DEPARTMENT OF COMMERCE AND LABOR

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 23

STANDARDIZATION OF ELECTRICAL PRACTICE IN MINES

[1st Edition]
Issued July 15, 1910

WASHINGTON
GOVERNMENT PRINTING OFFICE
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CONTENTS.

INTRODUCTION

In publishing at this time the first portion of the results of the work that has been done by the Bureau of Standards on the subject of the Standardization of Electrical Practice in Mines it is proper to explain the circumstances under which the work was taken up.

On March 11, 1909, the following letter was received from the secretary of the American Mining Congress:

THE AMERICAN MINING CONGRESS,
Denver, Colo., March 6, 1909.

S. W. STRATTON,
Director Bureau of Standards, Washington, D. C.

MY DEAR SIR: At the recent session of the American Mining Congress held at Pittsburg, Pa., a resolution offered by David B. Rushmore, of Schenectady, N. Y., as amended by the committee on resolutions, was adopted by the convention. Copy of these resolutions, as adopted, is herewith inclosed.

Our board of directors have requested me to ask you to accept a place upon this committee as the independent electrical engineer.

The representatives of the manufacturers selected are: David B. Rushmore, of Schenectady, N. Y., representing the General Electric Company, and W. A. Thomas, of Pittsburg, Pa., representing the Westinghouse Electric & Mfg. Co.

It is proposed to ask the coal operators to select two members, and that the U. M. W. of A and the A. F. of L. shall each be requested to choose a member to represent the miners. It has been thought best to have the membership of this committee centralized in the eastern portion of the country, in order that the attendance of the members of the committees at its meetings may be more easily secured. While it is not customary for this organization to go outside of its members in the appointment of its committees, yet this seems to be a committee requiring that this course shall be pursued, and we greatly hope that you will be willing to undertake this service, and that through the work of this committee much good may be accomplished. I shall also hope, through your connection with this committee, to have the pleasure of meeting you personally, and that through this work the Bureau of Standards and our organization may be brought into a close working sympathy.

Trusting that we may have an early and favorable response, I am,

Very respectfully, yours,

(Signed) JAMES F. CALLBREATH, Jr.,
Secretary.

The resolution referred to in the above letter, authorizing the appointment of a standing committee to standardize electrical practice in mining work, is as follows:

RESOLUTION NO. 7. INTRODUCED BY DAVID B. RUSHMORE, OF NEW YORK

Whereas the use of electricity in mines is increasing rapidly, and numerous small bodies are attempting to independently standardize the practice regarding its use, and as this subject can be best handled by a national body working in harmony with all the different interests concerned;

Therefore be it recommended, that a standing committee be appointed by the president of the American Mining Congress to standardize as far as possible and make recommendations concerning electrical practice in mining work, said committee to consist of seven members, as follows, viz: One electrical engineer, two representatives of the manufacturers of electrical equipment, two representatives of the labor organizations, and two mine operators.

The following reply was sent to Secretary Callbreath's letter:

DEPARTMENT OF COMMERCE AND LABOR,
BUREAU OF STANDARDS,
Washington, March 16, 1909.

Mr. JAMES F. CALLBREATH, Jr.,
Secretary The American Mining Congress, Denver, Colo.

MY DEAR SIR: I beg to acknowledge the receipt of your letter of March 6, requesting me to accept a place upon the committee to standardize electrical practice in mining work. In reply I would state that I would be pleased to do so, but I believe you would get better results from Dr. Edward B. Rosa, head of the electrical division of the bureau.

I am not only in sympathy with the work that you propose, but take this opportunity to offer your committee the services of the bureau in any way that may be possible.

Thanking you for your interest in the matter, I remain,

Yours, very truly,

(Signed) S. W. STRATTON,
Director.

The following letter, accepting the services of the Bureau of Standards, was received March 26:

THE AMERICAN MINING CONGRESS,
Denver, Colo., March 22, 1909.

