

1898/10

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TRANSACTIONS  
OF THE  
AMERICAN SOCIETY  
OF  
MECHANICAL ENGINEERS.

*VOL. XIX.*

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XXXVITH MEETING, NEW YORK, 1897.  
XXXVIIITH MEETING, NIAGARA FALLS, N. Y., 1898.



NEW YORK CITY:  
PUBLISHED BY THE SOCIETY,  
FROM THE LIBRARY BUILDING,  
NO. 12 WEST 31ST STREET.  
1898.

OFFICERS  
 OF THE  
 AMERICAN SOCIETY OF MECHANICAL  
 ENGINEERS,  
 1897-1898,  
 FORMING THE STATUTORY COUNCIL.

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*PRESIDENT.*

CHARLES WALLACE HUNT.....New York City.

*VICE-PRESIDENTS.*

E. S. CRAMP.....Philadelphia, Pa.  
 S. T. WELLMAN.....Cleveland, Ohio.  
 W. F. DURFEE.....New York City.  
 Terms expire at Annual Meeting of 1898.

JOHN C. KAER.....New York City.  
 CHAS. M. JARVIS.....Berlin, Conn.  
 WALTER S. RUSSEL.....Detroit, Mich.  
 Terms expire at Annual Meeting of 1899.

*MANAGERS.*

NORMAN C. STILES.....Watertown, N. Y.  
 E. D. MEIER.....St. Louis, Mo.  
 GEO. W. DICKIE.....San Francisco, Cal.  
 Terms expire at Annual Meeting of 1898.

H. S. HAINES.....In Europe.  
 GUS. C. HENNING.....New York City.  
 A. WELLS ROBINSON.....So. Milwaukee, Wis.  
 Terms expire at Annual Meeting of 1899.

JAS. B. STANWOOD.....Cincinnati, Ohio.  
 HENRY H. SUPLEE.....New York City.  
 GEO. RICHMOND.....New York City.  
 Terms expire at Annual Meeting of 1900.

*TREASURER.*

WM. H. WILEY.....No. 53 East 10th St., New York City.

*SECRETARY.*

PROF. F. R. HUTTON.....No. 12 West 31st St., New York City.

NOTE.

THE considerable bulk of the annual volume of *Transactions* has induced the Publication Committee to direct that the full list of members of the Society should be omitted from the preliminary matter therein. The list which would have been published in this volume is that which was corrected up to July, 1898, and which was issued at that time in pamphlet form as a second edition of the Nineteenth Catalogue. The following summary records the number of members in each grade :

Honorary Members.....	15
Members.....	1,394
Associate Members.....	124
Junior Members.....	343
Total Membership.....	1,876
Life Members *.....	73

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\* These Life Members are included in the total membership above, in the class to which they belong.

## PAST OFFICERS.

(EXECUTIVE.)

### PRESIDENTS.

R. H. THURSTON (April 7th, 1880—Nov. 3d, 1882), E. D. LEAVITT, JR. (Nov. 3d, 1882—Nov. 3d, 1883), JOHN E. SWEET (Nov. 3d, 1883—Nov. 7th, 1884), J. F. HOLLOWAY \* (Nov. 7th, 1884—Nov. 13th, 1885), COLEMAN SELLERS (Nov. 13th, 1885—Dec. 2d, 1886), GEO. H. BABCOCK † (Dec. 2d, 1886—Dec. 1st, 1887), HORACE SEE (Dec. 1st, 1887—Oct. 18th, 1888), HENRY R. TOWNE (Oct. 18th, 1888—Nov. 22d, 1889), OBERLIN SMITH (Nov. 22d, 1889—Nov. 14th, 1890), ROBT. W. HUNT (Nov. 14th, 1890—Nov. 20th, 1891), CHAS. H. LORING (Nov. 20th, 1891—Nov. 29th, 1892), ECKLEY B. COXE ‡ (Nov. 29th, 1892—Dec. 4th, 1894), E. F. C. DAVIS § (Dec. 4th, 1894—Aug. 6th, 1895), CHAS. E. BILLINGS ¶ (Aug. 6th, 1895—Dec. 3d, 1895), JOHN FRITZ (Dec. 3d, 1895—Dec. 5th, 1896), WORCESTER R. WARNER (Dec. 5th, 1896—Dec. 3d, 1897).

### TREASURERS AND SECRETARIES.

*Treasurers.*—LYCURGUS B. MOORE (April 7th, 1880—Dec. 2d, 1881), CHAS. W. COPELAND ¶ (Dec. 2d, 1881—Nov. 7th, 1884).

*Secretaries.*—LYCURGUS B. MOORE (*Acting*, April 7th, 1880—Nov. 4th, 1880), THOS. WHITESIDE RAE \*\* (Nov. 4th, 1880—March 1st, 1883).

## MEMBERS OF PREVIOUS COUNCILS.

### VICE-PRESIDENTS.

HENRY R. WORTHINGTON, †† COLEMAN SELLERS, ECKLEY B. COXE, ‡ Q. A. GILLMORE, WM. H. SHOCK, ALEX. L. HOLLEY, †† F. A. PRATT, W. P. TROWBRIDGE, §§ E. D. LEAVITT, JR., CHAS. E. EMERY, JOHN FRITZ, HENRY MORTON, WM. METCALF, S. B. WHITING, A. B. COUCH, W. R. ECKHART, J. V. MERRICK, CHARLES W. COPELAND, ¶ OLIN LANDRETH, HENRY R. TOWNE, C. H. LORING, HORACE SEE, ALLAN STIRLING, JOS. MORGAN, JR., C. T. PORTER, HORACE S. SMITH, W. S. G. BAKER, H. G. MORRIS, C. J. H. WOODBURY, THOS. J. BORDEN, WM. KENT, CHAS. B. RICHARDS, JOEL SHARP, GEO. W. WEEKS, DE VOLSON WOOD, S. W. BALDWIN, JOHN F. PANKHURST, ALEXANDER GORDON, GEO. I. ALDEN, E. F. C. DAVIS, IRVING M. SCOTT, C. W. HUNT, THOS. R. PICKERING, EDWIN REYNOLDS, C. E. BILLINGS, PERCIVAL ROBERTS, JR., H. J. SMALL, F. H. BALL, JESSE M. SMITH, M. L. HOLMAN, GEO. W. MELVILLE, CHAS. H. MANNING, and FRANCIS W. DEAN.

### MANAGERS.

W. P. TROWBRIDGE, §§ T. N. ELY, J. C. HOADLEY, || WASHINGTON JONES, WM. B. COGSWELL, F. A. PRATT, CHAS. B. RICHARDS, S. B. WHITING, J. F. HOLLOWAY, GEO. W. FISHER, ALLAN STIRLING, GEO. H. BABCOCK, S. W. ROBINSON, JNO. E. SWEET, R. W. HUNT, CHAS. T. PORTER, C. J. H. WOODBURY, W. F. DURFEE, OBERLIN SMITH, C. C. WORTHINGTON, WM. LEE CHURCH, WM. HEWITT, C. H. MORGAN, H. A. HILL, WM. KENT, S. T. WELLMAN, F. G. COGGIN, J. T. HAWKINS, T. R. MORGAN, SR., S. W. BALDWIN, FRED'K GRINNELL, MORRIS SELLERS, FRANK H. BALL, GEO. M. BOND, WM. FORSYTH, JAS. E. DENTON, CARLETON W. NASON, H. H. WESTINGHOUSE, ANDREW FLETCHER, WORCESTER R. WARNER, COLEMAN SELLERS, JR., JAS. M. DODGE, ROBT. FORSYTH, JESSE M. SMITH, CHAS. H. MANNING, C. W. PUSEY, JOHN THOMSON, JOHN B. HERRESHOFF, L. B. MILLER, W. S. RUSSEL, JOHN C. KAUFER, CHAS. A. BAUER, and ARTHUR C. WALWORTH.

\* Died, Sept. 1, 1896.

§ Died, Aug. 6, 1895.

\*\* Died, May 27, 1893.

§§ Died, Aug. 12, 1892.

† Died, Dec. 16, 1893.

† Unexpired term of Mr. Davis.

†† Died, Dec. 17, 1890.

|| Died, Oct. 21, 1886.

‡ Died, May 13, 1895.

¶ Died, Feb. 7, 1895.

\*\* Died, Jan. 29, 1882.

## HONORARY COUNCILLORS.

### Past Presidents of the Society.

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R. H. THURSTON.....	1880—1882.....	Ithaca, N. Y.
E. D. LEAVITT.....	1882—1883.....	Cambridgeport, Mass.
JOHN E. SWEET.....	1883—1884.....	Syracuse, N. Y.
COLEMAN SELLERS.....	1885—1886.....	Philadelphia, Pa.
HORACE SEE.....	1887—1888.....	New York City.
HENRY R. TOWNE.....	1888—1889.....	Stamford, Conn.
OBERLIN SMITH.....	1889—1890.....	Bridgeton, N. J.
ROBERT W. HUNT.....	1890—1891.....	Chicago, Ill.
CHARLES H. LORING.....	1891—1892.....	Brooklyn, N. Y.
CHARLES E. BILLINGS*.....	1895.....	Hartford, Conn.
JOHN FRITZ.....	1895—1896.....	Bethlehem, Pa.
WORCESTER R. WARNER.....	1896—1897.....	Cleveland, Ohio.

