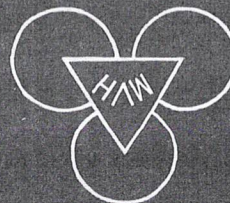


NEW
CATECHISM
OF
ELECTRICITY

A Practical Treatise,

BY
N. HAWKINS, M. E.,

*Author of Hand Book of Calculations for Engineers; Maxims
and Instructions for the Boiler Room; Aids to Engineers'
Examinations with Questions and Answers; Etc.*



RELATING TO THE DYNAMO AND MOTOR; WIRING; THE
ELECTRIC RAILWAY; ELECTRIC BELL FITTING; ELECTRIC
LAMPS; ELECTRIC ELEVATORS; ELECTRIC LIGHTING;
ELECTRO PLATING; THE TELEGRAPH AND TELE-
PHONE; MEASUREMENTS; AND TABLES.

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"The vital knowledge—that by which we have grown as a nation to what we are, and which now underlies our whole existence, is a knowledge that has got itself taught in nooks and corners; while the ordained agencies for teaching have been mumbling little else but dead formulas."

"That which our school courses leave almost entirely out, we thus find to be that which most nearly concerns the business of life. All our industries would cease, were it not for that information which men begin to acquire as they best may after their education is said to be finished. And were it not for this information, that has been from age to age accumulated and spread by unofficial means, these industries would never have existed."—Herbert Spencer.

WIRING RULES AND REQUIREMENTS.

National Board Fire Underwriters.

RULES AND REQUIREMENTS

Of the National Board of Fire Underwriters for the Installation of Wiring and Apparatus for Electric Light and Power as Recommended by the Underwriters' and National Electric Association.

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 provisions for the channeling and pocketing of buildings for electric light or power wires, and in specifications for electric gas lighting to require a two-wire circuit, whether the building is to be wired for electric lighting or not, so that no part of the gas fixtures or gas piping be allowed to be used for the gas lighting circuit.

Class A. Central Stations for Light or Power.

These Rules also apply to Dynamo Rooms in Isolated Plants, connected with or detached from buildings used for other purposes; also to all varieties of apparatus therein, of both high and low potential.

WIRING RULES AND REQUIREMENTS.

1. GENERATORS:

- a. Must be located in a dry place.
- b. Must be insulated on floors or base frames, which must be kept filled, to prevent absorption of moisture, and also kept clean and dry.
- c. 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 material.
- d. Must each be provided with a waterproof covering.

2. CARE AND ATTENDANCE:

- A competent man must be kept on duty in the room where generators are operating.
- Oily waste must be kept in *approved* metal cans and removed daily.

3. CONDUCTORS:

From generators, switchboards, rheostats or other instruments, and thence to outside lines, conductors—

- a. Must be in plain sight and readily accessible.
- b. Must be wholly on non-combustible insulators, such as glass or porcelain.
- c. Must be separated from contact with floors, partitions or walls through which they may pass, by non-combustible insulating tubes, such as glass or porcelain.
- d. Must be kept rigidly so far apart that they cannot come in contact.
- e. Must be covered with non-inflammable insulating material sufficient to prevent accidental contact, except that "bus bars" may be made of bare metal.

NATIONAL BOARD FIRE UNDERWRITERS.

f. Must have ample carrying capacity, to prevent heating. (See Capacity of Wires Table.)

4. SWITCHBOARDS:

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

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

c. Must be kept free from moisture.

d. Must be made of non-combustible material, or of hard wood in skeleton form, filled to prevent absorption of moisture.

e. Bus bars must be equipped in accordance with Rule 3 for placing conductors.

5. RESISTANCE BOXES AND EQUALIZERS:

a. Must be equipped with metal, or other non-combustible frames. (See Definitions.)

b. Must be placed on the switchboard, or, if not thereon, at a distance of a foot from combustible material, or separated therefrom by a non-inflammable, non-absorptive, insulating material.

6. LIGHTNING ARRESTERS:

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

b. Must be mounted on non-combustible bases in plain sight on the switchboard, or in any equally accessible place, away from combustible material.

WIRING RULES AND REQUIREMENTS.

c. Must be connected with at least two "earths" by separate wires, not smaller than No. 6 B. & S., which must not be connected to any pipe within the building, and must be run as nearly as possible in a straight line from the arresters to the earth connection.

d. Must be so constructed as not to maintain an arc after the discharge has passed.

7. TESTING:

a. All series and alternating circuits must be tested every two hours while in operation, to discover any leakage to earth, abnormal in view of the potential and method of operation.

b. All multiple arc low potential systems (300 volts or less) must be provided with an indicating or detecting device, readily attachable, to afford easy means of testing where the station operates continuously.

c. Data obtained from all tests must be preserved for examination by insurance inspectors.

These rules on testing to be applied at such places as may be designated by the association having jurisdiction.

8. MOTORS:

a. Must be wired under the same precautions as with a current of the same volume and potential for lighting. The motor and resistance box must be protected by a double pole cut-out and controlled by a double-pole switch, except in cases where one-quarter horse-power or less is used on low tension circuit, a single pole switch will be accepted.

NATIONAL BOARD FIRE UNDERWRITERS.

b. Must be thoroughly insulated, mounted on filled dry wood, be raised at least eight inches above the surrounding floor, be provided with pans to prevent oil from soaking into the floor, and must be kept clean.

c. Must be covered with a waterproof cover when not in use, and, if deemed necessary by the Inspector, be inclosed in an *approved* case. (See Definitions.)

9. RESISTANCE BOXES:

a. Must be equipped with metal or other non-combustible frames. (See Definitions.)

b. Must be placed on the switchboard, or at a distance of a foot from combustible material, or separated therefrom by a non-inflammable, non-absorptive, insulating material.

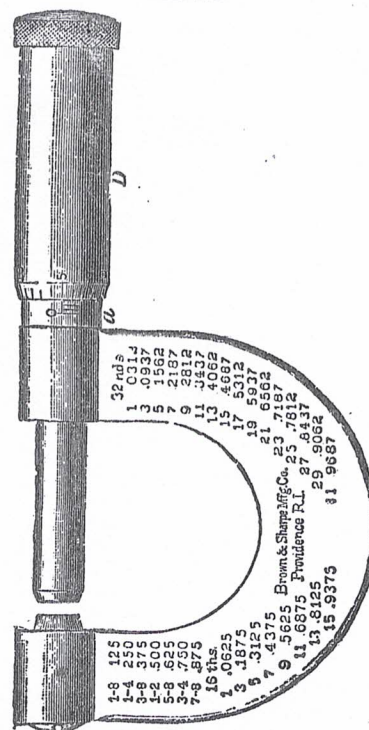
Class B. High Potential Systems, over 300 Volts.

