B. S. HANDBOOK SER. No. 6

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL SUPPLY STATIONS

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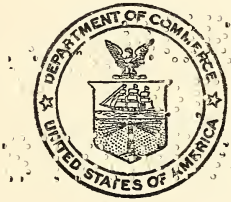
Comprising Part 1 and the Grounding Rules of the Fourth Edition National Electrical Safety Code

February 5, 1926



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PREFACE

Previous editions of the National Electrical Safety Code have been published in complete form. There has been some demand, however, for smaller handbooks containing a single part of the code, and in response to this demand the fourth edition is being issued not only as a whole, but also as separate publications dealing with the several subjects covered.

This volume contains part 1 dealing with generating stations and substations, along with the grounding rules contained in section 9.

The present edition of these rules is the result of a revision which has been carried out according to the procedure of the American Engineering Standards Committee and the revised rules have had the approval of the sectional committee organized according to those rules of procedure. A discussion of these rules will be found in the revised edition of Handbook Series No. 4.

Two sizes of type have been used in the text; the larger containing the rules proper, whereas explanatory notes, etc., are in smaller type.

Criticism of the rules and suggestions for their improvement are invited, and in future editions every effort will be made to perfect the rules both in the development of detail and in the modification of any requirements which it is found can be improved.

GEORGE K. BURGESS,
Director.

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SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL SUPPLY STATIONS

COMPRISING PART 1 AND THE GROUNDING RULES OF THE FOURTH EDITION, NATIONAL ELECTRICAL SAFETY CODE

DEFINITIONS

Alive or live means electrically connected to a source of potential difference, or electrically charged so as to have a potential different from that of the earth. The term "live" is sometimes used in place of the term "current-carrying" where the intent is clear, to avoid repetitions of the longer term.

Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength; not manual, without personal intervention. Remote control that requires personal intervention is not automatic, but manual.

Circuit means a conductor or system of conductors through which an electric current is intended to flow.

Circuit breaker means a device designed to open under abnormal conditions a current-carrying circuit without injury to itself. The term as used in this code applies only to the automatic type designed to trip on a predetermined overload of current.

Conductor means a metallic conducting material, usually in the form of a wire or cable, suitable for carrying an electric current. Does not include bus bars.

Conduit means (in interior work) a tube or duct especially constructed for the purpose of inclosing electrical conductors.

Current-carrying part means a part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

Dead means free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth. The term is used only with reference to current-carrying parts which are sometimes alive.

Disconnector means a switch which is intended to open a circuit only after the load has been thrown off by some other means.

Manual switches designed for opening loaded circuits are usually installed in circuit with disconnectors, to provide a safe means for opening the circuit under load.

Electrical supply equipment means equipment which produces, modifies, regulates, controls, or safeguards a supply of electrical energy. Similar equipment, however, is not included where used in connection with communication systems under the following conditions: (*a*) Where the voltage does not exceed 150; (*b*) where the voltage is between 150 and 400 and the power transmitted does not exceed 3 kilowatts.

Electrical supply station means any building, room, or separate space within which electrical supply equipment is located and the interior of which is accessible, as a rule, only to properly qualified persons.

This includes generating stations and substations and generator, storage battery, and transformer rooms, but excludes manholes and isolated transformer vaults on private premises.

Explosion proof means capable of withstanding without injury and without transmitting flame to the outside any explosion of gas which may occur within.

Exposed (applied to equipment) means that an object or device can be inadvertently touched or approached nearer than a safe distance by any person. It is applied to objects not suitably guarded or isolated.

Grounded means connected to earth or to some extended conducting body which serves instead of the earth, whether the connection is intentional or accidental.

Grounded system means a system having a permanent and effective electrical connection to earth. This ground connection may be at one or more points.

"Effective," as herein used, means a connection to earth of sufficiently low resistance and high current-carrying capacity to prevent any current in the grounding wire from causing a harmful voltage to exist between the grounded conductors and neighboring exposed conducting surfaces which are in good contact with the earth, or with neighboring surfaces of the earth itself, under the most severe conditions which are liable to arise in practice.

Permanently grounded means having such an effective connection to the earth (by use of an underground system of metallic pipe mains or other suitable means), as described in the preceding paragraph.

Guarded means covered, shielded, fenced, inclosed, or otherwise protected by means of suitable covers or casings, barrier rails or screens, mats or platforms, to remove the liability of dangerous contact or approach by persons or objects to a point of danger.

Inclosed means surrounded by a case which will prevent accidental contact of a person with live parts. A solid inclosure means one which will neither admit accumulations of flyings or dust, nor transmit sparks or flying particles to the accumulations outside.

Insulated means separated from other conducting surfaces by a dielectric substance or air space permanently

offering a high resistance to the passage of current and to disruptive discharge through the substance or space.

When any object is said to be insulated, it is understood to be insulated in suitable manner for the conditions to which it is subjected. Otherwise, it is, within the purpose of these rules, uninsulated. Insulating covering of conductors is one means for making the conductors insulated.

Insulating (where applied to the covering of a conductor, or to clothing, guards, rods, and other safety devices) means that a device, when interposed between a person and current-carrying parts, protects the person making use of it against electric shock from the current-carrying parts with which the device is intended to be used; the opposite of conducting.

Isolated means that an object is not readily accessible to persons unless special means for access are used.

Isolation by elevation means elevated sufficiently so that persons may safely walk underneath.

Low-voltage protection means the effect of a device operative on the reduction or failure of voltage to cause and maintain the interruption of power supply to the equipment protected.

Low-voltage release means the effect of a device operative on the reduction or failure of voltage to cause the interruption of power supply to the equipment, but not preventing the reestablishment of the power supply on return of voltage.

Manual means capable of being operated by personal intervention.

Panelboard means a single panel containing busses, fuses, and switches to control lights, fan motors, and similar devices of small individual as well as aggregate capacity, placed in or against a wall or partition and accessible only from the front.

Qualified means familiar with the construction and operation of the apparatus and the hazards involved.

Raceway means any channel for loosely holding wires or cables in interior work, which is designed expressly and used solely for this purpose. Raceways may be of metal, wood, or insulating material, and the term includes wooden and metal moldings consisting of a backing and capping and also metal ducts into which wires are to be pulled.

Reconstruction means replacement of any portion of an existing installation by new equipment or construction. Does not include ordinary maintenance replacements.

Service means the connecting conductors by which a supply of electrical energy is carried from a supply line to the building or premises served. For overhead circuits, it includes the conductors from the last line pole to the service switch or fuse. The portion of an overhead service between the pole and building is designated as "service drop."

Substantial means so constructed and arranged as to be of adequate strength and durability for the service to be performed under the prevailing conditions.

Switch means a device for opening and closing or for changing the connection of a circuit. In these rules a switch will always be understood to be manually operated unless otherwise stated.

Switchboard means a large single panel, frame, or assembly of panels on which are mounted (on the face or back or both) switches, fuses, busses, and usually instruments.

Tags means "men at work" tags of distinctive appearance, indicating that the equipment or lines so marked are being worked on.

Transformer vault means an isolated, fireproof inclosure, either above or below ground, in which transformers, and the devices necessary for their operation, are installed, and

which is not continuously under attendance during operation.

Utilization equipment means equipment, devices, and connected wiring which utilize electrical energy for mechanical, chemical, heating, lighting, testing, or similar purposes and are not a part of supply equipment, supply lines, or communication lines.

Voltage or volts means the highest effective voltage between any two conductors of the circuit concerned, except that in grounded multiwire circuits, not exceeding 750 volts between outer conductors, it means the highest effective voltage between any wire of the circuit and the ground.

In ungrounded circuits not exceeding 750 volts, voltage to ground means the voltage of the circuit.

When one circuit is directly connected to another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage unless the circuit of lower voltage is permanently grounded. Direct connection implies electrical connection as distinguished from connection merely through electromagnetic or electrostatic induction.

SEC. 9. RULES COVERING METHODS OF PROTECTIVE GROUNDING OF CIRCUITS, EQUIPMENT, AND LIGHTNING ARRESTERS FOR STATIONS

90. Scope of the Rules.

The following rules apply to the grounding of all lightning arresters except those on communication circuits, and of all circuits, equipment, or wire runways when the grounding is intended to be a permanent and effective protective measure.

They do not apply to the grounded return of electric railways, nor to the grounding or lightning protection wires which are independent of electric circuits or equipment.

These rules do not require that grounding shall be done, but cover the methods for protective grounding. The rules requiring grounding, in accordance with the methods specified below, are included under the various parts of this code.

Other methods of construction and installation than those specified in the rules may be used as experiments to obtain information if done where supervision can be given by the proper administrative authority.

91. Application of the Rules.

(a) **Waiving rules.**—The rules are intended to apply to all installations except as modified or waived by the proper administrative authority or its authorized agents. They are intended to be so modified or waived in particular cases wherever any rules are shown for any reason to be impracticable, such as by involving expense not justified by the protection secured; provided equivalent or safer construction is secured in other ways.

(b) **Application.**—The intent of the rules will be realized (1) by applying the rules in full to all new installations, reconstructions, and extensions, except where any rule is shown to be impracticable for special reasons or where the advantage of uniformity with existing construction is greater than the advantage of construction in compliance with the rules, providing the existing construction is reasonably safe; (2) by placing grounds on existing installations or bringing present grounds into compliance with the rules, except where the expense involved is not justifiable.

The time allowed for bringing existing installations into compliance with the rules will be determined by the proper administrative authority.

