capacity of the range.

The branch circuit for the vacuum cleaner outlets should be on the power section of the system and as but one outlet is used at a time, all the vacuum cleaning outlets in the residence may be placed on one No. 12 wire branch circuit and connected for 220 volts.

Where the lighting companies make separate rates (as in Art. 4) branch circuits to lighting appliances—to power appliances—and to heating appliances must, of course, be kept separate and connected to the proper section of panel equipments.

Knob Work With Flexible Non-Metallic Conduit.

Art. 10: In frame residence with stud partitions, it is permissible to carry wires on porcelain insulators on the sides of the beams and studs and through them by enclosing in porcelain tubes with flexible non-metallic conduit (flexible tube) from nearest knob to outlet, keeping the wires as far as possible from the floor or ceiling to prevent injury. Outlet boxes should be used for flush switches and receptacles; but for ceiling and side fixture outlets where there are no gas pipes and for surface switches and receptacles, wood fixture blocks should be built into the walls and securely fastened to beams and studs to give adequate support for the fixtures and fittings. This type of construction is known as "knob and tube" work and is not only the cheapest but also a very satisfactory method of installation for concealed wiring (see pp. 131-134).

Armored Cable.

Art. 10a: Some architects and engineers specify armored cable for frame or semi-frame residences (pp. 135 and 137). This armored cable is made by wrapping steel tape or ribbon around the two or more wires of the mains or circuits, thus giving a heavy metal sheathed main or branch circuit. Such cable is made in lengths of from 50 to 250 feet. Armored cable may be laid or drawn between beams and studs or furring strips with practically no liability to mechanical injury from nails, etc. Armored cable should not be placed in brick or concrete walls unless imbedded in plaster-of-paris or other suitable material to protect the sheath and wires from the corrosive action of the surrounding ingredients. For the same reason the best practice prohibits such armored cable being placed in brick or concrete walls where subject to considerable dampness. Outlet boxes in this construction are required at all outlets, and the metal armor should be grounded as called for in Art. 6.

Armored cable construction is very satisfactory in residences where the permanent decorations are not expensive or where the construction is such that the concealed lengths between outlets may be withdrawn and new lengths drawn in (in case of trouble) without injury to the finished surface. This construction is a little more expensive than knob and tube work (see Art. 12).

Flexible Steel Conduit.

Art. 10b: Where the character of a residence is such that it would be expensive to make repairs or alterations in the concealed wiring, good practice calls for the use of concealed conduits for the reception of the wires. These conduits should be large enough to permit the easy drawing in and withdrawal of the wires without the use of tackle. The smallest conduit generally used for electric light branch work is about ½ inch inside diameter. Conduits should be securely fastened to building construction and have easy bends to facilitate the drawing in of the wires. Flexible steel conduit is frequently used for this purpose, the construction of which is practically the same as armored cable but in larger and tube form. These flexible conduits are made in lengths of from 25 to 100 feet for lighting work and this type of wiring installation is more expensive than with armored cable (see Art. 12).

Rigid Conduits.

Art. 10c: For the highest class of residence work, architects and engineers generally specify rigid conduit construction (see p. 137). These rigid conduits are of gas-pipe thickness and are coated on the inside with a tough elastic and very smooth enamel. The exterior may either be coated with the same enamel or galvanized. The conduits come in ten-foot lengths and all diameters from ½-inch to 6-inch and are joined by means of screw couplings of the same material and the joints are made tight by the use of red or white lead. This prevents the entrance of any moisture. This is the most expensive character of concealed wiring work (see Art. 12).

Wood Moulding.

Art. 10d: This class of work, which is not permitted in concealed places, is frequently resorted to on account of the cheapness and where it is undesirable, or unnecessary for appearance, to run circuits inside of walls or ceilings. Wood moulding work is especially adapted to the cheaper class of cottages, bungalows, etc. For construction rules see pages 127-128.

Cleat Work.

Art. 10e: In dry places and where the wires are not liable to mechanical injury, or contact with other objects, circuits may be supported on porcelain cleats or knobs.

For this class of work the wires should be separated, by their insulating knobs or cleats, two and one-half inches from each other and at least one-half inch from the surface wired over (pp. 90 and 133), where the voltage does not exceed 300.

Metal Moulding.

Art. 10f: Where it becomes necessary, for mechanical reasons, to use metal moulding the suggestions given on pages 89 and 90 should be followed.

Bell Conduits.

Art. 10g: Bell and telephone cables and wires need not necessarily be in conduit nor need they be installed on knobs. In fireproof or semi-fireproof residences where the cables come in contact with brick or concrete and would not last and in frame residences where it is desired to make repairs to the concealed wiring without injury to the walls, such wires should be placed in concealed conduits, installed in the same manner as described above for electric light wiring. In the best class of residence work this is usually done.

Conduit Fittings.

Art. 11: In both armored cable and metallic conduit construction special fittings are used to connect the metal to the outlet box or cut-out box, or other opening, and in the case of conduit work these bushings and nipples are so designed and installed that the wire is drawn over smooth rounded surfaces to prevent abrasion of the braid covering of the conductors while they are being drawn in.

Approximate Wiring Costs.

Art. 12a: Due to the varied cost of labor and material and to varying methods of building construction, universal costs of electric light work for the several types of wiring hereinbefore described, cannot be given, but for the purpose of general comparison the following approximations may be a help:—

Knob and (Flexible) Tube Work	$1.50 to $2.50	per outlet	
B. X. Cable Work	2.00 to 5.00	"	"
Flexible Steel Conduit Work	3.50 to 5.50	"	"
Rigid Metallic Conduit Work	4.00 to 7.00	"	"

It must be borne in mind, however, that these proportions for the wiring work will not follow as proportions for the complete equipment, as the cost of fixtures, appliances and lamps, etc., will be the same for any one of the systems, and as these fixed costs are generally the larger part of the complete total the above proportions would apply to perhaps one-half or less of the total cost of any given installation.

Bell Costs.

Art. 12b: Bell call or annunciator requirements differ for almost every family and attempts to give costs in this class of work would be misleading. In a general way, however, the equipments will range from $3.00 to $10.00 per call; and from $1.50 to $8.00 per extension bell or annunciator drop. The smaller costs are for the simpler systems with concealed wires not in conduits, and the higher costs for more or less complicated call systems with wires in concealed rigid conduits.

House Telephone Costs.

Art. 12c: A house telephone system intercommunicating between various rooms of the residence and arranged on what is known as metallic circuit connections (to prevent cross-talk) will cost from $20.00 to $50.00 per instrument, depending upon the number and finish of the instruments, and whether or not the concealed wire is in conduit. Most of the telephone manufacturers of this class of instrument make a standard telephone with ten (10) buttons, thus providing for intercommunication between eleven (11) points.

Wire for Light and Power.

Art. 13a: All of the various fire underwriters organizations require "Rubber Covered" wire (see p. 76) for all classes of concealed residence wiring. These wires may have a single impregnated braid in case of knob and tube work and a double braid in the other classes of concealed work hereinbefore described. The life of rubber insulation depends largely upon the amount of pure unreclaimed Para rubber used in the insulating compound and the method of applying it to the copper conductor. The very best class used in residence wiring as well as the most expensive contains about 30 per cent. pure Para rubber.

In installations supplied by alternating current it is important that all the wires of any branch circuit, main or feeder should be in the same conduit. In fact, this should be absolutely insisted upon to prevent trouble from induction (see p. 131). Joints in wires should not be allowed where they will be concealed in conduits or be at inaccessible points. Where splicing is necessary the joint should first be made mechanically strong, then soldered for perfect electrical contact and insulated with rubber compound and tape and made equal in insulation to the rest of the wire (see p. 79).

Bell ad Telephone Wire.

Art. 13b: Wire used in bell and telephone systems may be of the same quality as above described but need not be as large in size. For small bell systems No. 18 B. & S. gauge is amply large for the section wires and No. 16 for the battery wires. These sizes are determined mainly by means of mechanical strength and in order to easily distinguish between battery and section wire.

Where there are a number of bell or telephone wires carried between two points a considerable distance apart, it is quite customary to buy the cable already made up and these wires are often as small as No. 20 or No. 22 B. & S. gauge. The separate wires in such cables may be insulated with two silk and one cotton wrapping impregnated with beeswax to keep the ends of the yarns from unraveling and the made-up cable encased in a heavy fireproof braided covering.

The most approved type of house telephone contains two wires for each call, two wires for battery talking, two wires for battery ringing. Each pair of wires should be twisted to prevent "cross-talk." This refers to metallic circuit connections in house intercommunicating telephone systems. Where silk and cotton cables are used in damp places the cable should be encased in lead to prevent moisture developing short circuits between the various wires.

Voltage Loss in Conductors.

Art. 14: The size of conductors given in the National Electrical Code for any given current is based only on the safe carrying capacity (see table, p. 91) without undue heating and does not necessarily determine, except where the distance is short, the size of conductor that good engineering practice requires. The proper size of conductors in any installation should be determined by the loss in volts between the service supply and the furthest outlet or appliance (electrically speaking) when the entire equipment is in simultaneous operation. In residence work 2 per cent. loss between the above mentioned points is not excessive (see pp. 79-82). Conductors smaller than No. 14 Brown and Sharp gauge must never be used in electric light work, except inside the lighting fixtures where a smaller conductor is permissible.

In proportioning the total voltage losses of a residence installation between the mains and branch circuits not more than 1 per cent. loss should be permitted in the branch circuit panel. A simple table, with examples worked out, to show its use, is given on pages 79 to 82. By its use the proper size of wire is easily determined for carrying any current any distance at any desired loss in volts.

There is a large rush of current at the moment of starting up single phase alternating current motors and the loss in such wires should be based on this momentary large amount which may vary from 100 to 200 per cent. overload of current. If this condition is not provided for it is quite possible to install wires that would be large enough to operate the motor after it is in motion, but too small to take care of this starting current (see pp. 14-25).

Room Switches.

Art. 15a: A liberal use of switches in a residence invites economy by encouraging the putting out of lights when leaving rooms. They soon pay for themselves. The most satisfactory switches are of the flush type and should be placed in metal cut-out boxes sunk in the wall and should generally be located just inside of entrance doors.

Large rooms with numerous outlets should be controlled by more than one switch, and in long living rooms it is often a good plan to place the lights of each end of the room on a different switch control, both for convenience of occupants and economy in bills.

For electroliers, switches are sometimes used, so designed that one turn of the handle lights one group of lights; the second turn lighting an additional group without putting out the first group, and a third turn will put all out.

Servants' rooms should have switches and high fixtures not only so that the lights will be more apt to be extinguished when not needed, but also to prevent the use of fixtures as clothes hangers.

Hall Switches.

Art. 15b: For hall and stairs it is customary to arrange lights that they may be turned on or off from any one of several switches known as 3-way and 4-way switches. A light in first floor hall and one on the second floor may be controlled by a switch at entrance door and also controlled from second floor. In the same manner an outlet on third floor may be controlled by a switch in second hall and one on third floor. This allows a person going to the third floor to come in late, light halls and stairs to room and put out lights again from above and thus do away with wasteful burning (see Hall Wiring, p. 205).

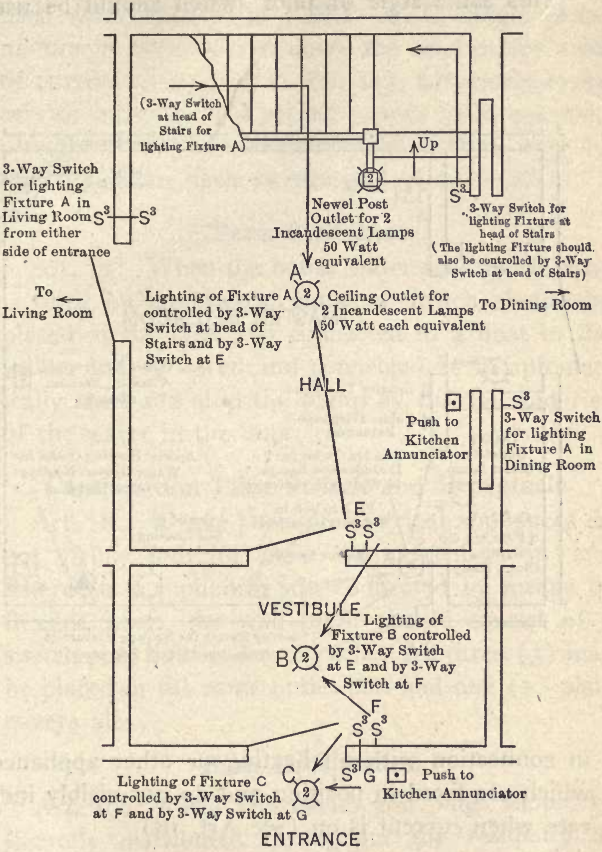
The three-way arrangement for servants' stairs especially will keep down the monthly bills, because of the ease with which the servants can put out lights. Sometimes this 3-way switch arrangement is used in bedrooms, one switch at door and the other at bed.

Master Switch.

Art. 15c: A master switch may be placed in the owner's bedroom and so connected that the switch will control the first, second and third floors, main hall and stairs, 3-way lights, either independent of whether the local switches have been used or not (see Master Bedroom, p. 206).

Closet Switches.

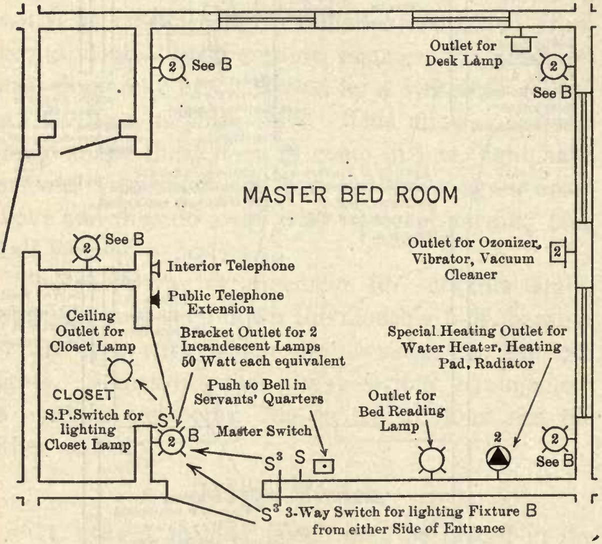
Art. 15d: Closet switches are often controlled by switches set in the door jambs and operated by movement of door. As closets, however, are often left open for ventilation, wall switches are preferable (see cut of closet below).



Pilot Switches.

Art. 15e: With switches operating lights not visible from the switch (as in case of cellar) it is economical to equip the switch with a small pilot light which burns when switch is in use.

This same style of pilot switch should be used



in connection with all heating or other appliances which are fixed in position and do not visibly indicate when current is on (see Art. 18).

Motor Switches.

Art. 16: Fused knife switches (see p. 107) in metal boxes should be used in connection with A. C. motors of ½ H.P. and larger. These switches should be double pole and located near the motor they control. Motor starting boxes are sometimes used with ½ H.P. to 1 H.P. A. C. single phase motors in order to cut down the momentary rush of current (described in Art. 14), but nearly every service company will permit motors to be operated directly from the switch. Small motors may be operated from flush switches of room type.

Tank Switches.

Art. 17: When the house water tank in the attic is filled by an electric pump, a switch should be placed at the tank and connected to a float in the water, and so wired and connected as to automatically start and stop the pump by the fall and rise of the water in the tank.

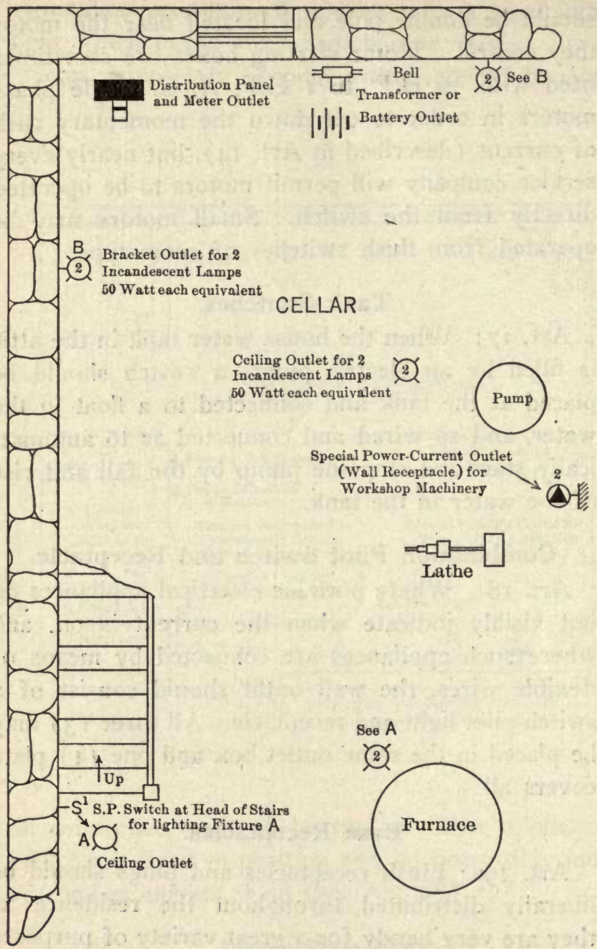
Combination Pilot Switch and Receptacle.

