DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 72

SCOPE AND APPLICATION OF THE NATIONAL ELECTRICAL SAFETY CODE

[1st Edition]

Issued June 17, 1918

PRICE, 20 CENTS

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CONTENTS

SCOPE AND APPLICATION OF THE NATIONAL ELECTRICAL SAFETY CODE

INTRODUCTION

The National Electrical Safety Code is a set of rules prepared by the Bureau of Standards after several years of study and investigation and of conferences with all the interests concerned. It is intended to furnish a guide for safe electrical practice and is concerned with both electrical construction and operation. The code deals with the generation, distribution, and use of electricity, and is subdivided for convenience into four principal parts. Its scope, its purpose, and the nature of its contents are discussed in this circular.

In this publication it has been attempted—first, to explain the need for such a code and to give examples of personal injuries by electricity, which show the many types of accidents occurring, most of which would be avoided by observance of the rules (Secs. I and II); second, to indicate reasons for the arrangement of the code in its present form, and at the same time to explain by means of discussion and examples the intended method of use of the code by engineers and inspectors (Secs. III to V); third, to provide a short summary of the provisions of the code for those who wish a general or bird's-eye view of these provisions (Secs. VI to X). Of course, it is not intended that this summary or abstract should take the place of the code. It is rather an attempt to give in short and readable form a helpful survey of the provisions of the code. It is necessary, of course, that the code itself be consulted in determining the actual requirements for any given piece of work.

The various sections of this circular will evidently be of value and interest to different classes of readers. The first three sections, showing the need for the code and the reasons for its present contents and arrangement, will be the sections of particular interest to public utility commissioners, city officials, legislators, corporation executives, and others who will have to pass upon general questions regarding the adoption or application of the safety code. Section IV will have especial value for those applying the code, such as electrical contractors, utility engineers, managers, and foremen, factory electricians, and all classes of inspectors. Section V will be useful mainly to inspectors. The remaining sections, summarizing the separate parts of the code, will be useful to any of the above classes of readers or others who desire a knowledge of the general scope of these parts without going over the text of the individual rules. This circular should, therefore, meet the needs of a large circle of persons who will come in contact with the code, including many who will not be concerned with the details of the rules.

The code is being adopted on trial by a great many administrative bodies and public utility companies and is very rapidly coming into use. It is hoped that this circular will make the scope and purpose of the code better known and facilitate its further introduction and use.

S. W. Stratton,
Director.

February 15, 1918.

I. NEED FOR THE CODE AND ITS PRESENT STATUS

The National Electrical Safety Code comprises a set of rules for practice in electrical construction and operation calculated to reduce to a minimum the personal hazard to the public and electrical workers and to be adequate and reasonable in their application. Such a standard set of rules has long been needed by the electrical industry in order to secure economy and stability as well as safety in electrical practice. This present publication is prepared at the suggestion of many conferees, particularly among administrators, in order to give to those contemplating using the code a clearer idea of its character, scope, and intended use.

INTERESTS NEEDING ELECTRICAL SAFETY RULES

The subject matter of the code necessarily covers a wide range of topics because of the many interests concerned and the manifold applications of electricity in the industries and in everyday life. The variety of subjects covered and the broad scope of an adequate safety code for electrical practice may be understood by a brief mention of some of these interests.

The electric light and power utilities, for instance, require for their guidance suitable standards for the methods of construction and operation of generating stations, substations, and transmission and distribution lines, both overhead and underground. Electric railway utilities have to deal with much the same problems, but with considerable variations in detail corresponding to their different character of service. The rules are applicable, although with important modification or variation in different circumstances, to large or small utilities, to generation and distribution at high or low voltages, and to the lines concerned, whether in open country, above city streets, above railroads, or in some manner exposing other lines or exposed by them. The need for specific treatment and detail adequately and reasonably to cover these and other varying conditions is explained at some length in Section III.

The signal utilities, including telephone and telegraph companies, are concerned only incidentally with the rules for reducing electrical hazard. Standards are needed by them, however, to assure adequate clearances between signal wires and supply wires and adequate strength requirements for the higher set of lines, wherever signal lines cross over or under supply wires, or are closely parallel, or are on a common set of poles. Such strength requirements, of course, will be similar whether supply or signal lines are located above. The necessary precautions for workers on signal lines are not dissimilar in many respects to those found desirable for workers on supply lines, since many of the hazards are mechanical, but in other respects they are very different. Signal lines crossing above railroads, of course, require clearance and strength provisions similar to those for supply lines. In some cases signal utilities operate generating stations to which the same rules apply as where these are owned by electric lighting utilities. There are also necessary protection features for signal instruments handled by persons to avoid dangerous voltages.

Railroads depend for their protection upon compliance with electrical requirements applying to overhead lines which pass above their tracks. Electrical conductors suspended across railway tracks are potential hazards, and adequate strength and clearance requirements are essential. Wherever railroad utilities operate signal lines or have electrified some portion of their system, they are, of course, concerned with the same rules as are signal, lighting, or electric railway utilities, as the case may be.

Besides the various interested classes of public utilities mentioned above, there are other large interests for whom electrical safety rules are necessary. Among these are the owners and operators of industrial plants where electricity is used in various applications. The guarding of wires and the live parts of apparatus, the grounding of metal appliance casings, or the isolation of dangerous features becomes a matter of prime interest. Since less precaution and less knowledge of the hazard can be expected of the employees of industrial concerns than of employees of electric-lighting utilities, greater precaution in the physical safeguarding is evidently necessary, and a guide to such safeguarding has been a long time desired.

Because of their relation to electrical installation work, electrical contractors and installers need in their daily work to apply suitable safety rules for guarding or isolating electrical equipment and wiring. In many cases the owners and operators of industrial concerns, although responsible for the safety of their workers, are not themselves electrically trained and can not be expected to become familiar with the necessary safety requirements for their electrical installations. In these cases they will hold the contractor responsible for attention to these safety features, as they have long held him responsible for the fire-prevention features dealt with in the National Electrical [Fire] Code.

The observance for many years of this latter code, until it has become the standard generally in municipalities, has brought about a far greater attention by municipal electricians to fire-prevention requirements on electrical installations than to accident-prevention requirements, for which no adequate set of rules has heretofore been available. These city inspectors, however, are charged with the safeguarding of life as well as of property and are rapidly adopting or incorporating the long necessary safety rules and making them effective on new construction through their inspections and issuance of bulletins. Their interest is in some cases limited by ordinance to factory and other utilization installations but in other cases extends to stations and sometimes to overhead and underground lines.

The casualty insurance inspectors have a somewhat similar interest in electrical safety rules. It is not their first duty to minimize electrical accident hazard, although this may result from their work, but they do recognize deficiencies in safeguarding by increased charges in casualty insurance rates. Credits are granted in the rates where extra protective features are provided. The safety code rules are now used by these inspectors as a standard, and their application has the great merit of charging, so far as information permits, an amount proportional to the actual hazard existing, so that where two rules are neglected, the one involving the greater hazard will entail the greater charge and thus offer the greater inducement for correction. This is a useful differentiation often lost sight of by administrators of rules, sometimes entailing overemphasis on some features and underemphasis on others.

A very large and growing use of electrical safety rules is by State industrial and public utilities commissions. While the jurisdictions and duties of these bodies vary somewhat from State to State, the industrial commissions have usually to do with situations where the hazards to workers are deemed the most important consideration, while the utilities commissions deal with situations where the public safety or the interutility hazards predominate. In all cases the labor commissions have interested themselves in the proper safeguarding of electrical installations in factories and workshops, through the guarding of live parts, grounding of machine frames, use of adequate working spaces, and like measures. In many cases they are also concerned with similar safety measures in electrical stations. In both these cases the potential hazards to the workers undoubtedly exceed those to the public. In some few cases labor commissions have administered rules for line construction, where the public hazard becomes for overhead lines the predominant one, and where the interutility hazards are also in many cases prominent, as at crossings, conflicts, and common use of poles.

Generally, public utility commissions have been concerned with construction and operating precautions for generating stations, substations, and lines, since the rules applied to these features of electrical practice affect the general adequacy of service, including reliability, convenience, and economy, as well as safety. Without exception these commissions have dealt with line construction features directly affecting the public safety and the safety of other utilities, such as clearances of wires above streets and walks and above other wires or railroads, and the strength of lines which by failure could fall upon these places.

Suitable safety standards for electrical practice have long been a recognized need of electrical manufacturers. In the absence of such standards, many imperfectly guarded appliances have been manufactured, and makeshift guarding has resulted from the effort of administrators or users to assure safety. The condition has been almost equally bad where such standards have existed but have differed in different jurisdictions, so that guards complying with some rules fail to meet others. No interest is more concerned in the general adoption of one national standard rather than many different standards in different localities than are the manufacturers of electrical equipment.

Of the interests named above, some represent the public at large and others represent important branches of the country's industry. It is evident that the experience of all sections of the country and of all the branches of industry referred to will serve usefully in the formulation, modification, and occasional revision of the electrical safety rules to be adopted by any one section or any particular branch of industry. A single national code is in every way preferable to many separately prepared sets, each arising out of a different local experience or out of the experience mainly of some one branch of the industry.

SCOPE AND ARRANGEMENT OF THE CODE

The code contains construction and installation requirements for the equipment and wiring of central stations and substations under Part 1, for overhead and underground lines under Part 2, and for the equipment and wiring of factories and similar utilization equipment under Part 3. Under Part 4 are contained requirements resting upon employers and operating precautions for employees engaged in electrical operations or in work about live electrical equipment. There is also a general section dealing with the method of protective grounding to be followed where such grounding is called for by the code. Another general section includes definitions of the special terms employed in the code. Following each part of the rules there is a discussion consisting of a series of explanatory notes giving, in some instances, reasons for the rules, and in others illustrations of their application. As to the scope of each part of the code and the character of rules contained, an idea may be obtained by examination of Secs. VI to X of this publication, which contain brief summaries of each of the parts of the code, beginning with the grounding section.

Questions may arise as to the considerations leading to the division of the code as above outlined. This was done partly because of the greater convenience in use for the administrator or other user endeavoring to secure a working familiarity with the code or to use it for reference. This convenience was further greatly facilitated by certain mechanical arrangements employed, which are briefly referred to in the next paragraph. A very considerable further cause for the subdivision of the code along the present lines is the division of jurisdictions by which, for instance, public utility commissions have no concern with Part 3, labor commissions rarely have interest in Part 2, municipal electricians rarely in Part 4, signal utilities rarely in Parts 1 and 3. In general, Parts 1 and 2 are concerned with situations where training of the workers and absence of distracting processes are depended upon for their protection in lieu of some of the physical safeguards which are necessary where, as in situations covered in Part 3, such distractions do exist and the workers or persons in the vicinity are not trained electrically.

Mechanical convenience in use of the code is facilitated by the numbering arrangement, which permits ready association of rule and section numbers with the subject matter. For instance, any rule numbered from 100 to 199 will be on stations, Part 1; any rule numbered from 300 to 399 will be on utilization equipment, Part 3; any rule in Sec. 24 of Part 2 (Rules 240 to 249) will have to do with line conductor clearances or separations; and similarly for the other parts and sections. In each part the preliminary sections are of a more general character, while succeeding sections take up the more specific requirements, and in any particular section the same arrangement holds; i. e., the more general rules are placed first.

HOW THE CODE WAS PREPARED

Very early in the course of the work all interests recognized the necessity for coordinating all agencies throughout the country in order to secure suitable rules for electrical practice. It was seen that only in this way could there be secured a code that would be both adequate and reasonable and to the maximum degree practicable, helpful, and free from embarrassment to all interests. The Bureau of Standards, under authorization of Congress, began in 1913 the study of the hazards of electrical practice, requesting from the start the active cooperation of all the interests concerned. This involved a study of all the existing sets of requirements on electrical construction, including a number of State statutes, commission orders, city ordinances, company specifications, and technical association reports, together with the regulations in effect in foreign countries. Examination and study were also made of current electrical practice in this country and of the history of electrical practice so far as this could be determined through the literature on the subject and through correspondence and personal conference.

The studies of the Bureau of Standards resulted in preliminary drafts of the National Electrical Safety Code, which were intended to include, as far as practicable, for all classes of electrical practice, the rules which experience had demonstrated to be necessary and reasonable. The differences between the practices required or employed in different sections or by different interests were studied to learn whether such differences were justified, and if so, to include in the rules a clear basis for such differentiation. In other respects the inconsistencies were removed and the arrangement made as convenient and logical as practicable.

METHOD ADOPTED TO ASSURE ADEQUACY AND REASONABLENESS

It was, of course, of the greatest importance to assure adequacy and reasonableness in the safety code, and this warranted the best effort of all the interests concerned. This has been freely and cordially given, often at considerable expense and inconvenience, by practically all the national and many of the State organizations concerned, as well as by hundreds of individuals. In addition to the preliminary study by the Bureau staff, the various preliminary drafts of the code were, for over two years, constantly before the representatives of all the interests. Conferences, correspondence, and inspections, all were utilized to the fullest extent to assure that no generally applicable and necessary requirement should be omitted and that no unreasonable, unnecessary, or ambiguous requirements should remain. Many of these conferences lasted several days, and one of them continued for nearly two weeks. They were held in all parts of the country in order to assure that no important interest and no local experience of important bearing would be overlooked. Through circular letters of inquiry and through constant correspondence this criticism and cooperation were extended to the widest possible limits. The conferees have been constantly urged to give their criticism, and it is safe to say that no other code of industrial practice has ever been subjected to such a searching study in advance of its recommendation for use as has the National Electrical Safety Code.

This study and public discussion were continued until it was generally agreed that the code should be submitted to field trial to demonstrate its practicability and to obtain experience on which to base its further development. The revised code was issued "for examination, trial, and constructive criticism" in November, 1916. It has had a wide circulation and is being extensively used, in some cases because of its adoption by administrative bodies, but in most cases voluntarily because of its practical value and helpfulness.

MAINTAINING ADEQUACY AND REASONABLENESS

The same methods of study and cooperation which were used in originally formulating the National Electrical Safety Code will be continued in the endeavor to keep it up to date. It will be revised and amended from time to time in the light of the experience gained in its application and with respect to progress in the art. Where the code is put into effect by an administrative body the same authority may modify it and adopt amendments when they are found desirable. This will be easier and more satisfactory than adequately revising a large number of sets of different local rules.

It is very desirable that the rules be adopted by administrative order rather than by inclusion in statute law. The electrical code of the fire underwriters is revised regularly every two years, and this has caused no difficulty in its use by municipalities, which have promptly adopted these revisions. In jurisdictions where the National Electrical Safety Code is adopted by State commissions or municipal bodies it is to be expected that later amendments will be similarly adopted. The fact that some agency exists for systematic study and regular revision of the code assures that amendments will be adopted as time demonstrates the need for them, so that the code will not become obsolete with respect to the nature of its requirements. A Federal agency having the general cooperation of State commissions, utility officials, manufacturers, workers, and engineers can more adequately and reasonably revise the code than can local bodies, and at the same time offers assurance that this necessary revision will be done.

ORGANIZATIONS COOPERATING IN DEVELOPING THE CODE

Among the various national organizations whose cooperation has assisted in the preparation of the code and whose continued cooperation is anticipated in considering suggested amendments of the code, when at proper intervals in the future these appear desirable, are the following.

This cooperation has in general been cheerful and continuous, and without this cooperation by every interest affected the production of a satisfactory, adequate, and reasonable code would have proven impossible.

American Electric Railway Association.
American Institute of Electrical Engineers.
American Railway Association.
American Railway Engineering Association.
American Telephone & Telegraph Co.
Associated Manufacturers of Electrical Supplies.
Association of Edison Illuminating Companies.
Association of Railway Telegraph Superintendents.
Electrical Manufacturers' Club.
Electric Power Club.
International Association of Municipal Electricians.
International Brotherhood of Electrical Workers.
National Association of Electrical Inspectors.
National Electrical Contractors' Association of the United States.
National Electric Light Association.
National Fire Protection Association.
National Safety Council.
National Workmen's Compensation Service Bureau.
Postal Telegraph Co.
Underwriters' Laboratories.
United States Independent Telephone Association.
Various State insurance commissions.
Various State labor commissions.
Various State public utility commissions.
Western Association of Electrical Inspectors.
Western Union Telegraph Co.

PRESENT STATUS OF THE CODE

The code has now been published in the second edition of November, 1916, and about 12 000 copies of this edition had been purchased up to October, 1917, and are now in use in all parts of the country. The voluntary use by utilities and electrical installers has become very large. All administrative bodies concerned with electrical practice have copies of the code, and most of them are utilizing it to a greater or less extent as their standard. The exact use made depends greatly upon whether any electrical rules had been previously in use by the administrator concerned. In a few States for years there have existed statutory requirements regarding certain features of electrical construction, and in these cases the adoption of the safety code has been sometimes delayed, and less adequate and reasonable rules have been continued in use. It is not the recommendation of the Bureau of Standards that legislative action be taken on the code, but rather that this be incorporated in rules or orders by administrative bodies, thus permitting more ready improvement in the code from time to time as experience in its application or progress in the art may justify its revision through a nation-wide study.

Since the method of adoption or use of the safety code by administrators who have taken action or are using it as a reference standard is of interest to others contemplating some such action, a partial list of the more definite actions thus far taken is given below. It may be observed that the type of action is naturally affected by the existence of partial sets of rules prior to the availability of the code, by the local attitude of the utilities and others affected by such rules, and by the facilities and character of organization of the administrative bodies. A very interesting history often lies back of the action on electrical rules taken by an administrator. The action recommended by the Bureau, where conditions permit, is that noted below as taken by the Public Utilities Commissions of West Virginia, Nevada, Colorado, and Georgia, by the Insurance Commission of North Carolina, and by the Corporation Commission of Virginia. Joint action or harmonious action by the several commissions of a State, where more than one exists, and harmonious action by these commissions and the municipalities is, of course, highly desirable and in the public interest. It is readily seen that harmonious action by the commissions and municipalities of contiguous States is hardly less helpful.

Whether the action is entirely informal or of a formal character, it will be remembered that the code is necessarily a progressive instrument, and where a needless hardship would otherwise result, a modification in application should be permissible, as stated in the code itself. Administrators will thus be the chief factors in making the code as helpful as possible to the industry as well as to the public.

It will be seen that the safety code is receiving general acceptance and is already a recognized standard for safety in electrical practice—a standard to which actual practice will conform more and more with the lapse of time. It will be the part of wisdom to make new construction conform to the code, even where there is no prospect of it being made mandatory immediately, for the reason that ultimately it may become mandatory everywhere, because it represents good and safe practice, and hence better protection to employees and public; because it will reduce the financial burden of damages and compensation resulting from accidents, and consequently will reduce casualty insurance rates; because it will also result in more harmonious relations, with better satisfied employees; and because it will reduce friction with Government inspectors and regulative bodies who may have or be given jurisdiction over such installations for the purpose of enforcing safety standards.