Mr. S. W. STRATTON, *Director,*
Bureau of Standards,
Department of Commerce & Labor,
Washington, D. C.

MY DEAR SIR: Your kind favor of March 16 is received. I greatly appreciate the kind words of your letter, and will accept and act upon your suggestion of the appointment of Dr. Edward B. Rosa upon the committee mentioned. I am writing to Doctor Rosa by this mail, and I am sure that the committee will be glad to avail itself of your kind offer of the services of the Bureau of Standards in connection with this work.

Thanking you for your interest in this matter, I am,

Very respectfully, yours,

(Signed) J. F. CALLBREATH, Jr.,
Secretary.

Accordingly, Dr. Rosa was appointed chairman of the committee, and six others, representing the manufacturers, the mine operators, and the mine workers, were appointed in accordance with the resolution. The chairman was notified of the appointment of the last member of the committee in a letter from the secretary dated August 5, 1909.

The first work that would naturally be taken up by the committee was a study of existing practice and of the laws and regulations under which electrical apparatus is now installed and operated. Then would follow a careful study leading to standardization of voltages, of electrical machinery intended for use in mines, and of methods of insulation of circuits, and of installation of machines. To do the subject justice obviously required a large amount of work and study, and yet the members of the committee were all very busy men and the American Mining Congress had provided no money to defray the expense of such an investigation. It appeared necessary for the Bureau of Standards to do a much larger share of the work than was at first contemplated, and accordingly a competent and experienced electrical engineer of the bureau staff, Mr. Burton McCollum, was detailed to assist the chairman of the committee in carrying on the work that had been undertaken. Such work is directly in line with the work of the bureau. The bureau is represented on the Standardization Committee of the American Institute of Electrical Engineers, and on the technical committees of several other engineering societies, and some of its

investigations have been undertaken in aid of the work of such committees. To aid in securing uniformity of practice among the States in the regulation and control of the use of electricity in mines, as well as in its use in transportation and industrial enterprises above ground, is clearly a proper function for the national Bureau of Standards.

The personnel of the committee, as well as a brief statement of its work, was sent out to the press on August 28 from the office of the secretary of the American Mining Congress, at Denver, as follows:

STANDARDIZING ELECTRICAL EQUIPMENT IN MINING

At the Pittsburg, Pa., session of the American Mining Congress, held early in December last year, a resolution was adopted authorizing the appointment of a committee of seven persons to report back for the consideration of that organization means for bringing about the standardization of electrical equipment in mining and recommendations looking to uniformity in electrical practice in general.

The resolution, which was introduced by David B. Rushmore of the General Electric Company, Schenectady, N. Y., was as follows:

"Recommended, that a standing committee be appointed by the president of the American Mining Congress to standardize, as far as possible, and make recommendations concerning electrical practice in mining work, said committee to consist of seven members, as follows, viz: One electrical engineer, two representatives of the manufacturers of electrical equipment, two representatives of labor organizations, and two mine operators."

The following members were appointed by the Mining Congress to serve on the committee:

Dr. Edward B. Rosa, of the Bureau of Standards, Washington, D. C., chairman; David B Rushmore, of the General Electric Company, Schenectady, N. Y., representing the manufacturers; W. A. Thomas, of the Westinghouse Company, Pittsburg, Pa., representing the manufacturers; J. R. Bent, of the Oglesby Coal Company, Oglesby, Ill., representing the mine operators; George R. Wood, of the Pittsburg Coal Company, Pittsburg, Pa., representing the mine operators; Thomas L. Lewis, president of United Mine Workers of America, Indianapolis, Ind., representing labor; James O'Connell, vice-president of American Federation of Labor, Washington, D. C., representing labor.

While the committee has been so recently organized that not a great deal of work has thus far been accomplished, it will render a preliminary report to the next session of the Mining Congress, which will be held at Goldfield, Nev., September 27 to October 2, 1909. It will then continue its work, and within the next few months it will doubtless be prepared to complete its recommendations in this important matter.