Art. 18: Where portable electrical appliances do not visibly indicate when the current is on, and where such appliances are connected by means of flexible wires, the wall outfit should consist of a switch pilot light and receptacle. All three (3) may be placed in the same outlet box and one (1) plate covers all.

Base Receptacles.

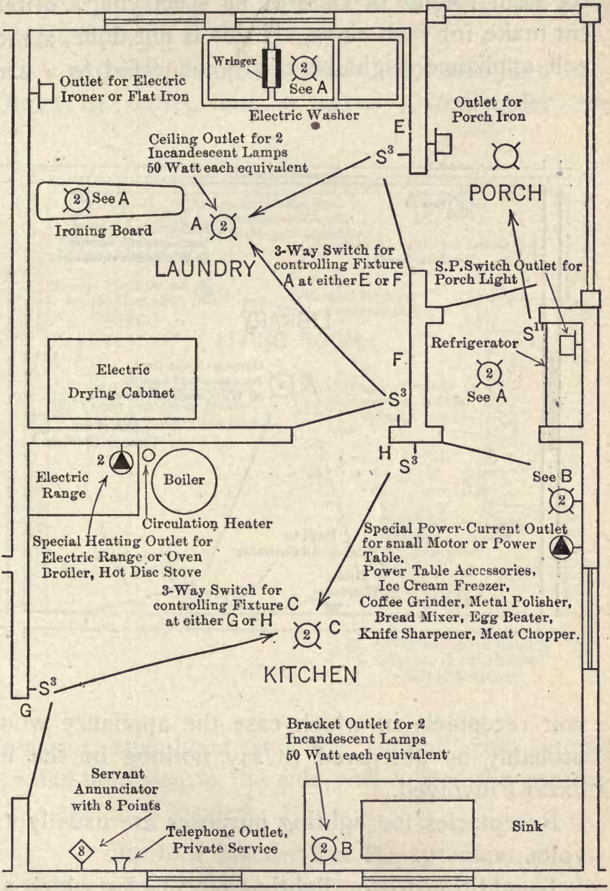
Art. 19a: Flush receptacles and plugs should be liberally distributed throughout the residence as they are very handy for a great variety of purposes and may be generally placed on or just above the baseboard. The plates may be painted to match surroundings and made very inconspicuous.

Receptacles for the same voltage and class of

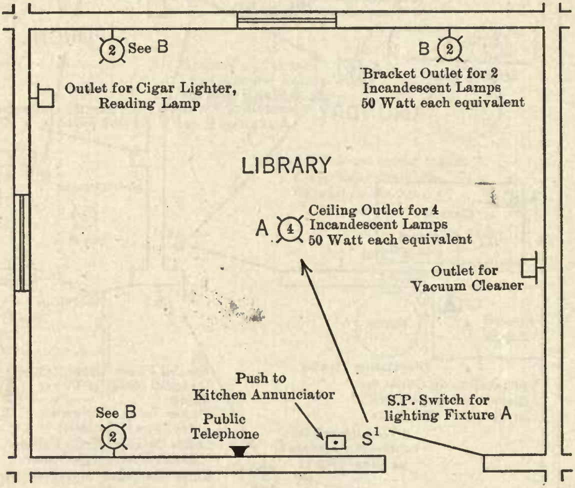


service should have interchangeable plugs to avoid the necessity of changing the plug on the flexible cord attached to any lamp or appliance should its location be changed.

Receptacles, however, should be so designed that



the plugs on apparatus of different voltage or class cannot be inadvertently connected to wrong receptacles. This may be accomplished by using the same make of receptacle with different openings for each voltage or class or by specifying a different make for each class. If this is not done, a 110-volt appliance might be easily connected to a 220-

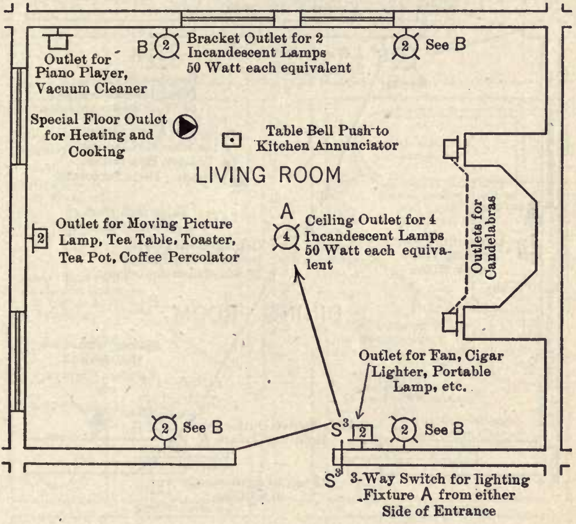


volt receptacle in which case the appliance would probably be destroyed to say nothing of the fire hazard involved.

Receptacles for lighting purposes are usually 110 volts.

In addition to the lighting receptacles which are usually installed for reading lamps, piano lamps, etc., there should be one or two spare receptacles in each main room and hall. One of the receptacles in main living room or hall should be placed so as to be near a suitable location for a Christmas tree, so that this may be illuminated without unsightly wires showing in the room.

A porcelain lamp receptacle, mounted in a condulet or outlet box, is often placed under the

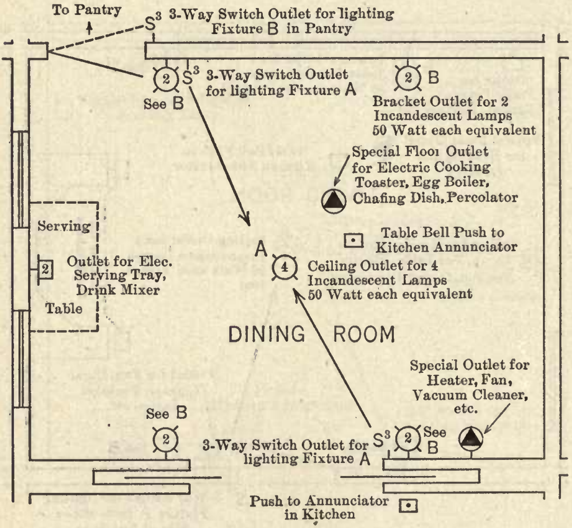


kitchen range-hood and the conduit run around under the hood to the side wall where the controlling switch is located.

Outdoor Decoration Receptacles.

Art. 19b: A waterproof receptacle and plug should be located outside the main entrance, controlled by a switch in hall for step and walk canopy lighting.

A similar receptacle and plug may be placed high up on pillar or wall of porch for electric decorations. These receptacles should be on a separate circuit from panel and controlled by a switch at porch door.



Porch Receptacles.

Art. 19c: The living porch should have one or more flush wall receptacles placed in the side wall twelve or fifteen inches above the floor (to prevent water splashing on them). These receptacles for use of reading lamp, chafing-dish, percolator, etc.

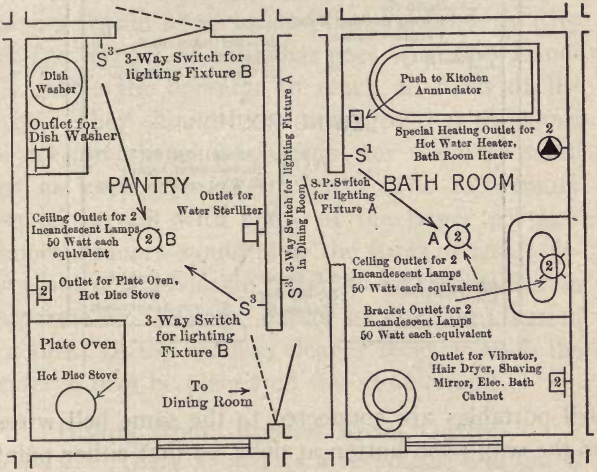
Bedroom porches may have a similar receptacle for reading light.

Servants' or kitchen porches should have a receptacle pilot light and switch (see Art. 18), so that ironing may be done on the porch in hot weather. ~~Should~~ a receptacle should be on a separate circuit.

Such

Mantel Receptacles.

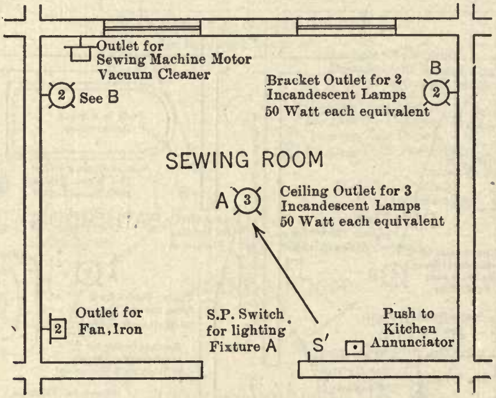
Art. 19d: Receptacles for mantel candles may be placed in the wall just above the shelf, or, where the design will permit, in the shelf itself. These



receptacles should be controlled by a switch at convenient location.

Bed Receptacles.

Art. 19e: Two receptacles, one for reading lamp and one for heating pad or similar sick room appliance, should be placed at the side of each bed and connected to 110-volt lighting circuit. These may both be in the same outlet box and covered with one plate. Alongside of this equipment but not in contact with same, may be placed a bell receptacle with removable portable cord and hand "pear push" for bell call. This bell receptacle and plug must be of entirely different design from the two before mentioned so that by no possibility may the bell plug be attached to either of the other receptacles. These



bell portables are connected to the same bell wires as the wall push button at door, so that either point rings the same bell or drop on the annunciator.

Floor Receptacles.

Art. 19f: Where receptacle outlets come in the floor, they should be placed in specially designed floor boxes which have cone shaped tops projecting above the floor to prevent water entering the box and to protect the wires. When these portables are not in use, the cone top can be removed and a flush top substituted.

Stereopticon Receptacles.

Art. 20: Stereopticon and moving picture machines are now made for home use. The receptacles for some have a larger capacity than those for lighting and are usually placed at the end of the long living room or hall. They should be connected to 110-volt power and by means of two No. 8 wires.

Vacuum Cleaner Receptacles.

Art. 21: Flush receptacles for portable vacuum cleaners should be so located that the thirty to fifty feet (30 to 50′) of cord that goes with the cleaner will enable the operator to reach all parts of the house. They should be so arranged that the plugs are not interchangeable, except for the very small type as explained in Art. 19a. The momentary rush of current with many of the larger portable vacuum cleaners would blow the fuses of small circuits and it is advisable to put these receptacles on a separate No. 12 wire, and as but one point is used at a time, all the vacuum cleaner receptacles in the residence may be placed on the same circuit.

Dining Room Special Front Outlet.

Art. 22: There should be a receptacle and outlet box placed in the floor under the dining-room table, a little off the center, so as to clear the center leg of table. This should be fitted with a removable plug connected to permanent table wiring (which is carried up the center leg of the table along the under framework and out on the crossbars, where the wiring should terminate in three 110-volt fused power receptacles. One of these may be used for electric chafing-dish or egg boiler, one for electric toaster and one for electric coffee percolator. This enables the housewife to use the above appliances and disconnect and remove them as desired, without reaching to the floor and with practically no exposed connections, except the short ones over the edge of the table. The three receptacles under the edge of the table may, if desired, be mounted in a neat box to match the woodwork. (See Dining Room, p. 212.)

Other Power Receptacles.

Art. 23: Flush receptacles for power and heating appliances are of sizes depending on capacity, but for most residence work, the standard 660 watt receptacle and plug manufactured by many companies, is satisfactory in the great majority of cases. For different classes of apparatus and voltage, these receptacles should not be interchangeable (see Art. 19a). For use with heating or similar appliances, they should be in connection with pilot lights and switches, as explained in Art. 18. This type of combined switch and receptacle should be used for laundry and pressing irons (and provision should be made at ironing table to hold up the cord connecting the iron). A laundry iron receptacle should always be placed to the right of the laundress.

Cellar Lighting.

Art. 24: Usually 10 or 15 watt lamps are sufficient for cellar lighting except in case of work bench or lathe, which should be brightly lighted by 25 watts or 40 watt lamps. (See pp. — to —.)

Outlets should be so located as to illuminate sinks, furnaces and any pumps or apparatus that need attention. Store rooms and vegetable rooms should be well lighted from ceiling with controlling switch at door. The wine room switch should preferably be placed outside the door, so that the room may be inspected through glass or grating of door without unlocking.

There should be at least one outlet in cellar controlled by pilot switch at the head of the stairs (see Art. 15e), and where there are few lights in the cellar it is sometimes advisable to put all on such a switch. (See Cellar, p. 208.)

Porch Lighting.

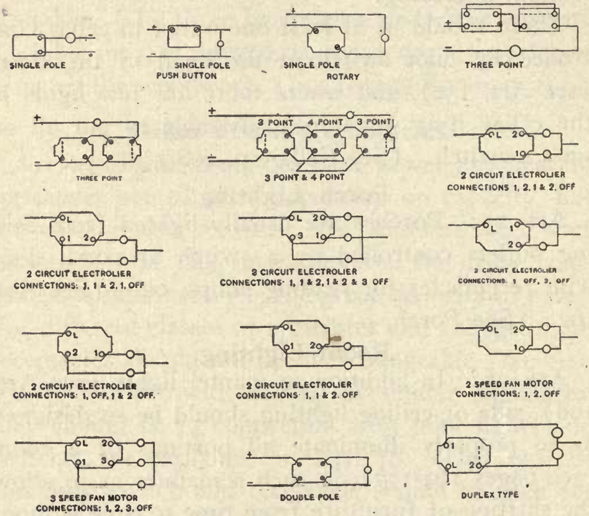
Art. 25: Porches are usually lighted from ceiling outlets controlled by a switch at porch door with receptacles for reading lamps, etc. (See Art. 19c. (See Porch, p. 209.)

Room Lighting.

Art. 26: In addition to mantel lights (see Art. 19d), side or ceiling lighting should be so designed as to properly illuminate all portions of a room (see pages 164-177), in such a manner as to allow the shifting of furniture from time to time without destroying the harmony of the interior. For this reason residence outlets should not be limited to the fewest possible permissible with the original furniture layout, but should be planned with a view of any re-arrangement of furnishings. Outlets not needed with first scheme may be capped until required. For economy as well as for convenience, room lighting should be controlled by switches (see Art. 15a). Most rooms require one or more receptacles for portable lights (Art. 19).

A cigar lighter may be placed on the lighting circuit of den or living room. It uses very little current and does away with burnt matches. It needs no switch beyond the self-contained one.

WIRING DIAGRAMS FOR FLUSH SWITCHES



Dining room—the table should be well lighted by ceiling domes or showers.

For bedrooms, in addition to the above room lighting, there should be a receptacle for desk lamp and there should also be a reading lamp at bed. (See Art. 19e.)

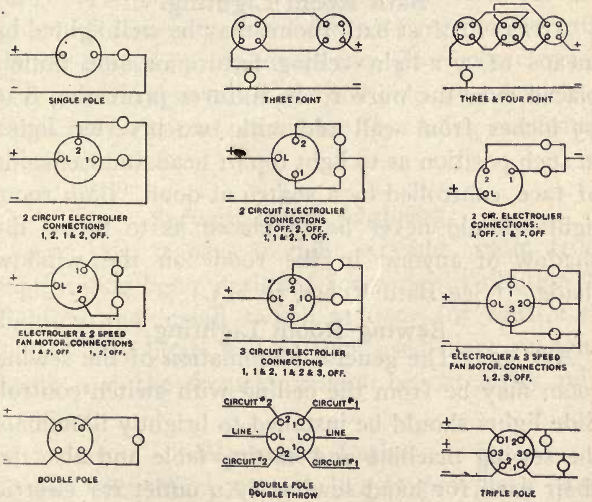
Hall Lighing.

Art. 27: Halls require a soft general illumination and the addition of portable table and vase lights is often advantageous. In addition to the wall switches for the regular lights, there should be up and down control between floors as mentioned in Art. 15b. (See Hall, p. 205.)

Pantry Lighting.

Art. 28: The pantry should be well lighted from a high center outlet so that contents of dressers and cupboards may easily be seen and this outlet should be controlled by a switch. (See Pantry, p. 213.)

WIRING DIAGRAMS FOR SURFACE SWITCHES



Kitchen Lighting.

Art. 29: Kitchens are generally lighted from ceiling outlet controlled by switch at door. When, however, there are appliances around side wall at which the cook works, there would be a shadow if only the center fixtures were used, and side outlets should be added at such points and at the sink. The range-hood should have a light under same, as detailed in Art. 19a. (See Kitchen, p. 209.)

Laundry Lighting.

Art. 30: Laundries are usually finished in light color and need comparatively little general illumination from ceiling fixture controlled by a switch at door. A drop light should be provided at ironing table and a side light at laundry machine. (See Laundry, p. 209.)

Bath Room Lighting.

Art. 31: Most bath rooms may be well lighted by means of a 2-light ceiling fixture or side outlets placed over the mirror, the fixtures projecting 8 to 15 inches from wall and with two inverted lights in such position as to light top of head and each side of face, controlled by a switch at door. Bath room lights should never be so placed as to throw the shadow of anyone in the room on the window shade. (See Bath Room, p. 213.)

Sewing Room Lighting.

Art. 32: The general illumination of the sewing room may be from the ceiling with switch control. Side lights should be installed to brightly illuminate the sewing machine and cutting table and also the chair used for hand sewing. An outlet for electric pressing iron (see Art. 32), should be installed and when the room is used in hot weather an electric fan adds to comfort. An 8-inch fan takes very little current—20 to 40 watts, and can be used on lamp socket. (See Sewing Room, p. 214.)

