RULES

ELECTRIC LIGHT AND POWER EQUIPMENTS

CONSISTING OF THE

"NATIONAL ELECTRICAL CODE"

WITH

EXPLANATORY NOTES

1915

INSPECTION DEPARTMENT

Associated Factory

Mutual Fire Insurance Companies,

31 Milk Street, Boston, Mass.

APPROVED FITTINGS

For satisfactory work, only approved fittings should be used. A pamphlet entitled "Approved Electrical Fittings," designed to aid wiremen by showing them in advance just what will be approved, is issued by this department.

Fittings not listed should not be used without special approval, which will be freely given on the application of members if the device is found to be reliable.

"Approved Electrical Fittings" is subject to semi-annual revision in April and October.

PREFACE TO TWELFTH EDITION.

As in previous editions, the National Electrical Code is given, with explanatory notes to make the reason for each rule clearer and to point out the special danger against which it guards. In a few cases these notes contain additional requirements applying especially to factory work. A number of cuts illustrating excellent methods of construction have also been included to still further emphasize and make clear important points frequently overlooked. The testimony of many wiremen and mill managers and our own experience have shown that the suggestions contained in these additional notes and cuts have been carried out to advantage in many cases, resulting in a more convenient and safer electric plant. In the Appendix is some additional information which could not well be included in the body of the Rules.

Power Stations, Transformer, Lightning Arrester and Switch Houses have in a number of instances been constructed largely of wood, which is objectionable; even where well built originally, stations have been rendered unsafe by the introduction of combustible materials for apparatus, wire frames, platforms, etc. Therefore, the important points essential for safe buildings and equipments of this kind are outlined in a special chapter, page 3. This matter is considered of great importance.

To enable those not especially familiar with electrical matters or too busy to give more than a few minutes to the subject, to quickly gain an idea of the Rules, a brief abstract of the requirements applying to Factory Mutual mills is also given, page 12, and special attention is called to this section.

It is impracticable to prepare a set of rules which will wisely cover every case, and the applications of electricity are still in a state of frequent change. If, therefore, in any instance it may appear that these rules do not cover the peculiar existing conditions in the best way, this Department will be pleased to give special consideration to the case.

No. 2.
12TH EDITION.
8,500-1916.

The National Electrical Code was originally drawn in 1897 as the result of the united efforts of the various Insurance, Electrical, Architectural and allied interests which through the National Conference on Standard Electrical Rules, composed of delegates from various National Associations, unanimously voted to recommend it to their respective associations for approval or adoption; and is here presented with the various amendments and additions which have been made since that time by them.

The National Conference has disbanded, the work of the Underwriters' National Electric Association and of the National Conference having been taken over by the National Fire Protection Association.

The following associations, formerly members of the National Conference, are represented on the Electrical Committee of the National Fire Protection Association: —

American Electric Railway Association
American Institute of Electrical Engineers.
Associated Factory Mutual Fire Insurance Co's.
National Board of Fire Underwriters.
National Electric Light Association.
National Electrical Contractors Association.
National Electrical Inspectors Association.

POWER HOUSES, TRANSFORMER STATIONS, AND GENERAL SUGGESTIONS FOR LARGE MILL POWER AND LIGHTING PLANTS.

These suggestions are intended especially for electric plants of fairly large capacity or high voltage, and for the rooms or buildings containing such equipments. Large values are frequently concentrated in such power and transformer houses, so that there is a chance of large loss from fire or water. The modern manufacturing plant is equipped with electrical drive and the older plants as fast as practicable are being similarly equipped. Nearly all are now lighted by electricity. Owing to the dependence of these manufacturing establishments on the power plants for their production, it is essential that the power plants be so constructed and equipped that the chances of interruption of electric service owing to short circuit or fire be eliminated as far as possible. If an accident occurs there is often delay in repairing or replacing damaged electrical machinery, which may easily result in a greater loss than the amount of damage to the machinery itself, due to the stoppage of motors or lights which depend directly on the power station. It is therefore of the greatest importance that these centres of power be made as fireproof as possible.

It is not intended in these suggestions to include the ordinary engine room, in which a few comparatively small, low-voltage generators are installed. Such rooms should ordinarily have the usual sprinkler protection of the mill. In brief, the construction must be fireproof, or else sprinklers must be provided.

Locations. — The location of the power house will usually be fixed by convenience to water or coal supply, as in the case of the water power station shown in Fig. 1. Where step-up transformers of large capacity or for very high voltages are used, a separate transformer building, detached from the main power house, is desirable, in order to keep the high voltages and possibilities of lightning troubles absolutely out of the power house. For smaller equipments a transformer room in the power house, but with a fire wall between it and the main generator room, may be provided.

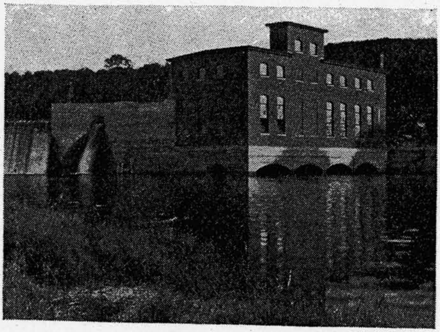


FIG. 1.
ISOLATED POWER HOUSE.

Where current from outside is transformed at the mill, it is desirable to place the transformer house outside the main building groups so that the high-voltage wires will be absolutely out of the way in case of fire. Such a transformer house would contain the necessary lightning arresters and switches, so that all current could be cut off from the buildings.

Fig. 2 well illustrates just such a building. This transformer house is located on the bank of a river opposite the mill supplied by the transformers. This house also serves as a distributing centre, for many of the motors in the mill take 2200 volts direct. The oil type circuit breakers, protecting both the high and low voltage mains, are mounted on a switchboard within the building. The 2200 volt mains and the 550 volt secondary wires which are carried across the river are plainly seen in the cut where they leave the building. The 2200 volt feeders from the power house are brought along the river bank and enter the wire tower from whence they drop to the switchboard. Lightning arresters located in the tower are connected to each of the incoming feed wires. As fire in the wooden shed back of the building could not be fought from the river side, the high-tension wires would not be in the way of the firemen even in case of fire here, so that the location of the transformer house is excellent.

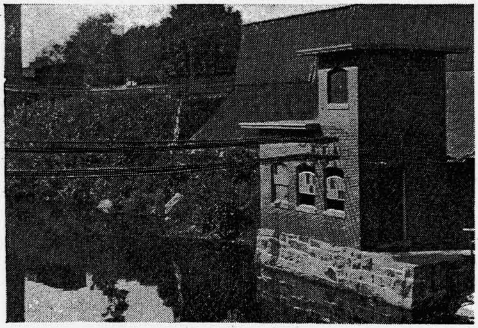


FIG. 2.
SEPARATE TRANSFORMER HOUSE.

Where there are no transformers, a small switch and lightning arrester house near the point where the wires enter the yard, and away from main buildings, is desirable for similar reasons. It is a good plan to carry the wires underground from such a transformer or switch house to the buildings, but where this cannot be done, the overhead wires should be most carefully arranged, so as not to be in the way in case of fire.

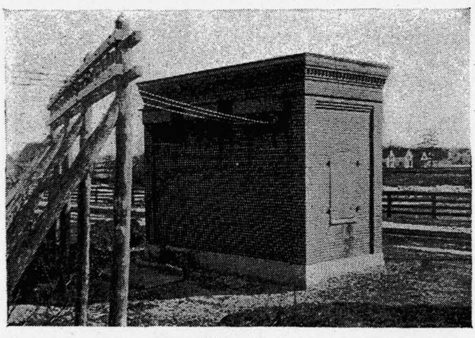


FIG. 3.
FIREPROOF LIGHTNING ARRESTER AND SWITCH HOUSE.

Fig. 3 shows a terminal house for a 13,000 volt line. This house contains only the lightning arresters and high-tension switches, and is located well away from other buildings. From this house the high-voltage wires are carried underground to the transformer house, so that the chance of accidental contact with these dangerous circuits, or their interference with firemen in the vicinity of the main buildings is reduced to a minimum. This terminal house is entirely fireproof, and the only openings are the window shown in the cut and a door in the opposite wall. Where a connection from a high-voltage transmission line must be brought into a mill yard, the above arrangement is excellent from a fire standpoint.

Construction. — Power houses and transformer and switch stations should be thoroughly fireproof. The walls should be of brick or equivalent, and should be bare on the inside, without combustible finish of any kind. Pressed or enameled brick may be used where artistic finish is desired. The floors should be fireproof, and with no wood or combustible top flooring except such small sections as may be desired around high-voltage apparatus, and any such sections should have no hollow spaces under them in which dirt might collect or a fire gain headway. For large power and transformer houses the roofs also should be entirely non-combustible. For power houses of moderate size, "1,000 K. W." or less, where the roofs are 20 or 25 feet above electrical machinery, and transformer houses having not more than, say, "200 K. V. A." capacity of oil insulated transformers in them, a solid plank and timber roof may be built, if a non-combustible roof is objectionable on account of expense or other reasons. The exposed wooden surfaces of both plank and timber of such a roof should then be fireproofed. This fireproofing may be done by covering the surfaces with metal lathing and hard plaster. Where metal lathing is not desirable, a covering of two layers of ¼ inch Sackett plaster board or equivalent laid to break joints and the whole covered with hard plaster may be used.

In general, such fireproofed roofs may be used on switch and lightning arrester houses unless these contain apparatus of considerable value, in which case an entirely fireproof building would generally be advisable.

The above points are well illustrated in Fig. 4, which shows an interior view of a power house. Attention is called to the very high roof which in this case is built of plank and timber fireproofed with expanded metal and plaster as suggested.

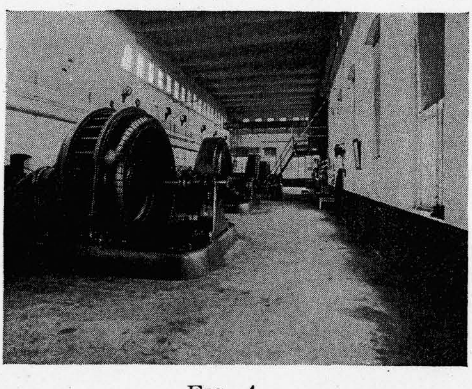


Fig. 4.
Interior of a Power House.

The objection to metal lathing in the vicinity of high-tension circuits is that in case of a short-circuit or other disturbance on these wires, the arc might follow to the metal work and in attempting to get to the ground would be liable to start other arcs at different points which might destroy the ceiling or ignite the woodwork back of the fireproofing. In such cases, therefore, the plaster board is preferable.

Underground Conduits and Wire Tunnels. — Where the distributing mains are run underground, a conduit system is believed the safest and best arrangement. A tunnel for the wires may, however, be built if preferred, but should not open directly into the power station or transformer house nor into any important building; connection into such buildings should be made by wires passing through bushings built in the walls. If necessary to enter the tunnel from a station or other building, a small doorway may be provided in the separating wall and protected with a standard automatically closing fire door.

Long wire tunnels, especially those of any considerable size, should be subdivided by brick walls about every 250 feet, the wires passing through the walls in bushings cemented in and of such sizes as to fit the wires as closely as practicable. The wires should then be built up with tape, if necessary, to entirely fill the bushings. Small doorways may be made through such walls, each opening being equipped with an automatically closing fire door.

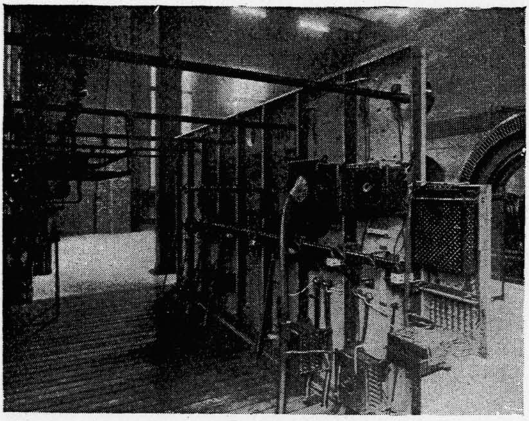


FIG. 5.
BACK OF SWITCHBOARD IN POWER HOUSE.

The subdividing walls are desirable in order to limit any trouble to a small section. Otherwise a bad short-circuit or a fire from any cause might extend the entire length, as the ordinary insulations, even where a slow-burning outer braid is used, will burn when thoroughly heated, and in such wire tunnels there are likely to be so many wires running close together that in the aggregate there would be considerable combustible material. The ordinary methods of fire-fighting would not be applicable in such cases, as access to the seat of the fire would be prevented by smoke and heat. Each section should be ventilated out of doors so as to keep the tunnel cool, and also to facilitate the escape of smoke and gases in case of accident. In tunnels, wire having a slow-burning outer insulation should always be used unless in conduit.

It is therefore evident from the fire standpoint that the conduit system is preferable, as a short-circuit or other disturbance would rarely extend beyond the point of starting, and would be much less liable to involve all of the circuits. Convenience of operation and extension, such as the withdrawal and insertion of wires and the adding of new circuits, can be readily taken care of by means of manholes at different points and the laying of a few extra ducts when the system is put in.

In conduits the wires are not subject to great changes in temperature, as often occur in tunnels, where steam pipes, water mains, etc., are often placed along with the wires.

Partitions, Offices, Supply Rooms, and General Interior Finish. — Many otherwise excellent stations and transformer houses have been rendered absolutely dangerous by the introduction of wooden sheathing, partitions, shelving, etc. Starting with the fundamental idea that the station shall be fireproof, it is essential that, in addition to non-combustible walls, floors and roofs, there should be almost nothing inside the building which can burn. Where the electrician's office is more than a simple desk and chair occupying one corner of the main room, for example, it should be cut off by fireproof partitions and protected by automatic sprinklers. The supply room should be cut off and sprinklered. Basements, although built all fireproof, almost invariably at times have more or less combustible material stored in them in the shape of supplies, packing cases, etc., so that they should generally be sprinklered. It is in fact rather better, where possible, to build stations without basements, putting the main floor directly on the ground and providing storage and office rooms in an adjacent section, cut off by a fire wall.

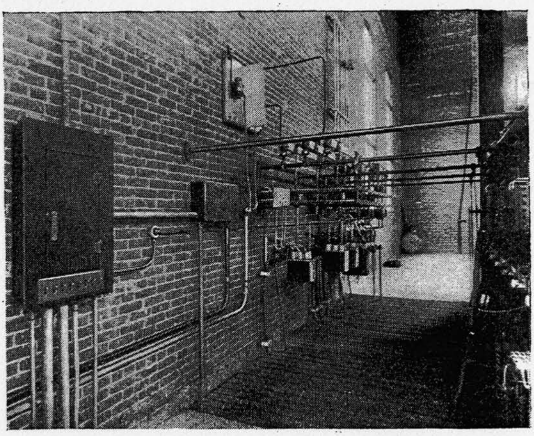


FIG. 6.
CIRCUIT BREAKERS ON WALL BACK OF SWITCHBOARD SHOWN IN FIG. 5.

Boiler rooms, where adjoining power or transformer houses, should be separated by fire walls with but few openings through them, and standard automatically closing fire doors should be provided at each opening.

Arrangement of Apparatus. — The apparatus, such as generators, switchboards, transformers, etc., should not be crowded, but should have liberal space around each piece in order to give free access to all parts for changes, repairs, etc., as well as for convenient care and manipulation.

Fig. 4, page 5, shows the interior of a hydro-electric power station, where liberal room has been left around the apparatus. Plenty of room around machinery, etc., is of great advantage when making repairs.

Figs. 5 and 6 are two views of the back of a well located switchboard. The board is mounted sufficiently far from the wall to give easy access to all the apparatus and wiring. In this instance, the oil circuit breakers have been mounted on the wall, but are operated by levers from the front of the switchboard. Due to this arrangement of apparatus, wiring, etc., the board itself is not crowded and repairs may be easily made, also there is less chance of destructive arcing occurring. The feed wires from the switchboard are shown running up the wall in Fig. 6. They leave the building through the side of the cupola, shown in Fig. 1. These wires, as well as the instrument wires on the switchboard, have a slow burning outer covering. The floor back of the switchboard consists of channel irons laid side by side so as to permit of quick removal in case it is necessary to get at the circuit breaker levers, etc., beneath.

Wiring. — All open wiring in stations, transformer and switch houses and tunnels should have non-combustible insulations or at least slow-burning outer coverings. For low-voltage equipments (550 volts and less) slow-burning insulation (see Rule 56, page 120) is satisfactory. For high voltages rubber or varnished cambric insulation is necessary, but this should have a heavy, slow-burning outer cover which will prevent flames running over the wire or the rapid combustion of the insulation.

A slow-burning covering is only suitable in dry places. If much dampness is present the covering absorbs moisture and there is liable to be a leakage of current over the surface, especially at high potentials. As the slow-burning covering is liable to be a partial conductor it should be cut away for a distance of at least 2 or 3 inches from bare live metal parts when the voltage is over 600.

Transformer Building. — Transformers, as stated, should not be located in the main power house except for comparatively small plants. The construction and fitting-up of a transformer house should follow closely the preceding suggestions for power houses. The structural steel work of the walls and roof should be protected by cement or equivalent. The main point is to have practically nothing to burn, and to have all parts of the apparatus readily accessible. The transformers should be set on brick, concrete, or stone foundations, and, where of the air blast type, all air passages should be non-combustible. Wooden wire racks and frames should be avoided.

The floors of all transformer houses except those containing but small capacity of transformers should be drained to a point where the discharge of burning oil will do no serious harm. In transformer houses containing two or more transformers of large capacity, it is also desirable to provide low concrete or brick walls from 6 to 12 inches high around each transformer, and drain each of the basins thus formed. The basins will limit the spread of burning oil.

The transformer house should be well ventilated to prevent the accumulation of explosive vapors which may be given off from the oil when hot, and to facilitate keeping the room cool, thus preventing overheating of the transformers. Good ventilation also assists in removing smoke in case of fire in the transformers, and allows men to enter and extinguish the fire, which would not be possible were there not free outlet for the smoke. Floors should also be kept clean and free from oil.

Lightning Arrester Room. — Lightning arresters should be placed either in separate fireproof rooms or outside the stations except that those of the spark gap type in small sized stations of moderate voltage may be mounted on the walls several feet distant from other apparatus. Woodwork should be avoided in the construction and mounting of choke coils.

Fire Protection. — Although the intention is to have practically nothing to burn in the buildings under discussion, experience shows that, even with the best of care, combustible material frequently gets into such places, as, for example, packing boxes and blockings, stagings, etc., used during repairs, temporary woodwork used in connection with experiments or for some other special purpose not originally contemplated, but often resulting in sufficient fuel to be dangerous. A moderate amount of protective equipment is therefore necessary for reasonable safety.

With the thoroughly fireproof construction advised, automatic sprinklers would generally not be necessary in the main generator or transformer room or in switch houses. There should, however, be a good supply of sand pails and fire extinguishers of the carbon tetrachloride type. These are for use on fires around electrical apparatus.

Carbon tetrachloride being a non-conductor, may be thrown directly on electrical apparatus without danger of shock to the operator or liability of causing short-circuit. It is especially effective in extinguishing fires in apparatus of an enclosed nature such as transformers where the resulting non-inflammable gas can be confined and the fire smothered. Water is of but little use for oil fires at transformers except to protect the surroundings.

Such fires cannot be handled at a distance, but must be fought at close range, which also emphasizes the necessity of so building and ventilating houses that they can be entered during a fire. When an air blast transformer is on fire, the damper should be immediately closed and the fan stopped; then the extinguishers or other methods can be applied.

There should also be several lengths of approved brand 1¼ inch linen hose, with ⅜ inch smooth bore nozzles. Enough lines should be provided so that a stream of water can quickly be brought to bear at any point, and two streams at any place where there may be special danger. Sprinklers should be provided in basements, supply rooms, offices, locker rooms. etc., where there is sure to be more or less burnable material. Fireproof *construction* does not prevent the *contents* of a room from burning with dangerous results.

In older stations which may have plank roofs and floors, sprinklers should usually be provided throughout, as it is better in most cases to take the risk of some added water damage than the certainty that under many conditions fire would destroy the station.

For stations of considerable value, or of great importance for the maintenance of electric current supply, one or more frostproof hydrants outside, from which streams may be obtained in case of some unexpected need, should be provided.

It is well to cover these hydrants with standard hose houses fully equipped with hose, play-pipes, etc. The capacity of such outside equipment needed will of course depend on the value and importance of the station, its construction, the probability of combustible materials ever being introduced, and the exposure in case of fire in any surrounding buildings.

There may seem little need for this heavier apparatus where the stations are all non-combustible; our whole experience, however, shows that conditions often change, that dangerous features creep in now and then, and that temporary needs often result in objectionable expedients; so that, taking it altogether, to make such a station thoroughly safe and as good a risk as the average fully equipped Mutual mill, it is necessary to have some outside equipment, though of lesser extent and capacity, on account of the fireproof construction, than would be required for a factory building of the same value.

Small hose and sprinklers must be supplied from some reliable *gravity* source, as a good public water system, a private reservoir on a near-by hill, or a liberal tank on a high trestle. The same source of supply is desirable for hydrants, although a pump could of course be used where it could be located so that it would be safe and have power even though there were a bad fire in the station. A good public fire department quickly available and with some reliable water supply would lessen and perhaps remove the need of outside equipment.

The power house shown in Fig. 1, page 3, is a good example of an isolated station needing just about such a fire protective equipment as above outlined, as the plant is not within easy reach of a public department or other outside aid. In this instance a 1000 gallon rotary fire pump driven by water-wheel has been provided in the station for supplying the yard system of a mill about 1800 feet distant through a 10 inch pipe. A 1,000,000 gallon reservoir on a hill is also connected to the system. To protect the station, a hydrant, connected to the above pipe, with hose house, hose, etc., has been provided near the station.

Important transformer stations should have substantially the same sort of protection. Small switch and lightning arrester houses, having comparatively little value, would not ordinarily need special protection other than a few sand pails and a few fire extinguishers of the carbon tetrachloride type. They should be kept absolutely free from combustibles, as a slight fire might be troublesome from interruption of service, though the actual money loss might be slight.

While the above covers the general requirements, each case usually needs some special study to get at the best results, so that it is desirable to take up this whole question of fire protection, as well as the general arrangement of the electric equipment, with the Underwriters before contracts are finally made.

STOCK ROOM.

It is strongly urged that every mill having an electric light or power plant should set aside a small room for the systematic storage of approved fittings, and should keep on hand a sufficient supply to insure that all repairs or extensions may be properly made. This will frequently prevent the use of makeshifts when fittings give out, and will be an incentive to the

FIG. 7.
STOCK ROOM FOR ELECTRICAL FITTINGS.

man in charge of the electric plant to keep everything about it in first-class condition. This room should be kept locked, and none but authorized persons should have access to it.

This is undoubtedly a large part of the secret of keeping a plant in good shape and up to date without special periods of more or less expensive overhauling.

Fig. 7 shows a section of a well arranged and well kept mill stock room for electrical supplies. This room also contains the electrician's drawing table, electrical measuring instruments, etc.

THE RULES IN BRIEF.

The following abstract of the Rules gives in concise form the general requirements for average Factory Mutual mills, and calls special attention to a number of important points frequently overlooked when laying out a plant.

Contracts.

It is advised that all contracts for electrical work contain the following clauses: —

All work shall conform strictly to the requirements given in "Rules for Electric Light and Power Equipments," issued by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies.

No fittings shall be used which are not listed in the latest edition of "Approved Electrical Fittings," issued by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies.

Generators

Generators should be located in clean, dry places, away from combustible materials; and a light location rather than a dark one is always preferable. It is not desirable to place them in the work-rooms of a plant where combustible material abounds, as in the ordinary textile mill, though they may sometimes be so located if properly cut off from the main room by a dust-tight plank partition. A location suitable for a first-class steam engine is none too good for a generator.

Motors.

The use of voltages above 550 in rooms where manufacturing processes are being carried on will be approved only when every practicable safeguard has been provided. (See Rule 8, page 33.)

Direct-current motors and alternating-current motors with brushes should be so located or enclosed, especially in dusty or linty places, that inflammable material or flyings cannot accumulate around them and become ignited by serious sparking at the brushes. Similar protection should also be provided in damp or wet places, as most electrical machinery is injured by continued exposure to moisture. In damp places induction motors of the squirrel cage type having the windings impregnated with a moisture repellent compound may be used.

Alternating-current induction motors of the type without brushes can be safely located in almost any part of a textile plant without being enclosed, being generally no more dangerous than any other piece of machinery running at the same speed.

Direct-current motors which have all of the working parts enclosed in an iron case are on the market, and these "enclosed" motors may be treated in the same way as induction motors without brushes.

Where an enclosure around the whole motor is provided, it should include the starting rheostat or auto-starter, as well as the main switch and fuses or circuit-breaker, and should, if possible, be of such a size as will permit the attendant to enter it and easily get at any part of the apparatus. It should preferably be made largely of glass, so as to keep the motor in full view of the attendants, thus promoting cleanliness and making it possible to quickly discover any derangement. (See Figs. 14 and 15, pages 36 and 37.) It should also be thoroughly ventilated, in order to prevent undue heating of the electrical machinery.

Where a motor is permitted to be used in a dusty or linty place without being enclosed, or if the enclosure provided for it is too small to include anything else, the rheostat, main switch and fuses should be placed in a dust-tight cabinet of approved construction. (See Fig. 14, page 36.) Similarly in wet places, these accessories should be protected from moisture in a cabinet or case which is thoroughly moisture-proof.

The above applies also to auto-starters and circuit-breakers unless they have tight cases. (See Figs. 11 and 13, pages 33 and 35.)

Many A. C. motors are protected by oil immersed circuit-breakers rather than fuses, and as these circuit-breaker cases, as well as the auto-starter cases, are usually made dust and moisture tight, no further enclosure is generally necessary.

Starting apparatus should be located in sight of the motor it controls so that the attendant will quickly notice anything wrong with the motor during starting and promptly open the circuit.

Switchboards.

Switchboards should be made of slate or marble, supported on metal frames, and should be located well away from combustible materials. They should always be open at the sides, and a space of at least 3 feet should be left between the ceiling and the board, in order to lessen the danger of communicating fire to the ceiling. (See Fig. 5, page 6.) They should be set out a good liberal distance from walls to provide ample space to work in and thus greatly tend to prevent accidents to workmen.

The instruments should be neatly arranged and the wiring on the back should be laid out in a careful and workmanlike manner.

It is recommended that all live parts, such as bus-bars and other conductors, be protected against accidental contact as far as practicable by suitable insulation, which shall be "flame-proof" or "slow-burning" and designed to withstand a reasonable amount of abrasion. The chances of accidental short-circuit and arcing at these points may thereby be greatly reduced. Insulated cable for bus-bars and connections is excellent for this purpose. However, the conductors could be wrapped or taped if this should be found more convenient, but this method should never be used unless it can be done *well*. Special precautions might also be necessary with either method if applied to high-voltage switchboards. (See Rule 3 *a*, page 27.)

In addition to the usual measuring instruments and other apparatus, the switchboard should contain reliable devices for testing for grounds unless the system is a permanently grounded one. The usual forms of ground detectors are described in the Appendix, page 178.

Generator Room Wiring.

Since there are generally a considerable number of wires brought close together in this room, particularly in the vicinity of the switchboard, the use of a "slow-burning" insulation is of great importance, and attention is therefore called to the paragraph on "Inside Wiring," page 15. As automatic sprinkler protection is not always advisable in generator rooms, the necessity for reducing as far as possible the chances of a fire at this point is at once evident. The desirability of fireproof construction throughout the generator room is especially emphasized in the chapter on "Power Houses," etc., page 3.

Special care should be exercised in rigidly supporting and thoroughly insulating the wires from generator to switchboard, as the main cutouts are usually on the switchboard and a short-circuit between these wires would, therefore, be likely to burn out the armature.

Outside Wires.

All outside lines should be carefully laid out through mill yards, so as not to interfere with fire streams or ladders, a definite plan being determined upon before work is commenced. Many wiremen are very careless about this matter, and if not cautioned will run the wires in the easiest way, regardless of looks or safety.

Wherever a high-voltage circuit enters the mill yard from a distant station, outside emergency switches should be so placed that in case of fire or other accident the current can be quickly and safely cut entirely out of the yard. (See Rule 24 *a*, page 71 and Figs. 29 and 30, pages 71 and 72.) Telephone or call-bell service from the mill to the power station is not usually sufficiently reliable to make these switches unnecessary. Lightning arresters should be provided on all wires which are liable to receive lightning discharges.

Fire Lights.

It is a good plan, where possible, to arrange in yards and buildings, on circuits entirely out of the way of ladders or fire streams, a few lights which may be thrown on at the time of a fire when the main lights are off, enabling firemen to move about quickly and safely.

Such lights can generally be best arranged on entirely separate circuits, and will often be useful for repair work and for lighting the help into and out of the mill, when the main lights are off. They can also be used to light the buildings for the watchmen, thus making it unnecessary for them to carry oil lanterns. These circuits may take current from a small, separate generator, driven by an independent engine or water-wheel; or from outside lines; or possibly from a storage battery, so isolated from the main buildings as not to be affected by a fire in them.

Transformers.

Where transformers are to be connected to high-voltage circuits, the Inspection Department should always be consulted before work is begun or the apparatus is purchased, as it is necessary in many cases for best protection to life and property, that the secondary system be permanently grounded, and sometimes this cannot be done unless provision is made for it when the transformers are built.

Transformers should always be located outside of buildings, unless special permission is given to put them inside. In general, it is dangerous to locate transformers with oil-filled cases inside, as it is entirely possible for a break-down of insulation to ignite the oil, which may result in a very stubborn fire. For the same reason, the placing of these transformers on roofs is also objectionable.

Even transformers which are not oil cooled may contain a considerable amount of combustible material which, if ignited, would make a hot fire, especially if the cases are ventilated as is customary with these types of transformers. Moreover a burn-out in the windings may cause dense smoke, which might easily be mistaken for a fire and cause fire streams to be thrown into the building, with a resultant water damage. They can, therefore, be permitted inside of buildings only after the circumstances have been carefully considered and the necessary safeguards provided.

Inside Wiring.

Rubber-covered wire must be used in all damp places, while rubber-covered or varnished cambric-covered wire must be used in all conduit, moulding, or concealed work, and throughout all systems on which the voltage exceeds 550.

For "open work" in dry places where the voltage is not over 550, slow-burning wire is recommended, as it fulfills every requirement for such work, is less expensive and will not carry fire. This wire has special merit for use in linty and dusty places, for lint does not readily adhere to the hard, smooth, outer surface, as is the case with wires having a weatherproof braid on the outside which in warm rooms becomes sticky. Morever what little lint may collect upon it can be easily brushed off, so that when "sweeping down" there is much less liability of breaking the insulators or badly deranging the wires.

Where of necessity a considerable number of "open wires" are brought close together, as, for example, about the ordinary distributing switchboard, the wires should have either the slow-burning insulation as just described, or if a rubber or varnished cambric insulation is necessary it should be protected by a heavy "slow-burning" outer braid.

The weatherproof, rubber and varnished cambric insulations in common use contain a large amount of inflammable material, which ignites easily and produces a fierce fire and dense smoke. It is therefore desirable to reduce, as far as possible, the amount of this inflammable material and to surround it with a tight, "slow-burning" cover to prevent rapid combustion. To still further reduce the amount of combustible material, the porcelain insulators by which the wires are held in place may be supported on an iron frame. (See Fig. 8, page 26.)

Before beginning work the circuits should be carefully mapped out and the work so planned as to secure the very simplest arrangement. The wiring should then be put up in a neat manner, and should present a thoroughly workmanlike appearance. (See Fig. 27, page 60.)

In many cases far too little attention is given to this matter while the work is in progress, the result being a general disappointment to all interested in the plant, especially to those who understand what a really first-class job of wiring looks like. This disappointment is probably felt by nobody more than by the owner, when he realizes that with reasonable care and common sense a better and undoubtedly safer equipment could have been installed at practically the same expense.

In mill work, "open" wiring securely supported on porcelain insulators is generally best on ceilings where wires are not liable to be interfered with. Mains of No. 8 B. & S. gage wire and larger are usually most conveniently carried through space from timber to timber and supported at each timber only. Smaller wires thus supported would be liable to be broken, and should therefore be wrapped around the beams or carried through them in holes bushed with porcelain, or they may be fastened to strong running-boards, well put up. The idea is to have the wires so rigidly supported on proper insulators that, even if they were bare, the insulation of the system would be perfect. All joints should be securely made and then carefully soldered and taped.

Wires should be carefully protected where liable to be deranged or injured, as in passing from story to story up side walls or columns, or near belts, or over shelves and similar places where anything is likely to be piled against them. Excellent protection can be secured by carrying them through iron conduit, first reinforcing the insulation of each wire by enclosing it in flexible insulating tubing unless the wire is approved rubber or varnished cambric covered, in which case the insulating tubing is unnecessary. Rubber-covered wire larger than No. 8 B. & S. gage should always have a double outer braid while No. 8 and smaller wires may have a single braid. An approved fitting having a separate entrance for each wire and having each such entrance equipped with a bushing of approved insulating material should be provided at each end of the conduit to prevent the wires resting on sharp edges of conducting material. On alternating-current systems, the two or more wires of the same circuit should be run in the same conduit to avoid induction effects. (See Figs. 31 and 32, pages 76 and 77.) Even on direct-current systems this arrangement is best, as then the expense and inconvenience of rewiring is avoided when it is desired to change such systems to alternating current, which frequently happens. Protection may also be obtained by strong wooden boxing, with a slanting top to keep out dirt, the holes through which the wires enter the top being bushed with short porcelain tubes. (See Fig. 31, page 76.)

The use of incandescent lamps in series on constant potential systems is not approved where the voltage of the circuit is over 250. (See note under Rule 23 *d*, page 68.)

Switches.

Knife switches should be enclosed in cabinets in all dusty or linty places or when so located that persons would be liable to come in contact with the bare live parts. Up to 250 volts and 30 amperes, approved indicating snap-switches are considered preferable for use on lighting circuits.

Cut-Outs.

Link fuses are not advised for general use about a factory, and will not be approved unless mounted on slate or marble bases made to conform to the specifications given in Rule 67, page 136, and enclosed in approved dust-tight, fireproofed cabinets. (See Fig. 33, page 78.) The ordinary porcelain link-fuse cut-outs are not permissible. Approved plug and cartridge fuses may be used almost anywhere in the ordinary manufacturing plant without the enclosing cabinet, such cabinets being necessary only in specially hazardous places (see Fig. 28, page 64), where exposed to mechanical injury, or where persons would be liable to come in contact with the bare live parts. These fuses of the enclosed type are strongly recommended for general use.

In 1903 the enclosed fuse was standardized by a special committee of the underwriters in consultation with the fuse manufacturers. (See specifications, page 140.) This was found necessary in order to secure an interchangeable fuse for any given capacity regardless of the make. This feature had previously been sadly lacking, and the result had been great inconvenience or the use of dangerous substitutes, such as fuse wire, wire nails, etc. The great advantages of an interchangeable fuse are evident, and it is urged that the National Electrical Code Standard fuse be used generally.

Rosettes.

While either fused or fuseless rosettes may be used in places which are not specially hazardous, it is advised that only those of the fuseless type be used. With fuseless rosettes the number of lamps per branch circuit should not exceed 16, or the load 660 watts, unless they are in places which are not specially hazardous when 32 lamps or 1320 watts may be put on a circuit if No. 14 wire is carried directly to keyless sockets or receptacles. (See Rule 23 *d,* page 68.) For convenience the branch cut-outs should be located over alleys or in other readily accessible places. With fused rosettes, 30 or 40 lamps could be placed on one circuit if desired, but it is better practice to have a smaller number, so that the blowing of a fuse at a branch cut-out will not extinguish so many lights.

Flexible Cord.

With the exception of wet rooms, storehouses, and especially hazardous rooms of textile mills and the like, approved plain flexible cord may be used for all pendants which hang freely in the air. If the lamp is to be moved about, so that the cord is liable to come in contact with surrounding objects, reinforced flexible cord like that described below for "Portable Lamps" should be provided.

Either the two insulated conductors which form the cord should be carefully knotted together, or else an approved device should be used in both socket and rosette, so as to prevent any strain from coming on the small binding screws in these fittings.

Portable Lamps.

In this class of work the fittings are subjected to much hard usage, and the very best possible construction is therefore necessary. Instead of the ordinary flexible cord made for pendant lamps, a special cord having an extra covering of rubber, reinforced by a tough outer braid, should be used. A list of manufacturers who can supply such cord is given in "Approved Electrical Fittings."

The cord should be connected to the wall or ceiling socket or receptacle by means of a "separable" attachment plug, which, upon being pulled, will separate and thus prevent any undue strain being put on the fittings or connections. It should also be knotted inside the socket, as explained above under "Flexible Cord." An approved metal shell socket with an outlet threaded for ⅜ inch pipe should be used, so that the whole cable may be drawn into the socket and still permit the use of a proper socket bushing.

The bulb of an incandescent lamp frequently becomes hot enough to ignite paper, cotton and similar readily ignitible materials, and in order to prevent it from coming in contact with such materials, as well as to protect it from breakage, every portable lamp should be surrounded with a substantial wire guard. Many of the lamp-guards now on the market are very flimsy and utterly worthless.

Waterproof Pendants.

For incandescent lamps in wet places, approved waterproof sockets should be used. These sockets should be suspended by separate, *stranded,* rubber-covered wires, soldered to the socket leads and also to the overhead wires. Where the pendant is over 3 feet long, the wires should be twisted together. The entire weight of the pendant should be borne by cleats or some other independent means, in order to prevent any strain on the connection to the overhead wires. (See Figs. 34 and 35, page 93.)

Especially Hazardous Places (such as Picker and Carding Rooms, Napping Rooms, Dust Chambers, Etc.)

For incandescent lamps in these more hazardous places, an excellent pendant can be secured by using approved reinforced flexible cord and a keyless socket with an outlet threaded for 3/8 inch pipe and properly bushed, as advised for "Portable Lamps" on page 18. The cord should be securely supported from the ceiling by a porcelain cleat or split knob, and the two conductors should then be separated and soldered to the overhead circuit. (See Fig. 36, page 95.) The regular "Waterproof Pendant" described above could also be used. As far as possible cut-outs should not be located in these rooms, but if this cannot be avoided they should be of the plug or cartridge type and should be enclosed in dust-tight cabinets of approved construction. (See Rule 70, page 144). If it is desired to control the lights from points in these rooms, it should be done by snap switches, which should be either enclosed in dust-tight cabinets or located where lint and flyings cannot accumulate around them.

Storehouses.

The best and safest light for storehouses is the incandescent lamp. Special care should be taken to so locate and protect the wires that the handling of storage in the building could never derange them. The pendants should be of the type advised above for "Especially Hazardous Places." The cut-outs and switches should be grouped and enclosed in dust-tight cabinets of approved construction. (See Rule 70, page 144.) Strong lamp guards should be provided, as advised for "Portable Lamps" on page 18.

Telephone, Call Bell, and Similar Circuits.

The arrangement of these wires should be as carefully planned as that of the lighting or power circuits. They should be so placed as never to be in the way of fire streams or ladders. Where possible, the signal wires about the yard should be kept entirely away from lighting or power circuits. This avoids the liability of the two systems crossing if breaks occur, and dangerous currents being conducted into buildings over wires ordinarily considered harmless.

Where the arrangement is of necessity such that crosses might occur if wires broke, protectors should be provided near the point where the signal wires enter each building. Protectors should also be provided on all foreign lines, such as public telephone or fire-alarm wires, and on all private lines which are liable to receive lightning discharges.

GENERAL PLAN

GOVERNING THE ARRANGEMENT OF RULES

CLASS A.— **GENERATORS, MOTORS, SWITCHBOARDS, ETC. Includes Electrical Equipment of Central Stations, Dynamo, Motor and Storage-Battery Rooms, Transformer Sub-Stations, etc.** Rules 1 to 11.

CLASS B.—**OUTSIDE WORK, all systems and voltages.** Rules 12 to 15.

CLASS C.— **INSIDE WORK :—**
General Rules, all systems and voltages. Rules 16 to 19.
Constant-Current Systems. Rules 20 to 22.
Constant-Potential Systems :—

General Rules, *all voltages.* Rules 23 to 25.
Low-Potential Systems, *550 volts or less.* Rules 26 to 43.
High-Potential Systems, *550 to 3500 volts.* Rules 44 to 46.
Extra-High-Potential Systems, *over 3500 volts.* Rules 47 and 48.

CLASS D.— **FITTINGS, MATERIALS, AND DETAILS OF CONSTRUCTION, all systems and voltages.** Rules 49 to 84.

CLASS E.— **MISCELLANEOUS.** Rules 85 to 89.

CLASS F.— **MARINE WORK.** Rules 90 to 99. (As the Factory Mutuals do not enter this class of work, this part of the Code is omitted from this book.)

The Rules are printed in large type, thus :—
b. Must never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings of combustible materials.

The fine-print notes belonging to the National Electrical Code are in the smaller fine type, thus :—

It is suggested that this be 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 conduits.

The explanatory notes added by the Factory Mutuals are printed in the larger of the fine types, thus :—

Charged storage batteries have in them at all times a large amount of stored energy, and should therefore be treated as carefully as generators of similar output.

GENERAL SUGGESTIONS

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

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

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

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

Architects are urged, when drawing plans and specifications, to make provision for the channeling and pocketing of buildings for electric light or power wires, and also for telephone, district messenger and other signaling system wiring.

RULES

"NATIONAL ELECTRICAL CODE."

CLASS A.

GENERATORS, MOTORS, SWITCHBOARDS, ETC.

Includes Electrical Equipment of Central Stations, Dynamo, Motor and Storage-Battery Rooms, Transformer Sub-Stations, Etc.

1. **Generators.**

a. Must be located in a dry place.

It is suggested that waterproof covers be provided, which may be used in case of emergency.

b. Must never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings of combustible materials.

Any generator, if badly designed, improperly handled, poorly cared for or overloaded, is liable to produce sparks, which may be of sufficient intensity to set fire to readily inflammable gases, dust, lint, oils and the like.

c. Must, when operating at a potential in excess of 550 volts, have their base frames permanently and effectively grounded.

Must, when operating at a potential of 550 volts or less, have their base frames permanently and effectively grounded wherever feasible. Where grounding of the frame is impracticable, special permission for its omission may be given in writing, in which case the frame must 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 must be kept filled to prevent absorption of moisture and must be kept clean and dry.