Any circuit attached to any machine, or combination of machines, which develop over 300 volts difference of potential between any two wires, shall be considered as a high potential circuit and coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to less than 300 volts.

10. OUTSIDE CONDUCTORS—ALL OUTSIDE, OVERHEAD CONDUCTORS (INCLUDING SERVICES):

a. Must be covered with some *approved* insulating material, not easily abraded, firmly secured to properly insulated and substantially built supports, all tie wires having an insulation equal to that of the conductors they confine. (See Definitions.)

FIG. 170.



MICROMETER WIRE GAUGE.

WIRING RULES AND REQUIREMENTS.

b. Must be so placed that moisture cannot form a cross connection between them, not less than a foot apart, and not in contact with any substance other than their insulating supports.

c. Must be at least seven feet above the highest point of flat roofs, and at least one foot above the ridge of pitched roofs over which they pass or to which they are attached.

d. Must be protected by *dead-insulated guard irons or wires* from possibility of contact with other conducting wires or substances to which current may leak. Special precautions of this kind must be taken where sharp angles occur, or where any wires might possibly come in contact with electric light or power wires.

e. Must be provided with petticoat insulators of glass or porcelain. Porcelain knobs or cleats and rubber hooks will not be approved.

f. 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. (See Definitions.)

g. Telegraph, telephone and similar wires must not be placed on the same cross-arm with electric light or power wires.

II. SERVICE BLOCKS :

Must be covered over their entire surface with at least two coats of waterproof paint.

12. ALL INTERIOR CONDUCTORS :

a. Must be covered where they enter buildings from outside terminal insulators to and through the walls, with

NATIONAL BOARD FIRE UNDERWRITERS.

extra waterproof insulation, and must have drip loops outside. The hole through which the conductor passes must be bushed with waterproof and non-combustible insulating tube, slanting upward toward the inside. The tube must be sealed with tape, thoroughly painted, and securing the tube to the wire.

b. Must be arranged to enter and leave the building through a double contact service switch, which will effectually close the main circuit and disconnect the interior wires when it is turned "off." The switch must be so constructed that it shall be automatic in its action, not stopping between points when started, and prevent an arc between the points under all circumstances ; it must indicate on inspection whether the current be "on" or "off," and be mounted in a non-combustible case, and kept free from moisture, and easy of access to police or firemen. So-called "snap switches" shall not be used on high potential circuits.

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

d. Must be covered in all cases with an *approved* non-combustible material that will adhere to the wire, not fray by friction, and bear a temperature of 150° F. without softening. (See Definitions.)

e. Must be supported on glass or porcelain insulators, and kept rigidly at least eight inches from each other, except within the structure of lamps or on hanger-boards, cut-out boxes, or the like, where less distance is necessary.

f. Must be separated from contact with walls, floors, timbers or partitions through which they may pass by non-combustible insulating tube.

WIRING RULES AND REQUIREMENTS.

g. Must be so spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered, to insure preservation, and covered with an insulation equal to that on the conductors.

13. ARC LAMPS—IN EVERY CASE :

- a.* Must be carefully isolated from inflammable material.
- b.* Must be provided at all times with a glass globe surrounding the arc, securely fastened upon a closed base. No broken or cracked globes to be used.
- c.* Must be provided with an *approved* hand-switch, also an automatic switch, that will shunt the current around the carbons should they fail to feed properly. (See Definitions.)
- d.* Must be provided with reliable stops to prevent carbons from falling out in case the clamps become loose.
- e.* Must be carefully insulated from the circuit in all their exposed parts.
- f.* Must be provided with a wire netting around the globe, and an *approved* spark arrester above to prevent escape of sparks, melted copper, or carbon, where readily inflammable material is in the vicinity of the lamps. It is recommended that plain carbons, not copper-plated, be used for lamps in such places. (See Definitions.)
- g.* Hanger-boards must be so constructed that all wires and current-carrying devices thereon shall be exposed to view and thoroughly insulated by being mounted on a waterproof non-combustible substance. All switches attached to the same must be so constructed that they shall be automatic in their action, not stopping between points when started, and preventing an arc between points under all circumstances.

NATIONAL BOARD FIRE UNDERWRITERS.

h. Where hanger boards are not used, lamps to be hung from insulated supports other than their conductors.

14. INCANDESCENT LAMPS IN SERIES CIRCUITS HAVING A MAXIMUM POTENTIAL OF 300 VOLTS OR OVER :

- a.* Must be governed by the same rules as for arc lights, and each series lamp provided with an *approved* hand spring switch and automatic cut-out.
- b.* Must have each lamp suspended from a hanger-board by means of a rigid tube.
- c.* No electro-magnetic device for switches and no system of multiple series or series multiple lighting will be approved.
- d.* Under no circumstances can series lamps be attached to gas fixtures.

Class C. Low Potential Systems, 300 Volts or less.

15. OUTSIDE OVERHEAD CONDUCTORS :

- a.* Must be erected in accordance with the rules for high potential conductors.
- b.* Must be separated not less than 12 inches, and be provided with an *approved* fusible cut-out, that will cut off the entire current as near as possible to the entrance to the building and inside the walls. (See Definitions.)

16. UNDERGROUND CONDUCTORS :

- a.* Must be protected against moisture and mechanical injury, and be removed at least two feet from combustible material when brought into a building, but not connected with the interior conductors.

WIRING RULES AND REQUIREMENTS.

b. Must have a switch and a cut-out for each wire between the underground conductors and the interior wiring when the two parts of the wiring are connected.

These switches and fuses must be placed as near as possible to the end of the underground conduit, and connected therewith by specially insulated conductors, kept apart not less than two and one-half inches. (See Definitions.)

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

17. INSIDE WIRING—GENERAL RULES :

At the entrance of every building there shall be an *approved* switch placed in the service conductors by which the current may be entirely cut off. (See Definitions.)