Closet Lighting.

Art. 33: Closet lights are desirable unless room fixtures are so placed as to illuminate them. Especially is this true of storage and servants' closets as it insures cleanliness. Closet lights should be controlled by wall or door switches. (See Art. 15d.) (See Closet, p. 206.)

Play Room Lighting.

Art. 34: The play room should be brightly lighted from the ceiling and controlled by a switch at door. This will prevent accidents to or from low side fixtures. The play room should also be wired for use as a bedroom with side lights and receptacles with outlets capped up for future use. If receptacles for play toys are installed they should be of such a character as not to permit the toys being connected to other outlets.

Servant Room Lighting.

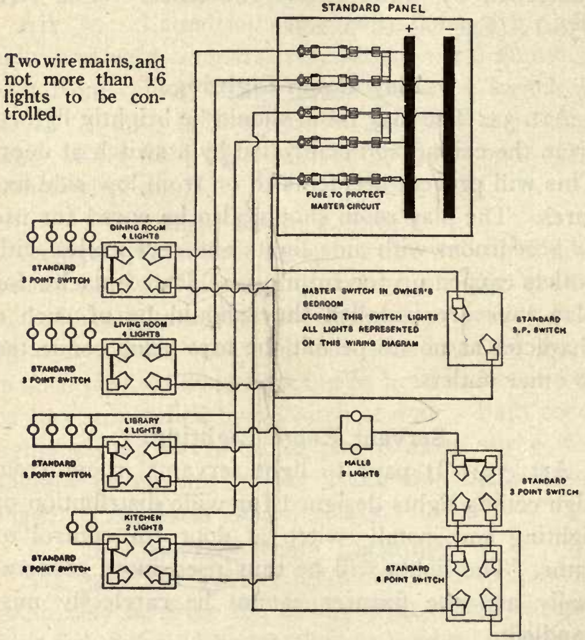
Art. 35: It pays to light servants' room from high ceiling lights designed for wide distribution of lighting and install switch at door for control of same. The lights will be thus used more economically and the fixtures cannot be carelessly mishandled.

Workshop Lathe.

Art. 36: Many owners like to provide a small workshop for their own use. A small wood turning lathe can be operated by a motor consuming about 200 watts. This lathe may be controlled by either a motor starter and switch, or by means of a switch only, as detailed in Art. 16. (See Cellar.)

House Pump.

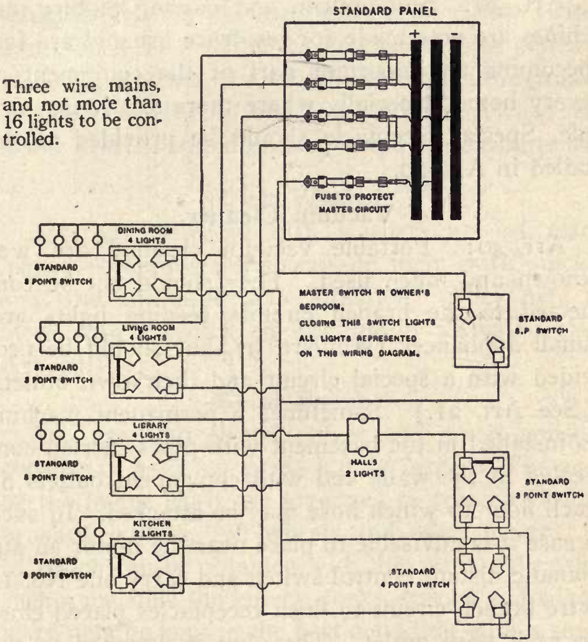
Art. 37: Where city water supply is not available and a well is used, a tank located on roof or attic can



Method of wiring for burglar lighting—2 wire.

be filled by electric pump. The well pipe may be from 1½-inch diameter up, depending on the quantity of water needed. The motor may be controlled by hand or it may be automatic in action, as noted in Art. 17. (See Cellar, p. 208.)

If wiring is installed a double throw switch is usually placed in the basement or at the pump to permit hand operation so that tests may be made from time to time to see that everything is working satisfactorily. Water cocks may be placed around the lawn and water pumped through them directly



Method of wiring for burglar lighting—3 wire.

for watering lawn, or for fire purposes without using up the water in the tank.

Refrigeration.

Art. 38: Where ice is expensive or difficult to obtain, an ice box refrigerator electrically operated can be installed. These outfits require little attention and in addition to keeping the box cool, can be used to make a small amount of ice for table and sick room use.

Stereopticon.

Art. 39: Stereopticon and moving picture machines are now made for residence use and are fast becoming an important part of the equipment of every home, especially where there are young people. Special receptacle should be provided as detailed in Art. 20.

Vacuum Cleaner.

Art. 40: Portable vacuum cleaners are well known and much used. They should not be connected to the branch circuits feeding lights and small appliances (see Art. 9), but should be provided with a special circuit and their own outlets. (See Art. 21.) Sometimes a permanent machine is installed in the basement with pipes carried concealed in the walls and with convenient outlets on each floor to which hose may be attached. In such a case it is advisable to place near the motor an automatic distant control switch and carry one No. 14 wire branch circuit to flush receptacles placed close to each hose outlet. The plug is attached to the end of the hose with a small chain. The connections are such that when the hose is in use and the plug inserted into the receptacle, the cleaner will start up and when the hose is removed thus pulling out the receptacle plug the motor stops, preventing waste of current. The receptacles that are used for connection to portable machines and their circuit are not used in this case.

Plate Warmer.

Art. 41: Plate warmers are very convenient and add much to the ease of service and success of dinners. They may be placed under dressers or pantry table and should be fitted with 2 or 3 heat switch and pilot light. When the first set of cold plates is placed in warmer, the switch is turned to high heat and left on for fifteen (15) minutes, when the lower heat is turned on and keeps the contents hot.

Dish Washer.

Art. 42: Electric dish washers are of many makes—occupy small space—do their work quickly and well and need little attention. They may be fitted with a switch on machine or at wall. (See Art. 16.)

Metal Polisher.

Art. 43: An electric silver and metal polisher consists of a 1/4 h.p. or 1/2 h.p. or larger. The ends of the motor shaft are arranged to receive various brushes, buffers, felt wheels and other fittings, all of which can be obtained with the outfit. By using such a machine the knives, forks, spoons and silverware may be kept in the best condition with a small expenditure of time and energy. Should have switch and receptacle on wall, omitting pilot light. (See Art. 18.)

Ice Cream Freezer.

Art. 44: An electric ice cream freezer insures the best and purest home product with but little trouble. The electric current expense is negligible. Should have switch on machine with receptacle on wall or combined switch and receptacle on wall, omitting pilot light. (See Art. 18.)

Electric Cooking Range

Art. 45: Cooking by electricity is fast coming into more general use. The freedom from odors and escaping gas, the cleanliness and the application of heat only where needed, appeals strongly to the housekeeper and in many parts of our country, such cooking may now be done as cheaply as with gas. (See Art. 5.)

An electric range for a family of six would occupy a floor space of about 22 inches by 28 inches. It is generally fitted with a number of separate switches for the various parts and utensils and should be on a separate 3-wire feeder with 3-pole main switch and pilot light. (See Kitchen, p. 209.)

Ironing Table.

Art. 46: Laundry ironing tables may be purchased complete with swinging arms to take care of the cords and with two (2) irons for different classes of work and so arranged with automatic stands that the iron when not in actual use takes only enough current to keep it hot. (See Art. 23.)

Clothes Washer and Wringer.

Art. 47: The simplest type of electric clothes washer and wringer may be mounted on the tubs and removed when not in use. Other types have all parts mounted on one stand which may be on rollers to bring it to the tubs on wash days and remove it at other times. Such a machine for a family of six would occupy a floor space of about 28 inches by 32 inches and the washing would be done better than by hand and with no danger of tearing laces and lingerie. Has switch on the machine and should connect to receptacle on wall. (See Laundry, p. 209.)

Starch Cooker.

Art. 48: A convenient and inexpensive appliance in the house laundry is an electrically heated pot for cooking starch. Should be connected to pilot switch and receptacle. (See Art. 18.)

Sewing Machine Motor.

Art. 49: Every home should have the sewing machine fitted with a motor which may be very small in size and can be arranged to start and stop by pressing a contractor with the foot. It is very inexpensive to operate and saves many a doctor's bill where much sewing is done. The motor may be 110 volts and should be connected to a base receptacle.

Bath Room Heater.

Art. 50: Heating rooms by electricity is not yet an economic fact, but for special cases where not in continual use, they are very convenient and not too expensive to operate. When taking a bath on a winter morning when the hot water is turned on an electric heater may also be turned on and by the time the tub is ready, the chill will be taken out of the air. For this purpose the heaters should have a capacity of four watts per cubic foot of room, although this is much greater than would be needed for continuous heating. These heaters should be on separate circuits and be supplied with combination pilot switches and receptacles. (See Art. 18.) (See Bath Room, p. 213.)

Other Bath Room Appliances.

Art. 51: Curling iron heaters may be mounted on the surface of the wall and are very small in size and consume current only when the iron is inserted into the heater. Hot water cups or stoves are much used, take up little space and should be connected to a combination pilot switch and receptacle. (See Art. 18.)

Entrance Ball Calls.

Art. 52: The push button at the main entrance door should not ring on the annunciators, but should be a distinctive call, ringing a separate bell in kitchen or pantry. An extension bell should be placed in servant's room or corridor and a second extension may be placed in a sewing room that is much used. These extensions are controlled by small lever switches for cutting them off in time of sickness. The push button at rear entrance should ring a buzzer in the kitchen, but without the extensions.

Bell Annunciators.

Art. 53: An annunciator should be placed in the kitchen with bell different in sound from adjacent bells and fitted with an indicating drop from each of the rooms, porches and baths in the house.

A second annunciator is often placed in servants' corridor and a third annunciator may be placed in the sewing room.

These two or three annunciators ring and indicate simultaneously for each call and are connected together by two or three wires more than the total number of calls or drops on each.

When a call is answered from any annunciator, a push at bottom of the annunciator resets all the annunciators, thus letting others know that the call is being attended to.

Wall Pushes.

Art. 54: Wall pushes are placed in the door trims of the various rooms, porches, bath, etc., and connected to the nearest annunciator. Bath room pushes are sometimes placed over tub rather than at the door.

Table Pushes.

Art. 55: In some rooms such as the living room, it is often desirable to have a table push on a flexible cord connected to a floor receptacle. These portable pushes are usually connected to the same wires as the wall push in such rooms. In case of the dining room, the table push rings a separate buzzer in the pantry while the wall push rings the annunciator.

Bed Pushes.

Art. 56: Portable push buttons are frequently located at beds and they connect to the same wires as the wall pushes. (See Art. 19e.)

When the mistress of the house has a special maid, her bed portable push is usually connected to a buzzer in the maid's room.

Battery and Cabinet.

Art. 57: The bell system may be operated from six to eight cells of dry battery, placed in a cabinet which may be located in the cellar. It is often well to use these batteries in duplicate with a throw-over switch so that while one set is being replaced or renewed, the other set is in use. (See Cellar, p. 208.)

Bell Ringing Transformer

Art. 58: Where alternating current is used for lighting, the bell system can be operated by a small bell ringing transformer which may be placed in the cellar and connected to one of the lighting circuits. These transformers may also be used for house intercommunicating telephone ringing, when the telephones are on metallic circuit. They cannot be used for telephone talking, which requires battery or direct current. (See Cellar, p. 208.)

Public Telephone.

Art. 59: It is quite usual to put conduits in a residence for use of the Public Telephone Co. and thus keep their wires out of sight. A Public Telephone outlet may be placed in the kitchen or pantry with extensions to living room, owner's bedroom and to still other points if desired. A ¾-inch conduit is ample for the above equipment.

"Dim-a-lite"

Art. 60: A "Dim-a-lite" lamp socket, which enables an incandescent lamp to be turned down to a dim light, should be placed on one of the fixtures or portables in every bedroom, hall and bath room.

List of Current-Consuming Devices

Art. 61: Time and additional work, and consequent expense, to all concerned, may be saved if the house owner, at the start, is presented with a complete list of devices, for possible use in the various rooms of his house, that he may check off just what he may need.

Without such a list, which follows, many devices, later on, may suggest themselves, as needs demand them, and additional outlets may have to be provided, and larger conductors may have to be installed to take care of them.

No one has ever complained of too many outlets —after they are once installed.

Halls.

Vacuum cleaner
Fan motor
Electric Talking Machine
Electric piano
Table lamp
Sewing machine
Dim-a-lite

Parlor or Reception Room.

Outlets
Table lamps
Vacuum cleaner
Fan motor
Electric piano
Electric Talking Machine

Dining Room

Toaster
Chafing Dish
Coffee Percolator
Tea kettle
Cigar lighter
Fan motor
Hot water heater
Radiant Grill
Luminous Radiator
Vacuum cleaner
Samovar

Kitchen

Electric Irons
Washing machine
Electric stoves
Electric Tea kettle
Disc stoves
Frying pans
Glue pot
Soldering iron
Radiant Grill
Toaster
Vacuum cleaner
Fan motor
Coffee grinder
Meat chopper
Bread mixer
Egg beater
Silver polisher
Knife grinder

Sitting Room or Library

Table or Desk Lamp
Vacuum cleaner
Fan motor
Cigar lighter
Sewing machine
Small pression iron
Luminous radiator

Bedroom or Boudoir

Luminous radiator
Vacuum cleaner
Curling iron
Water heater
Bed pan
Fan motor
Reading lamp at head of bed
Ozonator for sickness
Hair dryer
Massage vibrator
Baby milk warmer
Dim-a-lite

Nursery

Electric toys
Vacuum cleaner
Luminous radiator
Vacuum cleaner of extra streng
Ozonator
Fan motor
Electric Talking Machine
Baby milk warmer

Bath Room

Luminous radiator
Vacuum cleaner
Shaving mug
Curling iron
Water heater
Hair dryer
Massage vibrator
Dim-a-lite

Girl's Room

Vacuum cleaner
Bed pad
Fan motor
Curling iron
Hair dryer

Laundry

Washing machine
Irons
Fan motor
Laundry machine
Vacuum cleaner

Cellar Work Shop

Grinder
Glue pot
Soldering iron
Breast drill
Small motor for operating tools
Portable for cleaning heater

Garage

Several outlets for portables
Luminous radiator, if not heater
Glue pot
Soldering iron
Fire pumps
Small motor for tools
Portable drill
Grinding machine
Buffing machine
Charging batteries
Vacuum cleaner

Stables

Clippers
Electric milkers
Churns
Grind stones
Vacuum cleaner for currying

Offices

Vacuum cleaner
Luminous radiator
Cigar lighter
Hot water heater
Table or desk lamp
Fan motor

STANDARD SYMBOLS FOR WIRING PLANS

As adopted and recommended by The National Electrical Contractors Association of the United States and The American Institute of Architects

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Ceiling Outlet; Combination. 4/2 indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

If gas only.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Bracket Outlet; Combination. 4/2 indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

If gas only.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Standard 16 C. P. Lamps.

Outlet for Outdoor Standard or Pedestal; Combination. 6/6 indicates 6-16 C. P. Standard Incandescent Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S^1 S. P. Switch Outlet.

S^2 D. P. Switch Outlet.

S^3 3-Way Switch Outlet.

S^4 4-Way Switch Outlet.

S^D Automatic Door Switch Outlet.

S^E Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus: S^1 XII, meaning 12 Single Pole Switches.
Describe Type of Switch in Specifications, that is,
Flush or Surface, Push Button or Snap.

Meter Outlet.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse-Power.

Motor Control Outlet.

Transformer.

Main or Feeder run concealed under Floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

- Pole Line.
- Riser.
- Telephone Outlet; Private Service.
- Telephone Outlet; Public Service.
- Bell Outlet.
- Buzzer Outlet.
- 2: Push Button Outlet; Numeral indicates number of Pushes.
- Annunciator; Numeral indicates number of Points.
- Speaking Tube.
- Watchman Clock Outlet.
- Watchman Station Outlet.
- Master Time Clock Outlet.
- Secondary Time Clock Outlet.
- Door Opener.
- Special Outlet, for Signal Systems. as described in Specifications.
- Battery Outlet.
- —— - —— Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed. Kind of Service wanted ascertained by Symbol to which line connects.
- —— - - —— Circuit for Clock, Telephone, Bell or other Service, run under Floor above, concealed. Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 25-watt Incandescent lamps are desired, Specifications should describe capacity of lamp to be used.

Standard Wiring Symbols.

Art. 62: Owners, architects and contractors would save much time and misunderstanding by familiarizing themselves with, *and using,* the standard symbols as recommended by The National Electrical Contractors' Association and The American Institute of Architects, when indicating on plans just what is desired in the way of outlets, fixtures, receptacles etc., etc., as as given on pages 233-234.

MISCELLANEOUS.

DEFINITIONS OF ELECTRICAL UNITS.

All electrical units are derived from the following mechanical units:

The Centimeter is the unit of length, and equals .3937 inch, or .000000001 of a quadrant of the earth.

The Gram is the unit of mass, and is equal to 15.432 grains, the mass of a cubic centimeter of water at 4° C.