[NOTE.—The former Presidents of the Society are members of the Council for life or during their retention of active membership in the Society.]

\* Unexpired term of E. F. C. Davis.

**PAPERS**  
**OF THE**  
**NEW YORK MEETING**  
**(XXXVith)**

**NOVEMBER 30th TO DECEMBER 3d, 1897.**

**BEING ALSO THE EIGHTEENTH ANNUAL MEETING OF THE SOCIETY.**

DCCXLIX.

PROCEEDINGS

OF THE

NEW YORK MEETING

(XXXVith)

OF THE

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

November 30th to December 3d, 1897.

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THE eighteenth annual meeting of the Society (being also its thirty-sixth convention) was held in New York City during the period November 30 to December 3, 1897. The sessions for papers were convened in the auditorium of the Society's house, 12 West Thirty-first Street, and in the parlors and library adjoining the meeting hall a large number of guests and visitors was always to be found.

The opening session was called to order about nine o'clock on Tuesday evening by the Secretary of the Society, who, after a few words of greeting in the name of the New York members, read a letter just received from Mrs. R. Anna Cary, widow of the late Alanson Cary, as follows :

14 WEST 77TH STREET.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS,  
12 West 31st Street, New York.

*Gentlemen.*—The portrait of Robert Fulton, painted by himself, which was loaned to you two years ago by Alanson Cary, I now wish to present to the American Society of Mechanical Engineers, in his memory, feeling that it would be his desire to have me do so.

Hoping that this gift may prove acceptable, I remain,

Very truly yours,

R. ANNA CARY.

November 30, 1897.

of the Society's *Transactions* for the year 1899, and that the issue of the volume for 1900 come under the foregoing resolution.

*Resolved*, That similar institutions desiring to purchase back volumes of *Transactions* to complete their sets be permitted to do so at the regular member's rates of \$5.00 in paper covers and \$6.00 per volume in the morocco binding.

At a later meeting, October, 1897 :

*Resolved*, That State or Public Libraries which derive their income from taxation be allowed to procure back volumes or the current and future issues at the usual rates to non-members; viz., at \$10.00 per volume in paper binding and \$11.00 per volume in half morocco.

The Council and the Society have been advised, through Mr. Wm. J. Hammer, President of the International Conference on Standard Electrical Rules, that the conference and the other societies which were contributory to the conference have accepted the proposed standard, of which copies have been furnished to us for limited distribution to those interested. The conference requests that this Society will take the usual action which is customary in such cases, and the Council have directed that the communication of Mr. Hammer should be read at the annual meeting, and the report of Mr. C. J. H. Woodbury, member of the Society, as a delegate to represent the Society at the conference, and on whom was conferred the honor of being made its secretary, should be made matters of business for the annual meeting.

Pursuant to the provisions of an agreement entered into between the Society and Mr. Oberlin Smith, the Society has become the owner, by assignment, of the design patent taken out by Mr. Oberlin Smith for the oval form of the standard decimal gauge for measuring and indicating the thickness of metals, sheet and wire, by thousandths of an inch, the number of thousandths being the number of the notch in the edge of the oval gauge. It is not the intention of the Society to derive any business advantage from the ownership of this patent, but merely to protect the decimal gauge from abuse in unauthorized hands. In carrying out this purpose the Society has given manufacturer's license to the firm of Pratt & Whitney of Hartford, Conn., and will be glad to make a similar arrangement, upon request, with other firms of good standing.

It has been found to be of sufficient advantage to the Society and the profession of mechanical engineering in America to have the Society officially represented in the conferences which occur at stated intervals to discuss uniform methods of test and test-

*Resolved*, That the heartfelt thanks of the members in attendance at this conference are due, and are hereby tendered, to the New York members of the Society for their generous hospitality in entertaining their guests at the general conference held last evening.

*C. J. H. Woodbury*.—In rising to second this resolution I wish to say that it has always seemed to me that members of the Society are now, and have always been, deeply grateful to the New York members of the Society for the perennial spring of hospitality which we have always found flowing in the late afternoon for our annual meeting. We non-residents may be like the little lad who was reproached for not thanking a generous woman for her gift of candy, who replied that he did thank her, but had not told her so. It may be that we have not always told the New York members of our thanks, and it seems to me a proper action to spread a resolution of this sort upon the records of our Society.

Witty and humorous remarks were made by Messrs. Ashmun and Oberlin Smith, and, on motion, the resolution was adopted.

The President called on Mr. C. J. H. Woodbury, who had been appointed a delegate to represent the Society at the National Conference which had been summoned to consider the revision of rules and requirements for the installation of apparatus and wiring for electric light, heat, and power. He expressed that the Society had tendered to this Conference the use of its rooms for their meetings, and that a ballot letter of recognition had been received and filed from Mr. William J. Hambleton, the President of the Conference. Mr. C. J. H. Woodbury had been chosen the Secretary of the Conference, as well as representing the Society in its deliberation. Mr. Woodbury's report was as follows :

REPORT OF DELEGATE TO THE NATIONAL CONFERENCE ON  
STANDARD ELECTRICAL RULES.

BOSTON, MASS., *October 1, 1897.*

TO THE PRESIDENT AND COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

*Motion* : In accordance with the vote of the Council :  
*Resolved*, " That the American Society of Mechanical Engineers accept with pleasure the invitation from the National Conference on

Standard Electrical Rules, and until further action will send a delegate to future meetings of the Conference ;”

*Resolved* : “That Mr. C. J. H. Woodbury, of Boston, past Vice-President of this Society, be appointed the delegate of this Society to the National Conference on Standard Electrical Rules, until further action by the Council.”

The Conference included representatives from the following bodies :

American Society of Mechanical Engineers,  
 American Institute of Electrical Engineers,  
 American Street Railway Association,  
 Associated Factory Mutual Fire Insurance Companies,  
 National Association of Fire Engineers,  
 National Board of Fire Underwriters,  
 National Electric Light Association,  
 Underwriters' National Electric Association,  
 National Board of Fire Underwriters,  
 American Institute of Architects,  
 International Fire Chiefs' Association,  
 American Bell Telephone Company,  
 Western Union Telegraph Company,  
 Postal Telegraph Company,  
 General Electric Company,  
 Westinghouse Electric and Manufacturing Company,

and held a meeting in the Hall of the American Society of Mechanical Engineers on March 18-19, 1895, at which William J. Hammer was elected President ; C. J. H. Woodbury, Secretary.

The two days were occupied in a critical discussion of electrical rules, and a record of the conclusions taken and submitted to the following Code Committee:

F. B. Crocker, Chairman, American Institute Electrical Engineers.  
 William Brophy, } National Electric Light Association.  
                           } National Association of Fire Underwriters.  
 E. A. Fitzgerald, Underwriters' National Electric Association.  
 William R. Ford, American Street Railway Association.  
 E. V. French, Factory Mutual Fire Insurance Companies.  
 W. H. Merrill, National Board of Fire Underwriters.  
 Alfred Stone, American Institute of Architects.  
 W. J. Hammer, President of the Conference, *ex-officio*.

Copies of existing rules were printed in parallel columns, and four hundred and seventy-five copies sent to interested parties, with a communication from the Secretary asking for further comments and suggestions.

The replies were submitted to the Committee on Code, who held numerous meetings, and the result of their labors accepted by the members of the Conference on a letter ballot without reassembling of the body.

The Electrical Committee of the National Board of Fire Underwriters have accepted the suggestions in the identical form in which the rules are now issued by that body under the title of the “National Electrical Code,” edition of 1897, and the code has also been accepted by those of the bodies constituting that organization who have held meetings at which action could have been taken on the subject. In its present form it represents a consensus of opinion by those broadly interested in every department of the subject, and its adoption by the under-

writers and other organizations has accomplished the desired purpose of the unification of rules upon the subject of installation and maintenance of electrical plant.

A copy of the rules is submitted herewith, and forms a part of this report.

Respectfully submitted,

C. J. H. WOODBURY,

*Delegate from the A. S. M. E.*

At the conclusion of the report Mr. H. H. Suplee presented the following resolutions, which were adopted. The Standard Rules will be made an appendix to the papers of the meeting:

*Resolved*, That the American Society of Mechanical Engineers have listened with interest to the report of its delegate to the National Conference on Standard Electrical Rules, and his report concerning the National Electrical Code of Rules and requirements for installation of apparatus and wiring for electric light, heat, and power.