The reason for requiring a *positive* ground is to prevent a possible difference of potential existing between generator frame and near-by grounded objects, in the event of breakdown of the generator insulation, which might cause a person making contact between the two to receive a dangerous shock and also to provide a definite path for leak currents and thus prevent them from escaping at points where they might do harm. A good ground can be made by firmly attaching a wire to the generator frame and to any *main* water pipe that is thoroughly connected with underground pipes. The wire should not be smaller than No. 4 B. & S. gage and should be securely attached to the pipe by either soldering it to a brass plug screwed into a fitting, or to a heavy so-called ground clamp. While other reliable methods may be used under favorable conditions, a water pipe connected to underground pipes is the best and easiest obtainable in most Mutual Mills owing to the presence of sprinkler equipments. With direct-connected units, the engine or water-wheel would generally furnish a sufficiently good ground.

d. Constant potential generators, except alternating cur-

1. **Generators**—*Continued.*

rent machines and their exciters, must be protected from excessive current by safety fuses or equivalent devices of *approved* design.

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

For two-wire direct-current generators used in conjunction with balancer sets to obtain a neutral for three-wire systems, a protective device must be installed, which in case of the excessive unbalancing of voltages will operate to disconnect the three-wire system.

If a generator, not electrically driven, in a two-wire system has one terminal grounded, the safety device above mentioned must be placed in the grounded lead.

For three-wire direct-current generators compound or shunt wound, a safety device must be placed in each armature lead, and so connected as to receive the entire current from the armature. Fuses will not be acceptable. The safety device must consist of either: (1) a double pole, double coil, overload circuit-breaker, or (2) 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 above required must be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature from the system.

If this protection is not provided, an accidental short-circuit across the bus-bars or the exposed metal parts of the main switch on the switchboard is liable to result in considerable damage at the point where the "short" occurs or in a burned-out armature.

Owing to inherent qualities possessed by the alternating current generator it is not considered necessary to protect it, especially as an overload protective device would be liable to be opened frequently by momentary heavy synchronizing currents if the generator was operated in parallel with others. The quick opening of such a device is also liable to give rise to instantaneous high voltages on large systems. These objections to overload protective devices, however, do not apply where the generator is of relatively small size and is not run in parallel with others. It is advised that such machines be protected by circuit breakers or equivalent devices.

e. Must each 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.

The name-plate shows exactly what the machine was designed for. Such information is of great convenience, and tends to prevent overloading.

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

1. **Generators**—*Continued.*

g. The use of soft rubber bushings to protect the lead wires coming through the frames of generators 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 generator as may cause such bushings to be liable to rapid destruction. In such cases hardwood properly filled, or preferably porcelain or micanite bushings must be used.

Voltmeters and Ammeters.

A reliable voltmeter should be provided on the switchboard. On an ungrounded system it is best to have it so arranged as to show the voltage not only between the wires of opposite polarity, but also between each wire and the earth, thus serving as a very sensitive ground detector. (See Appendix, page 178.)

See also Rule 2 *e*, page 27.

It is also advised that a reliable ammeter be provided with every constant-potential generator, and that it be clearly marked to indicate the full load of the machine. This instrument indicates the amount of current given out by the generator and shows instantly if there is any undue load. It is always desirable to have all generator ammeters on a switchboard so graduated that a full scale deflection corresponds to the same degree of overload on each, so that when several machines of different sizes are running in parallel, each machine will be doing its share of the work when the ammeter pointers are in similar positions.

2. **Conductors.**—*From generators to switchboards, rheostats or other instruments, and thence to outside lines*:—

(For construction requirements, see Rules 49 to 57, pages 110 to 121.)

a. Must be in plain sight or readily accessible.

Wires from generator to switchboard may, however, be placed in a run-way in the brick or cement pier on which the generator stands. When protection against moisture is necessary, cable with grounded lead sheath or grounded conduit must be used.

As the leads between a generator and switchboard are not generally included in the protection afforded by the overload protective devices, they should be treated as especially dangerous, and extreme care should be taken that they are well supported, to avoid short circuits or grounds. They should also be carefully protected from chances of mechanical injury. It is advised that the leads be large enough to carry a 25% current overload of the generator without exceeding their safe carrying capacity as given by Rule 18, page 62. If a generator is selected which is much larger than the load to be carried, the matter of the size of the leads should be taken up with the Inspection Department.

b. Must have an *approved* insulating covering as called for by rules in Class "C" for similar work except that in central stations, on exposed circuits, the wire which is used must have a heavy braided, non-combustible outer covering.

Bus-bars may be made of bare metal.

Wires with inflammable outer braiding when brought close

2. **Conductors**—*Continued.*

together, as in the rear of switchboards, must, when required, be each surrounded with a tight, non-combustible outer cover.

Flame proofing must 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.

If the insulation on the wires were combustible, as is true of rubber or varnished cambric, a fire at this point would spread rapidly along the wires, producing intense heat and a dense smoke. Where the wires have a suitable non-combustible outer covering, and are well insulated and supported, it is believed that no appreciable fire hazard exists, even with a large group of wires.

For new installations, wire provided with the non-combustible outer covering should be obtained from the manufacturers, as such wire has a neater appearance when in place. In the case of old installations where combustible covered wire has been used, a very efficient non-combustible outer covering may be obtained by wrapping the wire with asbestos tape or strips. The thickness of

FIG. 8.
LARGE GROUP OF WIRES, WELL SUPPORTED.

this applied covering should be at least ⅛ inch. The asbestos should be dipped in silicate of soda (water glass) before being put

2. **Conductors**—*Continued.*

on the wire or else it should be well painted with the silicate after it is on the wire. After the silicate of soda has hardened it prevents the asbestos covering being easily injured if struck or rubbed.

Fig. 8, page 26, illustrates very well the need of a slow-burning outer covering on the wires where they are grouped.

It is also recommended that all live parts of the switchboard, such as bus-bars and other conductors, be protected against accidental contact as far as practicable by suitable insulation, which shall be "flame proof" or "slow-burning" and designed to withstand a reasonable amount of abrasion. The chances of accidental short-circuits may thereby be greatly reduced. Insulated cable for bus-bars and connections is excellent for this purpose. However, the conductors could be wrapped or taped if this should be found more convenient, but this method should never be used unless it can be done well. Due to the rather low insulating properties of most fireproofing compounds as used, special precautions would be necessary on high-voltage circuits to prevent current leakage over the outer fireproofed covering.

c. Must, where not in a conduit, be kept so rigidly in place that they cannot come in contact.

It is often necessary, also, to protect the wires against accidental blows from belts or from ladders, etc., in the hands of careless workmen. This may be done in about the same manner as is recommended for wires on side walls. (See Rule 26 *e,* page 76.)

d. Must in all other respects be installed with the same precautions as required by rules in Class "C" for wires carrying a current of the same volume and potential.

e. In wiring switchboards, the ground detector, voltmeter, pilot lights and potential transformers must be connected to a circuit of not less than No. 14 B. & S. gage wire that is protected by *approved* fuses, this circuit not to carry over 660 watts.

For the protection of instruments and pilot lights on switchboards, *approved* N. E. Code Standard Enclosed Fuses are preferred, but *approved* enclosed fuses of other designs of *not over 2 amperes* capacity, may be used.

3. **Switchboards.**

a. Must be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

Switchboards must not be built up to the ceiling, a space of 3 feet being left, if possible, between the ceiling and the board. The space back of the board must be kept clear of rubbish and not used for storage.

Great care in designing and locating a switchboard is necessary for several reasons: the rheostats, measuring instruments, fuses, etc., are possible sources of fire; there is a considerable number of bare live parts on the ordinary board which afford good opportunity for accidental short-circuits; and there is frequently a large amount of power available at the board to quickly follow up any trouble at this point.

3. **Switchboards**—*Continued.*

b. Must be made of non-combustible material.

The slate switchboard shown in Fig. 9, is an excellent example of a well-arranged modern board, equipped with all the necessary apparatus for controlling the output of one small generator. Attention is called to the use of enclosed fuses on this board, also the location of the ground detector lamps, which brings them near together, so that any difference in brilliancy may be readily noted. All of the wiring on the back of this board has slow-burning insulation, thus securing the slow-burning feature recommended in Rule 2 *b*, page 25. (See Rule 56, page 120.)

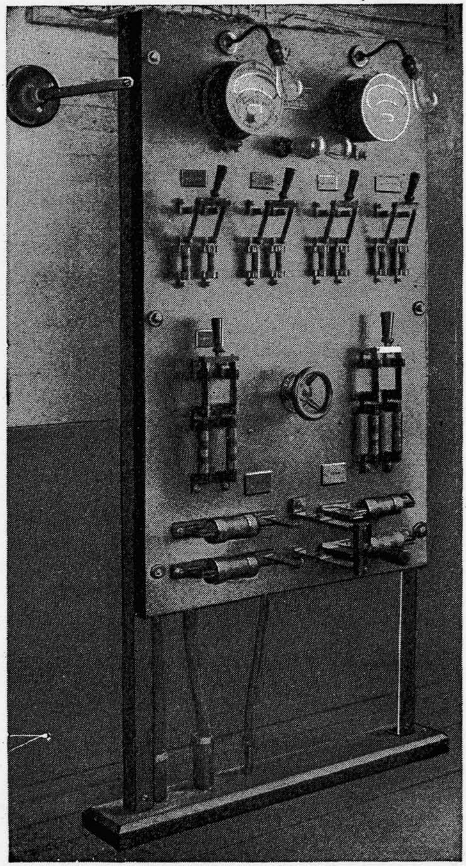


FIG. 9.
WELL-ARRANGED SLATE SWITCHBOARD.

c. Must be accessible from all sides when the connections are on the back, but may be placed against a brick or stone wall when the wiring is entirely on the face.

If the wiring is on the back, there must be a clear space of at least 18 inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall.

It is urged that the board be placed a good liberal distance from the wall, or apparatus on the wall, so as to provide ample space to work in. Where the men have plenty of room to work, not only can they do better work, but they are less liable to drop tools or otherwise cause short-circuits which may injure them or do considerable damage to apparatus and interrupt service. Figs. 5 and 6, pages 6 and 7, show good spacing between switchboard and wall.

The space back of the board should not be closed in, except by a grating or netting, as such an enclosure is almost sure to be used as a closet for clothing or for the storage of oil cans, rubbish, etc. An open space is much more likely to be kept clean and is more convenient for making repairs, examinations, etc.

d. Must be kept free from moisture.

3. **Switchboards**—*Continued.*

e. Wires with inflammable outer braiding, when brought close together, as in the rear of switchboards, must, when required, be each surrounded with a tight, non-combustible outer cover.

Flame proofing must 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.

See also notes under Rule 2 *b*, page 25.

4. **Resistance Devices.**

(*For construction requirements, see Rules 78 and 79, pages 162 and 165.*)

a. Must be placed on a switchboard, or at a distance of at least 1 foot from combustible material, or separated therefrom by a slab or panel of non-combustible, non-absorptive, insulating material such as slate, soapstone or marble, somewhat larger than the rheostat, which must be secured in position independently of the rheostat supports. Bolts for supporting the rheostat shall be countersunk at least 1/8 inch below the surface at the back of the slab and the bolt heads shall be covered with insulating material. For proper mechanical strength, slab should be of a thickness consistent with the size and weight of the rheostat, and in no case to be less than 1/2 inch.

If resistance devices are installed in rooms where dust or combustible flyings would be liable to accumulate on them, they must be equipped with dustproof face plates.

Rheostats, resistance boxes, etc., should be considered as stoves, which under some conditions may become red hot, and from which drops of heated metal may fall, or even be thrown some distance. Where exposed to dust or combustible flyings, a rheostat or resistance box should be so constructed or enclosed in an approved cabinet as to prevent the dust or fly settling on it and also to prevent sparks being thrown out if a fault develops.

b. Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided they do not carry or control the main current or constitute the regulating resistance of the device.

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

Under special authorization in writing, given in advance, incandescent lamps may be used for the purpose of resistances in series with other devices when mounted in porcelain receptacles upon non-combustible supports and so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated.

4. **Resistance Devices**—*Continued.*

c. Wherever insulated wire is used for connection between resistance elements and the contact device of a rheostat, the insulation must be non-combustible or "slow burning." For large rheostats and similar resistances, where the contact devices are not mounted upon them, the connecting wires having "slow burning" insulation may be so arranged in groups that the maximum difference of potential between any two wires in any group shall not exceed 75 volts. Each group of wires must either be mounted on non-combustible, non-absorptive insulators giving at least ½ inch separation from surface wired over, or, especially where it is necessary to protect same from mechanical injury, each group of wires may be encased in *approved* flexible tubing and placed in *approved* conduit, the flexible tubing to extend at least one inch beyond the ends of the conduit.

5. **Lightning Arresters.**

(*For construction requirements, see Rule 82, page 169.*)

a. Must be attached to each wire of every overhead circuit connected with the station.

The kind and degree of protection necessary depend largely on circumstances. A short outdoor line from one mill building to another will often require nothing, while a long overhead line through an open exposed country will generally need the most careful engineering to secure reasonable freedom from lightning disturbances.

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

b. Must be located in readily accessible places away from combustible materials, and as near as practicable to the point where the wires enter the building.

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

The arresters should be accessibly located at some point other than on the switchboard, so that they may be easily examined from time to time, and should always be isolated from combustible materials, as sparks are sometimes produced when lightning is discharged through them.

Where practicable, arresters of a type which requires oil for insulating purposes should be placed outside of the station or switchboard room. Where it is necessary to locate them inside buildings, they should be placed in separate, non-combustible, drained rooms made of brick or concrete. The entrance to such a room should be closed by a high non-combustible sill and a standard fire door. When a short-circuit occurs in such an arrester, the oil is liable to be thrown violently from the tank and ignited and therefore means should be provided for confining the fire and permitting the oil to quickly drain away. Lightning arresters which do not have oil insulation should also be placed in non-combustible buildings or rooms, but unless the rooms contain large values of arresters, switches, etc., the ceilings or roofs may be of plank and timber fireproofed in the manner described on page 5.

5. **Lightning Arresters**—*Continued.*

An arrester house would generally be an excellent place for the emergency switch, as this building would usually be located well away from the other buildings and would thoroughly protect the switch against the weather. For suggestions regarding the emergency switch see note to Rule 24 *a*, on page 71.

Kinks, coils, sharp bends, etc., may offer enormous resistance to the lightning, possibly preventing its discharge to ground through the arrester and causing it to leave the wires at some other point, where it might do considerable damage.

c. Must 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. gage copper wire, which must be run as nearly in a straight line as possible from the arresters to the ground connection.

Ground wires for lightning arresters must not be attached to gas pipes within the buildings nor be run inside of iron pipes.

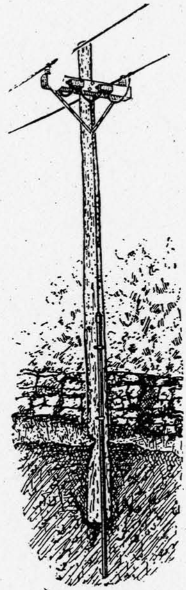


Fig. 10.
Ground Connection for Line Lightning Arrester.

Fig. 10 shows a convenient way of making a ground for a line arrester, it being assumed that there are a number of arresters distributed along the line, so that the protection of the system does not depend entirely on this one ground. In general, it is desirable to place from two to five arresters per mile, depending on the exposure and general situation of the line. In locating arresters, preference should be given to those places where earth which is always damp can be most easily and surely reached.

The ground connection shown in the cut consists of galvanized iron pipe with a nominal outside diameter of at least one inch. It should be in one piece if possible, and should be driven into the ground at least 8 feet, or even further if *permanently* damp earth is not found at that depth. If, however, it should prove impossible to drive the pipe far enough to reach earth that would surely be permanently damp, a small hole should be dug around it to a depth of 2 or 3 feet, and it should then be driven as far as possible and the hole filled with salt. The salt will be gradually dissolved by rain water and the solution will enter the earth near the pipe and improve the connection with "ground".

The pipe should extend above the ground for a distance of at least 7 feet, and the ground wire should be soldered to a brass plug screwed with considerable force into a coupling at the top of it. The wire must never be put inside the pipe, as this would tend to impede the lightning discharge. Both pipe and wire should be firmly fastened to the pole with strong staples, so as to guard against the ground connection being broken. The wire should be kept as straight as possible for the reason given in the note to Section *b*, the only bend in it being that necessary to form the drip loop.

Arresters at stations or at points where overhead lines enter manufacturing plants, should have better grounds than the one described above. Wherever an underground water main is available the arresters should be connected to it. Connection should be made to two or more lengths of pipe by soldering the ground wire to brass plugs which have been forcibly screwed into the pipe.

5. **Lightning Arresters**—*Continued.*

The ground wire should not be smaller than No. 0 B. & S. gage. Owing to its length and the fact that slight leakage occurs at some of the joints, which keeps the earth moist, an underground pipe system affords the best ground obtainable. Such a pipe system is almost always available at Mutual Mills without its being necessary to carry the ground wire more than 50 or 75 feet from the arresters.

In the few cases where an underground water-pipe system is not available, a reasonably reliable ground may be obtained by connecting the lightning arrester ground wire to several one-inch galvanized iron pipes driven into the ground until the lower ends are well below permanent moisture level. The distance between the driven pipes should be not less than 6 feet and their number should depend upon conditions such as moisture content and character of the earth, the value of the apparatus to be protected, the severity of the lightning storms, etc.

The ground wire should be of copper, and where it is embedded in the earth and liable to corrosion, it should be well coated with an asphaltum paint.

The lightning arresters should be inspected frequently, to be sure that they are in proper condition. This is especially necessary during the summer season, when lightning storms are most liable to occur. It is also of the greatest importance to maintain an excellent ground connection for the arresters, as the efficiency of the protection is absolutely dependent upon this feature. The entire ground connection should therefore be uncovered and carefully examined at least once a year, preferably in the spring, in order to know positively that the connection has not been impaired by corrosion or other accident and that the earth in the vicinity of the driven pipes is still damp, so that the equipment is in proper shape for the season's work.

d. All choke coils or other attachments, inherent to the lightning protection equipment, shall have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit in the station.

6. **Care and Attendance.**

a. A competent man must be kept on duty where generators are operating.

b. Oily waste must be kept in approved waste cans and removed daily.

7. **Testing of Insulation Resistance.**

a. All circuits except such as are permanently grounded in accordance with Rule 15, page 54, must 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 must not be attached to gas pipes within the building.

In Factory Mutual work, ground detectors of the continuously indicating type will be required on ungrounded systems for voltages below 250. For voltages above this, continuously indicating detectors which do not permanently ground the system are recommended and in some cases may be required.

The ground detectors most commonly used are fully explained and illustrated in the Appendix, page 178.

See also Rule 2 *e*, page 27.

b. Where continuously indicating detectors are not fea-

Testing of Insulation Resistance—*Continued.*

sible, the circuits should be tested at least once per day, and preferably oftener.

8. **Motors.**

a. Must, when operating at a potential in excess of 550 volts, have no exposed live metal parts, and have their base frames permanently and effectively grounded.

Must, when operating at a potential of 550 volts or less, have their base frames permanently and effectively grounded wherever feasible. Where grounding of the frame is impracticable, special permission for its omission may be given in writing, in which case the frame must 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 must be kept filled to prevent absorption of moisture and must be kept clean and dry.

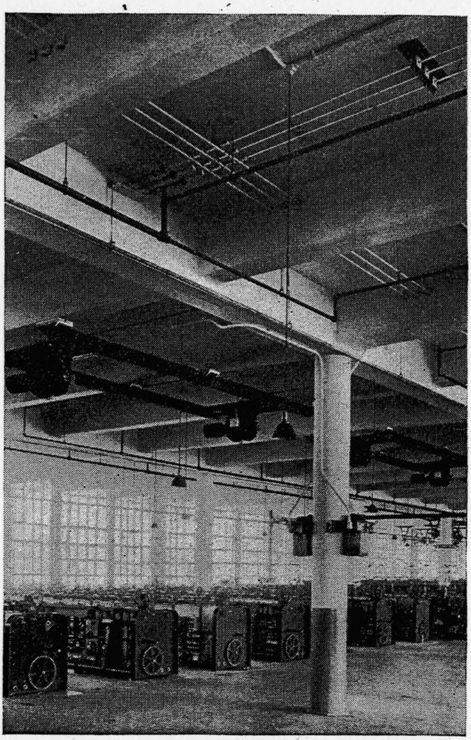


FIG. 11.
INDUCTION MOTORS ON CEILING, WITH CIRCUIT BREAKERS ON POST.

For the same reasons that similar requirements were made for generators, in the note to Rule 1 *c*, on page 23.

It is very common to suspend motors from the ceiling, as shown in Fig. 11, or to locate them on raised platforms swung from the ceiling or supported from below, as shown in Fig. 14, on page 36. Any one of these methods saves floor space and frequently prevents an accumulation of oil and dirt around the machine, besides reducing the liability of accidents to persons or machinery.

The installation of motors, circuit breakers and conduit shown in Fig. 11 is well arranged. The circuit breakers are mounted at such a height above the floor that they are protected somewhat from mechanical injury, although within reach, while the wires to circuit breakers and motors are protected by being run in conduit. By having the conduit enter the circuit breakers and the junction boxes attached to the motor frames, there are no exposed open wires.

8. **Motors**— *Continued.*

b. Motors operating at a potential of 550 volts or less must be wired with the same precautions as required by rules in Class "C" for wires carrying a current of the same volume.

Motors operating at a potential between 550 and 3,500 volts must, except in central and 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 must be completely enclosed in substantial grounded metal shields or casings and the conduit must enter and be properly secured to such casings or to suitable terminal boxes screwed or bolted to the casings.

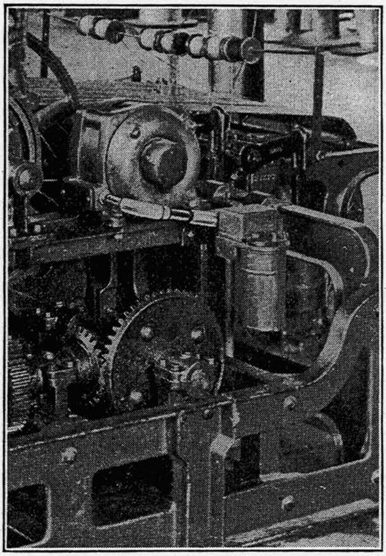


FIG. 12.
MOTOR WIRING IN IRON CONDUIT ON SIDE OF MACHINE.

The insulation of the several conductors for high potential motors, where leaving the metal sheath of cables, must be thoroughly protected from moisture and mechanical injury. This may be accomplished by means of a pot head or some equivalent method. The conduit must 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 must be obtained to install the wires for high potential motors according to the general rules for high potential systems.

Conductors carrying the current of only one motor must be designed to carry a current at least 25% 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 must 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 must be the percentage of the 30-minute current rating of the motor as given for the several classifications of service in the following table:—

8. **Motors** — *Continued.*

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.

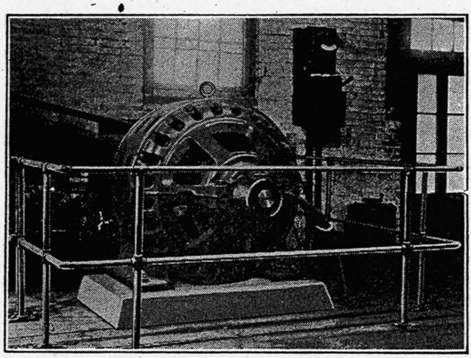


Fig. 13.
Induction Motor Surrounded by Pipe Railing.

When mounted directly on frames of machine tools, looms, etc., or set on the floor, special care should be taken to protect the leads at the motor terminals from mechanical injury. This applies to low-voltage as well as to high-voltage motors. The motors oftentimes are placed within a few feet of the floor, and the terminals are necessarily in exposed locations. Oil and dirt are also liable to injure the insulation on the wires, unless means are taken to prevent it. The wires to the motors should be run in iron conduit where exposed to injury, and the conduit should terminate preferably inside suitable junction boxes on the motor frames. If the conduit does not end in the manner mentioned, some other suitable means should be taken to afford the necessary protection to the wires. For a good example of protection of motor leads where exposed to injury see Fig. 12, page 34. In this instance the motor and its switch, which is of the oil-immersed type, are on the side of a loom frame. The protecting fuses are in an iron cabinet on the ceiling of the floor beneath. Fig. 13 shows a good method of protecting the motor leads by placing a substantial pipe railing around the motor.

c. Each motor with its starting device must be protected by a cut-out and controlled by a switch (see Rule 19 *a*, page 63), said switch plainly indicating whether "on" or "off" (except as provided for electric cranes, see Rule 43 *c*, page 105). 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 as allowed in Rule 24 *c*, page 72.

8. **Motors** — *Continued.*

The switch and rheostat must be located within sight of the motor, except in cases where special permission to locate them elsewhere is given, in writing.

Where the circuit-breaking device on the motor-starting rheostat disconnects all wires of the circuit, the switch called for in this section may be omitted.

Overload-release devices on motor-starting rheostats will not be considered to take the place of the cut-out required by this section.

An automatic circuit-breaker disconnecting all wires of the circuit may serve as both switch and cut-out.

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 without time limit device, rated in accordance with Table B of Rule 18. The rated continuous current capacity

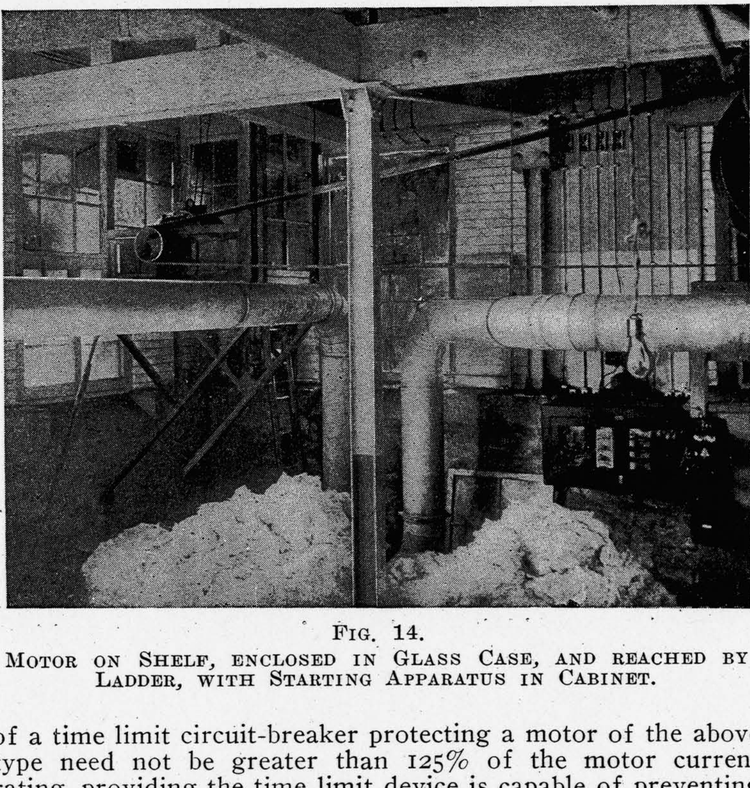


Fig. 14.
Motor on Shelf, enclosed in Glass Case, and reached by Ladder, with Starting Apparatus in Cabinet.

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 the great majority of cases where A. C. motors of the above type are started by means of auto-starters, the current-carrying capacity of

8. **Motors** — *Continued.*

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

Fig. 11, page 33, shows an automatic circuit-breaker used in this way for both switch and cut-out.

When not in use the motor should be entirely disconnected from the line by opening the controlling switch.

It is impracticable to specify definitely in these rules the size of conductor to be used with any particular size alternating-current motor of the squirrel cage type or other type requiring large start-

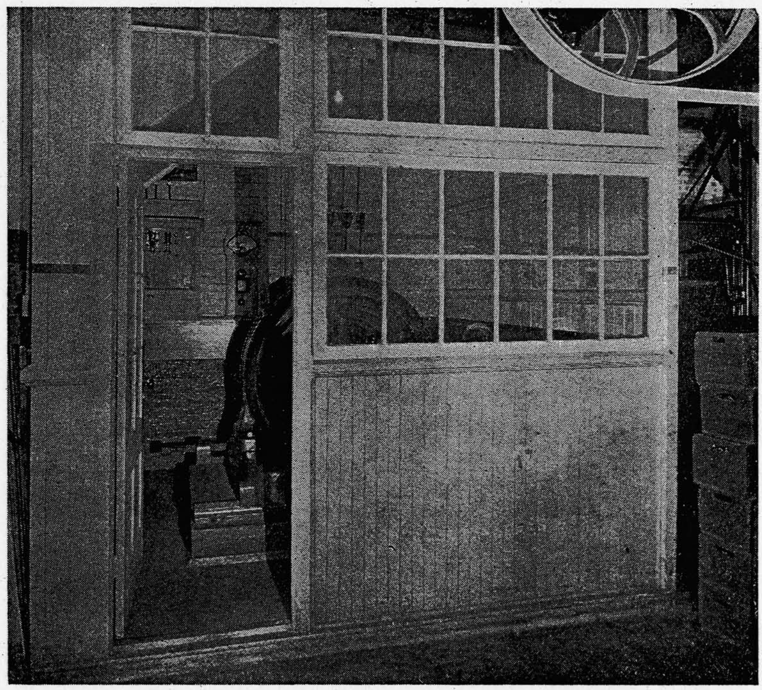


FIG. 15.
WELL-ARRANGED MOTOR ROOM.

ing current. The starting currents of such motors, even those of the same size, vary considerably and depend upon a number of factors, among which speed is one. The duration of the starting current, which depends upon the time taken to bring the motor up to speed, also has an important influence on the size of conductor necessary and the capacity of the fuse needed to properly protect it. If it is desired to use the smallest size conductor and fuse consistent with the starting current of any particular motor it is necessary to know the starting characteristics of the motor and its starting conditions. The first may be obtained from the motor manufacturer and the second from an investigation of conditions under which the motor will run. Where the trouble of obtaining this

8 **Motors** — *Continued.*

information is not taken, or where the information is difficult to obtain, the size of conductor indicated in the table and the corresponding capacity fuse may usually be depended upon to carry the starting current. In a few cases, however, where starting conditions are very severe larger sizes of wire may be necessary.

In order to cut down the size of the leads rubber-covered wire which, according to Rule 18, has a larger factor of safety than wire having a weatherproof insulation, is permitted to be protected in accordance with Table B of Rule 18. Where the motor is protected by a circuit-breaker having a time element device the breaker may be set to open at a 25% current overload of the motor, and in this case the wire, if rubber-covered, should be protected in accordance with the capacities of Table A.

d. Rheostats must be so installed as to comply with *all* the requirements of Rule 4, page 29. Auto-starters must comply with requirements of Rule 4 *c*.

Auto-starters, unless equipped with tight casings enclosing all current-carrying parts, in all wet, dusty or linty places, must 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 must be erected around them.

Iron pipe makes a neat and substantial railing for this purpose, and Fig. 13, page 35, shows an example of such an arrangement. These precautions would, of course, be unnecessary where the apparatus is included with the motor in a special motor room, such, for example, as is shown in Fig. 15, page 37.

Starting apparatus enclosed in a cabinet is shown in Fig. 14, page 36.

Guard railings should also be placed around rheostats if they are so mounted that the live parts are liable to be struck with resulting chance of short-circuit.

e. Must not be run in series-multiple or multiple-series, except on constant-potential systems, and then only by special permission.

The objection to combinations of this character is that the cutting-out of one motor, by accident or carelessness, may subject the others to a current or voltage greater than that for which they are designed; and if this occurs, and the protecting devices fail, as sometimes happens, there is very likely to be severe arcing, or a burn-out.

f. Must, if deemed necessary, be enclosed in an *approved* case.

Such enclosures must be readily accessible, dustproof 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 the enclosed type motor is recommended in dusty places, being preferable to wooden boxing.

Where deemed necessary, motors permanently located on wooden floors must be provided with suitable drip pans.

When it is necessary to locate a motor in the vicinity of combustibles or in wet or very dusty or dirty places, it is generally advisable to enclose it as above.

8. **Motors**— *Continued.*

Where the enclosure is built around the motor it should, if possible, be large enough to permit the attendant to enter it and easily get at any part of the apparatus, and this would generally mean a small room, such as is shown in Fig. 15, page 37. If the motor is suspended from the ceiling, a floor could generally be constructed below it and the four sides of this elevated motor room could be built mainly of windows. The windows lessen the chance of the motor being neglected, and allow any derangement to be at once noticed. Ready access to the room could be secured by means of a short flight of stairs or a ladder. This can also be done where the motor is supported on an elevated platform, as shown in Fig. 14, page 36.

With alternating-current motors having no brushes, the enclosure would generally be unnecessary, especially when suspended from the ceiling, as shown in Fig. 11, page 33.

Motors in exposed locations should be of such design that all live parts are protected from mechanical injury and resulting chances of short circuit or else suitable pipe rails should be placed around them. (See Figs. 12 and 13, pages 34 and 35.)

Where induction motors are so located as to be subjected to dampness and moisture it is recommended that the insulation on the conductors be impregnated with a moisture-repellant compound. Motors so treated can be obtained from the manufacturers.

g. Must, when combined with ceiling fans, be hung from insulated hooks, or else there must be an insulator interposed between the motor and its support.

h. Must each 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, except those used for railway service, must be marked with the maximum current which they can safely carry for 30 minutes, starting cold.

For the same reasons as given in the note to Rule 1 *e*, page 24.

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

j. Adjustable speed motors, unless of special and appropriate design, if controlled by means of field regulation, must be so arranged and connected that they cannot be started under weakened field.

k. 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 must be used.

9. **Railway Power Plants.**

a. Each feed wire before it leaves the power plant must be protected by an *approved* automatic circuit-breaker or other device, which will immediately cut off the current in case of

9. **Railway Power Plants**— *Continued.*

an accidental ground. This device must be mounted on a fireproof base and in full view and reach of the attendant.

An automatic circuit-breaker is preferable to a fuse, principally because it can be more quickly and safely reset.

10. **Storage or Primary Batteries.**

a. When current for light and power is taken from primary or secondary batteries, the same general regulations must be observed as apply to similar apparatus fed from generators developing the same difference of potential.

Charged storage batteries have in them at all times a large amount of stored energy, and should therefore be treated as carefully as generators of similar output.

b. Storage battery rooms must be thoroughly ventilated.

The action of the current in charging the battery liberates at times large quantities of hydrogen and oxygen, and if these should accumulate in the right proportions they would form an explosive mixture which might be exploded by any accidental spark.

c. Special attention is directed to the rules for wiring in rooms where acid fumes exist. (See Rule 26 *i* and *j*, page 79.)

d. All secondary batteries must be mounted on non-absorptive, non-combustible insulators, such as glass or thoroughly vitrified and glazed porcelain.

Special care should be taken to insulate the various cells from ground to prevent leakage and possible gradual damage to the plates. The acid fumes settling on the supporting structure and insulators are liable to form a conducting film after a time, which may be troublesome unless means are taken to prevent it. Insulators of glass, porcelain or similar materials of proper design will retain their insulating properties and prevent appreciable leakage of current over the surfaces.

e. The use of any metal liable to corrosion must be avoided in cell connections of secondary batteries.

Reduction of the cross-section of the connections by corrosion would probably cause them to be burned out by the normal current of the battery, and if pieces of the corroded metal fall into the electrolyte a rapid deterioration of the plates is liable to occur.

11. **Transformers.**

(*See also Rules 14, 15, 36 and 45, pages 53, 54, 97 and 107. For construction requirements, see Rule 81, page 167.*)

a. In central or sub-stations the transformers must be so placed that smoke from the burning out of the coils or the boiling over of the oil (where oil filled cases are used) could do no harm.

If the insulation in a transformer breaks down, considerable heat is likely to be developed. This would cause a dense smoke, which might be mistaken for fire and result in water being thrown into the building, and a heavy loss thereby entailed. Moreover,

11. **Transformers**—*Continued.*

with oil-cooled transformers, especially if the cases are filled too full, the oil may become ignited and boil over, producing a very stubborn fire.

b. In central or sub-stations casings of all transformers must be permanently and effectively grounded.

The cases or frames of transformers used exclusively to supply current to switchboard instruments must be grounded unless they are installed and guarded in all respects as required for the higher voltage circuit connected to them.

It is believed advisable to ground the casings of instrument transformers in order to guard against danger from shock. It is evident that all other metal work such as switchboard frames, instrument cases, etc., which are liable to come in contact with a live circuit should also be grounded to protect against this danger.

Class B.

OUTSIDE WORK.

(Not including Wiring for Light, Power and Heat Protected by Service Cut-out and Switch. For Signaling Systems see Class E.)

All Systems and Voltages.

12. **Wires.**

a. Line wires must have an *approved* weatherproof or rubber insulating covering (see Rules 57 and 50, pages 121 and 111). 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 (see Rule 50), but from the above-mentioned support to the line, except when run in conduit, may have an approved weatherproof insulating covering (see Rule 57) 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.

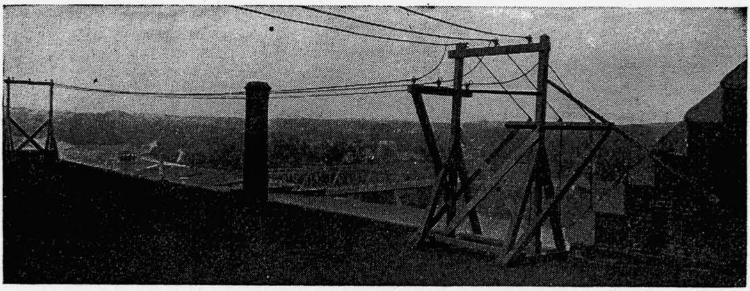


Fig. 16.
Substantial Wooden Roof Structures.

For conduit work the general rules for conduit installations must be followed and the conduit system must be waterproof.

Special care is needed to prevent a short-circuit between open wires occurring close enough to woodwork of buildings to ignite it.

12. **Wires**—*Continued.*

c. Must be at least 8 feet above the highest point of 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.

This rule is intended to insure that under no conditions could the wires sag and touch the roof; and also that persons walking on the roofs could not come into accidental contact with them.

Roof structures are frequently found which are too low or much too light for the work, or which have been carelessly put up. A stucture which is to hold the wires a proper distance above the roof in all kinds of weather must not only be of sufficient height, but must be substantially constructed of strong material.

Fig. 16, page 42, shows two good examples of durable wooden roof structures holding the wires well out of reach of persons on the roof. Fig. 17 shows a roof structure made of iron rods or pipes. This form of construction can easily be made sufficiently strong, and presents a somewhat neater appearance than the timber frame. The metal work should, of course, be kept painted to protect it against corrosion.

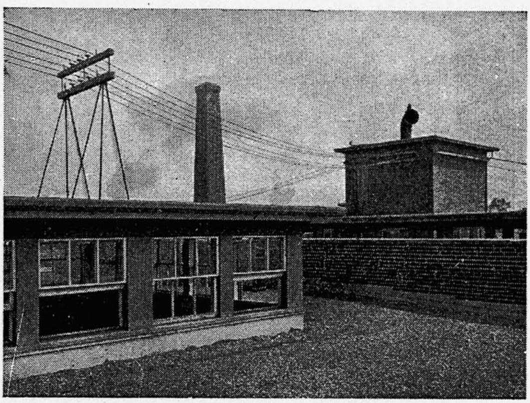


FIG. 17.
IRON PIPE ROOF STRUCTURE.

d. Must, where exposed to the weather, be provided with petticoat insulators of glass or porcelain; porcelain knobs or cleats and rubber hooks will not be approved. Wires on the exterior walls of buildings must be supported at least every 15 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 1 inch from the surface wired over, supports to be placed at least every 4½ feet.

The surface of porcelain knobs or cleats is not free from moisture during a rain, and they are, therefore, of practically no use as insulators in wet weather. A petticoat insulator, like those shown in Fig. 18, page 44, will nearly always have a dry space underneath its umbrella-like lower edge, and even if not dry, the length of the path offered to escaping current is so great that the leakage would be small.

Wires carrying over 600 volts in mill yards should be run in such a way that they will not cross lower voltage wires. If however, such a crossing is necessary, guard irons or wires should be provided, so that if one of the upper wires breaks or sags, it

12. **Wires**—*Continued.*

will not make connection with those beneath, with resulting chances of fire and danger to life.

e. Must be so spliced or joined as to be both mechanically and electrically secure without solder. 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.

An unsoldered joint is liable to become loosened or corroded, in either of which events the contact between the wires would become imperfect. This would cause heating at the joint and might result in the wire being completely melted off and a dangerous arc being formed at the break. A good mechanical joint is required for strength should the soldering give way or become corroded by traces of acid in the soldering fluid used.

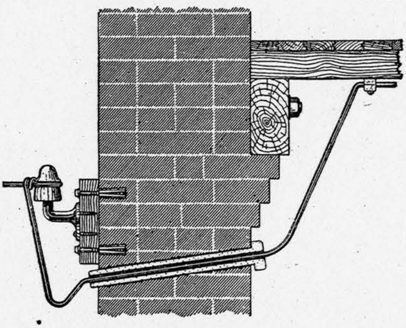


FIG. 18.
ENTRANCE BUSHING AND DRIP LOOP.

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. 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 connections 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 ex-

12. **Wires**—*Continued.*

posed 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.

The ground on the conduit system is not to be considered as a ground for the secondary system. (See Rule 15, page 54.)

Fig. 18, page 44, shows the proper arrangement of drip loop, bushing, etc., for wires entering buildings from out of doors. The insulator should be supported on a stout arm, which, for heavy wires or long spans, may need to be held in place by bolts passing entirely through the wall, rather than by expansion bolts, as shown in the sketch. With a very thick wall, the method of bushing shown in Fig. 26, page 59, could be used. In that case, however, some means should be provided to prevent the lower porcelain tube from slipping out of the iron pipe.

Fig. 19 shows the wires entering the building through iron conduit. The rubber-covered wires are spliced to the weatherproof type wires near the strain insulators as shown, and then enter a proper service head through separate holes in a porcelain plate.

It is rarely possible to insulate perfectly a conduit system throughout, and a *positive* ground is therefore required, so as first to provide a definite path for leaking currents and thus prevent them from escaping through parts of a building, etc., where they might do harm, and second to prevent any possible difference of potential occurring between conduit and near-by grounded material which might cause persons to receive dangerous shocks.