The Second is the unit of time and is the time of one swing of a pendulum, swinging 86464.09 times per day, or the 1/86400th part of a mean solar day.

The Volt is the unit of electro-motive force [E].

Electromotive force, which is the force that moves electricity, is usually written E. M. F. (in formulæ E) and various writers use it to express potential, difference of potential, electric pressure and electric force.

One volt will force an ampere of current through one ohm of resistance. Its value is purely arbitrary, but fixed.

The Ohm is the unit of resistance [R] and it is equal to the resistance of a column of pure mercury 1 square millimeter in section and 106.3 centimeters long at the temperature of melting ice.

One ohm is that resistance through which one ampere of current will flow at a pressure of one volt of E. M. F.

The Megohm = 1,000,000 ohms.

The Ampere is the unit of current strength [C]. Its value may be defined as that quantity of electricity which flows through one ohm of resistance when impelled by one volt of E. M. F.

One ampere of current flowing through a bath will deposit 0.017253 grain of silver or 0.004085 grain of copper per second.

The Coulomb is the unit of quantity [Q], and is the quantity of electricity passing per second, when the current is one ampere.

The Farad is the unit of capacity [K], and is capacity that will contain one coulomb at a potential of one volt.

A condenser of one farad capacity, if charged to two volts, will contain two coulombs; if to 100 volts, 100 coulombs, etc.

The Microfarad [mfd] = one millionth of a farad.

The Joule is the unit of work [W]. It is the work done or heat generated, by a watt in a second. It is equal to .7373 foot-pound.

The Watt is the unit of electrical power [P], is the energy contained in a current of one ampere with an electromotive force of one volt. 746 watts = one horsepower. A current of 7.46 amperes at 100 volts will do the work of the one horsepower.

A Horse-Power in a steam engine or other mover is 550 lbs. raised one foot per second, or 33,000 lbs. one foot per minute.

The Kilowatt [kw] equals to 1,000 watts.

The E. M. F. is distributed according to the resistance of the various parts of the circuit, except where there is counter E. M. F.

Counter E. M. F. is like back pressure in hydraulics. Thus, to find the available E. M. F., or the resulting current against a resistance where there is a counter E. M. F., the counter E. M. F. must be deducted. For example: Suppose a storage battery with a resistance of .02 ohm and a C. E. M. F. of 15 volts, and you wish to charge it with a dynamo which gives an E. M. F. of 20 volts at the battery binding posts. There are 20 — 15 = 5 volts working through a resistance of .02 of an ohm with consequently a current of 250 amperes. The impressed voltage is, however, 20 volts, and not 5 volts, and the power is 20 × 250 = 5000 watts, and not 5 × 250 = 1250 watts, as might perhaps be supposed. It is obvious that the C. E. M. F. has acted as a true resistance. In the above case 5 × 250 = 1250 watts were wasted in overcoming the resistance of the storage battery and the remaining 3750 watts were stored up in the chemical changes which they brought about in the active material of the storage battery.

Mils = Thousandths of an inch.

d^2 = circular mils.

The Circular Mil is now generally used as the unit of area when considering the cross-section of electric conductors, the resistance being inversely, and weight of copper directly, proportion to the circular mils.

General Formulae Ohms Laws (Direct Current.)

C. = current in amperes.
E. = electromotive force in volts.
R = resistance in ohms.
W. = energy in watts.

$$C. = \frac{E.}{R.} \qquad E. = C.R. \qquad R. = \frac{E.}{C.}$$

$$C.\ E. = W. \qquad W. = \frac{E^2}{R} \qquad C^2\ R. = W.$$

$$\frac{W.}{746} = H.P. \qquad W. = 746 \times H.P.$$

Formulæ giving the volts or amperes necessary for a given horsepower on circuits of constant current, and constant potential, respectively:

$$E. = \frac{746 \times H.P.}{C. \times K.}$$

$$C. = \frac{746 \times H.P.}{E. \times K.}$$

E. = potential of circuit.
C. = amperes.
K. = efficiency of machine.
H.P. = horsepower.

General Formulae for Direct Current Light and Power Wiring. When possible use the table on page 81 for conveniences.

c.m. = circular mils. (See page 91).

d. = length of wire, in feet, on one side of circuit.
n. = number of lamps in multiple.
c. = current in amperes per lamp (see p. 166).
v. = volts lost in lines (see pp. 25 and 81).
r. = resistance per foot of wire to be used.
10.8 ohms = resistance of one foot of commercial copper wire having a diameter of one mil and a temperature of 75° Fahrenheit.

It is an easy matter to find any of the above values by the following formulæ for direct current:

$$c.m. = \frac{10.8 \times 2d. \times n. \times c.}{v.}$$

$$v. = \frac{10.8 \times 2d. \times n. \times c.}{c.m.} \qquad c. = \frac{c.m. \times v.}{10.8 \times 2d. \times n.}$$

$$n. = \frac{c.m. \times v.}{10.8 \times 2d. \times c.} \qquad 2d. = \frac{c.m. \times v.}{10.8 \times c. \times n.}$$

$$r. = \frac{v.}{n. \times c. \times 2d.}$$

$$v. = n. \times c. \times 2d. \times r. \qquad c. = \frac{v.}{2d. \times n. \times r.}$$

$$n. = \frac{v.}{c. \times 2d. \times r.} \qquad 2d. = \frac{v.}{n. \times c. \times r.}$$

Unit.	Equivalent Value in Other Units.
1 H. P. =	746 watts. .846 K. W. 33,000 ft.-lbs. per minute. 550 ft.-lbs. per second. 2,545 heat-units per hour. 42.4 heat-units per minute. .707 heat-unit per second. .175 lb. carbon oxidized per hr. 2.64 lbs. water evaporated per hour from and at 212° F.
1 H. P. Hour =	746 K. W. hours. 1,980,000 ft.-lbs. 2,545 heat-units. 273,740 k. g. m. .175 lb. carbon oxidized with perfect efficiency. 2.64 lbs. water evaporated from and at 212° F. 17.00 lbs. water raised from 62° to 212° F.
1 Kilowatt =	1,000 watts. 1.34 H. P. 2,654,200 ft.-lbs. per hour. 44,240 ft.-lbs. per minute. 737.3 ft.-lbs. per second. 3,412 heat-units per hour. 56.9 heat-units per minute. .948 heat-unit per second. .2275 lb. carbon oxidized per hour. 3.53 lbs. water evaporated per hour from and at 212° F.
1 Watt per sq. in. =	8.19 heat units per sq. ft. per minute. 6,371 ft.-lbs. per sq. ft. per minute. .193 H. P. per sq. ft.
1 Kilogram Metre =	7.233 ft.-lbs. .00000365 H. P. hour. .00000272 K. W. hour. .0093 heat-units.
1 lb. Water Evaporated from and at 212° F. =	.283 K. W. hour. .379 H. P. hour. 965.7 heat-units. 103,900 k. g. m. 1,019,000 joules. 751,300 ft.-lbs. .0664 lb. of carbon oxidized.

Unit.	Equivalent Value in Other Units.
1 Heat-unit =	1,055 watt seconds.
	778 ft.-lbs.
	107.6
	.000293 K. W. hour.
	.000393 H. P. hour.
	.0000688 lb. carbon oxidized.
	.001036 lbs. water evaporated from and at 212° F.
I Heat unit per sq. ft. per min. =	.122 watts per sq. in.
	.0176 K. W. per sq. ft.
	.0236 H. P. per sq. ft.
1 Watt =	1 joule per second.
	.00134 H. P.
	3,412 heat-units per hour.
	.7373 ft.-lb.
	.0035 lb water evaporated per hour.
	44.24 ft.-lbs. per minute.
1 K. W. Hour =	1,000 watt hours.
	1.34 H. P. hours.
	2,654,200 ft.-lbs.
	3,600,000 joules.
	3,412 heat-units.
	367,000 kilogram metres.
	,235 lb. carbon oxidized with perfect efficiency.
	3.53 lbs water evaporated from and at 212° F.
	11.75 lbs. of water raised from 62° to 212° F.
1 Joule =	1 watt second.
	.000000278 K. W. hour.
	.102 k. g. m.
	.0009477 heat-units.
	.7373 ft.-lb.
1 ft.-lb. =	1.356 joules.
	.1383 k. g. m.
	.000000377 K. W. hours.
	.001285 heat-units.
	0000005 H. P. hour.
1 lb. Carbon Oxidized with Perfect Efficiency. =	14,544 heat units.
	1.11 lb. anthracite coal ox.
	2.5 lbs. dry wood oxidized.
	21 cu. ft. illuminating gas.
	4.26 K. W. hours.
	5.71 H. P. hours.
	11,315,000 ft.-lbs.
	15 lbs. of water evaporated from and at 212° F.

"WEATHERPROOF" INSULATED WIRE—SOLID CONDUCTORS.

Size B. & S.	Weatherproof Wire: Wgt. per 1,000 Ft.	Weatherproof Wire: Wgt. per Mile.	Weatherproof Wire: Diameter Over All.	Slow-Burning Weatherproof Wire: Wgt. per 1,000 Ft.	Slow-Burning Weatherproof Wire: Wgt. per Mile.	Slow-Burning Weatherproof Wire: Diameter Over All.	Slow-Burning Wire: Wgt. per 1,000 Ft.	Slow-Burning Wire: Wgt. per Mile.	Slow-Burning Wire: Diameter Over All.
0000	767	4050	25/32	862	4550	3/4	925	4890	3/4
000	630	3220	47/64	710	3750	45/64	760	4020	45/64
00	502	2650	39/64	562	2970	37/64	600	3170	37/64
0	407	2150	9/16	462	2440	17/32	495	2610	17/32
1	316	1670	1/2	340	1800	15/32	365	1930	15/32
2	260	1370	15/32	280	1480	7/16	320	1690	7/16
3	200	1050	27/64	230	1220	13/32	270	1425	13/32
4	164	865	25/64	190	1000	3/8	220	1160	3/8
5	134	710	11/32	155	820	11/32	190	1000	11/32
6	112	590	5/16	127	670	5/16	160	845	5/16
8	75	395	17/64	85	450	7/64	100	530	17/64
10	53	280	1/4	60	315	1/4	80	420	1/4
12	35	185	7/32	42	220	7/32	55	290	7/32
14	25	130	3/16	30	160	3/16	40	210	3/16
16	14	75	5/32	15	80	5/32	18	95	5/32
18	11	58	1/8	12	63	1/8	14	75	1/8

"WEATHERPROOF" INSULATED WIRE—STRANDED CONDUCTORS

Size B. & S.	Weatherproof Wire: Wgt. per 1,000 Ft.	Weatherproof Wire: Wgt. per Mile.	Weatherproof Wire: Diameter Over All.	Slow-Burning Weatherproof Wire: Wgt. per 1,000 Ft.	Slow-Burning Weatherproof Wire: Wgt. per Mile.	Slow-Burning Weatherproof Wire: Diameter Over All.	Slow-Burning Wire: Wgt. per 1,000 Ft.	Slow-Burning Wire: Wgt. per Mile.	Slow-Burning Wire: Diameter Over All
2000000 C.M.	7000	37000	2 1/8	7800	38500	2	7800	41000	2
1750000 C.M.	6200	32750	2	6550	34600	1 7/8	6900	36300	1 7/8
1500000 C.M.	5400	28500	1 7/8	5675	30000	1 3/4	6000	31300	1 3/4
1250000 C.M.	4500	23800	1 3/4	4780	25200	1 11/16	5000	26400	1 11/16
1000000 C.M.	3675	19400	1 21/32	3860	20400	1 39/64	3980	21000	1 39/64
900000 C.M.	3330	17600	1 39/64	3520	18600	1 9/16	3640	19200	1 9/16
800000 C.M.	3000	15800	1 9/16	3180	16800	1 33/64	3280	17300	1 33/64
700000 C.M.	2650	14000	1 15/32	2820	14900	1 27/64	2920	15400	1 27/64
600000 C.M.	2235	11800	1 21/64	2350	12400	1 9/32	2460	13000	1 9/32
500000 C.M.	1900	10000	1 1/4	1990	10500	1 13/64	2080	11000	1 13/64
450000 C.M.	1725	9100	1 3/16	1820	9600	1 9/64	1900	10000	1 9/64
400000 C.M.	1550	8200	1 9/64	1650	8700	1 3/32	1700	9000	1 3/32
350000 C.M.	1345	7100	1	1440	7600	3 1/32	1500	7900	31/32
300000 C.M.	1175	6200	31/32	1270	6700	15/16	1310	6900	15/16
250000 C.M.	985	5200	29/32	1060	5600	7/8	1120	5900	7/8
0000	800	4220	55/64	900	4750	53/64	940	5070	53/64
000	653	3450	51/64	735	3880	49/64	784	4150	49/64
00	522	2760	43/64	583	3080	41/64	625	3300	41/64
0	424	2240	39/64	480	2530	37/64	510	2700	37/64
1	328	1735	35/64	355	1870	33/64	380	2000	33/64
2	270	1425	33/64	290	1540	31/64	335	1770	31/64
3	206	1090	15/32	240	1270	29/64	280	1480	29/64

"RUBBER-COVERED" INSULATED WIRE—SOLID CONDUCTORS.

Size B. & S.	Diam. of Conductors, Mils.	Circular, Mils.	Single Braid: Diam. Over All.	Single Braid: Weight Per 1,000 Ft.	Double Braid: Diam. Over All.	Double Braid: Weight Per 1,000 Ft.
0000	460	211600	47/64	809	55/64	832
000	410	167803	11/16	666	13/16	690
00	365	133079	5/8	546	47/64	568
0	325	105524	19/32	453	45/64	476
1	289	83695	33/64	355	5/8	376
2	258	66373	29/64	275	9/16	295
3	230	52634	27/64	227	33/64	245
4	204	41743	25/64	186	15/32	200
5	182	33102	23/64	160	7/16	170
6	162	26250	5/16	128	25/64	135
8	129	16510	17/64	80	11/32	86
10	102	10382	15/64	58	19/64	64
12	81	6530	7/32	43	9/32	48
14	64	4107	13/64	32	1/4	37
16	51	2583	3/16	20	.....	...
18	40	1624	11/64	16	.....	...
19	36	1288	5/32	15	.....	...
20	32	1022	9/64	14	.....	...

"RUBBER-COVERED" INSULATED WIRES—STRANDED CONDUCTORS.

Size B. & S.	Concentric Strands No. Wires.	Concentric Strands Diam. Each.	Diam. of Conductors, Mils.	Single Braid Diam. Over All.	Single Braid Weight Per 1,000 Ft.	Double Braid Diam. Over All.	Double Braid Weight Per 1,000 Ft.
2000000 C.M.	91	148	1650	2	7246	2 9/64	7385
1750000 C.M.	91	139	1550	1 29/32	6394	2 3/64	6525
1500000 C.M.	91	128	1430	1 51/64	5539	1 15/16	5658
1250000 C.M.	91	117	1308	1 43/64	4678	1 13/16	4783
1000000 C.M.	61	128	1166	1 1/2	3754	1 5/8	3849
900000 C.M.	61	121	1104	1 7/16	3404	1 9/16	3491
800000 C.M.	61	115	1049	1 3/8	3058	1 1/2	3138
750000 C.M.	61	111	1013	1 11/32	2881	1 15/32	2956
700000 C.M.	61	107	978	1 5/16	2709	1 7/16	2880
650000 C.M.	61	103	943	1 17/64	2534	1 25/64	2600
600000 C.M.	61	99	906	1 1/4	2355	1 3/8	2418
550000 C.M.	61	95	870	1 13/64	2182	1 21/64	2240
500000 C.M.	37	116	821	1 1/8	1959	1 1/4	2010
450000 C.M.	37	110	779	1 3/32	1791	1 7/32	1840
400000 C.M.	37	104	738	1 3/64	1608	1 11/64	1650
350000 C.M.	37	97	688	1	1431	1 1/8	1468
300000 C.M.	37	90	639	15/16	1250	1 1/16	1285
250000 C.M.	37	82	583	7/8	1071	1	1103
0000	19	.105	530	13/16	899	15/16	942
000	19	.094	475	3/4	740	7/8	782
00	19	.083	425	45/64	607	13/16	647
0	19	.074	380	5/8	492	47/64	526
1	19	.066	329	9/16	387	43/64	417
2	19	.059	296	1/2	303	39/64	329
3	7	.086	263	29/64	249	9/16	272
4	7	.077	233	7/16	204	17/32	227
5	7	.068	209	13/32	175	1/2	192
6	7	.061	185	3/8	141	29/64	156

WIRE TABLE, STANDARD ANNEALED COPPER.