*Resolved*, That the American Society of Mechanical Engineers, pursuant to its approved policy in technical matters such as are concerned in the report of its delegate, accept the report of the Committee of the National Conference, which has been presented to the Society by Mr. Woodbury, and direct that the rules and requirements recommended be printed as one of the papers of this meeting and incorporated into the volume of *Transactions*, and the use of these rules be recommended to the membership of this Society.

#### FIFTH SESSION. FRIDAY, DECEMBER 3D.

The papers for the morning included certain ones which had been omitted from the regular programme of the previous evening, by reason of the interest attaching to the discussion on the revision of the code of boiler trials, and included the following papers: By Ms. George W. Dickie, entitled "Auxiliary Engines and Machinery for Naval Vessels"; by Mr. George W. Bissell, entitled "A Boiler Setting"; by Mr. H. M. Norris, entitled "An Accurate Cost-keeping System"; by Mr. George Richmond, entitled "Thermodynamics Without the Calculus"; by Mr. Charles T. Main, entitled "The Valuation of Textile Manufacturing Property"; by Mr. James Hartness, entitled "Screw Die for the Turret Lathe" and "Stay-bolt Threading Device"; by Mr. C. J. H. Woodbury, entitled "Dustless Buildings"; by Mr. Andrew Fletcher, entitled "The Stevens Valve Gear for Marine Engines"; by Mr. E. H. Mumford, entitled "Machine Moulding Without Stripping Plates"; by Mr. W. B. Smith Whaley, entitled "Electricity in Cotton Mills"; by Mr. A. L. Rice, entitled "Convenient Form of Wire Testing Machine." The discussions were presented by Messrs. Suplee, Halsey, Rogers, Oberlin

DCCXC.

## APPENDIX.

REPORT OF THE NATIONAL CONFERENCE ON STANDARD ELECTRICAL RULES, 12 WEST 81ST STREET, NEW YORK.\*

GENERAL PLAN GOVERNING THE ARRANGEMENT OF RULES.

CLASS A.—Central Stations, Dynamo, Motor and Storage Battery Rooms, Transformer Sub-Stations, etc. Rules 1 to 11.

CLASS B.—Outside work, all systems and voltages. Rules 12 and 13.

CLASS C.—Inside work. Rules 14 to 39. Subdivided as follows:

General Rules, applying to all systems and voltages. Rules 14 to 17.

Constant Current systems. Rules 18 to 20.

Constant Potential systems.

All voltages. Rules 21 to 23.

Voltage not over 300. Rules 24 to 31.

Voltage between 300 and 3,000. Rules 32 to 37.

Voltage over 3,000. Rules 38 and 39.

CLASS D.—Specifications for Wires and Fittings. Rules 40 to 55.

CLASS E.—Miscellaneous. Rules 56 to 59.

CLASS F.—Marine Wiring. Rules 60 to 72.

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\*This report is that referred to at page 33 of the current volume (xix.) of the *Transactions*, as reported by the delegate to the conference (Mr. C. J. H. Woodbury). It was accepted, and the use of its provisions recommended, which is the usual procedure with respect to similar work of committees. The code was ordered printed as an appendix to the volume.

President, William J. Hammer; Secretary and Treasurer, C. J. H. Woodbury; Committee on Code, Prof. Francis B. Crocker, Chairman; Frank R. Ford, Secretary; William Brophy, E. A. Merrill, Jr., E. A. Fitzgerald, Alfred Stone, E. V. French, Wm. J. Hammer (ex-officio).

## GENERAL SUGGESTIONS.

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

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

In laying out an installation, except for constant-current systems, the work should, if possible, be started from a centre of distribution, and the switches and cut-outs, controlling and connected with the several branches, be grouped together in a safe and easily accessible place, where they can be readily got at for attention or repairs. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

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

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

## CLASS A.

## STATIONS AND DYNAMO ROOMS.

INCLUDES CENTRAL STATIONS, DYNAMO, MOTOR, AND STORAGE-BATTERY ROOMS, TRANSFORMER SUB-STATIONS, ETC.

## 1. GENERATORS—

*a.* Must be located in a dry place.

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

*c.* Must be insulated on floors or base frames, which must be kept filled to prevent absorption of moisture and also kept clean and dry. Where frame insulation is impracticable, the Inspection Department having jurisdiction may, in writing, permit its omission, in which case the frame must be permanently and effectively grounded.

A high-potential machine which, on account of great weight or for other reasons, cannot have its frame insulated from the ground, should be surrounded with an insulated platform. This may be made of wood, mounted on insulating supports and so arranged that a man must always stand upon it in order to touch any part of the machine.

In case of a machine having an insulated frame, if there is trouble from static electricity due to belt friction, it should be overcome by placing near the belt a metallic comb connected with the earth, or by grounding the frame through a very high resistance of not less than 200 ohms per volt generated by the machine.

*d.* Every constant potential generator must be protected from excessive current by a safety fuse, or equivalent device, of approved design in each lead wire.

These devices should be placed on the machine or as near to it as possible.

Where the needs of the service make these devices impracticable, the Inspection Department having jurisdiction may, in writing, modify the requirements.

*e.* Must each be provided with a waterproof cover.

*f.* Must each be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and normal speed in revolutions per minute.

## 2. CONDUCTORS—

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

*a.* Must be in plain sight or readily accessible.

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

Bus bars may be made of bare metal.

*c.* Must be kept so rigidly in place that they cannot come in contact.

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

### 3. SWITCHBOARDS—

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

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

*b.* Must be made of non-combustible material or of hardwood in skeleton form, filled to prevent absorption of moisture.

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

*d.* Must be kept free from moisture.

*e.* Bus bars must be equipped in accordance with the rules for placing conductors.

### 4. RESISTANCE BOXES AND EQUALIZERS—

(For construction rules, see No. 52.)

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

### 5. LIGHTNING ARRESTERS—

(For construction rules, see No. 55.)

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

It is recommended to all electric light and power companies that arresters be connected at intervals over systems in such numbers and so located as to prevent

ordinary discharges entering the buildings over the wires connected to the lines.

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

Station arresters should generally be placed in plain sight on the switchboard.

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

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

Ground wires for lightning arresters must not be attached to gas pipes within the buildings.

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

#### 6. CARE AND ATTENDANCE—

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

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

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

#### 7. TESTING OF INSULATION RESISTANCE—

*a.* All circuits must be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground wires from detectors must not be attached to gas pipes within the building.

*b.* Where continuously indicating detectors are not feasible, the circuits should be tested at least once per day and preferably oftener.

*c.* Data obtained from all tests must be preserved for examination by the Inspection Department having jurisdiction.

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

## 8. MOTORS—

*a.* Must be insulated on floors or base frames, which must be kept filled to prevent absorption of moisture and must be kept clean and dry. Where frame insulation is impracticable the Inspection Department having jurisdiction may, in writing, permit its omission, in which case the frame must be permanently and effectively grounded.

A high-potential machine which, on account of great weight or for other reasons, cannot have its frame insulated, should be surrounded with an insulated platform. This may be made of wood, mounted on insulating supports, and so arranged that a man must stand upon it in order to touch any part of the machine.

In case of a machine having an insulated frame, if there is trouble from static electricity due to belt friction, it should be overcome by placing near the belt a metallic comb connected to the earth, or by grounding the frame through a very high resistance of not less than 200 ohms per volt generated by the machine.

*b.* Must be wired under the same precautions as required by rules in Class "C," for wires carrying a current of the same volume and potential.

The leads or branch circuits should be designed to carry a current at least fifty per cent. greater than that required by the rated capacity of the motor, to provide for the inevitable overloading of the motor at times without over-fusing the wires.

*c.* The motor and resistance box must be protected by a cut-out and controlled by a switch (see No. 17*a*), said switch plainly indicating whether "on" or "off." Where one-quarter horsepower or less is used on low-tension circuits a single-pole switch will be accepted. The switch and rheostat must be located within sight of the motor, except in such cases where special permission to locate them elsewhere is given, in writing, by the Inspection Department having jurisdiction.

*d.* Must have their rheostats or starting boxes located so as to conform to the requirements of Rule 4.

In connection with motors the use of circuit breakers, automatic starting boxes and automatic under-load switches is recommended and they *must* be used when required.

*e.* Must not be run in series-multiple or multiple-series.

*f.* Must be covered with a waterproof cover when not in use,

and, if deemed necessary, by the Inspection Department having jurisdiction, must be inclosed in an approved case.

From the nature of the question the decision as to what is an approved case must be left to the Inspection Department having jurisdiction to determine in each instance.

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

*h.* Must each be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

#### 9. RAILWAY POWER PLANTS—

*a.* Must be equipped in each feed wire before it leaves the station with an *approved* automatic circuit breaker (see No. 44) or other device, which will immediately cut off the current in case of an accident ground. This device must be mounted on a fire-proof base, and in full view and reach of the attendant.