The absence of uniformity in the installation of electrical equipment in coal and precious metal mines has given rise to problems very annoying to operators and even to manufacturers, and the work of this committee will be watched with interest.

Those having any views to offer on this subject are invited to send them to Dr. Edward B. Rosa, chairman of the committee, care of the Bureau of Standards, Washington, D. C.

The committee held its first meeting in Pittsburg, September 16 and 17, and in addition to reviewing the work that had been done and outlining further work for the ensuing months, prepared a preliminary report to the approaching session of the Mining Congress, which was held in Goldfield about two weeks thereafter. This preliminary report, which was presented to the congress and printed in its proceedings, is as follows:

I. PRELIMINARY REPORT OF THE COMMITTEE ON THE STANDARDIZATION OF ELECTRICAL EQUIPMENT OF MINES

The committee on the standardization of the electrical equipment of mines, appointed in accordance with a resolution of the last session of the American Mining Congress, has had one meeting and has done a considerable amount of work on the problem assigned to it, but is not as yet prepared to offer a final report.

After examining the mining laws relative to the use of electricity of those States that have legislated on the subject, and of a number of foreign

countries where a considerable application of electricity has been made in mining, the committee has prepared a draft of a code of rules suitable for enactment into law by any state legislature. This first draft is to be submitted to representatives of other mining organizations for criticism and suggestion, and then carefully revised in the light of the suggestions received, and of the further experience of the committee. One of the members of the committee, Mr. Rushmore, is spending several months this summer in Europe studying the applications of electricity to mining, and he will doubtless obtain information of value to the committee in the final revision of its code of rules.

In addition to this formal code of rules, which may be given the force of law, governing the use of electricity in mines, the committee proposes to prepare a set of recommendations setting forth what it considers the best practice and which, if followed, would tend to reduce the danger of personal injuries due to the use of electricity in mines, reduce the liability of explosions in gaseous mines, improve the efficiency and reliability of the service and tend to make the use of electricity more satisfactory both to the operators and the mine workers. These recommendations will go farther than is possible in a set of mandatory rules.

In order that this work may be performed most effectively, the committee is gathering data concerning many of the best installations of electrical apparatus in the mines of this country and Europe, and personally examining many of them. Important experiments are being conducted by the technological branch of the United States Geological Survey to determine the condition under which explosions could be caused in gaseous mines by the breaking of incandescent electric lamps, blowing of "safety" fuses, sparking at the brushes of motors, or flashes on electric signaling wires. The effect of acid mine water on various kinds of insulated wire and cables is being investigated, with the hope of finding an insulation that will be permanently satisfactory under the severest mine conditions. The committee is glad to take advantage of the results of these experiments, in the carrying out of which one of our members (Mr. Wood) has been retained by the Geological Survey as consulting engineer. The committee invites suggestions from manufacturers, mine operators, and mine workers relative to any of the various phases of the problem which has been assigned to it, and especially any results of experience which may be of value in revising its code of rules or in making up its series of recommendations.

(Signed) E. B. Rosa,
Chairman Committee of American Mining Congress on the Standardization of Electric Practice in Mines.

Washington, D. C., *September 20, 1909.*

In accordance with plans formulated by the committee at its Pittsburg meeting, the regulations and laws relating to the use of electricity in mines in European countries, South Africa, and New South Wales were collected and studied, the electrical installations in many mines were examined, and a considerable number of mining engineers, mine inspectors, and manufacturers of electrical machinery used in mines were consulted. No State of the Union had anything like a complete code of rules in their mining laws

respecting the use of electricity, although a careful set of rules had been prepared and submitted to the legislature of Pennsylvania a year ago. These rules were of much value to the committee and are published in this circular, although the legislature of Pennsylvania did not pass the bill. The work on a code of rules, begun in the summer, was continued, the members of the committee keeping in touch with the chairman by correspondence and assisting in the work. A second meeting of the committee was about to be called for January, 1910, when it was learned indirectly that the committee (which had been appointed by the American Mining Congress as a standing committee, and which it had been officially announced would continue its work) had been dismissed at the Goldfield meeting, and the president authorized to appoint a new committee. No notice of this action of the congress had been sent to any member of the committee and no explanation of the action of the congress has been made, nor do the published proceedings of the congress show why such action was taken.