Gage No. B. & S.	Diameter in Mils at 20° C	Cross Section Circular Mils	Ohms per 1000 Feet *		
			0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	211 600.	0.045 16	0.049 01	0.054 79
000	409.6	167 800.	.056 95	.061 80	.069 09
00	364.8	133 100.	.071 81	.077 93	.087 12
0	324.9	105 500.	.09055	.09827	.1099
1	289.3	83 690.	.1142	.1239	.1385
2	257.6	66 370.	.1440	.1563	.1747
3	229.4	52 640.	.1816	.1970	.2203
4	204.3	41 740.	.2289	.2485	.2778
5	181.9	33 100.	.2887	.3133	.3502
6	162.0	26 250.	.3640	.3951	.4416
7	144.3	20 820.	.4590	.4982	.5569
8	128.5	16 510.	.5788	.6282	.7023
9	114.4	13 090.	.7299	.7921	.8855
10	101.9	10 380.	.9203	.9989	1.117
11	90.74	8234.	1.161	1.260	1.408
12	80.81	6530.	1.463	1.588	1.775
13	71.96	5178.	1.845	2.003	2.239
14	64.08	4107.	2.327	2.525	2.823
15	57.07	3257.	2.934	3.184	3.560
16	50.82	2583.	3.700	4.016	4.489
17	45.26	2048.	4.666	5.064	5.660
18	40.30	1624.	5.883	6.385	7.138
19	35.89	1288.	7.418	8.051	9.001
20	31.96	1022.	9.355	10.15	11.35
21	28.46	810.1	11.80	12.80	14.31
22	25.35	642.4	14.87	16.14	18.05
23	22.57	509.5	18.76	20.36	22.76
24	20.10	404.0	23.65	25.67	28.70
25	17.90	320.4	29.82	32.37	36.18
26	15.94	254.1	37.61	40.81	45.63
27	14.20	201.5	47.42	51.47	57.53
28	12.64	159.8	59.80	64.90	72.55
29	11.26	126.7	75.40	81.83	91.48
30	10.03	100.5	95.08	103.2	115.4
31	8.928	79.70	119.9	130.1	145.5
32	7.950	63.21	151.2	164.1	183.4
33	7.080	50.13	190.6	206.9	231.3
34	6.305	39.57	240.4	260.9	291.7
35	5.615	31.52	303.1	329.0	367.8

* Resistance at the stated temperatures of a wire whose length is 1000 feet at 20° C. (Bureau of Standards)

Gage No. B. & S.	Diameter in Mils at 20° C	Pounds per 1000 Feet	Feet per Ohm *		
			0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
000	460.0	340.5	22 140.	20 400.	18 250.
000	409.6	507.9	17 560.	16 180	14 470.
00	364.8	402.8	13 930.	12 830.	11 480.
0	324.9	319.5	11 040.	10 180	9103.
1	289.3	253.3	8758.	8070.	7219.
2	257.6	200.9	6946.	6400.	5725.
3	229.4	159.3	5508.	5075.	4540.
4	204.3	126.4	4368.	4025.	3600.
5	181.9	100.2	3464.	3192.	2855.
6	162.0	79.46	2747.	2531.	2264.
7	144.3	63.02	2179.	2007.	1796.
8	128.5	49.98	1728.	1592.	1424.
9	114.4	39.63	1370.	1262.	1129.
10	101.9	31.43	1087.	1001.	895.6
11	90.74	24.92	861.7	794.0	710.2
12	80.81	19.77	683.3	629.6	563.2
13	71.96	15.68	541.9	499.3	446.7
14	64.08	12.43	429.8	396.0	354.2
15	57.07	9.858	340.8	314.0	280.9
16	50.82	7.818	270.3	249.0	222.8
17	45.26	6.200	214.3	197.5	176.7
18	40.30	4.917	170.0	156.6	140.1
19	35.89	3.899	134.8	124.2	111.1
20	31.96	3.092	106.9	98.50	88.11
21	28.46	2.452	84.78	78.11	69.87
22	25.35	1.945	67.23	61.95	55.41
23	22.57	1.542	53.32	49.13	43.94
24	20.10	1.223	42.28	38.96	34.85
25	17.90	0.9699	33.53	30.90	27.64
26	15.94	.7692	26.59	24.50	21.92
27	14.20	.6100	21.09	19.43	17.38
28	12.64	.4837	16.72	15.41	13.78
29	11.26	.3836	13.26	12.22	10.93
30	10.03	.3042	10.52	9.691	8.669
31	8.928	.2413	8.341	7.685	6.875
32	7.950	.1913	6.614	6.095	5.452
33	7.080	.1517	5.245	4.833	4.323
34	6.305	.1203	4.160	3.833	3.429
35	5.615	.095 42	3.299	3.040	2.719

* Length at 20° C of a wire whose resistance is 1 ohm at the stated temperatures. (Bureau of Standards).

WIRE TABLE, STANDARD ANNEALED COPPER. —CONTINUED.

Gage No. B. & S.	Diameter in Mils at 20° C	Ohms per Pound		
		0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	0.000 070 51	0.000 076 52	0.000 085 54
000	409.6	.000 1121	.000 1217	.000 1360
00	364.8	.000 1783	.000 1935	.000 2163
0	324.9	.000 2835	.000 3076	.000 3439
1	289.3	.000 4507	.000 4891	.000 5468
2	257.6	.000 7166	.000 7778	.000 8695
3	229.4	.001 140	.001 237	.001 383
4	204.3	.001 812	.001 966	.002 198
5	181.9	.002 881	.003 127	.003 495
6	162.0	.004 581	.004 972	.005 558
7	144.3	.007 284	.007 905	.008 838
8	128.5	.011 58	.012 57	.014 05
9	114.4	.018 42	.019 99	.022 34
10	101.9	.029 28	.031 78	.035 53
11	90.74	.046 56	.050 53	.056 49
12	80.81	.074 04	.080 35	.089 83
13	71.96	.1177	.1278	.1428
14	64.08	.1872	.2032	.2271
15	57.07	.2976	.3230	.3611
16	50.82	.4733	.5136	.5742
17	45.26	.7525	.8167	.9130
18	40.30	1.197	1.299	1.452
19	35.89	1.903	2.065	2.308
20	31.96	3.025	3.283	3.670
21	28.46	4.810	5.221	5.836
22	25.35	7.649	8.301	9.280
23	22.57	12.16	13.20	14.76
24	20.10	19.34	20.99	23.46
25	17.90	30.75	33.37	37.31
26	15.94	48.89	53.06	59.32
27	14.20	77.74	84.37	94.32
28	12.64	123.6	134.2	150.0
29	11.26	196.6	213.3	238.5
30	10.03	312.5	339.2	379.2
31	8.928	497.0	539.3	602.9
32	7.950	790.2	857.6	958.7
33	7.080	1256.	1364.	1524.
34	6.305	1998.	2168.	2424.
35	5.615	3177.	3448.	3854.

(Bureau of Standards)

Gage No. B. & S.	Diameter in Mils at 20° C	Pounds per Ohm		
		0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	14 180.	13 070.	11 690.
000	409.6	8920.	8219.	7352.
00	364.8	5610.	5169.	4624.
0	324.9	3528.	3251.	2908.
1	289.3	2219.	2044.	1829.
2	257.6	1395.	1286.	1150.
3	229.4	877.6	808.6	723.3
4	204.3	551.9	508.5	454.9
5	181.9	347.1	319.8	286.1
6	162.0	218.3	201.1	179.9
7	144.3	137.3	126.5	113.2
8	128.5	86.34	79.55	71.16
9	114.4	54.30	50.03	44.75
10	101.9	34.15	31.47	28.15
11	90.74	21.48	19.79	17.70
12	80.81	13.51	12.45	11.13
13	71.96	8.495	7.827	7.001
14	64.08	5.342	4.922	4.403
15	57.07	3.360	3.096	2.769
16	50.82	2.113	1.947	1.742
17	45.26	1.329	1.224	1.095
18	40.30	0.8357	0.7700	0.6888
19	35.89	.5256	.4843	.4332
20	31.96	.3306	.3046	.2725
21	28.46	.2079	.1915	.1713
22	25.35	.1307	.1205	.1078
23	22.57	.082 22	.075 76	.067 77
24	20.10	.051 71	.047 65	.042 62
25	17.90	.032 52	.029 97	.026 80
26	15.94	.020 45	.018 85	.016 86
27	14.20	.012 86	011 85	.010 60
28	12.64	.008 090	.007 454	.006 668
29	11.26	.005 088	.004 688	.004 193
30	10.03	.003 200	.002 948	.002 637
31	8.928	.002 012	.001 854	.001 659
32	7.950	.001 266	.001 166	.001 043
33	7.080	.000 7959	.000 7333	.000 6560
34	6.305	.000 5005	.000 4612	.000 4126
35	5.615	.000 3148	.000 2901	.000 2595

(Bureau of Standards)

FINE MAGNET WIRE.

No. B. & S. Gauge.	Diameter.	Ohms, Per Pound Single Cotton.	Ohms, Per Pound Double Cotton.	Feet, Per Pound Single Cotton.	Feet, Per Pound Double Cotton.
20	.0319	3.15	3.02	311	298
21	.0284	4.97	4.72	389	370
22	.0253	7.87	7.44	491	461
23	.0225	12.45	11.7	624	584
24	.0201	19.65	18.25	778	745
25	.0179	30.9	28.45	658	903
26	.0159	48.5	44.3	1188	1118
27	.0142	76.5	68.8	1533	1422
28	.0126	120.	106.5	1903	1759
29	.0112	190.5	164.	2461	2207
30	.0100	294.5	252.	2893	2534
31	.0089	461.	384.5	3483	2768
32	.0079	717.	585.	4414	3737
33	.0070	1115.	880.	5688	4697
34	.0063	1715.	1315.	6400	6168
35	.0056	2640.	1960.	8393	6737
36	.005	4070.	2890.	9846	7877
37	.0044	6180.	4230.	11636	9309
38	.0039	9430.	6150.	13848	10666
39	.0035	14200.	8850.	18286	11907
40	.0031	21300.	12500.	24381	14222

TABLE OF IRON, STEEL AND COPPER WIRE.

Gauge.	Diameter in .001 inch. Galvanized Iron B. W. G.	Copper B. S.	Copper Old B. W. G.	Pounds in One Mile. Galvanized Iron B. W. G.	Galvanized Steel.	Copper B. & S.	Copper Old B. W. G.	Feet in One Pound. Galvanized Iron B. W. G.	Galvanized Steel.	Copper B. & S.	Copper Old B. W. G.	Resistance in Ohms Per Mile. Galvanized Iron B. W. G.	Galvanized Steel B. W. G.	Copper, B. & S., 60° Fah.	Copper, Old B. W. G., 60° Fah.
1	.300	.289	.300	1251		1328	1438	4.22		4	3.7	3.76		.66	.61
2	.284	.258	.284	1121		1069	1289	4.72		5	4.1	4.19		.81	.68
3	.259	.229	.259	932		835	1072	5.65		6.3	4.9	5.04		1.04	.81
4	.238	.204	.238	787		662	905	6.70		8	5.8	5.97		1.31	.96
5	.220	.182	.220	673		526	774	7.87		10	6.8	6.99		1.65	1.13
6	.203	.162	.203	573		417	659	9.17		12.6	8	8.21		2.08	1.32
7	.180	.144	.180	450		330	518	11.25		16	10.2	10.44		2.63	1.65
8	.165	.129	.165	378		262	435	13.89		20	12.1	12.42		3.32	2.
9	.148	.114	.148	305		208	350	17.25		25	15.1	15.44		4.13	2.49
10	.134	.102	.134	250		165	287	21.29		32	18.4	18.83		5.17	3.04
11	.120	.091	.120	200		131	230	27.03		40	22.9	23.48		6.48	3.79
12	.108	.081	.109	165	163	103	190	32.2L	32.4	50	27.8	28.46	39.36	8.2	4.59
13	.095	.072	.095	125		82	144	41.65		64	36.6	37.47		10.39	6.04
14	.083	.064	.083	96	98	65	110	45.51	55.6	81	48	49.08	67.88	13.12	7.91
15	.072	.057	.072			51	83			102	63.7	65.23		16.55	10.5
16	.065	.051	.065		55	41	67		96.	126	78.2	80.03	110.70	20.7	12.9
17	.058	.045	.058			32	54			162	98.2	100.50		26.5	16.2
18	.049	.040	.049			26	38			208	137.6	140.80		33.7	22.7
19		.035	.042			20	28			256	187.3			41.5	30.9
20		.032	.035			16	20			323	269.7			52.5	44.5

Length of Belting for Various Purposes.

Open belting: $L = \frac{\pi}{2} S. + 2C. \left(1 + \frac{1 D^2.}{8 C^2.}\right)$

L = Length of belt.
S = Sum of pulley diameters.
C = Distance between centers of pulleys.
D = Difference of pulley diameters.
π = 3.141592, or, for practical purposes, 3.1416.

For calculating the length of belting approximately, add one-half the circumference of each pulley to twice the distance between centers of the pulleys.

To find the horsepower strength of double leather belting when:

d. = diameter of small pulley in inches.
r. = revolutions of small pulley per minute.
b. = breadth of belting in inches.
H.P. = horsepower to be transmitted.

$$H.P. = \frac{d \times r \times b}{1925}$$

"Double" belting is expected to transmit twice that of "single" belting, and "light double" one and one-half times that of "single."

Strength of wrought iron or steel Shafting.

(Formula as used by Pencoyd Iron Works.)

$d = \sqrt[3]{\frac{50 \text{ h. p.}}{R}}$ for bare shafts, or $H. P. = \frac{Rd^3}{50}$

or $d = \sqrt[3]{\frac{70 \text{ h. p.}}{R.}}$ for shafts carrying pulleys, etc.,

$$\text{or H.P.} = \frac{Rd^3}{70}$$

$$l = \sqrt[3]{720\, d^2} \text{ for bare shafts, or } d = \sqrt[2]{\frac{l^3}{720}}$$

$$\text{or } l = \sqrt[3]{140\, d^2} \text{ for shafts carrying pulleys, etc.,}$$

$$\text{or } d = \sqrt[2]{\frac{l^3}{140}}.$$

H.P. = horse-power transmitted.
d = diameter shaft in inches.
R = revolutions per minute.
l = length between supports in feet.

To find the horse-power of engines:

in which:

H.P. = indicated horse-power.
Ps = travel of piston in feet per minute.
A = area of piston in square inches.
M. E. P. = mean effective pressure in pounds per square inch.
Ip = initial pressure.

and:

$$(a)\ \text{M. E. P.} = \frac{34 \times Ip}{57} \qquad \text{at } 1/4 \text{ cut off.}$$

$$(b)\ \text{M. E. P.} = \frac{11 \times Ip}{13} \qquad \text{at } 1/2 \text{ cut off.}$$

An application of these formulæ in an appropriate example may be considered in the following **problem:**

It is desired to determine the I. H. P. of an engine whose cylinder is 10 inches in diameter and whose stroke is 12 inches, operating at 300 revolutions per minute, the initial steam pressure being 100 pounds per square inch, cutting off at ¼ and ½ stroke, respectively:

$$(a)\ \text{M.E.P.} = \frac{34 \times \text{Ip}}{57} = \frac{34 \times 100}{57} = 59.65 \text{ at } \tfrac{1}{4}$$

cut off.

$$(b)\ \text{M.E.P.} = \frac{11 \times \text{Ip}}{13} = \frac{34 \times 100}{13} = 84.6 \text{ at } \tfrac{1}{2}$$

cut off.

$$A = \frac{n}{4} \times \text{diameter}^2 = .7854 \times 10^2 = 78.54 \text{ square}$$

inches.

Ps = .2 feet per revolution and 30 revolutions per minute = 600 feet per minute.

$$\text{I. H. P. at } \tfrac{1}{4} \text{ cut off} = \frac{\text{Ps} \times \text{A} \times \text{M. E. P.}}{33{,}000} =$$

$$\frac{600 \times 78.54 \times 59.65}{33{,}000} = 85.18$$

$$\text{I. H. P. at } \tfrac{1}{2} \text{ cut off} = \frac{\text{Ps} \times \text{A} \times \text{M. E. P.}}{33{,}000} =$$

$$\frac{600 \times 78.54 \times 84.6}{33{,}000} = 120.8$$

To find the horse-power of a pulley:

Multiply the circumference of the pulley in feet by the revolutions per minute, and the product thus obtained by the width of the belt in inches, and divide the result by 600.

This rule is founded on the fact that good, ordinary, single leather belting, with a tension of fifty-five pounds per inch width, will require fifty square feet of belt surface passing over the pulley per minute for one horsepower. Fifty square feet per minute is equal to a belt one inch wide running 600 feet per minute.

To find the speed of a belt, multiply the circumference of the driving pulley in feet by the revolutions per minute.

Belts should always be run with the *grain* side next to the pulley.

Rule for Determining the Size of Pulley

D—Diameter of driver, or number of teeth in pinion.

d—Diameter of driven, or number of teeth in gear.

Rev.—Revolutions per minute of driver.

rev.—Revolutions per minute of driven.

$$D = \frac{d \times \text{rev.}}{\text{Rev.}} \qquad \text{Rev.} = \frac{d \times \text{rev.}}{D}$$

$$d = \frac{D \times \text{Rev.}}{\text{rev.}} \qquad \text{rev.} = \frac{D \times \text{Rev.}}{d}$$

To find the speed of the belt in feet per minute, multiply the circumference of the pulley in feet by the number of revolutions per minute. For best results, the belt speed should be from 3,500 to 4,500 feet per minute.

Resuscitation From Electric Shock.

As recommended by The National Electric Light Association. Follow these instructions even if the victim appears dead.