#### 10. STORAGE OR PRIMARY BATTERIES—

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

*b.* Storage-battery rooms must be thoroughly ventilated.

*c.* Special attention is directed to the rules for rooms where acid fumes exist. (See No. 24, *j.* and *k.*)

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

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

#### 11. TRANSFORMERS—

(For construction rules, see No. 54.)

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

## CLASS B.

## OUTSIDE WORK.

## ALL SYSTEMS AND VOLTAGES.

## 12. WIRES—

*a.* Service wires must have an *approved* rubber insulating covering. (See No. 40 *a.*) Line wires, other than services, must have an *approved* weatherproof or rubber insulating covering. (See No. 40 *a* and *b.*) All tie wires must have an insulation equal to that of the conductors they confine.

*b.* Must be so placed that moisture cannot form a cross connection between them, not less than a foot apart, and not in contact with any substance other than their insulating supports. Service blocks must be covered over their entire surface with at least two coats of waterproof paint.

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

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

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

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

All joints must be soldered, even if made with some form of patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these rules.

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

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

*i.* The metallic sheaths to cables must be permanently and effectively connected to "earth."

#### TROLLEY WIRES.

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

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

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

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

Guard wires should be insulated from the ground and should be electrically disconnected in sections of not more than 300 feet in length.

#### GROUND RETURN WIRES.

*n.* For the diminution of electrolytic corrosion of underground metal work, ground return wires must be so arranged that the difference of potential between the grounded dynamo terminal and any point on the return circuit will not exceed twenty-five volts.

It is suggested that the positive pole of the dynamo be connected to the trolley line, and whenever pipes or other underground metal work are found to be electrically positive to the rails or surrounding earth, that they be connected by conductors arranged so as to prevent as far as possible current flow from the pipes into the ground.

#### 13. TRANSFORMERS—

(For construction rules, see No. 54.)

*a.* Must not be placed inside of any building, excepting central stations, unless by special permission of the Inspecting Department having jurisdiction.

*b.* Must not be attached to the outside walls of buildings, unless separated therefrom by substantial supports.

## CLASS C.

## INSIDE WORK.

## ALL SYSTEMS AND VOLTAGES.

## GENERAL RULES—ALL SYSTEMS AND VOLTAGES.

## 14. WIRES—

(For special rules, see Nos. 18, 24, 32, 38, and 39.)

*a.* Must not be of smaller size than No. 14 B. & S., except as allowed under Rules 24 *u* and 40 *c*.

*b.* Tie wires must have an insulation equal to that of the conductors they confine.

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

Stranded wires must be soldered before being fastened under clamps or binding screws, and, when they have a conductivity greater than No. 10 B. & S. copper wire, they must be soldered into lugs.

All joints must be soldered, even if made with some form of patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these rules.

*d.* Must be separated from contact with walls, floors, timbers, or partitions through which they may pass by non-combustible, non-absorptive insulating tubes, such as glass or porcelain.

Bushings must be long enough to bush the entire length of the hole in one continuous piece, or else the hole must first be bushed by a continuous water-proof tube, which may be a conductor, such as iron pipe; the tube then is to have a non-conducting bushing pushed in at each end so as to keep the wire absolutely out of contact with the conducting pipe.

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

*f.* Must be so placed in wet places that an air space will be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact

with the pipe accidentally. Wires should be run over, rather than under, pipes upon which moisture is likely to gather, or which, by leaking, might cause trouble on a circuit.

#### 15. UNDERGROUND CONDUCTORS—

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

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

#### 16. TABLE OF CARRYING CAPACITY OF WIRES—

Below is a table showing the allowable carrying capacity of wires containing ninety-eight per cent. of the conductivity of pure copper, which must be followed in placing interior conductor:

TABLE A. Rubber Covered Wires. See No. 40 <i>a.</i>		TABLE B. Waterproof Wires. See No. 40 <i>b.</i>	
B. & S. G.	Amperes.		Amperes.
18	3		5
16	6		8
14	12		16
12	17		23
10	24		33
8	33		46
6	46		65
5	54		77
4	65		92
3	76		110
2	90		131
1	107		156
0	127		185
00	150		220
000	177		262
0000	210		312
Circular Mills.			
200,000	200		300
300,000	270		400
400,000	330		500
500,000	390		590
600,000	450		680
700,000	500		760
800,000	550		840
900,000	600		920
1,000,000	650		1,000
1,100,000	690		1,080
1,200,000	730		1,150
1,300,000	770		1,220
1,400,000	810		1,290
1,500,000	850		1,360
1,600,000	890		1,430
1,700,000	930		1,490
1,800,000	970		1,550
1,900,000	1,010		1,610
2,000,000	1,050		1,670

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the above tables.

The carrying capacity of sixteen and eighteen wire is given, but no smaller than fourteen is to be used, except as allowed under Rules 24 *u* and 40 *c*.

#### 17. SWITCHES, CUT-OUTS, CIRCUIT BREAKERS, ETC.—

(For construction rules, see Nos. 43, 44, and 45.)

*a.* Must, whenever called for, unless otherwise provided (for exceptions see No. 8 *c* and No. 22 *c*), be so arranged that the cut-outs will protect, and the opening of the switch or circuit breaker will disconnect, all of the wires; that is, in a two-wire system the two wires, and in a three-wire system the three wires, must be protected by the cut-out and disconnected by the operation of the switch or circuit breaker.

*b.* Must not be placed in the immediate vicinity of easily ignitable stuff or where exposed to inflammable gases or dust or to flyings of combustible material.

*c.* Must, when exposed to dampness, either be inclosed in a waterproof box or mounted on porcelain knobs.

#### CONSTANT-CURRENT SYSTEMS.

##### PRINCIPALLY SERIES ARC LIGHTING.

#### 18. WIRES—

(See also Nos. 14, 15, and 16.)

*a.* Must have an *approved* rubber insulating covering. (See No. 40 *a*.)

*b.* Must be arranged to enter and leave the building through an *approved* complete cut-out service switch (see No. 43), mounted in a non-combustible case, kept free from moisture, and easy of access to police or firemen. So-called "snap switches" must not be used on high-potential circuits.

*c.* Must always be in plain sight, and never incased, except when *required* by the Inspection Department having jurisdiction.

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

*e.* Must on side walls be protected from mechanical injury by a

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

#### 19. ARC LAMPS—

*(For construction rules see No. 49.)*

- a.* Must be carefully isolated from inflammable material.
- b.* Must be provided at all times with a glass globe surrounding the arc, securely supported upon a closed base. No broken or cracked globes to be used.
- c.* Must be provided with a wire netting (having a mesh not exceeding one and one-quarter inches) around the globe, and an improved spark arrester (see No. 50), when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks, melted copper or carbon. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

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

For the present, globes and spark arresters will not be required on so-called "inverted arc" lamps, but this type of lamp must not be used where exposed to flyings of easily inflammable materials.

- d.* Where hanger-boards (see No. 48) are not used, lamps must be hung from insulating supports other than their conductors.

#### 20. INCANDESCENT LAMPS IN SERIES CIRCUITS—

- a.* Must have the conductors installed as provided in Rule No. 18, and each lamp must be provided with an approved automatic cut-out.
- b.* Must have each lamp suspended from a hanger-board by means of rigid tube.
- c.* No electro-magnetic device for switches and no system of multiple-series or series-multiple lighting will be approved.
- d.* Under no circumstances can they be attached to gas fixtures.

## CONSTANT-POTENTIAL SYSTEMS.

## GENERAL RULES—ALL VOLTAGES.

21. AUTOMATIC CUT-OUTS (*Fuses and Circuit Breakers*)—

(See No. 17, and, for construction, Nos. 44 and 45.)

*a.* Must be placed on all service wires, either overhead or under-ground, as near as possible to the point where they enter the building and inside the walls, and be arranged to cut off the entire current from the building.

Where the switch required by Rule No. 22 is inside the building, the cut-out required by this section must be placed so as to protect it.

*b.* Must be placed at every point where a change is made in the size of wire, unless the cut-out in the larger wire will protect the smaller. (See No. 16.)

*c.* Must be in plain sight, or inclosed in an *approved* box (see No. 46), and readily accessible. They must not be placed in the canopies or shells of fixtures.

*d.* Must be so placed that no set of incandescent lamps, whether grouped on one fixture or several fixtures or pendants, requiring a current of more than six amperes shall be dependent upon one cut-out. Special permission may be given in writing by the Inspection Department having jurisdiction for departure from this rule in case of large chandeliers.

*e.* Must be provided with fuses, the rated capacity of which does not exceed the allowable carrying capacity of the wire, and, when circuit breakers are used, they must not be set more than about thirty per cent. above the allowable carrying capacity of the wire, unless a fusible cut-out is also installed in circuit (see No. 16).