LIST OF ACTIONS TAKEN ON THE NATIONAL ELECTRICAL SAFETY CODE BY VARIOUS ADMINISTRATIVE BODIES

FEDERAL BODIES

United States Employees' Compensation Commission has adopted the code as their electrical standard for inspection of Federal plants.

LEGISLATIVE BODIES

Montana statute prescribes line rules, requiring compliance with the code for future crossings of supply lines over signal lines or railroad tracks and all future electrical construction not provided for in the act. (Mar. 15, 1917.)

PUBLIC SERVICE, PUBLIC UTILITIES, AND RAILROAD COMMISSIONS

Arizona Corporation Commission is using the code as a reference standard.

Colorado Public Utilities Commission has issued bulletin recommending the code. (June 20, 1917.) Adopted part of code relating to grounding of low-potential circuits.

Connecticut Public Utilities Commission incorporated parts of the code in its joint-use requirements. (Mar. 26, 1917.) Requires in some cases that the code be complied with. Has issued circular letter recommending the code in other respects. (Jan. 2, 1918.)

District of Columbia Engineer Commissioner is using the code as a reference standard, and for high-voltage overhead systems; recommends a trial use of the code.

Georgia Railroad Commission has issued a bulletin recommending the code. (Oct. 9, 1917.)

Illinois Public Utilities Commission utilized portions of part 2 of the code in line-construction rules. (Oct. 12, 1916.) Is using the code as a reference standard.

Indiana Public Service Commission requires compliance with rules for grounding of low-voltage circuits. (Dec. 22, 1917.)

Kansas Public Utilities Commission issued brief of part 2 referring to the complete code. (July 30, 1917.)

Missouri Public Service Commission requires compliance with the code in particular cases.

Nevada Public Service Commission has issued bulletin recommending the code. (June 1, 1917.)

New Hampshire Public Service Commission has issued circular letter requesting trial application of code and is considering advisability of adoption. (Jan. 25, 1918.)

New York Public Service Commission, first district, is using the code as a reference standard.

Ohio Public Utilities Commission is using the code as a reference standard and as an authority for decisions in special cases.

Oregon Public Service Commission has issued bulletin recommending study of the code preliminary to hearing on its adoption. (Jan. 2, 1918.)

Pennsylvania Public Service Commission is using the code informally as a reference standard in cases not covered by formally adopted orders.

Utah Public Service Commission has tentatively adopted the code. (Feb. 4, 1918.)

Virginia Corporation Commission has issued a bulletin recommending the code. (Sept. 15, 1917.)

Washington Public Service Commission is using the code as a reference standard.

West Virginia Public Service Commission has issued bulletin recommending the code. (Feb. 28, 1917.)

Wisconsin Railroad and Industrial Commissions, acting jointly, have issued an order consisting of a condensed set of rules, complying fully with the code and referring to the code for more complete details. (Apr. 30, 1917.)

Hydro-Electric Power Commission of Ontario is using the code as a reference standard and is preparing rules generally in agreement with the code.

Nova Scotia Board of Commissioners of Public Utilities has adopted part 2 of the code.

INDUSTRIAL COMMISSIONS.

California Industrial Accident Commission adopted section 9 and parts 1 and 3 with some minor differences. Uses the code as a standard in inspecting stations.

Indiana Industrial Board is using the code as a reference standard.

Ohio Industrial Commission is using the code as a reference standard.

Pennsylvania Department of Labor and Industry made operative all of the code but part 2 verbatim. (July 1, 1917.)

Wisconsin Industrial and Railroad Commissions, acting jointly, have issued an order consisting of a condensed set of rules, complying fully with the code and referring to the code for more complete details. (Apr. 30, 1917.)

INSURANCE DEPARTMENTS

North Carolina Insurance Department issued bulletin recommending the code. (May 4, 1917.)

MUNICIPALITIES

Chicago Department of Electrical Inspection is using the code as a reference standard.

New York Department of Water Supply, Gas, and Electricity has indorsed the code for use.

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INSPECTION BUREAUS

The National Workmen's Compensation Service Bureau is using the code as their reference standard for determining casualty insurance rates for electrical stations and lines.

Indiana Inspection Bureau is using the code as a reference standard and has issued a bulletin recommending the code. (Oct. 23, 1917.)

Utilities Mutual Insurance Co. (New York State) has issued circular letter recommending application of the code. (Jan. 24, 1918.)

II. ONE HUNDRED TYPICAL ELECTRICAL ACCIDENTS

The following accounts of deaths and injuries resulting from electricity are representative of what is daily happening throughout the United States. They are brief extracts taken from newspaper articles as they have appeared in the daily press, supplemented in many cases by correspondence and other sources of information. The entire list is from the year 1913, and is divided into two groups, electrical workers and the public, of 50 accidents each. This number, however, is neither an indication of the ratio between the two groups, nor an indication of the total number of deaths and injuries caused by electricity occurring in one year.

It is to be particularly noted that repetition of most of these accidents will be avoidable by making new construction comply with the installation rules of the safety code, by securing observance by electrical workers of the operating rules of this code, and by educating the public to properly appreciate the necessity for prudence when in the vicinity of electrical lines or the exposed live parts of electrical equipment within buildings.

At the end of the list are cited a few cases of resuscitation which are representative of what can be accomplished by the simple prone-pressure method of artificial respiration, with which every person engaged in electrical work should be familiar. They show that efforts to resuscitate should always be made and long continued upon persons who are apparently dead from electric shock, asphyxiation, or drowning, and prove beyond a doubt that a large number of the deaths listed below could have been avoided.

ACCIDENTS TO THE PUBLIC

INSIDE OF BUILDINGS

1. A young lady went into the bathroom and attempted to turn on the electric light. When she took hold of the socket she was severely shocked and burned, and thrown to the floor. The burns were so severe that her hands had to be amputated. The service wires were crossed with a 2300-volt supply wire.

2. A young man was almost instantly killed when he picked up a telephone to answer a call. A live supply wire was crossed with the telephone wire.

3. A woman was electrocuted when she attempted to turn on an incandescent lamp in her kitchen. The shock was caused by crossed electric wires in front of the house.

4. An engineer had taken an electric lamp into a boiler to be used while cleaning the boiler. The lamp cord was old and badly worn, and became soaked with water. The man's clothes and hands were wet and when he took hold of the lamp to move it he was electrocuted.

5. A hotel keeper was killed and an employee fatally injured when they attempted to adjust some electric wires in the hotel cellar. The cellar floor was wet and there was a storm raging at the time. It is thought that there were crossed wires, as the lamps were not burning properly.

6. A man employed as a granite cutter was instantly killed when he stepped upon a cutting machine to make an adjustment. The machine frame had become alive through contact with a live wire.

7. A steam fitter was carrying about in a basement an electric lamp attached to an extension cord. He was seen to pitch forward suddenly, and when a fellow workman went to his side, he was dead. The hand holding the lamp was badly burned. It is thought that the wires were crossed with high-voltage wires outside of the building.

8. When a man attempted to make a call over the telephone he was killed as the result of a supply wire being crossed with the telephone circuit. A doctor was called, and unaware of the cause of the death, was fatally shocked when he went to the same telephone to summon assistance.

9. An inexperienced youth was left by the operator, in charge of an electric supply station, for a few minutes. During the operator's absence he tried to handle some of the machinery. He was electrocuted.

10. A boiler maker was working in the fire box of a locomotive boiler and was using an extension electric lamp. He came in contact with some live part of the lamp and was electrocuted.

11. A crane operator grasped a crane trolley wire, at a potential of 220 volts, and was electrocuted. He had put on cotton gloves believing that they were sufficient insulation.

12. A salt-fish worker was electrocuted when he attempted to turn on an electric-light switch at the fish plant. He was standing on damp ground and apparently touched a live part of the switch, which was of the open knife-blade type.

13. A man had just returned from an automobile ride and was preparing to put his machine in the garage. He was groping about in the dark trying to find the electric lamp which was on a drop cord. The cord was badly worn and he was electrocuted when he touched it. The floor of the garage was wet and the man's hands and clothing were damp. His body was badly burned at several places where it touched the floor upon which he fell. The electric-light company made an investigation and reported that the voltage could not have been more than 110.

14. A laundry-wagon driver went into the stable to care for the horse. He reached up for the electric lamp, and when he touched it, he uttered a groan and fell to the floor dead. At the same time all the other lights went out. There were two burns on his right hand. The brass shell of the socket was alive.

OUTSIDE OF BUILDINGS

15. A 12-year-old boy, while playing with some other boys, climbed a high-voltage transmission line tower and was killed through contact with one of the wires.

16. Two men were killed and a third was badly burned by an abandoned fire-alarm wire crossed with a live supply wire. The fire-alarm wire which had recently been broken was wound around the pole on which were the city electric-light wires at a voltage of 2300. When one of the men touched the wire, he was killed; one other man was killed and the third severely injured in attempting to rescue their fellow workers.

17. A heavy windstorm blew down many poles carrying electric wires. One man was electrocuted when a live wire broke and fell upon him.

18. A mill had just been equipped with electric motors for operating the machinery. A few days later, just after starting the mill, the miller noticed that one of the poles near the mill was on fire. He went to investigate and was killed when he touched a guy wire attached to the pole. Investigation revealed that the guy wire was in contact with one of the supply wires.

19. A little girl 4 years old was badly burned and shocked by contact with a telephone guy wire. The guy wire had become alive by a high-voltage supply wire falling upon it.

20. During a fire the fire chief asked the power company to turn off the current on certain wires in close proximity to the fire. This the power company refused to do. Certain of the wires were burned in two and fell upon a wire clothesline. A man was electrocuted in his back yard by contact with the clothesline.

21. A little girl 5 years old was able to get upon a transformer station roof, where she was playing. She took hold of the two primary wires entering the building and was so badly burned that she died a few hours later. There was a platform leading from the sidewalk to the transformer station roof, which was ordinarily closed by a fence and gate. It seems that this gate had been left open or that she had been able to open it.

22. A farmer was killed when a live electric wire, which ran alongside his property, parted and fell upon him.

23. Two men were severely shocked when a long iron rod which they were handling came in contact with an 11 000-volt transmission line wire. They were both rendered unconscious but were restored by artificial respiration.

24. One man was fatally shocked and burned, and another was severely burned, when a steel rule with which they were measuring a tank car in a railroad yard came in contact with an 11 000-volt overhead wire.

25. A boy climbed a 50-foot electric-light pole to rescue a playmate's kite which was entangled in the wires. He touched a live wire, which caused him to fall back among other wires and then to the ground. He was killed.

26. A boy had been in the habit of jarring an arc lamp-post in front of his home and causing it to start up when not burning properly. This time the arc wire was off the insulator and in contact with a guy wire. When the boy touched the guy wire to shake the pole, he was electrocuted. His sister brushed against the guy wire when he was found and was severely shocked and thrown to the ground.

27. While picking daisies near his home, a young boy was electrocuted when he touched a wire hanging loosely from a pole. His mother was severely shocked when she went to his rescue.

28. A workman was electrocuted while working upon the roof of a generating station. He had come in contact with a 22 000-volt wire. His clothing was set on fire, and he was hurled from the roof. He fell upon another man, knocking him down and setting his clothes on fire.

29. A brick mason was working alone upon a new substation. He was found lying dead by other workmen, upon 12 000-volt wires a few feet below where he had been working. It is thought that he made a misstep and fell from his scaffold to the wires.

30. A young man was in a tree spraying the tree to kill moths. A metal pipe attached to a hose which he held in his hand came in contact with a live wire running through the tree. He was electrocuted and fell to the street, 20 feet below.

31. A young boy started away on a fishing trip. and on his way he climbed the side of an iron bridge in order to shorten his journey. In doing so he came in contact with a live electric wire and was electrocuted.

32. Several boys were swimming in a river under a railway bridge. They were daring each other to "do stunts." One boy climbed the bridge, which was about 50 feet above the surface of the river. He came in contact with some high-voltage wires and was thrown into the river. When his body was recovered about an hour later his skull was found to be fractured and there were severe burns upon his feet.

33. A man, while mowing grass, was electrocuted by contact with a wire fence running along his lot. A neighbor who came to his rescue was also electrocuted. A telephone wire was broken and in contact with both the fence and a high-voltage supply wire.

34. A man was electrocuted while attempting to remove a broken supply wire from the path of several playing children. It is said that the electric-light company had been notified that the wire was down 10 days before the accident happened.

35. A laborer was killed when he picked up a broken electric-light wire to place it out of reach. Children had played with the wire all day, but as it was dead until about 6 o'clock, no harm had come to them.

36. A prominent citizen of a southern town was electrocuted when he took hold of an arc-lamp supporting chain to shake the lamp so that it would burn. The chain was alive as the result of defective insulation.

37. A small fire on a roof was caused by contact of a telephone wire with a 2 300-volt supply wire. The city fire marshal responded and attempted to climb a ladder to the roof. He came in contact with the rain spouting, which was alive, receiving a shock which caused him to fall to the ground, breaking his neck.

38. An elderly man was killed almost instantly when he stepped upon a broken electric-light wire. Several breaks had occurred in the electric lines as the result of a severe windstorm.

39. A 15-year-old boy received a severe electric shock from a live electric-light pole while playing about it. His condition was such that artificial respiration had to be applied in order to keep him alive. After this accident it became known that several people had received more or less severe shocks from the same pole.

40. A boy aged 10 was electrocuted by contact with a live supply wire while gathering chestnuts from a tree. He fell from the tree, and efforts to restore him by artificial respiration were futile.

41. A patrolman was electrocuted when he attempted to report from a police call box. The box had been made alive by crossed electric wires caused by a severe storm.

42. A man was electrocuted by a broken live wire which he attempted to pick up and place out of the way of others. The wire had been broken by a severe storm.

43. A young man and his wife were both electrocuted by a broken electric-light wire which fell in front of their store. The man's brother was severely shocked when he attempted to rescue them.

44. A woman and her two children were severely shocked and burned by a broken telephone wire which was crossed with a high-voltage supply wire. The wire fell in their back yard, and the children took hold of it while playing. The mother was shocked and burned while rescuing the children.

45. A young lady was electrocuted by coming in contact with a broken live wire. The wire had fallen during a heavy rain and windstorm.

46. A newsdealer was delivering papers with a horse and wagon when an overhead wire broke and fell upon the horse, which was instantly killed. The man got down from the wagon to see what was the matter with the horse and was killed by the same wire.

47. A bridge painter was severely shocked and burned, and thrown into a river, when he accidentally touched a high-voltage wire while painting a bridge. He was rescued from the river in an unconscious condition, with both legs broken and his hands and face badly burned. He regained consciousness after several hours, but his condition was so serious that he died five days later.

48. A boy aged 13 was electrocuted when he touched some live cables supported by a bridge upon which he had been climbing, and he fell 20 feet to the river. The voltage was 2 300.

49. A man and a boy were killed and several people injured by contact with live wires which were down as the result of a storm. The accidents were not from one wire alone, but from several, as the wires were down throughout the city.

50. One man was killed and two others were injured by a broken electric-light wire. One man stepped upon the wire during a rainstorm and was killed. The other two were injured in trying to rescue him.

ACCIDENTS TO ELECTRICAL WORKERS

INSIDE OF BUILDINGS

51. A night engineer for a street railway company was standing upon a ladder cleaning a switchboard and came in contact with some live part of a 13 000-volt switch. He was killed.

52. An electrician was installing a 550-volt, 3-phase motor and had finished the work except for the starting switch, which he did not have. He was anxious to start the motor, and therefore connected one lead to a terminal and attempted to start the motor by simultaneously attaching the other two leads. In doing this his hands slipped on to the live parts and he was electrocuted.

53. A machinist and electrician had three fingers badly burned while making a test to find a blown fuse. He accidently caused a short circuit which burned his hands.

54. A station operator had a narrow escape from death while standing upon a stepladder and working upon some station machinery. The ladder slipped, causing him to fall upon the live switches of the switchboard. He was severely burned and bruised.

55. A station oiler was cleaning a switchboard while standing on a stepladder. He lost his balance and fell upon some live switches, being electrocuted. His duties were to clean the front of the board only, but contrary to another employee's warnings, he was leaning over and cleaning the rear of the board when he lost his balance.

56. A station helper, a mere boy, told the operator that he was going to clean some of the machinery. The operator told the boy not to touch the machinery unless he was with him. The operator then went about some other work, but soon noticed a flash. He found the boy dead. He had come in contact with live parts at 40 000 volts.

57. An electrician was electrocuted while attending to some switches at a substation. His hand came in contact with some live part and he was thrown to the floor, dying a few minutes later.

58. A station operator was found dead in the station where he had been at work. He was alone at the time and a coroner's jury was unable to determine the exact cause of death. It appeared that he had been attempting to adjust an arc lamp without disconnecting it from the circuit.

59. A station operator was severely burned about the face and upper part of his body while working upon a transformer in the rear of the power house. It was learned that one side of his spectacles dropped off and caught on a live wire. This caused a flash which seared his face and set his clothing on fire. It was thought that he would recover, although the burns were very severe.

60. A young station operator, who had been employed at a substation for about four months, was electrocuted when he climbed upon a transformer to clean it. He had thrown a switch for the purpose of making the transformer dead, but had gone to the wrong transformer. The voltage was 70 000.

61. An electrician and helper were installing some new equipment in a transformer substation. The helper was standing upon a steel-reinforced concrete shelf of the substation, when his body came in contact with a live wire. His shoulder was badly burned when it came in contact with the wire, and he died almost instantly. His companion was severely burned about the face in trying to rescue him.

OUTSIDE OF BUILDINGS

62. A trolley lineman, while engaged in straightening a trolley bracket, was standing on some unguarded grounded part of the work car. His head accidently came in contact with the trolley wire while so standing. The wire burned through his skull where it touched his head. He died the next day.

63. A power lineman had just climbed a pole to place a crossarm. He was standing on a telephone cable messenger which had no guardarm, when he came in contact with a 2300-volt supply wire. The shock caused him to fall to the ground. His neck was broken from the fall. He had not been using his safety belt.

64. A lineman was electrocuted at the top of a pole by coming in contact with a live wire while reaching over to get hold of a rope used in stringing new wire. He was a new man, and although he had had some experience as a telephone lineman, he was inexperienced with supply-line work.

65. A telephone lineman was handling some telephone wires which were near live supply lines. He was shocked and fell from the pole when the telephone wires came in contact with the supply wires. His neck was broken from the fall. He had not been using his safety belt.

66. Two power linemen were badly burned and shocked when a cable which they were stringing came in contact with a live supply wire. They took hold of the cable with bare hands to assist a team of horses to pull it to sufficient tension. The horses were unharmed, as they were hitched to the cable by means of a rope.

67. A power lineman was making repairs upon a wire which had been broken by a severe storm. He received a severe shock and fall when another wire was blown against the one upon which he was working.

68. A gang of linemen were placing a new pole for a 60 000-volt switching station. They lost control of the pole, which fell against the main line. The pole was wet and one of the men was touching it when it struck the high-voltage wire. He was electrocuted.