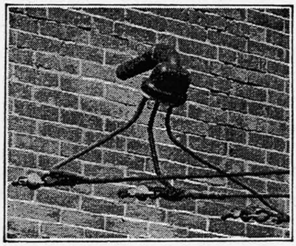


FIG. 19.
WIRES ENTERING BUILDING THROUGH CONDUIT AND SERVICE HEAD.

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 26 inches.

This distance between the two inside pins is necessary to allow a man to pass safely between the wires and reach the cross-arms above.

h. The metallic sheaths of cables must be permanently and effectively connected to "earth" approximately every 500 feet.

Any breakdown of insulation between the conductor and the sheath makes the cable practically a bare live wire, the dangerous condition of which is obvious. The ground connection required by this section keeps the sheath at the potential of the earth and prevents a dangerous flow of current from the sheath at any other point. The ground wire should be of sufficient size and so well connected to the sheath and to the earth that it can safely carry the current necessary to melt the fuses protecting the cable.

12. **Wires**—*Continued.*

Trolley Wires.

i. Must not be smaller than No. 0 B. & S. gage copper or No. 4 B. & S. gage silicon bronze, and must readily stand the strain put upon them when in use.

j. Must have a double insulation from the ground. In wooden pole construction the pole will be considered as one insulation.

k. Must be capable of being disconnected at the power plant, or of being divided into sections, so that in case of fire on the railway route, the current may be shut off from the particular section and not interfere with the work of the firemen. This rule also applies to feeders.

This requirement applies principally to street railways.

l. Must be safely protected against accidental contact where crossed by other conductors.

Where guard wires are used they must be insulated from the ground and electrically disconnected in sections of not more than 300 feet in length.

In Factory Mutual work, trolley wires must not be carried into buildings until special permission has been given and the best method of running and protecting the wires decided upon.

13. **Constant-Potential Pole Lines, over 5,000 volts.**

(Overhead lines of this class, unless properly arranged, may increase the fire loss from the following causes:—

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 carried close to buildings, hamper the work of firemen in case of fire in the building. The object of these rules is so to direct this class of construction that no increase in fire hazard will result, while at the same time care has been taken to avoid restrictions which would unreasonably impede progress in electrical development.

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, and it is advised that the Inspection Department be freely consulted as to any modification of the rules in particular cases.)

a. Every reasonable precaution must 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 in interest wherever possible.

It is evident that this is the very best way to guard against the accidental crosses above mentioned, and, therefore, it is strongly urged that every reasonable effort be made to secure the arrangement of the circuits.

b. 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

13. **Constant-Potential Pole Lines, over 5,000 volts**—*Continued.*

the high-pressure system, and which do not enter property other than that owned or occupied by such Company may be carried over the same poles.

It will be readily seen that if the taller pole should break near the ground and should fall toward the lower line, the upper line would strike the lower one unless the distance between the two lines were at least as great as the height of the taller pole.

It would be practically impossible to so arrange and guard the two sets of wires, if on the same line of poles, that all liability of contact between the wires would be absolutely avoided, and, therefore, separate pole lines, should be provided wherever possible.

An exception to this rule which must frequently be made is the case of the signaling wires of the electric company, since an additional pole line for these circuits would often be impracticable. However, it should be noted that these wires enter but comparatively few buildings, which, moreover, in most cases, are already subject to the hazard of the high-voltage current, and the owners appreciate perhaps more fully the dangers and safeguards needed under the conditions. Special precautions, however, should be taken regarding the installation and location of these wires and the instruments so that they could be burned out without setting fire to the surroundings. Danger to life when handling these telephones or instruments should also not be overlooked, but should be guarded against in every way possible, even from the fire standpoint, as accident to the attendant might prevent the prompt cutting off of current in case of trouble on the line.

c. Where such lines must necessarily be carried nearer to other pole lines than is specified in Section *b* above, or where they must necessarily be carried on the same poles with other wires, extra precautions to reduce the liability of a breakdown to a minimum must be taken, such as the use of wires of ample mechanical strength, widely spaced cross-arms, short spans, double or extra heavy cross-arms, extra heavy pins, insulators, and poles thoroughly supported. If carried on the same pole with other wires, the high-pressure wires must be carried at least 3 feet above the other wires.

This arrangement of circuits should never be adopted unless it is impossible to do otherwise. Where the two lines *must* be run on the same poles, the importance of heavy substantial line construction, as above outlined, cannot be too strongly emphasized.

With the high-pressure wires above the others, there will be far less danger to the wireman who may find it necessary frequently to work on the lower-voltage circuits. This relative location of the transmission line would also be preferable if these wires were larger than the others, as they would be less liable to break.

A separation between the high-pressure and low-pressure wires of say 5 feet would be preferable to that of 3 feet above mentioned wherever this greater distance can be secured.

d. Where such lines cross other lines, the poles of both lines must 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

13. **Constant-Potential Pole Lines, over 5,000 Volts**—*Continued.*

double-grooved, or to standard transposition insulators, and the line completed by loops.

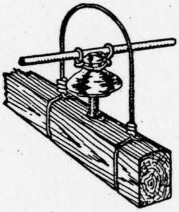


Fig. 20. End-Insulator Guard.

The object of these end-insulator guards is to prevent the line wire slipping over the end of the cross-arm, in case it becomes loosened from its supports, and falling upon the lower wires. Fig. 20 shows one form of such guard, consisting of a strong wire looped over the live wire and securely fastened to the cross-arm, the corners of which are cut to receive the wire so that it cannot be pulled off from the end of the arm or get out of place and touch the line wire. Another form of guard is shown in Fig. 23, page 50, which consists of a flat bar solidly bolted to the framework or cross-arm.

The dimensions and strength of the guards would depend on the existing conditions, such as voltage of circuit, size of line wire, whether on straight runs or at curves, etc. In any case, they should be of such design that they could resist the strain which may be put upon them at time of accident, and the upright bar form of guard should be of such length that the line wire would not be liable to jump over it. This would probably require that the bar extend at least 6 inches above the level of the wires. With the loop form, the radius should generally be at least 4 inches.

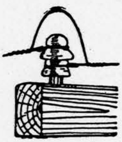


Fig. 21. Transposition Insulator.

Fig. 21 shows a transposition insulator wired as outlined in the above rule. In case the wire should break on either side of the cross-over span, this arrangement would prevent the wire from being drawn over the insulator due to the weight of the wire of the cross-over span, which otherwise might occur and result in contact with the high-pressure wires below. The insulator pins should, of course, be sufficiently strong to resist the strain from the cross-over span under the above conditions. The loop connections would generally be made with a McIntyre sleeve or equivalent.

One of the following forms of construction must then be adopted:—

1. 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.

Fig. 22, page 49, illustrates the above method of crossing of high-pressure and low-pressure wires. In the sketch, a high-voltage transmission line crosses a telephone line at a country road. In this case, unless both poles of the cross-over span are set very near the telephone line, the minimum length of the span is limited by the width of the road and the highway regulations and has been taken as 25 feet for this example. Assuming the height of the telephone line to be 20 feet, it is evident that the pole at the end of the cross-over span nearest the telephone line must be of sufficient height to raise the transmission line at least 45 feet above ground, in order that none of these upper wires, breaking at a pin on the other pole, can swing and touch the lower wires. The pole on the opposite side of the road is shown somewhat shorter, which, of course, is permissible and would still prevent contact between the two lines, even though the break should occur at a pin on the taller pole. To avoid any

13. **Constant-Potential Pole Lines, over 5,000 volts**—*Continued.*

chance of a wire in the span to the left of the cross-over span breaking and whipping back or being blown back against the lower wires, an additional pole has been shown about 25 feet from the tall pole.

Therefore, unless the tall pole should fall or its cross-arm burn

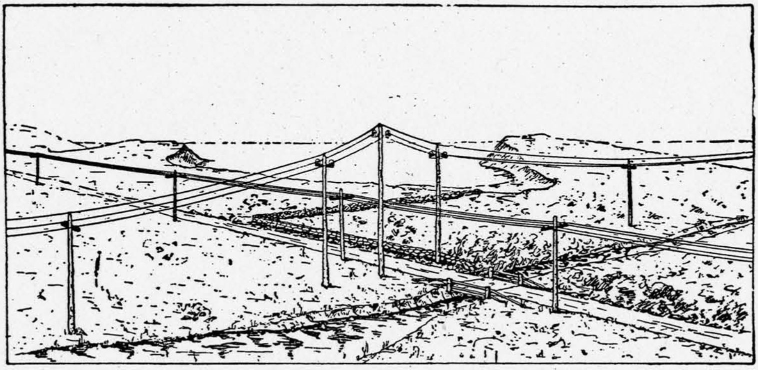


FIG. 22.
HIGH-PRESSURE LINE CROSSING OTHER LINES.

or break off, there is practically no chance of contact between the two lines. Such accidents to this pole could be largely avoided by using heavy substantial stock and carefully selected insulators, or by using iron cross-arms with iron pins thoroughly grounded, or, in fact, by making the entire pole structure of metal and grounding it. This latter construction would be stronger and probably more durable than the wooden pole, and the grounded metal work would surely prevent the burning off of the arms or pole in case of a broken insulator, etc., as the system would be immediately grounded and the transmission line shut down. The pole, whether of wood or iron, could also be guyed, if thought necessary, in order to secure greater strength. The pole should be carefully inspected sufficiently often to be sure that it is maintained in proper condition.

Care should be taken that the two poles on either side of the tall pole are not so short that when the wires are drawn tight the insulators or tie wires would be subjected to an undue upward tension. Any change in direction of these wires should be gradual, as sharp turns are almost sure to weaken the pole line. This "three-pole" cross-over, as it might be called, would of course be just as applicable where the crossing came in the open country instead of at a road.

A suggestion, somewhat in line with the construction above outlined and already briefly alluded to, has been made that the two poles of the cross-over span be set fairly near the lower line, making the span as short as practicable; then in order to protect against an upper wire breaking in either of the adjacent spans, it is suggested that a grounded metal guard be built out from each of the taller poles, just under the upper wires on the side away from the cross-over span, and so proportioned that the wire in falling would strike it before the wire could touch the lower line. By thus grounding the high-tension line, it is expected that a dangerous rise of voltage on the low-potential circuits would be prevented.

Existing conditions in any particular case will largely determine which arrangement is best or in what respects modifications are ad-

13. **Constant-Potential Pole Lines, over 5,000 volts**— *Continued.*

visable. The above suggestions, however, are given here, as they all have merit and are believed to be applicable to several different conditions which possibly may be most frequently met in practice.

Where crosses must occur, it is believed that, as a rule, the general style of crossing above outlined is preferable to that using a joint pole or interposed screen.

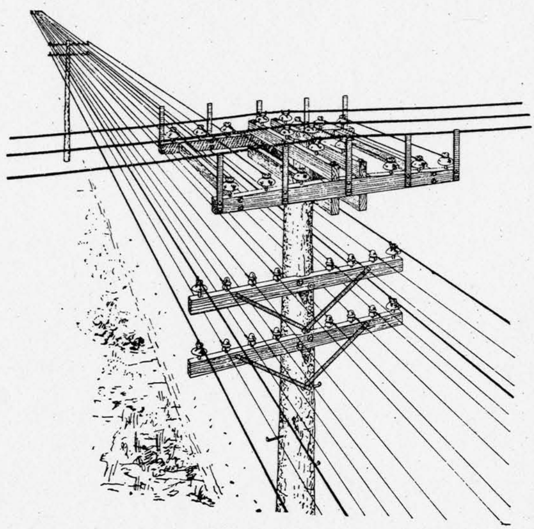


FIG. 23.
JOINT POLE CROSSING.

2. A joint pole may be erected at the crossing point, the high-pressure wires being supported on this pole at least 3 feet above the other wires. Mechanical guards or supports must 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.

Such guard wires should be supported on high-potential insulators, or should be grounded. When grounded they must 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 must 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.

A suggestion for a joint pole where a high-pressure transmission line crosses several telephone lines is illustrated in Fig. 23. The sketch shows a very strong and substantial wooden framework bolted to the top of a heavy pole and used to support the high-potential insulators for the transmission line and also those for the guard wires. The end insulator guards of flat iron bars are also bolted to this framework. The details of construction may be readily seen in the sketch. The telephone wires are shown 5 feet below the transmission line. The guard wires on the ends of the telephone cross-arms are located about 1 foot from the telephone wires and about 3 inches above them, and are carried one span on each side of the joint pole. These guard wires also are

13. **Constant-Potential Pole Lines, over 5,000 volts**—*Continued.*

supported on high-potential insulators. The upper framework is so laid out that the outer guard wires come directly over the guard wires on the lower cross-arms, so that if any of the high-tension wires break they cannot come in contact with the lower wires, for even if the free end were long enough to ordinarily reach these wires it would, with this arrangement, strike against the guard wire and thus be kept a safe distance from the telephone line. The above rule would require guard wires below the lower wires in addition to those above them, which of course can be provided, either by means of curved brackets bolted to the side of the lower cross-arm and designed to hold the insulators at the desired level, or an additional cross-arm could be provided below the others on which to support these lower guard wires. With the arrangement shown in the sketch this was not considered necessary to accomplish the desired results, and consequently it was omitted.

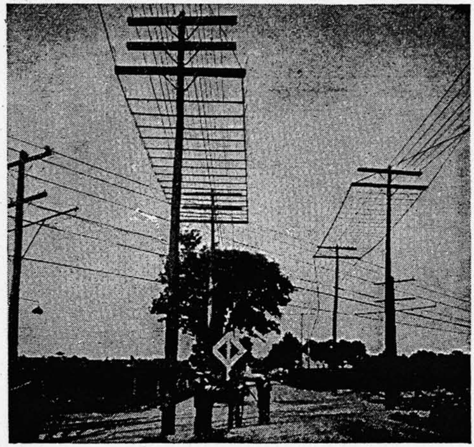


FIG. 24.
CROSSING PROTECTED BY SCREEN.

The end insulator guards extend about 6 inches above the level of the transmission line and are intended to prevent a broken wire from getting over the side of the framework where it could fall on the wires beneath.

Where it is not desired to insulate the guard wires, as above described, they should be thoroughly grounded. The high-potential insulators would not then be needed, but the precautions given in the rule regarding size of wire, protection against destruction by arcing, excellent ground connection, etc., should be taken. It has been suggested that the entire joint-pole structure be made of steel and effectively grounded. Such a pole could undoubtedly be made stronger than the wooden pole and would probably last longer. All leakage currents from the high-tension line would be carried directly to earth, and in case of a broken high-pressure insulator or wire at this point the line would be definitely grounded and the transmission line probably shut down. There would seem to be practically no chance of sufficient arcing at the pole to destroy it and allow contact between the two lines. The all-metal structure would, therefore, appear preferable to the wooden pole, from the standpoint of the protection of the low-voltage circuits against high-pressure current. However, the danger to linemen working on the low-pressure wires on this pole would be increased and any fault in the insulation of the transmission line at this point would probably mean the immediate shutting down of the plant.

Which construction is best will depend on conditions, and the objections to all of them, outside of the difficulties which may arise from mutual ownership, may lead, in the majority of cases, to the use of the independent form of cross-over, previously mentioned, in preference to the joint pole.

3. Whenever neither of the above methods is feasible,

13. **Constant-Potential Pole Lines, over 5,000 volts**— *Continued.*

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 must 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.

This method of guarding against accidental contact of the high-tension line with other lines at point of crossing, by means of a screen of wires or "cradle" placed between them, is especially applicable where the high-pressure wires are below the others, for then there is little difficulty in sufficiently insulating the screen to take care of the telephone or low-voltage circuits, or if the screen is grounded there is less liability of destructive arcing when a broken wire falls on to the screen, except possibly where the broken circuit is of very large capacity.

Fig. 24, page 51, shows two screens installed under these conditions. Here several signaling circuits cross above an electric railway and transmission line. In this case the grill is made largely of wooden strips instead of wires, but the general results are the same for an insulated screen. The cross-strips are of maple, 1 inch by 2 inches by 12 feet, spaced 12 inches on centres. They are held at the ends by suspension wires fastened to the lower cross-arms. The poles are relieved of any undue strain by extending the suspension wires on both sides of the cross-over span and firmly anchoring them to the ground as shown in the case of the screen at the right of the cut. In order to prevent a broken wire sliding off the screen at the sides, iron strips about 3-8 inch by 3-4 inch are fastened to the ends of the wooden strips and project upwards.

If a grounded screen is desired it should probably be made entirely of wire instead of part wood as in the cut.

e. When it is necessary to carry such lines near buildings, they must 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 must be carried at a height not less than that of the front cornice, and the height must be greater than that of the cornice, as the wires come nearer to the building in accordance with the following table:—

Distance of wire from building. Feet.	Elevation of wire above cornice of building. Feet.
25	0
20	2
15	4
10	6
5	8
2½	9

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

3. **Constant-Potential Pole Lines, over 5,000 volts**—*Continued.*

In order to make the intent of the above rule and its application as clear as possible, the following example is given. Fig. 25 shows in full lines a three-story building with flat roof and simple cornice overhanging about 2 feet. The poles carrying the high-pressure wires are set just inside the curbing, say 15 feet from the building. The cross-arm is 6 feet long, bringing the outside wires say 3 feet each side of the pole. Therefore, the wire nearest the building is 10 feet from the cornice, in horizontal projection. Reference to the above table will show that under these conditions the wires must be at least 6 feet above the cornice. If, now, the building had had a very steep pitched roof or especially one of the Mansard type, as shown in the dotted lines in this sketch, it will be readily seen that the above arrangement would not be satisfactory, for the wires would be very liable to interfere with fighting fire in the roof. This is a similar condition to the one referred to in the first fine-print note above. Assuming that the upper corner of the dotted roof is 5 feet back of the edge of the main cornice, this part of the roof is 15 feet from the nearest wire and consequently the wires must be raised 6 feet above their previous position in order that they may be 4 feet above the roof, as required in the above table when within 15 feet of the building, as in this case. The cut shows very clearly to what extent the dotted Mansard roof affects the height of the pole.

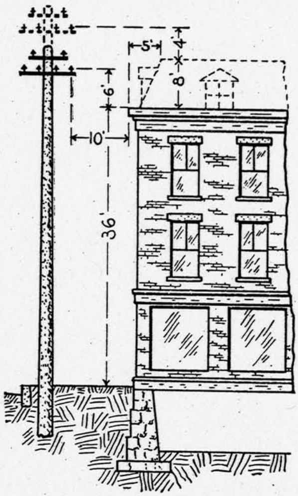


FIG. 25.
WIRES LOCATED WITH REFERENCE TO CORNICE.

14. **Transformers.**

(*See also Rules 11, 15, 36 and 45, pages 40, 54, 97 and 107. For construction requirements, see Rule 81, page 167.*)

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 built.

Where Factory Mutual mills are to take light or power from systems having a high primary voltage, the Inspection Department should always be consulted before work is begun or the apparatus purchased, so as to insure that only such apparatus is ordered as will meet the requirements of the case.

a. Must not be attached to any building when the potential exceeds 550 volts, except by special permission, and when attached to buildings must be separated therefrom by substantial supports.

The intent of this rule is to provide an air-space between the transformer and the wall. If the transformer is in direct contact with the wall, a leakage current at this point might do considerable damage by electrolysis or charring before it was discovered. Two heavy wooden cross-bars, as shown in Fig. 38, page 98, are considered sufficient for this purpose.

15. **Grounding Low-Potential Circuits.**

The grounding of low-potential circuits under the following regulations is only allowed when such circuits are so arranged that under normal conditions of service there will be no appreciable passage of current over the ground wire.

Direct-Current Three-Wire Systems.

a. Neutral wire must (except where supplied from private industrial power or lighting plants where the primary voltage does not exceed 550 volts) be grounded, and the following rules must be complied with:—

1. Must be permanently and effectively grounded at the central station. The ground connection must include all available underground complete metallic piping systems.

2. In underground systems the neutral wire must also be grounded at each distributing box through the box or on the individual service as provided in Sections *c* to *g* inclusive.

3. In overhead systems the neutral wire must be grounded every 500 feet, as provided in Sections *c* to *g*.

The grounding is necessary chiefly to prevent persons receiving dangerous shocks if a cross occurs between the low-voltage wires and some higher-voltage wires. At mills where current is generated on the premises at low voltage and there are no high-voltage wires to cross with, it is of course not necessary that the low-voltage wires be grounded. In such cases the advantage is all on the side of not grounding.

A good ground connection may be made through any *main* water pipe that is thoroughly connected to underground pipes. The wire should be securely attached to the pipe by soldering it to a brass plug screwed into a fitting, or to an approved ground clamp, or by any other equally thorough method.

The methods of grounding advised for lightning arresters on pages 31 and 32 should, in general, be followed in grounding low-potential circuits.

Alternating-Current Secondary Systems.

b. Transformer secondaries of distributing systems (except where supplied from private industrial power or lighting plants where the primary voltage does not exceed 550 volts) must 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. In either case the following rules must be complied with:—

1. The grounding must 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 must be grounded.

3. The ground connection must be at the transformers or on the individual service as provided in Sections *c* to *g*, inclusive, and when transformers feed systems with a neutral

15. **Grounding Low-Potential Circuits**—*Continued.*

wire, the neutral wire must also be grounded at least every 500 feet.

If the primary and secondary coils of a transformer come into contact electrically, the high-voltage primary current may flow to the secondary system. If this should happen, the life of any one handling any part of the secondary system would be endangered, and fires would probably be started by arcs caused by breaking down of the insulation of the wires or fittings on the secondary system. If, however, the secondary coil is grounded, a breakdown in the transformer cannot cause a dangerous difference of potential between the secondary system and the ground, and only with certain unusual combinations of contacts between the primary and secondary wires outside of the transformers will this protection fail to prevent the voltage of the secondary system from being raised above its normal limit. In order to secure the full benefit of the ground connection, reliable primary circuit breakers or fuses of proper carrying capacity must be provided.

The *middle* of the secondary coil is the proper point to ground, as there is then only half the normal secondary voltage between either side and the ground, thus reducing the liability of a breakdown of insulation and also materially lessening the danger of fire if a breakdown does occur.

There is an objection to grounding the secondary on the other hand, for when this is done, the first breakdown of insulation may mean a short-circuit and a possible fire. With a system free from grounds, a breakdown must exist on each side of the system to cause a short-circuit, and with proper ground detectors the first can generally be discovered and remedied before the second occurs.

Grounding is therefore a choice of evils, but it is believed to be a lesser one than to risk getting the primary current on the secondary system. This is especially true where the primary voltage is high, say 3500 or over. For this reason it is advised that all transformers be so designed and connected that the middle point of the secondary coil can be reached if, at any future time, it should be desired to ground it.

The ground connections should be carefully examined at least once a year to make sure that they are all in an effective condition. (See page 32.)

At mills where current is generated on the premises at low voltage and there are no high-voltage wires to cross with, it is of course not necessary that the low-voltage wires be grounded. In such cases the advantage is all on the side of not grounding.

Ground Connections.

c. When the ground connection is inside of any building, or the ground wire is inside of, or attached to any building (except central or sub-stations), the ground wire must be of copper and have an approved rubber insulating covering, National Electrical Code Standard, for from 0 to 600 volts.

d. The ground wire in direct-current 3-wire systems must 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 must never be less than No. 6 B. & S. gage.

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

These requirements for the size of the ground wire are intended to prevent the burning off of this connection, as well as to insure that it has sufficient mechanical strength to prevent its being easily broken.

15. Grounding Low-Potential Circuits—*Continued.*

e. The ground wire must, 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 straps or on porcelain knobs. Staples must never be used. The wire must be carried in as nearly a straight line as practicable, avoiding kinks, coils and sharp bends, and must be protected when exposed to mechanical injury.

This protection can be secured by use of approved conduit or moulding, and as a rule the ground wire on the outside of a building should be in conduit or moulding at all places where it is within 7 feet from the ground.

Kinks, coils, etc., are objectionable, as they impede the flow of an alternating current or a lightning discharge.

f. The ground connection for central stations, transformer sub-stations, and banks of transformers must be permanent and effective and must include all available underground piping systems including the lead sheaths of underground cables.

Methods of grounding are fully described on pages 31 and 32.

g. For individual transformers and building services, the ground connection may be made as in Section *f*, or may be made to water piping system running into the buildings.

With overhead service, 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 the service enters the cellar or basement, this connection may be made by carrying the ground wire through the cellar or basement and connecting as above.

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

Connections should not be made to piping systems which have cement joints, but should only be made to complete metallic pipe systems.

In connecting a ground wire to a piping system, the wire should be sweated into a lug attached to an 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 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 3 by 6 feet in size, with about 2 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 considerably more area might be necessary, depending upon

15. **Grounding Low-Potential Circuits**—*Continued.*

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.

Companies and Departments in charge of water works are urged to allow the attaching of ground wires to their piping systems in the full confidence that the integrity of such piping systems will not in any way be affected whatever may be the normal voltage.

Where an underground water-pipe system is not available it is advised that driven pipes be used for grounding purposes instead of buried plates. For the method of making a driven pipe ground, see notes on pages 31 and 32.

Class C.

INSIDE WORK.

(Including All Work for Light, Power and Heat Protected by Service Cut-out and Switch. For Signaling Systems, see Class E.)

All Systems and Voltages.

GENERAL RULES.

16. **Wires.**

(See also Rules 17, 18, 20, 26, 27, 44, 47 and 48, pages 61, 62, 65, 75, 83, 106, 108 and 109. For construction requirements, see Rules 49 to 57, pages 110 to 121.)

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

It has been found by experience that wires smaller than the sizes specified are not mechanically strong enough to be safely used.

b. Conductors of size No. 8 B. & S. gage or over used in connection with solid knobs must be securely tied thereto. If wires are used for tying they must have an insulation of the same type as the conductors they confine. Split knobs or cleats must be used for the support of conductors smaller than No. 8 B. & S. gage.

Knobs or cleats which are arranged to grip the wire, must be fastened by either screws or nails. If nails are used, they must be long enough to penetrate the woodwork not less than ½ the length of the knob and fully the thickness of the cleat, and must be provided with washers which will prevent under reasonable usage, injury to the knobs or cleats.

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

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

Connection by clamps, screws, etc., are not reliable where stranded wire is used. It is generally impossible to thoroughly connect all of the strands by such a method, and consequently the whole current has to be carried by a part of them, which is likely to result in their becoming dangerously hot.

See also note under Rule 12 *e*, page 44.

16. **Wires**—*Continued.*

d. Must be separated from contact with walls, floors, timbers or partitions through which they may pass by non-combustible, non-absorptive, insulating tubes, such as glass or porcelain, except at outlets where approved flexible tubing is required (see Rule 26 *u*, page 82).

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

An insulating tube or bushing should be continuous, and of sufficient length to extend beyond the face of the wall at least ¾ inch. On the other hand, it should not extend so far out as to make it liable to be broken by the strain on the wire or by the ordinary brushing down of the rooms.

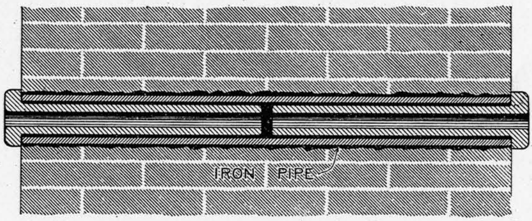


Fig. 26.
Bushing for Thick Wall.

Broken bushings should not be used, as the sharp edges will injure the insulation. Even where attempts have been made to smooth these edges, the conditions have generally been improved but little, if any. The presence of broken tubes is considered as evidence of poor workmanship.

With a very thick wall, a single tube of sufficient length may not be readily obtainable, in which case, where the wires carry direct current, the arrangement shown in Fig. 26 can be used. The iron pipe furnishes a continuous waterproof tube, and the bushings serve to insulate the wire and provide a smooth passage for it.

Where the wall is unusually thick, it is possible that two bushings would not be long enough to bush the entire length of the pipe. Under these conditions, the arrangement shown in Fig. 26 could still be used by inserting between the bushings a piece of flexible insulating tubing to protect the wire in this central space.

In all cases, the bushings should be firmly fastened in place, and the rough holes made in the wall for the tubes should be cemented up as soon as the latter are in place.

e. Where not enclosed in approved conduit, moulding or armored cable and where liable to come in contact with gas, water, or other metallic piping or other conducting material, must be separated therefrom by some continuous and firmly fixed non-conductor creating a permanent separation. Must not come nearer than 2 inches to any other electric lighting, power or signaling wire, not enclosed as above, without being permanently separated therefrom by some continuous and firmly fixed non-conductor. The non-conductor used as a separator must be in addition to the regular insulation on the

16. **Wires**—*Continued.*

wires. Where tubes are used, they must be securely fastened at the ends to prevent them from moving along the wire.

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

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 tube must be prevented from moving out of place either by a cleat or knob on each end, or by taping it securely in place.

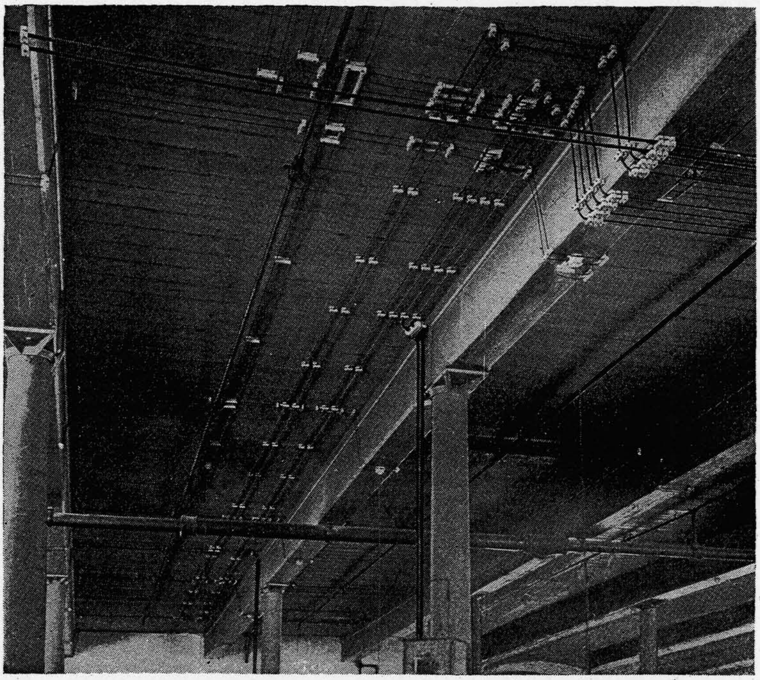


FIG. 27.
EXAMPLE OF GOOD OVERHEAD WIRING.

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.

Both of the methods described above are well illustrated in Fig. 27, which also shows the following additional good points:

1. The mains from timber to timber are very tight and well supported. By means of turnbuckles used with strain insulators, in the manner shown in Fig. 11, page 33, these wires may be kept taut.

2. Where the wires are wrapped around the timbers, the cleats on the ceiling are set off from the timbers about 3 or 4 inches, which is believed to be the best arrangement. Where these cleats are crowded into the corner, the vertical wires soon come in contact with the side of the timber, as a result of the inevitable slackening of the wires, caused by the shrinking of the wood as well as by rough usage received in "sweeping down" which in many places has to be done very often. On the other hand, if the distance between the cleat and the timber is made much greater, say 12 or

16. **Wires**—*Continued.*

even 18 inches, as has sometimes been done, the wires are too much exposed to the knocks of brooms, ladders, etc., and soon become deranged. With this arrangement any slack wire can later be readily taken up by moving the cleats a little nearer the corner, without disturbing the rest of the wiring.

3. The wires are protected in iron conduit the entire distance from floor to ceiling.

4. There is a general order and neatness evident throughout, indicating careful planning and good workmanship.

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

If the wires are below the pipes, water may drip down upon them and run along to and over the insulators, thus forming between the wires and the building a connection which would be liable, in time, to cause a short-circuit or a dangerous ground.

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

If a short-circuit should occur between open wires in an elevator shaft and the insulation on them become ignited, the fire might travel up the wires and perhaps spread to combustible material on the various floors. Even if the danger from the fire itself was small, smoke might spread through the building and cause a panic among those in it.

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

17. **Underground Conductors.**

a. Must be protected against moisture and mechanical injury where brought into a building, and all combustible material must be kept from the immediate vicinity.

There being often no safety fuses for such underground wires, a contact between wires, or between the wires and the ground, would result in serious arcing, and perhaps in even melting off the wires.

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

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

d. No underground service from a subway to a building, and no service from a private generating plant shall supply

17. **Underground Conductors**—*Continued.*

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 requirements do not apply to factory yards and factory buildings under single occupancy or management.

18. Table of Allowable Carrying Capacities of Wires.

(For construction requirements, see Rules 49 to 57, pages 110 to 121.)

a. The following table, showing the allowable carrying capacity of copper wires and cables of 98% conductivity, according to the standard adopted by the American Institute of Electrical Engineers, must be followed in placing interior conductors.

For insulated aluminum wire the safe carrying capacity is 84% of that given in the following tables for copper wire with the same kind of insulation.

B. & S. Gage.	Diameter of Solid Wire in Mils.	Table A. Rubber Insulation. Amperes.	Table B. Other Insulations. Amperes.	Circular Mils.
18	40.3	3	5	1,624
16	50.8	6	10	2,583
14	64.1	15	20	4,107
12	80.8	20	25	6,530
10	101.9	25	30	10,380
8	128.5	35	50	16,510
6	162.0	50	70	26,250
5	181.9	55	80	33,100
4	204.3	70	90	41,740
3	229.4	80	100	52,630
2	257.6	90	125	66,370
1	289.3	100	150	83,690
0	325.0	125	200	105,500
00	364.8	150	225	133.100
000	409.6	175	275	167.800
0000	460.0	225	325	211,600
Circular Mils.				
200,000		200	300	200,000
300,000		275	400	300,000
400,000		325	500	400,000
500,000		400	600	500,000
600,000		450	680	600,000
700,000		500	760	700,000
800,000		550	840	800,000
900,000		600	920	900,000
1,000,000		650	1,000	1,000,000
1,100,000		690	1,080	1,100,000
1,200,000		730	1,150	1,200,000
1,300,000		770	1,220	1,300,000
1,400,000		810	1,290	1,400,000
1,500,000		850	1,360	1,500,000
1,600,000		890	1,430	1,600,000
1,700,000		930	1,490	1,700,000
1,800,000		970	1,550	1,800,000
1,900,000		1,010	1,610	1,900,000
2,000,000		1,050	1,670	2,000,000

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

Approved varnished cambric-covered wires and cables will be permitted in Mutual Mills when installed in dry places. The insulation is considered the equivalent of rubber but will be permitted to carry the following currents.

B. & S. Gage.	Amperes.	Circular Mils.	Amperes.
6	50	400,000	450
4	80	500,000	550
3	100	600,000	630
2	120	700,000	720
1	150	800,000	780
0	175	1,000,000	900
00	200	1,200,000	1,030
000	250	1,400,000	1,150
0000	275	1,600,000	1,250
Circular Mils.			
200,000	275	1,800,000	1,320
300,000	375	2,000,000	1,400

There is a general agreement among those familiar with the effect of heat on rubber, that, if long life is desired, the temperature should not exceed 150° F.

In 1889, Dr. A. E. Kennelly made an elaborate series of careful experiments at the Edison Laboratory, to determine the temperature rise caused in wires under different conditions by currents of various strengths.

The currents given in Table A are about 60% of the currents which Dr. Kennelly found caused a rise of 75° F., or a final temperature of about 150° F., assuming 75° F. as the average indoor temperature. This margin of 40% is to allow for inevitable increase of current, such as that produced by the changing from one size lamp to those of a larger wattage, the adding of more lamps to a circuit, the overloading of a motor, etc. The currents given in Table A cause a rise of temperature of about 29° F. above the surroundings, but varying somewhat with the size of the wire. It is well to remember in this connection that the heating effect increases about as the square of the current,—*i. e.,* if the current is doubled, for instance, the heating effect increases four times.

The limiting temperature for slow-burning and weatherproof insulations is about the same as for rubber, but a smaller factor of safety is allowable, as the covering on this class of wire is not greatly depended on for insulation, this being secured by the porcelain or glass supports to which the wire is attached. The currents in Table B, therefore, were obtained by taking about 90% of the currents which Dr. Kennelly found caused the wire to reach a temperature of 150° F.,when the surrounding air was at 75° F. This allows a margin of only 10% instead of the 40 % considered necessary in Table A.

The factor of 84% for aluminum wire is safe when applied to the larger wires and cables. For No. 6 B. & S. gage wires a factor of 75% is advised. Aluminum wires smaller than No. 6 should not be used except by special permission.

It is interesting to note that, for any given size of wire, a current about three times as great as that given in Table A causes all ordinary insulations to begin to smoke.

Owing to the cooling effect of air currents, the safe carrying capacity of outdoor conductors may be several times greater than the above, without causing any dangerous rise of temperature. As the conditions will vary so widely, and as such outdoor conductors are not at all liable to cause fire, no table has been made for them.

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

a. On constant potential circuits, all service switches and all switches controlling circuits supplying current to motors or heating devices, and all fuses, unless otherwise provided (for exceptions as to switches see Rules 8 *c,* 25 *a,* and 43 *c,* pages 35, 73 and 105; for exceptions as to cut-outs see Rule

19. Switches, Cut-Outs, Circuit-Breakers, Etc.—*Continued.*

23 *a* and *b,* page 67), must be so arranged that the fuses will protect and the opening of the switch will disconnect all of the wires; that is, in the two-wire system the 2 wires, and the three-wire system the 3 wires, must be protected by the fuses and disconnected by the operation of the switch.

When installed without other automatic overload protective devices automatic overload circuit breakers must have the poles and trip coils so arranged as to afford complete protection against overloads and short-circuits. In two or three phase three-wire circuits and two-phase four-wire circuits there must be a trip-coil in each of two phases, and in four-wire three-phase circuits there must be a trip-coil in each phase. If a circuit breaker is also used in place of the switch it must 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.

b. Must, when placed where exposed to mechanical injury or in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust, or flyings of combustible material, be mounted in *approved* cut-out boxes or cabinets, except oil switches, circuit breakers and similar devices which have approved casings.

Cabinets and cut-out boxes must be of metal when used with metal conduit, armored cable or metal moulding systems.

An arc is always formed when a switch is opened while carrying current, the intensity and duration depending on the strength of the current, the design and condition of the switch and the speed with which it is operated. Combustible dust, lint or flyings are liable to be ignited by such an arc, and hence the switch should be so located or enclosed that they cannot accumulate around it. Under certain conditions, it may be necessary to use a type of switch that is operated from the outside of the enclosing cabinet or case. (See Fig. 11, page 33.)

In this instance the switch is also used as a circuit breaker. The case of the circuit breaker and method of operating levers is such that this requirement is complied with in the design of the switch or circuit breaker.

Ofttimes fuses are mounted on the ceiling. In rooms where they are exposed to combustible fly in the air or where the occupancy is such as to make these fuses hazardous if open they should be placed in approved cabinets. Fig. 28 shows an excellent example of fuse cabinets on a ceiling.

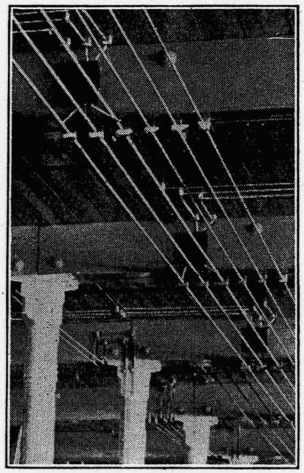


FIG. 28.
CUT-OUTS IN CABINETS ON CEILING.

Air-break circuit breakers, and link fuses, if operated by a

19. **Switches, Cut-Outs, Circuit-Breakers, Etc.**—*Continued.*

sudden heavy overload or a short-circuit on the system, make a considerable flash and often throw out hot melted metal, bits of hot carbon, etc., so that it is important to isolate them from all readily inflammable material.

c. Must, when located where exposed to moisture as in basements and similar places, be mounted in *approved* cut-out boxes or cabinets, and when located in wet places or outside of buildings must be mounted in approved "weather-proof" cut-out boxes or cabinets.

d. Time switches, sign flashers and similar appliances must be of approved design and enclosed in *approved* cabinets except sign flashers mounted as described in Rule 83 *b,* page 169.

These switches, being automatic, are liable to fail when no one is near, in which case severe arcing may result. The enclosing of the switches is therefore necessary in order to prevent as far as possible igniting surrounding combustible material, should such failure occur.

e. Must have the spacing within cabinets or cut-out boxes between the walls of the cabinet or cut-out box and current-carrying parts of devices as specified in Rule 70, page 144.

CONSTANT-CURRENT SYSTEMS.

Principally Series Arc Lighting.

Constant current systems will not be allowed inside buildings except by special permission.

Series arc lighting is seldom used as an inside system of illumination at the present day, and the systems already installed are being gradually replaced by multiple lamp systems. The greatest field for constant-current systems is street lighting. The disadvantages of the system for inside use are due to the fact that generally extra high voltages are used with consequent risk of break down of insulation and resulting danger of fire and loss of life and also due to the fact that an interruption of current causes loss of light over a considerable area.

New installations of constant current systems are advised against for Mutual Mills unless the maximum voltage obtainable on the circuit is not over 600. Where the conditions are such that higher voltages are considered necessary the matter should be taken up with the Inspection Department before work is begun.

20. **Wires.**

(*See also Rules 16, 17, 18 and 44, pages 58, 61, 62 and 106. For construction requirements, see Rules 49 and 50, pages 110 and 111.*)

a. Must have an *approved* rubber insulating covering. (See Rule 50, page 111.)

b. Must be arranged to enter and leave the building through an *approved* double-contact service switch (see Rule 65 *b,* page 130), mounted in a non-combustible case, kept free from moisture, and easy of access to police or firemen.

c. Must always be in plain sight, and never encased, except when *required* by this Department.

20. **Wires**—*Continued.*

d. Must be supported on glass or porcelain insulators, which separate the wire at least 1 inch from the surface wired over and must be kept *rigidly* at least 8 inches from each other, except within the structure of lamps, on hanger-boards or in cut-out boxes, or like places, where a less distance is necessary.

e. Must, on side walls, be protected from mechanical injury by a substantial boxing, retaining an air space of 1 inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than 7 feet from the floor. When crossing floor timbers in cellars or in rooms where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than ½ inch in thickness. Instead of the running boards, guard strips on each side of and close to the wires will be accepted.

These strips to be not less than ⅞ inch in thickness and at least as high as the insulators.