I. Immediately Break the Circuit.

With a single quick motion, free the victim from

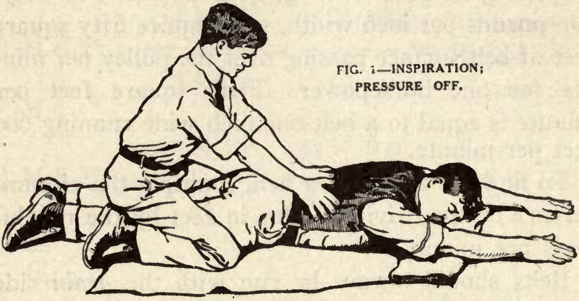


FIG. 1—INSPIRATION; PRESSURE OFF.

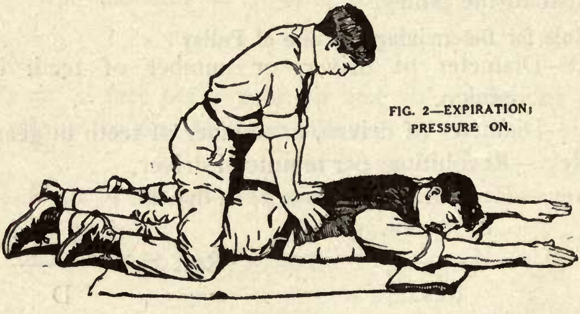


FIG. 2—EXPIRATION; PRESSURE ON.

the current. Use any *dry non-conductor* (clothing, rope, board) to move either the victim or the wire. Beware of using metal or any moist material. While freeing the victim from the live conductor have every effort also made to shut off the current quickly.

II. Instantly Attend to the Victim's Breathing.

As soon as the victim is clear of the conductor, rapidly feel with your finger in his mouth and throat and remove any foreign body (tobacco, false teeth, etc.). Then *begin artificial respiration at once.* Do not stop to loosen the victim's clothing now; *every moment of delay is serious.* Proceed as follows:

(a) Lay the subject on his belly, with arms extended as straight forward as possible and with face to one side, so that nose and mouth are free for breathing (see Fig. 1). Let an assistant draw forward the subject's tongue.

(b) Kneel straddling the subject's thighs, and facing his head; rest the palms of your hands on the loins (on the muscles of the small of the back), with fingers spread over the lowest ribs, as in Fig. 1.

(c) With arms held straight, swing forward slowly so that the weight of your body is gradually, but *not violently,* brought to bear upon the subject (see Fig. 2). This act should take from two to three seconds.

(d) Then immediately swing backward so as to remove the pressure, thus returnig to the position shown in Fig. 1.

(e) Repeat deliberately twelve to fifteen times a minute the swinging forward and back—a complete respiration in four or five seconds.

(f) As soon as this artificial respiration has been started, and while it is being continued, an assistant should loosen any tight clothing about the subject's neck, chest, or waist.

2. Continue the artificial respiration (if necessary, two hours or longer), *without interruption*, until natural breathing is restored, or until a physician arrives. If natural breathing stops after being restored, use artificial respiration again.

c. *Do not give any liquid by mouth until the subject is fully conscious.*

4. Give the subject fresh air, but keep him warm.

III. Send for Nearest Doctor as Soon as Accident is Discovered.

Switchboard and Electrical Fires

A one-quart liquid gas fire extinguisher, called Pyrene, has now been on the market for approximately eight years. Experimental and acceptance tests made by the largest electric light, power, railroad and transit companies and by the Underwriters' Laboratories, Inc., indicate that it is of great value to the electrical industry.

At several tests made, short circuit electrical arcs larger than any that had ever before been intentionally produced, were successfully handled by Pyrene

The extinguisher is small and light, working on the principle of a double-acting syringe, can be conveniently located and is easily transported from one point to another. As the liquid will not freeze at fifty degrees below zero, it can be left in exposed places during the winter. No periodic recharging is required, although they are refillable after use.

Pyrene is an absolute non-conductor of electric current, therefore perfectly safe to use.

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Trumbull Electric Mfg. Co.

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Hoyt Elecl. Inst. Co.
L. M. Pignolet
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BOLTS, EXPANSION
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Frank Adam Electric Co.
Bryant Electric Co.
Crouse-Hinds Co.
Detroit Fuse & Mfg. Co.
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Sprague Elec. Wks. of G. E. Co.
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CABLES, ARMORED
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Safety-Armorite Conduit Co.
Sprague Elec. Wks. of G. E. Co.
Standard Underground Cable Co.
Trumbull Elec. Mfg. Co.
Western Conduit Co.

CANOPY INSULATORS
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The Macallen Co.

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Gillette-Vebber Co.
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Cutter Electric & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

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Findlay Elec. Porcelain Mfg. Co.
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COMPOUNDS, INSULATING
H. W. Johns-Manville Co.
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American Circular Loom Co.
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CONDUIT, FLEXIBLE STEEL
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CONDUIT, RIGID METAL
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(See Motors)

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(See Motors)

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(See Switches, Knife)

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American Brass Co.
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(See Wire, Rubber Covered)

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Kerite Ins. Wire & Cable Co.
Lowell Ins. Wire Co.
National India Rubber Co.
The Okonite Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.
Rome Wire Co.
Simplex Wire & Cable Co.
Standard Underground Cable Co.

WIRE, FLEXIBLE CORD
(See Wire, Rubber Covered)

WIRE, SLOW-BURNING
American Brass Co.
American Electrical Works
Chicago Ins. Wire Co.
General Electric Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.
Standard Underground Cable Co.

WIRE, SLOW-BURNING WEATHERPROOF
Chicago Ins. Wire Co.
General Electric Co.
Standard Underground Cable Co.

WIRE, WEATHERPROOF
American Brass Co.
American Electrical Works
Chicago Ins. Wire Co.
General Electric Co.
National India Rubber Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.
Simplex Wire & Cable Co.
Standard Underground Cable Co.

WIRE, RESISTANCE
Driver-Harris Wire Co.

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Only Apparatus and Supplies that are officially approved, or permitted to be used, by the National Board of Fire Underwriters will be accepted in the following pages.

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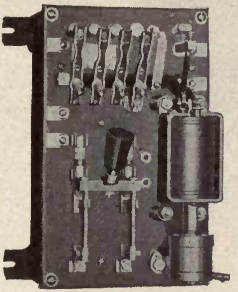
CUTLER-HAMMER



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MOTOR CONTROLLERS

Hand Operated and Automatic Types

Hand Operated Type Motor Starter with No-Voltage and Overload Release.

Cutler-Hammer Starters and Controllers are made for both direct and alternating current motors. When installing motors tell us what you wish to accomplish and we will send bulletin describing just the apparatus you need.

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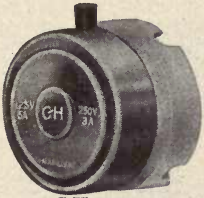

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Surface Switches

New No. 7500
Brass Shell
Push Button Socket

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Shell Pendent

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No. 500 Wiremold

The New And Different Metal Molding

WIREMOLD does not come apart—base and capping are permanently assembled at the factory.

WIREMOLD is two-wire size—just big enough for easy fishing of a pair of 14's or 12's.

WIREMOLD "fishes," it goes up in one piece—and in many other ways works like conduit.

WIREMOLD has just a few simple fittings—many of them standardized to work with things you always have on hand, like sockets for example.

WIREMOLD comes in ten-foot lengths—and complete with one coupling to each length—another one of the ways in which it resembles conduit.

WIREMOLD is manufactured only by

The American Conduit Manufacturing Company

at

PITTSBURGH

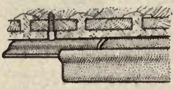


Fig. 1

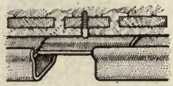


Fig. 2

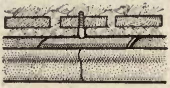


Fig. 3

Wiremold, like rigid conduit, is furnished with one coupling to each length.

To assemble, first shove the coupling forward and fasten to surface with a No. 8 flat head wood screw, as in Fig. 1 above, second start the end of the next length over coupling, as in Fig. 2, and third close up as in Fig. 3.

Fig. 1

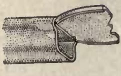


Fig. 2

Fig. 3

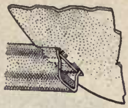
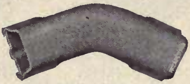


Fig. 4

Base plates of all "Wiremold" fittings are provided with coupling tongues, as can be seen from the broken edge view of a tee base in Fig. 1 and of an outlet box base in Fig. 3 above.

In coupling "Wiremold" to fittings it is therefore only necessary to shove the grooved edges of the molding over these tongues as in Figs. 2 and 4.

No. 511
90° Flat Elbow
Non-Splice Type

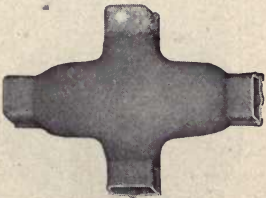


No. 512
45° Flat Elbow
Non-Splice Type

No. 513
90° Flat Elbow
Splice Type

No. 514
45° Flat Elbow
Splice Type

No. 515
Plain Tee

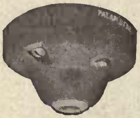


No. 516
Plain Cross

No. 517
Internal Elbow

No. 519
Corner Box

No. 518
External Elbow



No. 522
Cord Rosette

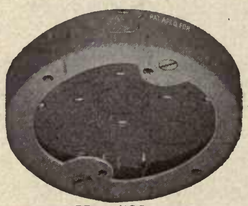
No. 525
Receptacle Base

No. 523
Fixture Rosette

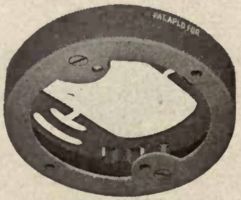
No. 531
Blank Cover
For Nos. 532-533

No. 532
2½" Outlet Box

No. 533
3" Outlet Box



No. 538
Fixture Box



No. 537
Extension Box

No. 581
½" Box
Connector

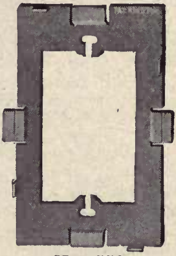
No. 588
Open Work Coupling

No. 582
½" Conduit
Coupling

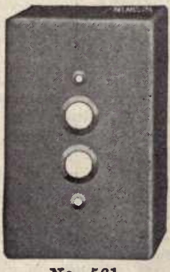
No. 584 ½" Elbow
Conduit Coupling

No. 583 ½" Elbow
Box Connector

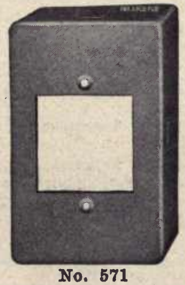
No. 550
Flush Switch Box



No. 551
Flush Switch Coupling Plate



No. 561
Push Switch Cover



No. 571
Standard Switch Cover

GENERAL ELECTRIC COMPANY

Moulded Material Sockets
Multi-Catch
Receptacles, Sockets
Multiple Receptacles
Outlet Box Receptacles
Panel Board Switches
Pendent Switches
Plates
Flush Receptacle, Flush Switch
Plug Cutouts
Plugs
Attaching, Fuse, Separable
Porcelain
Cleats, Insulators, Knobs, Receptacles, Sockets Specialties, Switches
Pull Sockets
Pull Switches
Punched Clip Lever Switches
Push Button Switches
Rack Insulators
Racks, Insulator
Receptacles
Candelabra, Car, Conduit Box, Condulet, Flush, Fluted-Catch, Locking, Machine Shop, Metal Shell, Miniature, Mogul, Multi-Catch, Multiple, Outlet Box, Porcelain, Separable, Series, Sign
Rings, Socket
Rosettes
Rotary Flush Switches
Separable
Receptacles and Attaching Plugs
Series
Receptacles, Sockets
Shadeholders, "Uno"
Sign Receptacles
Snap Switches
Accessories, Snap Switch and Buzzer, Snap Switch and Cutouts, Handles, Tubular
Socket
Keys, Plugs and Bushings, Rings
Sockets
Acorn, Aluminum Shell, Bracket, Candelabra, Candle, Decorative, Double-Catch, Electrolier, Fluted-Catch, Hard Rubber, Key, 660-Watt, Keyless, 600 Volt, Locking, Miniature, Mogul, Moulded, Multi-Catch, Porcelain, Pull, Pull 660-Watt, Series, Special, Streethood, Three-Way, Weatherproof, "9386" Type
Special Sockets
Specialties, Porcelain
Streethood Sockets
Sub-bases
Switches and Plug Cutouts
Automobile, Ceiling, Door, Electrolier, Entrance, Fan Motor, Flush Push Button, Flush Rotary, Lever, Locking, Momentary Contact, Motor Control, Motor Starting, Panel Board Type, Pendent, Plates Porcelain, Push Button, Snap
Swivel Attaching Plug
Swivel Attaching Plug and Socket
Terminal Ground Clamps
Three-Heat Connector Plug, Receptacles
"Uno" Shadeholders
Weatherproof Attaching Plugs and Sockets

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RELIABLE GE WIRING DEVICES

MACALLEN

Canopy Insulators

Patented July 13, 1897.

Regularly inspected and labeled under the supervision of the Underwriters' Laboratories, Inc., under the direction of the National Board of Fire Underwriters.

They are designed to go between the canopy and the wall or ceiling, where combination or straight electric fixtures are installed in buildings that are constructed with metallic lathing, or where there are metal ceilings or walls used.

They are made of a special compound that is thoroughly waterproof, strong, durable, and of the highest insulating qualities.

We manufacture these insulators to fit all standard sizes of canopies.

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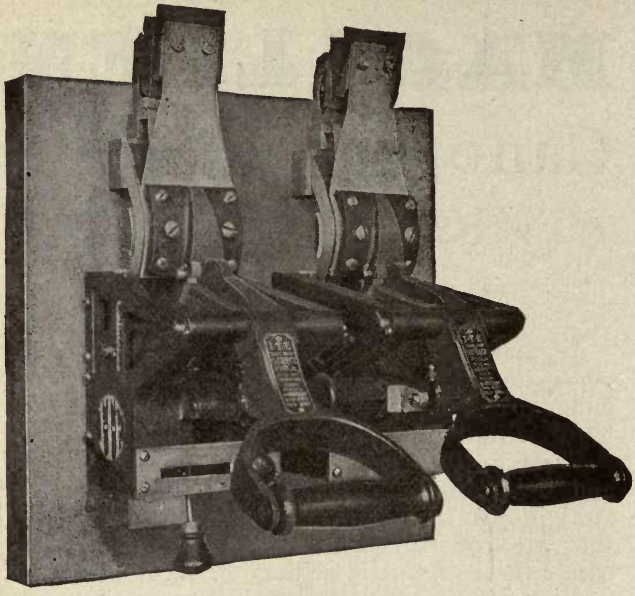
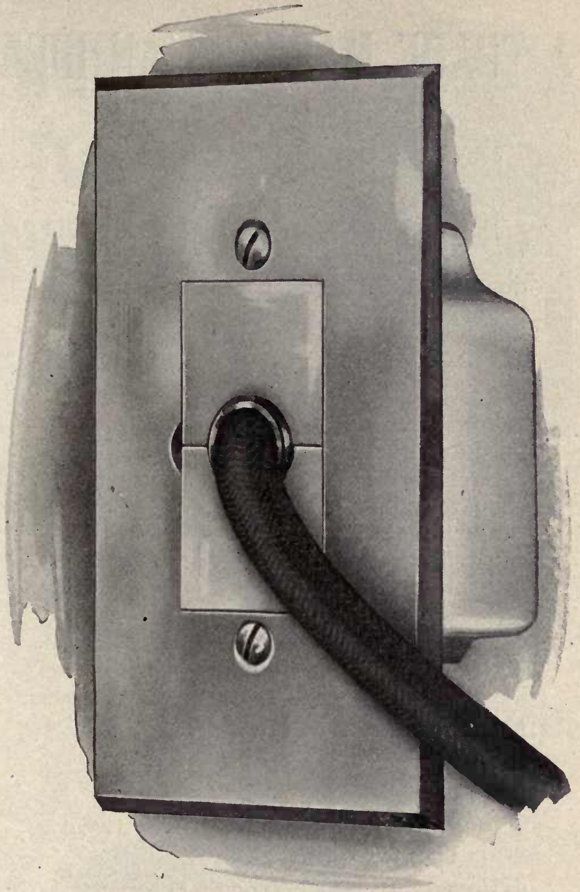


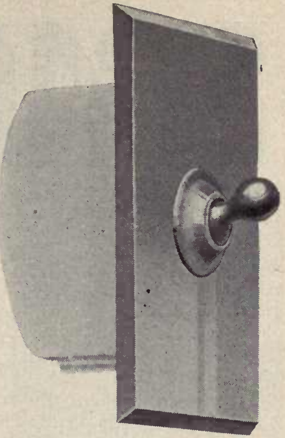


Flush Plugs, Screw Plugs and Flush Switches

The Cutter Co.

PHILADELPHIA

NEWTON TOGGLE SWITCHES



A distinct advance over all previous practice is represented in these switches, in which a lever movement replaces push button or key movement. The Newton Flush Toggle Switch plate is only ⅔ the size of the ordinary switch plate, has no fastening screws, is furnished in a variety of handsome styles and finishes. The Newton Surface Toggle Switch is handsome in appearance, and is self-indicating without any marker or dial. The Newton Toggle mechanism is durable and simple, the make-and-break quick and positive. Newton Toggle Switches are becoming the standards for all high-class work.

NEWTON MANUFACTURING CO.