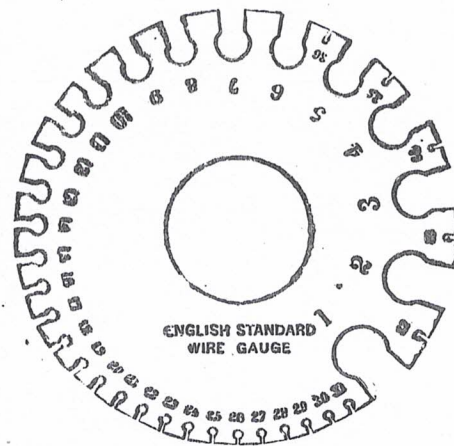
18. CONDUCTORS :

a. Must have an *approved* insulating covering, and must not be of size smaller than No. 14 B. & S., No. 16 B. W. G., or No. 4 E. S. G., except that in conduit installed under Rule 22, No. 16 B. & S., No. 18 B. W. G., or No. 4 E. S. G. may be used. (See Definitions.)

b. Must be protected when passing through floors ; or through walls, partitions, timbers, etc., in places liable to be exposed to dampness by waterproof, non-combustible, insulating tubes, such as glass or porcelain.

Must be protected when passing through walls, partitions, timbers, etc., in places not liable to be exposed to dampness by *approved* insulating bushings specially made for the purpose. (See Definitions.)

FIG. 171.



BIRMINGHAM WIRE GAUGE (B. W. G.)

NATIONAL BOARD FIRE UNDERWRITERS.

c. Must be kept free from contact with gas, water or other metallic piping, or any other conductors or conducting material which they may cross (except high potential conductors) by some continuous and firmly fixed non-conductor creating a separation of at least one inch. Deviations from this rule may sometimes be allowed by special permission.

d. Must be so placed in crossing high potential conductors that there shall be a space of at least one foot at all points between the high and low tension conductors.

e. 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* all pipes upon which condensed moisture is likely to gather, or which by leaking might cause trouble on a circuit.

f. Must be so spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered, to insure preservation, and covered with an insulation equal to that on the conductors. (See Definitions.)

Special Rules.**19. WIRING NOT ENCASED IN MOULDING OR APPROVED CONDUIT:**

a. Must be supported wholly on non-combustible insulators, constructed so as to prevent the insulating coverings of the wire from coming in contact with other substances than the insulating supports.

WIRING RULES AND REQUIREMENTS.

b. Must be so arranged that wires of opposite polarity, with a difference of potential of 150 volts or less, will be kept apart at least two and one-half inches.

c. Must have the above distance increased proportionately where a higher voltage is used.

d. Must not be laid in plaster, cement or similar finish.

e. Must never be fastened with staples.

In Unfinished Lofts between Floor and Ceilings, in Partitions and other concealed Places.

f. Must have at least one inch clear air space surrounding them.

g. Must be at least ten inches apart when possible, and should be run singly on separate timbers or studding.

h. Wires run as above immediately under roofs, in proximity to water-tanks or pipes, will be considered as exposed to moisture.

i. When from the nature of the case it is impossible to place concealed wire on non-combustible insulating supports of glass or porcelain, the wires may be fished on the loop system, if incased throughout in *approved* continuous flexible tubing or conduit.

j. Wires must not be fished for any great distance, and only in places where the Inspector can satisfy himself that the above rules have been complied with.

k. Twin wires must never be employed in this class of concealed work.

NATIONAL BOARD FIRE UNDERWRITERS.

20. MOULDINGS :

- a.* Must never be used in concealed work or in damp places.
- b.* Must have at least two coats of waterproof paint or be impregnated with a moisture repellant.
- c.* Must be made of two pieces, a backing and capping, so constructed as to thoroughly incase the wire and maintain a distance of one-half inch between conductors of opposite polarity and afford suitable protection from abrasion.

21. SPECIAL WIRING :

In breweries, packing-houses, stables, dye houses, paper and pulp mills, or other buildings specially liable to moisture or acid, or other fumes liable to injure the wires or insulation, except where used for pendants, conductors—

- a.* Must be separated at least six inches.
- b.* Must be provided with an *approved* water-proof covering. (See Definitions.)
- c.* Must be carefully put up.
- d.* Must be supported by glass or porcelain insulators. No switches or fusible cut-outs will be allowed where exposed to inflammable gases or dust, or to flyings of combustible material.
- e.* Must be protected when passing through floors, walls, partitions, timbers, etc., by water-proof, non-combustible, insulating tubes, such as glass or porcelain.

22. INTERIOR CONDUITS* : (See Definitions.)

- a.* Must be continuous from one junction box to another, or to fixtures, and must be of material that will resist the

*The object of a tube or conduit is to facilitate the insertion or extraction of the conductors to protect them from mechanical injury, and as far as possible, from moisture. Tubes or conduits are to be considered merely as raceways, and are not to be relied on for insulation between wire and wire, or between the wire and the ground.

WIRING RULES AND REQUIREMENTS.

fusion of the wire or wires they contain without igniting the conduit.

- b.* Must not be of such material or construction that the insulation of the conductor will ultimately be injured or destroyed by the elements of the composition.

- c.* Must be first installed as a complete conduit system, without conductors, strings or anything for the purpose of drawing in the conductors, and the conductors then to be pushed or fished in. The conductors must not be placed in position until all mechanical work on the building has been, as far as possible, completed.

- d.* Must not be so placed as to be subject to mechanical injury by saws, chisels or nails.

- e.* Must not be supplied with a twin conductor, or two separate conductors, in a single tube. (See Rule 22.)

- f.* Must have all ends closed with good adhesive material, either at junction boxes or elsewhere, whether such ends are concealed or exposed. Joints must be made air tight and moisture proof.

- g.* Conduits must extend at least one inch beyond the finished surface of walls or ceilings until the mortar or other similar material be entirely dry, when the projection may be reduced to half an inch.

23. DOUBLE POLE SAFETY CUT-OUTS :

- a.* Must be in plain sight or enclosed in an *approved* box, readily accessible. (See Definitions.)

- b.* Must be placed at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller).