21. **Series Arc Lamps.**

(*For construction of Arc Lamp, see Rule 74, page 156.*)

a. Must be carefully isolated from inflammable material.

b. Must be provided at all times with a glass globe surrounding the arc, and securely fastened upon a closed base. Broken or cracked globes must not be used.

c. Must be provided with a wire netting (having a mesh not exceeding 1¼ inches) around the globe and an *approved* spark arrester (see Rule 75, page 157), when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks of carbon or melted copper.

Outside arc lamps must be suspended at least 8 feet above sidewalks. Inside arc lamps must be placed out of reach or suitably protected.

Arc lamps, when used in places where they are exposed to flyings of easily inflammable material, must 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, and the requirements of Sections *b* and *c* above would, of course, not apply to them.

d. Where hanger-boards (see Rule 73, page 156) are not used, lamps must be hung from insulating supports other than their conductors.

e. Lamps when arranged to be raised and lowered either for carboning or other purposes, shall 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.

22. **Incandescent Lamps in Series Circuits.**

a. Must have the conductors installed as required in Rule 20, page 65, and each lamp must be provided with an automatic cut-out.

b. Must have each lamp suspended from a hanger-board (see Rule 73, page 156), by means of rigid tube.

c. No electro-magnetic device for switches and no multiple-series or series-multiple system of lighting will be approved.

d. Must not under any circumstances be attached to gas fixtures.

CONSTANT-POTENTIAL SYSTEMS.

GENERAL RULES—ALL VOLTAGES.

23. **Automatic Cut-Outs (Fuses and Circuit-Breakers).**

(*See also Rule 19, page 63. For construction requirements, see Rules 66 and 67, pages 135 and 136.*)

a. Must 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 by Rule 24 *a,* page 71, is inside the building, the cut-out required by this section must 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 conditions the switch may be placed between the source of the supply and the cut-out.

Must not 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.

The purpose of such cut-outs is to make sure that the wires inside a building cannot be subjected to a current larger than they can safely carry. They are absolutely necessary when taking current from a public plant, as the fuses in the mains are often changed without regard to the size of the wires in the buildings.

It is important that the grounded conductor be not broken as might be the case if a fuse or circuit breaker which was connected into it operated. The opening of a fuse or circuit breaker in a permanently grounded conductor even though it interrupted a current of dangerous amount, might still leave a high voltage on wires which would be dangerous from both the standpoints of personal safety and fire.

b. Must be placed at every point where a change is made

23. Automatic Cut-Outs—*Continued.*

in the size of wire [unless the cut-out in the larger wire will protect the smaller (see Rule 18, page 62)].

Must not be placed in any permanently grounded wire, except as called for in Section *d*.

It will frequently be found necessary to provide cut-outs where taps are taken from large mains. In such cases, if the clamps on the cut-outs are not sufficiently large and strong to give a firm and secure connection, a short length of smaller wire may be soldered to the main wire and then carried direct to the cut-out, which should be located as near as possible to the point of connection with the mains. Special care should be taken to guard these leads from accident as they may not be properly protected by the fuses in the main circuit.

See also note under Section *a*.

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

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

In such places as picker and carding rooms, cloth napping and shearing rooms, wood-working shops, etc., where inflammable dust or flyings are liable to accumulate about the fuses, approved cabinets should be provided in all cases, even with fuses of the enclosed type. See Fig. 28 and note under Rule 19 *b*, page 64, and Fig. 33, page 78.

d. Must 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 receptacles, and where the location of sockets 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 lighting, 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 for attachment plugs rated at not over 660 watts each may be connected to ordinary branch circuits, and where so installed will be considered as requiring not less than 40 watts. Heating and other appliances rated not over 660 watts

23. **Automatic Cut-Outs**—*Continued.*

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 must 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, must 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 must be protected by proper fuses.

The above shall 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 theatre wiring, 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 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 rosettes not to exceed 3 amperes, and a fuse of over 25 amperes must not be used in the branch circuit.

The idea is to have a small fuse to protect the lamp socket and the small wire used for fixtures, pendants, etc. It also lessens the chance of extinguishing a large number of lights if a short circuit occurs.

In Mutual Mills 1320 watts per branch circuit can be used without special permission being given, provided the contents of the rooms in which the circuits are located are not of a hazardous nature.

In Mutual Mills the requirement that fuses or circuit breakers must not be placed in any permanently grounded wire must not be interpreted as applying to lighting branch circuits, lines to individual motors, heaters or other appliances and pieces of apparatus where electrical energy is changed in character or to some other form of energy.

Incandescent lamps in series on constant-potential systems will not be approved in Factory Mutual mills where the voltage of the circuit is over 250. Sockets, flexible cord and rosettes are not suitable for over 250 or 300 volts, so that it would not be proper to use these fittings on circuits of higher voltage than this.

If ceiling rosettes are used,—either fused or fuseless,—there must be a separate one for each pendant and they must be supported independently of the overhead wires.

e. The rated capacity of fuses must not exceed the allowable carrying capacity of the wire as given in Rule 18, page 62. Circuit breakers must not be set more than 30% above allowable carrying capacity of the wire, unless a fusible cut-out is also installed on the circuit. Where a rubber-covered

23. Automatic Cut-Outs—*Continued.*

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 without time limit device, rated in accordance with Table B of Rule 18, page 62. 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, 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 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 of No. 18 B. & S. gage, will be considered as properly protected by 10 ampere fuses.

Specifications for fuses require that they shall be rated at a certain per cent of the maximum current which they will carry indefinitely, as follows: link fuses 80% and enclosed fuses 90%. The margin thus provided between the rating of the fuse and its actual melting point will permit the ordinary fluctuations in current without opening the circuit. In addition a fuse requires a little time to heat and so does not melt with the momentary rises of current. If fuses selected to conform to the above rule are not large enough to carry the load, it is evident that the wires also are overloaded, and either the load should be diminished or the size of the wire increased.

Circuit breakers without time element devices are so sensitive that it is often necessary to set them much above the ordinary current to keep them from being constantly opened by momentary rises in the current, such as might be caused by starting a motor or by a rise in the voltage of the generator due to a sudden decrease of load. Where the circuit breaker is not equipped with a time element device it is therefore generally necessary to use a larger wire than would be necessary if the protection was afforded by fuses.

In but few exceptional cases can the arrangement of fuses in multiple show any advantage over a circuit breaker. The current which fuses in multiple will carry is uncertain and may be considerably less than the combined rated capacities of the fuses. A slight change in contact resistance may make a great change in the distribution of current between the fuses. If the fuses blow a few times the arrangement will be more expensive than a circuit breaker would be.

See notes under Rule 8 *c*, page 35.

23. **Automatic Cut-Outs**—*Continued.*

f. Each conductor of motor circuits, except on main switchboard or when otherwise subject to competent supervision, must be protected by an *approved* fuse whether automatic overload circuit breakers are installed or not. 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.

24. Switches.

(*See Rule 19, page 63. For construction of Switches, see Rule 65, page 130.*)

a. Must be placed on all service wires, either overhead or underground, in the nearest readily accessible place, to the point where the wires enter the building, and arranged to cut off the entire current. Departure from this rule may be authorized only under special permission in writing.

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

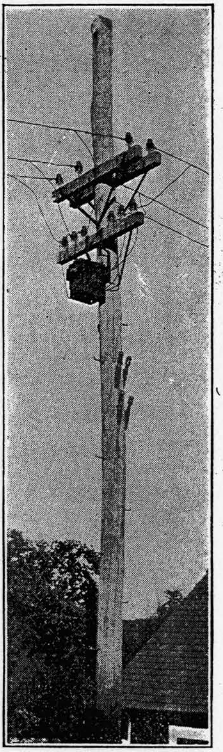


FIG. 29. OIL TYPE EMERGENCY SWITCH ON POLE.

The purpose of such switches is to make sure that current can be cut off from the inside wires for repairs, or in case of fire or other accident. They are, of course, absolutely necessary when taking current from public lines.

If there are any high-voltage wires in the mill yard, especially in the vicinity of the buildings, it might be necessary to shut off the current from these wires before any effective fire fighting could be done, in which case some means should be available for instantly disconnecting these wires from the source of power. If the power station is close at hand, arrangements could probably be made to have the circuit opened there at a moment's notice. Otherwise, an emergency switch should always be installed in each of these high-voltage wires at the point where they enter the mill yard.

24. Switches—*Continued.*

A good arrangement for such a switch, where a switch house as shown in Fig. 3, page 4, is not feasible, is illustrated in Fig. 29. The switch is of the oil immersed, weatherproof type and is designed for mounting on poles as shown. In this case access to the switch is afforded by foot spikes driven into the pole. A better arrangement would be to operate the switch by means of a rope reached from the ground, for it might be difficult to climb the pole during a dark stormy winter night when the spikes were covered with ice. The rope could be run in iron conduit on the pole and the lower end terminate in a wood box, the door of which should be arranged to be easily opened. The upper end of the conduit should be so secured that it could not come in contact with the switch case and the conduit should be thoroughly grounded by connecting to a pipe driven into the ground as shown in Fig. 10, page 31.

Another well arranged emergency switch is shown in Fig. 30. This switch which has auxiliary horn gap breaks is especially suitable on high-voltage lines. Ready means of operation is furnished by the rod running down the pole. The rod has a swiveled operating handle at the lower end. Normally the handle is kept locked in the proper position to prevent the switch being tampered with. Fig. 41, page 100, also shows a switch of this same type.

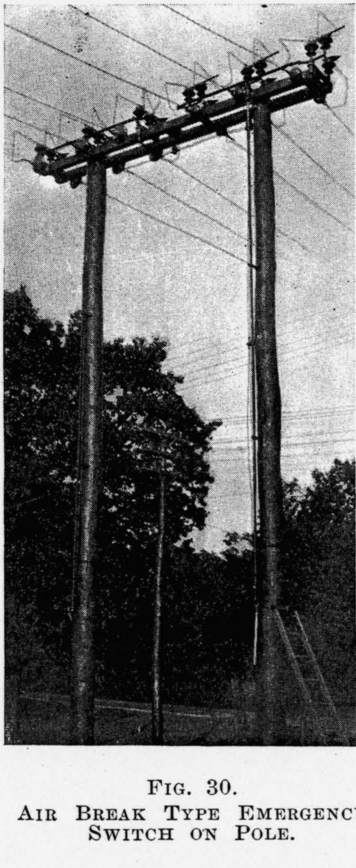


FIG. 30.
AIR BREAK TYPE EMERGENCY SWITCH ON POLE.

b. Must always be placed in dry, accessible places, and be grouped as far as possible. (See Rule 19 *c*, page 65.) Single-throw knife switches must be so placed that gravity will not tend to close them. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal as preferred, but if the throw be vertical a locking device must be provided, so constructed as to insure the blades remaining in the open position when so set.

When practicable switches must be so wired that blades will be "dead" when switch is open.

Up to 250 volts and 30 amperes, *approved* indicating snap switches are suggested in preference to knife switches on lighting circuits.

c. Single pole switches must 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

24. **Switches**—*Continued.*

system, except in the two-wire branch or tap circuit supplying not more than 660 watts.

This, of course, does not apply to the grounded circuits of Street Railway systems.

Three-way switches are considered as single pole switches.

d. Where flush switches or receptacles are used, whether with conduit systems or not, they must 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 must be enclosed in *approved* floor outlet boxes especially designed for this purpose. Departure from this rule may be authorized only under special permission in writing in cases where attachment plugs and receptacles are not subject to mechanical injury and the presence of moisture is not probable.

e. Where possible, at all switch outlets, unless outlet boxes which will give proper support for switches are used, a ⅞ inch block must be fastened between studs or floor timbers flush with the back of lathing to hold tubing, and to support switches. When this cannot be done, wooden base blocks, not less than ¾ inch in thickness, securely screwed to lathing, or *approved* fittings designed for the service, must be provided for switches.

f. Sub-bases of non-combustible, non-absorptive, insulating material, which will separate the wires at least ½ inch from the surface wired over, must be installed under all snap switches used in exposed knob and cleat work. Sub-bases must also be used in moulding work, but they may be made of hard wood or they may be omitted if the switch is approved for mounting directly on the moulding.

25. **Electric Heaters.**

It is often desirable to connect in multiple with the heaters and between the heater and the switch controlling same, an incandescent lamp of low candle power, as it shows at a glance whether or not the switch is open, and tends to prevent its being left closed through oversight.

Special care should be taken in arranging circuits for portable heaters to have switches so located that any department not in operation can have the current cut entirely out of it. Current should of course be cut off from all lines at night when work stops. A pilot lamp should be so connected to the heater circuits that it will be necessary to open the main switch in order to put out this light. A red pilot lamp would make the indication even more conspicuous, and thus emphasize the fact that current was on these circuits in case the switch, for any reason, had been left closed.

a. Each heater of more than six (6) amperes or 660 watts capacity must be protected by a cut-out, and controlled by a switch or plug connector plainly indicating whether "on" or

25. **Electric Heaters**—*Continued.*

"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.

Electric heaters should not be located in dusty or linty places, and practically the same precautions should be taken as required for resistance boxes (See Rule 4 *a*, page 29), especially for stationary heaters, unless the heaters are so designed that these precautions are unnecessary for desired safety.

b. Flexible conductors for smoothing irons and sad irons, and for all devices requiring over 250 watts, must have an *approved* insulation and covering complying with the requirements of Rule 51 *k,* page 117.

c. With portable heating devices, *approved* plug connectors must 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.

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

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

Devices of this description will often require a suitable heat-resisting material placed between the device and its surroundings. Such protection may best be secured by installing two or more plates of tin or sheet steel with a 1-inch air space between or by alternate layers of sheet steel and asbestos with a similar air space.

f. Must each 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.

550 VOLTS OR LESS.

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, shall be considered *as a low-potential circuit, and as coming under this class. The primary circuit not to exceed a potential of 3,500 volts, unless the primary wires are installed in accordance with the requirements as given in Rule 13, page 46, 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.*

Before pressure is raised above 300 volts on any previously existing system of wiring, the whole must be strictly brought up to all of the requirements of the rules at date.

26. **Wires.**

GENERAL RULES.

(See also Rules 16, 17, 18, 20 and 27, pages 58, 61, 62, 65 and 83. For construction requirements, see Rules 49 to 57, pages 110 to 121.)

a. When entering cabinets, cut-out boxes or junction boxes, except where they are in conduit, armored cable or metal moulding, they must 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 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.

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

Fresh plaster and cements may be either alkaline or acid, and until finally set have a corrosive action on the insulating materials of the wires. The amount of such alkaline or acid action is not only often sufficient to destroy the insulation, but will sometimes even injure the wire itself.

A staple driven over a wire will almost always cut through the insulation or even break the wire itself, and this may result in an arc which would develop heat enough to set fire to the insulation.

c. Must not be fished for any great distance, and only in places where the inspector can satisfy himself that the rules have been complied with.

It is desirable to do as little fishing as possible, as the condition of the fished wires is always somewhat uncertain.

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

A twin or multiple conductor wire or cable is made up by placing separately insulated wires under the same insulating covering. It is unsafe for light or power work, with open cleat construction, on account of the short distance between the conductors, and the readiness with which an arc starting at one end will follow along the wire or cable.

26. Wires—*Continued.*

Twin or multiple conductor wire or cable may be used in conduit work with reasonable safety, however, since the liability of mechanical injury to the wire or cable is there so small that the chance of starting an arc between conductors is greatly reduced. Moreover, the conduit gives some added protection to the surroundings against the heat of an arc, in case one should occur.

e. Must where exposed to mechanical injury be suitably protected. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires must be installed in *approved* conduit or armored cable or be attached by their insulating supports to the under side of a wooden strip, not less than ½ inch in thickness, and not less than 3 inches in width. Instead of the running boards, guard strips on each side of and close to the wires will be accepted. These strips to be not less than ⅞ inch in thickness and at least as high as the insulators.

Protection on side walls must extend not less than 7 feet from the floor and must consist of substantial boxing, retaining an air space of 1 inch around the conductors, closed at the top (the wires passing through bushed holes) or *approved* metal conduit or pipe of equivalent strength.

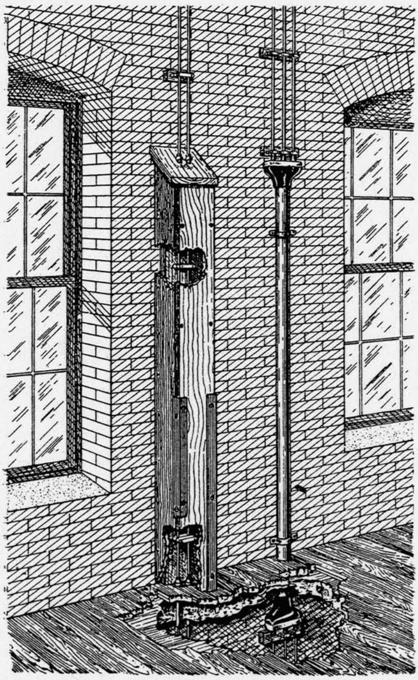


FIG. 31.
PROTECTION FOR WIRES ON SIDE WALLS.

When metal conduit or pipe is used, the insulation of each wire must be reinforced by *approved* flexible tubing extending from the insulator next below the pipe to the one next above it, unless the conduit is installed according to Rule 28, page 85 (Section *c* and *f* excepted), and the wire is approved for conduit use (see Rule 53, page 119). The two or more wires of a circuit *each* with its flexible tubing (when required), if carrying alternating current *must*, or if direct current, *may* be placed within the same pipe.

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.

26. **Wires**—*Continued.*

Fig. 31 shows both the wooden boxing and metal pipe protection. In the cut the boxing has been broken away to show the backing board on which the insulators should be mounted. This board should first be fastened to the wall, and the boxing then built around the wires as outlined in the above note. Good heavy stock should be used, as these boxes are generally subjected to considerable hard usage. Where the boxing is especially liable to knocks from trucks and the like, heavy angle irons should be securely fastened to the corners as shown. The floor bushings should have long heads, to surely prevent wash water from reaching the wires, and the bushings in the top should be short, say 1½ inches, to prevent breaking. A considerable slant should be given the top to prevent its use as a shelf, and to better shed dust, etc.

If there is any liability of storage or other materials being piled in the vicinity of these wires the protecting boxing or piping should be carried higher than 7 feet, so as to surely guard the wires from injury.

Although the cut illustrates a three-wire system with slow-burning type wire protected by the flexible tubing and iron conduit, the method is, of course, entirely applicable to any system. This arrangement is excellent for several reasons: —

1. It takes but little room, and is, therefore, much less in the way than wooden boxing.

2. It is mechanically very strong, giving ample protection to the wire against hard knocks, etc.

3. It provides an excellent floor bushing, which is readily made and is not easily broken.

4. The amount of combustible material at this point is considerably reduced.

5. Each wire passes through a bushing of insulating material and is separated from the other conductors where it passes out of the conduit, thus greatly reducing the chance of short circuit at this point.

Where approved rubber or varnished cambric wires are used in approved conduit the reinforcing insulating tubing will not be required.

Fig. 32 is a good illustration of iron conduit protection carried directly to the ceiling. The arrangement makes a neat appearance and the wires are not liable to be disarranged.

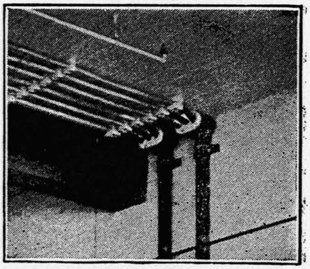


FIG. 32.
FITTINGS HAVING SEPARATE WIRE HOLES AT ENDS OF PROTECTING PIPES.

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

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

SPECIAL RULES.

For Open Work.

In Dry Places:—

g. Must have an *approved* rubber (Type Letters R. S. for wires smaller than No. 6 B. & S. gage and Type Letters R. D.

26. **Wires**—*Continued.*

for wires No. 6 and larger), slow-burning weatherproof (Type Letters S. B.·W.), or slow-burning insulation (Type Letters S. B.).

A slow-burning covering, that is, one that will not carry fire, is considered good enough where the wires are entirely on insulating supports. Its main object is to prevent the copper conductors from coming accidentally into contact with each other or anything else.

The slow-burning wire has special merit in linty and dusty places, for flyings will not readily adhere to the hard, smooth, dry outer surface. The result is that the "sweeping down" process is much less severe on the wiring, which can therefore be kept in better condition. Another good point is that fire will not run rapidly along the wires, even when grouped. (See note to Rule 2 *b*, page 25.) The wire can also be more readily drawn into flexible tubing where the iron pipe described in Section *e* is used.

Fig. 11, page 33, shows some neatly arranged slow-burning wires on the ceiling of a concrete cotton mill. The mains pass through porcelain tubes in the beams and are thus carried near the ceiling out of harm's way. At every second or third beam porcelain cleats bearing against the ends of the tubes are secured to the wires to so hold the wires that they will not be drawn through the beams if any slack occurs. A set of strain insulators is shown at the end of a run, with turnbuckles to take up slack.

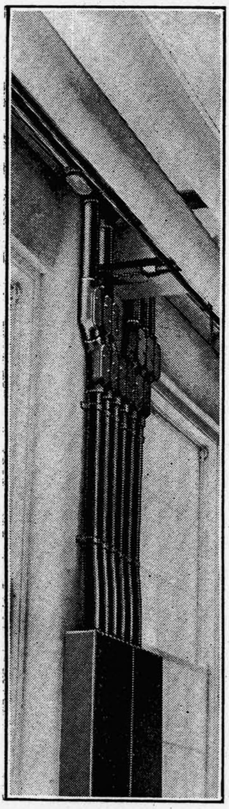


Fig. 33.
Cabinet Wiring Protected by Iron Conduit.

h. Must 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 4½ feet. If the wires are liable to be disturbed, the distance between supports must be shortened. In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about 6 inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

Must not be "dead-ended" at a rosette, socket or receptacle unless the last support is within 12 inches of the same.

The whole idea is to so rigidly secure the wires that they cannot come in contact with each other or any other conductors, if loosened

26. **Wires.**—*Continued.*

by shrinkage of timbers and floors or by being carelessly struck. See Fig. 27, page 60, for illustration of good wiring for buildings of mill construction.

In damp places or buildings especially subject to moisture or to acid or other fumes liable to injure the wires or their insulation:—

i. Must have an *approved* insulating covering.

For protection against water, rubber insulation must be used. For protection against corrosive vapors, either weatherproof or rubber insulation must be used.

j. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least 1 inch from the surface wired over, and must be kept apart at least 2½ inches for voltages up to 300, and 4 inches for higher voltages.

Rigid supporting requires under ordinary conditions, where wiring over flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed, the distance between supports must be shortened. In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about 6 inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

For Moulding Work (Wooden and Metal).

(*See Rule 29, page 89. For construction of Mouldings, see Rule 60, page 125.*)

k. Must have an *approved* rubber insulating covering (Type Letters R. S. for wires smaller than No. 6 B. &. S. gage and Type Letters R. D. for wires No. 6 and larger. See Rule 50, page 111), and must be in continuous lengths from outlet to outlet, or from fitting to fitting, no joints or taps to be made in moulding. Where branch taps are necessary in moulding work *approved* fittings for this purpose must be used.

The absence of the porcelain insulators required for open work, and the close proximity into which the wires are brought, make it necessary to have the best of insulation on them.

Single braided wire is considered good enough because the wire is simply laid in the moulding and therefore is not liable to have the outer covering injured.

The small amount of available space in moulding or conduit makes it very difficult to provide a satisfactory insulating covering over a joint.

l. Must never be placed in either metal or wooden moulding in damp locations; must never be placed in either metal or wooden moulding in concealed locations or where the difference of potential between any two wires in the same system is over 300 volts. When the electrical construction is being carried out in metal moulding, permission will be given to extend these mouldings through walls and partitions

26. **Wires**—*Continued.*

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 shall be used in metal moulding.

As a rule, wooden moulding should not be placed directly against a brick wall, as the wall is likely to "sweat" and thus introduce moisture back of the moulding.

If water should soak into the wood, it might cause leakage of current between the wires, charring the wood and starting a fire which would not be immediately discovered. The metal mouldings are not water tight.

It is to be understood that the sole object of the moulding is to furnish a convenient runway in which the wires are either protected from mechanical injury or concealed from view where appearance is a factor. Nails used for fastening on the capping must be very carefully driven, so as to avoid injuring the insulation, and must never be used to hold the wires in the grooves.

m. Must, for alternating current systems, if in metal moulding have the two or more wires of a circuit installed in the same moulding.

It is suggested that this be 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 mouldings.

For Conduit Work.

n. Must have an *approved* rubber insulating covering, and within the conduit tubing must be without splices or taps. Must be double braided (Type Letters R. D.) for twin, twisted pair or multiple conductor cables and for all single conductors of No. 6 B. & S. gage and larger. (See Rule 50, page 111.)

Slow-burning insulation may, however, be used in permanently dry locations where excessive temperatures are present, provided special permission in writing be given in advance. (See Rule 56, page 120.)

Here, too, the conductors need the best of insulating covering, as there is no other separation between them.

Single braided wire is considered good enough for sizes smaller than No. 6 B. & S. gage, for, due to their light weight and flexibility, the danger of the braid being injured when the wires are drawn into approved conduit is slight. An extra braid is needed on the larger and heavier wires to protect the braid next to the rubber when the wires are drawn over the floor or through the conduit.

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

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

No. 14 to 0 every 100 feet.
No. 00 to 0000 every 80 feet.
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.

26. **Wires**—*Continued.*

Above 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: —

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

2. Junction boxes may be inserted in the conduit system at the required intervals, in which insulating supports of *approved* type must 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.

3. 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 vertical position. Cables so suspended may be additionally secured to these insulators by tie wires.

Other methods may be used if specially approved.

This makes it absolutely necessary that the conduit should be complete from one junction box to another, and that all joints be carefully made. If wires were laid in the conduits while the latter were being installed, it would be very easy to neglect these points.

p. Must, for alternating systems, have the two or more wires of a circuit drawn in the same conduit.

It is suggested that this be 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 conduits.

Except in the case of stage pocket and border circuits the same conduit must not contain more than 4 two-wire, or 3 three-wire circuits of the same system, except by special permission, and must never contain circuits of different systems.

With alternating-current systems, if the wires of the same circuit are in different iron conduits, there will be trouble from inductive losses, and under certain conditions the conduits may become dangerously heated. This trouble disappears if the two or more wires of the same circuit are drawn into the same conduit.

Where a large number of wires are drawn into a conduit there is danger that some of them will get pinched and their coverings injured. Another objection is that if a short circuit attended by a flash should occur, the combustible insulation on the wires might get on fire and injure the wires to such an extent as to cause a serious interruption of the electric service.

A junction or outlet box is of course a part of the conduit line and therefore the number of wires in one of them should not exceed that permitted in a conduit.

For Concealed "Knob and Tube" Work.

q. Must have an *approved* rubber insulating covering (Type Letters R. S. for wires smaller than No. 6 B. & S. gage

26. **Wires**—*Continued.*

and Type Letters R. D. for wires No. 6 and larger. See Rule 50, page 111).

r. Must be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least 1 inch from the surface wired over. Should preferably be run singly on separate timbers, or studding, and must be kept at least 5 inches apart.

Must be separated from contact with the walls, floor timbers and partitions through which they may pass by non-combustible, non-absorptive, insulating tubes, such as glass or porcelain. Wires passing through cross timbers in plastered partitions must be protected by an additional tube extending at least 4 inches above the timber.

Rigid supporting requires, under ordinary conditions, where wiring along flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed the distance between supports must be shortened.

At distributing centers, outlets or switches where space is limited and the 5 inch separation cannot be maintained, each wire must be separately encased in a continuous length of approved flexible tubing.

It is believed that the use of a few extra knobs or cleats and a generous supply of tubes is advisable in such places, where the circuits are entirely concealed and any derangement of them could not, therefore, be seen.

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

There can, of course, be no assurance that such fished wires do not lie in close contact with gas or water pipes, or other wires, and so there is need of the protecting conduit.

t. When using either conduit or armored cable in mixed concealed knob and tube work, the requirements for conduit work or armored cable work must be complied with as the case may be. (See Sections *n* to *p* inclusive, and Rule 27, page 83.)

u. Must at all outlets, except where conduit is used, be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support to at least 1 inch be-

26. **Wires**—*Continued.*

yond the outlet. In the case of combination gas and electric outlets the tubes on the wires must extend at least flush with the outlet ends of gas caps, and if box or plate is used, gas pipes must be securely fastened into the outlet box or plate to secure good electrical connection.

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

It is suggested that *approved* outlet boxes or plates be installed at all outlets in concealed "knob and tube" work, the wires to be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support into the box.

An opening in a wall, etc., at an outlet may permit a flash between conductors to ignite combustible material in a concealed space and cause a fire which is difficult to get at.

27. **Armored Cables.**

(*See also Rule 26 s, page 82. For construction of Armored Cables, see Rule 54, page 119.*)

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

In case of service connections and main runs, this involves running such armored cable continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be. (See Rule 70, page 144.)

b. Must be equipped at every outlet with an *approved* outlet box or plate, as required in conduit work. (See Rule 59, page 124.)

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

For concealed work in walls and ceilings composed of plaster on wooden joist or stud construction, outlet boxes or plates and also cut-out cabinets must be so installed that the front edge will not be more than ¼ inch back of the finished surface of the plaster, and if this surface is broken or incomplete it shall be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or plate or of the cut-out cabinet. On wooden walls or ceilings, outlet boxes or plates and cut-out cabinets must be so installed that the front edge will either be flush with the finished surface or project therefrom. This will not apply to concealed work in walls or ceilings composed of concrete, tile or other non-combustible material.

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

Openings in walls, etc., at outlets should be closed for the reasons given under Rule 26 *u*, page 82.

27. Armored Cables—*Continued.*

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

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

If armor of cables and metal of couplings, outlet boxes, junction boxes, cabinets or fittings having protective coating of non-conducting material, such as enamel are used, such coating must be thoroughly removed from 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 must be cleaned of rust, scale, etc., at place of attachment of ground clamp.

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

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

The ground for the armored cable system is not to be considered as a ground for a secondary system (see Rule 15, page 54.)

It is rarely possible to perfectly insulate a conduit or armored cable system throughout and a *positive* ground is therefore required, so as first to provide a definite path for leaking currents and thus prevent them from escaping through parts of a building, etc., where they might do harm, and second to prevent any possible difference of potential occurring between conduit and near-by grounded metal work which might cause persons to receive dangerous shocks.

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

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

e. Where entering junction boxes, and at all other outlets, etc., must be provided with *approved* terminal fittings which will protect the insulation of the conductors from abra-

27. **Armored Cables**—*Continued.*

sion, unless such junction or outlet boxes are especially designed and approved for use with the cable.

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

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

This is necessary in order to avoid heating of armor and other troubles due to induction, which might occur if each conductor were separately encased. See also notes under Rule 26 *p*, page 81.

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

28. **Interior Conduits.**

(*See also Rule 26 n to p, pages 80 and 81. For construction of Conduit, see Rule 58, page 121, and for construction of Outlet, Junction and Flush Switch Boxes, see Rule 59, page 124.*)

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

It has been found in practice with sizes smaller than this, that the smallest wire permitted by Rule 16 *a*, page 58, cannot be readily drawn in and out of the conduit.

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

In case of service connections and main runs, this involves running each conduit continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be. (See Rule 70, page 144.)

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

They must be continuous in order that the wires may be readily drawn in after the conduit system is completed, and also to insure that the wire is protected throughout its whole length.

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

For the reason given under Rule 26 *o*, page 80.

d. Must be equipped at every outlet with an *approved* outlet box or plate. (See Rule 59, page 124.) At exposed ends of conduit (but not at fixture outlets) where wires pass from the conduit system without splice, joint or tap, an *approved* fitting having separately bushed holes for each conductor must be used. Departure from this rule may be authorized by special permission.

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

For concealed work in walls and ceilings composed of

28. **Interior Conduits**—*Continued.*

plaster on wooden joist or stud construction, outlet boxes or plates and also cut-out cabinets must be so installed that the front edge will not be more than ¼ inch back of the finished surface of the plaster, and if this surface is broken or incomplete it shall be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or plate or of the cut-out cabinet. On wooden walls or ceilings, outlet boxes or plates and cut-out cabinets must be so installed that the front edge will either be flush with the finished surface or project therefrom. This will not apply to concealed work in walls or ceilings composed of concrete, tile or other non-combustible material.

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

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

Openings in walls etc. at outlets should be closed for the reasons given under Rule 26 *u*, page 82.

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

f. Must have the metal of the conduit permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connections are made to gas piping, they must be on the street side of the meter. If the conduit system consists of several separate sections, the sections must be bonded to each other, and the system grounded, or each section may be separately grounded, as required above. Where short sections of conduit (or pipe of equivalent strength) are used for the protection of exposed wiring on side walls, and such conduit or pipe and wiring is installed as required by Rule 26 *e*, page 76, the conduit or pipe need not be grounded.

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

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

28. **Interior Conduits**—*Continued.*

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

The ground on the conduit system is not to be considered as a ground for a secondary system. (See Rule 15, page 54.)

It is rarely possible to perfectly insulate a conduit system throughout, and a *positive* ground is therefore required, so as first to provide a definite path for leaking currents and thus prevent them from escaping through parts of a building, etc., where they might do harm, and second to prevent any possible difference of potential occurring between conduit and near-by grounded metal work, which might cause persons to receive dangerous shocks.

g. Junction boxes must always be installed in such a manner as to be accessible. Such boxes are considered to be accessible when installed in an attic that has sufficient head room, but which is reached only by a portable ladder and permanent hatch.

h. All elbows or bends must be so made that the conduit will not be injured. The radius of the curve of the inner edge of any elbow not to be less than 3½ inches. Must have not more than the equivalent of 4 quarter bends from outlet to outlet, the bends at the outlets not being counted.

i. SIZE OF CONDUITS FOR THE INSTALLATION OF WIRES AND CABLES.

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	1½
1	0000	2
	C. M.	
0	250000	2
00	350000	2½
000	400000	2½
0000	550000	3
C. M.		
250000	600000	3
300000	800000	3
400000	1000000	3½
500000	1250000	4
600000	1500000	4
700000	1750000	4½
800000	2000000	4½

28. **Interior Conduits**—*Continued.*

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	¾	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	1½	2
0	1	1½	2	2
00	1	2	2	2½
000	1	2	2	2½
0000	1¼	2	2½	2½
C. M.				
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

SINGLE - CONDUCTOR COMBINATION.

Where special permission has been given in accordance with Rule 26 *p*, page 81, 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

29. Metal Mouldings.

(*See also Rule 26 k to m, pages 79 and 80. For construction of Mouldings, see Rule 60, page 125.*)

a. Must be continuous from outlet to outlet, to junction boxes, or *approved* fittings designed especially for use with metal mouldings, and must 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.

b. Such moulding where passing through a floor must be carried through an iron pipe extending from the ceiling below to a point 5 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, this ruling may be modified to require the protecting piping from the ceiling below to a point at least 3 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.

c. Backing must be secured in position by screws or bolts, the heads of which must be flush with the metal.

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

Metal mouldings and gas pipes must be securely fastened to outlet boxes, junction boxes and cabinets, so as to secure a good electrical connection. Moulding must 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 are used, such coating must be thoroughly removed from the threads of couplings and 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. Grounded pipes must be cleaned of rust, scale, etc., at the place of attachment of the ground clamp.

Connection to grounded pipes and to metal mouldings

29. **Metal Mouldings**—*Continued.*

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. 10 B. & S. gage. They shall be protected from mechanical injury.

It is rarely possible to perfectly insulate a metal moulding system throughout, and a *positive* ground is therefore required, so as first to provide a definite path for leaking currents and thus prevent them from escaping through parts of a building, etc., where they might do harm, and second to prevent any possible difference of potential occurring between conduit and near-by grounded metal work which might cause persons to receive dangerous shocks.

e. Must be installed so that for alternating systems the two or more wires of a circuit will be in the same metal moulding.

It is suggested that this be done for direct current systems also, so that they may be changed to the alternating system at any time, induction troubles preventing such change if the wires are in separate mouldings.

For the reasons given under Rule 26 *p*, page 81.

30. **Fixtures.**

(*For construction of Fixture Wire, see Rule 52, page 119. For construction of Fixtures, see Rule 77, page 159.*)

a. When 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, must be insulated from such supports by *approved* insulating joints placed as close as possible to the ceilings or walls. The insulating joint may be omitted in conduit, armored cable or metal moulding systems with straight electric fixtures in which the insulation of conductors is the equivalent of insulation in other parts of the system, and provided that *approved* sockets, receptacles or wireless clusters are used of a type having porcelain or equivalent insulation between live metal parts and outer metal shells, if any.

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

Where insulating joints are required fixture canopies of metal must 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 must be securely fastened in place, so as to separate the canopies thoroughly and permanently from the surfaces and outlet boxes from which they are designed to be insulated.

30. **Fixtures**—*Continued.*

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 must 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 ¾ inch in thickness, securely screwed to lathing, must be provided.

Fixtures having so-called flat canopies, tops or backs, will not be approved for installation, except where outlet boxes are used.

b. When installed out-of-doors, must be of water-tight construction.

c. Fixture wires must be not smaller than No. 18 B. & S. gage, and must have an *approved* rubber insulating covering (see Rule 52, page 119).

In wiring certain designs of show-case fixtures, ceiling bull's-eyes and similar appliances in which the wiring is exposed to temperatures in excess of 120 degrees Fahrenheit (49 degrees Centigrade), from the heat of the lamps, *approved* slow-burning wire must be used. All such forms of fixtures must be submitted for examination, test and approval before being introduced for use.

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

e. Must, when wired on the outside have the conductors so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture.

Must not, when wired on the outside, be used in show windows or in the immediate vicinity of especially inflammable stuff.

Chain fixtures must be wired with flexible conductors.

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

g. Must be free from short-circuits between conductors and from contacts between conductors and metal parts of fixtures, and must be tested for such conditions before being connected to supply conductors.

31. **Sockets.**

(*For construction of Sockets, see Rule 72, page 152.*)

a. In rooms where inflammable gases may exist the incandescent lamp and socket must 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 Factory Mutual work, a pendant like that shown on page 95, using a standard *keyless* socket, or an approved waterproof pendant like those shown on page 93, will be accepted in place of the pipe-hanger, but the vapor-tight globe will be required in all cases. The reinforced cord or stranded waterproof conductors should not be smaller than No. 14 B. & S. gage in order to safely carry the added weight of the vapor-tight globe.

If a stiff pendant supported by a "crow-foot" or equivalent is used, the pipe should be as short as possible, as a long one is liable to be wrenched out of place, or the "crow-foot" broken, by even a light blow. The wires should be *stranded* and should not be smaller than No. 16 B. & S. gage. They should be thoroughly protected with insulating tape where they emerge from the top of the pipe, — the edges of which must be carefully smoothed off, — or else a regular conduit outlet bushing should be provided. The use of a good outlet bushing is preferred.

Where there is even a slight possibility of the globe being struck and broken, a substantial guard should be placed around it.

b. In damp or wet places, or where exposed to corrosive vapors, weatherproof sockets especially approved for the location must be used. Unless made up on fixtures they must 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 3 feet long.

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

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

Departure from this rule may be authorized only by special permission in writing.

This form of construction is clearly shown in Figs. 34 and 35, in which is also indicated a method of supporting the pendant so that all strain is removed from the connection to the overhead wires.

Attention is called to the note under Rule 32 *d* for description of an approved pendant for use over especially inflammable material.

d. When the socket is not attached to a fixture, the inlet if threaded must be not less than ⅜ inch pipe size, and must be provided with an *approved* insulating bushing.

32. **Flexible Cord.**

(*For construction of Flexible Cord, see Rule 51, page 116.*)

a. Must have an *approved* insulation and covering. (See Rule 51, page 116.)

32. **Flexible Cord**—*Continued.*

b. Must not, except in street railway property, be used where the difference of potential between the two wires is over 300 volts.

c. Must not be used as a support for clusters.

It is not strong enough mechanically to safely sustain much weight.

FIG. 34. SHORT WATERPROOF PENDANT.

d. Must not be used except for pendants, wiring of fixtures, portable lamps or motors, and 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 must be used. (See Rule 51 *d,* page 117.)

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

The practice of making the pendants unnecessarily long and then looping them up with cord adjusters is strongly advised against. It offers a temptation to carry about lamps which are intended to hang freely in the air, and the cord adjusters wear off the insulation very rapidly.

The cord should be supported independently of the overhead circuit by a single cleat, and the two conductors then separated and soldered to the overhead wires.

The chances for short-circuits in flexible cord are considerable, as the wires of opposite polarity are brought very near together. As a result of continued bending in handling, some of the fine wires may break, and the loose, sharp ends may then puncture the insulation and form a short-circuit with the other conductor. Or, the insulation may deteriorate or become sufficiently worn to allow the bare wires to come into contact with each other. The arc formed at the instant the short-circuit occurs is liable to set fire to the insulation of the wire if it be at all of a combustible nature. This will sometimes occur even if the circuit is instantly opened by melting of the fuses. It is for these reasons that it is desirable to limit the use of flexible cord to those places where nothing else is suitable.

FIG. 35. LONG WATERPROOF PENDANT, WIRES TWISTED TOGETHER.

The type of pendant described above for portable work and illustrated in Fig. 36, page 95, should be used in all hazardous places, such as picker and carding rooms, napping rooms, dust chambers, woodworking shops, etc., and also for storehouses. Except in especially hazardous places, a ceiling rosette may be used in place of the soldered connections to the overhead wires. Fig. 11, page 33, shows a reinforced cord pendant hung from a rosette attached to a conduit outlet box.

32. **Flexible Cord**—*Continued.*

e. Unless provided with *approved* metal armor, must not be used in show windows or in show cases, except that *approved* portable cord may be used for the purpose of supplying current to portable lamps and other devices for exhibition purposes, and flexible cord may be used for chain fixtures.

Because a defective cord is very liable to set fire to the inflammable material about it. Records show an unfortunately large number of fires caused by the use of common flexible cord in show windows.

f. Must be protected by insulating bushings where the cord enters the socket.

The hole through which the wire must enter the socket is ordinarily threaded for attachment to fixtures. The sharp thread would soon cut through the insulation of the cord and cause a short-circuit, were it not for the bushing.

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

The electrical connection, which is generally made by clamping the fine wires under a flat-headed screw, has not sufficient mechanical strength to be trusted as a means of sustaining the weight of the lamp and fittings.

When knotting the cord, especially in the rosette, care should be taken to pull the knot hard against the porcelain, and with the knot in this position, to then fasten the wires under the binding screws. Unless this is done, the knot probably will not bear on the porcelain and will therefore be of no service in preventing the strain coming on the binding screws, which, in time, may result in a loose connection.