69. A lineman, while making a service tap, was severely burned and shocked by his foot coming in contact with some telephone wires while his hand was in contact with the supply wires. It was necessary to amputate several fingers and one toe.

70. A lineman, while working at the top of a pole, received a shock which caused him to fall over upon the crossarm in an unconscious condition. A fellow lineman went up the pole and fastened a rope around the man's body by means of which others lowered him to the ground. The second lineman then started to come down, but accidentally touched the same wire and received a shock which caused him to fall. His skull was fractured. The first lineman was restored by artificial respiration.

71. An arc-lamp trimmer was killed while repairing a lamp which was not burning properly. He had lowered the lamp, and in the act of throwing the arc-lamp cut-out he came in contact with some live part.

72. A cable splicer, while working upon a cable, came in contact with a high-voltage wire. His clothing was set afire, as was also the rope supporting the cable sling. The rope burned in two and allowed the man to fall a distance of about 50 feet to the ground. He died several hours later as the result of the burns and fall.

73. A lineman was instantly killed as the result of a fall from a pole. It is thought that he received a shock which caused him to lose his balance. He was not using his safety belt.

74. While stringing a new wire, a lineman was severely shocked and burned when the new wire sagged into a 16 000-volt transmission line. He was rendered unconscious, but the prompt application of resuscitative methods restored him.

75. A telephone lineman was killed by contact with a 2300-volt primary wire while working upon a telephone cable. The wire was 3 feet above the cable.

76. A lineman, while changing a transformer, came in contact with one of the primary wires and was electrocuted. His safety belt prevented him from falling, but he was lifeless when removed from the pole.

77. A lineman was sent to repair an insulator on a 10 000-volt line which had been damaged by some blasting. The power was to have been turned off at a certain time. The lineman having waited until after the stated time, ascended the pole, and took hold of the wire, receiving a shock which threw him from the pole. He was badly burned, and his skull was fractured. He died at a hospital a few hours later.

78. A telephone lineman was repairing a telephone cable. Within 10 inches of the pole he was working on was an electric-light pole carrying a transformer. In preparing to descend, the lineman came in contact with one of the primary wires leading to the transformer and was thrown to the ground by the shock. His skull was fractured and he died a few hours later.

79. A lineman accidentally brushed his hand against a 4000-volt wire while working upon other wires near by. He was rendered unconscious and hung suspended from the pole by his safety belt. Workmen removed him from the pole and applied artificial respiration for over an hour without success. He breathed once or twice during the treatment, but his heart failed to respond.

80. A telephone lineman was fatally injured when a pole upon which he was working broke, hurling him to the ground and falling upon him. He was removing the wires from the pole to place them upon a new one. The pole was badly decayed at the ground line.

81. A lineman while working upon the wires of one crossarm came in contact with the wires of the crossarm immediately below, causing his death. The voltage was 2300.

82. A telephone lineman was sent to make some repairs to a telephone line. The telephone wires were on the same pole and above a 6600-volt supply line. While working on the telephone wires, he came in contact with the supply line and was killed.

83. Two linemen were killed and another severely injured while stringing telephone wire near a high-voltage transmission line, when the telephone wire parted and fell upon the high-voltage line.

84. A lineman was electrocuted while repairing telephone wires. The telephone wires were on the same pole with high-voltage supply wires, and in some unknown manner he came in contact with the supply wires while working on the telephone wires.

85. A lineman was electrocuted while engaged in renewing lamps in an electric-sign arch suspended across a street. The current was shut off from the sign. It is thought that he took hold of a guy wire to steady himself and that this pulled the guy wire into contact with a 2300-volt primary wire to which it was very close.

86. A telephone lineman was making repairs at the top of a pole. A train was passing and he threw up his hand to one of the trainmen. His hand came in contact with a 16 000-volt wire on the same pole, and the shock threw him from the pole and under the train. His body was badly mangled. It is not known if death was due to the injuries from the train or the shock.

87. A lineman climbed a pole to make some repairs. He accidentally caused a short circuit while working among the wires. His shoulder, arm, and back were badly burned. He was very weak when taken to the hospital, and little hope was held for his recovery.

88. While seated in a cable car repairing cables which had been damaged by a storm, a telephone lineman came in contact with a high-voltage supply wire. He was electrocuted.

89. Accidentally brushing against a live wire as he was repairing an electric lamp at the top of a pole, a lineman was instantly killed. He had protected himself for his work with rubber gloves, but turning to look down upon the street for a moment, he allowed his shoulder to touch the high-voltage wire.

90. A lineman, while engaged in repairing some wires at the top of a pole, received a shock which caused him to fall. He was not using his safety belt. His drop line, which was attached to his belt, became entangled among the wires and arrested his fall when a few feet from the street. His back was broken, and it was thought that he would die. It is probable that the sudden stopping of his fall by the drop line attached to his belt is what broke his back.

91. A lineman was killed almost instantly when he fell from the top of a 30-foot pole after receiving a shock of 3500 volts. Burns were found upon the palm of his hand and the sole of his foot.

92. A power lineman was electrocuted while making a service tap. He had completed one side of the connection and was about to make the other one when he dropped his rubber glove. He attempted to complete his work with one ungloved hand, when his foot came in contact with a metal conduit running down the pole. This allowed him to receive a shock of 2300 volts, which killed him. His body swung out from the pole but was prevented from falling by his climbers and safety belt.

93. A telephone lineman was electrocuted when about ready to make a service connection for a telephone. He was in contact with an electric-light transformer at the time he touched the telephone wires. He had severe burns on the back of his neck and on his right leg where it was in contact with the transformer.

94. A lineman was fatally injured by shock and fall from an electric-light pole upon which he was repairing some wires. He fell 20 feet to the sidewalk, fracturing his skull, and died a few hours later. The side of his face was severely burned.

95. Three linemen were engaged in stringing new wire upon poles carrying live lines. The new wire accidently came in contact with the live lines and one of the men was electrocuted.

96. The dead body of a lineman was found hanging to a transmission-line tower, where it had hung for about three days. When the lineman failed to return home the alarmed family caused a search to be made. The voltage of the line was 60 000.

97. In the course of some work it became necessary for a lineman to climb a pole and splice a wire running to an arc lamp. He was assured that the current had been cut off so that the wire could be handled with safety. He climbed the pole and began work on the wire, but was shocked to unconsciousness by 2500 volts, which the wire was afterwards found to be carrying. He was not using his safety belt and fell heavily to the ground. Physicians applied resuscitative methods for over three hours before the man showed any signs of life. It was thought that he was entirely out of danger and would make a quick recovery. It was learned that the wire had been cut off according to instructions and had been made alive by another wire crossing and coming in contact with it.

98. A telephone lineman was severely injured when he climbed a telephone pole to adjust some wires. He leaned as far out as he could when the pole, which was rotten at the base, broke and fell with him. The pole fell against the eave of a house close-by and the impact jerked the man from the crossarm and hurled him to the roof unconscious. His jaw was fractured and he received severe cuts and bruises.

99. A lineman, while attaching some wires to a police-alarm system, received a shock which caused him to fall 20 feet. He was killed.

100. A surveyor, while using a steel tape which came in contact with a power line, was instantly killed.

TYPICAL CASES OF RESUSCITATION AFTER ELECTRICAL SHOCK

1. In May, 1914, a service company employee received a shock from a 2300-volt wire. He was so badly burned that his left arm was afterwards amputated at the shoulder. One of his companions immediately began to give him manual artificial respiration according to the prone pressure method, while others summoned a physician. The physician reached the scene of the accident within half an hour and immediately pronounced the man dead. The lineman who was working on him refused to give him up and continued the work of resuscitation in the ambulance on the way to the hospital, where two other physicians also pronounced him dead. The lineman insisted that he was not dead and continued his work for another hour and a half, when the man began to show signs of life and was finally fully resuscitated. The injured man is now no worse for the experience, except for the loss of his arm.

2. In July, 1914, an employee of a public utility company received a shock from a 33 000-volt wire, which seriously burned the top of his head and also one heel. A fellow employee who was with him at the time immediately began giving manual artificial respiration according to the prone pressure method. In the meantime, a doctor was summoned and pulmotor sent for, but before the arrival of the doctor and pulmotor the patient had been resuscitated by his fellow employee and removed to the hospital. After a time he entirely recovered from the effects of the shock.

3. A schoolboy in May, 1915, came in contact with an 11 000-volt wire while up in a tree trying to reach a bird's nest. He was resuscitated by railroad employees who were near at the time by the prone pressure method of resuscitation and without the aid of a physician. Resuscitation was accomplished in about 45 minutes.

4. In August, 1915, an employee of a public service company came in contact with live parts at 33 000 volts, while working upon a lightning arrester, and was rendered apparently lifeless. A companion at once began artificial respiration and the man was soon conscious.

5. A trolley lineman in July, 1916, received a shock from a 500-volt trolley circuit and was thought to be dead. His foreman, however, immediately began efforts for resuscitation by the prone pressure method and was successful in less than a half hour. The next day the lineman was able to resume work.

6. In November, 1916, a substation operator was working upon a 33 000-volt feeder and received a shock which caused him to fall 15 feet to a concrete floor. The local superintendent immediately applied artificial respiration, regardless of efforts of two doctors to prevent him, and continued it until the man regained consciousness. Another doctor, who had had some experience with similar cases, arrived shortly and assured the superintendent that his action and knowledge of the prone pressure method was undoubtedly responsible for saving the man's life.

7. In April, 1915, in Massachusetts, a boy picked up a broken electric wire and was apparently dead from shock, but was revived by artificial respiration.

8. In June, 1915, in Colorado, a boy took hold of an electric wire and was rendered unconscious and his pulse could not be felt. He was, however, successfully restored by artificial respiration.

9. In May, 1915, in California, a man was knocked down and rendered unconscious by an electric shock of 2300 volts. The prompt application of resuscitative methods restored him after he was apparently dead.

III. NECESSITY FOR DETAILS AND SPECIFIC TREATMENT OF CODE RULES

DEVELOPMENT OF TREATMENT

Original Rules General in Treatment.—It has sometimes been asserted by those to whose attention the safety code has come, but who are not familiar with its development, that the rules might well be less detailed and specific, the assumption being that it would be more satisfactory if it were a code of general results to be attained, rather than of specific measures to be carried out. It has been asserted in this connection that the conditions over the country differ far too widely to permit of the preparation of any detailed code which could be generally applicable. The first preliminary drafts of the code were largely of this general character which seemed to some conferees so desirable. The Bureau engineers began very naturally by preparing safety rules that were simple in form and free from detail and that indicated the results to be obtained without specifying with any fullness the method of obtaining them.

Details Added by Request.—These first rules, however, at once met much justifiable criticism by those attempting to apply them concretely, because they were not explicit or detailed enough. Over and over again the Bureau representatives were asked by those to whom the rules were to apply, particularly by utility engineers, to add explanatory notes; or to state definitely that certain alternatives would be permitted; or to put more concretely and precisely what was stated generally; or to cover a hazard that had given trouble, but for which provision was not explicitly included in the more general rules. The requests for additional details were especially urgent in regard to Part 2 on line construction. It was constantly and particularly urged as important to have the rules so specific that too much responsibility would not be thrown upon the inspectors. The code, according to this later and more considered judgment, should recognize exceptional conditions and thereby avoid requiring the inspector to violate a general brief rule where to enforce it would cause an unwarranted hardship. It should also offer sufficient detail to serve usefully as a guide and so avoid misinterpretations and opportunities for serious differences of opinion between administrators and those to whom the rules apply or between different interests. So the code grew in detail in successive drafts, following repeated conferences and more extended study.

Advantage of Detail.—Part of this development was to cover differences in climate and differences in practice in different parts of the country, factors which some persons originally thought could not be taken into account satisfactorily in a single code. The fact is that the code can secure this desirable Nation-wide applicability successfully only by being detailed, specific, and concrete, which, as before stated, some have thought at first it should not be. Instead of these added details making the code harder to comply with, they tend rather to give the code flexibility where this is needed and so to make it more reasonable and easier to comply with. Most engineers, in fact, now regard this feature as one of the code's distinctive merits and one of its chief claims to recognition as a truly national code.

EXAMPLES OF RULES WHERE DETAILS PROVE ESSENTIAL

The following features of the code are some examples of the details that came into existence to meet real needs, and while to a superficial reader they may at first appear unnecessary, their removal would be far from advantageous to actual users of the code. These examples are principally from Part 2 on line construction, where the code grew most in detail subsequent to the submission of the earlier preliminary drafts of more general rules.

Scope and Application of the Rules.—The statements in the code covering the scope and application of the rules were expanded and made more detailed largely at the request of representatives of the utilities and other users, in order to show very fully just what is covered and to what extent and under what circumstances the rules are intended to be retroactive. Exemptions are carefully specified in the case of temporary installations, or installations soon to be abandoned, or in emergencies, as well as in cases where the cost of complying with the rules might be prohibitive. As the rules are intended to be adopted by State commissions and municipalities and will sometimes be administered in a formal way, the wording must be such as to be appropriate, when so adopted, and as not to permit misunderstandings or misapplications through lack of explicitness.

Climatic Differences.—Another development in the code, which increased the detail appreciably, consisted in taking account of differences in climate and specifying three different loadings for overhead lines—heavy, medium, and light. The present code is the first to make such a differentiation systematically, and it is considered one of its many commendable features. Of course, it was impossible to take account of every local climatic peculiarity, and the subdivisions of loadings have not been multiplied as much as might be done. It was a choice between a moderate amount of detail to account for considerable climatic differences and extreme detail to account for small local climatic differences. Then, too, there are some unknown differences in weather conditions which are left to the judgment of the local administrator or user.

The National Electric Light Association's crossing specification, for instance, required as great strength of construction in southern California or Florida, where there is no ice or sleet load, as in the North, where it is sometimes very heavy. The National Electrical Safety Code requires one grade in the North and middle of the country, where heavy coatings of ice on wires occur occasionally; another in the South, where there is practically none; and an intermediate grade between, where trouble from ice on wires is not severe but does occur. The Bureau has used all the information at hand in drawing the boundaries of these regions on a map; any State adopting the rules may revise the map so far as that State is concerned. This seems to leave the rules in a satisfactory condition for the present, and to present no greater detail than is necessary for reasonableness.

Two Kinds of Crossings.—Another development that adds detail is in recognizing two degrees of hazard at crossings of supply lines over railroads, requiring those over main lines to have grade A construction, and those over sidings, branches, and unimportant railroads to have grade B construction. This had not been done before in other specifications, although now widely supported. Making this distinction lessens the burden on the electric companies where the hazards are less, and no engineer has objected except some few representatives of the steam railroads. It is found, indeed, that few of them actively object to the making of a discrimination so obviously just, although they may still object to what they believe inadequacy of the strength requirements in either case for the crossover lines. A similar distinction has been made in crossings of telephone lines over railroads, grade D being specified over main line railways and grade E over branches, sidings, and unimportant railways.

This is to reduce the expense to the telephone and telegraph companies, and is agreeable to them, while apparently not seriously opposed by the railroads.

In the same way a distinction has been made in crossings and conflicts of high-voltage supply lines with signal lines, grade A being specified where the supply lines exceed 7500 volts, and grade B where the supply lines are between 5000 and 7500 volts. This is to reduce the expense to the light and power companies where reduced hazard justifies such a step. It must be stated that there was for a long time an apparently irreconcilable disagreement between the light and power interests and the signal interests on this point, but the Bureau feels confident that such evidence as has been brought to light supports the distinction as now included in the rules on these points. Both interests express their readiness to utilize the evidence coming from trial use of the safety code to settle this, their single remaining point of controversy as to the adequacy of the code for one interest and its reasonableness for the other interest.

Much space could be saved in the rules by requiring one grade of construction for all cases, but thoughtful engineers will realize how much it means in the way of balance between the degree of hazard and the necessary expenditure to produce the required construction strength, to reduce the requirements in this way where it can reasonably be done, even though the rules are extended somewhat by so doing.

Exceptions in Crossing Requirements.—Another occasion for detail is in providing that the strength requirements for power lines crossing over telephone lines need not be observed when the latter are individual twisted pairs, and that a lower strength, grade B, may be used even for the highest-voltage power lines, instead of grade A, in certain cases where the signal lines crossed over include no toll lines and only a few local circuits. It takes several paragraphs to state the case fully and to avoid ambiguity, but though a detail, it will mean much in the aggregate to the power companies of the country, seeing that there are millions of such twisted-pair service wires and unimportant local signal lines. No power engineer has questioned the desirability of this detail and the signal engineers have generally admitted its propriety.

Calculation of Strength of Crossings.—In connection with the strength requirements for poles and other line supports, considerable detail is given in order to make it easy for any one to calculate the strength of a crossing or of a section of line to ascertain if it meets the rules. The National Electrical Safety Code is, in fact, the first example of a set of rules to give data and tables so that one not especially trained can in a few minutes select the necessary sizes of poles, guys, conductors, and sags for a wire crossing of any kind, with nothing but the code, a pencil, and a notebook.

To say merely, as has been stated in some sets of line rules, that there shall be a factor of safety of 6 or 4 or some other figure in the wood poles, and briefly specify the assumed wind pressures and ice loadings, conduces to brevity and sounds very simple, but such statements unfortunately mean little as a guide to most readers until translated into other and more detailed language. It is believed that the fuller treatment of the subject in the code, including some tabulated matter, is approved by every one who has read it carefully, and that the space required to give a clear, conveniently used treatment is fully justified by the importance of the subject. Many agree that a much more general actual application of strength requirements in the field is already resulting from a more general use of the safety code, and that the companies in general are glad to have so clear a guide. Certainly the bare statement in some other specifications (including the earlier editions of the code itself) requiring certain factors of safety provided a very inadequate guide and led to misunderstandings and disputes. These other specifications have also left untouched the very important matter of extent of deterioration to be permitted in wood poles. This adds some detail to the safety code, but at a point where detail is essential for safety and to make the intent clear.

Clearances of Conductors.—Sec. 24 of Part 2 deals with clearances of conductors and wires at crossings and elsewhere, containing several tables giving clearances of wires above railroads, roadways, and over other wires crossed over; also other tables specifying the clearances and separations of wires from one another where on the same supports. These tables are accompanied by a series of explanatory notes, giving exceptions and modifications in certain cases. Many of these notes were added at the request of electric railway or power companies, in order definitely to recognize construction which is proper in certain particular cases but not allowable generally and to take account of differences of practice not excessively hazardous per se, but objectionably hazardous because of the nonuniformity of practice. No objection has ever been offered to the considerable detail in this connection. The objection in the past has usually been that there was not enough detail, and hence, obviously necessary particulars have been added from time to time.