(c) **Temporary installations.**—It will sometimes be necessary to modify or waive certain of the rules in case of temporary installations or installations which are shortly to be dismantled or reconstructed.

(d) **Emergency.**—In cases of emergency or pending decision of the administrator the person responsible for the installation may decide as to modification or waiver of any rule, subject to review by proper authority.

92. Point of Attachment of Grounding Conductor.

(a) **Direct-current distribution systems.**—In three-wire direct-current systems the ground connections shall be made on the neutral at one or more supply stations.

In two-wire direct-current systems the ground connection shall be made at one station only.

No ground connection shall be made at individual services or within the building served. In two-wire systems the grounded side of the circuit shall be insulated from ground except at the station ground connection.

(b) **Alternating-current distribution systems.**—In alternating-current systems the ground connection shall be made at the building service or near the transformer (or transformers) either by direct ground connection (through water-piping system or artificial ground, see rule 94) or by the use of a system ground wire to which are connected the grounded conductors of many secondary mains and which is itself effectually grounded at intervals that will fulfill, for any secondary utilizing the system ground wire, the resistance and current-carrying requirements of rule 96.

When the secondaries of transformers are supplying a common set of mains, fuses, if installed, shall be located only at such points as not to cause the loss of the ground connections after any fuses in the transformer circuits or mains have been blown.

Alternating-current secondary circuits supplied from a transformer outside the building shall not be grounded inside buildings except at the service entrance.

In single-phase, three-wire systems the ground shall be on the neutral conductor. In single-phase two-wire systems the ground may be made on either conductor. In two-wire single-phase and in two or three phase systems the ground shall be made at that point of the system which brings about the lowest voltage from ground of unguarded current-carrying parts of connected devices. Where one phase of a two or three phase system is used for lighting, that phase should be grounded and at the neutral conductor, if one is used.

In the absence of direct grounds at all building services, ground connections shall be made to the grounded neutral or other grounded conductor of a secondary system supplying more than one utilization equipment, at intervals that will fulfill the resistance requirements of rule 96 (*a*).

(c) **Current in grounding conductor.**—Grounds shall be so arranged that under normal conditions of service there will be no objectionable flow of current over the grounding conductor.

Where the objectionable flow of current over a grounding conductor is due to the use of multiple grounds, one or more of such grounds shall be abandoned or the location changed.

(d) **Equipment and wire runways.**—For conduit, armored cable, metal raceways, generators, motors, transformers, and other equipment, the point at which the grounding conductor is attached shall, if practicable, be readily accessible.

No separate grounding conductor shall be required for noncurrent-carrying parts of equipment if grounded through the conduit, cable sheath, or metal raceway system of the

building by means of standard lock nuts and bushings or by a separate bond between the equipment and the conduit, armored cable, or metal raceway system.

For conduit, armored cable, or metal raceways the ground connection shall be as near as practicable to the point where the conductors in the conduit system concerned receive their supply.

(e) Service conduit.—When the service conduit is grounded, its grounding wire shall be run directly from it to the ground connection. The interior conduit, armored cable, or metal raceways, if well bonded to the service conduit, grounded as provided in this rule, needs no additional ground connection.

93. Grounding Conductor.

(a) Material and continuity.—In all cases the grounding conductor shall be of copper or of other metal which will not corrode excessively under the existing conditions and, if practicable, shall be without joint or splice. If joints are unavoidable they shall be so made and maintained as to conform to the resistance requirements of rule 96.

In no case shall a fuse or automatic circuit breaker be inserted in the grounding conductor or connection except in a ground connection from equipment where its operation will result in the automatic disconnection from all sources of energy of the circuit leads connected to equipment so grounded; no switch shall be so inserted except in plain sight, provided with distinctive marking and effectively isolated from unqualified persons. (See also rule 92 (*b*), par. 2.)

For lightning arresters and ground detectors the grounding conductor shall be as short and straight as practicable and free from sharp bends.

(b) Size and capacity.—The conductor or conductors for grounding circuits shall have a combined current capacity

sufficient to insure the continuity and continued effectiveness of the ground connection under conditions of excess current caused by accidental grounding of any normally ungrounded conductor of the circuit. No individual grounding conductor for electrical circuits shall have current capacity less than that of a No. 8 (0.128 inch) copper wire.

The grounding conductor for a direct-current system shall have a current capacity not smaller than the largest feeder of the same system leaving the station.

The grounding conductor for alternating-current systems shall have a current capacity not less than one-fifth that of the conductor to which it is attached, except that it need not be larger than No. 0 (0.325 inch) copper.

For lightning arresters the grounding conductor or conductors shall have a current capacity sufficient to insure continuity and continued effectiveness of the ground connection under conditions of excess current caused by or following discharge of the arrester. No individual grounding conductor shall have less conductance than a No. 6 (0.162 inch) copper wire.

For noncurrent-carrying parts of electrical equipment the conductance of a grounding conductor shall be not less than that provided by a copper wire of the size indicated in the following table. When there is no fuse or automatic circuit breaker protecting the equipment, the size of the grounding conductor will be determined by the design and operating conditions of the circuit.

Rating of fuse or circuit breaker which protects equipment or conductors	Size of grounding wire		Nominal size of grounding pipe
	A. W. G.	*Inch*	*Inch*
Not more than 100 amperes	10	0.102	½
More than 100, but not more than 200 amperes	6	.162	½
More than 200, but not more than 500 amperes	4	.204	¾
More than 500 amperes	2	.258	1

In portable cord to portable equipment protected by fuses not greater than 15 amperes capacity, a No. 18 (0.040 inch) grounding wire may be used.

Grounding wires for conduit, armored-cable, or metal-raceway systems shall have a conductance at least equivalent to No. 10 (0.102 inch) copper where largest wire contained is not larger than No. 0 (0.325 inch), and need not be larger than No. 4 (0.204 inch) where the largest wire contained is larger than No. 0; and for service conduit the grounding wire shall have a conductance not less than that of No. 8 (0.128 inch) copper wire.

(c) **Mechanical protection and guarding against contact.**—Where exposed to mechanical injury the grounding conductor shall be protected by substantial conduit or other guard. Guards for lightning-arrester grounding conductors shall be of nonmagnetic material unless the grounding conductor is electrically connected to both ends of the guard.

If the resistance of the ground connection is in excess of three ohms, the grounding conductor, except in rural districts, shall be protected and guarded by being inclosed in insulating conduit or molding to protect persons from injury by coming in contact with it.

NOTE.—Such a high resistance may exist where artificial grounds are necessarily permitted in lieu of the preferable grounds to buried metallic water-piping systems.

Mechanical protection and insulating guards should extend for a distance of not less than 8 feet above any ground, platform, or floor from which grounding conductors are accessible to the public.

NOTE.—Insulating mechanical protection is advisable for single arrester grounds, even when the connection is made to a water-piping system, and has therefore a low resistance, since a single connection is liable to be accidentally broken.

Even where ground connections have a resistance not exceeding that specified in rule 96 and no guard is therefore provided (or as an additional protection to persons even where guards are used) artificial grounds may be arranged to minimize the potential gradient along the surface of the earth by use of radial connecting wires underneath the earth surface or by other suitable means.

A grounding conductor for a circuit shall be guarded as required for current-carrying conductors of the circuit.

Exceptions.—(1) A grounding conductor for a circuit having multiple grounds, where such conductor is entirely outside buildings and has strength and current capacity not less than No. 6 (0.162 inch) copper wire.

(2) In stations substantial bare ground busses may be used.

(d) **Underground.**—Wires used for grounding conductors, if laid underground, shall, unless otherwise mechanically protected, be laid slack to prevent their being readily broken, and shall have joints carefully painted or otherwise protected against corrosion.

94. Ground Connections.

The ground connection shall be permanent and effective, and be made as indicated below, but always to water-piping systems, if available.

(a) **Piping systems.**—For circuits, equipment, and arresters at supply stations, connections shall be made to all available active metallic underground water-piping systems between which no appreciable difference of potential normally exists, if the pipe is of sufficient capacity, and to one such system if appreciable differences of potential do exist between them. At other places connections shall be made to at least one such system, if available. Gas piping should not be used for grounding circuits.

NOTE.—The protective grounding of electrical circuits and equipment to water-pipe systems in accordance with these rules should

always be permitted, since such grounding offers the most effective protection to life and property and is not injurious to the piping systems.

Ground connections from circuits should not be made to jointed piping within buildings except water piping.

(b) **Alternate methods.**—Where underground metallic piping systems are not available, other methods which will secure the desired permanence and conductance may be permitted. In many cases metal well casings, local metal drainpipes, and similar buried metal structures of considerable extent will be available and may be used in lieu of extended buried water-piping systems.

In some cases ground connection may be made to the steel frame of a building containing the grounded circuits or equipment, to which frames of machines and other non-current-carrying surfaces should also then be connected. In such cases the building frame should be itself well grounded by effective connection to the ground. This may require artificial grounding for steel-frame buildings supported on masonry or concrete footings.

(c) **Artificial grounds.**—When resort must be had to artificial grounds, their number should be determined by the following requirements:

(1) Not more than one such ground is required for lightning arresters, except where for large current capacity.

(2) At least two grounds are required for low-voltage alternating-current distribution circuits at transformers or elsewhere, except as specified in (3).