It is also a good practice to have the ends of the conductors dipped in melted solder where they are fastened under the binding screws. This binds the fine wires together, and leaves no loose ends to make short-circuits inside the socket.

h. Must where passing through covers of outlet boxes be protected by *approved* bushings especially designed for this purpose. So-called hard rubber or composition bushings threaded into box covers must not be used.

33. **Arc Lamps on Constant-Potential Circuits.**

(*For construction of Arc Lamps, see Rule 74, page 156.*)

a. Must have a cut-out (see Rule 19 *a*, page 63) for each lamp or each series of lamps.

The branch conductors must have a carrying capacity about 50% in excess of the normal current required by the lamp.

The use of arc lamps in series on constant-potential systems is not advised, as higher voltages are then necessary throughout the buildings. This system will be permitted in Factory Mutual risks only when the conditions are such that the use of single lamps in multiple is impracticable, and the lamps can be favorably located.

b. Must only be furnished with such resistances or regulators as are enclosed in non-combustible material, such

33. **Arc Lamps on Constant-Potential Circuits**—*Continued.*

resistances being treated as sources of heat. Incandescent lamps must not be used for this purpose.

Even when the arc lamp is burning properly, these resistances are quite hot, and they may be melted by excessive current if the lamp fails to burn as it should.

c. Must be supplied with globes and protected by spark arresters and wire netting around the globe, as in the case of series arc lamps (see Rule 21, page 66).

Outside arc lamps must be suspended at least 8 feet above sidewalks. Inside arc lamps must be placed out of reach or suitably protected.

In hazardous places such as picker and carding rooms, etc., an outer globe should be provided in order to keep flyings away from the hot inner globe and cap.

d. Lamps when arranged to be raised and lowered, either for carboning or other purposes, shall 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.

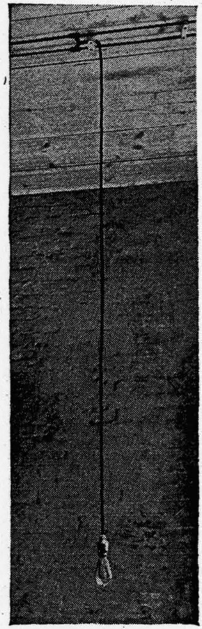


FIG. 36.
PENDANT WITH REINFORCED FLEXIBLE CORD.

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

Practically the same precautions in locating and mounting these devices should be taken as with resistance boxes, etc. (See Rule 4, page 29.) This would require that they be mounted on a slate base or equivalent, which in turn is fastened to the wall or other support, the attachments to be independent of each other, and the base to be of such size as to give a continuous separation between the device and the support. It will not be satisfactory to mount these devices on porcelain knobs.

34. **Vapor Lamps.**

Enclosed Mercury Vapor Lamps.

a. Must 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 5 lamps should be dependent upon single cut-out.

b. Must only be furnished with such resistances or regulators as are enclosed in non-combustible cases, such resist-

34. Vapor Lamps—*Continued.*

ances 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.

High Potential Vacuum Tube Systems.

c. The tube must be so installed as to be free from mechanical injury or liability to contact with inflammable material.

d. High-potential coils and regulating apparatus must be installed in approved steel cabinet not less than 1-10 inch in thickness; same to be well ventilated in such a manner as to prevent the escape of any flame or sparks, in case of burnout in the various coils. All apparatus in this box must be mounted on slate base and the enclosing case positively grounded. Supplying conductors leading into this high-potential case to be installed in accordance with the standard requirements governing low-potential systems, where such wires do not carry a potential of over 300 volts.

To protect against dangerous shocks any openings in the box near the high-voltage parts should be effectively screened or protected by other suitable means.

35. Gas Filled Incandescent Lamps.

a. Must be so grouped that not more than 660 watts (nor more than 16 sockets or receptacles) are to 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 may 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 permissible on the final cut-out shall be the maximum capacity for which such socket or receptacle is approved.

b. Must 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 *approved* fixtures where temperature of any exposed portion of same does not exceed 200 degrees Fahr. (93 degrees Centigrade).

c. Must 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 above 100 watts, must not, if provided

35. **Gas Filled Incandescent Lamps**—*Continued.*

with a shade, reflector, fixture or other enclosure above the socket, be used in either medium or Mogul base types of sockets or receptacles having fibre or paper linings.

d. Fixtures within buildings must be wired with conductors of *approved* slow-burning or asbestos covering where the temperature to which wire is subjected at any point exceeds 120 degrees Fahr. (49 degrees Centigrade). Where fixtures are placed outside of buildings *approved* rubber insulated wire is required.

36. Transformers.

(See also Rules 11, 14, 15 and 45, pages 40, 53, 54 and 107. For construction of Transformers, see Rule 81, page 167.)

Oil Transformers.

a. Must not be placed inside of any building except central stations and sub-stations, unless by special permission.

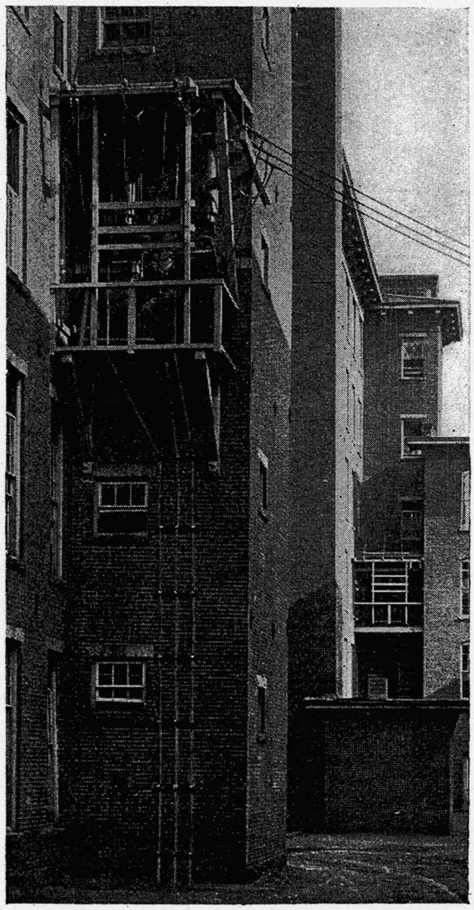


Fig. 37.
Transformers on Outside Platforms.

An outside location is always preferable; first, because it keeps the high-voltage primary wires entirely out of the building and second, for the reasons given in the note to Rule 11 *a*, page 40.
It is very rarely necessary to locate transformers inside of buildings, especially in factory work, for there is generally plenty of available space on the outside walls. Wherever possible the transformer should be placed on a blank wall and when this cannot be done, it is advised that the windows in the vicinity of them be made of wire glass, with tinned sashes. Under these conditions, a severe fire about the transformers would probably not seriously endanger the building before it could be extinguished.
The transformer station shown in the foreground of Fig. 37 consists of four transformers with a capacity of 25 K. W. each.

36. **Transformers**—*Continued.*

The roof was found necessary, at this particular mill, to protect the apparatus from ice and snow falling from above, and the platform was provided for the convenience and safety of the electrician in making repairs and changes. As a general rule, however, as little combustible material as possible should be used around the transformers. The three wires running down the wall are the ground wires from the three lightning arresters, which are mounted on the horizontal cross-bars in front of the transformers. These wires should usually be protected by heavy wooden boxing extending 7 or 8 feet above the ground and firmly secured to the wall.

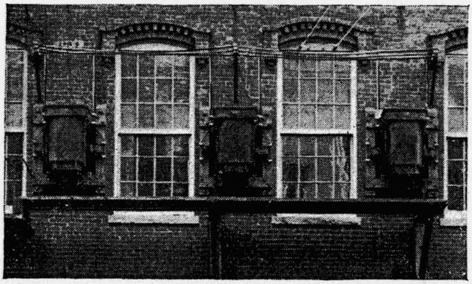


FIG. 38.
TRANSFORMERS ON OUTSIDE WALL.

The station visible in the background of Fig. 37 is in every way similar to the one in the foreground.

Fig. 38 shows three transformers, each bolted to heavy wooden cleats on the outside wall of a brick building. The arrangement fulfils the requirements of Rule 14 *a,* page 53. The primary fuse boxes have been placed at the sides of the transformers. A plank platform beneath the transformers affords ready access to the transformers, fuses, wiring, etc.

Where it is impracticable or undesirable to locate transformers on the outside wall of a building, it may be feasible to place them in an underground vault just outside the foundation wall, as shown in Fig. 39. At this plant, the primary wires are brought to fuse boxes on the wall, and lead-covered cable is carried thence in iron conduit down into the vault. The cover is removable, and is made of wood tinned on both sides like a standard fire-door. Good ventilation is obtained by the two iron pipes shown at the ends.

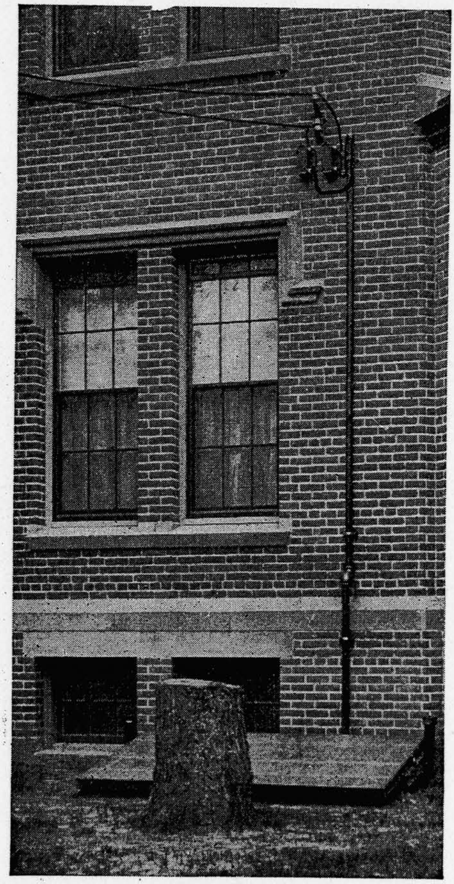


FIG. 39.
TRANSFORMER VAULT UNDERGROUND OUTSIDE OF BUILDING.

36. **Transformers**—*Continued.*

one pipe extending nearly to the bottom of the vault, and the other only just inside the top. The other requirements of Rule 45, page 107, have also been well carried out in this enclosure.

The secondary wires enter the building through iron pipes cemented into the wall, and the spaces between the wires and the pipes are filled up by cement, the wires being lead-covered.

This is an excellent arrangement, as all high-voltage wires are kept out of the building and there is absolutely no opening between the vault and the building through which smoke or fire could pass.

Fig. 40 shows the transformers mounted on poles. This method of mounting is relatively inexpensive, and places them out of the way and where the boiling over of the oil will not be objectionable.

Fig. 41, page 100, shows two high-voltage transformers mounted on a steel structure well away from buildings and at such a height above ground that there is but little danger of persons reaching the high-voltage parts and receiving dangerous shocks.

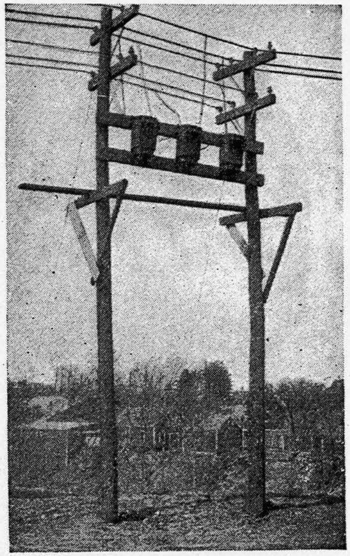


FIG. 40.
TRANSFORMERS ON POLES.

Air Cooled Transformers.

The following Sections do not apply to apparatus or fittings, the operation of which depends either wholly or in part upon special transformers embodied in the devices, but all such apparatus or fittings must be submitted for special examination and approval before being used.

b. Must not be placed inside of any building excepting central stations and sub-stations, if the highest voltage of either primary or secondary exceeds 550 volts.

In Factory Mutual work, all air-cooled transformers, except those of the very smallest sizes, say 5 kilowatts or less, should be placed outside main buildings or in separate non-combustible rooms. A short-circuit is liable to ignite the insulation on the conductors, which, owing to the ventilating ducts, would burn fiercely. Also dense smoke would be emitted.

c. Must, with the exception of bell ringing and other signaling transformers, be so mounted that the case will be at a distance of at least 1 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.

37. Decorative Lighting Systems.

a. Special permission may be given in writing for the temporary installation of *approved* Systems of Decorative Lighting, provided the difference of potential between the wires of any circuit shall 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.

38. Theatre and Moving Picture Establishment Wiring.

As this rule has no application to Factory Mutual risks it is not printed here. For the complete rule reference should be had to the latest edition of the National Electrical Code, published by the National Board of Fire Underwriters.

39. Outline Lighting.

(*Other than Signs on Exterior of Buildings.*)

a. Must be connected only to low-potential systems.

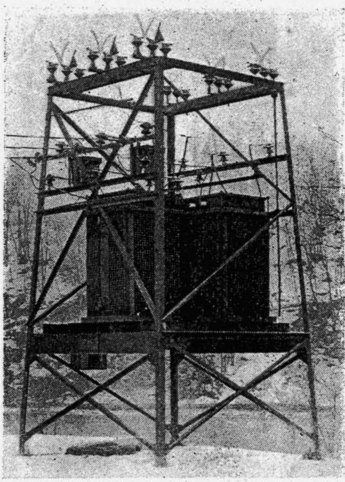


FIG. 41.
TRANSFORMERS ON A STEEL STRUCTURE.

b. Open or conduit work or metal trough construction may be used, but moulding will not be permitted.

c. Where flexible tubing is required, the ends must be sealed and painted with a moisture repellant, and kept at least ½ inch from surface wired over.

d. Wires for use in rigid or flexible steel conduit must comply with requirements for conduit work (see Rule 26 *n* to *p* inclusive, pages 80 and 81, and Rule 53, page 119). Where armored cable is used, the conductors must be protected from moisture by lead sheath between armor and insulation.

e. Must be protected by its own cut-out, and controlled by its own switch; single pole switches must not be used. Cut-outs, switches, flashers and similar appliances must be of *approved* types and be installed as required by the Code for such appliances, and, if outside the building, must, with the exception of transformers of weatherproof type, be installed in *approved* weatherproof cabinets.

f. Circuits must be so arranged that not more than 1,320 watts will be finally dependent upon a single cut-out.

39. **Outline Lighting**—*Continued.*

g. Sockets and receptacles must be of the keyless porcelain type and wires must be soldered to lugs on same. Miniature receptacles will not be approved for outdoor work.

h. For open work, wires must be *approved* rubber covered, not less than No. 14 B. & S. gage and must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wires at least 1 inch from the surface wired over. Rigid supporting requires, under ordinary conditions where wiring over flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed, the distance between supports should be shortened. In those parts of circuits where wires are connected to *approved* receptacles which hold them at least 1 inch from surface wired over, and which are placed not over 1 foot apart, such receptacles will be considered to afford the necessary support and spacing of the wires. Between receptacles more than 1 foot, but not more than 2 feet apart, an additional non-combustible, non-absorptive insulator maintaining a separation and spacing equivalent to the receptacles must be used. Except as above specified, wires must be kept apart at least 2½ inches for voltages up to 300, and 4 inches for higher voltages.

i. For metal trough construction, the troughs and other details must comply with the requirements of Rule 83 *a* to *f*, inclusive, pages 169 and 170.

40. **Car Wiring and Equipment of Cars.**

As there are but few cars in Factory Mutual Equipments this rule is not printed here. For the complete rule reference should be had to the latest edition of the National Electrical Code, published by the National Board of Fire Underwriters.

41. **Car Houses.**

a. The trolley wires must be securely supported on insulating hangers.

b. The trolley hangers must be placed at such a distance apart that, in case of a break in the trolley wire, contact with the floor cannot be made.

c. Must have an emergency cut-out switch located at a proper place outside of the building, so that all the trolley wires in the building may be cut out at one point, and line insulators must be installed, so that when this emergency switch is open, the trolley wire will be dead at all points within 100 feet of the building. The current must be cut out of the building when not needed for use in the building.

This may be done by the emergency switch, or if preferred a second switch may be used that will cut out all current from the building, but which need not cut out the trolley wire outside as would be the case with the emergency switch.

41. **Car Houses**—*Continued.*

If the feed to the car house is underground this emergency switch may be installed inside the building, but must be located at a point as near as practicable to where the underground feeder enters the building.

d. All lamps and stationary motors must be installed in such a way that one main switch may control the whole of each installation, lighting and power independently of the main cut-out switch called for in Section *c*.

e. Where current for lighting and stationary motors is from a grounded trolley circuit, the following special rules to apply: —

1. Cut-outs must be placed between the non-grounded side and lights or motors they are to protect. No set or group of incandescent lamps requiring over 2,000 watts must be dependent upon one cut-out.

2. Switches must be placed between non-grounded side and lights and motors they are to protect.

3. Must have all rails bonded at each joint with a conductor having a carrying capacity at least equivalent to No. 0 B. & S. gage annealed copper wire, and all rails must be connected to the outside ground return circuit by a not less than No. 0 B. & S. gage copper wire or by equivalent bonding through the track. All lighting and stationary motor circuits must be thoroughly and permanently connected to the rails or to the wire leading to the outside ground return circuit.

f. All pendant cords and portable conductors will be considered as subject to hard usage.

g. Must, except as provided in Section *e*, have all wiring and apparatus installed in accordance with the rules for constant-potential systems.

h. Must not have any system of feeder distribution centering in the building.

i. Cars must not be left with the trolley in electrical connection with the trolley wire.

41. A. **Lighting and Power from Railway Wires.**

a. **Must not be permitted, under any pretense, in the same circuit with trolley wires with a ground return, except in electric railway cars, electric car houses, power houses, passenger and freight stations connected with the operation of electric railways.**

Lighting from trolley wires is forbidden because of the danger of introducing into a building a circuit of relatively high voltage which is thoroughly connected with the earth on one side. The inevitable fluctuation in voltage would also frequently require over-fusing of the lighting circuits to prevent blowing fuses under normal conditions.

42. **Garages.**

For the purposes of this rule a garage is considered as that building or portion of a building in which one or more self-propelled vehicles carrying volatile inflammable liquid for fuel or power are kept for use, sale, storage, rental, repair, exhibition or demonstration purposes; and all that portion of a building that is on or below the floor or floors on which such vehicles are kept which is not separated therefrom by tight unpierced fire walls and fire-resisting floors.

In addition to the general requirements of the Code the following rules shall apply: —

a. In garages used for more than two vehicles, as above, all conductors except those required for pendant lamps or portable conections must be installed in *approved* metal conduit or *approved* armored cable, except that *approved* metal moulding may be used only in offices and showrooms. Metal conduit, armored cable or metal moulding must be so installed that all outlet and junction boxes shall be located at least 4 feet above the floor. In garages used for one or two vehicles, as above, conduit or armored cable construction is not required.

Gasoline vapor is heavier than air and therefore tends to settle towards the floor. By keeping all electrical apparatus and fittings where sparking is liable to occur at least 4 feet above the floor the chances of igniting the inflammable vapor if sparking occurs are greatly reduced.

b. Flexible cord for pendant lights must be *approved* reinforced cord.

c. Flexible cords for portable lamps, motors or other apparatus must be *approved* cord designed for rough usage. The portable cord must carry the male end of an *approved* pin plug connector or equivalent, the female end being of such design or so hung that the connector will break apart readily at any position of the cable. The connector must be kept at least 4 feet above the floor.

d. Flexible cable for charging must be of *approved* theatre stage type, this cable carrying parts of *approved* connectors of at least fifty amperes capacity. The connectors must be of such design or so hung that at least one will break apart readily at any position of the cable. Current-carrying parts of connectors must be shielded to prevent accidental contact. The fixed, or wall connector, must be kept at least 4 feet above the floor, and if not located on switchboard or charging panel, must be protected against accidental contact.

e. Cut-outs, switches and receptacles must be placed at least 4 feet above the floor, except as provided in Section *g* below.

42. **Garages**—*Continued.*

f. All portable lights must be equipped with *approved* keyless sockets of moulded composition or metal-sheathed porcelain type. These sockets must be equipped with handle, hook and substantial guard.

g. Switchboards and charging panels, at or upon which are mounted devices which in operation may produce a spark, must be located in a room or enclosure provided for the purpose unless all such spark-producing devices are at least 4 feet above the floor or surrounded by vapor-proof enclosures.

h. Motors or dynamos, not actually a part of a vehicle, if not located at least 4 feet above the floor must be of the fully enclosed type. Motors located 4 feet or more above the floor, if not of the fully enclosed type, must be provided with wire screen of not less than No. 14 mesh over openings at commutator end.

The screen over the motor openings will prevent incandescent particles from the commutator being thrown to the dangerous zone near the floor.

43. Electric Cranes.

All wiring, apparatus, etc., not specifically covered by special rules herein given, must conform to the Standard Rules and Requirements of the National Electrical Code, except that the switch required by Rule 8 c, page 35, for each motor may be omitted.

The following rules apply to cranes and hoists in machine shops, erecting shops, foundries, etc. Cranes or hoists should never be placed in Factory Mutual buildings where readily combustible material is stored or being worked unless by special permission.

a. **Wiring.** — 1. All wires except bare collector wires, those between resistances and contact plates of rheostats and those subjected to severe external heat, must be *approved,* rubber-covered and not smaller in size than No. 12 B. & S. gage. Insulation on wires between resistances and contact plates of rheostats must conform to Section *d,* while wires subjected to severe external heat must have *approved* slow-burning insulation.

2. All wires excepting collector wires and those run in metal conduit or approved flexible cable must be supported by knobs or cleats which separate them at least 1 inch from the surface wired over, but in dry places where space is limited and the distance between wires as required by Rule 26 *h,* page 78, cannot be obtained, each wire must be separately encased in approved flexible tubing securely fastened in place.

Collector wires must be supported by approved insulators so mounted that even with the extreme movement permitted the wires will be separated at all times at least 1½ inches from

43. **Electric Cranes**—*Continued.*

the surface wired over. Collector wires must be held at the ends by approved strain insulators.

3. Main collector wires carried along the runways must be rigidly and securely attached to their insulating supports at least every 20 feet, and separated at least 6 inches when run in a horizontal plane; if not run in a horizontal plane, they must be separated at least 8 inches. If spans longer than 20 feet are necessary the distance between wires must be increased proportionately but in no case shall the span exceed 40 feet.

The collector wires are constantly subject to wear, due to the collectors passing over them, and due to the sparking which occurs. The wires are liable to be so worn in time that they will break, and unless the wires are supported as required the loose ends in many cases will drop to the floor and cause severe arcing or dangerous shocks to persons coming in contact with them.

4. Where bridge collector wires are over 80 feet long, insulating supports on which the wires may loosely lie must be provided at least every 50 feet.

Bridge collector wires must be kept at least 2½ inches apart, but a greater spacing should be used whenever it may be obtained.

It would also be advisable to rigidly support the bridge collector wires every 20 feet or so, but owing to limitations imposed by crane design it is seldom practicable to do so.

5. Collector wires must not be smaller in size than specified in the following table for the various spans.

Distance between rigid supports. Feet.	Size wire required. B. & S.
0 to 30	6
31 to 60	4
Over 60	2

The collector wires should be of good liberal size, owing to the fact that they are being constantly subjected to wear and therefore a greater factor of safety is necessary.

b. **Collectors.** — Must be so designed that sparking between them and collector wires will be reduced to a minimum.

If sparking occurs, heated particles of metal are liable to fall into combustible material beneath and cause a fire.

c. **Switches and Cut-Outs.** — 1. The main collector wires must be protected by a cut-out and the circuit controlled by a switch. Cut-out and switch to be so located as to be easy of access from the floor.

2. Cranes operated from cabs must have a cut-out and switch connected into the leads from the main collector wires and so located in the cab as to be readily accessible to the operator.

43. **Electric Cranes**—*Continued.*

3. Where there is more than one motor on a single crane, each motor lead must be protected by a cut-out located in the cab if there is one.

d. **Controllers.** — Must be installed according to Rule 4, page 29, except that if the crane is located outdoors the insulation on wires between resistances and contact plates of rheostats must be rubber where the wires are exposed to moisture and insulation is necessary and also where they are grouped. If the crane operates over readily combustible material, the resistances must be placed in an enclosure made of non-combustible material, thoroughly ventilated and so constructed that it will not permit any flame or molten metal to escape in the event of burning out the resistances. If the resistances are located in the cab, this result may be obtained by constructing the cab of non-combustible material and providing sides which enclose the cab from its floor to a height at least 6 inches above the top of the resistances.

e. **Grounding of Iron Work.** — The motor frames, the entire frame of the crane and the tracks must be permanently and effectually grounded.

HIGH-POTENTIAL SYSTEMS.

550 TO 3500 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, shall be 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 10% above the 550 volt limit will be allowed at the generator or transformer without coming under high-potential systems.

44. **Wires.**

(*See also Rules 16, 17, 18 and 20, pages 58, 61, 62 and 65. For construction requirements, see Rules 49 and 50, pages 110 and 111.*)

a. Must have an *approved* rubber-insulating covering. (See Rule 50, page 111.)

An *approved* varnished cambric covering may be used on wires and cables, instead of rubber, if desired.

b. Must be always in plain sight and never encased, except as provided for in Rule 8 *b*, page 34, or where specially required.

In Factory Mutual work all high-voltage, constant-potential wires should be run in iron conduit, except in generator or switchboard rooms, etc. The wire must be multiple conductor, lead-sheathed cable.

44. Wires—*Continued.*

c. Must (except as provided for in Rule 8 *b,* page 34) be rigidly supported on glass or porcelain insulators, which raise the wire at least 1 inch from the surface wired over, and must be kept about 8 inches apart.

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least about every 4½ feet. If the wires are unusually liable to be disturbed, the distance between supports must be shortened.

In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about 10 inches and run from timber to timber, not breaking around, and may be supported at each timber only.

d. Must be protected on side walls from mechanical injury by a substantial boxing, retaining an air space of 1 inch around the conductors, closed at the top (the wires passing through bushed holes) and extending not less than 7 feet from the floor. When crossing floor timbers, in cellars, or in rooms where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than ½ inch in thickness.

45. **Transformers.**

(See also Rules 11, 14, 15 and 36, pages 40, 53, 54 and 97. For construction of Transformers, see Rule 81, page 167.)

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

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

This is to reduce the amount of high-voltage primary wire in the building to as small an amount as possible.

b. 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.

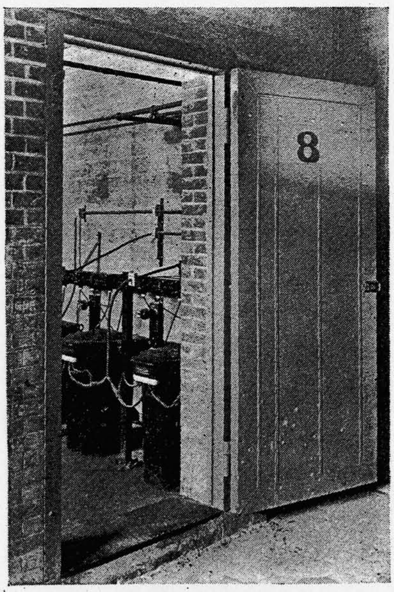


FIG. 43.
TRANSFORMER ROOM IN BASEMENT OF BUILDING.

Unless the transformers are few in number and of small size, say 3 or 4 rated at not over 10 kilowatts each, the floor of the

45. **Transformers**—*Continued.*

room or vault should be pitched towards one side and drained to a safe point. A sill, at least 6 or 8 inches high, should be placed in the doorway to prevent overflowing oil leaving the room. If the doorway is in an inside wall it should be closed by two standard fire doors, one on each side of the wall.

It is better to arrange the transformer room or enclosure so that it can be entered only from outdoors, since then, even if the door should happen to be open at the time of a fire in this room, it is probable that no especial harm would be done. Moreover, the fire could doubtless be better handled from the outside.

c. The transformer cases must be permanently and effectually grounded, and the enclosure in which they 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 6 inches air space on all sides of the transformer.

The object of an air-tight enclosure is to prevent smoke from escaping or fire from spreading, in case the transformer coils should become overheated from an overload or should be ignited by a break-down in the insulation between the primary and secondary coils. This is especially important with oil-cooled transformers, as explained in the note to Rule 11 *a*, page 40.

These rooms generally should be thoroughly drained by a liberal sized pipe leading to a safe point outside the building.

For requirements regarding grounding of transformer secondary circuits, see Rule 15 *b*, page 54. See also note at head of Rule 15, page 54.

Fig. 43, page 107, shows a transformer room constructed entirely of brick and concrete and having a standard fire door in the entrance. The door is normally kept closed and locked. Attention is called to the high threshold intended to prevent the escape of oil if any of the transformers should boil over. Ventilation and light are obtained by windows opening outdoors in one of the walls.

46. **Series Lamps.**

a. No multiple series or series multiple system of lighting will be approved.

b. Must not, under any circumstances, be attached to gas fixtures.

EXTRA-HIGH-POTENTIAL SYSTEMS.

OVER 3500 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, shall be 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.

47. **Primary Wires.**

a. Must not be brought into or over buildings, except power stations and sub-stations.

48. **Secondary Wires.**

a. Must be installed under rules for high-potential systems 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 requirements as given in Rule 13, page 46, or are entirely underground, within city, town and village limits.

In every case where it is desired to carry the secondary circuits of an extra-high-potential system into Factory Mutual risks, it is advised that the Inspection Department be consulted before the work of installation is begun, in fact, before the apparatus is even ordered. Each such case will be treated on its own merits and such precautions recommended as appear necessary to secure a safe arrangement. (See note at head of Rule 14, page 53.)

Class D.

FITTINGS, MATERIALS AND DETAILS OF CONSTRUCTION.*

All Systems and Voltages.

The following rules are but a partial outline of requirements. Devices or materials which fulfill the conditions of these requirements and no more, will not necessarily be acceptable. All fittings and materials should be submitted for examination and test before being introduced for use.

Insulated Wires, Cables and Cords—Rules 49 to 57.

49. General.

a. Wires, cables and cords of all kinds designed to meet the following specifications must have a distinctive marking the entire length of the coil so that they may be readily identified in the field. They must also be plainly tagged or marked as follows:—

Wires described under Rule 57, page 121, need not have the distinctive marking but are to be tagged.

1. The maximum working pressure or voltage for which the wire was tested or approved. This may be omitted for the wires described under Rules 55, 56 and 57, pages 120 and 121.
2. The words "National Electrical Code Standard."
3. Name of the manufacturing company and, if desired, trade name of the wire.
4. Month and year when manufactured.
5. The proper type letter for the particular style of wire or cable as given in the following rules for each type of insulation.

b. Conductors or the strands of conductors must not vary in either diameter or in conductivity more than the specified per cent from the specified standards. The standard for diameters and milages shall be that adopted by the American Institute of Electrical Engineers.

---

* In preparing Class D, the Underwriters have, from the beginning, received valuable aid from the manufacturers interested in the various fittings. No important change is ever made in this Class until after the fullest discussion with the manufacturers who have always been found ready to cooperate.

50. **Rubber-Covered Wire.**

R S, Rubber-covered single braided for voltage 0–600
R S-15, Rubber-covered single braided for maximum voltage 1500
R S-25, Rubber-covered single braided for maximum voltage 2500
R S-35, Rubber-covered single braided for maximum voltage 3500
R S-50, Rubber-covered single braided for maximum voltage 5000
R S-70, Rubber-covered single braided for maximum voltage 7000
R D, R D-15, etc., Rubber-covered double braided.
R S L, Rubber-covered, single braided, leaded.
R D L, Rubber-covered, double braided, leaded.
A C, Wires for use in armored cable.
A C L, Leaded wires for use in armored cable.

A. Conductors.

1. **Material and Sizes.**

a. Conductors shall be of soft annealed copper of nominal diameters and milages according to the Standards adopted by the American Institute of Electrical Engineers and may be either solid or stranded.

b. Variations below the standard diameters and milages shall be permitted as follows:

x. For solid conductors, No. 4 B. & S. gage and smaller, a variation of not more than .002 inch in diameter.

y. For solid conductors, larger than No. 4 B. & S. gage, a variation of not more than 1% below the nominal standard diameter.

z. For stranded conductors, a variation of not to exceed 1½% below the standard area in circular mils of a solid conductor of the same nominal capacity, the area of the stranded conductor being taken as the sum of the circular mil areas of all of the individual wires.

2. **Conductivity.**

a. The conductivity of solid conductors shall not be less than ninety-seven per cent of that of pure copper of the specified size.

b. The conductivity of the individual wires in a stranded conductor shall not be less than is given in the following table, which applies to tinned conductors.

50. **Rubber-Covered Wire**—*Continued.*

B. & S. Gage No.	Per cent.	B. & S. Gage No.	Per cent.
4 and larger	97.0	23	95.2
15	96.8	24	95 0
16	96.6	25	94.8
17	96.4	26	94.6
18	96.2	27	94.4
19	96.0	28	94.2
20	95.8	29	94.0
21	95.6	30	93.8
22	95.4		

3. **Miscellaneous.**

a. No individual conductor, whether solid or stranded shall be less than No. 14 B. & S. gage in nominal size.

b. All conductors shall be tinned. In the case of stranded conductors the individual wires shall be separately tinned. In measuring the diameter of individual wires for determining the size and carrying capacity of conductors, the measurements taken shall include the thickness of the tin coating.

c. The individual wires in a stranded conductor or in a stranding unit need not be of the same nominal diameters.

d. If splices are made in solid conductors or in the individual wires of stranded conductors, they must be made in a workman-like manner and so as not to increase the diameter of the conductor or individual wire or lessen the mechanical strength thereof. Joints or splices in stranded conductors, as a whole, must be made only by separately joining each individual wire as described above, and the over-all diameter of the entire stranded conductor must not be increased thereby.

B. Insulation.

1. **General.**

a. Conductors shall be insulated for their entire length.

b. The insulation for all rubber-covered wires and cables shall consist of a properly vulcanized rubber compound which must comply with the following requirements.

c. The insulation shall be applied directly to the surface of the conductor or of a separator, consisting of a close wind or braid of fine cotton or of paper.

d. The insulation must adhere to the conductor, or to the separator if one is used, sufficiently to prevent its removal from the conductor in an uninjured, unbroken condition for lengths greater than 3 inches except when special methods or appliances are used for the purpose.

50. **Rubber-Covered Wire**—*Continued.*

2. **Thickness.**

a. The insulation must be of the nominal thickness given in the following table, the requirements of which vary according to the sizes of conductors and the maximum working pressures:

b. TABLE OF NOMINAL THICKNESSES OF RUBBER INSULATION FOR RUBBER-COVERED WIRES AND CABLES.

	Nominal Thickness of Rubber Insulation in 64ths inch					
	Type Letters					
	RS	RS-15	RS-25	RS-35	RS-50	RS-70
	For Working Pressures Not Over					
Size Conductor. B. & S. Gage	600 Volts	1500 Volts	2500 Volts	3500 Volts	5000 Volts	7000 Volts
14 to 8	3	4	6	8	12	16
7 to 2	4	5	6	8	12	16
1 to 0000	5	6	7	8	12	16
Circular Mils.						
225,000 to 500,000	6	7	8	9	12	16
525,000 to 1,000,000	7	8	9	10	12	16
Over 1,000,000	8	9	10	11	14	18

c. The insulation shall be applied so as to provide a circular cross section for the insulated conductor and the conductor proper should be well centered in the insulating wall.

d. When combinations of colored compounds are employed they shall be so united as to form one mass, which mass shall be taken as a whole in all measurements and tests.

C. Coverings.

1. **General.**

a. All single conductor rubber insulated wires and cables must have a covering of fibrous material applied directly to the surface of the insulating wall.

b. For certain special service conditions, one or more additional coverings are required. These additional outer coverings may be of fibrous material or may be of lead. For other special service conditions for multiple conductor cables the number, arrangement and kinds of coverings may be submitted for special approval.

c. The fibrous coverings, either tape or braid, may be applied to the rubber insulated conductor either before or after the process of vulcanizing the rubber compound.

2. **Fibrous Coverings.**

Fibrous coverings are of two types, tapes and braids.

a. TAPES.

x. Tape may be used in the place of a braid except that it may not be the final outer cover of any wire or cable.

50. **Rubber-Covered Wire**—*Continued.*

y. Tapes may be of any suitable width and shall be rubber-filled and shall be at least .010 inch thick. They shall be laid as a helical winding in a workmanlike manner without creases or folds. For sizes of wire larger than No. 8 B. & S. gage the successive convolutions of the tape shall overlap at least ¼ inch. For sizes No. 8 B. & S. gage and smaller the successive turns of the tape shall overlap at least ⅛ inch.

z. It is not considered necessary to establish requirements for or to define the degree to which the tape shall adhere to the surface of the insulating compound or to itself.

b. BRAIDS.

w. Braids must in all cases be closely woven and shall conform in all cases as to thickness, lay and workmanship with approved samples.

Definite minimum requirements for braid construction are under consideration and are being applied experimentally.

x. All braids must be thoroughly saturated with a moisture-proof compound to preserve the cotton fiber.

y. The saturating compound employed may be practically colorless or may be of any color desired.

z. In addition, the manufacturer may apply a finishing compound to the exposed surface of outer braids. The wire should be wiped to remove excess amounts of saturating or finishing compounds.

3. **Lead Coverings.**

a. Lead coverings may be applied to single or multiple conductor cables.

b. For two conductor cables the conductors may be laid parallel or may be twisted together.

c. Lead covered multiple conductor cables with more than two conductors must in all cases have the conductors spirally laid.

d. In all cases the individual conductors in lead-covered cables must have a fibrous covering applied to the surface of the rubber compound. These fibrous coverings shall comply with all the requirements given above for tapes or for braids.

e. There shall be a fibrous covering over the twisted conductors. In two conductor cable with the conductors parallel (twin wire) this enclosing fibrous covering may be omitted.

50. **Rubber-Covered Wire**—*Continued.*

f. The lead covering for wires and cables for working pressures not over 600 volts shall be of the nominal thickness given in the following table. The thickness of lead coverings for cables designed for working pressures of more than 600 volts need not be greater than is called for in the table for a cable of the same number of conductors and of the same diameter under the lead.

g. TABLE OF NOMINAL THICKNESSES FOR LEAD COVERINGS IN INCHES.

Size Conductor. B. & S. Gage.	0-600 Volts Single Conductor Solid or Stranded	0-600 Volts Twin and Twisted Pair Wires
14	2/64ths	2/64ths
12	2/64ths	3/64ths
10	3/64ths	3/64ths
8	3/64ths	3/64ths
6 to 2	4/64ths	4/64ths
1 to 0000	4/64ths	5/64ths
Circular Mils.		
225,000 to 500,000	5/64ths	6/64ths
525,000 to 1,000,000	6/64ths	8/64ths
Over 1,000,000	7/64ths	10/64ths

All Voltages Multiple Conductor

For all cables for use in armored cable the thickness of the lead covering shall be at least two sixty-fourths inch. For all other multiple conductor cables the minimum thickness of lead to be provided shall be according to the inside diameter of the lead tube as follows:

Diameter Not over	Lead Thickness
0.500	3/64ths
0.750	4/64ths
1.125	5/64ths
1.500	6/64ths
2.00	7/64ths
Over 2.00	8/64ths

The average thickness shall not be less than is required in the foregoing and no variation exceeding 10% below the required thickness shall be permitted.

4. **Number of Coverings.**

a. The number of braids or tapes for all wires and cables not lead covered shall not be less than called for in the following:

b. For any single conductor wire or cable there shall be at least one braid for sizes from No. 14 B. & S. gage to and including No. 8 B. & S. gage. For all single conductor cables larger than No. 8 B. & S. gage there must be at least two braids or a tape and a braid.

c. For twin wires, for twisted pair wires, and for all other multiple conductor cables, except as provided in Section C 4 *b,* there shall be a covering of braid at least 1-64 inch in thickness or of tape on each individual wire and in addition there shall be a braid enclosing the parallel or the twisted conductors which shall be not less than 1-64 inch in thickness for conductors No. 10 B. & S. gage and smaller and not less than 1-32

50. **Rubber-Covered Wire**—*Continued.*

inch in thickness for wires larger than No. 10 B. & S. gage. If a tape is used to enclose the parallel or the twisted conductors, as the case may be, it must be supplemented by an outside braid of the required thickness.

Twin wires are wires having two insulated conductors laid parallel and the whole enclosed in an outer covering, either a braid or tape and a braid or lead.

d. Multiple conductor cables having more than two conductors shall in all cases have the individual conductors twisted together and not laid parallel. Fillers of jute or other suitable material may be used.

5. **Miscellaneous.**

a. Twin wires may be used in armored cable only when the twin wires are lead covered (Type Letters ACL). When not lead covered all wires for use in Armored Cable (Type Letters AC) having two or more conductors must have the conductors twisted together in a helical lay.

D Tests.

All tests both on the wires as a whole and on individual test specimens, shall be performed according to specifications.

These test specifications have not been printed here in full as they are of such a nature and require such special apparatus that only well equipped laboratories can make the tests. A copy of the test specifications however will be sent upon request.

The following are the tests specified:—

a. On the Wire as a whole: Voltage Test, Insulation Resistance Test.

b. On Test Specimens: Wrapping Test, Chemical Tests, Physical Tests for recovery, stretch and tensile strength.

51. **Flexible Cords.**

(*For installation requirements, see Rule 32, page 92.*)

Cords for pendant lamps and for portable use including Elevator Lighting and Control Cables and Theatre Stage and Border Cable. (For cords for Portable Heating Apparatus, see Section k, page 117.)

a. Must comply with the requirements of Rule 49 *a* and *b*, page 110.

b. **Conductors.** — Each conductor must have a carrying capacity not less than that of a No. 18 B. & S. gage wire and be built up from wires of the specified sizes.

c. **Insulation.** — The insulation must consist of properly applied and properly vulcanized rubber compound complying with the specified physical and chemical tests.

51. Flexible Cords—*Continued.*

The insulation must be of the nominal thickness given in the following table:

B. & S. Gage.	Thickness, Inches.
18 and 16	1-32
14 to 8	3-64

For exception see Type Letters PS below (Section *f*).

d. **Coverings.** — Each conductor must be covered with a tight, close wind of fine cotton or some other method must be employed to prevent a broken strand puncturing the insulation.