Separation of Line Conductors.—One instance of detail that might at first thought seem unnecessary is in the statement of the separation of line conductors. This separation should depend upon the size and sag of the conductor and the voltage of the circuit, and yet be as simply specified as possible. This subject was studied very carefully, and valuable assistance was received from many operating engineers throughout the country; but after a preliminary draft of the rules was issued containing a brief and apparently simple statement of required separations, attention was called to the probability that these rules required an unnecessarily great separation for very long spans. The subject was taken up anew, however, and by a new form of expression, not so simple as the first, nor as simple as is included in some other sets of rules, but sufficiently so for convenient use, proper separations for all conditions even up to spans of 1000 feet or more were successfully specified. One who knows nothing of the history of rule 242 would have little appreciation of the amount of time and study by many engineers that went into its preparation and might readily imagine that he could formulate a simpler statement answering the purpose equally well. In fact this has been asserted several times by conferees, who have failed, nevertheless, thus far to bring forward such an improvement.

Pole Wiring and Clearances from Structures.—The rules on pole wiring, clearances of wires from buildings and bridges, and on climbing space (rules 246–249) are examples of rules that contain considerable detail. The fact is that these subjects were never adequately treated in any code or specification before. The detail included is not an embarrassment to an electric company, but rather, of the most practical use. Much of it is to protect companies from the wrong interpretations which would surely be put upon general rules in many special cases and, in fact, have been put upon certain too brief rules of previous specifications.

DETAILS ESSENTIAL TO REAL STANDARDIZATION

Many other examples might be cited of detailed rules or notes inserted at the request of utility companies to permit them to do what they felt to be just, yet feared they might not other-

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wise be permitted to do under an ordinary interpretation of a general rule. It is these detailed rules largely that make the code practicable and acceptable. To strip the rules of such detail would result often in a hardship to the utilities, as well as a less efficient guide to practice. It has appeared impossible to make the rules more brief and general in character and at the same time have them so clear and definite as to be understood uniformly and enforced in a fair and acceptable manner.

The code is, of course, more than a mere set of safety rules. Part 2, for instance, is a standardization of line construction in very many of its features. It is necessary to go so far in the matter of standardization, because safety can only be assured by proper strengths and clearances, both of which must be very clearly and definitely specified, and because there are so many interests concerned in line construction in a given territory. Frequently several power companies, several telephone and telegraph companies, several electric railway and steam railway companies, and a municipality all have overhead lines crossing or paralleling one another in the same city, and confusion and disputes result if there is no standardization of construction with clearly and definitely specified minimum clearances, separations, and methods of supporting poles and attaching conductors.

One who has not attempted to formulate such a set of specifications covering with sufficient definiteness all ordinary combinations of line conductors can have no idea of what a mass of detail it is necessary to deal with, and competent critics now generally agree that it is idle to talk about stripping the code of detail and leaving it general and simple, and still, to expect it to be either acceptable to utility companies or worthy of adoption by State commissions. Even recently, certain officers of State commissions have stated it as their opinion that some of the provisions of the safety code are of too general a nature for the ready use of the constructor in the field. Also, in a number of cases, utilities have expressed the opinion that it would be necessary to prepare more extended specifications based on the code and that, for this reason, the code should be sufficiently specific to leave as little opportunity as practicable for misconstruction of the intent of any requirement and hence, mistakes in such specifications.

FEASIBLE ABRIDGMENT OF THE RULES

It is, however, manifestly possible to prepare simplified and abbreviated rules where this is desirable for administrative purposes, provided that reference is definitely made to the complete code for particulars, exceptions, and alternatives not contained in the abbreviated rules. Such a briefer presentation of the subject matter may encourage the study of those responsible for electrical installations of relatively small extent, whose thorough study of the more comprehensive and detailed code could not be anticipated, and whose actual opposition rather than desirable and intelligent support might be received by the administrator were the complete code presented for their comment or adoption. The preparation of such briefer sets of rules for introductory purposes may be aided by reference to the summaries of the different parts of the code in the following sections, VI to X, inclusive, of this publication. Instances where such briefer sets of rules have already been adopted by administrators may be given, and where the complete code is referred to, the result has apparently been satisfactory.

IV. HOW TO FIND THE CODE RULES FOR A PARTICULAR SITUATION

The use of the safety code by all interests, on a scale broad enough to make it the active agency for good which it should be, requires a very considerable degree of familiarity with the code by all classes of users. It is readily apparent to the thoughtful reader that the code can not omit the many rules in which he is not interested, nor can it segregate the comparatively few rules in which he alone is interested. Others will need a slightly different or more extended set, and all the rules, of course, need to be arranged systematically so that they lend themselves conveniently to the use of all.

Separation of the code rules into too many groups would have the further serious disadvantage that these would come into use by many interests, would lose identity with the national code, and would be subject to uncoordinated amendments by their different users. We should, therefore, have chaotic conditions instead of the electrical standard which all have desired, striven for, and now have ready for use. This tendency is observable where different State commissions have adopted varying sets of electrical rules, proceeding from local studies or compromises.

But nothing stands in the way of utilizing convenient and simple brief lists of the rules covering subjects such as frequently have a detached interest for many users. For the user unfamiliar with the code and approaching its necessarily considerable bulk with some hesitation, such lists will be particularly useful.

The more aggressive student of the code can quickly make his own list or lists of code rules applying to the one or more conditions in which he is interested. To do this most easily he should first use the very complete table of contents which is printed with the rules. For related subjects not appearing in the table of contents he may refer to the subject index, not printed with the code in its present edition, but to be included in amended form with later editions, and now available in a separate pamphlet which will be sent free by the Bureau to applicants. The Bureau staff is now preparing lists of rules on subjects of sufficiently general interest to warrant it.

As instances of the classes of subjects which are of more or less special interest to various rather large classes of users, and for which, therefore, a list might prove rather widely useful, the following might be mentioned.

(1) Subjects in which several branches of the electrical industry are alike interested, but from diverse viewpoints. Among these are the various types of crossings of overhead lines with

other lines or railroads, overhead conflicts, common use of poles, clearances of lines from buildings, and similar matters.

(2) Subjects which have particular interest for certain classes of manufacturers, engineers, installers, or operators. Among these are industrial control apparatus and warning signs, switchboard construction and installation, and operating precautions in generating stations.

Some of the foregoing lists are already prepared and are undergoing careful preliminary criticism before submission to the more general study which is desirable before their dissemination or inclusion in the code. Other subjects for lists are being taken up, and proposals from the field of additional topics for which such lists would be useful are invited of readers.

It will be readily seen how much such lists will reduce the labor and occasional dismay of persons beginning the use of the code. To more confirmed code users, the reference to such lists is likely to become constantly rarer. This has proved the case with the National Electrical [Fire] Code, which has many points of similarity with the safety code but is less systematically arranged and consequently less easily used by its new acquaintances. The lists will, therefore, be of most particular service to the beginner. However, as most users during the next few years may properly be classed as beginners, the preparation of such lists is felt by the Bureau to be well warranted at this time.

Another and more permanent aid to convenient use of the code is the preparation of charts and diagrams which have the readily recognized advantage of moving pictures over ordinary reading matter; they arrest the attention and convey the thought more quickly and clearly where the subject is simple enough to lend itself to such presentation. From a careful study of the safety code, still continuing, it is judged by the Bureau engineers that at least half of the code rules are susceptible of clear presentation in diagrammatic or other graphic form, some charts to cover several rules, others only a part of one rule. Some of these charts must necessarily refer for further details to code rules or notes. A few are already available in tentative form for inquirers. When succeeding editions of the code are prepared, some of the more useful charts will be included.

The safety code is already preeminent among sets of electrical requirements in the degree and success with which it supplements its general or special rules with conveniently arranged and quickly usable tabular matter, the laborious computations or comparisons being already made, which the user of other sets of rules has been forced to supply. Actually, of course, in the use of past sets of rules the user has often failed to make laborious and difficult computations and has guessed or followed unreliable "rule of thumb" methods or criteria. The use of tabular matter having been so successful in making the code a really valuable guide to users, the extension of tabular matter, as far as seems practicable, is now being undertaken by the Bureau engineers. Where it seems feasible, the utilization of charts may supplement or replace tabular treatment.

Our conferees are enthusiastically indorsing, and to the extent permitted by their other activities, actively assisting in this extension of graphic and tabular presentation of the code. To a large extent such material on the drafting board or in the pocket notebook will make the code appear in its real simplicity and equally aid administrators and those to whom the rules apply.

It should be understood that where persons, in spite of the above noted convenient aids to office and field use of the code, still find other assistance necessary, the Bureau engineers stand ready to extend this assistance by correspondence or otherwise. Requests of this kind may have the advantage of calling attention to respects in which the code may be made clearer and, therefore more truly and widely useful for its purpose as a working guide.

As illustrations of the lists of rules applying to particular subjects the following two lists are presented, one prepared by the Bureau for use of pole inspectors, and one by a manufacturer for his own convenience. A list of the rules of the code calling for protective grounding may be found on page 68.

I. RULES APPLYING TO WARNING AND DANGER SIGNS AND TAGS

GENERAL

Definition of tags	53
Fire extinguishers, signs warning against improper use of	107
Heeding warning signs	421, 460
Removal of tags	436, 485, 490
Traffic, signs to protect	523, 577, 580

STATIONS

Placing men-at-work signs	470
Providing men-at-work signs	415
Removal of tags	457, 458, 459
Stations, rooms and spaces, signs warning against entrance to	104*a*
Tagging:	
Disconnectors and circuits	435, 451
Switches, starters, etc	164*b*
Temporary wiring, tagging of	156
Warning signs:	
At unattended and unlocked entrances	416
Against error in handling switches	206
On disconnectors	164*a*, *b*
On lever-operated switches	169*a*
To protect traffic	523

LINES

UTILIZATION EQUIPMENT

II. RULES APPLYING TO WOOD POLES

V. SPIRIT AND PROCEDURE OF INSPECTIONS BASED ON THE CODE

METHOD OF INTRODUCING THE CODE

In considering the adoption in whole or part of the National Electrical Safety Code, the method to be used in applying the code deserves very careful thought. It is important that there be a thoroughly sympathetic attitude of the administrator of the code toward the electric lighting and other utility companies, and also toward the contractors and building owners who will be affected; it is also important to adopt at the start a reasonable plan of application. To be reasonable, such a plan must recognize that the introductory period will be beset with many difficulties and differences of opinion and will call for many explanations and the exercise of much judgment and tact on the part of inspectors. The rules as well as their administration are on trial. Gradually the application will become easier, as the rules are better understood, and to a large extent their observance has become a habit, as is now the case with the National Electrical [Fire] Code.

Early Applications Principally to New Installations.—While the inspectors and managers of utility and other properties may be expected to check up existing installations against the provisions of the new code, the attention of official inspection agencies will naturally be devoted at first more especially to new installations. This has been the past experience with new building codes and other codes. Even after a municipal or underwriting inspection department has been long established in any community, its principal inspection activity is usually and properly directed to new equipment. This is not because the inspection of existing installations would not reveal defects, but because correction of those defects often means duplication of expenditure, whereas the securing of correct new installations means simply the proper direction of the initial expenditure. Of course, as time goes on, old installations are frequently altered, and opportunity is thus given to apply the rules. Most established inspection departments have developed for old installations a method of inspection which for most classes of installations, except dwellings, enables these defective and hazardous conditions to be readily ascertained, and a reconstruction of a hazardous installation is finally called for, not because it does not accord with the standard for new construction, but because it has become definitely hazardous. Experience in the inspection of new installations under the code will determine to what extent the standard should be adhered to in making such corrections of defective conditions in existing installations.

In the application of a new code, one will find, in general, a greater departure from its provisions in existing electrical installations than the departure from the National Electrical [Fire] Code, since interior wiring installations have been made to comply with the fire code for many years.[1] In other words, the departures in existing interior wiring from the requirements of the fire code are only such as would be expected to exist, because of the constant but slow development of that code, and because of progressive overloading and injury from the frequent tampering with such interior wiring which occurs even under a fairly efficient inspection system. The departures from the new safety code, on the other hand, would be expected to be more considerable, as no coded requirements or definite inspection policies have ever been in existence to guide practice in respect to safety.

For these reasons, the application of the new safety code to old construction should be made only in the case of pronounced hazards, and not in cases of mere nonconformity. Even where hazards of considerable degree are suspected, it will be of greater importance, before applying the code to their correction, to establish a thorough understanding between the inspector and those to whom the safety rules apply with regard to the application of the code requirements to new installations and reconstructions. Only after such understanding is established in the simpler case of new installations can the more complicated and difficult cases of old installations, which have grown up without a safety guide, be handled with the mutual understanding so absolutely necessary to successful promotion of safety and advancement of the industry. We will therefore discuss first the application to new installations and then, briefly, to existing ones.

In passing, it may be said that the time-limit retroactive clause which had crept into certain electrical construction statutes, and even into a few commission orders,[2] finds no parallel in the

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[1] For problems of inspection in dwellings, see electrical section, Bureau of Standards Circular No. 75, Safety for the Household. Also see paper on Hazards of Domestic Electrical Appliances, by W. J. Canada, in National Fire Protection Association Quarterly, No. 2, Oct. 1917.

[2] See Ill. Pub. Util. Com. Gen. Order, No. 30. Also Washington Statute, Chap. 130, S. L. 1913.

National Electrical [Fire] Code, the application of which has been so universal and, in general, so successful. The National Electrical Safety Code has in its introductory rules distinctly limited its application to existing construction to cases where the expense is warranted by the added protection, this being a variable condition and a proper criterion to which none can properly object. It would be exceedingly unfortunate if, as has happened in one or two cases already, an announced and maintained plan of making the rules retroactive within a definite time limit should operate in additional jurisdictions to cause a mistaken opposition to the rules themselves, and thus lead to the adoption of less safe construction standards in order that the retroactive application may be less burdensome.

The plan of inspection, even for new construction, will vary considerably between utilization equipment, station equipment, and line construction. Since the first two are simpler and have a greater similarity to the interior wiring inspections which have heretofore occupied the principal attention of electrical inspectors (mostly, in the past, those of municipalities or of boards of fire underwriters), suggestions are first given for these classes of installation.

APPLICATION TO NEW UTILIZATION INSTALLATIONS

Before attempting inspection of either old or new equipment, in addition to having a knowledge of the rules, it is necessary that some definite outline be followed and that a well considered plan as to method of procedure be established. To fix upon such an outline and procedure, it would probably be well to have in mind some proposed installation and develop a plan adequately covering the conditions likely to be met with in such an installation. For example, take an interior wiring proposition where a number of motors are to be installed, numerous lighting fixtures to be found, and where manufacturing processes are to be carried on. It may be further assumed that many persons are employed here in various activities.

The application of the rules of the fire code as to service protection, size of mains, feeders and circuit wires, and also, as to the mechanical protection for the wires and electrical protection against overloads, are well known to the electrical inspector. In addition to these, he must necessarily become somewhat familiar with the rules of the safety code which apply (300 to 393), since in considering plans or specifications, or in making supervisory inspections during the construction period, he should be prepared to give timely suggestions on accident as well as fire prevention features. A procedure for conducting such a study or inspection is outlined below with the various points to be observed numbered consecutively.

In the inspection of existing installations the same features will be checked, but in this case it is not their avoidance so much as their possible correction which must be in the mind of the inspector. The cost of correction, involving as it often does a duplication of expenditure, must be considered with great care; whereas in the supervisory inspection or examination of plans, only the reasonableness of the first cost need be taken into consideration, and this has already been well considered by all interests in the preparation of the code rules themselves.

HOW TO INSPECT A NEW UTILIZATION INSTALLATION

1. Determining Kind of Installation.—The inspector should first ascertain whether all the electrical equipment is properly utilization equipment (300)[3]—i. e., is it so situated with respect to nonelectrical equipment, processes, or activities that persons operating it will be interfered with or their attention distracted by these other activities? If so, it is utilization equipment, even though generally operated by electrically trained persons whose attention, however, must be partly or wholly directed toward other activities.

Where, however, the arrangement is such that an inclosure is provided for electrical equipment, which is so planned that only electrically qualified persons have access, and during their attendance these persons are not distracted by nonelectrical activities, such equipment may properly be designated as station equipment and subject to the generally less rigid requirements for stations.

If, however, for any reason in such a separate inclosure, the space, guards, or other protection called for under the station rules is impracticable, the requirements for utilization equipment would still apply. It will be evident to the inspector that electrical equipment in utilization locations is, under most circumstances, to be considered as utilization equipment, because more or less an auxiliary to the other activities.

2. Determining Hazard.—The inspector having determined which portions of the equipment, if any, are station equipment, it will be advisable to ascertain if any locations are to be considered as hazardous under the meaning of this term in the safety code and, therefore, as calling for special isolation or inclosure or other protection.

Such locations might be, for instance, those where explosives are stored or are under process of manufacture, or inflammable gas is generated, used, or likely for any reason to be present, or inflammable flyings may exist. Dry-cleaning establishments, gas works, planing mills, and certain drug and explosives factories, and the portion of a garage near the floor, will be among such hazardous locations.

If electrical equipment can not be kept out of such locations, it should be so constructed, sparking or arcing parts so inclosed, and metal frames so grounded as to adequately prevent shock, explosion, or sudden fire (307, 314, 321, 341). Other kinds of locations requiring special treatment of electrical apparatus will be those where conducting chips or dust are present, since insulating platforms can not, in

[3] Numbers in parenthesis refer to the individual rules in the code.

these locations, be depended upon (306*a*, 326*c*, 343*b*). Additional precautions are also necessary in damp locations where insulation must be especially good and live parts especially well isolated unless thoroughly inclosed.

3. Order of Inspection.—After checking off the locations which are to be considered stations, and locations where special hazards exist and extra precautions may, therefore, be required, the inspection of such portions of the equipment as are to be considered utilization equipment may proceed. In order to avoid overlooking portions of the installation, it will be better to begin at the place where the installation receives its energy and to follow it systematically.

If there are several systems of wiring with their connected equipment, they may be followed simultaneously, if this will save time and can be carried out without confusion. The voltage of each system should be observed, as in many instances this will determine the character of protection required for connected equipment. It should also be ascertained whether these systems are among those for which grounding is required and, if so, whether grounded, and what arrangement of grounding is employed (304, Sec. 9).

It may be observed by the user of the safety code that Part 3 on utilization treats of utilization equipment as nearly as may be in this order, beginning with the more general requirements under Sec. 30, and proceeding to the individual classes about as they might be taken up on inspection.

4. Switches.—It should be ascertained if the main switch is in a location where it will be readily accessible for operation and if the voltage requires the arrangement to be such that live parts are inclosed or adequately guarded against contact during the operation of the switch. This same feature should be observed in subsequent inspection of each switch throughout the installation (327).

5. Cut-outs.—The arrangement of switches and cut-outs is the next important item for consideration. It should be noted whether cut-outs are arranged so that, before fuses can be exposed for renewal, all parts likely to be touched must necessarily be disconnected and dead. This is recommended, although not required, for voltages up to 300 to ground, and where not provided on voltages between 150 and 300, the switch must be placed ahead of the fuses. Also, on circuits up to 150 volts, where automatic disconnection is not provided, the placing of the switch ahead of the fuse is recommended. Above 300 volts, automatic disconnection is required, except in cases where unauthorized persons are excluded. It may be stated here that many manufacturing plants provide automatic disconnection even for the lower-voltage circuits, recognizing the protection afforded their employees (see rule 324).