(3) Where no part of the circuit or equipment protected can be reached by persons while they are standing on the ground or damp floors, or by persons while touching any metallic piping to which the grounding conductor is not effectively connected, a single artificial ground may be used even if its resistance exceeds that specified in rule 96. In

such cases it is desirable to provide guards for the grounding conductor in accordance with rule 93 (*c*) wherever it is otherwise accessible, or to provide insulating mats or platforms so located that persons can not readily touch the grounding conductors without standing on such mats or platforms.

(d) **Grounds to railway returns.**—Protective ground connections should not be made to railway negative-return circuits when other effective means of grounding are available, except ground connections from electric railway lightning arresters.

When ground connections are of necessity made to the grounded track return of electric railways, they shall be made in such a manner as not to afford a metallic connection (as indirectly through a grounded neutral with multiple grounds) between the railway return and the other grounded conducting bodies (such as buried piping and cable sheaths).

NOTE.—This rule does not prohibit the making of drainage connections (which are not protective grounds) between piping systems and railway negative-return circuits for the prevention of electrolysis.

Multiple protective ground connections from other circuits to railway returns should be avoided, and where multiple artificial grounds are made on such other circuits near such railway returns, they should be so arranged as to prevent the flow of any considerable current in and between such connections, which flow would reduce their effectiveness, or otherwise cause damage.

95. Method.

(a) **Piping.**—Ground connections to metallic-piping systems shall be made (except as permitted below) on the street side of water meters, which might interrupt the continuity of the underground metallic-pipe systems, but connections may be made immediately inside building walls to secure accessibility for inspection and test. When water meters are located outside buildings or in concrete pits within

buildings where piping connections are embedded in concrete flooring, the ground connection may be made on the building side of the meters.

Ground connections for equipment, conduit, armored cable, or metal raceways, and the like, or as a multiple ground for alternating-current secondaries, may be made to the water-piping system at a point near the part to be protected, provided there are no insulating joints or fittings in the pipe to prevent a good ground. In such cases care shall be taken to electrically connect all parts of the piping system liable to create a hazard (if they become alive) and the pipe system shall be shunted where necessary around meters, etc., in order to keep the connection with the underground piping system continuous.

Gas-piping systems within buildings should not be used for purposes of this rule, except that gas piping need not be insulated from otherwise well-grounded electrical fixtures, and where the making of another ground connection for a fixture would involve a long run and the fixture is, therefore, of course, not within reach of plumbing or plumbing fixtures, the gas piping may for small fixtures be utilized as the sole ground connection. Where gas piping is so used it must be bonded to the water-piping system at the point of entrance of water piping. (See rules 93 (*a*) and 94 (*a*).)

(b) Ground clamps.—The ground connection to metallic-piping systems shall be made by means of an approved clamp firmly bolted to the pipe after all rust and scale have been removed, or by means of a brass plug which has been tightly screwed into a pipe fitting or, where the pipe is of sufficient thickness, screwed into a hole in the pipe itself, or by other equivalent means.

The grounding conductor shall be attached to the clamp or to the plug by means of solder or by an approved solderless

connector. The point of connection shall be as readily accessible as possible, and the position should be recorded.

NOTE.—With bell-and-spigot-joint pipe it may be necessary to connect to several lengths where circuits or equipment of large current capacity are being grounded.

(c) **Contact surfaces.**—If conduit, couplings, or fittings having protective coating of nonconducting material, such as enamel, are used, such coating shall 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 shall be free from rust, scale, etc., at the place of attachment of ground clamp.

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

In ice houses, packing plants, etc., where a great deal of moisture is present and where conduits are attached to metal cabinets, cut-out, pull or junction boxes, compensators, etc., by means of standard lock nuts and bushings, these conduits should be bonded together with approved ground clamps.

(d) **Artificial grounds.**—Artificial grounds should be located where practicable below permanent moisture level or, failing in this, at least 6 feet deep. Each ground should present not less than 2 square feet of surface to exterior soil. Areas where ground water level is close to the surface should be used when available.

Where facilities are not available for determining the resistance of the ground connection (see rule 96), the exposed surface should be not less than 4 square feet.

Where copper ground plates are used, they should be at least 0.06 inch thick. When driven pipes are used, they should be of galvanized iron and not smaller than three-

fourths inch internal diameter, and when cast-iron plates are used they should be at least 0.25 inch thick.

96. Ground Resistance.

(a) **Limits.**—The combined resistances of the grounding wire and the connection with the ground shall not exceed 3 ohms for water-pipe connections nor 25 ohms for artificial (buried or driven) grounds. Where it is impracticable to obtain with one ground, artificial-ground resistance as low as 25 ohms, this requirement shall be waived, and two artificial grounds, at least 6 feet apart and with combined area of not less than 4 square feet, shall be provided.

(b) **Checking.**—The resistance of station grounds should be checked when made.

NOTE.—With artificial grounds this check may be made by measuring the voltage between the grounded point of the circuit, or the grounded frame of the equipment, or the grounded point of the lightning arrester, and an auxiliary metal reference rod or pipe driven into the ground, while a measured current is flowing through the ground connection and any exposed metal piping or other artificial ground not less than 20 feet distant.

If the station ground is to water piping, the check may be made with current flowing through the water piping and some independent piping system or artificial ground not less than 20 feet distant.

The auxiliary rod or pipe should be at least 10 feet from any artificial ground or piping systems through which the measured current is made to flow.

All ground connections shall be inspected periodically.

Ground connections on distribution circuits should, when installed, be tested for resistance unless multiple grounding to water-piping systems is used.

97. Separate Grounding Conductors and Grounds.

(a) **Grounding conductors.**—Grounding conductors from equipment and circuits of each of the following classes, when required by these rules, shall be run separately to the

ground (or to a sufficiently heavy grounding bus or system ground cable which is well connected to ground at more than one place):

(1) Lightning arresters.

(2) Secondaries connected to low-voltage lighting or power circuits.

(3) Secondaries of current and potential instrument transformers and cases of instruments on these secondaries.

(4) Frames of direct-current railway equipment and of equipment operating in excess of 750 volts.

(5) Frames of utilization equipment or wire runways other than covered by item (4), except that if a secondary distribution system has multiple grounds to water piping, service conduits may utilize the same grounding conductors.

(6) Lightning rods.

(b) **Arrester grounds.**—Lightning-arrester ground connections shall not be made to the same artificial ground (driven pipes or buried plates) as circuits or equipment, but should be well spaced and, where practicable, at least 20 feet from other artificial grounds.

SEC. 10. PROTECTIVE ARRANGEMENTS OF STATIONS AND SUBSTATIONS

100. Scope of the Rules.

The following rules apply to the electrical supply equipment of indoor and outdoor stations and substations. Provided the equipment is in separate rooms or inclosures, under control of properly qualified persons and accessible only to such persons, they also apply to similar equipment, including generators, motors, storage batteries, transformers, lightning arresters, etc., when installed in factories, mercantile establishments, vehicles, or elsewhere.

101. Application of the Rules and Exemptions.

(a) **Application and waiving of rules.**—The rules are intended to apply to all installations, except as modified or waived by the proper administrative authority or its authorized agents. They are intended to be so modified or waived in particular cases wherever any rules are shown for any reason to be impracticable such as by involving expense not justified by the protection secured; provided equivalent or safer construction is secured in other ways, including special working methods.

Other methods of construction and installation than those specified in the rules may also be made as experiments to obtain information, if done where supervision can be given by the proper administrative authority.

(b) **Intent of rules.**—The intent of these rules which constitute a minimum standard will be realized—

(1) by applying the rules in full to all new installations, reconstructions, and extensions;

(2) by altering existing installations as needed in a manner approved by administrative authority.

The time allowed for bringing existing installations into compliance with the rules will be determined by the administrative authority.

(c) **Waiver for temporary installation.**—It will sometimes be necessary to modify or waive certain of the rules in cases of temporary installations or installations which are shortly to be dismantled or reconstructed.

(d) **Waiver in emergencies.**—In cases of emergency or pending decision of the administrator, the person responsible for the installation may decide as to modifications or waiver of any rule, subject to review by proper authority.

102. General Requirements.

(a) **Inclosure of rooms and spaces.**—Rooms and spaces shall be so arranged with fences, screens, partitions, or walls as to prevent entrance of unauthorized persons or interference by them with equipment inside, and entrances not under observation of an authorized attendant shall be kept locked. Signs prohibiting entrance to unauthorized persons shall be displayed at entrances.

(b) **Rooms and spaces.**—All rooms or spaces in which electrical supply equipment is installed shall comply with the following requirements:

(1) *Fireproof construction.*—They shall be, as far as practicable, noncombustible.

(2) *Storage and manufacturing processes.*—They shall be used neither for the storage of material nor for manufacturing processes causing hazard to electrical operators, except those materials or processes attendant upon the production or distribution of a supply of electrical energy.

(3) *Hazardous conditions.*—They shall be free from combustible dust or flyings, inflammable gas, or acid fumes, in dangerous quantities. (For battery rooms, see section 13; for auxiliary equipment in hazardous locations, see rule 117.)

(4) *Ventilation.*—They should be well ventilated.

(5) *Moisture and weather.*—They should be dry. In outdoor stations or stations in wet tunnels or subways, all live parts of equipment should be inclosed in weatherproof cases, unless the equipment is suitably designed to withstand the prevailing atmospheric conditions.

(c) **Rotating machinery.**—Rotating machinery shall be installed upon suitable supports or foundations and if necessary secured in place.