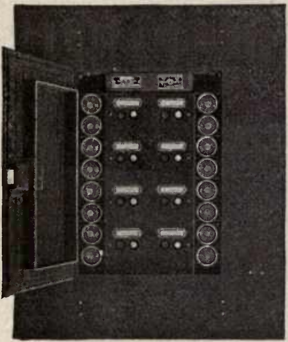
LYNBROOK, NEW YORK

Newton Toggle Switches are officially approved. Send for descriptive pamphlet giving styles, finishes and prices. Discounts quoted on request.

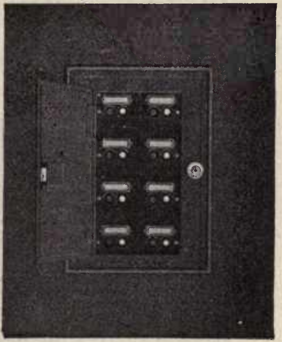
"CIRCLE T"

TRUMBULL

SAFETY PANELS



Showing Fuses



Inner door open, fuses locked

NO LIVE PARTS

Door Within a Door

This type of panel is equipped with push switches and plug fuse receptacles only.

Base is moulded heat proof composition, with a backing of ¼" "Transite," insulation resistance being much higher than any grade of slate or marble, and non-absorptive.

All copper bars are enclosed between the base and back. The main lugs are covered by a removable moulded section.

This panel can be furnished in a regular cabinet, but where access to the fuses is to be limited to but certain persons, it can be furnished in a cabinet having a door within a door. The door over the fuses to be locked, the inner door furnished with a catch only or lock if desired.

THE TRUMBULL ELEC. MFG. CO.

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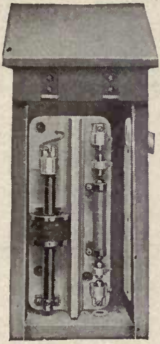
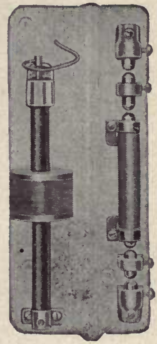
YOUR ONLY PRICE FOR SAFETY



Type CE-2 Pole Arrester



Type CE-2 Station Arrester

The circuit breaker used in combination with a small air gap distance and a low series resistance has given

Garton-Daniels Lightning Arresters

their well known characteristics of efficiency and durability.

The air gaps mean protection to your electrical apparatus because they arc over and discharge potentials but slightly higher than normal.

The low series resistance will eliminate surges, winking lights and other voltage disturbances on your circuits, because it limits the flow of line current following the lightning discharge to ground to a moderate value—about 10 amperes.

The circuit breaker will eliminate grounds and short-circuits on your lines, because it cuts off this flow of line current to ground.

You can get complete lightning protection only from an arrester combining these three essential functions.

An installation of Garton-Daniels is your only price for Safety. Write for catalog.

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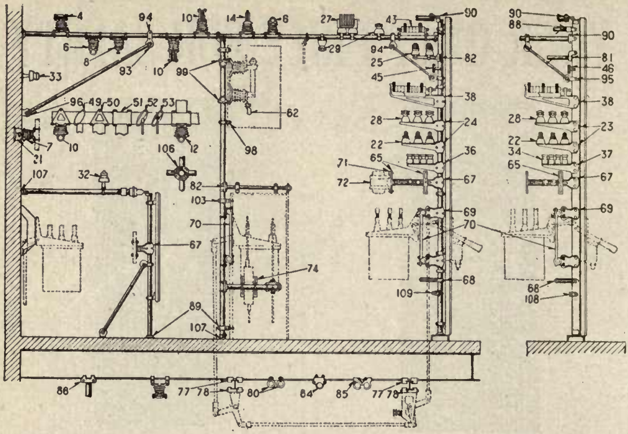

4 Bus Support with corrugated insulator
6 Bus Support with corrugated insulator
7 Bus Support with corrugated insulator
8 Bus Support with corrugated insulator
10 Bus Support with corrugated insulator
12 Bus Support with corrugated insulator
14 Bus Support with corrugated insulator
21 Insulator, Corrugated Porcelain
22 Bus-Strap Support
23 Bus-Bar Bracket
24 Bus-Bar Bracket
25 Bus-Strap Support
27 Bus-Strap Support
28 Bus-Rod Bracket and Supports
29 Bus-Rod Bracket and Supports
32 Bus-Rod Bracket and Supports
33 Bus-Rod Bracket and Supports
34 Insulator, Plain Porcelain
36 Bus-Rod Bracket and Supports
37 Bus-Rod Bracket and Supports
38 Bus-Strap Bracket
43 Bus-Strap Bracket
45 Bus-Wire Bracket
46 Bus-Wire Bracket
49 Bus-Bar Clamps
50 Bus-Bar Clamps
51 Bus-Bar Clamps
52 Bus-Bar Terminal
53 Bus-Bar Terminal
62 Terminal
65 Universal Auxiliary Bracket
67 Universal Mounting Bracket
68 Universal Mounting Strap
69 Universal Mounting Bracket
70 Mounting Bracket for Oil Circuit Breakers
71 Mounting Bracket for Current Transformers
72 Mounting Bracket for Current Transformers
74 Pipe Mounting Bracket
77 I-Beam Clamps
78 I-Beam Clamps
80 Pipe Conduit Clamps
81 Pipe Bracket
83 Pipe Saddle Clamps
84 Clamp
85 Clamp
88 Pipe End
89 Pipe End
90 Pipe Brace and Clamp
93 Wall Brace with Angular Adjustment
94 Wall Brace with Angular Adjustment
95 Wall Brace with Angular Adjustment
96 Wall Brace with Angular Adjustment
98 Barrier Bracket for Pipe Mounting
99 Mounting Clamp Bracket
103 Mounting Clamp Bracket
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108 Mounting Clamp Bracket
109 Mounting Clamp Bracket

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1500—to the Largest

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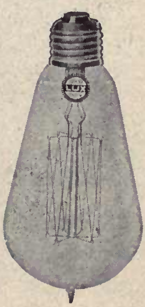

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THE KEY TO SAFETY

Two expensive elements of loss face the lamp user. To stop *breakage* he must use a *guard,* to stop *theft* he must use a *lock.* A guard fastened with wire or set screw cannot stop a thief; nor can a patent socket prevent lamp breakage.

The *Loxon Lamp Guard,* which locks the lamp into a socket with a key, *does this double duty at single cost.*

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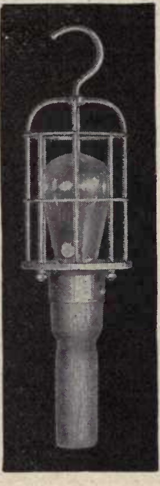

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DAYS KERITE
KERITE INSULATED WIRE & CABLE COMPANY
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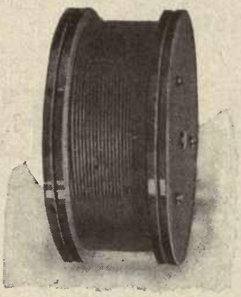
Write

Paraxel Insulated Wire

Into Your Specifications

(30% Para Rubber Compound)



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Lead Covered Underground Cable.

Aerial Cables.

Flexible Cables.

Special Cables, also.

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RUBBER WIRES.

STANDARD Products received the highest specific award granted Electric Wires, Cables and Accessories.

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Write our nearest office concerning your requirements.

Standard Underground Cable Co.

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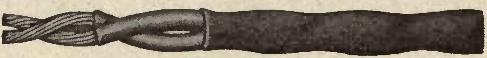
MAGNET WIRE.—Covered with pure asbestos fibre in a smooth flexible mass, which will not crack nor break, even when sharp bends are made. Tough, moisture-proof and indestructible under any commercial temperature.

FIXTURE WIRE.—For installations where temperature makes rubber covered wires impracticable, this smooth, flexible, tenacious asbestos fibre covering will give best protection and longest service. Especially adapted for wiring Type C Fixtures.

FIXTURE WIRE.—Same construction as the above, with the addition of a silk covering over the asbestos fibre to give a neat, attractive appearance where wiring of fixtures is exposed to view. Made in single, parallel and twisted pair conductors.



HEATER CORD.—Asbestos insulated throughout; will not burn nor deteriorate like rubber. The special application of the asbestos fibre re-enforces the strands of the conductor against their breaking and puncturing the insulation. The occurrence of short circuits is thereby eliminated and longer life obtained.

STOVE WIRE.—Furnishes perfect wiring for electric stoves and ranges, in and around ovens and boiler rooms. Insulated with especially treated asbestos fibre and a tightly braided asbestos covering.

MOVING PICTURE CABLE.—A very flexible conductor having a wall of asbestos fibre and a braided asbestos covering; moisture-proof; widely used where wires are subjected to high temperatures —projectors, searchlights, railroad controllers, cranes, etc.

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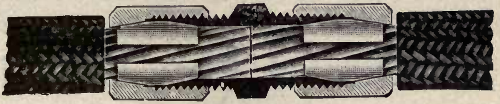
DOSSERT CONNECTORS



2-Way Type A Showing Details.

Dossert Connectors eliminate entirely the use of solder in making electrical connections and splices, and are approved for use without solder by the National Board of Fire Underwriters for all classes of wiring.

By their use much labor is saved and splices obtained that will withstand any overload. Many careful tests show that a splice made by means of a Dossert Connector will not heat as much as the cable which it connects when the cable is heavily overloaded.

Type A Connectors are for use on cables, stranded, or solid wires, rods and tubing. They are simple and effective, and by their use splices can be quickly made in condutcors of any size. Type A Connectors, however, should not be used on a cable that is to be subjected to heavy tensile strains.

Type B Connectors are for use on stranded wires or cables only, and are designed to make a joint which will withstand heavy tensile strains. They are not made for wires smaller than No. 0.

Cable Tap

The Cable Tap is used to connect a branch wire, rod, or bleeder, to a main wire, rod or feeder. It does not splice the main, but simply clamps on to it. Branch wire is connected to cable tap by means of a nut and sleeve as shown in Type A cut.

With Dossert devices any combination of different sizes of cables, stranded and solid wires, rods and tubing can be connected together. The cable tap will tap from any size main to any size branch. Terminal and switchboard lugs, front or back connected; angle and swivel lugs, insulated connectors; two-ways, three-ways, equalizers, cable anchors, reducers, elbows, Y's, service box lugs and plugs, grounding devices and stud connectors for threaded rods and flat strips or blocks made in every necessary size and form for all conceivable connections ranging from No. 14 to 2,500,000 C. M. conductors.

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NYELCO STAR

Semi-Indirect Unit

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A Size and Style for Every Duty

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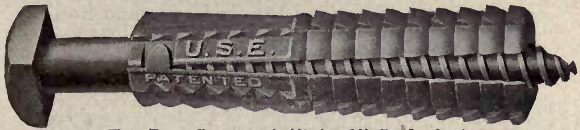

For Lag Screws (¼″ to 1″ Inclusive)

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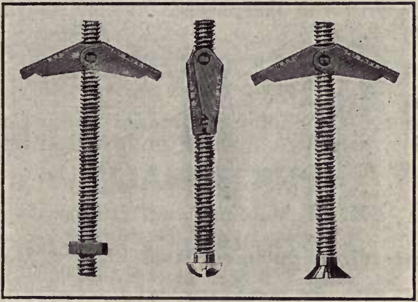
SPRING

TOGGLE



QUICK

AUTO-MATIC

SURE

SPRING in head automatically spreads wings as soon as toggle passes through hole. Arrow points on wings grip walls, insure instant bearing and prevent turning in hole. Toggle wings when opened and "set," clamp directly on threads of bolt, providing a positive nut-locking effect which prevents work from loosening under vibration, and supplying holding quality equal to strength of bolt itself.

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"XDUCT" GALVANIZED CONDUIT

Easy-Bending Spellerized Steel Tube, Doubly Protected by Copper-Plating and Zinc-Coating. Clean Threads, Smooth Enameled Interior.

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Easy-Bending Spellerized Steel Tube, Protected by Coatings of Special Enamel. Smooth Interior.

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Seamless Interwoven Canvaslike Interior covered by a Light Cotton Braid. Clean to Handle. Easy to Cut and Fish.

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Armature Tapes

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Jamaica Plain, BOSTON, MASS.

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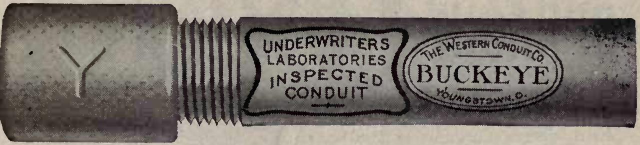

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BUCKEYE CONDUIT

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REALFLEX ARMORED CONDUCTOR

is the best evidence of their quality and the advantages they offer to users.

BUCKEYE Conduit is made from the best steel we can produce for that especial purpose. It is made in the best manner and with the utmost care.

REALFLEX is rapidly being recognized as the most flexible, durable and handsome of all armored conductors.

You want the best. Try them.

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And other conduit products of Sprague manufacture are the Standard

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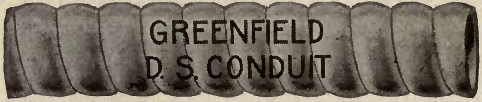

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OF GENERAL ELECTRIC COMPANY

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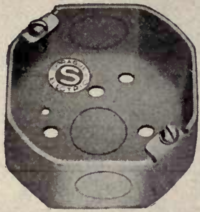
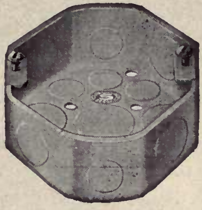


3¼ inch Outlet Box

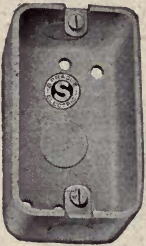


3¼ inch Loom and Conduit Box

Non-Adjustable Floor Box

Gang Switch Boxes For ½ inch or ¾ inch Conduit

Outlet Switch and Junction Box 4 inches square, 1⅝ in. deep



Switch Boxes Outlets for ½ inch or ¾ in., only

Interchangeable with Boxes and Covers of other manufacture

Clean Cut Knockouts

Carried in Stock by Leading Distributors

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Easiest to "Fish." Try it and prove it.

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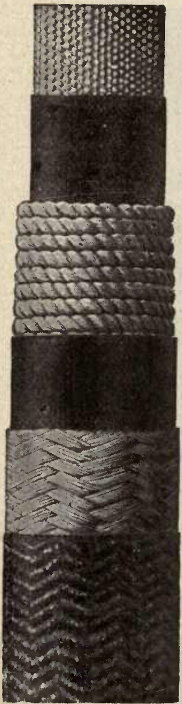


← Inner lining of heavy canvas.

← Water-proof coating.

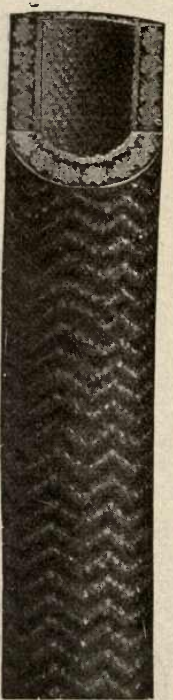
← Hard fibre cord.

← All intersects filled with special compounds.

← Outer jacket.

← Outer coating, protection against dampness and abrasion.

→ Finished Conduit.



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FLEXIBLE NON-METALLIC CONDUIT

This is the only interwoven wall conduit because it is the only single wall conduit.

The "roller-bearing wireway" reduces friction in fishing 75%, saving time and labor.

Of the highest grade only.

Approved by Underwriters' Laboratories, Inc.

Sold by live jobbers—everywhere

Tubular Woven Fabric Co.

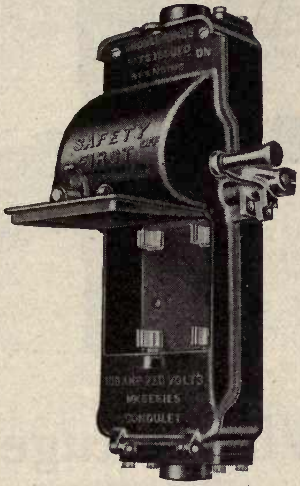
Mfrs., Pawtucket, R. I.

A. HALL BERRY, General Sales Agent

97 Warren St., New York **9 S. Clinton St., Chicago**

Fused Ironclad Switches

MK Series



Type MKC
(Door Open)

Type MKC
(Door Closed)

All live metal parts are protected. Door to fuses cannot be opened when switch is closed. Switch cannot be closed when door is open.

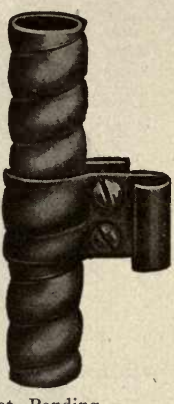
End plates are made with various sizes and arrangements of hubs to meet all conduit requirements.

CROUSE-HINDS COMPANY
Syracuse, N. Y., U. S. A.
Boston New York Cincinnati Chicago

"Griptite" and "Flexclamp"

GROUND CONNECTION CLAMPS

**For Rigid and Flexible Conduit
National Electrical
Code Standard**



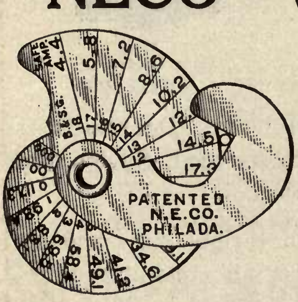
Made of one piece of copper insuring perfect and permanent contact.