6. Working Spaces.—Where switches are not so arranged that their live parts are inaccessible even during switch operation or where fuses or their terminals are at any time exposed to contact, if this is permitted by the rules, it should be ascertained whether the working space for the operator adjacent to the switch is sufficiently liberal (305) and whether suitable insulating floors or mats are provided and maintained (306*a*, 327*c*).

7. Protection of Workers.—The equipment controlled by the different switches in the installation should be examined to see whether the danger from live or moving parts is such as to require provisions in the switches for locking in the open position to protect workmen (323*c*).

8. Conductors.—The conductors and their inclosures should next be examined and it should be learned whether service conduit is isolated from interior conduit and other metal work, or is connected thereto; and whether in either event such conduit is grounded, and if grounded, in what manner (318). The lack of grounding for conduit within reach of persons may, in some cases, constitute a serious hazard.

9. Special Conductor Protection.—Keeping in view the voltage of the conductors concerned, it should be determined whether their mechanical protection by inclosure in conduit, metal sheathing, or compartments or screens of various kinds is adequate for their own protection and for the safeguarding of persons in the vicinity. If bare

conductors are noted, the inspector will need to decide whether they should be guarded and whether they are in hazardous situations from which they should be excluded (311, 313).

The inspector should make sure that neutral conductors in three-wire systems are not interrupted by single-pole automatic cut-outs or switches, and that grounded conductors are not so interrupted between the source of energy and the point of ground wire attachment (310).

10. Grounding of Equipment.—The voltage of different systems being known, the connected equipment of all kinds should be examined as it is reached in the course of the inspection to ascertain whether it is grounded in accordance with the safety code (Sec. 9) where required. (See p. 64.)

11. Switchboards.—Switchboards should next be examined to see whether they are located in inclosures inaccessible to unqualified persons and so as to avoid distraction of the operator's attention by nonelectrical processes, or whether the arrangement is such that all current-carrying parts are inclosed during operation. If the voltage is low, it should be ascertained whether inclosure of such parts is not still possible. If all switches are separately guarded, the necessity for such an inclosure of the switchboard as a whole will be obviated (335).

12. Motors.—Motors should be examined to see whether they are likely to be driven at excessive speed by current or load changes (340), and it should be learned whether moving parts are adequately guarded to protect persons in the vicinity. Where bearings or other parts require attention during operation, it should be ascertained if safe means are provided, including, with large machines, steps, handrails, and sometimes guard rails, and with small machines sometimes screens or other covers (343, 344). It should be ascertained whether the voltage and conditions call for use of insulating platforms or for guarding of the live parts in other ways, or whether these parts are sufficiently isolated by elevation.

13. Electric Furnaces.—Where electric furnaces are installed, the means to shield the eyes of those in the vicinity should be examined, and the guarding and grounding checked (Sec. 35).

14. Electric Lighting Devices.—Where lighting fixtures are installed, it should be ascertained whether the proximity of grounded objects, plumbing and the like, is such as to call for the grounding of the fixture frames (360). Electric signs should be examined to check the accessibility, the grounding of their metal frames, and the degree of guarding of the live parts. The provision for disconnecting signs from the source of energy should also be examined (363, 364).

15. Portable Devices.—Portable devices and their connectors should always be carefully checked. In general, the cord should be as short as practicable, the liability to abrasion or other deterioration should be noted, and whether or not the cord is suitable for the purpose (372, 374).

16. Cranes and Cars.—The inspector of electrically operated cars, cranes, or elevators will carefully check the grounding of the noncurrent-carrying metal parts by which the operator is surrounded, noting the hazards due to the elevation of crane operators or to the high voltage of car wiring, and will ascertain whether the means for readily disconnecting from the source of energy are at hand and provisions afforded for preventing operation of these vehicles by unauthorized persons. (Sec. 38.)

17. Conclusion.—In examining the plans or supervising the installation, or in making an inspection of an existing installation, the inspector will, where there is noted a failure to provide the working spaces, isolation by elevation, guarding, or grounding called for in the code, carefully consider the possibility of removing these features of nonconformity with the code requirements and of hazard. Where such nonconformities are observed in plants or in installations in process of construction a deficient working space or an obstruction in a sufficient working space may readily be remedied or removed without unreasonable cost.

In an existing installation the moving of equipment or the removal of obstructions so as to provide a sufficiently clear working space may, in some instances, be impracticable, but in some instances, at least, the guarding of the live parts adjacent to such an insufficient or obstructed working space may accomplish the purposes of the safety code requirements. In the same way a deficiency in guarding noted in plans or in a supervisory inspection may be readily corrected without excessive cost, whereas with existing equipment the installation of adequate guards might result in too restricted working space and entail the construction of many guards on other live parts to overcome the hazard brought about by the constriction of space.

Discretion must necessarily be exercised in deciding whether such a guard should be called for. Where grounding called for by the code is found to be omitted this can usually be as easily cared for in existing installations as in installations under construction, and frequently the expense of thorough grounding is warranted by the added safety secured (301).

SIMPLICITY OF INSPECTION UNDER UTILILIZATION RULES

The above outline indicates the great simplicity of the safety rules so far as concerns electrical installations for users of electricity. There will be some variations to the foregoing in special cases, but in general utilization installations have already been subjected to such careful treatment in the fire code (to which reference is made in the safety code for items not covered therein) that only a residue of requirements, where the personal hazard outweighs the fire hazard, remained to be included in the safety code. The inspector is accustomed to inspecting this class of installation, and the occupants are accustomed to having these inspections made and to acquiesce in the requests of the inspector. For these reasons the difficulty of applying some additional rules is small.

APPLICATION TO NEW STATION INSTALLATIONS

For station equipment there is a greater number of points taken up by the safety code than by the fire code, and for this reason it is all the more necessary for an inspector to have a definite method of procedure outlined. The station rules properly call for a less degree of physical safeguarding for equal voltages than do the utilization rules, since only electrically trained men, not distracted by commercial processes or other activities, are supposed to be in attendance, and their personal precaution and observance of the operating rules, covered in still another part of the safety code, may for these reasons be partly depended upon for their protection. These less rigid station rules also apply to electrical equipment even on premises of consumers, if so isolated as not to be accessible to any but electrically trained persons. From the safety standpoint such places are regarded as stations.

The following outline is suggested as a guide for inspection of proposed stations, since it takes up all the important points likely to be found in station equipment. As in the case of utilization equipment, proper consideration of plans and specifications in advance will accomplish much, especially in the way of providing proper working spaces about equipment. In considering a proposed station, or in making an inspection in a station, the inspector would give attention principally to the following matters.

HOW TO INSPECT A NEW STATION INSTALLATION

1. **Determining Hazards.**—It should be noted whether rooms or spaces are to be used only for electrical processes. They should be generally free from combustible gas, well illuminated and with duplicate means for emergency illumination. The equipment should be protected from the existing atmospheric conditions (102).

2. **Precautionary Measures.**—The structure housing station equipment should be properly designed effectively to exclude unauthorized persons. Adequate exits from rooms and working spaces are a matter deserving the inspector's careful attention; also the guarding of openings and stairways. Special attention should be given to the matter of fire extinguishers used around live parts. One of the recommended types contains carbon tetrachloride, which is nonconducting and safe.

3. **Grounding of Equipment.**—Throughout the station, the inspector should give very careful consideration to grounding of equipment frames, cases, and wire runways, except railway and series lighting equipment, where such are surrounded by adequate insulating floors and barriers to prevent persons from touching at the same time these frames and any grounded objects.

4. **Guarding and Isolation.**—It should be ascertained whether live parts are properly guarded when near passageways or working spaces. Where these parts are elevated a sufficient distance above the floor line, guarding is not required. The required distances above the floor are specified for various voltages in rule 116. Below 7500 volts, dependance in some cases may be placed on liberal spaces about live parts, if insulating platforms are properly placed. It should also be noted whether working spaces are provided (114).

5. **Motors.**—An important item often overlooked by inspectors is the provision of proper speed-control devices which are called for with direct-current motors, and for some types of equipment operating electrically in parallel where weakening or reversal of field current might cause overspeed. The inspector should note whether proper protection of moving parts has been provided and if field switches are properly guarded. Arcing shields for large commutators and circuit breakers may be necessary (120, 121, 122).

6. **Storage Battery Rooms.**—Storage batteries are required to be in rooms or compartments provided with well-drained floors, and so ventilated as to prevent danger from acid spray and inflammable gas. Live parts above 150 volts are to be guarded if adjacent to passageways and not elevated out of reach, and no two parts having a voltage between them as great as 150 should be adjacent to a passageway, unless guarded or separated at least 3 feet. Illumination requires careful consideration, and may be obtained from outside the battery compartment or from incandescent lamps in keyless waterproof sockets.

7. **Instrument Transformers.**—The secondaries of current transformers are sometimes the source of considerable hazard, necessitating that they be so arranged as to be readily short-circuited to permit removal of instruments, and if the primary voltage is high, such secondaries are to be in conduit. Low-voltage circuits supplied through transformers with high-voltage windings should be well grounded unless identified and run as required for the high voltage concerned.

8. **Location of Transformers.**—The location of transformers should be given due consideration. Those of large oil capacity are, in general, to be placed in separate rooms so cut off from other portions of the station as to minimize the oil fire hazard.

9. **Cut-outs.**—All conductors should be protected against injury from short circuits or overloads, either by the design of the system (as with constant-current energy sources) or by automatic cut-outs. No cut-out however, should be placed in a grounded conductor between the ground connection and the source of energy supply. This mistake is sometimes made. Guarding insulated and uninsulated conductors is required and specified in rules 151, 152, and 153.

10. **Switches.**—The proper location of switches should next be given careful attention. In the first place it should be determined whether switches are accessible and also whether they are properly marked so as to indicate the nature or location of the circuits controlled. Switches are required to be placed in all leads to motors and generators, except in grounded conductors. If switches are to be used only as disconnectors, they should be so marked. For the protection of workmen and equipment on circuits above 750 volts, it is recommended that air-break switches be placed in series with the oil switches.

11. **Circuit Breakers.**—It should be required by the inspector that circuit breakers be guarded or placed in such a position that sudden movements or flashes from them can do no harm to persons likely to be near by (167).

12. **Guarding of Live Parts.**—Switches and cut-outs are required to have live parts guarded, the nature of necessary guarding being different for low and high voltage parts. Above 750 volts this guarding must consist of complete isolation of the switch, which should be operated by means of electrical control or levers to distant or completely incased working parts. In general, oil switches of large oil capacity should preferably be placed in separate fireproof compartments.

Below 750 volts the guarding of switches and cut-outs may consist of the use of insulating handles and guard disks, combined with the use of insulating platforms on surrounding floors. Even above 750 volts, the guards or isolation may occasionaally be dispensed with, if on such rare occasions a working space of liberal dimensions is kept clear about the exposed live parts. This space needs to have greater width for the higher voltages, not less than 7 or 8 feet for voltages as high as 100 000, while 2 or 3 feet might suffice for 2300 or 6600 volts.

13. **Switchboards.**—The next important feature to occupy the attention of an inspector is the lighting of the station. Switchboards are required to be well lighted and simply arranged, with operating conditions clearly shown, and control devices quickly accessible. All equipment should be so placed as to minimize the probability of short circuits, and boards should be guarded from passageways. So far as practicable the placing of live parts at the working face should be minimized, and where parts above 300 volts are exposed, insulating platforms are required. Parts above 750 volts should be at least 6 feet above floors, and cases of instruments operating above 750 volts should be grounded.

14. **Lightning Arresters.**—For lightning arresters, the following points should be observed. Good separation is required from other equipment and from combustible parts of buildings. If having large amounts of oil, this separation should be accomplished by means of fireproof partitions. Provision for disconnection is required, and the guarding and grounding are to be such as is required for other equipment of equal voltage (sec. 18).

COMPARATIVE SIMPLICITY OF INSPECTION UNDER STATION RULES

It will no doubt be apparent that the inspection of central or substations under the safety code will involve no serious difficulties for the average inspector. While less accustomed usually to detailed inspections in stations than in factories, he merely has to take up the various features with the representative of the public utility, instead of with a factory owner or his electrical contractor. Usually, where new installations are concerned, the inspector will meet at least as great success in procuring a favorable attitude on the part of the station owner, as with a factory owner, since the object of any rule he applies will ordinarily be equally as clear to the station owner as to the inspector, and the value of compliance with suitable safety precautions will be generally recognized by station owners.

APPLICATION TO NEW LINE CONSTRUCTION

In the case of inspection of new line construction, however, the inspector will find more difficulties. These may, in some cases, include a lack, on his own part, of familiarity with line construction details, and also the necessity of considering the greater number of interests, than with station or utilization equipment, which his suggestions and conclusions will quite directly affect. Among these interests are included the various public utilities using the streets or alleys. For underground construction this joint occupancy of the highways does not entail so many opportunities for disagreement as with overhead lines, and the duty of the inspector is correspondingly lightened. Such lines, therefore, will be considered first.

NEW UNDERGROUND LINES

A suggested method to be followed by inspectors is given below, which is an outline of the most important points to be considered. For details the code itself should be referred to.

HOW TO INSPECT NEW UNDERGROUND LINES

1. **Separation of Lines.**—The proper separation of signal and supply lines is one of the first things to be considered. They should, in general, be well separated, usually in separate duct lines and manholes if the signal lines are for public use, and if brought to the same manhole they should have their respective ducts well separated, and the cables should generally be maintained at opposite sides. Protective coverings, where necessary, should be provided against arcs, particularly where some of the cables are of high voltage or large current capacity.

2. **Conductor Protection.**—It is desirable and important for ducts to be smooth and well bushed at openings, so as not to present any difficulties in pulling in cables. They should also be well spaced from gas mains, steam pipes, and railway tracks, and have good depth or strong covers to afford protection from traffic. Ducts must drain toward manholes and enter not less than 6 inches from top or bottom of manhole.

3. **Manholes.**—Inspectors should see that manholes have liberal clear working spaces, at least 6 feet vertically by 3 feet laterally, and openings for access at least 2 feet across and preferably round, to prevent the covers from falling into the man-

holes. Covers and manhole construction should be substantial. The manholes should be well ventilated, free from gas, and drained where necessary, and should prevent entrance of unsanitary drainage or other foreign matter.

4. **Identification of Conductors.**—A matter not to be overlooked is the tagging of cables. This is resorted to by many companies so as to serve as a ready means of identification. Cables and their joints are to be accessible—i. e., not covered by other cables or rendered inaccessible by obstructions such as underground transformers or other equipment.

5. **Guarding Live Parts.**—Protective equipment, such as switches and fuses, is required to have current-carrying parts inclosed in suitable cases, and joints or terminals of cables are required to be guarded against contact.

NEW OVERHEAD LINES

When overhead lines are to be considered by the inspector, their exposure of other lines, of railways, or of public traffic, all render necessary the proper application of carefully considered and specific requirements. In general, isolation of lines must be depended upon for protection of the public, rather than guards; the strength of conductors and their supports must be enough to assure maintenance of this isolation under the stress of extreme weather conditions. The necessary strength, again, depends on what these extreme weather conditions are likely to be in the particular district and the frequency of their recurrence. These weather factors vary widely over the country. The degree of danger, if isolation is not maintained, also varies, being greater where many persons are concerned, as in the case of travelers in trains where wires cross above railways and train-signal wires, or as in the cases where high-voltage lines cross above telephone lines used by many persons, or where high-voltage lines pass along busy city streets or thickly settled residence districts. Away from other lines, and in rural districts, on the other hand, the failure to maintain isolation may impose comparatively little hazard, and the strength necessary from the safety viewpoint may be easily secured.

It will not be attempted here to give a complete method of procedure for the inspection of lines, as too many factors are involved and conditions too varied are present, which call for the exercise of good judgment on the part of the inspector. However, for the general guidance of superintendents, foremen, inspectors, and others interested in safe construction and standard practice, an outline of procedure is given below, which will be helpful in making inspections under the safety code. For details the code itself should, of course, be used.

HOW TO INSPECT NEW OVERHEAD LINES

1. **Overhead Clearances.**—Proper clearance of lines should first be given due consideration. Overhead conductors above streets, tracks, and pathways should not be less than the values specified in the safety code. These clearances are governed by the character of traffic and the location and voltage of the lines concerned (sec. 24 and other rules which apply).

2. **Clearance from Structures.**—The clearance of overhead lines from buildings and bridges should be not less than the specified values, these depending upon whether the portion of the structure concerned is ordinarily accessible or not, and due regard should be paid to necessity for clear space for raising fire ladders (247, 248).

Both the above classes of clearances are almost entirely for the protection of the public, whose safety must be the prime consideration.

3. **Wire Crossings.**—Where lines of one voltage class pass over or near lines of another voltage class, either at crossings or parallels, the lines which by falling or by overturing of their supports could touch the others, need to have strength sufficient to give reasonable assurance that this danger does not exist. This is partly to protect the public, partly for users of the lower lines, and partly for workers on the lower lines. The degree of danger because of the number of persons exposed, as well as the severity of weather conditions in the different parts of the country, is considered in the specific strength requirements called for by the code for different combinations of these conditions. These requirements apply both to the wires and to their supports.

4. **Sags.**—The wires need to be sagged just deeply enough to avoid overstressing them at low temperatures and under severe ice and wind loads. If too deeply sagged, however, they may blow about and come in contact with other conductors, where the ordinary and practicable crossarms are widely separated. All conductors in any line will need to have nearly the same sag or the separation between them at the pole will not be maintained at the center of the span.

The smaller conductors, when at the higher level, fix the sag for all in a given span, since they are most affected by wind and ice, and therefore are required to have the most liberal sags from this standpoint; while, on the other hand, being the lightest, they are most liable to be blown about, and are therefore required to have as little sag as possible without exceeding the allowable unit stress. Large conductors, when below smaller conductors, should be given sags to average about the same as the smaller conductors, under ordinary conditions, but small conductors should not be permitted in such long spans as will make their use or the use of neighboring conductors dangerous.

Many computations, measurements, and discussions have led to the recommended sags tabulated in the safety code for various conductor sizes, span lengths, conditions of weather in different sections of the country, and degrees of hazard. These tables, while simple and readily used, are too long even to abstract here, and should be referred to when occasion requires. Their use is much simpler than would be an attempt to check the necessary sags by a rule specifying the maximum permissible stress, under a certain assumption of loading, which was the plan previously followed in strength specifications for overhead lines.

5. **Supporting Structures.**—In the same way the strength of poles or towers necessary to prevent their breaking or overturning under various weather conditions depends on the number of wires and on the length of spans. Towers, unfortunately for the inspector, always need calculation, but for ordinary wood-pole construction tables are given in the code which call for different sizes of poles, according to the weather conditions of the district concerned, the degree of hazard which failure of the line would cause, the span length, and the size and number of wires. As the use of these tables is much simpler than discussion of the considerations leading to adoption of the values given, this discussion will not be detailed here. These

considerations, experimental data, measurements in the field, and much other matter of interest to engineers are being prepared for later issuance by the Bureau in a pamplet on Engineering Data on Strength Considerations in Overhead Line Construction.