NATIONAL BOARD FIRE UNDERWRITERS.

c. Must be supported on bases of non-combustible, insulating, moisture-proof material.

d. Must be supplied with a plug (or other device for enclosing the fusible strip or wire) made of non-combustible and moisture-proof material, and so constructed that an arc cannot be maintained across its terminals by the fusing of the metal.

e. Must be so placed that on any combination fixture no group of lamps requiring a current of six amperes or more shall be ultimately dependent upon one cut-out. Special permission may be given *in writing* by the Inspector for departure from this rule in case of large chandeliers.

f. All cut-out blocks must be stamped with their *maximum* safe-carrying capacity in amperes.

24. SAFETY FUSES:

a. Must all be stamped or otherwise marked with the number of amperes they will carry indefinitely without melting.

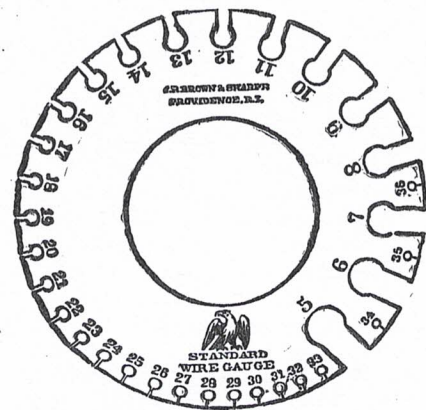
b. Must have fusible wires or strips (where the plug or equivalent device is not used), with contact surfaces or tips of harder metal, soldered or otherwise, having perfect electrical connections with the fusible part of the strip.

c. Must all be so proportioned to the conductors they are intended to protect that they will melt before the maximum safe-carrying capacity of the wire is exceeded.

25. TABLE OF CAPACITY OF WIRES:

It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects,

FIG. 172.



BROWN & SHARPE WIRE GAUGE (B. & S. W. G.)

WIRING RULES AND REQUIREMENTS.

and not upon the amount of current to be used on the circuit. Below is a table showing the safe-carrying capacity of conductors of different sizes in Brown & Sharpe gauge, which must be followed in the placing of interior conductors:

TABLE A. Concealed Work.		TABLE B. Open Work.	
B. & S. G.	Amperes.		Amperes.
0000.....	218.....		312
000.....	181.....		262
00.....	150.....		220
0.....	125.....		185
1.....	105.....		156
2.....	88.....		131
3.....	75.....		110
4.....	63.....		92
5.....	53.....		77
6.....	45.....		65
8.....	33.....		45
10.....	25.....		32
12.....	17.....		23
14.....	12.....		16
16.....	6.....		8
18.....	3.....		5

NOTE.—By "open work" is meant construction which admits of all parts of the surface of the insulating covering of the wire being surrounded by *free* air. The carrying capacity of 16 and 18 wire is given, but no wire smaller than 14 is to be used except as allowed under Rules 18 (a) and 27 (d).

26. SWITCHES:

- a. Must be mounted on moisture-proof and non-combustible bases, such as slate or porcelain.
- b. Must be double pole when the circuits which they control supply more than six 16 candle-power lamps, or their equivalent.

NATIONAL BOARD FIRE UNDERWRITERS.

c. Must have a firm and secure contact; must make and break readily, and not stop when motion has once been imparted by the handle.

d. Must have carrying capacity sufficient to prevent heating.

e. Must be placed in dry, accessible places, and be grouped as far as possible, being mounted—when practicable—upon slate or equally non-combustible back boards. Jackknife switches, whether provided with friction or spring stops, must be so placed that gravity will tend to open rather than close the switch.

27. FIXTURE WORK.

a. In all cases where conductors are concealed within or attached to gas fixtures, the latter must be insulated from the gas pipe system of the building by means of *approved* joints. The insulating material used in such joints must be of a substance not affected by gas, and that will not shrink or crack by variation in temperature. Insulating joints, with soft rubber in their construction, will not be approved. (See Definitions.)

b. Supply conductors, and especially the splices to fixture wires, must be kept clear of the grounded part of gas pipes, and where shells are used the latter must be constructed in a manner affording sufficient area to allow this requirement.

c. When fixtures are wired outside, the conductors must be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture.

d. All conductors for fixture work must have a water-proof insulation that is durable and not easily abraded, and

WIRING RULES AND REQUIREMENTS.

must not in any case be smaller than No. 18 B. & S., No. 20 B. W. G., No. 2 E. S. G.

e. All burrs or fins must be removed before the conductors are drawn into a fixture.

f. The tendency to condensation within the pipes should be guarded against by sealing the upper end of the fixture

g. No combination fixture in which the conductors are concealed in a space less than one-fourth inch between the inside pipe and the outside casing will be approved.

h. Each fixture must be tested for "contacts" between conductors and fixtures, for "short circuits," and for ground connections before the fixture is connected to its supply conductors.

i. Ceiling blocks of fixtures should be made of insulating material; if not, the wires in passing through the plate must be surrounded with hard rubber tubing.

28. ARC LIGHTS ON LOW POTENTIAL CIRCUITS :

a. Must be supplied by branch conductors not smaller than No. 12 B. & S. gauge.

b. Must be connected with main conductors only through double pole cut-outs.

c. Must only be furnished with such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as stoves.

Incandescent lamps must not be used for resistance devices.

d. Must be supplied with globes and protected as in the case of arc lights on high potential circuits.

NATIONAL BOARD FIRE UNDERWRITERS.**29. ELECTRIC GAS LIGHTING :**

Where electric gas lighting is to be used on the same fixture with the electric light—

a. No part of the gas piping or fixture shall be in electrical connection with the gas lighting circuit.

b. The wires used with the fixtures must have a non-inflammable insulation, or, where concealed between the pipe and the shell of the fixture, the insulation must be such as required for fixture wiring for the electric light.

c. The whole installation must test free from "grounds."

d. The two installations must test perfectly free from connection with each other.

30. SOCKETS :

a. No portion of the lamp socket exposed to contact with outside objects must be allowed to come into electrical contact with either of the conductors.

b. In rooms where inflammable gases may exist, or where the atmosphere is damp, the incandescent lamp and socket should be enclosed in a vapor-tight globe.

31. FLEXIBLE CORD :

a. Must be made of conductors, each surrounded with a moisture-proof and non-inflammable layer, and further insulated from each other by a mechanical separator of carbonized material. Each of these conductors must be composed of several strands.

b. Must not sustain more than one light not exceeding 50 candle-power.

WIRING RULES AND REQUIREMENTS.