103. Illumination.

(a) **Under normal conditions.**—Rooms and spaces where electrical apparatus or machinery is located shall have means for artificial illumination in accordance with Table 1. The means of illumination shall be maintained ready for use at all times.

TABLE 1.—*Illumination intensities*

		Minimum	Modern practice
		Foot-candles	*Foot-candles*
1	Switchboard instruments, gauges, switches, etc	1	2 to 4
2	Switchboards with no exposed live parts	½	1 to 2
3	Storage-battery room	½	1 to 2
4	Generating room, boiler room, pump room	1	2 to 4
5	Stairways and passageways where there is moving machinery, exposed live parts, hot pipes, etc. (measured at floor level)	1	2 to 4
6	Any traversed space (measured at floor level)	¼	1 to 2

NOTE.—The above illumination values are to be measured at working surfaces, except as stated.

NOTE.—It is not intended that this rule should require permanent lighting in switch cells and similar small spaces occupied by electrical apparatus where permanent lighting is impracticable. The Code of Lighting Factories, Mills, and Other Work Places includes general standards of illumination required from the point of view of safety.

(b) **Emergency source.**—A separate emergency source of illumination, from an independent generator, storage battery, gas main, lanterns (the latter two should never be used in battery rooms), or other suitable source, shall be provided in every station where an attendant is located.

(c) **Fixtures and pendants.**—Arrangements of permanent fixtures and plug receptacles shall be such that portable cords need not be brought into dangerous proximity to live or moving apparatus. All lamps shall be arranged to be controlled, replaced, or trimmed from safely accessible places.

Pendent conductors shall not be installed where they can be readily moved so as to bring them in contact with live parts of electrical supply equipment.

(d) **Attachment plugs.**—Portable conductors shall be attached to fixed wiring only through separable attachment plugs which will disconnect all poles by one operation. (See sec. 37 of the code, for portables and pendants.)

104. Floors, Floor Openings, Passageways, Stairs.

(a) **Floors.**—Floors shall have even surfaces and afford secure footing. Projecting nails, loose boards, uneven or greasy wood floors, and slippery floors should be avoided.

NOTE.—Otherwise slippery floors or stairs should be provided with antislip treads.

(b) **Passageways.**—Passageways (including stairways) and working spaces shall be unobstructed, and (except such as are used solely for infrequent inspection, construction, and repair) shall, where possible, provide at least 6.5 feet headroom. (See rule 114 for working space.)

(c) **Railings.**—All floor openings over 18 inches deep and raised platforms over 4 feet high shall be provided with suitable railings.

Except for loading platforms, such rails are recommended where height exceeds 18 inches, especially where they are adjacent to live or moving parts or the working space on the platform is restricted.

(d) **Stair guards.**—All stairways consisting of four or more risers shall be provided with handrails.

For very long and steep stairs occasional landings or turns are recommended.

(e) **Continuity.**—The heads of permanent ladders shall be provided with guards such as gates or sliding pipe sections whenever the heading breaks the continuity of a railing adjacent to working space.

For very long ladders occasional landings, turns, or safety loops are recommended.

(f) **Floor toe boards.**—All floor openings over 6 feet deep, and the edges of all raised platforms over 6 feet high, shall, where possible, be provided with suitable toe boards.

(g) **Stair toe boards.**—Toe boards shall, where practicable, be arranged at back of stairway treads where over exposed live or moving parts or over working spaces, passageways, or other stairways.

105. Exits.

(a) **Clear exits.**—Each room or space and each working space about equipment shall have suitable means of exit which shall be kept clear of all obstructions.

(b) **Double exits.**—If the plan of the room or space and the character and arrangement of equipment are such that an accident would be liable to close or make inaccessible a single exit, as in the case of long narrow rooms, platforms, passageways, spaces behind switchboards, or wire and pipe tunnels, a second exit shall, if practicable, be provided.

106. Fire-Fighting Appliances.

(a) **Fire extinguishers.**—Each room or space where an operator is in attendance shall be provided with adequate approved fire-extinguishing appliances conveniently located and conspicuously marked. Any such appliances which have not been approved by Underwriters' Laboratories for use on live parts should be plainly and conspicuously marked with a warning to that effect.

(b) **Temperature conditions.**—Fire extinguishers shall not be installed in locations subject to conditions of high or low temperature which will reduce their effectiveness.

Tetrachloride extinguishers are not adversely affected by temperatures between 60° C. (140° F.) and minus 40° C. (−40° F.).

107. Oil-Filled Apparatus.

For the purpose of these rules oil-filled apparatus is divided into three classes each of which requires different treatment: (1) Oil switches and circuit breakers; (2) transformers, induction regulators, etc.; and (3) lightning arresters. The necessary safety precautions depend largely on whether they are located in buildings or outdoors.

(a) **Oil switches or circuit breakers.**—When located on floors of buildings or in galleries, oil switches or circuit breakers should be separated from other apparatus by adequate noninflammable barriers, or otherwise adequately isolated. Floors and floor drains should be so arranged that oil will quickly collect in a suitable drainage or storage system provided for the purpose either inside or outside of the building as may be advisable.

Where switches or switch compartments are constructed to prevent an appreciable amount of oil being thrown outside of the compartment, exterior drainage or storage systems are not necessary.

When located outdoors they should be adequately isolated.

When located near building walls these should be of fire-resistive construction and should have doors or windows so located and arranged that burning oil is not liable to pass through them to inflammable material or apparatus.

NOTE.—It should be recognized that oil-switch or circuit-breaker failures may depend upon the size and rupturing capacity of the switch or circuit breaker and the short-circuit duty that may be required of it. The short-circuit current depends on the generating capacity supplying the system on which the switch or circuit breaker is used as modified by the current-limiting characteristics of the system or by special apparatus installed for that purpose. By "generating capacity" is meant all of the apparatus contributing to the short-circuit current.

(b) **Transformers, induction regulators, etc.**—When in buildings, transformers, induction regulators, etc., should

preferably be located on lower floors or in basements so that oil which leaks out or is spilled can not drip on other apparatus. Where this is not practicable, adequate provision should be made to prevent leakage on other apparatus. Floors and floor drains should be so arranged that oil will quickly collect in a suitable drainage or storage system provided for the purpose either inside or outside of the building as may be advisable. When the apparatus contains large quantities of oil, each unit or group should preferably be placed in a separate fireproof compartment suitably ventilated. Induction regulators when nonautomatic should be arranged for remote control.

When located outdoors they should be adequately isolated. Provision should be made for quickly draining away to a safe distance any oil that may be spilled. This may be done by ditches and drains or the oil may be absorbed and danger of spreading removed by paving the yard around the transformers or other devices with cinders or other absorbent material to a depth of several inches.

When located in buildings, transformer tanks containing large quantities of oil shall, where practicable, be so arranged that approved fire-quenching material may be introduced above the oil inside the tank or in the surrounding compartment, except where tanks are completely filled with oil or where the space above the oil is filled with an inert gas.

(c) **Lightning arresters.**—When located in buildings, lightning arresters containing oil should be separated from other equipment by fire walls adequate to completely isolate them in case of fire.

When located outdoors they should be adequately isolated. Provision for quickly draining away oil should be made as indicated for transformers in (*b*) above.

SEC. 11. PROTECTIVE ARRANGEMENTS OF EQUIPMENT

110. General Requirement.

All electrical supply equipment shall be of such construction and so installed and maintained as to reduce the life hazard as far as practicable.

111. Inspections.

(a) **Regular equipment.**—Electrical supply equipment shall comply with these safety rules when placed in service, and shall thereafter be periodically cleaned and inspected. Defective equipment shall be put in good order or permanently disconnected. Defective wiring, when hazardous, shall be repaired or removed.

(b) **Idle equipment.**—Infrequently used equipment or wiring maintained for future service should be thoroughly inspected before use to determine its fitness for service.

(c) **Emergency equipment.**—Equipment or wiring maintained for emergency service should be periodically inspected and, where necessary, tested to determine its fitness for service.

(d) **New equipment.**—New equipment should be thoroughly inspected before being put in service.

112. Guarding Shaft Ends, Pulleys, and Belts, and Suddenly Moving Parts.

(a) **Transmission machinery.**—This code is supplemented by the Safety Code for Mechanical Power Transmission Apparatus A. E. S. C. B15, which specifies methods for safeguarding pulleys, belts, and other equipment used in the mechanical transmission of power.

(b) **Suddenly moving parts.**—Parts of equipment which move suddenly in such a way that persons in the vicinity are liable to be injured by being struck, such as handles and levers of circuit breakers, shall be guarded or isolated.

113. Protective Grounding.

(a) **Grounding method.**—All grounding which is intended to be a permanent and effective protective measure, such as lightning-arrester grounding, grounding of circuits, equipment, or wire raceways, shall be made in accordance with the methods specified in section 9, Methods of protective grounding.

(b) **Grounding noncurrent-carrying metal parts.**—All electrical supply equipment, if operating at more than 150 volts to ground, or if in hazardous locations, shall have the exposed noncurrent-carrying parts, such as frames of generators and switchboards, cases of transformers, lightning arresters and switches, and operating levers, permanently grounded.

It is recommended that exposed noncurrent-carrying parts of electrical apparatus operating at 150 volts or less to ground be permanently grounded.

It is recommended that all metallic guards (including rails, screens, etc.) about electrical supply equipment should be permanently grounded.