6. **Working Space.**—The safety of workmen on overhead lines, so far as it may be secured by permanent physical safeguards, depends on the liberality of spaces left for access along the pole to wires at different levels, and for access horizontally to the conductors most remote from the pole at any particular level. These spaces, called climbing spaces and lateral working spaces, respectively, in the code, are clearly and simply specified as to dimensions according to the voltage of the line wires adjacent to them. The necessity for a sufficient lateral working space, of course, also operates to limit the minimum vertical separation between different wire levels and between cross arms.

7. **Conductor Separation.**—The separation between conductors, whether in the same horizontal plane or in different planes, must be enough to prevent them from swinging together in the wind. Even in short spans where such swinging is unlikely, the necessity for working on one wire and being protected from others in the same horizontal plane necessitates use of a fairly liberal spacing. The necessary separation increases as the span lengthens, because the sag necessarily increases and makes swinging together more probable. Simple rules for ascertaining the proper separation for any size of conductor and for any depth of sag are given in the code. For very long spans, even the relatively large vertical separations between cross arms do not provide sufficient separation to prevent conductors from blowing together, and additional separation will become necessary vertically as well as horizontally.

8. **Accessibility.**—The rules also require the proper guying of poles, the use of adequate cross arms and pins, and the rendering of poles difficult of access for children and the public, often by eliminating pole steps near the ground, but relatively easy of access for workmen.

9. **Segregated Specifications.**—The rules include segregated sets of minimum requirements applying respectively to power lines crossing over railroads, to such lines crossing over publicly used signal lines, to signal lines crossing over railroads, and to situations where different classes of conductors parallel each other, either on the same pole line or on adjacent parallel pole lines.

GREATER COMPLEXITY OF INSPECTORS' PROBLEMS WITH LINE RULES

From the foregoing it may be seen that, while the application of the safety code to new interior wiring installations is readily made, and the application to new station construction and to underground line installations is not difficult, its intelligent application to new overhead lines involves considerable study of rules and practice on the part of the inspector. The conditions of weather, surroundings, and character of lines are so varied and the interests concerned are so diverse that very brief requirements would provide no adequate or reasonable guide. The application of the specific code requirements, often in tabular form, however, involves no considerable technical knowledge, unless steel towers need to be calculated, and these cases are sufficiently rare to offer no serious obstacle to general use of the rules by inspectors. The Bureau of Standards often can be of assistance in making such calculations and in ascertaining whether an existing or proposed construction complies with the code requirements.

In initiating the inspection of new lines in any territory, it will usually be sufficient for the inspector to begin by checking only the simple items of proposed clearance. The minimum strength requirements generally become operative only with comparatively heavy lines. Where such lines are to be used, the company will usually be of considerable size and will accordingly have a competent man to plan its line in accordance with the safety code. In fact, it is anticipated that the use of the code requirements for overhead lines by the utilities themselves will be much more general at first than their use by inspectors. This should aid the inspector, who can discuss line matters with the utilities involved. The Bureau corps of engineers will be glad to be of assistance on any matter coming into question or dispute.

HOW TO EXTEND INSPECTION TO COVER STATIONS AND LINES AS WELL AS UTILIZATION EQUIPMENT

With underwriting and municipal inspection departments, the extension of inspection from new interior wiring to include also new station installations and new line construction will not seriously tax the resources of the department, since the number of such new installations will not be excessive. In large jurisdictions the administration would, of course, be benefited by turning over these new duties to one or more additional inspectors, particularly fitted by experience to handle them. The careful study of such new installation problems will, of course, the better fit the inspector for successfully handling the more difficult existing installation problems when these are later taken up.

The inspector could require from the utilities or others concerned notification as to any new construction, extension, or reconstruction contemplated, so that permits could be issued (where the extent of the work would warrant), and inspections could be made, as the work proceeds, in the same manner as with building wiring installations to-day in these same jurisdictions. There will be a certain amount of station and line installation work done by large mercantile or manufacturing concerns who operate private plants and have a more or less extended yard wiring. Of course, the hazards depend on the voltages and plant capacities involved and not at all on the question of ownership by private concerns or public utilities. Municipalities will not find difficulty in establishing jurisdiction; however, an underwriting department sometimes might, although the objector would probably find little public support for such an attitude in a community where the inspection department had established itself as a helpful and even necessary institution, which is the position generally of underwriting inspection departments.

PARALLEL INSPECTIONS OF NEW INSTALLATIONS BY OVERLAPPING ADMINISTRATIONS

It will often be found that there are several inspections by different administrators proceeding in certain territories on new installations—of factories, of stations, and of lines—some by State public service, industrial, or insurance commissions, and some by casualty underwriters. These are in addition to the inspections by the longer established fire underwriters and municipal inspectors. The inspection by these newer inspection departments is frequently not as thoroughly systematized and as universal as that of the longer established departments. This is largely because States and casualty underwriters will have far less inspectors and partly because their duties will usually include so many inspections other than electrical that the electrical inspections will necessarily be less thorough and, in particular, will not usually cover the new installation work until after it has been actually placed in service.

Thus, their inspections often will not have the same directive tendency as the inspections of the older agencies, and this will limit their results, because they will often be under the necessity of avoiding the duplication of installation costs which would be involved in their calling for reconstruction to comply with the code, unless the hazards involved are so large as to warrant this expense. In directing new work, as is possible where the inspection is supervisory as well as critical, this question of duplicating cost is, fortunately for administrator and installer, entirely avoided. This parallel inspection, which will be encountered, still more emphasizes the necessity for uniformity of rules; that is, for a single safety code.

Such duplication of inspections by different administrators will often be found unwise and unnecessary. An effective cooperation between the various administrators will result in much better, as well as more frequent, inspection, and a study by the newer inspection agencies of the methods and results of the older agencies will often be advantageous.

The Industrial Department of Pennsylvania, although unusually well equipped with inspectors, has realized the undesirability of overlapping and the advantage of coordination in inspections and has effected an arrangement with the Underwriters of the Middle Department by which the electrical inspectors of the latter organization are now inspecting the electrical equipment of factories from the life hazard as well as the fire hazard standpoint. This is possibly the first case where a fire insurance inspection agency has definitely assumed a directive relation to electric wiring and equipment installations, to minimize both fire and life hazards, and has established an inspection avowedly from both standpoints, with the assured support of the authority of the State.

A similar arrangement is under contemplation in the State of California, by which the Industrial Accident Commission will deputize the municipal and underwriters' inspectors, and thus make its safety inspections at a minimum cost and with the maximum of effectiveness. These two industrial commissions are as well provided with technical and executive staffs of high abilities as are any State commissions in the country, and their action in this respect may well be followed by the many commissions having relatively meager staffs for the administration of their adopted rules for safety.

HOW TO HANDLE EXISTING INSTALLATIONS

So far we have left untouched the question of applying the rules to existing installations. The extent to which such application is advisable is clearly set forth in the introduction to each of the four parts of the code. In most cases the old inspection department, by regular established routine, now gives its primary attention to requests for inspections of new electrical installations and assumes that, in general, all others are standard or that their variations from standard are not sufficient to cause serious hazards, this being the custom with municipal inspection departments generally and with many fire underwriting departments.

There is, however, another duty of the electrical inspector to his community, and that is in reasonably minimizing the hazards of these existing installations. Even had electrical installers in the past been gifted with greater wisdom than were the makers of rules and had their installations, therefore, been initially without any serious fire or life hazard, it is certain that few installations can remain long without some addition or change which may introduce more or less serious hazards, and it is equally certain that none continue in place without an accelerating deterioration which also results in an increase of hazards. Sooner or later the changing needs of the users may call for replacement or reconstruction of the installation as a whole, or of some major part, and this is brought to the attention of the inspection agency as a new installation or as an extension. This reason for reinspecting old installations could, of course, be made to apply with equal force to line construction and station construction, portions of electrical construction where inspectors, because lacking a code, have heretofore assumed little responsibility. Prior to any occasion for such general reconstruction, there accumulate numerous conditions of hazard to life and property which deserve and should receive careful attention and treatment. These at present come to the knowledge of inspection departments in various ways and to varying extents. In the case of certain installations known to be of particularly large extent or peculiar hazard, a regular reinspection has often been arranged for by inspection departments. In the great majority of jurisdictions, however, reinspections of all installations once a year would mean several times as large an inspection force as now exists or as would be at all practicable.

The plan has, therefore, commonly been to let minor hazards accumulate until brought to the attention of the inspection department by special means. This might often be through report from some individual who has had impressed on him some special danger in a particular installation. Inspectors are familiar with the various sources through which such information regarding defects in existing installations usually comes to them. Then the installation will be inspected, and the inspector will decide whether some minor equipment and appliance changes will, for the present, suffice or whether a complete rebuilding is necessary. Such discretion has, in the past, been assumed by electrical inspectors, although using a code (the National Electrical [Fire] Code) which sets a fixed standard for all wiring. The safety code provides definitely that the necessity for application of any rule to existing electrical installations depends on the balance between the degree of hazard which will be removed and the cost of removal; that is, upon the practicability of the application. The practical application of this principle will require the inspector and the owner to confer and together decide when changes are necessary.

In the cases of existing installations, the character of service rendered by State commissions and by underwriters, entailing the inspection of occupied buildings and of lines in actual use, varies from the character of service which so many municipalities have been limited to, involving usually only inspections on new interior wiring. The new powers and duties, which have followed upon the growth of compensation laws and the advance of public safety, encourage among inspection authorities of every kind, however, a closer inspection of existing construction than has heretofore been considered necessary or practicable. This should not lead to unnecessary hardship or duplication of costs, as this would cause a severe setback to the electrical industry, and safety would not be enhanced to any commensurate extent. Indeed, safety might be decreased by the substitution of other forms of energy which are less safe but whose hazards have not been so carefully studied.

It is, therefore, of the greatest importance that newly organized inspection agencies, whose duties are such as to permit the inspection of old equipment, should use great discretion in ordering changes and should, either of themselves or through other inspection agencies, direct a large part of their energies to the avoidance in new installations of those defects whose correction in old installations is so difficult or costly as sometimes to be impracticable. Another portion of their labors may well be given to the adoption, with existing hazards, of expedients in protection which could not be tolerated with new equipment. Above all they should avoid obscuring the end in view (the maximum feasible degree of safety) by trimming down the requirements for new installations to a point where they appear to be generally feasible for full application under some time-limiting retroactive clause which may unfortunately have been written into their rules, to existing equipment as well. Such a confusion tends to put on owners of past construction an unnecessary burden of extra costs and to relieve new construction of necessary reasonable requirements.

INSPECTION OF EXISTING STATIONS

When inspectors come to apply the standard to existing station or line equipment, they will find confronting them conditions very different from those where existing interior wiring is being inspected, and a very different treatment is warranted.

Considering stations first, it is noteworthy that the installation in a station is in the hands of presumably qualified operators, whose constant attention and trained judgment may rightly be relied upon to minimize fire and life hazards which would be serious in interior wiring where no such expert and constant attention existed. This fact, combined with the great costs sometimes involved in making changes, makes intelligent discretion necessary in calling for installation changes to comply with the safety code. Generally, insulating platforms or mats may properly be called for, and where live parts exposed at moderate heights above the floor are adjacent to passageways their guarding on some definite and adequate plan usually may be reasonably required. Yet some cases will arise where the use of guards would obstruct the passage of persons, and where this is true and only infrequent inspection by operators is necessary such passageways should rather be discontinued as such and screened to prevent such use, omitting guards for the live parts themselves. The occasionally necessary examinations by station operators can then be made with special portable protective devices and the reasonable safety of the attendant still secured. With utilization equipment, of course, it would be unwise to depend on any such special precautions of attendants.

The frequency of reinspections of central and substations by the authorities will be, probably, at least as great as those of utilization installations, because they are brought so often to the attention of the inspector, so the inspector must exercise his discretion as to the extent of his recommendations for improvements under his code of rules. As grounding of equipment frames probably involves the least cost for the protection secured and usually no cost above that which would have been necessary in similarly protecting new equipment, this is generally a suitable starting point for the inspector. Later, the questions of guarding and of moving minor equipment in order to secure adequate working space or to isolate live parts can be taken up as seems warranted by the added safety, with due attention to the costs entailed by each improvement.

Where any considerable rearrangement of the installation is contemplated for other than safety reasons, a rather complete rearrangement from the safety standpoint can usually be made. It seems probable that all proposed station changes involving rearrangement or replacement of any rotating machine or of any considerable portion of switchboard or stationary equipment might well be brought to the attention of the inspector by the station owner in advance as part of a regular plan of procedure. The advantage of establishing a sympathetic understanding on new station work before attempting to handle the more difficult problems of existing station installations seems obvious.

INSPECTION OF EXISTING LINE INSTALLATIONS

When existing overhead line construction comes before the inspector for consideration, he has indeed a difficult problem before him. Such obvious defects as the lack of sufficient clearance are the most imminent causes of personal and property hazard in line construction. The different hazards of line construction are so complex and interrelated, however, that the inspector must use care while calling for the betterment in one direction that this does not increase some other less obtrusive hazard. For instance, conductors carried too close to buildings are a hazard to occupants and repairmen. Moving them away, however, might crowd the conductors on the pole and reduce the clear climbing space for linemen. Moving other wires out also, so as to retain this climbing space, may cause the conductors to obstruct the usual space for fire ladders to a distance farther than 8 feet from buildings of over three stories where such space for ladders may be needed and is required elsewhere in the code. If wires are kept 3 feet away from buildings, this leaves room for only 5 feet active wire space on cross arms. Out of this a 30-inch climbing space must be left free along the pole, allowing only four wires on an ordinary arm; or by the use of side arms, all the space available for wires may be at one side of the pole, and six wires could then be used if spans are short enough to permit such close wire spacing. In some existing situations, where close to buildings of four or more stories, the requirements to move wires away from buildings might necessitate, (1) higher poles (more cross arms), or (2) the labor of changing regular arms to side arms, or (3) simply the moving over of wires near the buildings to vacant pins, if such exist, nearer to the pole.

The seriousness of the hazard will, then, determine what should be done. If very serious, and buildings are high, the setting of new poles may be warranted, although very costly. More often it would be possible to rearrange wires and arms at much less expense. Not infrequently it will be sufficient to guard by a suitable screen or other means, together with a plain warning sign, some fire escape, balcony, or other projection which may be the only part of the building closely exposed by the wires, thus avoiding the moving of wires themselves.

In the same way the clearance of existing conductors above streets and walks may be readily checked on inspection, and this may be found too small, endangering ordinary traffic. This is usually a matter involving more hazard than the proximity of wires to a single building, since more persons are exposed and the hazard is less suspected. The rearrangement of wires or arms and poles, the placing of new arms, or even the placing of new poles will more often be warranted. The clearances of wires above ground called for in the code have been arrived at with due consideration of the far greater advantages from moderate but uniform clearances in all territories than from greater clearances in some territories than are usual in others. Such inequality may encourage the use of higher vehicles, which later go into the communities of less clearance and endanger life and property there.

Similarly, the strength of guys, the placing of traffic guards or guys, the elimination of pole steps too readily accessible to children, and similar matters are readily and usefully taken into consideration by the inspector while inspecting the existing pole lines. Correction of defects in these respects by compliance with code requirements will, usually, at almost negligible expense, secure important increases in the safety of the public.

However, the safety provided by moderate clearances is assured only by their careful maintenance. This involves adequate pole strengths, sizes of conductors, span lengths, and sags of conductors used. In ordinary cases of good construction, as before stated, only a few of the smallest conductors on any pole line and a very few poles out of the hundreds or thousands installed will be found weaker than is necessary to meet the very moderate strength requirements of the safety code. It would, under such conditions, become the duty of the inspection department, after ascertaining any respects in which line failures are more liable to occur than if the construction conformed to the code, to decide whether the removal of the defect should be required in view of, (1) the expense involved, (2) the hazards due to congestion of traffic, (3) the exposure, if any, of other lines, or (4) all of these considerations.

NONSTANDARD METHODS FOR MITIGATING HAZARDS OF EXISTING CONSTRUCTION

As has been the habit of the more successful, long-established inspection departments in the case of interior wiring, it will be advisable, after inspection has revealed defects in existing installations of any kind, from either life or fire standpoints, to consider carefully any nonstandard means by which the hazards may have, nevertheless, been already satisfactorily reduced, or by which they can be more readily and cheaply obviated than by a strict compliance with the letter of the code, yet not to encourage extension through the community of nonstandard methods, even in the improvement of existing construction. If improvement seems essential, either in the way of standardizing the construction or removing its hazards by other methods, the inspection department must decide as to how soon such changes can reasonably be effected. A contemplated early rearrangement of the installation for other reasons should almost always, except with unusual hazards, constitute a sufficient cause for slightly delaying changes called for from safety considerations alone.

REASONABLENESS IN RULES AND IN INSPECTIONS

It should be the confident assumption of the inspection department, whether underwriting or municipal, that the public utility or other industry to which the code is being applied is well disposed toward making its physical arrangements as safe as practicable. The inspection department well knows that absolute safety is impossible and that, in approaching this ideal, a point is reached where further improvement can be obtained only at a prohibitive expense. The effort in formulating the code has been to set an entirely moderate minimum standard for new equipment, in the realization that the degree of application which will be found reasonable to existing equipment depends on the original plus the correction expense involved in securing compliance with the standard. This careful treatment and attitude have met almost universal response in the support of the industry in all its branches to the safety code as a guide.

Apprehension has been freely expressed as to whether this same appreciation of the limits of reasonable safety could be expected of the diverse inspection authorities whose actual handling of the code can so greatly either help or harm the industry. The Bureau is confident that the application of the code in this spirit, regardless of the minor oppositions and disagreements which are not a new matter to most inspectors, will result in bringing to the administrators of the safety code the increased confidence and support of their entire communities, including those most affected by particular expenses to which they have been put by such an application of the code. Best of all, the administrators will have introduced, largely without friction, an agency which should reduce the electrical personal disability waste far below its present millions of dollars yearly, and so enhance one of the chief assets by which electricity has secured its amazing growth and deserved popularity—its safety.

COMPARISON OF EXISTING INSTALLATIONS WITH THE SAFETY CODE REQUIREMENTS, MADE BY THOSE TO WHOM THE RULES APPLY

Whether an administration of the safety code has been established or not, those responsible for existing installations, whether in stations, on lines, or in utilization situations, will wish to ascertain what discrepancies of importance exist between their present practice and the code requirements. This will be in view of the probable later adoption of the code in the community concerned, and because owners in general desire to assure the safety of their plants and employees as far as practicable, in the light of the best guide available for their use. In the absence of any stable or comprehensive standard heretofore, installations have naturally varied very much according to individual opinion and experience, and in some cases there has been a lack of balance in the treatment of the various hazards, some having been given close attention and careful treatment and others having been overlooked or neglected.