The Bureau of Standards thus found itself with a very interesting and important piece of work partially completed, but no committee to cooperate with and no organization to which to report results. The chairman of the new committee, Samuel A. Taylor, of Pittsburg, having stated that he did not intend to take up such work as the original committee had undertaken, it has seemed best that the bureau should carry on the work to completion and publish the results. This is now being done, with the cordial support and assistance of several members of the old committee and of the manufacturers of electrical machinery used in mines, of state mine inspectors, of numerous electrical and mining engineers, and of the representatives of organized labor. A great many persons have thus been consulted in this work, and useful suggestions and criticisms have been received from a larger number than can be separately named; nevertheless, especial acknowledgment should be made to certain of those who have given us most help and encouragement. Among these are Mr. W. A. Thomas, of the Westinghouse Electric and Manufacturing Company, Pittsburg, Pa.; Mr. D. B. Rushmore and Mr. Larsen, of the General Electric Company; Mr. George R. Wood, consulting electrical engineer, Pittsburg, Pa.; Mr. George Harrison, chief inspector of mines of Ohio, Columbus, Ohio; Prof. A. E. Kennelly, chairman of the standardization committee of the American Institute of Electrical Engineers, Harvard University, Cambridge, Mass.; Mr. H. M. Warren, electrical engineer, Mr. F. J. Duffey, general foreman electrical department, Mr. T. J. Williams, mine superintendent, Mr. P. J. Devers, mine superintendent, of the Delaware and Lackawanna Railway Company, Scranton, Pa.; Mr. H. N. Eavenson, chief engineer, United States Coal and Coke Company, Gary, W. Va.; Mr. L. R. Kingsland, electrical engineer, Consolidation Coal Company, Fairmont, W. Va.; and Mr. Gerald Sherman, superintendent of mine department, Copper Queen Consolidated Mining Company, Bisbee, Ariz. Mr. Thomas L. Lewis, president of the United Mine Workers of America, and Mr. James O'Connell, president of the International Association of Machinists, Washington, D. C., have also maintained an active interest in the work, and are in hearty accord with the provisions of the proposed code.

Many of the changes in practice which are recommended in the proposed rules are in the interest of better engineering, to secure more reliable service

and greater economy of operation; but very many of the changes and precautions proposed are in the interest of the mine workers, who are often exposed to unwarranted hazard where electrical installations are not properly made. The fire risk, due to live wires and electrical machinery, is such that very stringent rules have been adopted by the underwriters, acting in conjunction with various electric lighting and electrical engineering societies. The life hazard is a matter of quite as much importance; and below ground, where dampness and darkness and limited space (and sometimes explosive gases) make the difficulties and dangers greater than usual, there is need of many improvements in method and material of electrical installation, and also of a closer and more systematic inspection of such installations by the State. The best results can only be secured by cooperation between mine operators, manufacturers, and engineers, and this bureau will encourage and assist as far as possible this very important work.

Some mine operators have expressed the feeling that the work which the committee undertook and which is now being carried on by the bureau is not necessary; that the mine owners and operators can safely be left to themselves without any limitation or supervision by the State. This is perhaps true of some, particularly certain large operators who have employed able consulting engineers and who in some cases have shown exceptional enterprise and a commendable desire to make their electrical installations as safe as possible for the mine workers. But this is by no means the rule, and the records show a larger number of electrical accidents in American mines, where there has been very little official regulation or inspection of the electrical equipment, than in England and other countries, where there has been for some years very careful legal requirements and government inspections.