- c. Must not be used except for pendants, wiring of fixtures and portable lamps or motors.
- d. Must not be used in show windows.
- e. Must be protected by insulating bushings where the cord enters the socket. The ends of the cord must be taped to prevent fraying of the covering.
- f. Must be so suspended that the entire weight of the socket and lamp will be borne by knots under the bushing in the socket, and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws.
- g. Must be equipped with keyless sockets as far as practicable, and be controlled by wall switches.

32. DECORATIVE SERIES LAMPS :

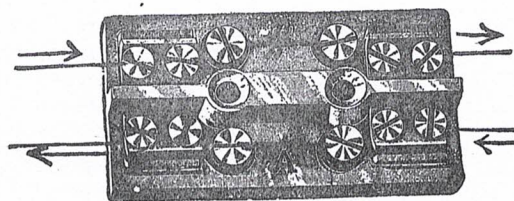
Incandescent lamps run in series circuits shall not be used for decorative purposes inside of buildings.

Class D. Alternating Systems.—Converters or Transformers.

33. CONVERTERS :

- a. Must not be placed inside of any building, except the Central Station, unless by special permission of the Underwriters having jurisdiction.
- b. Must not be placed in any but metallic or other non-combustible cases.
- c. Must not be attached to the outside walls of buildings, unless separated therefrom by substantial insulating supports.

FIG. 173.



LINE CUTOUT.

FIG. 174.

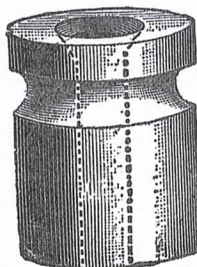
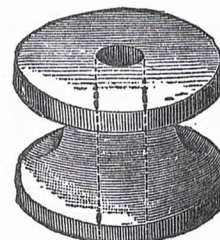
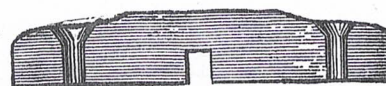


FIG. 175.



PORCELAIN INSULATORS.

FIG. 176.



WOOD CLEAT.

NATIONAL BOARD FIRE UNDERWRITERS.

34. IN THOSE CASES WHERE IT MAY NOT BE POSSIBLE TO EXCLUDE THE CONVERTERS AND PRIMARY WIRES ENTIRELY FROM THE BUILDING, THE FOLLOWING PRECAUTIONS MUST BE STRICTLY OBSERVED:

Converters must be located at a point as near as possible to that at which the primary wires enter the building, and must be placed in a room or vault constructed of, or lined with, fire-resisting material, and used only for the purpose. They must be effectually insulated from the ground, and the room in which they are placed be practically air-tight, except that it shall be thoroughly ventilated to the out-door air, if possible through a chimney or flue.

35. PRIMARY CONDUCTORS:

a. Must each be heavily insulated with a coating of moisture-proof material from the point of entrance to the transformer, and, in addition, must be so covered and protected that mechanical injury to them, or contact with them, shall be practically impossible.

b. Must each be furnished, if within a building, with a switch and a fusible cut-out where the wires enter the building, or where they leave the main line, on the pole or in the conduit. These switches should be enclosed in secure and fire-proof boxes preferably outside the building.

c. Must be kept apart at least ten inches, and at the same distance from all other conducting bodies when inside a building.

36. SECONDARY CONDUCTORS:

Must be installed according to the rules for "Low Potential Systems."

WIRING RULES AND REQUIREMENTS.

Class E. Electric Railways.

37. All rules pertaining to arc light wires and stations shall apply (so far as possible) to street railway power stations and their conductors in connection with them.

38. POWER STATIONS:

Must be equipped in each circuit as it leaves the station with an *approved* automatic "breaker," or other device that will immediately cut off the current in case the trolley wires become grounded. This device must be mounted on a fire-proof base, and in full view and reach of the attendant. (See Definitions.)

39. TROLLEY WIRES:

a. Must be no smaller than No. 0, B. & S. copper or No. 4, B. & S. silicon bronze, and must readily stand the strain put upon them when in use.

b. Must be well insulated from their supports, and in case of the side or double pole construction, the supports shall also be insulated from the poles immediately outside of the trolley wire.

c. Must be capable of being disconnected at the power house, 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*.

d. Must be safely protected against contact with all other conductors.

NATIONAL BOARD FIRE UNDERWRITERS.

40. CAR WIRING:

Must be always run out of reach of the passengers, and must be insulated with a water-proof insulation.

41. LIGHTING AND POWER FROM RAILWAY WIRES:

Must not be permitted, under any pretense, in the same circuit with trolley wires with a ground return, nor shall the same dynamo be used for both purposes, except in street railway cars, electric car houses, and their power station.

42. CAR HOUSES:

Must have special cut-outs located at a proper distance outside, so that all circuits within any car house can be cut out at one point.

43. GROUND RETURN WIRES:

Where ground return is used it must be so arranged that no difference of potential will exist greater than five volts to fifty feet, or fifty volts to the mile between any two points in the earth or pipes therein.

Class F.

44. 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 applied to similar apparatus fed from dynamo generators developing the same difference of potential.

WIRING RULES AND REQUIREMENTS.

b. All secondary batteries must be mounted on *approved* insulators.

c. Special attention is directed to the rules for rooms where acid fumes exit.

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

Miscellaneous.

45. a. The wiring in any building must test free from grounds; *i. e.*, each main supply line and every branch circuit shall have an insulation resistance of at least 25,000 ohms, and should have an insulation resistance between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) of not less than the following:

Up to	10 amperes,	.	.	.	.	.	.	4,000,000
"	25 "	.	.	.	.	.	.	1,000,000
"	50 "	.	.	.	.	.	.	800,000
"	100 "	.	.	.	.	.	.	300,000
"	200 "	.	.	.	.	.	.	160,000
"	400 "	.	.	.	.	.	.	80,000
"	800 "	.	.	.	.	.	.	22,000
"	1,600 "	.	.	.	.	.	.	11,000

All cut-outs and safety devices in place in the above.

Where lamp sockets, receptacles, and electroliers, etc., are connected, one-half of the above will be required.

b. Ground wires for lightning arresters of all classes, and ground detectors, must not be attached to gas pipes within the building.