Except in hazardous locations exposed noncurrent-carrying parts of equipment operating at more than 150 volts to ground may be left ungrounded and either isolated, or guarded, or provided with insulating mats as required for live parts at the same voltage. Such isolation, guarding, or mats should be so arranged that persons can not inadvertently touch these parts while also touching a grounded surface.

NOTE.—Hazardous locations include those where dampness, acid fumes, explosives, inflammable gas, or flyings normally exist.

(c) **Grounding equipment during repairs.** — Electrical equipment or conductors normally operating at more than 750 volts, on or about which work is occasionally done while separated from a source of electrical energy by switches

or disconnectors only, shall be provided with some means, such as switches, connectors, or readily accessible ground conductor for grounding them. (See operating rules 423 and 424 of the code.)

114. Guarding Live Parts.

(a) **Where required.**—(1) Guards shall be provided for all parts exceeding 300 volts to ground unless the boundary of the guard zone around the part has a vertical clearance of more than 7 feet 6 inches for voltages up to 7,500, and 8 feet 6 inches for voltages of more than 7,500, above any permanent supporting surface for workmen, or a horizontal clearance of more than 3 feet from the nearest edge of any such surface, or both. This includes parts exposed through windows, wall openings, etc.

Exception.—Guards need not be provided where it is necessary to permit routine inspection of rotating equipment as required under operating conditions.

NOTE.—The rule applies to the electrical parts energized or considered available for service in temporary or partially completed installations, as well as to permanent installations.

DEFINITIONS.—The guard zone means the space of minimum clearance from guards to electrical parts where guards may be installed by workmen without definite engineering design. The radius of this zone varies with the voltage as specified in column 4 of Table 2. See rule 422 (c) of the code, for working clearances about live parts.

"Permanent supporting surface for workmen" includes floors, platforms, or structures used regularly and frequently by workmen for inspections and maintenance near live adjacent parts; runways, ladders, stairways, etc.

(2) Parts over or near frequently traveled passageways through which material may be carried, or in or near spaces such as corridors, storerooms, boiler rooms, etc., used for nonelectrical work, should, where practicable, be guarded or given clearances in excess of those specified as may be

necessary to secure reasonable safety. The guards should be substantial; should, where practicable, completely shield or inclose without openings the parts; and when in spaces used for nonelectrical work should be removable only by means of tools or keys.

TABLE 2.—*Minimum clearances from live parts*

1	2		3		4
Voltage between phases	Minimum vertical clearance of unguarded parts		Minimum horizontal clearance of unguarded parts		Minimum clearance from guards to parts. Radius of guard zone
	Feet	*Inches*	*Feet*	*Inches*	*Inches*
600	7	8	3	2	2
2,300	7	9	3	3	3
6,600	7	10	3	4	4
11,000	9	0	3	6	6
22,000	9	3	3	9	9
33,000	9	6	4	0	12
44,000	9	10	4	4	16
66,000	10	5	4	11	23
88,000	11	0	5	6	30
110,000	11	7	6	1	37
132,000	12	2	6	8	44

NOTE.—Interpolate for intermediate values.

The clearances in column 4 of this table are not a requirement for definite engineering design of either apparatus or guards, but are solely for the guidance of workmen installing guards without such design.

For example, the minimum clearances in the table above are not intended to refer to the clearances between live parts and the walls of the cells, compartments, or similar inclosing structures. They do not apply to the clearances between bus bars and supporting structures, nor to clearances between the blade of a disconnecting switch and its base.

For the relation of the above clearance tables to the manufacture of electrical apparatus, see discussion of rule 114 (*a*).

(3) Parts of indeterminate potential, such as telephone wires exposed to induction from high-tension lines, ungrounded neutral connections, ungrounded frames, ungrounded parts of lightning arresters, ungrounded instrument cases connected directly to the high-voltage circuit, etc., shall be classified and, where practicable, guarded on the basis of the maximum voltage which may be present.

(b) **Strength of guards.**—Guards shall be sufficiently strong and shall be supported rigidly and securely enough to prevent them from being displaced or dangerously deflected by a man slipping or falling against them.

(c) **Types of guards.**

(1) *Location or isolation.*—Parts having clearances equal to or greater than specified in (*a*) above are guarded by location. Parts are guarded by isolation when all entrances to inclosed spaces, runways, ladders, etc., are kept locked or warning signs posted at all entrances, in which case no other permanent guards need be supplied.

(2) *Grounded metal cable sheaths.*—These are suitable guards except where exposed to mechanical injury. Where so exposed metal conduit or other suitable guards should be provided.

(3) *Railings.*—Railings are not substitutes for complete guards, and if used shall be located at a horizontal distance of at least 3 feet (and preferably not more than 4 feet) from the nearest point of guard zone, which is less than 7½ feet above the floor.

(4) *Shields or inclosures.*—Guards inside of the guard zone or less than 4 inches outside, shall completely inclose the parts from contact up to the heights listed in column 2 of Table 2. They shall not be closer to the live parts than listed in column 4 of Table 2, except when suitable insulating material is used with circuits of less than 7,500 volts. (See note under Table 2.) If more than 4 inches outside of the guard zone, the guards need not extend more than 7½ feet above the floor. Covers or guards, which must at any time be removed while the parts they guard are alive, should be arranged so that they can not readily be brought in contact with live parts.

(5) *Insulating covering on conductors or parts.*—The insulating covering on parts exceeding 750 volts to ground

shall not be considered a protection. For parts less than 750 volts, positive barriers, inclosures, or similar arrangements are preferable, but in dry places where not exposed to mechanical injury, varnished-cloth tape, or other insulation suitable for the voltage involved may be used as a guard. The taping over connections shall be of a type and thickness suitable for the voltage involved. Friction tape is not acceptable as the sole protection.

Exception.—On circuits not exceeding 7,500 volts between phases, when other guarding is impracticable, insulation suitable for the voltage involved may be used back of switchboards or in equivalent sheltered locations. Insulating mats or platforms shall be provided so that an operator can not readily touch the insulating covering without standing on the mats.

(6) *Mats.*—Suitable insulating mats placed so that a person can not inadvertently come in contact with the live parts without standing on the mat may be used in the following cases:

Parts less than 750 volts to ground exposed at switchboards, switches, or on rotating machinery.

Disconnect switches less than 7,500 volts between phases mounted on back of switchboards or in similar sheltered locations when barriers are placed between each blade so as to extend beyond the disconnected parts in any position. Other means of guarding may be used where convenient.

Ungrounded frames of existing high-voltage series generators.

As provided for in paragraphs (*c*) (5) and (*c*) (8) of this rule.

Mats should be of rubber, or in dry locations they may be of wood fastened with wood pins, cork matting or heavy (one-fourth inch) linoleum laid without joints and without metal fastenings. A "nonslip" surface should be main-

tained and the mats should be laid and maintained so as to reduce the tripping hazard to a minimum.

NOTE.—Beveled edges will help in many cases.

(7) *Parts below supporting surfaces for persons.*—The supporting surfaces above live parts shall be solid without openings exceeding one-eighth inch in width. Toe boards at least 6 inches high shall be provided at all edges.

(8) *Special rules for plug-type switchboards.*—A mat is a suitable guard when placed so that the operator must stand on it when operating the plugs. Suitable guards on handles of all plugs shall be provided.

(d) Parts of less than 300 volts to ground.—It is recommended that live parts of more than 150 volts to ground be inclosed or guarded when in exposed locations.

115. Working Space About Electrical Equipment.

(a) Where required.—Adequate and readily accessible working space with secure footing shall be maintained about all electrical parts or equipment which require adjustment or examination when exposed *while in service.*

(b) Width of working space.—The horizontal clearance from the farthest edge of the working space to the nearest live part of more than 300 volts to ground, exposed after removing guards, shall be not less than 3 feet plus the guard zone radius as given in column 4 of Table 2. (When the live parts are on only one side, column 3 of Table 2 gives the minimum permissible value for the total width of the free space.) See also rule 104 (*b*) for head room.

(c) Elevated parts.—Clearance about normally elevated or isolated parts requiring occasional adjustment should be provided so the men need not come within the danger zone (see rule 422 (*c*) of the code), around adjacent energized parts, unless guarded in accordance with rules 114 to 116, inclusive.

116. Equipment for Work on Live Parts.

(a) **7,500 volts or less between phases.**—When it is necessary for men to bring their bodies or any material or tools handled into the danger zone (see rule 422 (*b*) of the code), suitable protective devices, such as rubber gloves, rubber sleeves (if necessary), insulating tools, portable rubber mats or insulating stools, rubber blankets, insulated fuse pullers, testing and grounding devices, switch sticks, etc., should be provided, periodically examined, and kept in safe condition. When the voltage exceeds the limit of 5,000 volts set for standard rubber gloves, special gloves should be furnished if the work is conducted so that their use is necessary.

(b) **More than 7,500 volts.**—Suitable protective devices, such as testing and grounding devices, switch sticks, fuse pullers, special insulated tools, etc., should be provided, periodically inspected, and kept in safe condition. Such devices shall provide an ample margin of safety for the voltage involved and should be constructed so that the workman's body can remain outside of the danger zone. (See rule 422 (*c*) of the code.)

117. Hazardous Locations.

(a) **Inclosure of arcing and heating parts.**—In locations where inflammable gas or inflammable flyings normally exist in dangerous quantities, all parts where sparking, arcing, or dangerous heating is liable to occur, shall be inclosed so as to reduce the hazards as far as practicable.

This inclosure shall be by one of the following methods:

(1) By placing in separate compartments or rooms.