In the case of utilization equipment, the engineer or electrician might proceed to examine his situation from the electrical safety standpoint along much the same lines as would an inspector. Often such an inspection will have the advantage that the future plans for the business concern are in the mind of the inspector. He can thus often lay out a schedule of changes in the electrical equipment which will add little to the expense as compared with what would otherwise be required, but which will accomplish the end of bringing the installation into conformity with the standard; whereas such a general rearrangement of the installation might, from the standpoint of the administrator's inspector, seem to involve an expense unwarranted solely by the additional safety secured.

Where the safety code is already adopted, but no inspection of the individual plants has yet been made by inspectors of the administration, such a preliminary inspection by the owner of the installation will well prepare him for a discussion of the subject with the representative of the administration, and such discussions should be encouraged by both as means for accomplishing the desired safety with the least duplication of costs. Without such cooperation, minor requirements may be applied by the inspector which will have no place in the general scheme of rearrangements called for by the later development of the installation for other causes.

A listing of equipment to be replaced, provided with greater clearances, guarded, or grounded, because of the development of business, compared with a list of costs of necessary equipment replacements, moving to secure greater working space, guarding or grounding to secure compliance with the safety code, will often show a sufficiently small expense directly chargeable to application of the code to an existing installation so that the installation betterment can be carried through without embarrassment to the owner. In coming to an understanding with the owner regarding changes, the following provisions of the code, under application of rules, should be considered:

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

It will sometimes be necessary to modify or waive certain of the rules in cases of temporary installations or installations which are shortly to be discarded or reconstructed.

In cases of emergency, or pending decision of the administrator, the person responsible for the installation may decide as to modifications or waiver of any rule, subject to review by proper authority.

VI. SUMMARY OF SECTION 9 OF THE NATIONAL ELECTRICAL SAFETY CODE: RULES COVERING THE METHODS OF PROTECTIVE GROUNDING OF CIRCUITS, EQUIPMENT, AND LIGHTNING ARRESTERS FOR STATIONS, LINES, AND UTILIZATION INSTALLATIONS

OBJECT OF GROUNDING

One of the principles of protection of widest application throughout the National Electrical Safety Code is the protective grounding of metal frames or other parts of machines or appliances. The object of such grounding is to prevent these metal parts from acquiring a different potential from that of the earth and grounded objects in the vicinity through breakdown of insulation between them and the live parts within the apparatus. A second application of this principle of protection is the grounding of low-voltage circuits. Such circuits, where exposed through transformer windings or in overhead line construction to danger of contact with higher voltage lines, are so protected by proper grounding that such contact can not raise them to dangerous potentials.

In order to assure that equipment or circuits can not be brought to potentials much different from that of the earth or of plumbing and other grounded objects within buildings, it is essential that the ground connections between the equipment or circuits and the earth be mechanically substantial and of sufficiently low electrical resistance. To secure this is the purpose of the specifications in sec. 9 of the code.

90. **Single Specification Applicable for Many Conditions.**—The rules of the code which call for protective grounding are listed at the end of this chapter.

The specifications for the methods of grounding are included as an introductory section to the code, because these methods are applicable to protective grounding in general, and such grounding is called for in all parts of the code. Thus, much repetition is avoided, and the rules, as a whole, are reduced in bulk.

91. **Extent of Application to New and Old Installations.**—The intent is that the rules shall apply fully to new installations or extensions; also, to existing construction where the expense

involved is justified. Grounding, in general, can be so readily and cheaply done and the degree of safety is so much improved that the application of the specification should probably be generally made to existing circuits, equipment, and arresters, no less than to future installations.

92. **Where to Attach the Ground Conductor.**—The specification begins by designating the place or places for attaching the ground conductors to direct-current distribution systems, alternating-current distribution systems, lightning arresters, equipment, and wire runways. With direct-current systems, close limitation is placed on the number of points on the system to which ground connections may be attached, station locations only being permissible, but with alternating-current systems, the use of separated multiple connections is urged. With 3-wire direct-current or alternating-current systems, ground connections should be made to the neutral conductor. The place in a multiphase alternating-current system at which the ground connection should be made is that which results in the lowest maximum voltage to ground of the protected circuits.

For lightning arresters the place of attachment of the ground conductor is fixed by the location of the arrester, and this position should be such that the ground conductor is as short and direct to the earth as possible. For equipment, conduit, or metal molding the point of attachment of the ground conductor should be accessible to inspection.

The reason that direct-current systems are limited as to the number of permissible ground connections, while a multiplicity of grounds is urged for alternating-current systems, is because of the greater danger from electrolysis with direct-current systems, whereas with alternating-current systems the danger from electrolysis is more remote. At the same time the exposure of alternating-current secondary distribution systems to higher voltages is much greater, and the assurance against loss of ground connections, together with the decrease of resistance due to multiple connections, strongly supports that practice for the latter type of circuits.

93. **How to Run the Ground Conductor.**—The specification next makes clear the necessary continuity and current capacity of the ground conductor and any of its joints. Placing any automatic cut-out in the ground conductor is, in general, prohibited. The numbers and sizes of ground conductors necessary for circuits, lightning arresters, and electrical equipment are also specified.

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These requirements depend on the necessity that a ground conductor must remain serviceable while carrying current equal to the full current capacity of the circuit, or arrester, or of the largest circuit connected with the electrical equipment or wire runway concerned.

The use of suitable mechanical and electrical protection for ground conductors is also required. Insulating guards are required where few ground connections or high-resistance grounds make a rise in the potential of the ground wire likely through chance disconnection from the ground, or through passage of current over the high resistance. Because of this liability of disconnection from the ground and rise in potential, due to passage of current over a relatively high ground or contact resistance, the insulation and guarding of a ground conductor for a circuit is required to be equal to that of the circuit wires, except for certain ground wires entirely outside of buildings and very substantial ground busses in stations. The method of mechanical protection necessary for ground wires where carried underground is separately specified.

94. **Ground Connection to Earth.**—The grounding specification then defines the nature of connection between the ground conductor and earth which is to be used to assure effectiveness and permanency. Connection should preferably be made to extended underground metallic water piping systems wherever such are available, but advantage may be taken of restricted underground metal piping and other buried metal structures. Ground connections may even be made to the steel frames of buildings under certain restrictions, in cases where water piping systems are not available. The making of ground connections to gas piping is generally not permissible. In case of inability to utilize either of the types of grounds outlined above, artificial grounds, such as driven pipes and buried plates, are permitted. At least two artificial grounds are required for any low-voltage circuit, while a single ground of that type is permissible for arresters and equipment if the resistance of the ground is sufficiently low and the current capacity of the arresters or equipment not great.

Finally, ground connections to railway returns or to artificial grounds in the neighborhood of railway returns are dealt with, the former, except for railway lightning arresters, being definitely prohibited where other effective means of grounding are available. Multiple ground connections, partly to railway returns and partly to other metallic structures in contact with earth, are always prohibited.

95. **Place and Manner of Attachment to Pipes and Plates.**—The specification then indicates the place and manner of attachment of a ground conductor to a piping system or other ground. It requires that such connections, if made to piping systems, be attached generally outside of gas or water meters or that the meters be shunted. In the case of a protective ground for equipment, however (but not for circuit ground connections), the ground connection is permitted to be made to water piping near the equipment, provided the electrical continuity of the piping system is maintained from the point of such attachment back to the entrance of the water service to the building. The method of grounding just described is not permissible for grounding circuits. Gas piping is permitted to be used as the sole ground connection for electric fixtures not within reach of other plumbing or plumbing fixtures.

The required method of attaching the ground wire to pipes is specified. The specification states that artificial grounds should be located below permanent moisture level, or at least 6 feet deep in the soil, and at least 2 square feet of exterior surface is required to be provided for contact with the earth.

96. **Resistance of the Ground Connection.**—The specification proceeds to designate limits for the permissible resistance of ground connections, relating this with the current capacity of the high-voltage circuit which exposes grounded circuits, or the lightning arresters, equipment, or wire runways.

In general, where water piping systems are used for the ground connection, the ground resistances will be but a fraction of an ohm, but the specification permits considerably larger resistance values for this type of ground connection. Where resort must be had to artificial grounds, including driven pipes, resistance values as low as those obtained when using water piping systems are generally impossible to obtain, and only under exceptionally good soil conditions or with very large numbers of grounds used in multiple can such values be even approached. While two artificial grounds will sometimes not keep the ground resistance even below the much larger resistances named as the desirable maximum for artificial grounds—25 ohms—two grounds are all that are *definitely* required. The necessity for multiple grounds is also increased through the liability that one or more of a group of such grounds may dry out and so become entirely ineffective.

A method for checking the resistance of grounds is given, and inspection, and in certain cases testing of ground connections, is called for.

97. **Restricting Joint Use of Ground Conductors.**—Finally, the grounding specification prohibits the joint use of a single ground conductor by different kinds of circuits or equipments, where such use would create a serious liability to fire or life hazard. *Common use of a ground conductor for secondaries entering buildings, and machine frames, electrical conduit, fixtures, or other appliances within buildings, is prohibited.* It is generally desirable also that artificial grounds, which are used for a lightning-arrester ground connection, should not be used as a ground for other purposes.

RULES OF THE CODE REFERRING TO PROTECTIVE GROUNDS OR REQUIRING THEIR USE

Part I.—STATIONS

Rule 113 (*b*)	Grounding of noncurrent-carrying metal parts of station equipment, in general.
Rule 123 (*b*)	Grounding of inclosing cases where inflammable gas exists.
Rule 124	Grounding of noncurrent-carrying parts of generators.
Rule 125 (*b*)	Grounding of inclosed cases where excessive moisture exists.
Rule 140 (*b*)	Grounding of conduit containing secondary circuits.
Rule 141	Grounding of low-voltage circuits of instrument transformers.
Rule 142	Grounding of transformer cases.
Rule 153	Grounding of metal conduit or other metal sheathing for conductors.
Rule 163	Use of grounding switches where necessary.
Rule 168	Grounding of noncurrent-carrying parts of switches and cut-outs.
Rule 175	Grounding of switchboard frames. Use of grounding switches where necessary.
Rule 176 (*f*)	Grounding instrument cases.
Rule 182	Running of ground wires.
Rule 183	Grounding of lightning arrester frames.
Rule 184 (*b*)	Use of grounded mechanisms to adjust arresters.

Part II.—LINES

Rule 205, 207	Noncurrent-carrying parts of overhead line equipment within reach from the ground. Metal conduit cable sheaths and equipment cases within reach of the public are required generally to be grounded.
Rule 246	Separation and mechanical protection of ground conductors.
Rule 252	Under some circumstances the accessible portions of guy wires are required to be grounded.
Rule 288 (*f*)	Protection of signal lines for use by the public.

Part III.—UTILIZATION EQUIPMENT

Rule 304........Calls in general for the grounding of low-voltage circuits to which other than qualified electrical workmen are exposed, with certain exceptions, including circuits which are not exposed to high-voltage circuits in any way, also including circuits over 150 volts to ground, for whose current-carrying parts guarding is required, so that the personal hazard is otherwise considerably reduced. This same rule also calls for the grounding of noncurrent-carrying metal parts of electrical utilization equipment in general.

Rule 307 (*c*).....Grounding of equipment frames in special cases.

Rule 310........Prohibits the use of automatic cut-outs between the point of installation of a ground wire on a circuit and a source of energy supply.

Rule 313........Requires the grounding of metal conduits or metal sheathing of conductors in general.

Rule 314........Conductors in grounded conduit where inflammable gas exists.

Rule 318........Calls for the grounding in general of service conduit or armored cable.

Rule 326........Calls for the grounding of noncurrent-carrying metal parts of switch and fuse cases.

Rule 334........Calls for the grounding of switchboard frames.

Rule 342 (*b*), 343.Require the grounding of motor frames under certain circumstances.

Rule 351........Calls for the grounding of metal frames of electric furnaces and welders in general.

Rule 360........Requires the grounding of electric-light fixtures and other fixed electrical devices.

Rule 363........Frames of electric signs to be grounded.

Rule 366........Lamp suspension chains to be grounded when within reach from the ground.

Rule 371........Recommends the grounding, where practicable, for metal frames of portable devices.

Rule 380, 381...Calls for the grounding of metal frames and casings of electrical equipment; also of exposed metal piping on electric cars, cranes, and elevators.

Rule 390........Requires the grounding of exterior metal parts of signaling devices under certain conditions, particularly of fire and police alarm boxes.

Rule 391, 392...Calls for further grounding for frames of signal devices, under certain conditions.

Rule 393........Requires the grounding of arresters on signal systems.

It may be noted that the last-named rule includes also a brief specification for the method of grounding to be followed under this particular condition. This specification includes requirement for minimum size of conductor, for its mechanical protection, and for the character of connection; use of a cold-water pipe in service being required where this is available, but steam, water, gas pipes, or even driven rods or pipes, under certain restrictions, being permitted where such water pipes are not available. The methods of connecting the ground conductor to pipes, driven rods, or buried electrodes are also given.

VII. SUMMARY OF PART I OF THE NATIONAL ELECTRICAL SAFETY CODE: RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL SUPPLY STATIONS AND EQUIPMENT

The rules apply to the character of installation of generators, motors, storage batteries, transformers, and arresters, where under control of qualified operators whose attention is not distracted by nonelectrical processes and inaccessible to others (100).[4] The rules are to be applied generally to new construction and to a limited extent to existing construction. Any rule may be modified or waived when found impracticable (101).

For convenient use the rules are divided into 9 sections, 10 to 18, inclusive.

Sec. 10. Protective Arrangements of Stations and Substations.—The spaces in which electrical supply equipment is installed must be kept clear of dangerous processes, materials, gases, or dampness (102), must be properly illuminated and provided with emergency lighting (103), and must be inaccessible to unauthorized persons (104). Floors must give good footing, floor openings and stairways must be protected (105), and adequate exits from such spaces (106) and safe fire-fighting facilities must be provided (107).

Sec. 11. Protective Arrangements of Equipment.—Electrical supply equipment is required to be so installed as to minimize the attendant life hazard and to comply with the rules (110), and the installation must thereafter be properly inspected and maintained (111). Noncurrent-carrying parts exposed to contact are generally required to be permanently and effectively grounded (113), with given exceptions, the grounding to be in accordance with the methods given in sec. 9. Current-carrying parts are required generally to be either provided with adequate working spaces (114), guarded (115), or isolated (116), and the voltage and other determining conditions are outlined. Equipment must also be sufficiently identified by suitable means (117).

Sec. 12. Rotating Equipment.—Prime movers and, under given conditions, certain electric motors, must have automatic speed-

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[4] Numbers in parenthesis refer to the individual rules in the code.

limiting devices (120), and no-voltage releases are required for certain field rheostats (120). Prime movers or motors driving generators are required to have conveniently located stopping devices (120), Special protection of windings, etc., is called for where exposed to steam or oil (125). Guards are required for pulleys, belts, and other moving parts (121). The character of guarding for live parts is specified (122) and special rules given for grounding noncurrent-carrying parts (124). In locations where inflammable gas or flyings exist, special inclosures are required for parts which spark or arc during operation (123).

Sec. 13. Storage Batteries.—Batteries above 50 kw-hrs. capacity are required to be in separate inclosures (130), ventilated to the outside of the building (131), and illuminated as specified (134). They are to be set on well-drained, acid-resisting floors with suitable insulating supports (132). Live parts at high voltage are required to be so separated or barriered that persons can not readily make short circuits between them (133). All conductors in battery rooms are required, if subject to corrosion, to be well coated with corrosion-resistive material (135).

Sec. 14. Transformers, Reactances, Induction Regulators, Balance Coils, and Similar Equipment.—Means must be provided for readily short-circuiting current transformer secondaries (140). Low-voltage circuits of instrument transformers and the cases of transformers in general are required to be permanently grounded unless identified and guarded as high-voltage parts (141). Transformers used with utilization equipment are required to be installed under station, line, or utilization rules, respectively, according as they are so located or of such voltage that they come within the scope of any one of the parts of the rules (143).

Sec. 15. Conductors.—Automatic cut-outs are required to protect conductors against electrical overload (150), and mechanical guards or flame-proof covering to protect against mechanical injury or spread of flames, under certain given conditions (151). Even where mechanical disturbance is unlikely, effective isolation (152), or guards, mats, and other protection, is specified according to given conditions of voltage and other factors, to safeguard persons in the vicinity of conductors (153). In gaseous surroundings, conduit must be sealed to prevent entrance of gases (154). A number of special rules cover damp locations (154), use of flexible cords (155), the safeguarding of temporary wiring (156), and taping of joints (157).

Sec. 16. Fuses and Other Cut-outs; Switches and Controllers.—Detailed requirements are given for the character of these protective and control devices, which must be accessible, must identify the equipment controlled, must not be subject to accidental operation (160), and must be suitably inclosed if in gaseous or other hazardous locations (161). Some of the places and conditions requiring use of switches or of disconnectors are specified (162). Arrangement for the locking or blocking of switches is required under given conditions and airbreak switches are specified for certain places (164).

Automatic cut-outs are required for given conditions (165), and provision must be made for their safe disconnection in a specified manner (166). The suitable isolation or shielding of fuses and circuit breakers is required to avoid burning or striking persons in their vicinity (167). Grounding of exposed noncurrent-carrying metal parts of switches or cut-outs is required under certain given conditions (168), and the special requirements for suitably guarding live parts of these devices are detailed (169), including the use of sufficient working spaces, isolation by elevation, barriers, or mats, as the given conditions determine.

Sec. 17. Switchboards.—The points of control are required to be readily accessible (170), the board to be well lighted (171), equipped with necessary instruments (172), orderly in arrangement and with points of control well identified (173). It is required that arrangement of boards be such that temporary barriers may be placed about live parts while work is being done on the board, and suitable normal separation of parts of different potential is called for (174). Detailed requirements are given for the grounding of switchboard frames (175) and for the guarding of live parts by isolation, barriers, or adequate working spaces, according to the voltage and other conditions involved (176).

Sec. 18. Lightning Arresters.—Provision for disconnection of arresters is required under certain specified conditions (181), and suitable location (180), ground connections (182), and guarding of live parts of arresters (184) are specified. Metal frames or cases of arresters must be grounded unless marked as high-voltage parts and suitably guarded (183). Arresters installed with utilization equipment must comply with either line or station rules, according as they are so located or of such voltage that they come within the scope of such rules (185).

VIII. SUMMARY OF PART 2 OF THE NATIONAL ELECTRICAL SAFETY CODE: RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL SUPPLY AND SIGNAL LINES

The rules on overhead and underground lines cover both transmission and distribution lines and their auxiliary equipment. They are intended to apply to all new installations except where, for special reasons, any rule can be shown to be unreasonable or impracticable. Existing installations should be supplied with any necessary guards within a reasonable time as determined by the proper administrative authority.

The rules of Part 2 are divided into 10 sections numbered 20 to 29, inclusive, of which 20 is general, 21 to 28 apply to overhead lines, and 29 applies to underground lines.