Cords of the several types must comply with the specifications of the following table with respect to their outer protective coverings, and the special rules indicated in the last column of the table.

e. (Type Letters C, CB and CC.) In these classes are included flexible cords which under usual conditions hang freely in air.

f. (Type Letters PO and PS.) These cords are for use only in offices, dwellings or similar places where not liable to rough usage.

For Type PO the conductors may be either laid parallel or twisted together.

Type PS cord may be made only with conductors of No. 18 or No. 16 B. & S. gage and may have insulation only 1-64 inch in thickness.

g. In the outer cover tape may be substituted for an inner braid.

h. (Type Letter T.) Shall consist of not more than three conductors, each not exceeding No. 4 B. & S. gage, twisted together and with a filler. The insulation on each conductor of No. 6 to No. 4 B. & S. gage shall be 1-16 inch in thickness.

i. (Type Letter B.) The conductors must be cabled.

j. (Type Letter E.) Conductors for elevator lighting cables shall not be smaller than No. 14 and for elevator control cables not smaller than No. 16 B. & S. gage.

k. **For Portable Heating Apparatus.** — (Type Letter H.)

This cord is for use with all smoothing and sad irons and with other heating devices requiring over 250 watts.

1. Must comply with the requirements of Rules 49 *a, b* and 51 *b,* pages 110 and 116.

2. The covering must consist of a layer of rubber or other *approved* material at least 1-64 inch thick (the rubber is not subject to the tests specified for other rubber compounds), a braided covering of asbestos 1-32 inch thick and of specified quality, an outer braid 1-64 inch thick enclosing either all the conductors as a whole or each conductor separately.

51. **Flexible Cords**—*Continued.*

Use	Type Letter	Trade Name	Braid on Each Conductor	Reinforcement or Filler	Outer Cover	For Additional Rules See
Pendants Dry Places	C	Lamp Cord	Glazed Cotton or Silk			51e
Pendants Damp Places	CB CC	Brewery Cord Canvasite Cord	Cotton Wp. " "		Cotton Wp.	51e 51e
Portable Dry Places	P PO PS CA PA	Reinforced Cord Parallel Cord Special Reinf. Cord Armored Cord Armored Reinf. Cord	Cotton " " " "	Rubber Jacket Rubber Jacket Rubber Jacket	Glazed Cot. or Silk " " Armor Glazed Cotton and Armor	51f 51f
Portable Damp Places	PWp PkWp PAWp	Reinforced Cord Wp Packinghouse Cord Armored Reinf. Cord Wp.	Cotton " "	Rubber Jacket Filler Rubber Jacket	Cotton Wp, 2 Cotton both Wp. Cotton Wp. and Armor	51g
Theatre Stages	T	Stage Cable	Cotton Wp.	Filler	2 Cotton both Wp.	51g&h
Theatre Borders	B	Border Light Cable	Cotton Wp.		2 Cotton both Wp.	51g&i
Elevator Lighting and Control	E	Elevator Cable	Cotton	Rubber Jacket and or	1 or more Cotton both Wp. 3 Cotton, outer one Wp.	51g&j

52. **Fixture Wire.**

(For installation requirements, see Rule 30, page 90. For construction of Fixtures, see Rule 77, page 159.)

a. Fixtures may be wired with *approved* flexible cord (see Rule 51, page 116), or *approved* rubber-covered wire, (see Rule 50, page 111).

In wiring certain fixtures *approved* slow-burning wire must be used.

For other wires for use in fixtures the following rules apply. (Type Letters F-64 and F-32.)

b. Must comply with the requirements of Rule 49 *a* and *b*, page 110.

c. **Conductors.** — May be either solid or stranded in a specified manner and must not be smaller than No. 18 B. & S. gage.

If stranded conductor is used each conductor must be covered with a tight close wind of fine cotton or some other method must be used to prevent a broken strand puncturing the insulation. Solid conductors must be tinned.

d. **Insulation.** — The insulation must consist of properly applied and properly vulcanized rubber compound complying with the specified physical and chemical tests.

The thickness of insulation shall not be less than 1-64 inch for No. 18 B. & S. gage wire and not less than 1-32 inch for No. 16 B. & S. gage.

e. **Coverings.** — Must be a braid which if of cotton must be at least 1-64 inch in thickness.

53. **Conduit Wire.**

(For installation requirements, see Rule 26 n to p, pages 80 and 81.)

For conduit work wires of Type Letters RS (No. 14 to No. 8 inclusive), RD, RSL or RDL may be used. (See Rule 50, page 111.)

54. **Armored Cable and Cord.** (Type Letters AC, CA, PA and PA Wp.)

(For installation requirements for Armored Cable, see Rule 27, page 83; for Armored Cord, see Rules 32 e and 51, pages 94 and 116.)

a. The armored cable or cord must comply with specified tests for flexibility and for resistance to withdrawal of the conductors from the armor. The armor must comply with specified tests for weight, tensile strength and elongation.

b. Strips if used in forming the armor must be of a specified thickness and if of steel must be protected against corrosion in an approved manner.

c. The conductors must comply with the requirements for

54. **Armored Cable and Cord**—*Continued.*

rubber-covered wires or cords of the specified types and construction.

d. The cable or cord must have a distinctive marker its entire length.

55. **Slow-burning Weatherproof Wire.** (Type Letters SBW.)

(*For installation requirements, see Rule 26 h, page* 78.)

This wire is not as burnable as "weatherproof" nor as subject to softening under heat. It is not suitable for outside work.

a. The insulation must consist of 2 coatings, one to be fireproof and the other weatherproof. The fireproof coating must be on the outside and must comprise about .6 of the total thickness of the wall.

The thickness of the completed covering shall be not less than that specified for rubber insulation of 0-600 volt rubber-covered wires. See Rule 50 B 2 *b,* page 113.)

Fire will not run along this wire under ordinary conditions, and lint will not adhere to its hard, smooth outer surface.

b. Must comply with the requirements of Rule 49 *a* and *b,* page 110.

The fireproof coating should be of the same kind as that required for "slow-burning wire," and finished with a hard, smooth surface.

56. **Slow-burning Wire.** (Type Letters SB.)

(*For installation requirements, see Rule 26 g and h, pages 77 and 78.*)

a. The insulation must consist of 3 braids of cotton or other thread, all the interstices of which must be filled with the fireproofing compound or with material having equivalent fire resisting and insulating properties. The outer braid must be specially designed to withstand abrasion, and its surface must be finished smooth and hard.

The thickness of the completed covering shall be not less than that specified for the rubber insulation of 0-600 volt rubber-covered wires. (See Rule 50 B 2 *b,* page 113.)

b. Must comply with requirements of Rule 49 *a* and *b,* page 110.

This insulation is especially useful in hot, dry places where ordinary insulations would perish, and where wires are bunched as on the back of a large switchboard or in a wire tower, so that the accumulations of rubber insulation would result in an objectionable large mass of highly inflammable material.

Fire will not run along this wire and lint will not adhere to its smooth hard outer surface. It is therefore a good wire for general use in dry places on low-potential systems where the "open" cleat style of wiring is adopted. (See note under Rules 2 *b* and 26 *g*, pages 25 and 77.)

57. **Weatherproof Wire.** (Type Letters WR.)

(For installation requirements, see Rule 26 i and j, page 79.)

a. The insulating covering shall consist of at least three braids, all of which must be thoroughly saturated with a dense moisture-proof compound, which must comply with the specified requirements.

The thickness of the completed covering shall be not less than that specified for the rubber insulation of 0-600 volt rubber-covered wires. (See Rule 50 B 2 *b,* page 113.)

b. Must comply with the requirements of Rule 49 *a* and *b,* page 110.

This wire is for use outdoors, where moisture is certain, and where fireproof qualities are not necessary.

58. **Metal Conduits.**

(For installation requirements, see Rules 26 n to p and 28, pages 80, 81 and 85.)

a. Each length of conduit must have the maker's name or initials stamped in the metal or attached thereto in a satisfactory manner, so that inspectors can readily see the same.

The use of paper stickers or tags cannot be considered satisfactory methods of marking, as they are readily loosened and lost off in the ordinary handling of the conduit.

This requirement makes it difficult for irresponsible makers to successfully get their products on the market, and renders it possible to place the responsibility for faulty pieces.

Rigid.

b. The tube used in the manufacture of the conduit must be of mild steel; and must be of sufficiently true, circular section to admit of cutting true, clean threads; it must be very closely the same in wall thickness at all points. Welds must be thoroughly well made.

c. The tube must be thoroughly cleaned to remove all scale and rust from both the inside and the outside surfaces by some process, mechanical or otherwise, which will permit the protecting coating to take a smooth finish and which will not reduce the weight of the tube sufficiently to cause the finished conduit to weigh less than is given in Section *i,* page 123.

The surfaces of the tube for enameled conduit must be thoroughly washed or otherwise treated to remove all acid left by the pickling solutions if they are used as a part of the cleaning process.

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

58. **Metal Conduits**—*Continued.*

Enameled Conduit.

e. The enamel coating on either the inside or the outside surface of the finished conduit must not soften at ordinary temperatures; it must have an even and smooth appearance and must be of a uniform quality at all points of the length of the tube. It must be of sufficient weight and toughness to resist smashing or flaking and must be of sufficient elasticity to prevent its cracking or flaking at any time up to one year from month of manufacture when ½ inch conduit is bent in a curve, the inner edge of which has a radius of 3½ inches.

The enamel coating must not be seriously affected by soaking at 70 degrees Fahrenheit (21 degrees Centigrade) for 24 hours in any of the following aqueous solutions:—

1. Sulphuric acid of 1.3 specific gravity containing 40 per cent by weight of anhydrous sulphuric acid.
2. Commercial strong hydrochloric acid containing 20 per cent by weight of anhydrous hydrochloric acid.
3. Acetic acid containing 20 per cent by weight of anhydrous acetic acid.
4. Saturated solution of carbonate of soda, containing 20 per cent by weight of anhydrous carbonate of soda.

Conduits with Metallic Coatings.

f. The metallic coating on either the inside or the outside surface of the finished conduit must not soften at ordinary temperatures, and must be of uniform quality at all points of the length of the tube. It must be of sufficient elasticity to prevent its cracking or flaking at any time up to one year from the month of manufacture when ½ inch conduit is bent in a curve, the inner edge of which has a radius of 3½ inches.

This rule does not apply to enamel or other substances applied to interior metallic coatings for the purpose of distinguishing the conduit, from ordinary commercial pipe nor to additional *approved* protective coatings of enamel or other substances applied to either exterior or interior metallic coatings.

All metallic protective coatings on either interior or exterior surfaces must be of an *approved* weight and quality to afford protection against corrosion.

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

g. 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 specifications for conduit so far as they apply.

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

58. **Metal Conduits**—*Continued.*

The taper of threads on conduit must not exceed ¾ inch per foot. The perfect thread must be tapered for its entire length. Couplings must be tapped straight. If threads are cut after the protective coatings are applied they must be treated to prevent corrosion taking place before the conduit is actually installed.

The number of threads and the length of the threaded portion must be approximately in accordance with the following table: —

Electrical Trade size. Inches.	Number of threads per inch.	Length of perfect thread. Inches.	Total length of thread. Inches.
¼	18	0.29	0.57
⅜	18	0.30	0.57
½	14	0.39	0.75
¾	14	0.40	0.76
1	11½	0.51	0.94
1¼	11½	0.53	0.97
1½	11½	0.55	0.98
2	11½	0.58	1.12
2½	8	0.89	1.51
3	8	0.95	1.57
3½	8	1.00	1.62
4	8	1.05	1.67
4½	8	1.10	1.72
5	8	1.16	1.78
6	8	1.26	1.89

i. The finished conduit as shipped must be in 10 foot lengths, with each end reamed and threaded. For each length at least one coupling must be furnished. The finished conduit with coupling must not weigh less than is given in the following table. All finished conduit must be inspected visually, both inside and out, for poor coatings, hard scale or other similar defects. It must have an approved interior coating of a character and appearance which will readily distinguish it from ordinary commercial pipe commonly used for other than electrical purposes.

Electrical Trade size. Inches.	Minimum weight of finished conduit for ten, 10-foot lengths with couplings. Pounds.
¼	38.5
⅜	51.5
½	79.0
¾	105
1	153
1¼	201
1½	249
2	334
2½	527
3	690
3½	831
4	982
4½	1150
5	1344
6	1770

58. **Metal Conduits**—*Continued.*

Flexible Conduit.

j. Must 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.

k. Must be of such design that after a 3-foot sample has been subjected to a tension of 200 pounds for one minute, the conduit will not be opened up at any point.

l. For steel conduits the internal diameter, the thickness of the strip and the weight of the finished conduit must be not less than the values given in the following table. For flexible conduit of other than the strip type an equivalent construction must be provided.

Electrical Trade Size Inches	Internal Diameter Inches	Thickness of Strip Inches	Weight in Pounds per 100 ft.		Radius of Curvatures Inches
			Single Strip	Double Strip	
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

m. If of steel the metal must be thoroughly galvanized or coated with an approved rust preventive. Interior surfaces of the conduit must be free from burrs or sharp edges which might cause abrasion of the wire coverings.

n. Must have a distinctive marking its entire length so that the flexible conduit may be readily identified in the field. Coils must also be plainly tagged or marked with the name or trade-mark of the manufacturing company.

59. **Outlet, Junction and Flush Switch Boxes.**

(*For installation requirements, see Rules 27 and 28, pages 83 and 85. For boxes for panel-boards, cut-outs and switches other than snap switches, see Rule 70, page 144.*)

a. Must be of pressed steel having wall thickness not less than .078 inch (No. 14 U. S. metal gage), or of cast metal having wall thickness not less than ⅛ inch. Junction boxes of larger sizes must comply with requirements of Rule 70, page 144, but must in all cases be of metal.

b. Must be well galvanized, enameled or otherwise properly coated, inside and out, to prevent oxidation.

59. **Outlet, Junction and Flush Switch Boxes**—*Continued.*

It is recommended that the protective coating be of conductive material such as tin or zinc.

c. Must be so made that all openings not in use will be effectively closed by metal which will afford protection substantially equivalent to the walls of the box.

Fittings which are designed for bringing conductors from metal conduits to exposed wiring must be provided with non-absorptive, non-combustible, insulating bushings, which, except with flexible cord, must separately insulate each conductor.

d. Must be plainly marked, where it may readily be seen when installed, with the name or trade-mark of the manufacturer.

e. Must, in case of combination gas and electric outlets, be so arranged that connection with gas pipe at outlet may be made by means of an approved device. Fixture studs, where not a part of the box, must be made of malleable iron or other *approved* material.

Must be arranged to secure in position the conduit or flexible tubing protecting the wire.

This rule will be complied with if the conduit or tubing is firmly secured in position by means of some *approved* device which may or may not be a part of the box.

f. Switch and outlet boxes must 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.

g. Switch and receptacle boxes must completely enclose the switch or receptacle on sides and back, and must provide a thoroughly substantial support for it. The retaining screws for the box must not be used to secure the switch in position. Boxes for floor outlets shall be designed to completely enclose the receptacle and attachment plugs, if any, to protect them from mechanical injury and to exclude moisture.

h. Covers for outlet boxes if made of metal must be equal in thickness to that specified for the walls of the box, or must be of metal lined with an insulating material not less than 1-32 inch in thickness, firmly and permanently secured to the metal. Covers may also be made of porcelain or other *approved* material, provided they are of such form and thickness as to afford suitable protection and strength.

60. **Mouldings.**

(*For installation requirements, see Rule 26 k to m, pages 79 and 80.*)

Wooden Mouldings.

a. Must have, both outside and inside, at least two coats

60. **Mouldings**—*Continued.*

of waterproof material, or be impregnated with a moisture repellent.

This is necessary in order to fill up the pores of the wood and prevent the possibility of its becoming saturated with water.

b. Must be made in two pieces, a backing and a capping, and must afford suitable protection from abrasion. Must be so constructed as to thoroughly encase the wire, be provided with a tongue not less than ½ inch in thickness between the conductors, and have exterior walls which under grooves shall not be less than ⅜ inch in thickness, and on the sides not less than ¼ inch in thickness.

It is suggested that only hard wood be used.

Metal Mouldings.

(*For installation requirements, see Rules 26 k to m and 29, pages 79, 80 and 89.*)

c. Each length of such moulding must have maker's name or trade-mark stamped in the metal, or in some manner permanently attached thereto, in order that it may be readily identified in the field.

The use of paper stickers or tags cannot be considered satisfactory methods of marking, as they are readily loosened and lost off in ordinary handling of the moulding.

This requirement makes it difficult for irresponsible makers to successfully get their products on the market, and renders it possible to place the responsibility for faulty pieces.

d. Must be constructed of iron or steel with backing at least .050 inch in thickness, and with capping not less than .040 inch in thickness, and so constructed that when in place the raceway will be entirely closed; must be thoroughly galvanized or coated with an approved rust preventive both inside and out to prevent oxidation.

e. Elbows, couplings and all other similar fittings must 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 must be free from burrs or sharp corners which might cause abrasion of the wire coverings.

f. Must at all outlets be so arranged that the conductors cannot come in contact with the edges of the metal, either of capping or backing. Specially designed fittings which will interpose substantial barriers between conductors and the edges of metal are recommended.

g. When backing is secured in position by screws or bolts

60. **Mouldings**—*Continued.*

from the inside of the raceway, depressions must be provided to render the heads of the fastenings flush with the moulding.

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

61. **Tubes and Bushings.**

a. **Construction.** — Must be made straight and free from checks or rough projections, with ends smooth and rounded to facilitate the drawing in of the wire and prevent abrasion of its covering.

b. **Material and Test.** — Must be made of non-combustible insulating material, which, when broken and submerged for 100 hours in pure water at 70° Fahr. (21° Cent.) will not absorb over ½ of 1% of its weight.

c. **Marking.** — Must have the name, initials or trade-mark of the manufacturer stamped in the ware.

So that inspectors may know who is responsible for defective fittings.

d. **Sizes.** — Dimensions of walls and heads must be at least as great as those given in the following table: —

Diameter of hole. Inches.	External Diameter. Inches.	Thickness of Wall. Inches.	External Diameter of Head. Inches.	Length of Head. Inches.
5/16	9/16	1/8	13/16	½
3/8	11/16	5/32	15/16	½
½	13/16	5/32	1 3/16	½
5/8	15/16	5/32	1 5/16	½
¾	1 3/16	7/32	1 11/16	5/8
1	1 7/16	7/32	1 15/16	5/8
1¼	1 13/16	9/32	2 5/16	5/8
1½	2 3/16	11/32	2 11/16	¾
1¾	2 9/16	13/32	3 1/16	¾
2	2 15/16	15/32	3 7/16	¾
2¼	3 5/16	17/32	3 13/16	1
2½	3 11/16	19/32	4 3/16	1

An allowance of 1-64 inch for variation in manufacturing will be permitted, except in the thickness of the wall.

62. **Cleats.**

a. **Construction.** — Must hold the wire firmly in place without injury to its covering.

Sharp edges which may cut the wire should be avoided.

b. **Supports.** — Bearing points on the surface must be made by ridges or rings about the holes for supporting screws, in order to avoid cracking and breaking when screwed tight.

c. **Material and Test.** — Must be made of non-combustible in-

62. **Cleats**—*Continued.*

sulating material, which, when broken and submerged for 100 hours in pure water at 70° Fahr. (21° Cent.) will not absorb over ½ of 1% of its weight.

d. **Marking.** — Must have the name, initials or trade-mark of the manufacturer stamped in the ware.

For the same reason as given under Rule 61 *c*, page 127.

e. **Sizes.** — Must conform to the spacings given in the following table: —

Voltage	Distance from Wire to Surface.	Distance between Wires.
0-300	½ inch.	2½ inches.

63. **Flexible Tubing.**

(*For installation requirements see Rules 26 e, s and u, and 85 n, pages 76, 82 and 174.*)

a. Must have a sufficiently smooth interior surface to allow the ready introduction of the wire.

b. Must be constructed of or treated with materials which will serve as moisture repellents.

c. The tube must be so designed that it will withstand all the abrasion likely to be met with in practice.

d. The linings, if any, must not be removable in lengths of over 3 feet.

e. The ¼ inch tube must be so flexible that it will not crack or break when bent in a circle with 6-inch radius at 50° Fahr. (10° Cent.), and the covering must be thoroughly saturated with a dense moisture-proof compound which will not slide at 150° Fahr. (65° Cent.). Other sizes must be as well made.

f. Must not convey fire on the application of a flame from Bunsen burner to the exterior of the tube when held in a vertical position.

g. Must be sufficiently tough and tenacious to withstand severe tension without injury; the interior diameter must not be diminished or the tube opened up at any point by the application of a reasonable stretching force.

h. Must not close to prevent the insertion of the wire after the tube has been kinked or flattened and straightened out.

i. Must have a distinctive marking the entire length of the tube, so that tubing may be readily identified in the field.

64. **Knobs.**

a. **Construction.** — Split knobs must be constructed in two parts, a base and a cap, arranged to hold the wire firmly in place without injury to its covering. Sharp edges must be avoided. Solid knobs must be constructed with smooth groove, to contain wire.

b. **Supports.** — Bearing points on the surface wired over must be made by a ring or by ridges on the outside edge of the base, to provide for stability. At least ¼ inch surface separation must be maintained between the supporting screw or nail and the conductor, and the knob must 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) must be so constructed as to require the use of two supporting screws.

c. **Material and Test.** — Must be made of non-combustible, insulating material, which, when broken, and submerged for 100 hours in pure water at 70° Fahr. (21° Cent.) will not absorb over ½ of 1% of its weight.

d. **Marking.** — Must have the name, initials or trade-mark of the manufacturer stamped in the ware.

For the same reason as given under Rule 61 *c*, page 127.

e. **Sizes.** — Must be so constructed as to separate the wire at least 1 inch from the surface wired over, and also conform to the following minimum dimensions: —

Size of Wire Inclusive.	Size of Base. Inches.			Solid Knobs, Groove. Inches.		Split Knobs, Thickness of Cap, Inches from Top of Wire Groove.
	Circular Knobs, Diameter.	Square Knobs or Single Wire Cleats.				
B. & S. Gage and Circular Mils.		Width.	Length.	Depth.	Diameter.	
14–10	1⅛	¾	1¾	3/16	¼	⅜
8–4	1½	⅞	2	5/16	5/16	⅝
2–00	2	1	2¼	7/16	⅝	⅝
000–300,000	2½	1⅛	2¾	7/16	25/32	⅞
400,000–1,000,000	3	1⅜	3¾	⅝	1¼	1

65. **Switches.**

(*For installation requirements, see Rules 8 c, 19, 20 b and 24, pages 35, 63, 65 and 71.*)

General Rules.

a. Must, when used for service switches, indicate, on inspection, whether the current be "on" or "off."

b. Must, for constant-current systems, close the main circuit and disconnect the branch wires when turned "off"; must be so constructed that they shall be automatic in action, not stopping between points when started, and must prevent an arc between the points under all circumstances. They must indicate whether the current be "on" or "off."

Knife Switches.

Knife switches must be made to comply with the following Specifications, except in those few cases where peculiar design allows the switch to fulfill the general requirements in some other way, and where it can successfully withstand the test of Section *i*. In such cases the switch should be submitted for special examination before being used.

c. **Base.** — Must be mounted on non-combustible, non-absorptive insulating bases. Other materials than slate, marble or porcelain must be submitted for special examination before being used. Bases with an area of over 25 square inches must have at least 4 supporting screws. Holes for the supporting screws must be so located or countersunk that there will be at least ½ 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 must be countersunk.

d. **Mounting.** — Pieces carrying the contact jaws and hinge clips must be secured to the base by at least 2 screws, or else made with a square shoulder, or provided with dowel-pins, to prevent possible turnings, and the nuts or screw-heads on the underside of the base must be countersunk not less than ⅛ inch and covered with a waterproof compound which will not melt below 150° Fahr. (65° Cent.).

If the contact jaws or hinge clips get turned so as to be out of line, it may be impossible to close the switch, especially at the first attempt, and severe arcing may result from the efforts to do so. Even if the blade enters the jaws, the contact may be imperfect, causing undesirable heating.

e. **Hinges.** — Hinges of knife switches must 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 must be of sufficient strength to take up any wear in the hinge and maintain a good contact at all times.

f. **Metal.** — All switches must have ample metal for stiffness and to prevent rise in temperature of any part of over 50°

65 **Switches** —*Continued.*

Fahr. (28° Cent.), 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 1 square inch for each 75 amperes; the whole device must be mechanically well made throughout.

Too little attention is frequently given the question of mechanical strength, with the result that after a comparatively short time of service the switches rattle to pieces or break unless very carefully handled, and even then repairs are often necessary to keep them in working order. A cheap switch is seldom a rugged, durable device.

g. **Cross-Bars.** — All cross-bars less than 3 inches in length must be made of insulating material. Bars of 3 inches and over, which are made of metal to insure greater mechanical strength, must be sufficiently separated from the jaws of the switch to prevent arcs following from the contacts to the bar on the opening of the switch under any circumstances. Metal bars should preferably be covered with insulating material.

To prevent possible turning or twisting the cross-bar must be secured to each blade by 2 screws, or the joints made with square shoulders or provided with dowel-pins.

If each blade is secured to the cross-bar by only one screw, without dowel pins or a square shoulder fitting closely in a recess in the bar, a slight loosening of the screws will allow one blade to close and open the circuit before the other, resulting in arcing and ultimate injury to the switch. Such construction is also liable to result in a weak switch.

h. **Connections.** — Switches for currents of over 30 amperes must be equipped with lugs, firmly screwed or bolted to the switch, and into which the conducting wires shall be soldered. For switches designed for currents of 30 amperes or less heavy clamps or screw and washer connections with upturned lugs may be used.

A set screw gives a contact at only one point, is more likely to become loosened, and is almost sure to cut into the wire.

See also Rule 16 *c*, page 58.

i. **Test.** — Must operate successfully at 50% overload in amperes and at rated voltage, under the most severe conditions with which they are liable to meet in practice.

This test is designed to give a reasonable margin between the ordinary rating of the switch and the breaking-down point, thus securing a switch which can always safely handle its normal load. Moreover, there is enough leeway so that a moderate amount of overloading would not injure the switch.

j. **Marking.** — Must 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, must be marked 250 V., D. C., 500 V., A. C. When 250-volt fuse terminals are

65. **Switches**—*Continued.*

mounted on the switch base the marking of the switch must be 250 V., D. C. and A. C. When 600-volt fuse terminals are mounted on the switch base the terminals must be spaced for 600-volt fuses and the switches marked 500 V., A. C.

Triple pole switches designed with 125-volt spacings between adjacent blades must be marked 125 volts and may be used on 3-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 3-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.

The name of the maker renders it possible to place the responsibility for defects.

k. **Spacings and Dimensions.** — Spacings and dimensions must be at least as great as those given in the following tables: —

Table 1.

NOT OVER 125 VOLTS D. C. AND A. C.

For Switchboards and Panel Boards: —

		Width and Thickness, Inches Blades.	Clips and Hinges.	Minimum separation of nearest metal parts of opposite polarity. Inches.	Minimum break distance. Inches.
30	amperes	½ x 5/64	½ x 3/64	1	¾
60	"			1¼	1

Table 2.

NOT OVER 125 VOLTS D. C. AND A. C.

For individual switches: —

30	amperes	½ x 5/64	½ x 3/64	1¼	1
60 & 100	"			1½	1¼
200	"			2¼	2
400 & 600	"			2¾	2½
800 & 1000	"			3	2¾

A 300-ampere switch with the spacings of the 200-ampere switch above may be used on switchboards.

Table 3.

250 VOLTS ONLY, D. C. AND A. C.

For all switches: —

30	amperes	½ x 5/64	½ x 3/64	1¾	1½

Table 4.

NOT OVER 250 VOLTS D. C. NOR OVER 500 VOLTS A. C.

For all switches: —

30	amperes	⅝ x ⅛	⅝ x 1/16	2¼	2
60 & 100	"			2¼	2
200	"			2½	2¼
400 & 600	"			2¾	2½
800 & 1000	"			3	2¾

A 300-ampere switch with the spacings of the 200-ampere switch above may be used on switchboards.

65. **Switches**—*Continued.*

Cut-out terminals on switches for over 250 volts must be designed and spaced for 600 volt fuses.

Table 5.

NOT OVER 600 VOLTS D. C. AND A. C.

For all switches:—

		Width and Thickness, Inches. Blades.	Clips and Hinges.	Minimum separation of nearest metal parts of opposite polarity. Inches.	Minimum break distance. Inches.
30	amperes	⅝ x ⅛	⅝ x 1/16	4	3½
60	"			4	3½
100	"			4½	4

Where barriers of *approved* design and made of suitable non-absorptive, non-combustible, insulating material or of impregnated hard wood are placed between parts of opposite polarity the minimum separation of these parts on switches described in Table 5 may be that given in Table 4.

Auxiliary contacts of either a readily renewable or a quick-break type or the equivalent are recommended for D. C. switches, designed for over 250 volts, and must be provided on D. C. switches designed for use in breaking currents greater than 100 amperes at a voltage of over 250.

For 3-wire direct current and 3-wire single phase systems the separation and break distances for plain 3-pole knife switches must not be less than those required in the above table for switches designed for the voltage between the neutral and outside wires.

Snap Switches.

Flush, push-button, door, fixture and other snap switches used on constant-potential systems, must be constructed in accordance with the following specifications.

l. **Base.** — Current-carrying parts must be 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 ⅛ inch. There must in no case be less than 3-64 inch space between supporting screws and current-carrying parts.

Sub-bases must be so designed as to separate the wires at least ½ inch from the surface wired over. They must be of a non-combustible, non-absorptive insulating material, except for use with wooden moulding, where they may be of hard wood.

m. **Mounting.** — Pieces carrying contact jaws must be secured to the base by at least 2 screws, or else made with a square shoulder, or provided with dowel-pins or otherwise arranged, to prevent possible turnings; and the nuts or screw heads on the under side of the base must be countersunk not less than ⅛ inch, and covered with a waterproof compound which will not melt below 150° Fahr. (65° Cent.).

65. **Switches**—*Continued.*

n. **Metal.** — All switches must have ample metal for stiffness and to prevent rise in temperature of any part of over 50° Fahr. (28° Cent.) at full load. The whole device must be mechanically well made throughout.

o. **Insulating Material.** — Any material used for insulating current-carrying parts must retain its insulating and mechanical strength when subject to continued use, and must not soften at a temperature of 212° Fahr. (100° Cent.).

p. **Binding Posts.** — Binding posts must be substantially made and the screws must be of such size that the threads will not strip when set up tight. Switches with the set-screw form of contact will not be approved.

A set screw is likely to become loosened, and is almost sure to cut into the wire. A binding screw under the head of which the wire may be clamped and a terminal plate provided with upturned lugs or some other equivalent arrangement, afford reliable contact.

q. **Covers.** — Covers made of conducting material, except face plates for flush switches, must be lined on sides and top with tough and tenacious insulating material at least 1-32 inch in thickness, firmly secured so that it will not fall out with ordinary handling. The side lining must extend slightly beyond the lower edge of the cover.

Without this lining there is danger of the cover forming a short-circuit in the switch, especially if the cover is removed or replaced while the switch is "alive." The side lining should extend at least 3-64 inch beyond the lower edge of the cover.

r. **Handle or Button.** — The handle or button or any exposed parts must not be in electrical connection with the circuit.

s. **Test.** — Must "make" and "break" with a quick snap, and must not stop when motion has once been imparted by the button or handle.

Must operate successfully at 50% overload in amperes and at 125 volts direct current, for all 125 volt or less switches and at 250 volts direct current, for all 126 to 250 volt switches under the most severe conditions which they are liable to meet in practice. For switches rated higher than 10 amperes, this test shall be at 25% overload instead of 50%.

When slowly turned "on" and "off" at a rate not to exceed 10 times per minute, while carrying the rated current at rated voltage, must "make" and "break" the circuit 6,000 times before failing.

t. **Marking.** — Must 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 may be placed on the sub-plate. On surface switches with covers constructed of

65. **Switches**—*Continued.*

porcelain or other moulded insulating material the marking may be on the inside of the cover. On all other types they must be placed on the *front* of the cap, cover or plate.

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

Indicating switches are much preferred for all work, as by showing at once whether the current is "on" or "off" they tend to save mistakes and possible accidents. The fact that lights do not burn or that a motor does not run is not necessarily a sure sign that the current is off, but the indicating switch makes it possible to tell at a glance whether the circuit is open or closed.

66. **Circuit Breakers.**

(*For installation requirements, see Rules 8 c, 19, 23 e and f, pages 35, 63, 69 and 71.*)

Circuit Breakers for operation on circuits of 550 volts or less must be made to comply with the following specifications, except in those few cases where peculiar design allows the breaker to fulfill the general requirements in some other way, and where it can successfully withstand the test of Sections c and d. In such cases the breakers should be submitted for special examination and approval before being used.

a. **Base.** — Must be mounted on non-combustible, non-absorptive, insulating bases, such as slate or marble. Bases with an area of over 25 square inches must have at least 4 supporting screws. Holes for the supporting screws must be so located or countersunk that there will be at least ½ 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 must be countersunk.

b. **Mounting.** — Pieces carrying contact parts must be screwed to the base by at least 2 screws, or else made with a square shoulder, dowel-pin, or equivalent device, to prevent possible turning, and the nuts or screw heads on the under side of the base of "front connected" breakers must be countersunk not less than ⅛ inch, and covered with a waterproof compound which will not melt below 150° Fahr. (65° Cent.). All breakers must be provided with easily accessible means of tripping them by hand without injury to the operator.

c. **Breaking Capacity.** — Must successfully operate 3 times with 2 minute intervals intervening without incapacitating the breaker, the conditions of testing current to be as given in the following table: —

Current rating of breakers.	Per cent of voltage drop in test circuit with rated current flowing.	Minimum available capacity of supply system not including overload capacity.
0 to 100 Amperes	2	1,000 Amperes
101 to 300 Amperes	3	3,000 Amperes
400 Amperes	4	4,000 Amperes
500 Amperes	5	5,000 Amperes

66. **Circuit Breakers**—*Continued.*

No filing of contacts or other repairing of the breaker to be made during the test.

Multiple breakers must comply with above requirements whether the test is on all poles at once or on one pole individually.

The above test is designed to represent service conditions.

In the event of an overload or short circuit, usually two or more attempts to close the breaker are made before the cause of the breaker opening is discovered and removed.

d. **Voltage Test.** — Must successfully withstand 2,000 volts A. C. for 1 minute between live metal and ground, between poles in multi-polar breaker, and between terminals with breaker open.

e. **Carrying Capacity.** — The maximum rise in temperature at rated current must not exceed 90° Fahr. (50° Cent.) for coils, or 54° Fahr. (30° Cent.) for other parts.

f. **Calibration.** — Must not have a plus or minus error greater than 10% at any point of its calibration.

g. **Mechanism.** — Metal work of automatic overload circuit breakers must be substantial in construction, and must have ample metal for stiffness. The contact parts shall be arranged so that thoroughly good bearings are obtained; the entire device must be mechanically well made throughout.

h. **Marking.** — Must be plainly marked, where it will be visible when installed, with the name of the maker and the current and voltage for which the device is designed.

For the same reasons that similar requirements were made for switches. (See note under Rule 65 *j*, page 131.)

67. **Cut-Outs.**

(For installation requirements, see Rules 8 c, 19, 23, 25 a and 33 a, pages 35, 63, 67, 73 and 94.)

These requirements do not apply to rosettes, attachment plugs, car lighting cut-outs, and protective devices for signaling systems.

General Rules.

a. Must be supported on bases of non-combustible, non-absorptive, insulating material.

b. Cut-outs must 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.

c. Cut-outs must operate successfully on short-circuits, under the most severe conditions with which they are liable to meet in practice, at 25% above their rated voltage, and for

67. **Cut-Outs**—*Continued.*

link fuse cut-outs with fuses rated at 50% 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 enclosed fuse cut-outs classified as required under Section *o*. 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, and it is with these conditions that all tests should be made. (See Section *i*.)

d. Must be marked where it will be plainly visible when installed with the name of the maker, and current and voltage for which the device is designed.

For the same reasons that similar requirements were made for switches. (See note under Rule 65 *j*, page 131.)

It is also desirable to mark cut-outs on completed systems with the size of fuse which should be used in them. This will lessen the liability of a melted fuse being replaced with one too large to properly protect the wires.

Link-Fuse Cut-Outs.

The following rules 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 must be enclosed in cabinet boxes made to meet the requirements of Rule 70, page 144. 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.

e. **Base.** — Must be mounted on bases made of strong non-combustible, non-absorptive, insulating material. The design of the base must 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 25 square inches must have at least 4 supporting screws. Holes for supporting screws must be kept outside of the area included by the outside edges of the fuse-block terminals, and must be so located or counter-sunk that there will be at least ½ inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part.

The proper thickness of the base depends very largely upon the size of the cut-out, but even for the smaller sizes the bases should generally be at least ⅜ inch thick.

f. **Mounting.** — Nuts or screw-heads on the under side of the base must be countersunk not less than ⅛ inch, and covered with a waterproof compound which will not melt below 150° Fahr. (65° Cent.).

g. **Metal.** — All fuse-block terminals must have ample metal for stiffness and to prevent rise in temperature of any part of over 50° Fahr. (28° Cent.) at full load. Terminals,

67. **Cut-Outs**—*Continued.*

as far as practicable, should be made of compact form instead of being rolled out in thin strips; and sharp edges or thin projecting pieces, as on wing thumb nuts and the like, should be avoided. Thin metal, sharp edges and projecting pieces are much more likely to cause an arc to start than a more solid mass of metal. It is a good plan to round all corners of the terminals and to chamfer the edges.

h. **Connections.** — Clamps for connecting the wires to the fuse-block terminals must be of solid, rugged construction. so as to insure a thoroughly good connection and to withstand considerable hard usage. For fuses rated at over 30 amperes, lugs firmly screwed or bolted to the terminals and into which the conducting wires shall be soldered must be used.

See note under Rule 65 *h,* page 131.

i. **Test.** — Must operate successfully in tests repeated at least 25 times when blowing only one fuse at a time on short-circuits with fuses rated at 50% above and with a voltage 25% above the current and voltage for which the cut-out is designed.

j. **Spacings.** — Spacings must be at least as great as those given in the following table, which applies only to plain, open link fuses. The spaces given are correct for fuse-blocks to be used on direct-current systems, and can therefore be safely followed in devices designed for alternating currents. If the copper fuse-tips overhang the edges of the fuse-block terminals, the spacings should be measured between the nearest edges of the tips.

	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 "

A space must be maintained between fuse terminals of the same *polarity* of at least ½ inch for voltages up to 125 and of at least ¾ inch for voltages from 126 to 250. This is the minimum distance allowable, and greater separation should be provided when practicable.

For 250 volt boards or blocks with the ordinary front-connected terminals, except where these have a mass of compact form, equivalent to the back-connected terminals usually found in switchboard work, a substantial barrier of insulating material, not less than ⅛ inch in thickness, must be placed in the "break" gap — this barrier to extend out from the base at least ⅛ inch farther than any bare live part of the fuse-block terminal, including binding screws, nuts and the like.

For 3-wire systems cut-outs must have the break-distance required

67. **Cut-Outs**—*Continued.*

for circuits of the potential of the outside wires, except that in 125-250 volt systems with grounded neutral the cut-outs in 2-wire, 125 volt branch circuits may have the spacings specified for not over 125 volts.

Enclosed-Fuse Cut-Outs — Plug and Cartridge Type.

k. **Base.**—Must be made of non-combustible, non-absorptive, insulating material. Blocks with an area of over 25 square inches must have at least 4 supporting screws. Holes for supporting screws must be so located or countersunk that there will be at least ½ inch space, measured over the surface, between the screw-head or washer and the nearest live metal part, and in all cases when between parts of opposite polarity must be countersunk.

l. **Mounting.** — Nuts or screw-heads on the under side of the base must be countersunk at least ⅛ inch and covered with a waterproof compound which will not melt below 150° Fahr. (65° Cent.).

m. **Terminals.** — Except for sealable service and meter cut-outs, terminals must be of either the Edison plug, spring clip or knife blade type, of *approved* design, to take the corresponding standard enclosed fuses. They must be secured to the base by 2 screws or the equivalent, so as to prevent them from turning, and must be so made as to secure a thoroughly good contact with the fuse. End stops must be provided to insure the proper location of the cartridge fuse in the cut-out.

n. **Connections.** — Clamps for connecting wires to the terminals must be of a design which will insure a thoroughly good connection, and must be sufficiently strong and heavy to withstand considerable hard usage. For fuses rated to carry over 30 amperes, lugs firmly screwed or bolted to the terminals and into which the connecting wires shall be soldered must be used.

See also Rule 16 *c*, page 58.

It is recommended that the clamps for the main wires in branch cut-outs be designed to securely hold a wire at least as large as No. 0 B. & S. gage; for it is frequently desired to connect such cut-outs to these larger wires. If the clamps are poor or are too small, loose connections and heating may result, or some less desirable method of wiring may be used.

o. **Classification.** — Must be classified as regards both current and voltage as given in the following table, and must 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 "	

67. **Cut-Outs**—*Continued.*

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 "

p. **Design.** — Must be of such a design that it will not be easy to form accidental short circuits across live metal parts of opposite polarity on the block or on the fuses in the block.

68. **Fuses.**

(*For installation requirements, see Rules 8 c, 19, 23, 25 a and 33 a, pages 35, 63, 67, 73 and 94.*)

Link Fuses.

a. **Terminals.** — Must have contact surfaces or tips of harder metal, having perfect electrical connections with the fusible part of the strip.

The use of the hard metal tip is to afford a strong mechanical bearing for the screws, clamps or other devices provided for holding the fuse.

b. **Rating.** — Must be stamped with about 80% of the maximum current which they can carry indefinitely, thus allowing about 25% overload before the fuse melts.

With naked open fuses, of ordinary shapes and with not over 500 amperes capacity, the *minimum* current which will melt them in about 5 minutes may be safely taken as the melting point, as the fuse practically reaches its maximum temperature in this time. With larger fuses a longer time is necessary. This data is given to facilitate testing.

c. **Marking.** — Fuse terminals must be stamped with the maker's name or initials, or with some known trade-mark.

For reasons entirely similar to those given under Rule 65 *j*, page 131.

Enclosed Fuses — Plug and Cartridge Type.

These requirements do not apply to fuses for rosettes, attachment plugs, car-lighting cut-outs and protective devices for signaling systems.

d. **Construction.** — The fuse casing must be sufficiently dust-tight so that lint and dust cannot collect around the fusible wire and become ignited when the fuse is blown.