## 22. SWITCHES—

(See No. 17, and, for construction, No. 43.)

*a.* Must be placed on all service wires, either overhead or under-ground, in a readily accessible place, as near as possible to the point where the wires enter the building and arranged to cut off the entire current.

*b.* Must always be placed in dry, accessible places, and be grouped as far as possible. Knife switches must be so placed that gravity will tend to open rather than close the switch.

*c.* Must not be single-pole, except when the circuits which they control supply not more than six 16 candle-power lamps or their equivalent.

*d.* Where gangs of flush switches are used, whether with conduit systems or not, the switches must be inclosed in boxes constructed of or lined with fire-resisting material. Where two or more switches are placed under one plate, the box must have a separate compartment for each switch. No push buttons for bells, gas-lighting circuits, or the like shall be placed in the same wall plate with switches controlling electric light or power wiring.

### 23. ELECTRIC HEATERS—

*a.* Must, if stationary, be placed in a safe situation, isolated from inflammable materials, and be treated as sources of heat.

*b.* Must each have a cut-out and *indicating* switch (see No. 17 *a*).

*c.* Must have the attachments of feed wires to the heaters in plain sight, easily accessible and protected from interference, accidental or otherwise.

*d.* The flexible conductors for portable apparatus, such as irons, etc., must have an *approved* insulating covering (see No. 40 *c*, 3).

*e.* Must each be provided with name plate, giving the maker's name and the normal capacity in volts and amperes.

### LOW-POTENTIAL SYSTEMS.

#### 300 VOLTS OR LESS.

Any circuit attached to any machine, or combination of machines, which develops a difference of potential, between any two wires, of over ten volts and less than 300 volts, shall be considered as a low-potential circuit; and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to ten volts or less. The primary circuit not to exceed a potential of 3,000 volts.

### 24. WIRES—

#### GENERAL RULES.

(See also Nos. 14, 15, and 16.)

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

*b.* Must never be fastened with staples.

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

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

e. Must be protected on side walls from mechanical injury. When crossing floor timbers in cellars or in rooms, where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip, not less than one-half inch in thickness, and not less than three inches in width.

Suitable protection on side walls may be secured by a substantial boxing, retaining an air space of one inch around the conductor, closed at the top (the wires passing through bushed holes), and extending not less than five feet from the floor; or by an iron-armored or metal-sheathed insulating conduit sufficiently strong to withstand the strain it will be subjected to; or plain metal pipe, lined with insulating tubing, which must extend one-half inch beyond the end of the metal tube.

The pipe must extend not less than five feet above the floor, and may extend through the floor in place of a floor bushing.

If iron pipes are used with alternating currents, the two or more wires of a circuit *must* be placed in the same conduit. In this case the insulation of each wire must be reinforced by a tough conduit tubing projecting beyond the ends of the iron pipe at least two inches.

f. When run immediately under roofs, or in proximity to water tanks or pipes, will be considered as exposed to moisture.

#### SPECIAL RULES.

For open work :

*In dry places.*

g. Must have an *approved* rubber or weatherproof insulation. (See No. 40 a and b.)

h. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one-half inch from the surface wired over, and they must be kept apart at least two and one-half inches.

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

This rule will not be interpreted to forbid the placing of the neutral of a three-wire system in the center of a three-wire cleat, provided the outside wires are separated two and one-half inches.

In damp places, such as Breweries, Packing Houses, Stables, Dye Houses, Paper or Pulp Mills, or buildings specially subject

to moisture or acid or other fumes liable to injure the wires or their insulation, except where used for pendants :

*i.* Must have an *approved* rubber insulating covering (see No. 40 *a*).

*j.* Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one inch from the surface wired over, and they must be kept apart at least two and one-half inches.

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

*k.* Must have no joints or splices.

For moulding work :

*l.* Must have *approved* rubber insulating covering (see No. 40 *a*).

*m.* Must never be placed in moulding in concealed or damp places.

For conduit work :

*n.* Must have an *approved* rubber insulating covering (see No. 40 *e*).

The use of concentric wire (see No. 40 *e*) is recommended in preference to twin conductors.

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

*p.* Must not have wires of different circuits drawn in the same conduit.

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

It is advised that this be done for direct-current systems also, so that they may be changed to alternating systems at any time; induction troubles preventing such a change unless this construction is followed.

For so-called concealed work :

*r.* Must have an *approved* rubber insulating covering (see No. 40 *a*).

*s.* Must be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least one inch from the surface wired over, and must be kept at least ten inches apart,

and, when possible, should be run singly on separate timbers or studding.

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

*t.* When from the nature of the case it is impossible to place concealed wiring on non-combustible insulating supports of glass or porcelain, the wires, if not exposed to moisture, may be fished on the loop system if incased throughout in approved continuous flexible tubing or conduit. (See page 45.)

For fixture work :

*u.* Must have an *approved* rubber insulating covering (see No. 40 *d*), and shall not be less in size than No. 18 B. & S.

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

*w.* Must, when fixtures are wired outside, be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture.

## 25. INTERIOR CONDUITS—

(See also Nos. 24 *n* to *q*, and 41.)

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

*a.* Must be continuous from one junction box to another or to fixtures and the conduit tube must properly enter all fittings.

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

*c.* Conduits must extend at least one-half inch beyond the finished surface of walls or ceilings, except that, if the end is threaded and a coupling screwed on, the conduit may be left flush with the surface, and the coupling may be removed when work on building is completed.

*d.* Must, after conductors are introduced, have all outlets plugged with special wood or fibrous plugs, made in parts, and the outlet then sealed with approved compound. Joints must be made air-tight and moisture proof.

*e.* Must have the metal of the conduit permanently and effectually grounded.

## 26. FIXTURES—

(See also No. 24 *u* to *w*.)

*a.* Must, when supported from the gas piping of a building, be insulated from the gas-pipe system by means of *approved* insulating joints (see No. 51) placed as close as possible to the ceiling.

It is recommended that the gas outlet pipe be protected above the insulating joint by a non-combustible, non-absorptive insulating tube, having a flange at the lower end where it comes in contact with the insulating joint, and that, where outlet tubes are used, they be of sufficient length to extend below the insulating joint, and that they be so secured that they will not be pushed back when the canopy is put in place. Where iron ceilings are used, care must be taken to see that the canopy is thoroughly and permanently insulated from the ceiling.

*b.* Must have all burrs, or fins, removed before the conductors are drawn into the fixture.

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

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

*e.* Must be tested for "contacts" between conductors and fixtures, for "short circuits" and for ground connections before it is connected to its supply conductors.

*f.* Ceiling block fixtures should be made of insulating material; if not, the wires in passing through the plate must be surrounded with non-combustible, non-absorptive insulating material, such as glass or porcelain.

## 27. SOCKETS—

(For construction rules, see No. 47.)

*a.* In rooms where inflammable gases may exist the incandescent lamp and socket must be inclosed in a vapor-tight globe, and supported on a pipe-hanger, wired with approved rubber-covered wire (See No. 40 *a*) soldered directly to the circuit.

*b.* In damp or wet places, or over specially inflammable stuff, waterproof sockets must be used.

When waterproof sockets are used, they should be hung by separate stranded rubber-covered wires, not smaller than No. 14 B. & S., which should preferably

be twisted together when the drop is over three feet. These wires should be soldered direct to the circuit wires, but supported independently of them.

#### 28. FLEXIBLE CORD—

*a.* Must have an *approved* insulation and covering. (See No. 40*c.*)

*b.* Must not be used as a support for clusters.

*c.* Must not be used except for pendants, wiring of fixtures and portable lamps or motors.

*d.* Must not be used in show windows.

*e.* Must be protected by insulated bushings where the cord enters the socket.

*f.* Must be so suspended that the entire weight of the socket and lamp will be borne by knots under the bushing in the socket, and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws.

#### 29. ARC LIGHTS ON LOW-POTENTIAL CIRCUITS—

*a.* Must have a cut-out (see No. 17 *a*) for each lamp or each series of lamps.

The branch conductors should have a carrying capacity about fifty per cent. in excess of the normal current required by the lamp, to provide for heavy current required when lamp is started or when carbons become stuck without over-fusing the wires.

*b.* Must only be furnished with such resistances or regulators as are enclosed in non-combustible material; such resistances being treated as sources of heat. Incandescent lamps must not be used for resistance devices.

*c.* Must be supplied with globes and protected by spark arresters and wire netting around globe, as in the case of arc lights on high-potential circuits. (See Nos. 19 and 50.)

#### 30. ECONOMY COILS—

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

## 31. DECORATIVE SERIES LAMPS—

*a.* Incandescent lamps run in series shall not be used for decorative purposes inside of buildings, except by special permission in writing from the Inspection Department having jurisdiction.