NATIONAL BOARD FIRE UNDERWRITERS.

c. Where telephone, telegraph or other wires connected with outside circuits are bunched together within any building, or where inside wires are laid in conduit or duct with electric light or power wires, the covering of such wires must be fire resisting, or else the wires must be inclosed in an air-tight tube or duct.

d. All conductors connecting with telephone, district messenger, burglar-alarm, watch-clock, electric-time, and other similar instruments, must be provided near the point of entrance to the building with some protective device which will operate to shunt the instruments in case of a dangerous rise of potential, and will open the circuit and arrest an abnormal current flow. Any conductor normally forming an innocuous circuit may become a source of fire hazard if crossed with another conductor, through which it may become charged with a relatively high pressure. (See Definitions.)

e. The following formula for soldering fluid is suggested :

Saturated solution of zinc	.	.	.	.	.	.	.	.	5 parts
Alcohol	.	.	.	.	.	.	.	.	4 parts
Glycerine	.	.	.	.	.	.	.	.	1 part

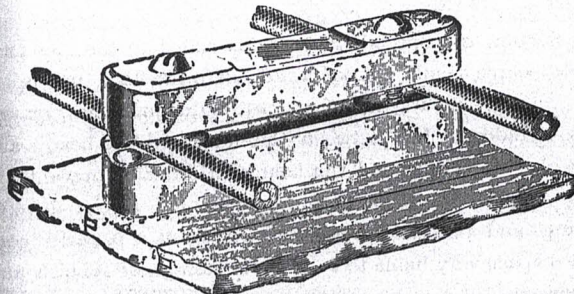
DEFINITIONS

of the word **APPROVED** as used in these rules, and notice of the approval of certain wires and materials, and the interpretation of certain rules.

RULE 2. CARE AND ATTENDANCE:

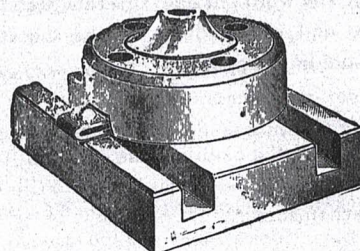
Approved waste cans shall be made of metal, with legs raising can three inches from the floor, and with self-closing covers.

FIG. 177.



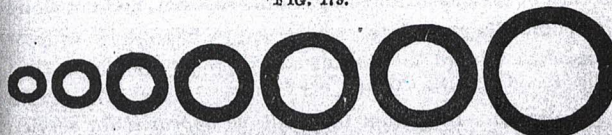
PORCELAIN CLEAT.

FIG. 178.



PORCELAIN ROSETTE.

FIG. 179.



RUBBER TUBING.

WIRING RULES AND REQUIREMENTS.

RULE 4. SWITCHBOARDS:

Section *a*. Special attention is called to the fact that switchboards should not be built down to the floor, nor up to the ceiling, but a space of at least eighteen inches, or two feet, should be left between the floor and the board, and between the ceiling and the board, in order to prevent fire from communicating from the switchboard to the floor or ceiling, and also to prevent the forming of a partially concealed space very liable to be used for storage of rubbish and oily waste.

RULE 5. RESISTANCE BOXES:

Section *a*. The word "frame" in this section relates to the entire case and surroundings of the rheostat, and not alone to the upholding supports.

RULE 8. MOTORS:

Section *c*. From the nature of the question, the decision as to what is an *approved* case must be left to the Inspector to determine in each instance.

RULE 9. RESISTANCE BOXES:

Section *a*. The word "frame" in this section relates to the entire case and surroundings of the rheostat, and not alone to the upholding supports.

RULE 10. OUTSIDE CONDUCTORS:

Section *a*. Insulation that will be *approved* for service wires must be solid, at least $\frac{3}{4}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry

NATIONAL BOARD FIRE UNDERWRITERS.

fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime water, with a current of 550 volts, and after three minutes' electrification.

Section *f*. All joints must be soldered, even if made with the McIntyre or any other patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these Rules.

RULE 12. INTERIOR CONDUCTORS:

Section *d*. Insulation that will be *approved* for interior conductors must be solid, at least $\frac{3}{4}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime water, with a current of 550 volts, and after three minutes' electrification.

RULE 13. ARC LAMPS:

Section *c*. The hand switch is to be *approved*, if placed any where except on the lamp itself, must comply with requirements for switches on hanger-boards as laid down in Section *g* of Rule 13.

Section *f*. An *approved* spark arrester is one which will so close the upper orifice of the globe that it will be impossible for any sparks thrown off by the carbons to escape.

RULE 15. OUTSIDE OVERHEAD CONDUCTORS:

Section *b*. An *approved* fusible cut-out must comply with the sections of Rules 23 and 24 describing fuses and cut-outs

WIRING RULES AND REQUIREMENTS.

The cut-out required by this section must be placed so as to protect the switch required by Rule 17.

RULE 16. UNDERGROUND CONDUCTORS :

Section *b*. The cut-out required by this section must be placed so as to protect the switch.

RULE 17 :

The switch required by this rule to be *approved* must be double pole, must plainly indicate whether the current is "on" or "off," and must comply with Sections *a*, *c*, *d* and *e* of Rule 26 relating to switches.

RULE 18. CONDUCTORS :

Section *a*. In so-called "concealed" wiring, moulding and conduit work, and in places liable to be exposed to dampness, the insulating covering of the wire, to be *approved*, must be solid, at least $\frac{3}{8}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime water, with a current of 550 volts, and after three minutes' electrification.

For work which is *entirely* exposed to view throughout the whole interior circuits, and not liable to be exposed to dampness, a wire with an insulating covering that will not support combustion, will resist abrasion, is at least $\frac{1}{8}$ of an inch in thickness, and thoroughly impregnated with a moisture repellant, will be *approved*.

NATIONAL BOARD FIRE UNDERWRITERS.

Section *b*. Second paragraph. Except for floors, and for places liable to be exposed to dampness, glass, porcelain, *metal sheathed* Interior Conduit and Vulca Tube, when made especially for bushings, will be *approved*. [The two last named will not be approved if cut from the usual lengths of tube made for conduit work, nor when made without a head or flange on one end.]

Section *f*. All joints must be soldered, even if made with the McIntyre or any other patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these Rules.

RULE 21. SPECIAL WIRING :

Section *b*. The insulating covering of the wire to be *approved* under this section must be solid, at least $\frac{3}{8}$ of an inch in thickness and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime water, with a current of 550 volts after three minutes' electrification, and must *also* withstand a satisfactory test against such chemical compounds or mixtures as it will be liable to be subjected to in the risk under consideration.