Still another reason for this work is that some of the States are taking a very lively interest in the question and have commissions preparing such regulations for submission to the respective state legislatures. It is very desirable that as far as possible the regulations of the several States shall be uniform. If there is no coordinating influence at work, the States are likely to have regulations that will be very different, and much confusion would therefore result to manufacturers and others who have to deal with work in more than one State. It is not improbable that in many cases such commissions would make their recommendations without consulting as carefully as we have done all the interested parties. Much good may indeed be expected from an earnest effort on the part of a national bureau which consults all the interests affected, including mine workers, mine owners, superintendents, inspectors, consulting engineers familiar with the use of electricity in mines, and the manufacturers of the electrical equipment, in which a code of regulations and restrictions is drawn up, which shall have the approval of the largest possible number, and shall be an expression, not alone of the government bureau that collects and arranges the information, but of the ablest and most experienced men of the various classes mentioned who are using electricity in carrying on mining operations.

Owing to the widely varying conditions which prevail in different mines it is impossible to formulate a series of rules or requirements that will apply to every case or that will cover every emergency. Mandatory rules must necessarily be conservative, and will not go as far in many cases as the best

practice would dictate. Hence we are preparing a set of recommendations to accompany the rules contained in this publication, and which are intended to set forth what is considered the best practice in many matters in which the formal rules, that may be given the force of law, are not complete. If the rules are made too minute or too specific, they can not be enforced without often doing injustice. But the recommendations will point out many desirable features of construction and operation that could not be required of all operators or under all conditions.

We have aimed to be very conservative in the preparation of these rules, which may become mandatory, and in many cases have been more conservative than some mine operators and experienced engineers consulted have thought necessary. While it has not been possible to draw up a proposed code of rules that meets with the unqualified approval in every detail of all those who have been consulted, we nevertheless have the assurance that the code of rules hereinafter presented represents the concensus of opinion of the great majority of those who have expressed their opinions in regard to this matter. We invite criticism and suggestion concerning the matter here submitted from any one who has had considerable experience in the use of electricity in mines, in order that we may improve the rules as much as possible in the next edition, which will be carefully revised. In the continuation of this work the Bureau of Standards will have the cooperation of the Bureau of Mines, which has recently been established. The latter Bureau will continue the experimental work begun in the Technological Branch of the Geological Survey, relative to the use of electrical apparatus in explosive atmospheres, and advantage will be taken in future editions of this report of the results of these very important experiments, as well as any other results pertinent to this work obtained by the Bureau of Mines. We believe that better construction and more careful operation will not only be of advantage to the mine workers by reducing the dangers, but will also be of advantage to the mine operators in affording more reliable service. That has proven to be the case in electricity used for lighting, for power, and for transportation, and it will surely be the same with electricity employed in the coal and metal mines.

S. W. Stratton, *Director.*

II. PROPOSED RULES FOR THE INSTALLATION AND USE OF ELECTRICITY IN MINES

DEFINITIONS

The expression "pressure" means the difference of electrical potential between any two electrical conductors.

Low pressure

(*a*) Where the conditions of the system are such that the pressure between any two conductors, or between any conductor and the earth, at the terminals where the electricity is being used can not exceed three hundred (300) volts, this shall be deemed a low pressure system.

Medium pressure

(*b*) Where the conditions of the system are such that the pressure between any two conductors, or between any conductor and the earth, at the terminals where the electricity is being used, can exceed three hundred (300) volts, but can not exceed six hundred (600) volts, this shall be deemed a medium pressure system.

High pressure

(*c*) Where the conditions of the system are such that the pressure between any two conductors, or between any conductor and the earth, at the terminals where the electricity is being used can exceed six hundred (600) volts, this shall be deemed a high pressure system.

SECTION 1.—GENERAL

Size of conductors

Rule 1.—All electrical apparatus and conductors shall be sufficient in size and capacity[1] for the work they may be called upon to do, and so installed, operated, maintained, and safeguarded as to reduce the danger from accidental shock or fire or overheating to the minimum, and shall be of such construction and so operated that the rise in temperature caused by ordinary working will not injure the insulating materials.