## HIGH-POTENTIAL SYSTEMS.

## 300 TO 3,000 VOLTS.

Any circuit attached to any machine, or combination of machines, which develops a difference of potential, between any two wires, of over 300 volts and less than 3,000 volts, shall be considered as a high-potential circuit and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 300 volts or less.

## 32. WIRES—

(See also Nos. 14, 15, and 16.)

*a.* Must have an *approved* rubber insulating covering. (See No. 40 *a.*)

*b.* Must be always in plain sight and never incased, except where required by the Inspection Department having jurisdiction.

*c.* Must be rigidly supported on glass or porcelain insulators, which raise the wire at least one inch from the surface wired over, and must be kept apart at least four inches for voltages up to 750 and at least eight inches for voltages over 750.

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least about every four and one-half feet.

If the wires are unusually liable to be disturbed, the distance between supports should be shortened.

In buildings of mill construction, mains of No. 8 B. & S. wire or over, where not liable to be disturbed, may be separated about six inches for voltages up to 750 and about ten inches for voltages above 750 and run from timber to timber, not breaking around, and may be supported at each timber only.

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

**33. TRANSFORMERS (when permitted inside buildings ; see No. 13)—**

(For construction rules, see No. 54.)

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

*b.* Must be placed in an enclosure constructed of or lined with fire-resisting material ; the inclosure to be used only for this purpose and to be kept securely locked and access to the same allowed only to responsible persons.

*c.* Must be effectually insulated from the ground and the inclosure in which they are placed must be practically air-tight, except that it shall be thoroughly ventilated to the outdoor air, if possible, through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

**34. CAR WIRING—**

*a.* Must be always run out of reach of the passengers, and must have an *approved* rubber insulating covering. (See No. 40 *a.*)

**35. CAR HOUSES—**

*a.* Must have the trolley wires securely supported on insulating hangers.

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

*c.* Must have cut-out switch located at a proper place outside of the building, so that all trolley circuits in the building can be cut out at one point, and line circuit breakers must be installed, so that when this cut-out switch is open the trolley wire will be dead at all points within 100 feet of the building. The current must be cut out of the building whenever the same is not in use or the road not in operation.

*d.* Must have all lamps and stationary motors installed in such a way that one main switch can control the whole of each installation—lighting or power—independently of main feeder switch. No portable incandescent lamps or twin wire allowed, except that portable incandescent lamps may be used in the pits, connections to be made by two *approved* rubber-covered flexible wires (see No. 40 *a.*), properly protected against mechanical injury ; the circuit to be controlled by a switch placed outside of the pit.

*e.* Must have all wiring and apparatus installed in accordance with rules under "Class C" for constant-potential systems.

*f.* Must not have any system of feeder distribution centring in the building.

*g.* Must have the rails bonded at each joint with not less than No. 2 B. & S. annealed copper wire; also a supplementary wire to be run for each track.

*h.* Must not have cars left with trolley in electrical connection with the trolley wire.

### 36. LIGHTING AND POWER FROM RAILWAY WIRES—

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

### 37. SERIES LAMPS—

*a.* No system of multiple-series or series-multiple for light or power will be approved.

*b.* Under no circumstances can lamps be attached to gas fixtures.

### EXTRA HIGH-POTENTIAL SYSTEMS.

#### OVER 3,000 VOLTS.

Any circuit attached to any machine or combination of machines, which develops a difference of potential, between any two wires, of over 3,000 volts, shall be considered as an extra high-potential circuit, and as coming under that class, unless an approved transforming device is used which cuts the difference of potential down to 3,000 volts or less.

### 38. PRIMARY WIRES—

Must not be brought into or over buildings, except power and sub-stations.

### 39. SECONDARY WIRES—

*a.* Must be installed under rules for high-potential systems, when their immediate primary wires carry a current at a potential of over 3,000 volts.

The high line insulation required for extra high-potential current tends to make the insulation resistance between primary and secondary coils of trans-

formers a comparatively weak point, and lightning discharges would be apt to take this path to the earth. With the present means of protection against transformer breakdowns and the consequent liability of secondary wiring being subjected to the strain of the primary current, it is not deemed advisable to permit a primary current with a potential of over 3,000 volts without an intermediate step-down transformer. The presence of wires carrying a current at a potential of over 3,000 volts in the streets of cities and towns is also considered as increasing the fire hazard.

#### CLASS D.

### FITTINGS, MATERIALS, AND DETAILS OF CONSTRUCTION.

#### ALL SYSTEMS AND VOLTAGES.

#### 40. WIRE INSULATION—

*a. Rubber Covered.*—The insulating covering must be solid, at least three-sixty-fourths of an inch in thickness and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at seventy degrees Fahrenheit and three day's submersion in lime water, and after three minutes' electrification with 550 volts. (See page 44.)

*b. Weatherproof.*—The insulating covering must not support combustion, must resist abrasion, must be at least one-sixteenth of an inch in thickness, and thoroughly impregnated with a moisture repellent.

*c. Flexible Cord.*—Must be made of two stranded conductors, each having a carrying capacity equivalent to not less than a No. 16 B. & S. wire, and each covered by an *approved* insulation, and protected by a slow-burning, tough-braided outer covering.

1. Insulation for *pendants* under this rule must be moisture and flame proof.

2. Insulation for *cords used for all other purposes*, including portable lamps and motors, must be solid, at least one-thirty-second of an inch in thickness, and must show an insulation resistance between conductors and between either conductor and the ground of at the least one megohm per mile after one week's *submersion* in water at seventy degrees Fahrenheit, and after three minutes' electrification, with 550 volts.

3. The flexible conductors for *portable heating apparatus*, such as irons, etc., must have an insulation that will not be injured by

heat, such as asbestos, which must be protected from mechanical injury by an outer, substantial, braided covering, and so arranged that mechanical strain will not be borne by the electrical connection.

*d. Fixture Wire.*—Must have a solid insulation, with a slow-burning, tough, outer covering, the whole to be at least one-thirty-second of an inch in thickness and to show an insulation resistance between conductors and between either conductor and the ground of at least one megohm per mile after one week's submersion in water at seventy degrees Fahrenheit, and after three minutes' electrification with 550 volts.

*e. Conduit Wire.*—Must comply with the following specifications:

1. *For lined metal conduits* single wires and twin conductors must comply with section (a) of this rule.

Concentric wire must have a braided covering between the outer conductor and the insulation of the inner conductor, and, in addition, must comply with section (a) of this rule.

2. *For unlined metal conduits* single wires and twin conductors must comply with section (a) of this rule, and, in addition, have a second outer fibrous covering, at least one-thirty-second of an inch in thickness and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

Concentric conductors must have a braided covering between the outer conductor and the insulation of the inner conductor, and comply with section (a) of this rule, and, in addition, must have a second outer fibrous covering at least one-thirty-second of an inch in thickness and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

#### 41. INTERIOR CONDUITS—

(For wiring rules, see Nos. 24 and 25.)

*a.* Each length of conduit, whether insulated or uninsulated, must have the maker's name or initials stamped in the metal or attached thereto in a satisfactory manner, so that the inspectors can readily see the same.

#### LINED METAL CONDUITS.

*b.* The metal covering, or pipe, must be at least equal in thickness or of equal strength to resist penetration by nails, etc., as the ordinary commercial form of gas pipe of same size.

*c.* Must not be seriously affected externally by burning out a

wire inside the tube when the iron pipe is connected to one side of the circuit.

*d.* Must have the insulating lining firmly secured to the pipe.

*e.* The insulating line must not crack or break when a length of the conduit is uniformly bent at temperature of 212 degrees Fahrenheit to an angle of ninety degrees, with a curve having a radius of fifteen inches, for pipes of one inch and less, and fifteen times the diameter of the pipe for larger pipes.

*f.* The insulating lining must not soften injuriously at a temperature below 212 degrees Fahrenheit and must leave water in which it is boiled practically neutral.

*g.* The insulating lining must be at least one-thirty-second of an inch in thickness, and the materials of which it is composed must be of such a nature as will not have a deteriorating effect on the insulation of the conductor and be sufficiently tough and tenacious to withstand the abrasion test of drawing in and out of same long lengths of conductors.

*h.* The insulating lining must not be mechanically weak after three days' submersion in water, and, when removed from the pipe entire, must not absorb more than ten per cent. of its weight of water during 100 hours of submersion.

*i.* All elbows must be made for the purpose, and not bent from lengths of pipe. The radius of the curve of the inner edge of any elbow not to be less than three and one-half inches. Must have not more than the equivalent of four quarter bends from outlet to outlet; the bends at the outlets not being counted.

#### UNLINED METAL CONDUITS.

*j.* *Plain iron or steel pipes* of equal thickness, or of equal strength, to resist penetration of nails, etc., as the ordinary commercial form of gas pipe of the same size, may be used as conduits, provided their interior surfaces are smooth and free from burs; pipe to be galvanized, or the interior surfaces coated or enamelled to prevent oxidization with some substance which will not soften so as to become sticky and prevent wire from being withdrawn from the pipe.