The fusible wire must be attached to the terminals in such a way as to secure a thoroughly good connection and to make it difficult for it to be replaced when melted.

The fuse casing should also be so tight that the requirements for test (see Section *k*) may be fulfilled.

e. **Classification.** — Must be classified to correspond with the different classes of cut-out blocks, and must be so designed

68. **Fuses**—*Continued.*

that it will be impossible to put any fuse of a given class into a cut-out block which is designed for a current or voltage lower than that of the class to which the fuse belongs.

f. **Terminals.** — The fuse terminals must be sufficiently heavy to insure mechanical strength and rigidity. The styles of terminals, except for use in sealable service and meter cut-outs, must be as follows:—

NOT OVER 250 VOLTS:

0-30 Amps.	*A.* Cartridge fuse (ferrule contact). *B.* Approved plugs or cartridge fuses in approved casings for Edison plug cut-outs not exceeding 125 volts, but including any circuit of a three-wire 125-250 volt system with grounded neutral.
31-60 "	Cartridge fuse (ferrule contact) for use also in approved casings for large size Edison plug type 250-volt cut-outs.
61-100 " 101-200 " 201-400 " 401-600 "	Cartridge fuse (knife blade contact).

NOT OVER 600 VOLTS:

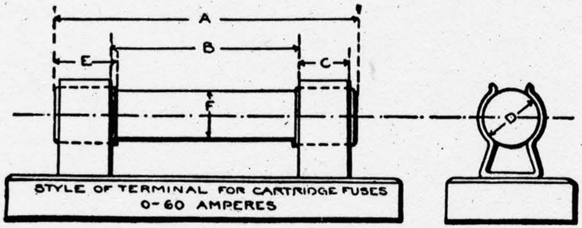
0-30 Amps. 31-60 "	Cartridge fuse (ferrule contact).
61-100 " 101-200 " 201-400 "	Cartridge fuse (knife blade contact).

g. **Dimensions.** — Cartridge enclosed fuses and corresponding cut-out blocks, except for sealable service and meter cut-outs, must conform to the dimensions give in the table on page 142.

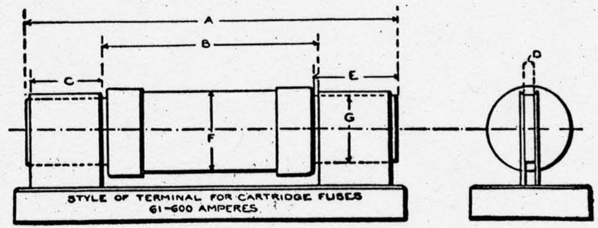
h. **Rating.** — Fuses must be so constructed that with the surrounding atmosphere at a temperature of 75° Fahr. (24° Cent.) they will carry indefinitely a current 10% greater than that at which they are rated, and at a current 25% greater than the rating, they will open the circuit without reaching a temperature which will injure the fuse tube or terminals of the fuse block. With a current 50% greater than the rating and at room temperature of 75° Fahr. (24° Cent.), the fuses starting cold, must blow within 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 "

68. **Fuses**—*Continued.*



Form 1. CARTRIDGE FUSE — Ferrule Contact.



Form 2. CARTRIDGE FUSE — Knife-Blade Contact.

Voltage.	Rated Capacity. Amperes.		A Length over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches.	D Diameter of Ferrules or Thickness of Terminal Blades. Inches.	E Min. Length of Ferrules or of Terminal Blades outside of Tube. Inches.	F Diameter of Tube. Inches.	G Width of Terminal Blades. Inches.		Rated Capacity. Amperes.
0-250	0-30	Form 1	2	1	1/2	9/16	1/2	1/2		Form 1	0-30
	31-60	Form 1	3	1 3/4	5/8	13/16	5/8	3/4		Form 1	31-60
	61-100	Form 2	5 7/8	4	7/8	1/8	1	1	3/4	Form 2	61-100
	101-200	Form 2	7 1/8	4 1/2	1 1/4	3/16	1 3/8	1 1/2	1 1/8	Form 2	101-200
	201-400	Form 2	8 5/8	5	1 3/4	1/4	1 7/8	2	1 5/8	Form 2	201-400
	401-600	Form 2	10 3/8	6	2 1/8	1/4	2 1/4	2 1/2	2	Form 2	401-600
251-600	0-30	Form 1	5	4	1/2	13/16	1/2	3/4		Form 1	0-30
	31-60	Form 1	5 1/2	4 1/4	5/8	1 1/16	5/8	1		Form 1	31-60
	61-100	Form 2	7 7/8	6	7/8	1/8	1	1 1/4	3/4	Form 2	61-100
	101-200	Form 2	9 5/8	7	1 1/4	3/16	1 3/8	1 3/4	1 1/8	Form 2	101-200
	201-400	Form 2	11 5/8	8	1 3/4	1/4	1 7/8	2 1/2	1 5/8	Form 2	201-400

68. **Fuses**—*Continued.*

i. **Marking.** — Must be marked, where it will be plainly visible, with the name or trade-mark of the maker, the voltage and current for which the fuse is designed, and the words "National Electrical Code Standard." Each fuse must have a label, the color of which must be green for 250-volt fuses and red for 600-volt fuses.

It will be satisfactory to abbreviate the above designation to "N. E. Code St'd" where space is necessarily limited.

j. **Temperature Rise.** — The temperature of the exterior of the fuse enclosure must not rise more than 125° Fahr. (70° Cent.) above that of the surrounding air when the fuse is carrying the current for which it is rated.

k. **Test.** — Must not hold an arc or throw out melted metal or sufficient flame to ignite easily inflammable material on or near the cut-out when only one fuse is blown at a time on a short-circuit on a system of the voltage for which the fuse is rated.

The normal capacity of the system must be in excess of the load on it just previous to the test by at least 5 times the rated capacity of the fuse under test.

The resistance of the circuit up to the cut-out terminals must be such that the impressed voltage at the terminals will be decreased 1% when a current of 100 amperes is passed between them.

For convenience a current of different value may be used, in which case the per cent. drop in voltage allowable would vary in direct proportion to the difference in current used.

The above requirement regarding the capacity of the testing circuit is to guard against making the test on a system of so small capacity that the conditions would be sufficiently favorable to allow really poor fuses to stand the test acceptably. On the other hand, it must be remembered that if the test is made on a system of very large capacity, and especially if there is but little resistance between the generators and fuse, the conditions may be more severe than are liable to be met with in practice outside of the large power stations, the result being that fuses entirely safe for general use may be rejected if such test is insisted upon.

69. **Panel Boards.**

The following specifications are intended to apply to all panel and distributing boards used for the control of light and power circuits, but not to such switchboards in central stations, sub-stations or isolated plants as directly control energy derived from generators or transforming devices.

a. **Design.** — The specifications for construction of switches and cut-outs (see Rules 65 and 67, pages 130 and 136) must be followed as far as they apply.

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, except in the case of service switches, when Rule 23 *a*, page 67, must be complied with. When the branch switches are between the fuses and bus-bars,

69. **Panel Boards**—*Continued.*

the connections must 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 ½ inch must be provided between such live metal parts and the cabinet in which board is mounted.

b. **Spacings.** — The following minimum distance between bare live metal parts (bus-bars, etc.) must be maintained: —

	Between parts of opposite polarity, except at switches and link fuses.		Between parts of same polarity.
	When mounted on the same surface.	When held free in air.	At link fuses.
Not over 125 volts,	¾ inch	½ inch	½ inch
" " 250 "	1¼ "	¾ "	¾ "
" " 600 "	2 "	1¾ "	

At switches or enclosed fuses, parts of the same polarity may be placed as close together as convenience in handling will allow.

It should be noted that the above distances are the minimum allowable, and it is urged that greater distances be adopted wherever the conditions will permit.

The spacings given in the first column apply to the branch conductors where enclosed fuses are used. Where link fuses or knife switches are used, the spacings must be at least as great as those required by Rules 65 and 67, pages 130 and 136.

The spacings given in the second column apply to the distance between the raised main bars and between these bars and the branch bars over which they pass.

The spacings given in the third column are intended to prevent the melting of a link fuse by the blowing of an adjacent fuse of the same polarity.

Panel boards of special design in which the insulation and separation between bus-bars and between other current-carrying parts is secured by means of barriers or insulating materials instead of by the spacings given above, must be submitted for special examination and approval before being used.

c. **Marking.** — Must 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.

70. Cabinets and Cut-Out Boxes.

For Cut-Outs, Switches, Circuit Breakers, Feeder and Branch Circuit Panel-boards, etc.

(For installation requirements, see Rules 8 d, 19 b-e and 23 c, pages 38, 64, 65 and 68.)

General.

Design.

a. The design and construction must be such as to insure ample strength, rigidity and interior spacings. The following general and special requirements including those for hinges, latches, etc., will usually provide these conditions. Other constructions and details as well as special designs of hinges, latches, etc., must be submitted for special approval before being used.

70. Cabinets and Cut-Out Boxes—*Continued.*

b. The spacing within cabinets and boxes must be sufficient to provide ample room for the distribution of wires and cables and for the required separation between metal parts and current-carrying parts of devices and apparatus.

There must be an air space of at least 1-16 inch except at points of support, between the base of the device and the wall of the cabinet or box on which the device is mounted.

Must be deep enough to allow the doors to be closed when 30-ampere branch circuit panel-board 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.

Construction.

c. Cast metal cabinets and boxes shall be at least ⅛ inch in thickness, and must conform as far as practicable to the following requirements for sheet metal construction.

Sheet metal cabinets and boxes must be so constructed as to insure ample strength and rigidity in order that they shall keep their shape, and that doors shall close tightly. The thickness of the metal used must not be more than 6% less than the nominal thickness of the gage specified. Completed cabinets and cut-out boxes must either be of galvanized metal or must be painted or enameled to prevent corrosion. Seams at corners, back edges and splices in sheets must be flanged or lapped over unless made with a continuous weld, or they may be butt-jointed if reinforced by angle or flat iron strips of a thickness not more than one gage less than the thickness of the sheet. Flanged or lapped seams and splicing strips must be riveted at points located not over 1½ inches from the ends of seams and not over 6 inches between rivets. Seams must not show open cracks when finished and before they are painted or enameled.

Fittings.

d. Doors hung directly to the sides of the cabinet or box proper must shut closely against a rabbet providing a lap of at least ¼ inch or must have either turned flanges for the full length of all four edges or angle strips riveted to them. These flanges or angle strips must fit closely to the outside of the walls of the cabinet or box proper and must overlap the edges of the box at least ½ inch.

Strips used to provide rabbets or angle strips fastened to edges of the door must be riveted at points not more than 1½ inches from the ends of strips and at points not more than 6 inches between rivets in the length of the strips.

e. Rivets, screws, bolts and similar fastenings in sheet metal cabinets and boxes shall be of a diameter at least 50%

70. **Cabinets and Cut-Out Boxes**—*Continued.*

greater than the thickness of the sheet metal with which they are used. Spot welds, screws and bolts will be considered the equivalent of rivets. Metal into which screws are threaded should always provide for the engagement of at least 2 full threads. Where possible ends of screws or bolts shall be headed over.

f. Holes for metal conduit, armored cable or flexible tubing in cabinets and boxes intended for stock, and not made for a particular location must be provided with knockouts, covers or plugs of metal not less than No. 16 U. S. gage, which must be so secured in place that they may be removed readily but will not drop out with ordinary handling.

g. Cabinets and cut-out boxes must be marked with the manufacturer's name or trade-mark, so that the marking can be plainly seen when they are installed.

h. For wet locations and out-of-door service must be at least 1/8 inch in thickness if of cast metal and of No. 10 U. S. gage if of sheet metal and must be so designed and constructed that a beating rain or moisture running down conduits or wall will not allow water to enter. They must be provided with external fastenings for mounting. Hinges must be of cast metal or of sheet bronze. Threaded holes for conduits must be reinforced to provide metal at least 1/4 inch in thickness. Bushed holes for open wiring must not be located either in the top or back, except when special hood fittings are provided, and when located in the sides must be formed to provide a downward direction for wires leaving the cabinet or cut-out box. When of sheet iron or steel, the completed cabinet or cut-out box after forming shall be well galvanized, and when made of other materials shall be treated to give protection from corrosion.

Cabinets.

For enclosing cut-outs, switches, circuit breakers, distributing boards, panel-boards and similar devices.

Design.

i. Cabinets may be designed for either surface or flush mounting and are usually provided with removable frames or mats, trims, etc., in which swinging doors are hung. When for the enclosure of apparatus connected within the cabinet to the wires of more than 4 circuits not including the supply circuit or a continuation thereof, they shall have a back wiring space or one or more side wiring spaces, side gutters or side wiring compartments unless the wires leave the cabinet directly opposite their terminal connections.

j. There must be an air space of at least 1 inch between the current carrying parts of any enclosed fuse or other de-

70. **Cabinets and Cut-Out Boxes**—*Continued.*

vice and the door, unless the door is lined with an approved insulating material or is of a thickness at least that of No. 12 U. S. gage when the air space must be not less than ½ inch.

There must be a space of at least 2 inches between open link fuses and metal or metal-lined walls or metal, metal-lined or glass-paneled doors.

Except as noted above there must be an air space of at least ½ inch between the walls, back, gutter partition, if of metal, or door and the nearest exposed current-carrying part of devices mounted within the cabinet where the potentials do not exceed 250 volts. This spacing must be increased to at least 1 inch where the potentials exceed 250 volts.

Cabinets having one or more side wiring spaces, side gutters or side wiring compartments must be furnished with covers, barriers or partitions extending around or from the side or sides of all bases or groups of bases of the switches, cut-outs, circuit breakers or feeder and circuit branch panel-boards within the cabinet and providing a close fit with the door, frame or sides of the cabinet so as to enclose these spaces, gutters or compartments and the wires stowed within them. At sides where wires or cables are led from the cabinet at points directly opposite their terminal connections to devices or apparatus within the cabinet, and other wires or cables are not placed, these covers, barriers or partitions may be omitted.

When cabinets have back wiring spaces which are not entirely enclosed, covers must be furnished to provide equivalent enclosure.

Construction.

k. Cabinets shall be made of cast or sheet metal, except that wood may be used for doors and trims as covered in Section *m,* below.

Sheet metal, except for "weatherproof" cabinets, must be of not less than No. 14 U. S. gage and when any surface exceeds 1200 square inches in area or any dimensions exceeds 4 feet the sheet metal used must be at least No. 10 U. S. gage.

l. When the box proper is made of 1 piece not less than 2 rivets must be used at each corner and an additional rivet shall be used for each 3 inches or fraction in depth in excess of 6 inches. When the box proper exceeds 6 inches in depth or 24 inches in length or width it must have all 4 edges reinforced for their full length by turning them at least 90 degrees or by angle iron strips.

Fittings.

m. When door frames (fronts, trims, mats, etc.) are used, whether for flush or surface mounted cabinets, and the doors are hung to the frame and not to the side wall of the box proper the frame must be fastened to the box. There must

70. Cabinets and Cut-Out Boxes—*Continued.*

be at least 1 fastening located not more than 6 inches from each of the four corners of the box, and fastenings shall not be placed more than 24 inches apart along the sides of the frame. Fastening screws or screws of clamps securing frames in position must not be less than 5-32 inch in diameter (No. 8 size) for frames not exceeding 360 square inches in area and not less than 3-16 inch in diameter for larger frames.

Metal frames (fronts, trims, mats, etc.) and doors for sheet metal cabinets must be of a thickness at least that of the box proper.

Wooden frames (fronts, trims, mats, etc.) and doors must be made of well seasoned material at least ¾ inch thick, thoroughly filled, painted or varnished and shall be put together with mortised joints or their equivalent. Wherever exposed to the interior of the cabinet the wood frame or door must be lined with sheet metal at least No. 16 U. S. gage, or with rigid asbestos board ⅛ inch thick, and secured firmly in place.

n. Double doors must be provided where the door opening exceeds 24 inches in width. Meeting edges of double doors must be rabbeted at least ¼ inch.

Doors hung in frames must shut closely against a rabbet providing a lap of at least ¼ inch and formed as a permanent part of either the box proper, the frame or the door itself.

Glass panels in doors must be at least ¼ inch in thickness, must fit tightly in the door and must be firmly supported for the full length of all sides.

o. Barriers in cabinets having side wiring spaces, side gutters, or side wiring compartments must be firmly secured in position and must fit closely with the bases of devices and with the frame or door. If the wire spaces are exposed when doors are open, covers must be provided to entirely enclose them.

Barriers of sheet metal must be of at least No. 14 U. S. gage and when more than 24 inches in length must be either reinforced or flanged at both top and inner edges or must be of at least No. 12 U. S. gage. Holes in metal barriers for wires and cables must be bushed.

Slate and marble barriers must be at least ½ inch thick. Composition barriers must be submitted for special approval.

p. Hinges for doors must be of strong and durable design and of metal not less than 3-64 inch in thickness for doors not over 12 inches in either dimension, and not less than 1-16 inch for all larger doors. At least 2 hinges must be provided on each door. Hinges must be spaced not to ex-

70. Cabinets and Cut-Out Boxes—*Continued.*

ceed 4 inches from the ends of doors and not more than 24 inches apart, distances to be measured from the centers of hinges. Each leaf of detachable hinges must be securely fastened to the doors and to the side walls or the frames of cabinets by not less than 2 screws, rivets or the equivalent.

q. Latches must be of substantial design and construction, and must be provided for all doors. They must have their parts securely fastened to the doors, side walls or frames by not less than 2 screws, rivets or the equivalent, and must have a substantial knob or vault door handle or other means for readily opening doors. Single doors not over 48 inches long must be provided with not less than 1 latch placed near the center of the side of the door. Single doors over 48 inches long, and all double doors regardless of their length, must have a 3-point latch operated by a single knob or handle and holding the doors closed at points near the center, top and bottom of the sides of the doors. All latches must engage edges of doors, side walls or frame at least ⅛ inch.

The above does not require separate latching devices to be attached to the door which closes first, in the case of double doors.

A lock may be used if desired, but if used shall be in addition to the latch or in combination with the latch.

r. Lamp receptacles and similar fittings placed on barriers or elsewhere within cabinets must be of approved patterns and must be securely mounted.

Cut-Out Boxes.

For enclosing cut-outs, switches, circuit breakers, distributing boards, panel-boards and similar devices, when the devices within the cut-out box are connected to the wires of not more than four circuits, not including the supply circuit or a continuation thereof.

Design.

s. Cut-out boxes are usually designed for surface mounting and have swinging doors or covers secured directly to a wall of the box. When intended for installation out-of-doors they shall be of the "weatherproof" pattern.

t. There must be an air space of at least 1 inch between the current-carrying parts of any enclosed fuse or other device and the door, unless the door is lined with an approved insulating material.

There must be a space of at least 2 inches between open link fuses and the door or walls.

Except as noted above, there must be an air space of at least ½ inch between the walls, back or door and the nearest

70. **Cabinets and Cut-Out Boxes**—*Continued.*

exposed current-carrying part of devices mounted within the cut-out box where the potentials do not exceed 250 volts. This spacing must be increased to at least 1 inch where the potentials exceed 250 volts.

Construction.

u. Cut-out boxes shall be made of cast or sheet metal and shall not have any surface exceeding 360 square inches in area or any dimension exceeding 24 inches.

Sheet metal shall be of at least No. 16 U. S. gage.

v. When the box proper of sheet metal cut-out boxes is made of one piece and does not exceed 4 inches in depth only 1 rivet need be used at each corner. For deeper boxes, not less than 2 rivets shall be used at each corner and an additional rivet shall be used for each 3 inches or fraction in depth in excess of 6 inches. When the box proper exceeds 6 inches in depth it must have all 4 edges reinforced for their full length by turning them at least 90 degrees or by angle iron strips.

Fittings.

w. When the door frames are used, whether for flush or surface mounted cut-out boxes and the doors are hung to the frame and not to the side wall of the box proper the frame must be fastened to the box. There must be at least 1 fastening located not more than 6 inches from each of the four corners of the box. Fastening screws or screws of clamps securing frames in position must not be less than 5-32 inch in diameter (No. 8 size).

Doors and door frames, if used for sheet metal cut-out boxes, must be entirely of metal of a thickness at least that of the box proper.

Doors hung in frames must shut closely against a rabbet providing a lap of at least ¼ inch and formed as a permanent part of either the box proper, the frame or the door itself. Meeting edges of double doors, if used, must be rabbeted at least ¼ inch.

x. Hinges for doors must be of strong and durable design, and of metal not less than 3-64 inch in thickness for doors not over 12 inches in either dimension, and not less than 1-16 inch for all larger doors. At least 2 hinges must be provided on each door. Hinges must be spaced not to exceed 4 inches from the ends of doors, distances to be measured from the centers of hinges. Each leaf of detachable hinges must be securely fastened to the doors and to the side walls or door frames by not less than 2 screws, rivets or the equivalent.

y. Latches must be of substantial design and construc-

70. **Cabinets and Cut-Out Boxes**—*Continued.*

tion, and must be provided for all doors. They must have their parts securely fastened to the doors and side walls or frames by not less than 2 screws, rivets or the equivalent, and must have a substantial knob or vault door handle or other means for readily opening doors. Doors must be provided with not less than 1 latch placed near the center of the side of the door. Double doors must have a 3-point latch operated by a single knob or handle and holding the doors closed at points near the center, top and bottom of the sides of the doors. All latches must engage edges of doors, side walls or frame at least ⅛ inch.

The above does not require separate latching devices to be attached to the door which closes first in the case of double doors.

A lock may be used if desired, but if used shall be in addition to the latch or in combination with the latch.

z. Lamp receptacles and similar fittings placed within cut-out boxes must be of approved patterns and must be securely mounted.

71. **Rosettes.**

Ceiling rosettes, both fused and fuseless, must be constructed in accordance with the following specifications:—

a. **Base.** — Current-carrying parts must be mounted on non-combustible, non-absorptive, insulating bases. There should be no openings through the rosette bases except those for the supporting screws and in the concealed type for the conductors also, and these openings should not be made any larger than necessary.

There must be at least ¼ inch space, measured over the surface, between supporting screws and current-carrying parts. The supporting screws must be so located or countersunk that the flexible cord cannot come in contact with them.

Bases for the knob and cleat type must have at least 2 holes for supporting screws; must be high enough to keep the wires and terminals at least ½ inch from the surface to which the rosette is attached, and must have a porcelain lug under each terminal to prevent the rosette from being placed over projections which would reduce the separation to less than ½ inch.

Bases for the moulding and conduit box types must be high enough to keep the wires and terminals at least ⅜ inch from the surface wired over.

b. **Mounting.** — Contact pieces and terminals must be secured in position by at least 2 screws, or made with a square shoulder, or otherwise arranged to prevent turning.

The nuts or screw heads on the under side of the base must be countersunk not less than ⅛ inch and covered with

71. **Rosettes**—*Continued.*

a waterproof compound which will not melt below 150° Fahr. (65° Cent.).

c. **Terminals.** — Line terminal plates must be at least .06 inch in thickness, and terminal screws must not be smaller than No. 6 standard screw with about 32 threads per inch.

Terminal plates for the flexible cord and for fuses must be at least .06 inch in thickness. The connection to these plates must be by binding screws not smaller than No. 5 standard screw with about 40 threads per inch. At all binding screws for line wires and for flexible cord, up-turned lugs, or some equivalent arrangement, must be provided which will secure the wires being held under the screw-heads.

d. **Cord Inlet.** — The diameter of the cord inlet hole should measure 13-32 inch in order that standard portable cord may be used.

e. **Knot Space.** — Ample space must be provided for a substantial knot tied in the cord as a whole.

All parts of the rosette upon which the knot is likely to bear must be smooth and well rounded.

f. **Cover.** — When the rosette is made in 2 parts, the cover must be secured to the base so that it will not work loose.

In fused rosettes, the cover must fit closely over the base so as to prevent the accumulation of dust or dirt on the inside, and also to prevent any flash or melted metal from being thrown out when the fuses melt.

g. **Marking.** — Must 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 may be rated 3 amperes, 250 volts; fused rosettes, with link fuses, not over 2 amperes, 125 volts.

h. **Test.** — Fused rosettes must have a fuse in each pole and must operate successfully when short-circuited on the voltage for which they are designed, the test being made with the 2 fuses in circuit.

When link fuses are used the test shall be made with mounting screws in position, and grounded, and with loose cotton placed about the device. The fuse wire should melt at about 7 amperes in 1-inch length. No destructive arcing or inoperative conditions should result after six tests on the same sample.

Fused rosettes equipped with enclosed fuses are much preferable to the link fuse rosettes.

72. Sockets and Lamp Receptacles.

(*For installation requirements, see Rule 31, page 92.*)

a. **Classification.** — Lamp-holding devices to be classed accord-

72. **Sockets and Lamp Receptacles**—*Continued.*

ing to diameters of lamp bases, as Candelabra, Medium and Mogul Base, to be known respectively as ½ inch, 1 inch and 1½ inch nominal sizes, with ratings as specified in the following table:—

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

(*a*) This rating may be given only to sockets having a switch mechanism which produces both a quick "make" and a quick "break" action.

(*b*) Ratings to be assigned later, pending further discussion with manufacturers.

Miniature sockets and receptacles having screw shells smaller than the candelabra size may be used for Decorative Lighting Systems, Christmas Tree Lighting outfits, and similar purposes. (See Rue 37, page 100.)

b. **Marking.** — All sockets and receptacles must 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 to be rated as specified above, the device being marked with a single marking applying to each end.

c. **Shell.** — Metal used for shells must be moderately hard, but not hard enough to be brittle or so soft as to be easily dented or knocked out of shape. Brass shells must be at least .013 inch in thickness, and for Mogul sockets not less than .025 inch, and shells of any other material must be thick enough to give the equivalent stiffness and strength.

d. **Lining.** — The inside of metal shells must be lined with insulating material, which must absolutely prevent the shell from becoming a part of the circuit, even though the wires inside the sockets should become loosened or detached from their position under the terminal screws.

The material used for lining must be at least 1-32 inch in thickness, and must be firm, compact, tough and tenacious. It must not be injuriously affected by the heat from the largest lamp permitted in the socket, and must leave water in which it is boiled practically neutral. It is preferable to have the

72. **Sockets and Lamp Receptacles**—*Continued.*

lining in one piece. The lining must not extend beyond the metal shell more than 1/8 inch, but must prevent any current-carrying part of the lamp base from being exposed when a lamp is in the socket.

The cap must also be lined, and this lining must comply with the requirements for shell linings.

The length of the candelabra lamp base is 5/8 inch, that of the medium lamp base is 15-16 inch and that of the Mogul lamp is 1 5/8 inches in a vertical plane from the bottom of the centre contact to the upper edge of the screw shell.

In sockets and receptacles of standard forms a ring of any material inserted between an outer metal shell of the device and the inner screw shell for insulating purposes and separable from the device as a whole, is considered an undesirable form of construction. This does not apply to the use of rings in lamp clusters or in devices where the outer shell is of porcelain, where such rings serve to hold the several porcelain parts together, and are thus a necessary part of the whole structure of the device.

e. **Cap.** — Caps when made of sheet brass must be at least .013 inch in thickness and .025 for Mogul sockets, and when cast or made of other metals must be of equivalent strength.

The inlet piece must contain sufficient metal for 5 full threads, and when not in one piece with the cap must be riveted or otherwise secured to give the strength of a single piece.

In pendant sockets there must be sufficient room in the cap for a knot in the cord without crowding. All parts of the cap upon which the knot is likely to bear must be smooth and well insulated.

The cap lining called for in Section *d* will provide a sufficiently smooth and well-insulated surface for the knot to bear upon.

f. **Frame and Screws.** — The frame which holds the moving parts must be sufficiently heavy to give ample strength and stiffness.

Brass pieces containing terminal screws must be sufficiently heavy to give ample strength and stiffness, and have at least .06 inch of thread for terminal screws.

Terminal post screws must not be smaller than No. 5 standard screw, with about 40 threads per inch.

g. **Spacing.** — For candelabra sockets and medium size sockets rated at 250 volts, points of opposite polarity must everywhere be kept not less than 3-64 inch apart, and for Mogul sockets and sockets rated at 600 volts not less than 1/8 inch apart, provided, however, if substantial barriers of approved insulating material are used to separate such parts, these distances may be correspondingly reduced, but in no event must the separation distances measured over the surfaces of the barriers be less than those specified above.

h. **Connections.** — The parts to which wiring connections are made must be designed to securely grip the conductors. An

72. **Sockets and Lamp Receptacles**—*Continued.*

upturned lug or some equivalent arrangement must be provided to hold the wires under the screw heads.

i. **Lamp Holder.** — The socket must firmly hold the lamp in place so that it cannot be easily jarred out and must provide a contact good enough to prevent undue heating with the maximum current allowed. The holding pieces, springs and the like, if a part of the circuit, must not be sufficiently exposed to allow them to be brought in contact with anything outside of the lamp and socket.

j. **Base.** — The base on which current-carrying parts are mounted must be of porcelain or other non-combustible, non-absorptive, insulating material approved for such use.

k. **Key.** — The key handle must not soften or become injured when used to operate the socket at a temperature of 150 degrees Fahr. The handle should be thoroughly substantial and securely, but not necessarily, rigidly attached to the spindle or lever which it is designed to control.

l. **Sealing.** — All screws in porcelain pieces, which can be firmly sealed in place, must be so sealed by a waterproof compound which will not melt below 200° Fahr. (93° Cent.).

m. **Assembly.** — The socket as a whole must be so put together that parts will not rattle loose or fall apart under the most severe conditions they are likely to meet with in practice. The base of the socket must be secured or held in the shell in such a manner as to prevent turning or displacement relative to the shell.

n. **Test.** — Sockets when slowly turned "on" and "off" at a rate of approximately 10 times per minute, while carrying a load of 6-10 of an ampere at 125 volts for Candelabra, and 1 ampere and 3 amperes at 250 volts for Medium sized 250-watt and 660-watt sockets respectively, must "make" and "break" the circuit 6,000 times before failing, and when new must operate successfully at least 50 times at 50% in excess of the above currents based on either 125 and 250 volts direct current and except for pull sockets when operated in either direction in any position.

The candelabra socket, being rated at 125 volts only, should not be subjected to 250-volt tests.

o. **Keyless Sockets.** — Keyless sockets of all kinds must comply with the requirements for key sockets as far as they apply.

p. **Sockets of Insulating Material.** —Sockets made of porcelain or other insulating material must conform to the above requirements as far as they apply, and all parts must be strong

72. **Sockets and Lamp Receptacles**—*Continued.*

enough to withstand a moderate amount of hard usage without breaking.

Lead wires furnished as a part of sockets and intended to be exposed after installation must be of *approved* stranded, rubber-covered wire, not less than No. 14 B. & S. gage (No. 18 B. & S. gage for candelabra sockets), be sealed in place and spaced at the point of entrance to the shell a distance of ¼ inch in the clear from each other, or from exterior metal parts of the socket.

q. **Inlet Bushing.**—When the socket is not attached to a fixture, the inlet, if threaded, must have not less than ⅜ inch pipe size and must be provided with a strong insulating bushing. The edges of the bushing must be rounded and all inside fins removed, so that in no place will the cord be subjected to the cutting or wearing action of a sharp edge.

Bushings for sockets having threaded outlets should have a hole not less than 9-32 inch in diameter for plain pendant cord, and 13-32 inch in diameter for reinforced cord.

73. Hanger-Boards for Series Arc Lamps.

(For installation requirements, see Rules 21 d and 22 b, pages 66 and 67.)

a. Hanger-boards must be so constructed that all wires and current-carrying devices thereon will be exposed to view and thoroughly insulated by being mounted on a non-combustible, non-absorptive, insulating substance. All switches attached to the same must be so constructed that they shall be automatic in their action, cutting off both poles to the lamp, not stopping between points when started and preventing an arc between points under all circumstances.

74. Arc Lamps.

(For installation requirements, see Rules 21 and 33, pages 66 and 94).

a. Must be provided with reliable stops to prevent carbons from falling out in case the clamps become loose.

b. All exposed parts must be carefully insulated from the circuit.

c. Must, for constant-current systems, be provided with an *approved* hand switch, and an automatic switch that will shunt the current around the carbons, should they fail to feed properly.

The hand switch to be approved, if placed anywhere except on the lamp itself, must comply with requirements for switches on hanger-boards as laid down in Rule 73.

74. **Arc Lamps**—*Continued.*

d. Terminals must be designed to secure a thoroughly good and permanent contact with the supply wires, which contact must not become loosened by motion of the lamp during trimming.

75. **Spark Arresters.**

(*For installation requirements, see Rules 21 c and 33 c, pages 66 and 95.*)

a. Spark arresters must so close the upper orifice of the globe that it will be impossible for any sparks, thrown off by the carbons, to escape.

76. **Insulating Joints.**

(*For installation requirements, see Rule 30 a, page 90.*)

a. **Materials.** — All materials excepting metal parts and materials used for exterior finish and waterproofing must be hard and must resist the action of illuminating gases.

Metal parts of joints and studs must be of malleable iron, mild steel, or tough brass of such quality as to permit the parts to bend considerably before breaking when subjected to light hammer blows.

Materials used for exterior finish and waterproofing of joints and studs must finish smooth and hard, and be insulating as well as non-absorptive and should preferably be non-combustible.

b. **Design.** — Insulating joints (not studs designed to be mounted with screws or bolts) must have a substantial exterior metal casing insulated from both screw connections.

✱ All exposed surfaces of insulating materials of joints and studs must be smooth, hard and waterproof. Such insulating materials as are absorptive must have exposed surfaces waterproofed.

Stops must be provided to limit the length of the threaded connections at insulating joints and studs. Shoulders, if provided as stops, must be at least 3-64 inch wide and 1-16 inch thick.

The edges of the holes forming the gas-ways of joints must be free from burrs, fins, or similar projections liable to reduce the insulating distance between the screw connection castings.

c. **Threading.** — Screw connections of joints and studs must be taper threaded. The pitch and form of threads must conform to the Briggs' standard for standard wrought-iron pipe or to the standard for brass tubing as given in the following table: —

76. **Insulating Joints**—*Continued.*

Trade size Inches.	Wrought-Iron Pipe. Outside Diameter. Inches.	Wrought-Iron Pipe. Threads per Inch.	Brass Tubing. Outside Diameter Inches.	Brass Tubing. Threads per Inch.
⅛	.405	27		
¼	.540	18	¼	27
⅜	.675	18	⅜	27
½	.840	14	½	27
¾	1.050	14	¾	27
1	1.315	11½		
1¼	1.660	11½		
1½	1.900	11½		
2	2.375	11½		
2½	2.875	8		
3	3.500	8		

Threads must be full and clean cut.

The threaded portion of joints and studs must be provided with at least 5 threads, and holes should be well centered in castings.

d. **Hickeys.** — Hickeys, if provided as a part of joints and studs, must be of malleable iron, mild steel or tough brass, of such quality as to permit the parts to bend considerably before breaking when subjected to light hammer blows.

Hickeys must have smooth, rounded edges to prevent injury to wire coverings.

The threaded portions of hickeys must be provided with at least 5 full and clean-cut threads conforming to the same standard as the threads on the joint or stud of which they form a part.

e. **Heat Test.** — Insulating joints and studs must be made entirely of material (with the exception of exterior finishing or waterproofing material) that is non-combustible and that will not give way or soften when subjected to the heat of a ½ inch Bunsen gas flame regulated so that the air is shut off and the flame reduced to a height of two inches. In this test the joint or stud is to be held about 1 inch above the flame, and subjected to heat from this flame for about 5 minutes or until all parts of the joint or stud are thoroughly heated. While the joint or stud is heated to this temperature, one screw connection casting is to be held rigidly while a force of about 30 pounds is applied to the other, first in a direction to tighten the screw connection, then in a direction to bend the joint on its axis, the force being applied at the end of a 10 inch lever arm. The materials must not soften so that one casting can be moved relative to the other.

f. **Leakage Test.** — Each insulating joint having female thread connections which are not "blank ended" in the castings must be tested and show no leak when subjected to an air pressure of not less than 25 pounds per square inch for 1 minute. In this test one end of the joint is to be closed while air pressure is applied at the other end to the joint immersed in water.

76. **Insulating Joints**—*Continued.*

The joint must not leak (as shown by the formation of air bubbles) during the 1 minute period.

g. **Dielectric Strength Test.** — Each insulating joint and stud must be tested and show a dielectric strength sufficient to resist throughout 1 minute, the application of an alternating current voltage, derived from apparatus of not less than 1,500 watts capacity, of 4,000 volts between screw connections and 3,000 volts between either screw connection separately and the exterior metal casing.

h. **Torsion Test.** — Insulating joints and studs must be able to withstand, without injury, the application to screw connection or base castings of a twisting force of 30 pounds applied at the end of a lever arm at least as great as is given in the following table. In this test the joint or stud is to have one screw connection or its base held to prevent turning while the force is applied to the other casting in a direction to tighten up the screw connection.

The force is to be applied slowly and steadily. The center of the joint is to be considered as the point of application of the force. There must be no movement of one casting relative to the other and the joint or stud must be able to withstand after this test, the tests specified under Sections *f* and *g*.

Largest Size of Pipe Upon Which Joint or Stud can be Threaded	Length of Lever Arm, Inches.			
	Torsion.		Bending.	
Inch.	Joints.	Studs.	Joints.	Studs.
1/8	10	10	5 1/2	5 1/2
1/4	20	20	9 1/2	9 1/2
3/8	30	30	13 1/2	9 1/2
1/2 and larger	30	30	22	9 1/2

i. **Bending Test.** — Insulating joints and studs must be able to withstand without injury, the application to screw connection or base castings, of a bending force of 100 pounds applied at the end of a lever arm at least as great as given in the table under Section *h.* In this test the joint or stud is to have one screw connection or its base held rigidly while the bending force is applied to the other casting. The force is to be applied slowly and steadily. The center of the joint is to be considered as the point of application of the force. There must be no movement of one casting relative to the other and the joint or stud must be able to withstand after this test, the tests specified under Sections *f* and *g*.

j. **Marking.** — Each joint and stud must be marked with the name or trade-mark of the manufacturer.

77. Fixtures.

(*For installation requirements, see Rule 30, page 90. For construction of Wires, see Rule 52, page 119.*)

a. **Mechanical Construction.** — Fixtures must be of metal or wood,

77. Fixtures—*Continued.*

except that other materials to be used must be submitted for special examination before being used. Materials other than metal must be reinforced by metal, or the fixtures otherwise constructed to secure requisite mechanical strength.

In all fixtures not made entirely of metal, mechanical strength must be secured practically equivalent to an all-metal fixture of similar size and form.

In all fixtures not made entirely of metal, wireways must be metal lined unless *approved* armored conductors with suitable fittings are used. An exception is made in the case of wireways in glass, marble or similar non-absorptive, non-combustible insulating materials.

All arms must be reliably secured, to prevent turning by threading and soldering, brazing, threading locked by set screw or an equivalent method.

With screw joints of arms and stems there must be not less than 5 threads all engaging at fixture supports, fixture bodies, etc.

All methods of fastening arms or making joints between metal parts by threading, brazing or otherwise, must be such as to secure in every case ample strength and reliability.

Sockets must, except on pendant cords, be attached to the metal of the fixtures and must be secured in a reliable and permanent manner by threading locked by set-screws or brazing or an equivalent method.

All burrs and fins in wire-ways must be removed and all sharp edges at points where wires emerge from arms, stems, chains, etc., must when practicable, be removed or rounded, but in every case it must be possible to pull in and also to withdraw the wires without injuring them.

Where supply wires enter casings of fixture stems in either straight electric or combination gas and electric fixtures, there must be suitable fittings having smooth, rounded edges to prevent injury to the wire coverings and to prevent the wires from coming into contact with the edges of the ends of casings.

Fixtures for installation outdoors or where exposed to moisture must be so constructed that water cannot enter the wireways, sockets or other electrical parts.

b. **Electrical Construction.** — Conductors must be not smaller than No. 18 B. & S. gage.

The following table showing the allowable current-carrying capacity of copper wires must be followed.

(Sockets and receptacles will be considered as requiring not less than 40 watts each.)

77. **Fixtures**—*Continued.*

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

On chains or similar parts where conductors are not completely enclosed in metal, the conductors must be stranded and must have rubber insulation not less than 1-32 inch in thickness. Wires and flexible cords must, when fixtures are externally wired, be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture, and must be protected against abrasion where they pass through sheet metal pans, canopies, etc.

Conductors must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered (unless made with some form of *approved* splicing device) and covered with an insulation equal to that on the conductors, *i. e.,* with both rubber and friction tape. Wires must, within the arms and stems, be without splices and taps, *i. e.,* it should not be necessary to withdraw the wires to inspect splices and taps.

Receptacles must be so installed as to afford permanent and reliable means to prevent possible turning relative to the surfaces on which they are mounted.

Receptacles having exposed terminals must not be used in canopies unless completely enclosed in metal.

c. **Materials.** — Tubing used in threaded arms and stems must not be lighter than No. 18 B. & S. gage. The thickness of unthreaded arms will depend largely upon the method used, and all methods of fastening arms or stems must be such as to secure in every case strength equivalent to that of a threaded connection. Such methods must be submitted for examination, test and approval. Tubing should not be kinked, flattened or cracked.

Canopies must be made sufficiently large, except where outlet boxes are used, to permit the storing away of splices to fixture leads and to allow supply conductors, and especially the splices to wires to be kept clear of the grounded part of gas pipes.

All methods of fastening arms or stems to fixture supports must be such as to secure in every case strength equivalent to that of a threaded connection.

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

77. **Fixtures**—*Continued.*

wire especially approved for the purpose, must be used in wiring fixtures in which the wiring is exposed, from the heat of lamps to temperatures in excess of 120° Fahr. (49° Cent.). All such forms of fixtures must be submitted for examination, test and approval before being introduced for use.

All fixtures should, where possible, be sufficiently ventilated to avoid exposing the wiring to high temperatures, and the wiring of fixtures should be so disposed as to be kept as free as possible from excessive temperatures.