RULE 22. INTERIOR CONDUITS :

The American Circular Loom Co. Tube, the *brass-sheathed* and the *iron-armored* tubes made by the Interior Conduit and Insulation Company, and the Vulca Tube are approved

WIRING RULES AND REQUIREMENTS.

NOTE.—The use of two *standard* wires, either separate or twin conductor, in a straight conduit installation is approved in the *iron-armored* conduit of the Interior Conduit and Insulation Company, but not in any of the other approved conduits. Rule 22. e.) (See *Addenda*.)

RULE 23. DOUBLE POLE SAFETY CUT-OUTS:

Section a. To be *approved*, boxes must be constructed, and cut-outs arranged, whether in a box or not, so as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

RULE 27. FIXTURE WORK:

Section a. Insulating joints to be *approved* must be entirely made of material that will resist the action of illuminating gases, and will not give way or soften under the heat of an ordinary gas flame. They shall be so arranged that a deposit of moisture will not destroy the insulating effect, and shall have an insulating resistance of 250,000 ohms between the gas pipe attachments, and be sufficiently strong to resist the strain they will be liable to in attachment.

RULE 38. POWER STATIONS:

Section a. Automatic circuit breakers should be submitted for *approval* before being used.

RULE 44. STORAGE OR PRIMARY BATTERIES:

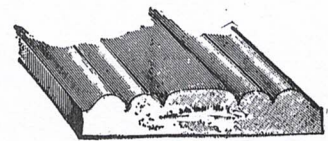
Section b. Insulators for mounting secondary batteries to be *approved* must be non-combustible, such as glass, or thoroughly vitrified and glazed porcelain.

INSIDE WIRING.

FIG. 180.

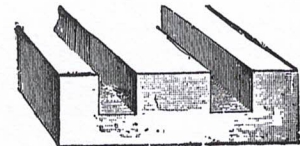
COVERED
WIRE.

FIG. 181.



CLEAT COVER.

FIG. 182.



CLEAT.

FIG. 183.



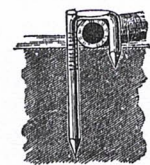
FIG. 184.



FIG. 185.



FIG. 186.



DOUBLE-POINTED TACKS.

NATIONAL BOARD FIRE UNDERWRITERS.

RULE 45. WIRE PROTECTORS:

Protectors must have a non-combustible, insulating base, and the cover to be provided with a lock similar to the lock now placed on telephone apparatus or some equally secure fastening, and to be installed under the following requirements:

1. The protector to be located at the point where the wires enter the building, either immediately inside or outside of the same. If outside, the protector to be inclosed in a metallic waterproof case.
2. If the protector is placed inside of building, the wires of the circuit from the support outside to the binding posts of the protector to be of such insulation as is approved for service wires of electric light and power, and the holes through the outer wall to be protected by bushing the same as required for electric light and power service wires.
3. The wires from the point of entrance to the protector to be run in accordance with rules for high potential wires; *i. e.*, free of contact with building, and supported on non-combustible insulators.
4. The ground wire shall be insulated, not smaller than No. 16 B. & S. gauge. This ground wire shall be kept at least three (3) inches from all conductors, and shall never be secured by uninsulated, double-pointed tacks.
5. The ground wire shall be attached to a water pipe, if possible; otherwise may be attached to a gas pipe. The ground wire shall be carried to and attached to the pipe outside of the first joint or coupling inside the foundation walls, and the connection shall be made by soldering, if

WIRING RULES AND REQUIREMENTS.

possible. In the absence of other good ground, the ground shall be made by means of a metallic plate or a bunch of wires buried in a permanently moist earth.

Addenda.

In addition to the foregoing Rules and Requirements, the *New York Board of Fire Underwriters* will require as follows:

UNDERGROUND CONDUCTORS: (See Rule 16.)

Must end outside of the main walls of the building and not be brought into a building where it is possible to avoid it; and when brought into the building, or any vault or area connected with same, must be removed at least *two* feet from all combustible material and kept free and clear of contact with any conducting material.

RULE 22. INTERIOR CONDUITS:

- c.* Must not be supplied with a twin conductor, or two separate conductors, in a single tube, unless the said two separate conductors, or twin conductor having an approved insulation, are enclosed in a complete, fully insulated, continuous iron conduit, and are in circuits installed as per table of Capacity of Wires (see Rule 25) for currents not to exceed 100 amperes.

The Rules and Regulations of the Board of Electrical Control and all existing regulations of The Local Authorities in reference to the stringing of wires, must be strictly observed.

NATIONAL BOARD FIRE UNDERWRITERS.

CENTRAL STATIONS—TESTING :

Companies furnishing electricity from Central Stations must enter into an agreement with the New York Board of Fire Underwriters, binding themselves to test their lines for ground connections at least *once* every day (and preferably three times per day), and report the result of such test to the Board weekly.

ELECTRIC LIGHTS AND MOTORS IN GENERAL STORAGE STORES :

Incandescent electric lights may be permitted when the entire plant is in full compliance with the rules of the Board, and an approved device, working automatically, is provided to cut out of building all the electric current when any excessive load is developed from any cause, and a certificate is issued to that effect ; provided the warehousemen will agree, in writing, to discontinue the use of lanterns and use no other lights (except in office) than the fixed incandescent lights that may be approved, and not to permit any alterations to be made in the electric plant after the certificate is issued, without the written consent of this Board ; it being understood that in case the electric plant is unable to run by reason of breakdown or accident, then lanterns as provided for in rules for Storage Stores may be used.

Electric power will be permitted for hoisting only, when the wires and motor are fully protected from contact with goods on storage and are placed as may be previously agreed upon with this Board, and a certificate issued that all is in full compliance with the Rules and Regulations of the Board.

WIRING RULES AND REQUIREMENTS.

Electric Heating and Cooking Apparatus ; also Glue Pots, Sad Irons, Curling Irons, Etc.