Made for all Standard sizes of rigid and flexible metallic conduit.

Patented

Pat. Pending

"NECO" Wire Gauge



Our IMPROVED "NECO" POCKET WIRE GAUGE, for measuring wire from No. 18 to No. 000 B. & S. Gauge. On the front is also given the carrying capacity of copper wire in amperes and on the reverse side the approx. decimal equivalent of the various size wires.

Mailed to any address in the United States or Canada upon receipt of **60 cents** in cash or money order.

Manufactured by

Novelty Electric Company

Wholesale Electrical Supplies

50-52-54 North 4th St., PHILADELPHIA

**Agents for Okonite Wires and Cables
Holtzer Cabot Motors**

The GeeVee Electrical Fittings Service Cap

For service entrance work. Furnished with three hole two piece insulator. Seal furnished to close unused hole when used with but two wires. Brass Screws; galvanized finish. Insulators for sizes 1″ and under, made of approved molded insulation; above 1″ of porcelain.

Can be applied after service is connected up by cutting out reduced section of frame with hacksaw.

List Prices.

No.	Size	Unit Pkg.	Each
6012	½ inch	10	**$0.45**
6034	¾ inch	10	**.50**
6001	1 inch	5	**.90**
6114	1¼ inch	2	**1.50**
6112	1½ inch	2	**2.00**
6002	2 inch	1	**3.00**
6212	2½ inch	1	**4.50**
6003	3 inch	1	**7.00**

The GeeVee Electrical Fittings Terminal, Form "A"

For motor loop, meter loop and other inside work. A two-piece, cast iron terminal furnished with a three-hole, two-piece insulator. Seal furnished to close unused hole when used with but two wires. Galvanized finish. Insulators for sizes 1″ and under, made of molded insulation; for sizes above 1″ of porcelain.

No.	Size	Unit Pkg.	Each
10012	½ inch	10	**$0.32**
10034	¾ inch	10	**.35**
10001	1 inch	5	**.63**
10114	1¼ inch	2	**.92**
10112	1½ inch	2	**1.20**
10002	2 inch	2	**2.10**
10212	2½ inch	1	**4.00**
10003	3 inch	1	**6.50**

THE GILLETTE-VIBBER CO.
TRADE GV MARK
NEW LONDON, CONNECTICUT.

Trade Reg. U. S. **D** Mark Pat. Off.

Electrical Safety

"Square D" Steel Enclosed

Service Switches and Distributing Cabinets

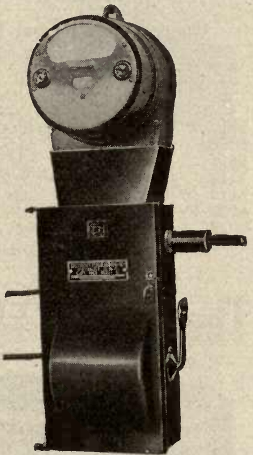
A line of Installation and Service Devices Unequalled in Excellence of Design and Finish, in Quality, in Safety of Operation and in Low Price.

"SQUARE D" Features

All live parts enclosed
Control outside box
Removable top and bottom end plates
End plates interchangeable
End Plates Standard Equipment
Meter protective trim
Meter trim and end plates interchangeable
Convenient knockouts
Ground wire lugs
Exclusive "locking off" device
Roominess inside
Connections easily made
Not less than 30 Amp. capacity
Made from 16 Ga. steel
Corners electrically welded
Finished in lustrous black enamel
Switch and cutout mounted ready to install
Satisfactory operation assured
Prevents accidental contact with live parts
Prevents tampering with service

Approved by Underwriters' Laboratories.

Send for Bulletin 39 S.W.



No. 5211*E. With meter protective trim. Switch in "on" position, cabinet sealed.*

"ARKLESS" Fuses N. E. C. S.

Only Guaranteed Mechanical Indicator Made

All National Electrical Code Standard "ARKLESS" Fuses comply strictly with the requirements of the National Board of Fire Underwriters and are approved by the Underwriters' Laboratories after examination and test under the provisions of the National Electrical Code. We guarantee "ARKLESS" fuses to indicate, and will replace, free of charge, every "ARKLESS" fuse that fails to indicate when blown.

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DETROIT FUSE & MFG. CO.

Detroit, Mich.

"Union" Fuses

Much depends upon the Enclosed Fuse. It is usually the only Protection for apparatus of many times its own value. Its cost is slight compared with the value that it guards.

Is it wise to experiment with fuses not *proven* to be reliable?

"Union" Fuses have stood the test of time. They are approved by the National Board of Fire Underwriters, are carried in stock by Jobbers in all Cities and the sizes, above 60 amperes, if returned to the factory, can be reloaded at a large saving to the user and are "Approved."

"Union" Cut-Outs, either in porcelain or slate, are carefully designed and well made.

"Union" Outlet Boxes and Covers accommodate all regular wiring devices.

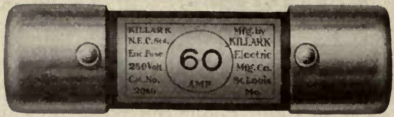
"Union" Switch Boxes are the original and the most complete line.

Write for Cat. No. 28.

Chicago Fuse Mfg. Co.

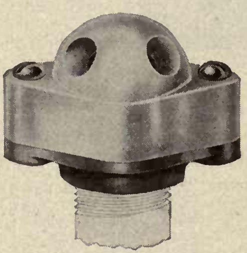
Chicago New York

"Killark" Enclosed Fuses



Accurately rated, carefully calibrated.
Operate consistently and give dependable protection.

"Electrolet" Conduit Fittings



Type "A"

Inexpensive, convenient, easy to install and make the best looking job for—
- Meter Loops.
- Motor Connections.
- Entrances to Buildings.
- Box Outlets.
- *All* Combination Wiring.

Type "FB"
Entrance Fitting

The "FB" Entrance Fittings are reversible and may be installed either as Type "F" or Type "B" fittings.

Killark Electric Manufacturing Co.

KILLARK ST. LOUIS

ST. LOUIS

General Sales Representative

W. DOUGLAS WOOLLEY

411 S. Jefferson Street
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KILLARK ST. LOUIS

SIX-IN-ONE FUSE PLUG

ACTUAL SIZE

Six Fuses in one Plug—made in amperages from 3 to 30 for 125 maximum voltage. Fits standard installation, self-contained, non-refillable.

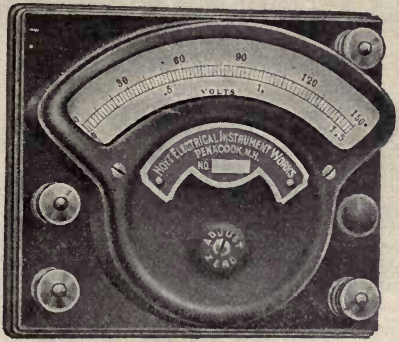
How It Operates

The upper revolving part of **SIX-IN-ONE** contains six chambers for six separate fuse wires. When one of the fuses burns out, all that is necessary is to pull slightly on this upper part, which stands under the pressure of the spring, and to turn the part to the right. The new fuse snaps in at once.

The construction of the **SIX-IN-ONE** throughout is substantial so that the finished device itself has the appearance of value, taking it immediately out of the class of the single plug fuse so cheap in construction and appearance. The materials used in its manufacture are carefully selected and the workmanship of every part is of the highest class. It is built for service and in appearance it compares with the ordinary single fuse plug as a fine Swiss timepiece compares with a dollar watch.

ATLAS SELLING AGENCY, Inc.

Sole Selling Agents **450 Fourth Avenue, NEW YORK CITY**



Type 445 Voltmeters and Ammeters
Size 4 x 4¼"

The Hoyt line comprising

Pocket Voltmeters, Ammeters and Voltammeters, Miniature Switchboard Voltmeters and Ammeters, Switchboard Voltmeters and Ammeters, Portable Voltmeters and Ammeters for direct current, and Switchboard Voltmeters and Ammeters for alternating current, offers a wide and comprehensive list from which to make your selection of measuring instruments.

Catalogue on request.

Hoyt Electrical Instrument Works

Penacook, N. H.

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HEMINGRAY

REGISTERED.

No. 19, Deep Groove Double Petticoat. No. 71, High Voltage Triple Petticoat. No. 2, Cable Double Petticoat.

For years the name "Hemingray" has been synonymous, not only with "glass insulators," but with "good glass insulators." The Hemingray insulators have been and are *good insulators,* because they have been and are of good design and material subjected to proper processes of manufacturing, including especially perfect annealing. In a glass insulator, "good design" means more than proper lines electrically,—it means a design which so distributes the material that good annealing is possible. Given such a design and a proper proportioning of materials (including *not too much cullet*), it is possible to obtain, and the Hemingray Glass Company does produce a completed insulator, every part of which is perfectly annealed.

Thorough annealing is of supreme importance in a glass insulator, and faults which have been found against glass as a material for line insulators have been due to the past practice of some other manufacturers who not only have used improper annealing methods, or material which was practically incapable of being properly annealed, but also have accepted for manufacture certain designs of insulators which so distributed the material as to make proper annealing practically impossible, no matter what materials or methods were used. The HEMINGRAY GLASS COMPANY has followed as one of its first principles the practice of not accepting for manufacture any design which their sixty-five years of experience would indicate could not be properly and perfectly annealed. This is the prime reason for the uniform success o fthe Hemingray insulator; the reason for its superior mechanical quality of strength and capabilities to withstand the shocks of sudden blows or rapid and extreme temperature changes; the reason for its remarkable electrical qualities as a high voltage insulator.

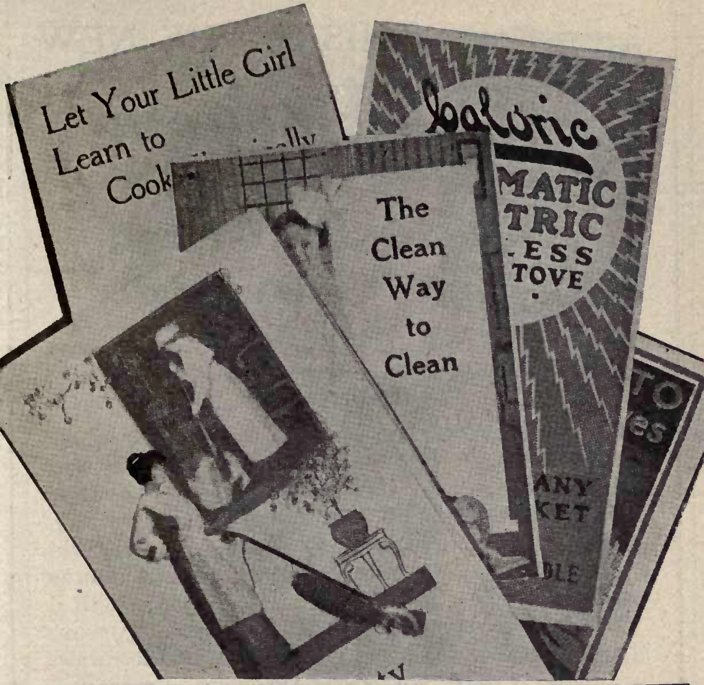
Insulators for Telephone, Telegraph, Light and Power

HEMINGRAY GLASS CO.

Established 1848 Iucorporated 1870

COVINGTON, KY.

Factories - - - - MUNCIE, INDIANA



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Have you any new current consuming device that you would like to advertise to our consumers?

We would be glad to enclose booklets, circulars or other advertising matter in our mail, outlining the usefulness and convenience of articles of this character.

The United Electric Light & Power Co.
General Offices: 130 East 15th Street, New York

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The Cook Wedge Split Insulator

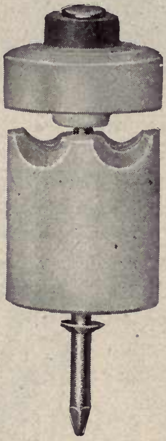
Two GROOVE for 10, 12, 14 Wire

Makes Standard Wiring Easy

Made of the Best Hard White Porcelain. No Burrs or Rough Edges to Cut Insulation, but Firmly Grips the Wire when Screwed in Place—The Cap Needs no Centering. Once Used Never Replaced.

Trial Orders Packed 500 in a box

Now Furnished Complete with Nail and Leather Nail Head



Note that the Nail is not Weakened by Crimping

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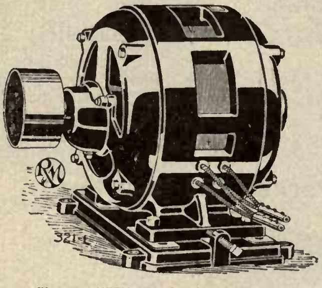
Ask Your Jobber or Write Us for Samples and Prices

COOK POTTERY CO.

Trenton, N. J.

SOLE MANUFACTURERS.

Robbins & Myers Motors and Fans



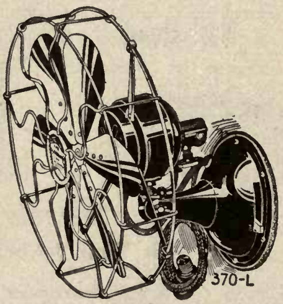
Type "K" Polyphase Motor.

The R & M line of motors includes sizes from 1/40 to 25 horse-power, inclusive. For direct or alternating current circuits. In addition to the standard frames, special frames can be furnished, adapted to the particular requirements of any motor driven machine.

Robbins & Myers Direct Current Generators are made in capacities ranging from ¼ to 10 kilowatts, inclusive. They can be furnished with fly-wheel pulleys for service with gas engines.

The Robbins & Myers line of Fans includes types and sizes for all services for operation on all direct and alternating current circuits.

Bulletins on R & M Motors, Generators or Fans will be furnished on request.



12-Inch Oscillating Fan, Drawn Steel Frame.

THE ROBBINS & MYERS CO.

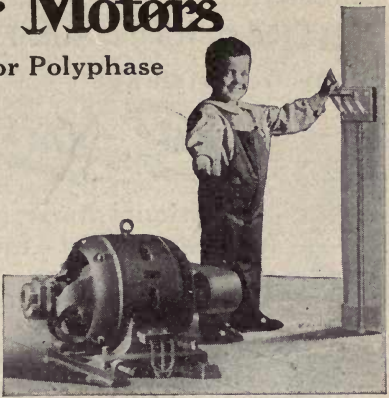
SPRINGFIELD, O.

New York Philadelphia Cleveland Chicago St. Louis
Boston Rochester Cincinnati San Francisco

Wagner Motors

Single-phase or Polyphase

Started and Stopped with a Single-throw Switch.



What could be more simple? Simplicity means dependability, the most important factor in motor purchases, and dependability means freedom from repairs and that is economy.

Ask about Wagner,Quality BA & BW motors,—Bulletins 110L and 111L.

Wagner Electric

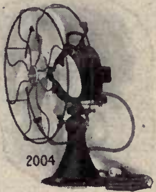
Manufacturing Company, St. Louis, Mo.

383

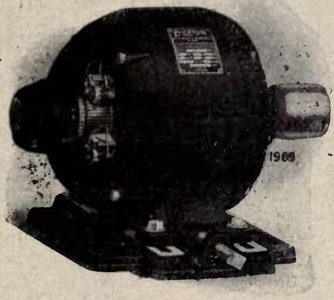
Emerson Fans

With the 5-year Factory-to-user Guarantee

For Alternating and Direct Currents. Sold by fifty leading jobbers. Factory Stocks at St. Louis and New York City.



Emerson Small Motors



2 H. P. and Less

Split Phase Types. Repulsion-Start Types. Single and Multiphase Motors. Direct Current Motors.

Large Stocks always on hand. Special types developed.

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The Emerson Electric Mfg. Co.

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Send For Catalogue

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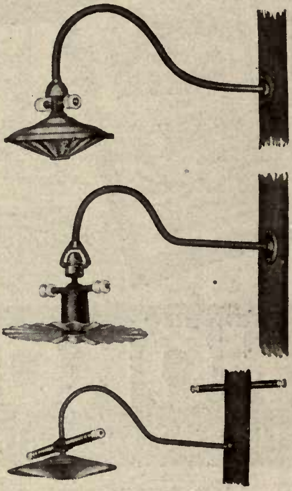

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We wish to make clear that these goods are manufactured in our own plant.

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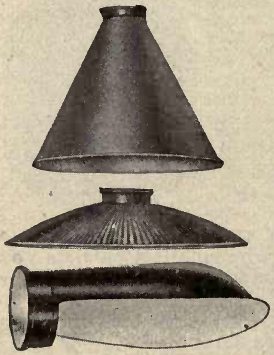

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SHALLOW CONE
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HALF REFLECTORS
TIN OR ALUMINUM

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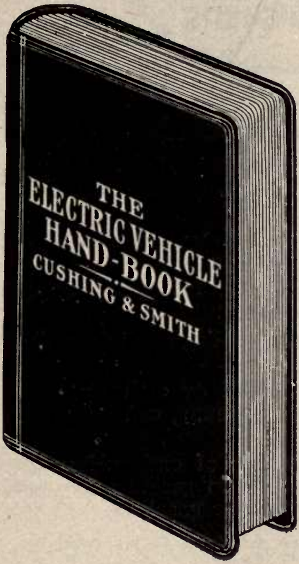

By

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