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

Canopy insulators, if provided, must be of *approved* types. They must be securely fastened in place so as to separate the canopies thoroughly and permanently from the surfaces and outlet boxes from which they are designed to be insulated. A strip of a good grade of hard fiber 1-16 inch thick, permanently attached to the canopy at the ends, and at intermediate points in such a manner that the strip will permanently extend at least 3-16 inch beyond the entire upper edge of the canopy rim will be acceptable. Where the above construction is impracticable a sheet of a good grade of hard fiber 1-16 inch thick, permanently attached to the canopy and cut to conform to the general outline of the canopy and with the edges of the sheet at least flush with the edges of the canopy will be acceptable. The insulating strip or sheet must be secured by rivets or screws and the rivets or screws must be so located or countersunk that the desired effective insulation distance is obtained.

d. **Tests.** — Each fixture (after wiring and assembly) must 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.

e. **Markings.** — Each fixture must be marked with the manufacturer's name or trade-mark.

78. Rheostats, Resistance Boxes and Equalizers.

(For installation requirements, see Rules 4 a and 8 c, pages 29 and 35.)

a. **Materials.** — Must be made entirely of non-combustible materials, except such minor parts as handles, magnet insulation, etc. All segments, lever arms, etc., must be mounted on non-combustible, non-absorptive, insulating material.

Holes for the supporting screws which secure this material in position must be so located or countersunk that there will be at least ½ inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part.

78. **Rheostats, Resistance Boxes and Equalizers**—*Continued.*

Rheostats used in dusty or linty places or where exposed to flyings of combustible material, must be so constructed that even if the resistive conductor be fused by excessive current, the arc or any attendant flame will be quickly and safely extinguished. Rheostats used in places where the above conditions do not exist may be of any approved type.

Wood or other suitable material may be used for parts of the casings or covers of drum controllers, providing these parts are properly lined or treated with fire-resisting materials, and so arranged that should the combustible parts within the casing be ignited, the fire would be confined within the casing or cover.

In drum controllers and apparatus of like nature, where the controlling mechanism is entirely enclosed in a substantial tight metal case or compartment, hard wood or other suitable material may be used for bases for mounting current-carrying parts, or for other parts which cannot readily be made of non-combustible material, provided such combustible material is present only in such amount and so disposed that, even if it be totally destroyed by fire or excessive heat, the effect shall be confined to the interior of the case.

b. **Construction.** — Must be so constructed that when mounted on a plane surface the casing will make contact with such surface only at the points of support. An air space of at least ¼ inch between the rheostat casing and the supporting surface will be required.

The construction throughout must be heavy, rugged and thoroughly workmanlike.

c. **Connections.** — Clamps for connecting wires to the terminals must be of a design which will insure a thoroughly good connection, and must be sufficiently strong and heavy to withstand hard usage. For currents above 30 amperes, lugs into which the connecting wires shall be soldered, or approved solderless connectors must be used. Clamps or lugs will not be required when leads are provided as a part of the device.

See also Rule 16 *c*, page 58, regarding soldering of wires at terminal connections.

d. **Marking.** — Must be plainly marked, where it may be readily seen after the device is installed, with the rating and the name of the maker; and the terminals of motor-starting rheostats must be marked to indicate to what part of the circuit each is to be connected, as "line," "armature" and "field."

e. **Contacts.** — The design of the fixed and movable contacts and the resistance in each section must be such as to secure the least tendency toward arcing and roughening of the contacts, even with careless handling or the presence of dirt.

In motor-starting rheostats, the contact at which the circuit is broken by the lever arm when moving from the running to the starting position, must be so designed that there will be no detrimental arcing. The final contact, if any, on which the arm is brought to rest in the starting position must have no electrical connection.

78. **Rheostats, Resistance Boxes and Equalizers**—*Continued.*

Experience has shown that sharp edges and segments of thin material help to maintain an arc, and it is recommended that these be avoided. Segments of heavy construction have a considerable cooling effect on the arc, and rounded corners tend to spread it out and thus dissipate it.

It is recommended that the circuit-breaking contacts be so constructed as to "break" with a quick snap, independently of the slowness of movement of the operator's hand, or that a magnetic blowout or equivalent device be used. For dial type rheostats the movable contact should be flexible in a plane at right angles to the plane of its movement, and for medium and larger sizes the stationary contacts should be readily renewable.

f. **No-Voltage Release.** — Motor-starting rheostats must be so designed that the contact arm cannot be left on intermediate segments, and for direct current circuits must be provided with an automatic device which will interrupt the supply circuit before the speed of the motor falls to less than ⅓ of its normal value. In motor-starting rheostats for alternating current circuits the automatic interrupting device may be omitted.

g. **Overload Release.** — Overload release devices which are inoperative during the process of starting a motor will not be approved, unless other circuit-breakers or fuses are installed in connection with them.

If, for instance, the overload release device simply releases the starting arm and allows it to fly back and break the circuit, it is inoperative while the arm is being moved from the starting to the running position.

h. **Test.** — Must, after 100 operations under the most severe normal conditions for which the device is designed, show no serious burning of the contacts or other faults, and the release mechanism of motor-starting rheostats must not be impaired by such a test.

Field rheostats, or main-line regulators, intended for continuous use, must not be burned out or depreciated by carrying the full normal current on any step for an indefinite period. Resistances intended for intermittent use (such as on electric cranes, elevators, etc.) must be able to carry their rated current on any step for as long a time as the character of the apparatus which they control will permit them to be used continuously.

Starting duty resistances for direct-current motors shall be so constructed that when the voltage marked on the name-plate or not more than 10% in excess thereof is applied to the main line terminals, and the starting arm or other starting mechanism is operated at such a rate that the current through the resistance does not fall below the rated full load current, and this test is continued for not more than 3 minutes, there shall be no resultant flaming or moulten droppings; or if the resistance conductor is fused, the arc or any attendant flame or moulten droppings shall be confined within the rheostat.

Starting duty resistances for alternating current motors shall be tested as specified above for direct current starting

78. **Rheostats, Resistance Boxes and Equalizers**—*Continued.*

resistances, except that for starters especially designed for squirrel cage or single phase motors the test conditions shall be so modified either by reduction in the applied voltage or by the use of supplementary resistances as to produce approximately the same current conditions as will be met with in service.

Continuous duty resistances shall either be so constructed that if the resistance element be fused the arc or any attendant flame or molten droppings shall be confined within the rheostat or they shall be so constructed with such capacity that if subjected to a current flow throughout the whole or any part of the resistance element, 25% in excess of that at which they are rated, for a period of 2 hours, there shall be no resultant flaming or molten droppings.

79. Auto-Starters.

(*For installation requirements, see Rule 8 d, page 38.*)

Construction and Test of Auto-Starters Ranging to a Maximum of 100 Horse Power and 3,500 Volts.

Under this class are included all such devices for starting A. C. motors as employ transformer windings whereby the potential impressed upon the motor terminals during process of starting may be made less than the full line voltage and which have switching devices for accomplishing this result.

Apparatus designed for starting A. C. motors by employing ohmic resistance coils are to be judged under Rule 78, page 162.

a. **Construction.** — Coils and switches of auto-starters used in dusty and linty places or where exposed to flyings of combustible material, must be completely enclosed in substantial metal cases so constructed as to effectually exclude ordinary dust, lint or flyings of combustible material.

Auto-starters used in places where the above conditions do not exist, may be of any *approved* type.

Cases for either transformer coils or switches must provide for access to the interior for inspection and for renewal of oil, and must be so constructed that when mounted on a plane surface the casing will make contact with such surface only at points of support. An air space at least ¼ inch between the casing and supporting surface will be required.

The oil tank shall be marked in a suitable manner to indicate the proper oil level. When such device carries a visual oil indicator, the marking shall be for the proper oil level with the starter assembled. If the visual indicator is not used, markings shall indicate the oil level prior to assembling.

The switch must provide an off position, a running position and at least one starting position. It must be so arranged that it will be held in off and running positions but cannot be left in a starting position or without the proper running overload protective devices in the circuit.

79. **Auto-Starters**—*Continued.*

The construction throughout must be thoroughly substantial.

If the oil is above the proper level it is liable to be thrown out when the starter is operated and cause the floor beneath to become oil soaked.

b. **Connections.** — Clamps for connecting wires to the terminals must be so designed as to insure a thoroughly good connection and must be sufficiently strong and heavy to withstand hard usage. For currents above 30 amperes, lugs into which the connecting wires may be soldered, or *approved* solderless connectors must be used. Clamps or lugs will not be required when leads are provided as a part of the device.

c. **Marking.** — Must be plainly marked, where it may be readily seen after the device is installed, with the rating and name of the maker; terminals to be so marked as to indicate to what part of the circuit each is to be connected.

d. **Insulation Test.** — The insulation of the completely assembled apparatus must withstand for 1 minute a potential test between live metal parts and frame, core and case as follows:

Rated Terminal Voltage of Circuit.	Testing Voltage.
Not exceeding 400 volts	1,500 volts
401–800	2,000 "
801–1,200	3,500 "
1,201–2,500	5,000 "
2,501 up	Double normal rated Voltages

e. **Tests.** — With full line voltage applied to line terminals and current taken from taps giving between 40 and 60% of the normal line voltage, 300% of full load current of the motor applied for the first 15 seconds of each 4-minute period for 1 hour must show no resultant flaming or molten droppings. The oil, if any, in which the transformer windings are immersed shall not overflow the containing case.

80. **Reactive Coils and Condensers.**

a. Reactive coils must be made of non-combustible material, mounted on non-combustible bases and treated, in general, as sources of heat.

This rule is not intended to apply to lightning arrester choke coils and similar apparatus in the construction of which non-combustible insulation is not practicable. These should, however, be mounted on non-combustible bases, the same as the other forms of reactive coils, etc.

Under some conditions reactive coils may get very hot, so that they should be treated about the same as rheostats, although the danger of extreme overheating is perhaps not as great.

b. Condensers must be treated like other apparatus oper-

80. **Reactive Coils and Condensers** – *Continued.*

ating with equivalent voltage and currents. They must have non-combustible cases and supports, and must be isolated from all combustible materials and, in general, treated as sources of heat.

81. **Transformers.**

(*For installation requirements, see Rules 11, 14, 15, 36 and 45, pages 40, 53, 54, 97 and 107.*)

It is advised that every transformer with either primary or secondary voltages over 550 volts be so constructed that the middle point of the secondary coil can be reached, to permit the transformer to be grounded at this point.

The following sections do not apply to transformers installed in Central or substations (see Rule 11, page 40), outside of buildings (see Rule 14, page 53), in fireproof vaults in buildings (see Rule 45, page 107), nor to instrument transformers.

Air-Cooled Transformers.

a. **Construction.** — Must be placed in substantial metallic or other non-combustible cases, which completely enclose all current-carrying parts, with the exception of the terminals of the low voltage windings as specified below. Sheet metal cases must be not less than 1-32 inch in thickness and cast iron must be not less than ⅛ inch in thickness.

Must be so constructed that when mounted on a plane surface the casing will make contact with such surface only at the points of support. An air space of at least ¼ of an inch between the transformer casing and the supporting surface will be required.

Leads of *approved* cable at least 6 inches in length and so secured as to prevent strain coming on the connections to the coils, must be brought out of the case through *approved* insulating bushings, except for bell-ringing and toy transformers, the low voltage terminals of which may be binding posts mounted on the case.

The construction throughout must be substantial and thoroughly workmanlike.

b. **Marking.** — Must be plainly marked where it can be readily seen after installation, with the name of the maker, with the frequency, the high voltage and all low voltages, and the rated capacity in kilovolt-amperes.

c. **Test.** — Must be so constructed as to withstand the following tests: —

1. Normal voltage shall be applied to the high voltage winding, and the low voltage circuit shall be loaded to full rated current until an approximately constant temperature is indicated by a thermometer on the case when the insulation must withstand a voltage test between high voltage and low voltage coils and between high voltage coils and the core made in accordance with the Standardization Rules of the American Institute of Electrical Engineers.

81. **Transformers**--*Continued.*

2. Normal voltage shall again be applied to the high voltage winding while the transformer is still heated to full operating temperature and the low voltage circuit loaded to three times rated current until an approximately constant temperature is indicated by a thermometer on the case, or until burn-out occurs.

The case must not be injured by this test and if the transformer is burned out there shall be no escape of flames or molten metal.

Bell-Ringing or Other Signaling Transformers.

d. Transformers for bell-ringing or other signaling service must be constructed in accordance with the requirements of Section *a* and the following specifications, and may be approved for use when all wiring on the high voltage side is in accordance with the requirements of Class C.

e. **Marking.** — Must be plainly marked where it can be seen after installation, with the name of the manufacturer, the frequency, the high voltage and all low voltages, and the proper terminals must be marked "Line" and "Bell." The rating of high voltage winding must not be over 125 volts.

f. **Tests.** — The design of the transformer must be such that when any two low-voltage terminals are short-circuited while the rated voltage is impressed on the high-voltage coil, the input measured by a wattmeter in the high-voltage circuit will not be more than 25 watts.

The transformers shall be run at normal high voltage and with the low-voltage side short-circuited until a constant temperature is reached as indicated by a thermometer on the outside of the case. The rise in temperature so measured shall not exceed 50° C. (122° F.).

At the end of the heating test above the insulation shall withstand for one minute the application of 2,500 volts A. C. between high and low voltage coils and between high voltage coil and core or case.

Toy Transformers.

g. Transformers for operating toys must be constructed in accordance with the requirements of Section *a* and the following specifications.

h. **Marking.** — Must be marked with the name of the manufacturer, high and all low voltages, the frequency and the rated capacity in volt-amperes.

The high-voltage rating must not exceed 125 volts, nor the low voltage rating exceed 25 volts.

i. **Tests.** — Must be so constructed as to stand the following tests: —

81. **Transformers**—*Continued.*

1. Normal voltage shall be applied to the high-voltage winding, and the low-voltage circuit shall be loaded to full rated current until an approximately constant temperature is indicated by a thermometer on the case, when the insulation must withstand for one minute application of 2,500 volts A. C. between high-voltage and low-voltage coils, and between high-voltage coils and core or case.

2. With the high-voltage coil connected to a circuit of the rated voltage and frequency and with the low-voltage coils short-circuited, the input as measured by wattmeter must not exceed 250 watts. When so connected, and run until constant temperature is reached or until burnout occurs, the case must not be injured and there must be no escape of flames or molten metal.

82. **Lightning Arresters.**

(*For installation requirements, see Rule 5, page 30.*)

a. Lightning arresters must be of *approved* construction.

Whenever lightning is discharged through an arrester, the generator current tends to follow the discharge current. The arrester must be so designed as to break this arc, as otherwise the generators may be injured and the service interrupted. The arrester itself would be injured, and might not then afford protection against a second discharge.

83. **Electric Signs for Low-Potential Systems.**

(*For installation requirements, see Rule 23 d, page 68.*)

a. **Material.** — Must be constructed entirely of metal or other *approved* non-combustible material except that wood may be used on outside for decoration if kept at least 2 inches from nearest lamp receptacles.

Sheet metal must be not less than No. 28 U. S. metal gage.

All metal must be galvanized, enameled or treated with at least 3 coats of anti-corrosive paint, or otherwise protected in an approved manner against corrosion.

b. **Construction.** — Must be so constructed as to secure ample strength and rigidity.

Must be so constructed as to be practically weatherproof and so as to enclose all terminals and wiring other than the supply leads, except that open work will be permitted for signs on roofs or open ground where not subject to mechanical injury, provided the wiring is in accordance with Section *e* below.

Transformers, unless of the weatherproof type, cut-outs, flashers and other similar devices, must be enclosed in *approved* cut-out boxes or cabinets, except that if on or within the sign structure, must be in a separate, completely enclosed, accessible and weatherproof compartment, or in a substantial weatherproof box or cabinet of metal of thickness not less than that of the metal of the sign itself.

83. **Electric Signs for Low-Potential Systems**—*Continued.*

Each compartment must have suitable provision for drainage through one or more holes each not less than ¼ inch in diameter.

c. **Marking.** — Must have the maker's name or trade-mark permanently attached to the exterior.

d. **Receptacles.** — Must be so designed as to afford permanent and reliable means to prevent possible turning; must be so designed and placed that terminals will be at least ½ inch from other terminals and from metal of the sign except that where open work is permitted, this separation must be 1 inch.

Miniature receptacles will not be approved for use in outdoor signs.

e. **Wiring.** — Must be approved rubber covered, not less than No. 14 B. & S. gage.

Must be neatly run, and so disposed and fastened as to be mechanically secure.

Must be soldered to terminals, and exposed parts of wires and terminals must be treated to prevent corrosion.

Must, where they pass through walls or partitions of the sign, be protected by *approved* bushings.

On outside of sign structure, except where open work is permitted, must be in *approved* metal conduit or in *approved* lead sheathed armored cable.

For open work, wire must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wires at least 1 inch from the surface wired over. Rigid supporting requires, under ordinary conditions where wiring over flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed, the distances between supports should be shortened.

In those parts of circuits where wires are connected to *approved* receptacles which hold them at least 1 inch from surface wired over, and which are placed not over 1 foot apart, such receptacles will be considered to afford the necessary support and spacing of the wires. Between receptacles more than 1 foot, but less than 2 feet apart, an additional non-combustible, non-absorptive, insulator maintaining a separation and spacing equivalent to the receptacles must be used. Except as above specified, wires must be kept apart at least 2½ inches for voltages up to 300, and 4 inches for higher voltages.

f. Leads from sign must pass through the walls of sign either through *approved* metal conduit or armored cable, or must be neatly cabled and pass through one or more *approved* non-combustible, non-absorptive bushings.

g. Not over 1,320 watts shall be dependent upon final cut-out.

84.

Left blank for future use.

Class E.

MISCELLANEOUS.

85. **Signaling Systems.**

Governing wiring for telephone, telegraph (except wireless telegraph apparatus), district messenger and call-bell circuits, fire and burglar alarms, and all similar systems which are hazardous only because of their liability to become crossed with electric light, heat or power circuits.

a. Outside wires should be run in underground ducts or strung on poles, and kept off of the roofs of buildings, except by special permission, and must not be placed on the same cross-arm with electric light or power wires. They should not occupy the same duct, manhole or handhole of conduit systems with electric light or power wires.

Single manholes, or handholes separated into sections by means of partitions of brick or tile will be considered as conforming with the above rule.

The liability of accidental crossing of overhead signaling circuits with electric light and power circuits, may be guarded against to a considerable extent by endeavoring to keep the two classes of circuits on different sides of the same street.

When the entire circuit from Central Station to building is run in underground conduits, Sections b to m inclusive do not apply.

b. When outside wires are run on same pole with electric light or power wires, the distance between the two inside pins of each cross-arm must not be less than 24 inches.

Signaling wires being smaller and more liable to break and fall, should generally be placed on the lower cross-arms.

This distance between the inside pins is necessary to allow a man to safely pass between the wires and reach the cross-arms above.

When the wires are carried in approved cables, the next three Sections (c, d and e) do not apply.

c. Where wires are attached to the outside walls of buildings, they must have an *approved* rubber insulating covering, and on frame buildings or frame portions of other buildings shall be supported on glass or porcelain insulators, or knobs.

d. The wires from last outside support to the cut-outs or protectors must be of copper, and must have an *approved* rubber insulation. Must be provided with drip loops immediately outside the building and at entrance.

e. Wires must enter building through *approved* non-combustible, non-absorptive, insulating bushings sloping upward

85. Signaling Systems—*Continued.*

from the outside, and both wires may enter through the same bushing, if desired.

See Rule 12 *f*, page 44.

Installations where the Current-carrying Parts of the Apparatus Installed are Capable of Carrying Indefinitely a Current of Ten Amperes.

f. An all-metallic circuit shall be provided, except in telegraph systems.

g. At the entrance of wires to building, *approved* single pole cut-outs, designed for 251 — 600 volts potential and containing fuses rated at not over 10 amperes capacity, shall be provided for each wire. These cut-outs must not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases, or dust, or to flyings of combustible material.

h. The wires inside building shall be of copper not less than No. 16 B. & S. gage, and must have insulation and be supported, the same as would be required for an installation of electric light or power wiring, 0-600 volts potential.

i. The instruments shall be mounted on bases constructed of non-combustible, non-absorptive, insulating material. Holes for the supporting screws must be so located or countersunk, that there will be at least ½ inch space, measured over the surface, between the head of the screw and the nearest live metal part.

Installations where the Current-carrying Parts of the Apparatus Installed are not Capable of Carrying Indefinitely a Current of Ten Amperes.

j. Must be provided with an *approved* protective device located as near as possible to the entrance of wires to building. The protector must not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases, or dust, or flyings of combustible materials.

k. Wires from entrance to building to protector must be supported on porcelain insulators, so that they will come in contact with nothing except their designed supports.

l. The ground wire of the protective device shall be run in accordance with the following requirements: —

1. Shall be of copper and not smaller than No. 18 B. & S. gage.

2. Must have an insulating covering *approved* for voltages from 0 to 600, except that the preservative compound may be omitted.

85. **Signaling Systems**—*Continued.*

3. Must run in as straight a line as possible to a good permanent ground. This may be obtained by connecting to a water or gas pipe connected to the street mains or to a ground rod or pipe driven in permanently damp earth. When connections are made to pipes, preference shall be given to water pipes. If attachment is made to gas pipe, the connection in all cases must be made between the meter and the street mains. In every case the connection shall be made as near as possible to the earth.

When the ground wire is attached to a water pipe or a gas pipe, it may be connected by means of an *approved* ground clamp fastened to a thoroughly clean portion of said pipe, or the pipe shall be thoroughly cleaned and tinned with rosin flux solder, and the ground wire shall then be wrapped tightly around the pipe and thoroughly soldered to it.

When the ground wire is attached to a ground rod driven into the earth, the ground wire shall be soldered to the rod in a similar manner.

Steam or hot-water pipes must not be used for a protector ground.

m. The protector to be approved must comply with the following requirements:—

For Instrument Circuits of Telegraph Systems.

1. An *approved* single pole cut-out, in each wire, designed for 2,000 volts potential, and containing fuses rated at not over 1 ampere capacity. When main line cut-outs are installed as called for in Section *g,* the instrument cut-outs may be placed between the switchboard and the instrument as near the switchboard as possible.

For all Other Systems.

1. Must be mounted on non-combustible, non-absorptive, insulating bases, so designed that when the protector is in place, all parts which may be alive will be thoroughly insulated from the wall to which the protector is attached.

2. Must have the following parts:—

A lightning arrester which will operate with a difference of potential between wires of not over 500 volts, and so arranged that the chance of accidental grounding is reduced to a minimum.

A fuse designed to open the circuit in case the wires become crossed with light or power circuits. The fuse must be able to open the circuit without arcing or serious flashing when crossed with any ordinary commercial light or power circuit.

A heat coil, if the sensitiveness of the instrument demands it, which will operate before a sneak current can damage the instrument the protector is guarding.

85. **Signaling Systems**—*Continued.*

Heat coils are necessary in all circuits normally closed through magnet windings, which cannot indefinitely carry a current of at least 5 amperes.

The heat coil is designed to warm up and melt out with a current large enough to endanger the instruments if continued for a long time, but so small that it would not blow the fuses ordinarily found necessary for such instruments. The smaller currents are often called "sneak" currents.

3. The fuses must be so placed as to protect the arrester and heat coils, and the protector terminals must be plainly marked "line," "instrument," "ground."

An easily read abbreviation of the above words will be allowed.

The Following Rules Apply to All Systems whether the Wires from the Central Office to the Building are Overhead or Underground.

n. Wires beyond the protector, or wires inside buildings where no protector is used, must be neatly arranged and securely fastened in place in some convenient, workmanlike manner.

They must not come nearer than 2 inches to any electric light or power wire in the building, unless separated therefrom by some continuous and firmly fixed non-conductor creating a permanent separation; this non-conductor to be in addition to the regular insulation on the wire.

The wires would ordinarily be insulated, but the kind of insulation is not specified, as the protector is relied upon to stop all dangerous currents. Porcelain tubing or *approved* flexible tubing may be used for encasing wires where required as above.

o. Wires where bunched together in a vertical run within any building must have a fire-resisting covering sufficient to prevent the wires from carrying fire from floor to floor unless they are run either in non-combustible tubing or in a fire-proof shaft, which shaft must be provided with fire stops at each floor.

Signaling wires and electric light or power wires may be run in the same shaft, provided that one of these classes of wires is run in non-combustible tubing, or provided that when run otherwise these two classes of wires shall be separated from each other by at least 2 inches.

In no case shall signaling wires be run in the same tube with electric light or power wires.

p. Transformers or other devices for supplying current to signaling systems from light, heat or power circuits must be of a design expressly approved for this purpose. The primary wiring must be installed in accordance with the rules for "Class C," and the secondary wiring in accordance with "Class E."

86. **Wireless Telegraph Apparatus.**

NOTE.—These rules do not apply to Wireless Telegraph apparatus installed on shipboard.

In setting up Wireless Telegraph apparatus (so-called) all wiring within the building must conform to the Rules and Requirements of the National Electrical Code for the class of work installed and the following additional specifications:—

a. Aerial conductors to be permanently and effectively grounded at all times when station is not in operation by a conductor not smaller than No. 4 B. & S. gage copper wire, run in as direct a line as possible to water pipe at a point on the street side of all connections to said water pipe within the premises, or to some other equally satisfactory earth connection.

b. Aerial conductors when grounded as above specified must be effectually cut off from all apparatus within the building.

c. Or the aerial to be permanently connected at all times to earth in the manner specified above, through a short-gap lightning arrester; said arrester to have a gap of not over .015 inch between brass or copper plates not less than 2½ inches in length parallel to the gap and 1½ inches the other way with a thickness of not less than ⅛ inch mounted upon non-combustible, non-absorptive, insulating material of such dimensions as to give ample strength. Other *approved* arresters of equally low resistance and equally substantial construction may be used.

d. In cases where the aerial is grounded as specified in Section *a,* the switch employed to join the aerial to the ground connection shall not be smaller than a standard 100 ampere knife switch.

e. Where supply is obtained direct from the street service the circuit must be installed in *approved* metal conduits or armored cable. In order to protect the supply system from high potential surges, there must be inserted in circuit either a transformer having a ratio which will have a potential on the secondary leads not to exceed 550 volts, or 2 condensers in series across the line, the connection between said condensers to be permanently and effectually grounded. These condensers should have capacity of not less than ½ microfarad.

87. **Electric Gas Lighting.**

a. Electric gas lighting, unless it is the *frictional* system, must not be used on the same fixture with the electric light.

88. **Insulation Resistance.**

The wiring in any building must comply with the following requirements:—

The complete installation must have a resistance between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) 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	"
"	1,600 "	12,500	"

The test must be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only ½ of the resistances specified in the table will be required.

88 A. **Additional Rules for Factory Mutual Work.**

In this work, the following rules, which are additional to the "Code," must be carefully followed, as the more or less isolated location of the majority of factory properties makes it possible to introduce some very desirable requirements not universally feasible.

a. Foreign wires (*i. e.,* those not owned or controlled by the insured, such as any public light or power wires, public telephone, telegraph, and city fire-alarm wires, etc.) of all kinds, not used by the insured, should be kept off of all buildings, and out of the yards of properties insured by these companies.

Foreign signal wires, such as telephone, telegraph, etc., with their generally long circuits and often careless line construction, are especially liable to come in contact with light and power wires. If they are attached to mill buildings or allowed to cross mill yards, there is always the danger that they will break and come in contact with some private mill wire, sending a dangerous current into the buildings, and thereby probably causing a fire. Foreign light and power wires are excluded for similar reasons. Such wires, moreover, are liable to be in the way of fire-streams and ladders.

Under this heading would also come trolley wire supports, which are not desirable on buildings, as they tend to conduct lightning to the building and also may not always be thoroughly insulated from the live trolley wire.

b. All wires used by the insured should be systematically laid out through the yards. Special care should be taken to so locate them that they will not interfere with fire-streams or ladders.

This matter is ordinarily given too little attention, with the result that an unsightly tangle of wires eventually results, inviting crosses which may conduct dangerous currents into the buildings, and often so located as to obstruct fire-streams and hinder the putting up of ladders. In general, wires should approach

88 A. **Additional Rules for Factory Mutual Work**—*Continued.*

buildings as nearly at right angles as possible, and where they are run parallel to the buildings, they should be kept at least 50 feet away from them if possible.

c. Private wires (*i. e.,* those owned and controlled by the insured, such as watch-clock, private telephone, call-bell and similar wires) must be arranged about as follows: —

1. Where possible, run them so that they cannot fall or be fallen upon by any wire carrying a dangerous current or likely to come in contact with a wire carrying a dangerous current.
2. Where crosses cannot be prevented, provide guard wires that will absolutely prevent contacts.
3. Where crosses must occur, and guard wires cannot be arranged, provide protectors as required by Rule 85, page 171.

It will generally be found possible in arranging private wires about the mill yards to so keep them by themselves that there will be no possibility of their coming in contact with circuits carrying dangerous currents. Such avoidance of the possibility of danger is always preferable to the putting in of protectors, besides being generally less expensive.

APPENDIX.

GROUND DETECTORS.

With the exception of intentionally grounded wires, it is always important to keep the wires of any electric light or power system absolutely free from contacts with anything which could connect them to the earth, such as walls or floors of masonry, iron beams, etc., and, above all, iron pipes of any kind. This is accomplished in ordinary mill work, first, by the porcelain knobs or cleats on which the wires are supported, and next, by the insulation on the wires themselves. Wires do sometimes get out of place, however, and come in contact with damp walls, sprinkler pipes, etc., and then in time the insulation on the wire wears through, helped by the jar of the building, and the copper itself comes in contact with the wall, pipe, etc., thus putting the wire into electrical connection with the earth. Nothing will usually happen, however, until a wire of opposite polarity also becomes "grounded," for until then there is no complete circuit made. When this does occur, the current follows through the earth or pipes from one "ground" to the other, forming arcs at these points, and perhaps elsewhere, and these arcs are very liable to cause fire.

The purpose of the ground detector is to give a warning when the first break in insulation occurs, thereby giving time to repair it before the second one, with its possible accompanying fire, can follow.

The instant a detector shows a ground, steps should be taken to find and remedy it. By throwing off one circuit after another, the one on which the ground exists will soon be found, as when it is cut off the detector lamps will again burn with equal brilliancy. Inspection along this circuit will then generally soon disclose the trouble. Where the circuits are not well sub-divided by switches, fuses may be removed to accomplish the same result.

DIRECT-CURRENT CIRCUITS.

Fig. 43 on page 179 shows a very good and simple detector for any two-wire low-voltage system. The lamps for the detector should be of the same candle-power and voltage,— the voltage being about the same as that of the regular lamps in the plant,—and two lamps should be selected which, when connected in series, burn with equal brilliancy. Although somewhat greater sensitiveness can be obtained with low candle-power lamps, such as 8 c. p., for example, it is believed in general to be preferable to use lamps of same candle-power as those throughout the plant, as then a burned-out or broken detector lamp can be immediately replaced by a good lamp from the regular stock, thus avoiding the necessity of keeping on hand a few spare special lamps.

The detector lamps, being two in series across the proper voltage for one lamp, burn only dimly. If, however, a ground occurs on any circuit, as at *a,* the current from the positive bus-bar through lamp No. 1 divides on reaching *b,* instead of all going through lamp No. 2, as it did when there was no ground. Part now goes down the ground wire and through the ground to *a,* as indicated by the broken line, and thence through the wires to the negative bus-bar. This reduces the resistance from *b* to the negative bus-bar, and therefore more current flows through lamp No. 1 than before, while less current flows through lamp No. 2. Lamp No. 1 consequently brightens and lamp No. 2 dims. If the ground had occurred at *c* instead of *a,* lamp No. 2 would have brightened and lamp No. 1 dimmed.

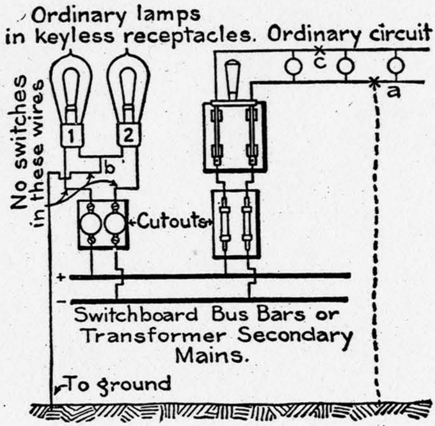


FIG. 43.
TWO-LAMP GROUND DETECTOR.

Attention is called to the following points, which are frequently neglected in this form of detector: —

1. The lamp receptacles should be keyless and there should be no switches of any kind in any of the connecting wires, so that the detector will always be in operation. In order to be of the greatest value, the indications must be given instantly when a ground occurs, and not have to wait until the engineer or electrician remembers to close a switch.

2. The wires should be protected by small fuses where they connect to the bus-bars. If these fuses are omitted, a short-circuit across these wires would either burn up the wires or blow the main generator fuses.

3. The lamps should be placed very close together, within 1 or 2 inches of each other if possible. The farther apart they are, the harder it is to detect any slight difference in brilliancy between them.

4. The ground wire should be carefully soldered to a pipe which is thoroughly connected to the ground, or some other equally good ground connection should be provided.

Fig. 44, page 180, shows a lamp ground detector for a three-wire Edison system. In principle it is exactly the same as the two-lamp detector of Fig. 43, page 179. Its indications are as follows: —

Switch on point No. 1	Ground at *a*, — A bright, B & C dim.	
	" " *b*, — B&C " A "	
	" " *c*, — A " B & C "	

Switch on point No. 2	Ground at *a*, — A & B bright, C dim.	
	" " *b*, — C bright, A & B "	
	" " *c*, — C " A & B "	

With the lamp switch at point No. 1, grounds at *a* and *c* give the same indication, but by throwing the switch to point No. 2, it will be at once evident whether the ground is

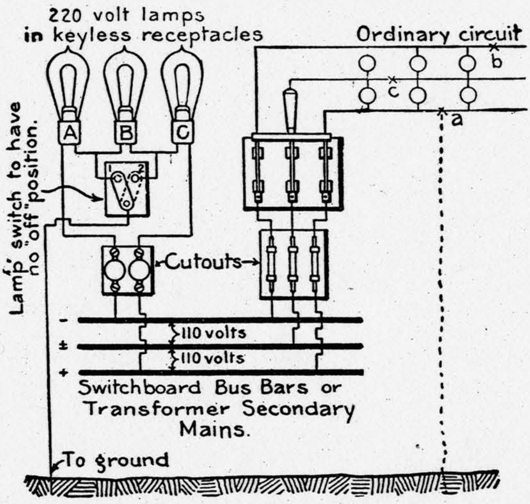


Fig. 44.
Lamp Ground Detector for Three-Wire System.

on the positive or negative side. It is to remove the uncertainty which would otherwise exist that this switch is needed. It should have no "off" position, so that the detector can never be left out of circuit.

The man in charge of a plant can readily familiarize himself with the indications of the detector by purposely putting a ground on the different wires and noting the indications.

If the neutral is permanently grounded, as required in Rule 15, page 54, a ground detector is, of course, of no use.

The same degree of sensitiveness on both sides can be obtained by means of the lamp switch, but for grounds on the neutral, there is never more than half the full voltage available to operate the lamps, so that the indications are necessarily less sensitive.

An ordinary volmeter can be used as an intermittent ground detector on direct-current circuits of any voltage, the method being as shown in Fig. 45. The voltmeter ordinarily used to indicate the pressure on the system, can of course be used for this purpose, the voltmeter switch shown in the cut being arranged to give the different desired connections.

If, for example, the system shown in Fig. 45 were of about 100 volts, the voltmeter would register 100 when the levers of the switch were on the inside contact points as shown. If, now, the right-hand lever were moved to the outside contact point as shown dotted, and there were a ground on the system, as at *a,* current would pass from the positive bus-bar through the circuit to *a,* thence through the ground to the ground wire, and through the voltmeter to the negative bus-bar, causing the voltmeter to read something below 100, unless the ground at *a,* were practically a perfect connection, in which case the voltmeter reading would be 100. If the positive side of the system were entirely free from grounds, the voltmeter reading would be 0.

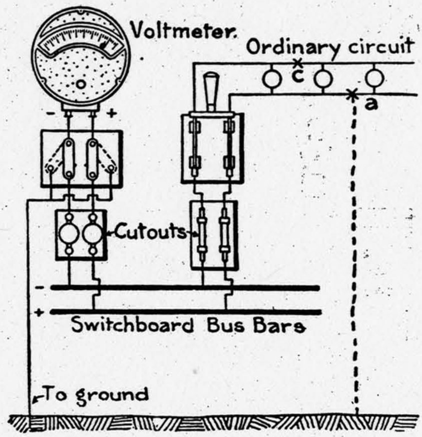


FIG. 45.
VOLTMETER GROUND DETECTOR.

Assume that under these conditions the voltmeter reads 50, and that the resistance of the voltmeter itself was 20,000 ohms, it will be evident that if, with no external resistances, as when connected directly to the bus-bars, the voltmeter reads 100, while now it reads 50, the total resistance under the new conditions must be 40,000 ohms, of which 40,000 — 20,000 = 20,000 ohms must be the resistance of the ground at *a*.

If the voltmeter had read only 20 the total resistance would have been $\frac{100}{20} \times 20{,}000 = 100{,}000$, and the resistance of the ground 100,000 — 20,000 = 80,000 ohms.

A table may, therefore, be computed in this way showing the resistance of the ground for any given reading of the voltmeter. It is a good plan in any low-voltage system to connect the voltmeter in this way, besides having a lamp ground detector, as the voltmeter gives a more exact idea of just what the insulation is, while the lamp detector gives an instantaneous indication of a ground and is not dependent on the attendant remembering to throw it in, as is the case with the voltmeter.

Where none of the above-mentioned methods are available, fair results can be obtained by frequent tests with a powerful magneto while the current is cut off from the system.

ALTERNATING-CURRENT CIRCUITS.

For all ordinary low-voltage single-phase systems, the lamp detectors above described can be used with good results.

For ordinary low-voltage three-phase circuits, a lamp detector connected as in Fig. 46, may be used. The indication is the same as that with the lamp detectors described above. Thus, when a ground comes on one wire, the lamp attached to that wire dims and the other two brighten.

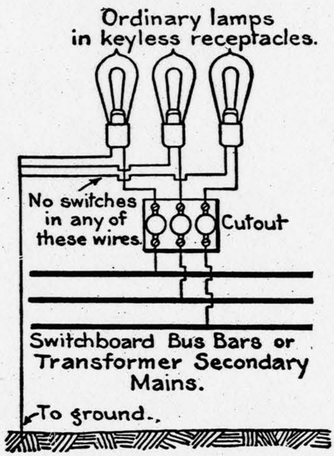


FIG. 46.
THREE-PHASE LAMP DETECTOR.

For ordinary two-phase (or quarter-phase) systems, where the phases are entirely insulated from each other, the two-lamp detector can be used, one detector on each phase. There are, however, in this class of wiring several complicated systems, to all of which the lamp detector principle is applicable, although the exact method of connections differs in each case, so that no general rule can be given.

With alternating-current systems where the voltage is too high for the methods suggested above, excellent results can be obtained where direct current is available by testing the line with a direct-current voltmeter, as in Fig. 45, page 181. This can be done, of course, only while the high-voltage current is cut off. If there is no direct current at hand, the line may be frequently tested out with a powerful testing magneto when the current is off the system. With extra high voltages, there is usually either no ground or else a fairly good one, so that either of these two methods can be used to advantage.

There are also a few instruments on the market especially designed for this work, such as the electrostatic detector, in which the difference of static charge on adjacent segments moves a pivoted vane, to which is attached an indicating needle moving over a dial. There is also the "transformer and lamp" detector, in which a small transformer is used with an incandescent lamp in the secondary circuit. One of the primary wires is connected with the ground, and by means of switches suitably arranged, the other primary is connected to any wire of the system, a ground being indicated by the burning of the lamp. The indications of this instrument are misleading, except to those thoroughly acquainted with its operation under all conditions.

INDEX TO RULES.

THE ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES

1	MANUFACTURERS MUTUAL F. INS. CO.,	*Providence,*	JOHN R. FREEMAN, Pres.
2	RHODE ISLAND MUTUAL F. INS. CO.,	*Providence,*	JOHN R. FREEMAN, Pres.
3	BOSTON MFRS. MUTUAL F. INS. CO.,	*Boston,*	J. P. GRAY, Pres.
4	FIREMEN'S MUTUAL INS. CO.,	*Providence,*	F. W. MOSES, Pres.
5	STATE MUTUAL F. INS. CO.,	*Providence,*	JOHN R. FREEMAN, Pres.
6	WORCESTER MFRS. MUTUAL INS. CO.,	*Worcester,*	W. E. BUCK, Pres.
7	ARKWRIGHT MUTUAL F. INS. CO.,	*Boston,*	R. W. TOPPAN, Pres.
8	BLACKSTONE MUTUAL F. INS. CO.,	*Providence,*	WM. B. McBEE, Pres.
9	FALL RIVER MFRS. MUTUAL INS. CO.,	*Fall River,*	C. S. WARING, Pres.
10	MECHANICS MUTUAL F. INS. CO.,	*Providence,*	JOHN R. FREEMAN, Pres.
11	WHAT CHEER MUTUAL F. INS. CO.,	*Providence,*	FRANK L. PIERCE, Pres.
12	ENTERPRISE MUTUAL F. INS. CO.,	*Providence,*	JOHN R. FREEMAN, Pres.
13	MERCHANTS MUTUAL F. INS. CO.,	*Providence,*	WM. B. McBEE, Pres.
14	HOPE MUTUAL F. INS. CO.,	*Providence,*	FRANK L. PIERCE, Pres.
15	COTTON AND WOOLEN MFRS. M. I. CO.,	*Boston,*	BENJ. TAFT, Sec.
16	AMERICAN MUTUAL F. INS. CO.,	*Providence,*	JOHN R. FREEMAN, Pres.
17	PHILADELPHIA MFRS. M. F. INS. CO.,	*Philadelphia,*	E. I. ATLEE, Pres.
18	RUBBER MFRS. MUTUAL INS. CO.,	*Boston,*	BENJ. TAFT, Sec.
19	PAPER MILL MUTUAL INS. CO.,	*Boston,*	R. W. TOPPAN, Pres.

The Associated Factory Mutual Fire Insurance Companies were organized more than seventy-five years ago, by certain prominent manufacturers of New England, for the purpose of providing insurance at actual cost. They confine their business almost exclusively to large isolated manufacturing properties. They have improved the construction of buildings, introduced better fire protection, and each risk is subject to regular expert inspection. They insist upon complete sprinkler protection, fire pumps, and ample water supply from at least two independent sources.

These methods have resulted in preventing interruption of business by fire, and have enabled the Mutual Companies to return to policy holders a large proportion of their premiums which otherwise would have been used in payment of heavy fire losses.