ELECTRIC HEATERS, RANGES AND STOVES :

a. These must be placed in safe situations (out of easy reach of inflammable materials) and separated from and supported on non-conducting and incombustible standards or bases so as to be at least four inches from woodwork of any description or other inflammable material, unless protected by non-combustible materials such as sheet metal and asbestos, or the like, so combined as to prevent appreciable transmission of heat, while securing full insulation. The heating wires or resistances of these heaters, etc., must be inclosed in non-combustible cases adapted to prevent accidental contact with any exterior object or material. These electric Heaters, Stoves, etc., must never be concealed, but must be at all times in plain sight.

b. They must have double pole switches, cut-outs, etc., arranged as required for electric lights or power apparatus employing the same current and potential.

c. The attachment of feed-wires to "heaters," etc., must be in plain sight, easily accessible and protected from interference, accidental or otherwise.

d. Attachment of conductors to "heaters," etc., must be securely made in the same manner that conductors are attached to motors or generators dealing with currents equal to those employed in these devices, and such conductors must be continuous from the "heater" etc., to the switch or

NATIONAL BOARD FIRE UNDERWRITERS.

cut-out, which must not be within two feet of said "heaters" etc. These conductors must be thoroughly well insulated and also covered with a good mechanical protection.

PORTABLE COOKING APPARATUS, GLUE POTS, CURLING IRONS, ET

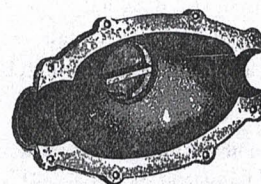
a. The heating coils or resistances of these instruments must be inclosed in non-combustible cases, which in turn must be mounted on non-conducting and incombustible bases raising the same at least one inch from any surface on which they stand.

b. These instruments must not be attached to lamp sockets, and when current of more than ten amperes is required they must conform to the same rules as Heaters, Ranges, etc.

c. Where currents of ten amperes or less are required, these instruments may be connected by specifically approved flexible double or twin-wire conductors, provided such conductor is composed of two multi-strand conductors, each of which is insulated by a waterproof material and asbestos while both are surrounded by a covering affording adequate mechanical protection. These flexible cords must also be connected to "plug switches" having double-pole fuses in their sockets which will cut out the circuits if a cross connection should occur in the flexible conductor. Moreover, such "plug switch" must be so arranged that the plug will pull out and break the connection if an abnormal mechanical strain is brought on the flexible conductor.

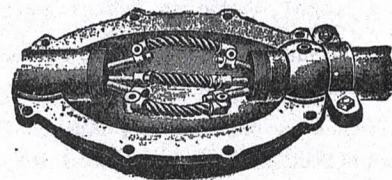
EDISON CONDUIT JUNCTION BOX

FIG. 187.



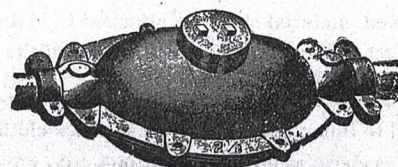
COVER.

FIG. 188.



OPEN.

FIG. 189.



CLOSED.

WIRING RULES AND REQUIREMENTS.

The leading-in wires of these flexible cords must be connected to heaters or the like at the point of lowest temperature, and where such wires are detachable at the heater, their terminals must be arranged with female ends protected by porcelain extending at least one-eighth inch beyond the metal terminals.

If the connection at the heater is fixed, a separable double-pole connector must be placed in the circuit so that in case an undue strain is brought on the conductors the device will be automatically cut out and disconnected.

Flexible cord connections longer than six feet will not be permitted.

Receptacles for plug attachments must be placed at least six inches above the floor.

Where switches are provided they must conform to the rules laid down in Section 26 of the General Requirements.

Where a number of utensils are grouped for general cooking service, installations to be approved must be provided with slate, soapstone or other approved slab or table for utensils to rest upon. Plug receptacles mounted on slate or other approved material shall be attached to mains running at least six inches above the working surface of the table.

Sad irons and other heating appliances that are intended to be applied to inflammable articles, such as clothing, must be arranged as above as far as connections, etc., are concealed and must also be provided with approved attachments which will cut off current when they are not in actual use.

NATIONAL BOARD FIRE UNDERWRITERS.

The leading-in wires to these forms of apparatus must be connected through porcelain connecting blocks, and the cable or cord of the same must be passed through an insulated elastic spiral or spring so arranged as to protect the same from kinking, chafing or like injury at or near the point of connection.

These conductors must be so placed that they will at all times be at least four feet from the floor and well protected against contact with water pipes or other possible ground connections.

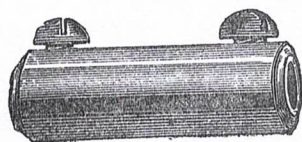
The use of no flexible cord will be permitted, unless specifically approved by this Board.

FIG. 190.



CONNECTORS.

FIG. 191.



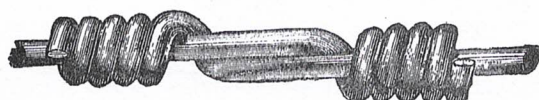
CONNECTORS FOR LINE WORK.

FIG. 192.



SLEEVE.

FIG. 193.



WESTERN UNION WIRE JOINT.

FIG. 194.



MCINTIRE SLEEVE AND JOINT.

WIRING.

Wire Gauges.—In practice sizes of wires or conductors are designated in two ways: first, by measurements in 1,000th of an inch, and, secondly, by the number of circular mils they contain, a circular mil being a circle one one-thousands of an inch in diameter, and the number of these circles contained in a cross section of a piece of wire is called a size of so many circular mils of cross section, or so many circular mils wire, the other being mils diameter. A copper bar one square inch in size, contains 1,273,200 circular mils, and a round wire, one inch in diameter contains exactly one million circular mils.

Wire gauges are employed for accurately measuring the diameter of a wire, this is done so as to calculate the resistance of a given length of such wire.

Fig. 172, page 391, shows a form of wire gauge called the round wire gauge. Notches are cut in the edges. Numbers indicating the different sizes of the wire are affixed to each of the openings; the number 5 in the gauge indicates that wire that will just pass through straight sides of the opening is No. 5 wire Brown & Sharp gauge (B. & S. G.)

Fig. 171, page 385, shows the Birmingham wire gauge (B. W. G.) In general electric practice the Brown & Sharp (American) Wire Gauge is used for copper wire and the Birmingham Wire Gauge for iron wire.

The Micrometer Wire Gauge is shown in Fig. 170, page 379. This is a device used for measuring the diameter of a wire in the thousandths of an inch. Micro as a prefix denotes the millionth part.