(2) By using nonabsorptive, noncombustible casings of the solidly inclosed type when inflammable dust or flyings are present.

(3) By using nonabsorptive, noncombustible explosion-proof casings when inflammable gas exists in dangerous quantities.

(b) **Grounding.**—The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded as specified in section 9.

118. Shielding of Equipment from Deteriorating Agencies.

Suitable shields or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads or electrical devices or equipment where susceptible to injury by being installed directly under rotating equipment or in other locations where dripping oil, excessive moisture, steam, vapors, or similar agents exist. (For battery rooms see rule 135.)

119. Identification.

(a) **Equipment in general.**—Electrical supply equipment shall be suitably identified when necessary for safety. The identification may be by position, color, number, name plate, label, design, or other means, but the method of identification chosen shall be uniform throughout any one system. (See rule 164 (*a*) for switches.)

The voltage and intended use shall be shown when important.

Identification marks should not, if avoidable, be placed on removable covers or casings, such as instrument covers and disconnector compartment doors, where the interchanging of these removable parts might lead to accident.

(b) **Generators and motors.**—Generators and motors shall each be provided with a name plate giving the maker's name, the rating, normal full-load speed, and the voltage.

SEC. 12. ROTATING EQUIPMENT

(This includes generators, motors, motor generators, and converters)

120. Speed-Control and Stopping Devices.

(a) **Speed limits for prime movers.**—Prime movers driving generating equipment shall be provided with automatic speed-limiting devices, where harmful overspeed can otherwise occur, in addition to their governors, if necessary, as with some types of steam turbines.

(b) **Stops for rotating equipment.**—Stopping devices, such as switches or valves which can be operated from locations convenient to machine operators, shall be provided for prime movers or motors driving generating equipment.

Devices which operate in such a way that the development of defects or their becoming inoperative will stop the units protected, should be used where practicable.

Controls to be used in emergency for machinery and electrical equipment should be so located as to permit operation with a minimum of danger during such emergency. (See rule 165 for fuses and circuit breakers.)

(c) **Speed limit for motors.**—Machines of the following types shall be provided with speed-limiting devices unless their inherent characteristics or the load and the mechanical connection thereto are such as to safely limit the speed, or unless the machine is always under the manual control of a qualified operator:

(1) Separately excited direct-current motors.

(2) Series motors.

(3) Motor generators and converters which can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

NOTE.—The required limitation of speed may be obtained by the use of a relay, centrifugal switch, or other similar device which will cut off the supply of energy when excessive speed is attained.

(d) **Low-voltage or under-voltage protection.**—All motors so employed or arranged that an unexpected starting of the motor is a hazard, except those with an emergency use, and where the opening of the circuit may cause a special hazard, such as exciter or condenser-pump motors, shall be equipped with low-voltage protection which will automatically cause and maintain the interruption of the motor circuit when the voltage falls below an operating value.

(e) **Adjustable-speed motors.**—Adjustable-speed motors, if controlled by means of field regulation, shall be so equipped and connected that the field can not be weakened sufficiently to permit a dangerous speed.

(f) **Protection of control circuits.**—Where speed-limiting or stopping devices are electrically operated, the control circuits by which such devices are actuated shall be in conduit or otherwise suitably protected from mechanical injury, in accordance with rule 151.

121. Guards for Live Parts.

(a) **Guards on rotating equipment.**—Guards complying with rule 114 shall be provided.

(b) **Access to live parts.**—Where necessary, steps and handrails shall be installed on or about large machines to afford ready access to live parts which must be examined or adjusted during operation.

(c) **Frame switches.**—Where switches are installed on the frames of generating equipment for the purpose of reducing inductive voltage in generator and converter field coils they shall be suitably constructed or guarded to prevent passers-by from inadvertently coming in contact with the live parts, to protect persons handling them, and to prevent their being accidentally opened or closed.

(d) **Arcing shields.**—Suitable shields or barriers other than rails shall be provided where practicable to prevent arcing on

large commutators or any other parts of moving apparatus from injuring persons in the vicinity, as in the case of narrow working spaces located immediately above or beside such equipment.

Exception.—Twenty-five-cycle apparatus of less than 150 volts to ground is exempted.

It is recommended that where suitable shields have not been installed, goggles should be available.

122. Grounding Machine Frames.

(a) **Grounding machine frames.**—All frames of rotating electrical equipment shall be permanently grounded except as permitted below and in rule 113.

(b) **Coupled machines.**—Where two or more machines, either of which operates at more than 150 volts to ground, are mechanically coupled together and the operator can touch the frames of more than one at a time, the frames of all such shall be permanently grounded or bonded together electrically.

Exception.—This rule may be waived with high-voltage series generator sets in existing installations where for operating reasons the generators must have their frames insulated from the ground and the motor frame is grounded, and where it is impracticable to place insulating barriers between the grounded and ungrounded frames.

(c) **Auxiliaries.**—Exciters and auxiliary circuits electrically connected to generators or other machines of more than 750 volts to ground (with frames ungrounded) shall be installed, protected, and identified as machines and circuits of the same voltage as that of the machine for which they are auxiliaries.

123. Terminal Bases and Bushings.

(a) **Terminal bases.**—Terminal bases, when used on motors or generators should preferably be of suitable noncom-

bustible, nonabsorptive, insulating material, such as slate, marble, or porcelain.

(b) **Bushings.**—Bushings where used for wires coming through the frames of motors or generators should preferably be of porcelain, suitable composition material, or of hardwood properly filled, except that soft rubber may be used if not exposed to oils, grease, or other deleterious substances in such quantities as to cause their rapid destruction.

124. Deteriorating Agencies.

(a) **Protection required.**—Suitable shields or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads, balance coils, or other electrical devices belonging to motors and generating equipment where installed directly under equipment or in other locations where dripping oil, excessive moisture, steam, vapors, or similar injurious agents exist.

(b) **Grounding.**—The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded.

125. Motors.

(a) **Control.**—If the starting is caused automatically (not manually), as, for example, by a float switch, or if the starting device or control switch is not located close to the motor and all parts of the machinery operated, the starting arrangement shall be designed so that it can positively be kept open by means of locks or equivalent devices.

(b) **Motors in hazardous locations.**—Motors with their auxiliary equipment, at which sparking or arcing or high temperature is liable to occur, when in rooms normally containing explosives, inflammable gas, or inflammable flyings, shall be so installed as to reduce the hazard by inclosure in an adequately ventilated separate compartment, by solidly

inclosed or explosion-proof type of equipment, or, when protected against flyings only, by partitioning off a space or by a suitable boxing.

Motors should be protected from dust. Inclosed-type motors are recommended in dusty places, being preferable to boxing.

Where practicable, motors permanently located on wooden floors should be provided with suitable drip pans.

SEC. 13. STORAGE BATTERIES

The following rules (except 133) apply only to storage batteries exceeding 50 kilowatthours capacity at the eight-hour rate of discharge.

130. Isolation.

Storage batteries shall be made inaccessible to other than properly qualified persons by being placed in a separate room or inclosure.

131. Ventilation.

Rooms or inclosures containing storage batteries shall be so ventilated as to remove acid spray and prevent dangerous accumulation of inflammable gas.

The battery room ventilating system shall be so arranged as not to carry any gases therefrom into other rooms or spaces of the building where electrical apparatus or equipment is located.

Communication of drafts to other rooms should be prevented.

132. Suitable Supports and Floors.

The cells, except small cells of insulating material set in sand trays, on shelves, or otherwise separated from the floors, shall be supported by suitable insulators, such as glass or

thoroughly vitrified and glazed porcelain. Suitable drainage or other means shall be provided beneath cells to prevent the accumulation of electrolyte in case of leakage or spraying.

Acid-resistive floors, such as vitrified brick set in pitch, are recommended where large batteries are installed.

133. Guarding Live Parts in Battery Rooms.

(a) **Separation of parts of more than 150 volts.**—The arrangement of cells and connections shall be such that any two current-carrying parts between which a voltage exceeding 150 exists shall be properly guarded if the parts are otherwise so exposed that persons are liable to make accidental contact with both at the same time.

(b) **Precaution against parts of more than 150 volts.**—No conductor of more than 150 volts to ground shall be placed in any passageway, unless guarded or isolated by elevation.

(c) **Form of Guards.**—Guards shall comply with rule 114.

134. Illumination.

Storage-battery rooms should be lighted, if practicable, from outside lamps. Heating devices with open flames or exposed incandescent resistors shall not be installed.

If lamps are inside, only incandescent electric lamps in keyless porcelain or composition sockets, controlled from points not exposed to battery vapor, shall be used.

It is recommended that switches and incandescent lamps located in battery rooms be put in vapor-proof inclosures.

135. Acid-Resistive Coverings.

Conductors in battery rooms, if of such material or so located as to be liable to corrosion, shall have suitable protective coverings or coatings, unless the ventilation is such as to render this unnecessary.

SEC. 14. TRANSFORMERS, INDUCTION REGULATORS, RHEOSTATS, GROUND DETECTORS, AND SIMILAR EQUIPMENT

140. Current-Transformer Secondary Circuits.

(a) **Short-circuiting.**—Secondary circuits of current transformers, including constant-current and instrument transformers, shall be provided with means (such as permanent connections for jumpers) for short-circuiting them which can be readily connected while the primary is energized and which are so arranged as to permit the removal of any instrument or other device from such circuits without opening the circuits.