*k.* All elbows must be made for the purpose, and not bent from lengths of pipe. The radius of the curve of the inner edge of any elbow not to be less than three and one-half inches. Must have not more than the equivalent of four quarter bends from outlet to outlet; the bends at the outlets not being counted.

**42. WOODEN MOULDINGS.—**

*(For wiring rules, see No. 24.)*

*a.* Must have, both outside and inside, at least two coats of waterproof paint, or be impregnated with a moisture repellent.

*b.* Must be made of two pieces, a backing and capping so constructed as to thoroughly incase the wire, and provide a one-half-inch tongue between the conductors, and a solid backing, which, under grooves, shall not be less than three-eighths of an inch in thickness and must afford suitable protection from abrasion.

It is recommended that only hardwood moulding be used.

**43. SWITCHES—**

*(See Nos. 17 and 22.)*

*a.* Must be mounted on non-combustible, non-absorptive insulating bases, such as slate or porcelain.

*b.* Must have carrying capacity sufficient to prevent undue heating.

*c.* Must, when used for service switches, indicate, on inspection, whether the current be "on" or "off."

*d.* Must be plainly marked, where it will always be visible, with the name of the maker and the current and voltage for which the switch is designed.

*e.* Must, for constant-potential systems, operate successfully at fifty per cent. overload in amperes, with twenty-five per cent. excess voltage under the most severe conditions they are liable to meet with in practice.

*f.* Must, for constant-potential systems, have a firm and secure contact; must make and break readily, and not stop when motion has once been imparted by the handle.

*g.* Must, for constant-current systems, close the main circuit and disconnect the branch wires when turned "off"; must be so constructed that they shall be automatic in action, not stopping between points when started, and must prevent an arc between the points under all circumstances. They must indicate, upon inspection, whether the current be "on" or "off."

**44. CUT-OUTS AND CIRCUIT BREAKERS—**

*(For installation rules, see Nos. 17 and 21.)*

*a.* Must be supported on bases of non-combustible, non-absorptive insulating material.

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

*c.* Cut-outs must operate successfully, under the most severe conditions they are liable to meet with in practice, on short circuits with fuses rated at 50 per cent., and with a voltage 25 per cent., above the current and voltage for which they are designed.

*d.* Circuit-breakers must operate successfully, under the most severe conditions they are liable to meet with in practice, on short circuits when set at 50 per cent. above the current, and with a voltage 25 per cent. above that for which they are designed.

*e.* Must be plainly marked where it will always be visible, with the name of the maker, and current and voltage for which the device is designed.

#### 45. FUSES—

(*For installation rules, see Nos. 17 and 21.*)

*a.* Must have contact surfaces or tips of harder metal having perfect electrical connection with the fusible part of the strip.

*b.* Must be stamped with about eighty per cent. of the maximum current they can carry indefinitely, thus allowing about twenty-five per cent. overload before fuse melts.

With naked open fuses, of ordinary shapes and not over 500 amperes capacity, the *maximum* current which will melt them in about five minutes may be safely taken as the melting point, as the fuse practically reaches its maximum temperature in this time. With larger fuses a longer time is necessary.

Inclosed fuses, where the fuse is often in contact with substances having good conductivity to heat, and often of considerable volume, require a much longer time to reach a maximum temperature on account of the surrounding material which heats up slowly.

This data is given to facilitate testing.

*c.* Fuse terminals must be stamped with the maker's name, initials, or some known trade-mark.

#### 46. CUT-OUT CABINETS—

*a.* Must be so constructed, and cut-outs so arranged, as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

A suitable box can be made of marble, slate or wood, strongly put together, the door to close against a rabbet so as to be perfectly dust tight, and it should be hung on strong hinges and held closed by a strong hook or catch. If the box is wood the inside should be lined with sheets of asbestos board about one-sixteenth of an inch in thickness, neatly put on and firmly secured in place by shellac and tacks. The wires should enter through holes bushed with porcelain bushings, the bushings tightly fitting the holes in the box and the wires tightly fitting the bushings (using tape to build up the wire, if necessary), so as to keep out the dust.

#### 47. SOCKETS—

(See No. 27.)

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

b. Must, when provided with keys, comply with the requirements for switches. (See No. 43.)

#### 48. HANGER-BOARDS—

a. Hanger-boards must be so constructed that all wires and current-carrying devices thereon shall be exposed to view and thoroughly insulated by being mounted on a non-combustible, non-absorptive insulating substance. All switches attached to the same must be so constructed that they shall be automatic in their action, cutting off both poles to the lamp, not stopping between points when started, and preventing an arc between points under all circumstances.

#### 49. ARC LAMPS—

(For installation rules, see No. 19.)

a. Must be provided with reliable stops to prevent carbons from falling out in case the clamps become loose.

b. Must be carefully insulated from the circuit in all their exposed parts.

c. Must, for constant-current systems, be provided with an *approved* hand switch, also an automatic switch that will shunt the current around the carbons, should they fail to feed properly.

The hand switch to be approved, if placed anywhere except on the lamp itself, must comply with requirements for switches on hanger-boards as laid down in Rule 48.

## 50. SPARK ARRESTERS—

(See No. 19 c.)

*a.* Spark arresters must so close the upper orifice of the globe that it will be impossible for any sparks thrown off by the carbons to escape.

## 51. INSULATING JOINTS—

(See No. 26 a.)

*a.* Must be entirely made of material that will resist the action of illuminating gases and will not give way or soften under the heat of an ordinary gas flame or leak under a moderate pressure. They shall be so arranged that a deposit of moisture will not destroy the insulating effect and shall have an insulating resistance of at least 250,000 ohms between the gas-pipe attachments, and be sufficiently strong to resist the strain they will be liable to be subjected to in being installed.

*b.* Insulating joints having soft rubber in their construction will not be approved.

## 52. RESISTANCE BOXES AND EQUALIZERS—

(For installation rules, see No. 4.)

*a.* Must be equipped with metal, or with other non-combustible frames.

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

## 53. REACTIVE COILS AND CONDENSERS—

*a.* Reactive coils must be made of non-combustible material, mounted on non-combustible bases, and treated, in general, like sources of heat.

*b.* Condensers must be treated like apparatus operating with equivalent voltage and currents. They must have non-combustible cases and supports and must be isolated from all combustible materials, and, in general, treated like sources of heat.

## 54. TRANSFORMERS—

(For installation rules, see Nos. 11 and 38.)

*a.* Must not be placed in any but metallic or other non-combustible cases.

## 55. LIGHTNING ARRESTERS—

(For installation rules, see No. 5.)

a. Must be mounted on non-combustible bases and must be so constructed as not to maintain an arc after the discharge has passed, and must have no moving parts.

## CLASS E.

## MISCELLANEOUS.

## 56. INSULATION RESISTANCE—

The wiring in any building must test free from grounds, *i.e.*, the complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) of not less than the following :

Up to	5 amperes	.....	4,000,000
"	10 "	.....	2,000,000
"	25 "	.....	800,000
"	50 "	.....	400,000
"	100 "	.....	200,000
"	200 "	.....	100,000
"	400 "	.....	50,000
"	800 "	.....	25,000
"	1,600 "	and over.....	12,500

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

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

## 57. PROTECTION AGAINST FOREIGN CURRENTS—

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

b. All aerial conductors and underground conductors, which are directly connected to aerial wires, connecting with telephone, telegraph, district messenger, burglar-alarm, watch-clock, electric time, and other similar instruments, must be provided near the point of entrance to the building with some approved protective device

which will operate to shunt the instruments in case of a dangerous rise of potential and will open the circuit and arrest any abnormal current flow. Any conductor normally forming an innocuous circuit may become a source of fire hazard if crossed with another conductor charged with a relatively high pressure.

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

1. The protector to be located at the point where the wires enter the building, either immediately inside or outside of the same. If outside, the protector to be enclosed in a metallic, waterproof case.

2. If the protector is placed inside of building, the wires of the circuit from the support outside to the binding posts of the protector to be of such insulation as is approved for service wires of electric light and power (see No. 40 *a*) and the holes through the outer wall to be protected by bushing the same as required for electric light and power service wires.

3. The wire from the point of entrance to the protector to be run in accordance with rules for high-potential wires ; *i.e.*, free of contact with building and supported on non-combustible insulators.

4. The ground wire shall be insulated not smaller than No. 16 B. & S. gauge copper wire. This ground wire shall be kept at least three inches from all conductors and shall never be secured by uninsulated, double-pointed tacks and must be run in as straight a line as possible to the ground connection.

5. The ground wire shall be attached to a water pipe if possible, otherwise may be attached to a gas pipe. The ground wire shall be carried to, and attached to, the pipe outside of the first joint or coupling inside the foundation walls and the connection shall be made by soldering, if possible. In the absence of other good ground, the ground shall be made by means of a metallic plate or a bunch of wires buried in a permanently moist earth.