Sec. 20. General Protective Requirements.—Lines are to be so installed, inspected, and repaired as to comply with the requirements and minimize the life hazard (202, 204). The rules are minimum requirements, but their interdependence must be considered if any one requirement is increased (203). Lines are to be isolated or guarded, poles are not to be stepped too near the ground and metal parts are to be grounded if within reach (205, 207). Switches, conductors, and poles are to be so arranged and marked as to facilitate identification and safety in operation (206, 208).

Sec. 21. Grades of Construction Required for Crossings, and Other Conditions of Hazard.—In order to provide a degree of strength in overhead lines comparable with the hazard involved, and to limit the expense of construction to an amount warranted in minimizing the hazard, three grades of construction for supply lines and two for signal lines are prescribed.

Grade A, the highest grade of construction, is required for supply lines where they cross important railways and for supply lines above 7500 volts, where crossing, conflicting with, or on common poles above signal lines (211, 214).

A lower grade of construction, grade B, is required for supply lines over unimportant railroads, or where supply lines between 5000 and 7500 volts cross, conflict with, or are on common poles above signal lines; or where supply lines over 7500 volts are in urban districts either alone or crossing, conflicting with or on common poles above other supply lines (212, 215, 217).

A still lower grade of construction, grade C, is required in urban districts for supply lines between 750 and 5000 volts either alone or crossing, conflicting with, or on common poles above signal lines; for supply lines from 750 to 7500 volts in urban districts or crossing, conflicting with, or on common poles above other supply lines; and for supply lines over 7500 volts in rural districts where crossing, conflicting with, or on common poles above supply lines under 750 volts (216, 218, 219).

Two other grades of construction are specified for signal circuits crossing over railways, grade D where the railway is important, and grade E where spurs, branches, or unimportant railways are concerned (213). (Unimportant railways are generally those having not more than a single parallel signal circuit.) Several alternative methods of construction for telegraph and other signal lines not for public use and for supply lines exposing them are permitted. The signal lines may be considered either as signal lines for public use, as supply lines of the highest voltage to which they are exposed, or they may be protected in such a manner as to prevent their voltage to ground from exceeding 400 volts (210, 213).

Where none of the above hazards are present, no special requirements are made as to strength of construction for supply lines (212, 216, 218, 219).

Sec. 22. Strength and Sags of Conductors.—The requirements as to conductors for any particular installation are determined not only by the grade of construction required, but also by the wind and ice loading which is likely to be experienced in any locality (220, 222). Three loading districts, known as heavy, medium, and light, respectively, are outlined in the map of the United States given in Appendix A of the code.

Since the tension in a conductor of any given size depends upon the amount of sag of the wire between its supports, it is necessary to put limitations upon the amount of sag in order to keep this tension below the actual strength of the wire. The greater the sag the less the tension produced in the wire. Tables of recommended values of sags based upon definite loading assumptions regarding the wind pressure and coating of ice which are encountered in the different districts are given in Appendix A for different kinds of wire and for different lengths of span. Tables of stresses and tensions in conductors corresponding to these sags are also given.

Some limitations are placed on conductors as regards material, minimum sizes, and lengths of spans (221, 223). Soft-drawn copper in the smaller sizes is considered as unsatisfactory, and sizes smaller than No. 6 are prohibited, with recommendations that this size be limited to spans not over 150 feet in heavy-loading districts.

Sec. 23. Strength of Poles, Towers, and Other Line Supports.—The tension in the line conductors determines the pull upon the cross arms, and consequently upon the pole in the direction of the line. In most cases pulls are balanced on opposite sides of the pole. At the ends of a line, however, or in case of wires breaking, this is not true, and the pole must have sufficient strength to support the unbalanced pull in the wires.

Poles must also have sufficient strength to support the dead weight of the wires upon them and to resist being blown over sidewise by the wind. The strength required by the rules to resist such transverse force differs with the different grades of construction A, B, and C. Both the transverse pressure assumed and the weight to be supported are different in the three loading districts, since part of the dead weight consists of the ice clinging to the wires under bad weather conditions.

A table of transverse wind pressures on conductors is given in Appendix B for various sizes of bare and covered conductors for combinations of grades of construction and loadings. Other tables in this appendix include those of vertical loads on conductors and resisting moments of poles. These will be found of great convenience in making rapid calculations as to the strength of existing or proposed lines. Minimum requirements and other specifications are made for crossarms, conductor fastenings (231), wood and reinforced-concrete poles (235), and steel towers (234). Methods of meeting transverse strength requirements by the use of side guys are also specified (233, 235).

Sec. 24. Clearances and Separations of Line Conductors.—Minimum clearances and separations are, therefore, prescribed for all characters of wire crossings, conflicts, and common use of poles; and adequate climbing and working spaces on poles, depending on the voltage, and in some cases also on established practice, are provided, in order to insure reasonable safety to workmen (240, 242, 246, 249). In all cases the necessary increase in clearance, as span length or voltage increases, is specified (240). Where conductors are strung to different sags, the necessity is stated of suitable modification of the otherwise required vertical separation at the pole (244).

Illustrative drawings are given following the discussion regarding pole wiring and the relative positions and levels of supply and signal lines. The necessary clearances are given for conductors in conflicting pole lines (245). Certain clearances are required for conductors from buildings and bridges according to voltages and other given conditions (247, 248,)

Sec. 25. Supporting Structures and Attachments.—The proper clearance of poles from hydrant's and curb lines is specified (250). The use and proper method of installing guys and anchors, including the use of guy insulators and traffic guards, is required and specified (251, 252). Transformers, regulators, lightning arresters, switches, and lamps are to be installed so as not to obstruct climbing space and so that they are safely accessible (253, 255, 256). Insulators are to be identified by markings, and at locations where hazards are considerable, are to be of greater dielectric strength if subjected to greater stress than elsewhere in the line. Test requirements are also given (254). Tree trimming is called for to prevent mechanical injury to live conductors (257).

Sec. 26. Crossing of Supply Lines with Railways and with Signal Lines.—This section is a segregated and conveniently arranged crossing specification for supply lines with railways and with signal lines. It contains in sufficient detail all rules specially pertaining to these subjects, and reference is made to general rules to be found in previous general sections but having a bearing also on crossings. Such clearance and separation requirements as apply, although fully given in Sec. 24, are here repeated in a form convenient for ready reference in considering this vital phase of crossing construction. Underground and underbridge crossings of supply lines beneath railways are covered, as well as overhead crossings.

Power, railway, and signal engineers, as well as inspectors, can find in this section, either directly or by reference, all necessary rules and specifications relating to these types of crossings.

Sec. 27. Overhead Supply Lines (or Signal Lines Which Have Taken on the Character of Supply Lines) in Various Situations.—This section is devoted to overhead supply lines exclusively in various situations in both urban and rural districts and includes signal lines which have taken on the character of supply lines, and railway feeders, and contact conductors. As in Sec. 26, reference is made to previous sections for general requirements while clearances and special features are given in detail. Rules for all possible conditions, where only supply lines are concerned, including crossings, conflicts, and common use of poles by different supply lines, are either given in detail or by reference to preceding sections.

Parallel pole lines are required to be properly separated. Where this is not practicable combining the lines into a single pole line is recommended (270*a*). Utilities should agree upon and maintain a standard of levels (270*b*). Proper specified clearances of poles from fire hydrants and signal pedestals is to be maintained (270*c*).

Sec. 28. Signal Lines at Crossings, Conflicts, and Commonly Used Poles.—This section contains practically all the rules of the code applicable to signal-line construction except for such signal lines as have taken on the character of supply lines, which are treated under Sec. 27. But few references are made to previous general sections, as signal lines are exempt from most of the general requirements for supply lines. Rules somewhat less severe than for supply lines are given in detail covering minimum requirements, materials, and sags for signal lines crossing railroads. The crossing requirements vary somewhat, depending upon whether the crossing is over important or unimportant railroads. Special attention is given to the subject of common use of poles by both supply and signal lines, as this type of construction is considered preferable to separate conflicting lines. Such rules as are necessary are given for signal lines alone or where concerned only with signal lines.

Sec. 29. Manholes, Handholes, Splicing Chambers and Ducts, Conductors, and Equipment.—The duct system is required to be so laid out as to avoid short curves and to secure proper drainage (292*d*). Manholes are required to be conveniently accessible, of sufficient strength, and to have sufficiently large openings and working space (292 *b* and *c*). Covers must require a tool for removal, and openings must allow mechanical guards to be used. The duct arrangements must be such that conductors may be installed and maintained without mechanical injury, and sufficient distance must be provided between ducts for signal conductors and those for supply conductors.

Supply and signal conductors are required to be maintained in separate conduits and manholes with given exceptions (295). Cables must be suitably identified, sufficiently accessible from the working space, properly supported, and suitably protected against arcing (296). The necessary mechanical protection is outlined for connections to overhead lines (297). Joints are required to be so arranged as to leave no bare current-carrying parts exposed in manholes, and cables of different voltages are required to be separated as far as practicable (297).

IX. SUMMARY OF PART 3 OF THE NATIONAL ELECTRICAL SAFETY CODE: RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL UTILIZATION EQUIPMENT

The rules apply to the character of installation of motors, fixtures, and other electrical utilization equipment, and of the wiring in connection therewith, where such equipment or wiring is accessible to other than qualified electrical operators, and where the operating voltage is between 25 and 750 volts (300). The conditions are outlined under which any rule may be modified or waived (301).

For convenient use the rules are divided into 10 sections, numbered 30 to 39, inclusive, covering the subjects noted below.

Sec. 30. Protective Arrangements.—Electrical utilization equipment is required to be so installed as to minimize the attendant life hazard and to comply with the rules of the National Electrical Safety Code, the National Electrical [Fire] Code, and other nonconflicting accepted standards (302), and the installation must thereafter be properly maintained with repairs and changes made only by properly qualified persons (303). Noncurrent-carrying parts which persons can touch are required generally to be permanently grounded in accordance with the methods given in Sec. 9, with the few permissible exceptions noted (304.)

Current-carrying parts are required generally to be either provided with adequate working spaces, according to the voltage (305), guarded, or isolated by elevation (306). Equipment, if in hazardous locations, must have sparking or arcing parts specially inclosed (307). Storage batteries, transformers, and lightning arresters, where used in connection with utilization equipment, must be installed generally as station equipment (308). All electrical equipment shall be suitably identified when necessary for safety (309).

Sec. 31. Conductors.—Automatic cut-outs are required to protect conductors against excessive current, excepting neutral conductors in three-wire systems and certain other conductors (310). Mechanical guards or flame-proof coverings are called for under certain given conditions, and bare conductors are restricted to certain locations (311). Even where mechanical disturbance is unlikely, effective isolation, guards, mats, or other protection is specified, under given determining conditions of voltage and other factors, to safeguard persons in the vicinity of the conductors (312, 313).

Conduit in gaseous surroundings must be sealed to prevent entrance of gases (314). A number of special rules cover the running of conductors to avoid excessive inductance (315), care in the use of pendants and portables (316), requirements for taping of joints (317), and the safeguarding of temporary wiring (319). Certain methods for guarding, grounding, or isolating service conductors in conduits are also outlined (318).

Sec. 32. **Fuses and Other Cut-outs, Switches, and Controllers.**—Detailed requirements are given for the arrangement and design of protective and control devices, which must be accessible, must identify the equipment they control, must not be subject to accidental operation (320), and must be suitably inclosed if in gaseous locations (321). Some of the places and conditions are specified where the use of switches or disconnectors is required (322, 323). Arrangement for locking or blocking of switches is required under given conditions with certain exceptions noted (320).

Provision must be made for the safe disconnection of fuses from the circuit before the fuses are handled, this disconnection to be automatic where any but qualified operators have access (324). The suitable isolation or shielding of fuses or circuit-breakers is required to avoid the burning or striking of persons in their vicinity (325). Grounding of exposed noncurrent-carrying metal parts of switches or cut-outs is required under certain given conditions (326), and the special requirements for suitably guarding live parts of these devices are detailed (327), including use of sufficient working space, and in general inclosure of such parts as are above 150 volts to ground (327).

Sec. 33. **Switchboards and Panel Boards.**—The points of control are required to be readily accessible to the operator (330), and switchboards above 150 volts are required to be inaccessible to unqualified persons (335*a*). Switchboards are to be wired and equipped in an orderly manner, with all parts arranged or marked to assure their ready identification (332). It is required that the arrangement of the boards be such that suitable normal separations are provided between parts at different potentials (332) and that barriers are installed to reduce the liability of accidental short circuits by tools or other objects (333). Detailed requirements are given for the grounding of switchboard frames (334) and for the guarding of live parts by isolation, barriers, or mats. Theater switchboards and, in general, switchboards operating at over 150 volts to ground are required to be inaccessible to unqualified persons (335).

Sec. 34. Motor-Driven Machinery.—Certain electric motors must have speed-limiting devices and no-voltage releases are required for field rheostats under given conditions, special mechanical protection being required for the circuit wiring controlling the speed-limiting devices. It is required, in general, that manually controlled starters be designed so that they return automatically to the starting position when their energy supply fails (340).

In gaseous or other hazardous locations special inclosures are required for parts which arc or spark during operation (341), and where exposed to steam or vapor, special protection of windings and leads is required (342). Detailed requirements are given for the guarding of live parts, particularly above 150 volts to ground, under certain specified conditions (343), and for the protection, in general, of belts, gears, etc., where harmful contact might otherwise accidentally result (344).

Sec. 35. Electric Furnaces and Welders.—Intensely glowing or arcing parts are required to be so screened or otherwise inclosed as to be inaccessible and practically invisible to unauthorized persons, and appliances are required to protect suitably the authorized operators (350). The grounding of exterior metal frames is required where operating voltages exceed 150 volts to ground (351), and live parts of furnaces above that voltage are required to be suitably guarded (352).

Sec. 36. Lighting Fixtures and Signs.—The grounding of fixtures is required under a number of everyday conditions specified in the rules (360). Means are specified for securing adequate insulation (361) and accessibility of electric signs and for guarding their live parts (363) and controlling their circuits when outside (364). Means are also specified for safely isolating, guarding, or handling lamps in series circuits whether in or out of buildings (366 and 367).

Sec. 37. Portable Devices, Cables and Connectors.—The grounding of exterior metal of portable devices is strongly recommended where practicable, for devices operating above 150 volts to ground or at even lower voltages wherever located in bathrooms, laundries, etc., where the good contacts to earth make extra precaution necessary (371). Cable connectors are required to be so arranged that live parts are not exposed (372). The use of portable cords and connectors having identified parts is required where portable devices are grounded. Detailed requirements are given on the character (373) and arrangement of portable and pendant cords under given conditions of voltage and surroundings (374).

Sec. 38. Electrically Operated Cars, Cranes and Elevators.—Special requirements are given for the guarding of live and moving parts, according to the special conditions existing (380). Grounding is required from noncurrent-carrying metal parts of electrical equipment over 150 volts to ground, and for similar parts of portable cranes, derricks, etc., in the vicinity (381). The energy supply to cars, cranes and elevators is required to be controllable at readily accessible points (382), and the movement of such vehicles is required to be controllable only by authorized operators and conveniently located for them (383). In subways auxiliary systems of emergency lighting are required (384).

Sec. 39. Telephone and Other Signal Apparatus on Circuits Exposed by Supply Lines.—It is required that noncurrent-carrying parts be made harmless by the use of suitable protectors, by grounding, or by installation of the apparatus concerned in insulating booths according to various given conditions (390). The guarding of current-carrying parts in specified manner is also required under certain defined conditions (391). Certain specified protection against induced voltages is required for signaling equipment, where, under normal operating conditions, more than 150 volts to ground would otherwise exist on the signal lines and connected devices (392).

Means for grounding of arresters on signaling systems are specified in some detail, these applying in lieu of the grounding methods of sec. 9 which are otherwise generally applicable throughout the rules (393).

X. SUMMARY OF PART 4 OF THE NATIONAL ELECTRICAL SAFETY CODE: RULES TO BE OBSERVED IN THE OPERATION OF ELECTRICAL EQUIPMENT AND LINES

NECESSITY FOR OPERATING RULES

Even with all the safeguarding of construction that is feasible, the requirements for continuity of service and maintenance of its efficiency demand the attendance of employees on or about live electrical equipment. Sometimes the complete guarding of live parts, especially at the lower voltages, even where accessible to operators, would not be practicable, and dependence on liberal spaces, insulating platforms, and portable insulating guards or appliances for working on the live parts may be necessary. The operating safety rules are intended to supplement the physical safeguarding where this can not be complete or where it must be occasionally removed or rendered inoperative.

SCOPE

The rules are divided into two principal parts—one for electrical operation in general and one covering commercial signal operation, but omitting those requirements in the general portion which have no bearing on such operation. The rules are preceded by a statement on their scope calling attention to the fact that while most of the rules find application in the larger industrial or private plants and even in moderate-sized utilities, some do not apply or apply less fully in the smaller. No attempt was made to restrict their scope to rules applicable to all installations, large and small, because such a restriction would have required omission of many rules necessary in many instances as a guide and causing no confusion in cases where they do not apply.

RULES FOR EMPLOYERS

In the rules for electrical operation in general two sections on organization and protective methods and devices are addressed to the employer, the first section calling for the issuance of rules, the proper choice and instruction to employees to assure their qualifications for the duties assigned, and the arrangement of the organization to avoid dangerous misunderstandings. The protective methods specified in the second section cover the supervision of uninstructed persons, the use of diagrams to assist persons in directing operations, the use of clear instructions to employees and the provision of adequate protective appliances and signs.

RULES FOR EMPLOYEES

The rules addressed to the employee comprise five sections to electrical employees in general, and eight sections covering special kinds of electrical operations, including work around supply stations and switchboards, work on underground and overhead lines, work about series lamps, work about meters, testing operations, about the electrical equipment of tunnels and subways, and work about signal lines used in conjunction with supply lines.

The sections addressed to electrical employees in general begin with one covering general precautions requiring familiarity with the rules, fitness for the work in hand, proper supervision of assistants, simple precautions about live parts, and the use of proper safety appliances, such as safety belts, etc., the use of proper types of extinguishers about live parts, and the repetition of messages to avoid dangerous misunderstandings.

A second section deals with the relations and procedures in general necessary for workmen in order to avoid the hazards through misunderstandings, including the duties of chief operators, the duties of foremen, the necessity for special authorizations for hazardous work, the precautions in restoring service afterward, the tagging of circuits being worked on, and measures to protect traffic where work is being done. The next section covers the specific precautions to be observed in handling live equipment or lines of varying voltages, including the stringing and tapping of wires. The next two sections include a detailed procedure for assuring that the killing of lines to protect workmen is carried out in a reliable manner, to avoid subjecting men to danger through misunderstanding.

RULES FOR COMMERCIAL SIGNAL SYSTEMS

The rules for commercial telephone and telegraph systems are to a large extent substantially repetitions of rules already given for electrical employers and employees in general, but with such of the former rules omitted as have no particular bearing on commercial signal operation. This has permitted a briefer set of rules which is regarded by both employers and employees in commercial signal work as more suitable for placing in the hands of employees who usually have no occasion to acquaint themselves with the hazards of other than signal operation.