(b) **Protection when of more than 7,500 volts.**—Where primaries are of more than 7,500 volts, secondary circuits unless otherwise adequately protected from injury or contact of persons, shall be in permanently grounded conduit.

141. Grounding Low-Voltage Circuits of Instrument Transformers.

The low-voltage circuits of all instrument transformers shall be permanently grounded unless the circuits are installed, guarded, and plainly identified as required for the high-voltage circuits of the transformers, in accordance with rule 150.

NOTE.—This will sometimes require marking to distinguish such a low-voltage circuit from others with which it is associated, but which are protected by ground connections.

142. Grounding Transformer Cases.

The metal case or exposed frame of each transformer, reactor, induction regulator, and similar equipment, which is located where dampness or inflammable gas normally exists, or which is connected to a circuit operating at more than 150 volts to ground, shall be permanently grounded.

Exception.—Exception is permissible in accordance with rule 113 (*b*), in locations free from inflammable gas, where the entire transformer is isolated or guarded as required for the highest-voltage circuit connected with the transformer, and is plainly and conspicuously identified as of that voltage.

143. Location and Arrangement of Transformers.

Transformers shall be installed according to one of the following methods:

(1) On poles or (when permitted by local authority) on walls of buildings, and in compliance with the overhead line rules. (See Part 2 for mounting and wiring.)

(2) In outdoor inclosures such that unauthorized persons can not, without special effort, come in contact with any part of the casings or wiring.

(3) In ventilated transformer vaults or rooms which shall be made inaccessible to unauthorized persons.

Where the amount of oil in transformer casings is considerable and the transformers are located in buildings used for other than station purposes, they should be placed in suitable transformer vaults.

(4) In rooms containing other equipment.

If in stations, such transformers should be isolated from other equipment and oil sills or suitable arrangements for draining should preferably be provided.

144. Resistance Devices.

Rheostats shall be not less than 1 foot from combustible material or separated therefrom by a slab or panel of noncombustible, nonabsorptive material of suitable thickness, not less than one-half inch, somewhat larger than the rheostat, and secured in place by bolts independently of the rheostat supports.

Rheostats or resistance devices shall not be placed where spattering molten metal due to high temperature in the rheostat may fall upon inflammable material or spaces frequently occupied by persons.

Rheostats or resistance devices exposed to excessive dust or flyings should preferably be installed in suitable cabinets or equipped with dustproof side and face plates. (For installation in hazardous locations see rule 117.)

145. Ground Detectors.

Every station supplying circuits which are not permanently grounded in accordance with section 9 shall be provided with one or more reliable means of ground detection which can be applied to determine the existence of a ground on any such circuit extending outside the station.

SEC. 15. CONDUCTORS

150. Electrical Protection.

(a) **Fuses required.**—Conductors shall be suitable for the location, use, and voltage. Conductors should be protected against excessive heating by the design of the system or by suitable fuses or automatic circuit breakers except as provided in rule 165.

Automatic circuit breakers may be set so as to interrupt the circuits only on excessive short circuits, if constant attendance is provided and protection is thus also afforded by manual operation.

(b) **Fuses in grounded conductors.**—Conductors normally grounded for the protection of persons shall be arranged without fuses or automatic circuit breakers interrupting their continuity between the source of electrical supply and the point at which the ground conductor is attached, unless the circuit breaker opens all conductors of the circuit with one operation.

(c) **Circuits exposed to higher voltages.**—If exposed through transformer windings or outdoor circuits to higher voltages, circuits of less than 750 volts shall be isolated or grounded unless placed in grounded conduit or other suitable duct or identified and guarded as required for conductors of the highest voltage to which they are exposed.

151. Precaution Against Mechanical and Thermal Damage.

(a) **Protection against injury.**—Where exposed to mechanical injury suitable casing, armor, or other means shall be employed to prevent injury or disturbance to conductors, their insulation, or supports.

(b) **Flame proofing.**—Where conductors with insulating coverings are closely grouped and any one is liable to damage from near-by conductors (as sometimes on the rear of switchboards or in cableways), they shall have a substantial flameproof outer covering.

Flame proofing shall be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used.

(c) **Protection against contact.**—Large conductors liable to be torn from their supports by the forces to which they are subjected (as by the magnetic fields produced) shall be so supported that they can not come in contact with the surfaces along which they are run if uninsulated or with other conductors and equipment.

NOTE.—This applies in particular to generator leads and conductors liable to large short-circuit currents.

(d) **Conductors between generators and outside lines.**—Conductors between generators and outside lines shall be accessible and supported on approved noncombustible, nonabsorptive insulators or placed in approved cable, metal conduit, tile, or other fireproof ducts.

(e) **High temperatures.**—Insulated conductors exposed to excessive temperatures shall have insulation which remains effective and does not rapidly deteriorate under such conditions.

152. Isolation.

All conductors of more than 750 volts, and ungrounded bare conductors of more than 300 volts to ground, shall be isolated by elevation or guarded in accordance with rule 114, so that no person can inadvertently come in contact with them; provided that busses and bus structures and line connections thereto may be installed in accordance with rule 115, in suitable locations specially arranged for such purposes.

153. Guarding Conductors.

(a) **Metal-sheathed cable outlets of more than 750 volts.**—The insulation of the several conductors of multiple-conductor cable, where leaving the metal sheath at outlets, shall be thoroughly protected from mechanical injury, moisture, and electrical strains by means of a pothead or equivalent method.

(b) **Form of guards.**—Guards shall comply with rule 114.

154. Guarding in Hazardous Locations.

(a) **Conduit or metal sheath.**—Conductors in locations where inflammable gas normally exists shall be in metal conduit or metal-sheathed cable. All fittings and outlets of such conduit and cable shall be electrically and mechanically continuous with the conduit or metal sheath, and the conduit shall be sealed to prevent entrance of gases.

NOTE.—This rule does not apply to conductors of large cross section which obviously can not be placed in conduit, such as copper bars connecting large cells with end-cell switches.

(b) **Insulating supports.**—Conductors in damp locations, if neither in conduit nor in waterproof metal sheaths in

other suitable ducts, shall be effectively isolated and supported on a suitable type of insulator.

155. Taping Ends and Joints.

Ends and joints of insulated conductors, unless otherwise adequately guarded, shall have equal insulating covering with other portions of the conductor.

156. Wiring for Illumination.

Wiring installed for the illumination of the station should be installed and protected as required for similar utilization equipment and conductors in part 3 of the code.

SEC. 16. FUSES, CIRCUIT-BREAKERS, SWITCHES, AND CONTROLLERS

160. Accessible and Indicating.

(a) **Arrangement.**—All switches, fuses, automatic circuit breakers, starting rheostats, and other control devices shall be readily and safely accessible to authorized persons, unless remotely controlled. They shall be so arranged or marked as to identify the equipment controlled by them, and (except fuses) shall indicate whether they are open or closed.

(b) **Accidental closing.**—Switches shall be so installed as to minimize the danger of accidental operation, and where practicable so that gravity can not close them; such switches as may tend to close by gravity shall be provided with a proper latch or stop block to prevent accidental closing. Where practicable, the blades of knife switches should be dead when the switches are open.

161. Oil Switches.

Oil circuit breakers and oil switches shall, wherever practicable, be isolated from other types of switches and other electrical apparatus to conform to rule 107(*a*).

Remote control of switches and circuit breakers shall be used on circuits of more than 7,500 volts, or when they may be subject to large short-circuit values.

NOTE.—Remote control may be of mechanical, electrical, or other type. It is not intended to prohibit the use of switches and circuit breakers operated manually by means of levers or poles from a remote position. (See note in rule 107(*a*) for conditions usually applying to electrical systems.)

162. Where Switches are Required.

Suitable disconnectors, switches or circuit breakers which may be manually operated shall be inserted in all leads to all supply equipment and all outgoing supply circuits, except as listed below.

Exceptions.—(1) Where two or more pieces of electrical supply equipment or supply lines are operated as a single unit no switch is necessarily required between them.

(2) Switches are not required in transformer vaults except as may be deemed necessary by the engineer in charge to meet operating requirements.

(3) Switches are not required in leads to instrument transformers.

(4) Switches are not required in grounded conductors.

NOTE.—In most cases the switch called for should be capable of opening the circuit under loads. In some cases, as between generators and transformer banks used with them, disconnectors only would be required.

163. Switches or Other Grounding Devices.

It is recommended that switches or other suitable means be provided, where practicable, to facilitate short-circuiting and grounding equipment or lines for which the operating rules (see rules 423 and 424 of the code) require grounding to protect workmen. (See rule 113 (*c*).)

164. Capacity of Switches and Disconnectors.

(a) **Suitability.**—Switches used otherwise than as disconnectors shall be of suitable voltage and ampere rating for the circuit on which they are installed and should prefereably be marked with the current which they can safely interrupt.

Disconnectors shall be of suitable voltage and ampere rating for the circuit on which they are installed.

It is recommended that disconnectors be marked with warning against opening when carrying load. Where a group of disconnectors is contained in one room or compartment a single conspicuous sign may be sufficient.

(b) **Locking.**—Remotely controlled switches, oil switches, and disconnectors shall be so arranged that they can be secured in the open position or plainly tagged to prevent careless closing while work is being done on equipment controlled by them.

It is important that the control circuit be tagged or provided with a positive disconnecting means near the apparatus to prevent accidental operation of the mechanism.

For switches and disconnectors the accidental opening of which may cause hazard, similar arrangements are desirable for retaining them in closed position.