#### 58. ELECTRIC GAS LIGHTING—

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

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

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

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

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

## 59. SOLDERING FLUID—

a. The following formula for soldering fluid is suggested :

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

NOTE.—It has been deemed advisable to eliminate from this edition of the National Electrical Code the supplement giving the list of approved materials and names of manufacturers of the same, which appears in the copies sent out by the National Board of Fire Underwriters and appearing on pages 44 and 45.

This is in accordance with the action taken at a meeting of the Conference relative to the publication by the National Conference of the National Electrical Code.

## CLASS F.

## MARINE WORK.

## 60. GENERATORS—

- a. Must be located in a dry place.
- b. Must have their frames insulated from their bed-plates.
- c. Must each be provided with a waterproof cover.
- d. Must each be provided with a name-plate, giving the maker's name, the capacity in voltage and amperes and normal speed in revolutions per minute.

## 61. WIRES—

a. Must have an *approved* insulating covering.

The insulation for all conductors, except for portables, to be approved, must be at least one-eighth inch in thickness and be covered with a substantial waterproof and flameproof braid. The physical characteristics shall not be affected by any change in temperature up to 200 degrees Fahrenheit. After two weeks' submersion in salt water at 70 degrees Fahrenheit it must show an insulation resistance of one megohm per mile after three minutes electrification, with 550 volts.

b. Must have no single wire larger than No. 12 B. & S. Wires to be stranded when greater carrying capacity is required. No single solid wire smaller than No. 14 B. & S., except in fixture wiring, to be used.

Stranded wires must be soldered before being fastened under clamps or binding screws, and when they have a conductivity greater than No. 10 B. & S. copper wire they must be soldered into lugs.

*c.* Must be supported in approved moulding, except as switchboards and portables.

Special permission may be given for deviation from this rule in dynamo rooms.

*d.* Must be bushed with hard rubber tubing one-eighth inch in thickness when passing through beams and non-watertight bulkheads.

*e.* Must have, when passing through watertight bulkheads and through all decks, a metallic stuffing tube lined with hard rubber. In case of deck tubes they shall be boxed near deck to prevent mechanical injury.

*f.* Splices or taps in conductors must be avoided as far as possible. Where it is necessary to make them they must be so spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered, to insure preservation, covered with an insulating compound equal to the insulation of the wire and further protected by a waterproof tape. The joint must then be coated or painted with a waterproof compound.

#### 62. PORTABLE CONDUCTORS—

*a.* Must be made of two stranded conductors, each having a carrying capacity equivalent to not less than No. 14 B. & S. wire, and each covered with an approved insulation and covering.

Where not exposed to moisture or severe mechanical injury, each stranded conductor must have a solid insulation at least one-thirty-second of an inch in thickness, and must show an insulation resistance between conductors, and between either conductor and the ground, of at least one megohm per mile after one week's submersion in water at seventy degree Fahrenheit and after three minutes' electrification with 500 volts, and be protected by a slow-burning, tough, braided outer covering.

Where exposed to moisture and mechanical injury—as for use on decks, holds, and fire rooms—each stranded conductor shall have a solid insulation, to be approved, of at least one-thirty-second of an inch in thickness and protected by a tough braid. The two conductors shall then be stranded together, using a jute filling. The whole shall then be covered with a layer of flax, either woven or braided, at least one-thirty-second of an inch in thickness and treated with a non-inflammable waterproof compound. After one week's submersion in water at seventy degrees Fahrenheit, with 550 volts and a three minutes' electrification, must show an insulation between the two conductors, or between either conductor and the ground, of one megohm per mile.

#### 63. BELL OR OTHER WIRES—

*a.* Shall never be run in same duct with lighting or power wires.

## 64. TABLE OF CAPACITY OF WIRES—

B. & S. G.	Area Actual C. M.	No. of Strands.	Size of Strands B. & S. G.	Amperes.
19	1,288	..	..	..
18	1,624	..	..	3
17	2,048	..	..	..
16	2,583	..	..	6
15	2,257	..	..	..
14	4,107	..	..	12
12	6,530	..	..	17
..	9,016	7	19	21
..	11,368	7	18	25
..	14,386	7	17	30
..	18,081	7	16	35
..	2,709	7	15	40
..	30,856	19	18	50
..	38,912	19	17	60
..	49,077	19	16	70
..	60,088	37	18	85
..	75,776	37	17	100
..	99,064	61	18	120
..	124,928	61	17	145
..	157,563	61	16	170
..	198,677	61	15	200
..	250,527	61	14	235
..	296,387	91	15	270
..	373,737	91	14	320
..	413,639	127	15	340

When greater conducting area than that of 12 B. & S. G. is required, the conductor shall be stranded in a series of 7, 19, 37, 61, 91 or 127 wires, as may be required; the strand consisting of one central wire; the remainder laid around it concentrically, each layer to be twisted in the opposite direction from the preceding.

## 65. SWITCHBOARDS—

*a.* Must be made of non-combustible, non-absorptive insulating material, such as marble or slate.

*b.* Must be kept free from moisture, and must be located so as to be accessible from all sides.

*c.* Must have a main switch, main cut-out and ammeter for each generator.

Must also have a voltmeter and a ground detector.

*d.* Must have a cut-out and switch for each side of each circuit leading from board.

## 66. RESISTANCE BOXES—

*a.* Must be made of non-combustible material.

*b.* Must be located on switchboard or away from combustible material. When not placed on switchboard they must be mounted on non-inflammable, non-absorptive insulating material.

*c.* Must be so constructed as to allow sufficient ventilation for the uses to which they are put.

#### 67. SWITCHES—

*a.* Must have non-combustible, non-absorptive insulating bases.

*b.* Must operate successfully at fifty per cent. overload in amperes with twenty-five per cent. excess voltage, under the most severe conditions they are liable to meet with in practice, and must be plainly marked where it will always be visible with the name of the maker and the current and voltage for which the switch is designed.

*c.* Must be double-pole when circuits which they control supply more than six 16-candle-power lamps or their equivalent.

*d.* When exposed to dampness, they must be enclosed in a watertight case.

#### 68. CUT-OUTS—

*a.* Must have non-combustible, non-absorptive insulating bases.

*b.* Must operate successfully, under the most severe conditions they are liable to meet with in practice, on short circuit with fuse rated at fifty per cent. above, and with a voltage twenty-five per cent. above the current and voltage they are designed for, and must be plainly marked where they will always be visible with the name of the maker and current and voltage for which the device is designed.

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

*d.* In places such as upper decks, holds, cargo spaces, and fire rooms a watertight and fireproof cut-out may be used, connecting directly to mains when such cut-out supplies not more than six 16-candle-power lamps or their equivalent.

*e.* When placed anywhere except on switchboards and certain places, as cargo spaces, holds, fire rooms, etc., where it is impossible to run from centre of distribution, they shall be in a cabinet lined with fire-resisting materials.

*f.* Except for motors, search-lights, and diving lamps, shall be so placed that no group of lamps, requiring a current of more than six amperes, shall ultimately be dependent upon one cut-out.

A single-pole covered cut-out may be placed in the moulding when same contains conductors supplying current for not more than two 16-candle-power lamps or their equivalent.

#### 69. FIXTURES—

*a.* Shall be mounted on blocks made from well-seasoned lumber treated with two coats of white lead or shellac.

*b.* Where exposed to dampness, the lamp must be surrounded by a vapor-proof globe.

*c.* Where exposed to mechanical injury, the lamp must be surrounded by a globe protected by a stout wire guard.

*d.* Shall be wired with same grade of insulation as portable conductors which are not exposed to moisture or mechanical injury.

#### 70. SOCKETS—

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

#### 71. WOODEN MOULDINGS—

*a.* Must be made of well-seasoned lumber and be treated inside and out with at least two coats of white lead or shellac.

*b.* Must be made of two pieces, a backing and a capping, so constructed as to thoroughly incase the wire and provide a one-half-inch tongue between the conductors and a solid backing which, under grooves, shall not be less than three-eighths inch in thickness.

*c.* Where moulding is run over rivets, beams, etc., a backing strip must first be put up and the moulding secured to this.

*d.* Capping must be secured by brass screws.

#### 72. MOTORS—

*a.* Must be wired under the same precautions as with a current of same volume and potential for lighting. The motor and resistance box must be protected by a double-pole cut-out and con-

trolled by a double-pole switch, except in cases where one-quarter horse-power or less is used.

The leads or branch circuits should be designed to carry a current at least fifty per cent. greater than that required by the rated capacity of the motor, to provide for the inevitable overloading of the motor at times.

*b.* Must be thoroughly insulated. Where possible, should be set on base frames made from filled, hard, dry wood and raised above surrounding deck. On hoists and winches they shall be insulated from bed-plates by hard rubber, fibre, or similar insulating material.

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