Locking is recommended rather than blocking wherever parts of equipment are remote from the point of control.

(c) **Air break.**—Unless a switch operating on a circuit between 750 and 7,500 volts makes an air break, it is recommended that there shall be installed between it and the source of energy supply a suitable air or oil break disconnector or equivalent device having an air or oil gap suitable for the operating voltage of the circuit.

An air-break switch or air-break disconnector shall be inserted in each conductor between electrical supply equipment or lines and sources of energy of more than 7,500 volts,

if the equipment or lines may have to be worked on without protective grounding while the sources may be alive. (For lightning arresters see rule 181.)

(d) **Alinement.**—Knife switches shall maintain such alinement under service conditions that they can be closed with a single unhesitating motion.

165. Where Fuses or Automatic Circuit Breakers are Required.

All circuit leads to motors, constant-potential generators, transformer primaries, and station auxiliaries, and all outgoing circuits shall be protected from excessive current by suitable fuses or automatic circuit breakers, except as indicated below.

Fuses and automatic circuit breakers may be omitted from the following:

(1) A motor-driven generator or rotary converter when the supply leads to such apparatus are already protected by fuses or automatic circuit breakers.

(2) Grounded conductors.

(3) Circuits for field excitation.

(4) Leads of alternating-current generators.

(5) Leads connecting two or more pieces of electrical supply equipment operated as a single unit.

(6) Circuits supplying interconnected three-wire systems of direct-current distribution.

(7) Leads of series transformers.

(8) Leads of potential transformers or other circuits the opening of which may cause greater hazard to life or property through interruption of service.

166. Disconnection of Fuses Before Handling.

Fuses in circuits of more than 150 volts to ground or more than 60 amperes shall be arranged in one of the following ways:

(1) So that the fuses are necessarily disconnected from all sources of electrical energy before they can be touched.

(2) So that the fuses can be disconnected from all sources of electrical energy by a suitable switch.

(3) So that the fuses can be conveniently handled by means of insulating handles or portable appliances provided for the purpose.

Exception.—Circuits of less than 150 volts to ground and less than 60 amperes capacity are exempted from the provisions of this rule.

The use of insulating gloves and mats is permissible on circuits not exceeding 750 volts.

167. Arcing or Suddenly Moving Parts.

(a) Protection from burns.—Fuses and circuit breakers shall, as far as possible, be so located and shielded that persons will not be burned by their operation.

(b) Protection against moving parts.—Handles or levers of circuit breakers and similar parts which may move suddenly, in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

168. Grounding Noncurrent-Carrying Metal Parts.

Exposed noncurrent-carrying metal parts of switch and fuse cases, levers, and other similar parts to which leakage is liable to occur from live parts, and thereby create a hazard, shall be permanently grounded in accordance with rule 113.

Exception.—Minor parts, such as ferrules of knife switches, which are not liable to become alive, are excepted.

169. Guarding Live Parts of Switches, Fuses, and Automatic Circuit Breakers.

Switches, fuses, and automatic circuit breakers shall be isolated or guarded in accordance with rules 114 and 115.

SEC. 17. SWITCHBOARDS

170. Location and Accessibility.

(a) **General location.**—Switchboards shall, where practicable, be so placed that the operator will not be endangered by any live or moving parts of machinery or equipment located near the board.

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

(b) **Spaces about boards.**—The space back of the board shall be kept clear of rubbish and shall not be used for storage.

(c) **Accessibility.**—Switchboards shall be accessible to authorized operators from both sides when the connections are on the back (see rule 115 for working space), but may be placed against a wall when operating at not more than 750 volts with the wiring entirely on the face.

(d) **Arrangements.**—Switchboards shall have all switches so arranged that the points of control are readily accessible to the operator. Instruments, relays, and other devices requiring reading or adjustments shall be so placed that work can be readily performed from the working space.

171. Material and Illuminaton.

(a) **Material.**—Switchboards shall be made of noncombustible material and be kept free from moisture.

(b) **Illumination.**—Sufficient illumination shall be provided both for the front and rear of the switchboard so that the switchboard may be readily operated and instruments conveniently read.

172. Necessary Equipment.

Switchboards which control generating equipment or outgoing supply circuits shall (except in substations without regular attendance) be equipped with such instruments as

are necessary to show operating conditions. (See rule 145 for ground detectors.)

173. Arrangement and Identification.

Connections, wiring, and equipment of switchboards and panelboards shall be arranged in an orderly manner, and all switches, fuses, and circuit breakers shall be plainly marked, labeled, or arranged so as to afford ready means for identifying circuits or equipment supplied through them, in accordance with rule 119.

174. Spacings and Barriers Against Short-Circuit.

(a) **Bare parts.**—Switchboards shall have the number of bare parts at different potentials on any panel reduced to a minimum, and these parts shall be effectively separated. Protection or separation of such parts by suitable barriers is recommended where the voltage exceeds 750.

It is recommended that such parts, including bus bars, should be so located, or provided with such insulating coverings or barriers, that parts at different potentials will not be readily short-circuited by tools or other conducting objects.

(b) **Fuses.**—Fuses should be so located as to minimize the danger, in removing or replacing them, of short-circuiting parts at different potentials by the fuses or by the hands of the operator.

175. Switchboard Grounding.

(a) **Frames.**—Switchboard frames and noncurrent-carrying parts shall be permanently grounded under the conditions and with the exceptions noted in rule 113.

Exception.—Parts of switchboards, such as name plates, screws, and similar small parts which are not liable to become alive, except under very unusual circumstances,

are not considered as coming under the rule and may be left ungrounded.

(b) **Circuits worked on.**—Where protective grounds are occasionally required on circuits for the protection of workmen, a permanent ground connection shall be provided, and also suitable means for effectively and readily connecting the parts being grounded to the ground connection, in accordance with rule 113 (*c*).

176. Guarding Live Parts on Switchboards.

(a) **Guards.**—Live parts of switchboards shall be guarded in accordance with rule 114.

(b) **Plug-type switchboards.**—Plug-type switchboards should, except while connections are being changed, have no current-carrying part exposed on face of boards and, if practicable, they and their plug connectors shall be so arranged where the operating voltage exceeds 150 as to have all current-carrying parts guarded so long as they are alive, even while connections are being changed.

(c) **Exposed parts of more than 7,500 volts.**—No switchboard shall have current-carrying parts of more than 7,500 volts exposed (unguarded) unless these parts are effectively isolated by elevation, except at times when occasionally left exposed by removal of covers or entrance into inclosures, such as switch and instrument-transformer cells or compartments, which are ordinarily unoccupied by persons. For such parts, if exposed while alive for any purpose (including busses and disconnectors in compartments), working space shall be provided complying with the requirements under rule 115.

177. Instrument Cases.

When mounted on switchboards, metal cases of instruments (unless isolated by elevation) operating at more

than 750 volts shall be grounded or inclosed in suitable covers which are either of grounded metal or of insulating material.

SEC. 18. LIGHTNING ARRESTERS

180. Location.

(a) **Where required.**—Lightning arresters shall be attached to all ungrounded sides of each system of more than 7,500 volts connected to overhead circuits except circuits in cables with grounded metal sheath.

Exception.—This rule need not be complied with in locations where thunderstorms are infrequent at all seasons of the year.

(b) **Indoors.**—Lightning arresters with auxiliaries, when installed inside of buildings shall be located well away from all other equipment, passageways, and combustible parts of buildings. When of a type containing oil they should be installed in accordance with rule 107

181. Provisions for Disconnecting.

(a) **Air-break disconnectors.**—Lightning arresters on circuits of more than 7,500 volts shall be so arranged, isolated, and equipped that they may be readily disconnected from conductors to which they are connected by air-break manual disconnectors, having air gaps of not less than four times the equivalent needle-point sparking distance in air of the operating voltage of the circuit to which the arresters are connected, and never less than 8 inches.

These disconnecting devices should be installed at a sufficient distance from all parts of the arrester equipment to make it safe to perform maintenance and inspection work on any part of the arrester.

(b) **Working space.**—Such disconnectors, unless remotely controlled and operated, shall have the adjacent working spaces required by rule 115 for disconnectors generally.

182. Connecting Wires.

Ground wires shall be run as directly as possible and be of low impedance and ample current capacity. (See sec. 9 for methods of protective grounding.)

Kinks, coils, and sharp bends in the wires between the arresters and the outdoor lines shall be avoided as far as possible.

183. Grounding Frames and Cases of Lightning Arresters.

All noncurrent-carrying metal parts of arresters shall be grounded, unless effectively isolated by elevation or guarded as required for live parts of the voltage of the circuit to which the arrester is connected, and suitably identified as of that voltage, in accordance with rule 113.

184. Guarding Live and Arcing Parts.

(a) **Protection from contact or arcing.**—All current-carrying parts of arresters on circuits of more than 750 volts, unless effectively isolated by elevation, shall be adequately guarded to protect persons from inadvertent contact with them, or from injury by arcing, in accordance with rule 114.

(b) **Making adjustments.**—Lightning arresters, unless provided with disconnectors which are always opened before work is done on the arresters, shall be so arranged that necessary adjustments are possible (without approach to current-carrying parts) through the use of permanently grounded mechanisms or suitable insulating appliances. Where charging or adjusting must be done with arresters alive, permanently grounded mechanisms or suitable insulating appliances shall always be provided.

(c) **Insulation of attachments.**—All choke coils, gap electrodes, or other attachments, inherent to the lightning protective 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.

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