Grounding of machine frames

All metallic coverings or armoring of cables, and the frames and bed plates of generators, transformers, and motors, and the metallic coverings of switches, fuses, and circuit breakers, shall be efficiently grounded.[2]

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[1] The table of carrying capacities of the National Electric Code should be followed where practicable. It can be obtained by addressing Mr. C. M. Goddard, secretary, Underwriters National Electric Association, 141 Milk street, Boston.

[2] See Note A, page 31.

Grounding of electric circuits

Rule 2.—All alternating current systems in which the normal working pressure does not exceed the limits of medium pressure, and all three-wire direct current systems shall be grounded. Where practicable, the neutral shall be grounded.[3]

Pressure limits for alternating current machines

Rule 3.—A higher pressure than a medium pressure shall not be used for portable motors, nor for any other purpose underground except for alternating current transmission, or for application to alternating current apparatus in which the whole of the high pressure circuit is stationary. For work underground, when taking current at a pressure higher than a medium pressure, all transformers shall be of the oil insulated type and a motor shall not be of less normal rating than twenty (20) brake horsepower.

High pressure transformers and motors

Danger signals

All high and medium pressure lines and apparatus shall be marked at frequent intervals by the use of the word "Danger," together with a statement of the voltage, so as to indicate clearly that they are dangerous. All low-pressure power or lighting wires shall be marked with the word "Caution," together with a statement of the voltage of the line.[4]

Testing of insulation

Leakage limit

Rule 4.—The insulation of each circuit or section[5] of circuit shall be measured at least once every three months, and a record of all such measurements shall be kept at the office of the mine. If the resistance measurements show that the leakage current in any section of a lead-covered cable, or any two or three wire cable, under normal conditions of operation, may exceed 1/1000 of the maximum working current[6] for the given conductor, the defect shall be located and repaired at once. It shall be the duty of the mine foreman, or some other responsible official designated for the purpose, to see that the tests required are regularly made, and that a portable testing set be available for the purpose.[7]

Employment of mine electricians

Rule 5.—At every mine where electricity is used below ground, a competent mine electrician and, where necessary, an assistant mine electrician also, shall be employed, subject to the authority of the mine foreman or other responsible official. No mine shall be permitted to operate without an electrician for a continuous period exceeding thirty (30) days unless a written permit to so operate shall be obtained from the department of mines. The electrician shall have full charge of all electrical apparatus used in connection with the mine.

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[3] See Note B.
[4] See Note C.
[5] See Rule 26.
[6] See Rule 1.
[7] See Note D.

Licensing of mine electricians

After the expiration of twelve (12) months from the passage of this act, no person shall be permitted to act as a mine electrician unless he shall be the holder of a certificate of competency issued by the department of mines.[8]

Instruction of electrical operators

Every person appointed to operate any electrical apparatus in connection with a mine shall be instructed in his duty by the mine foreman or electrician before taking charge of the apparatus.

Fire buckets

Rule 6.—Fire buckets filled with clean, dry sand shall be kept in the mines where stationary electrical apparatus is located, ready for immediate use.

Resuscitation of victims of electric shock

Rule 7.—Instructions shall be placed at the mine entrance, and in every generating, transforming, and motor house, for the resuscitation of persons suffering from electric shock. All employees operating the electrical apparatus shall be required to acquaint themselves with these instructions.

Recording of accidents

Every personal accident occurring in connection with the operation of the electrical equipment shall be promptly reported by the person injured, or by some other person on his behalf, to the mine foreman, and shall be recorded by him at the office of the mine.

Plans of electric circuits of mines

Rule 8.—A plan on a scale not smaller than 200 feet to the inch shall be kept at the mine, showing the position of all permanent electrical machinery and fixed cables or conductors in the mine, and shall be corrected as often as may be necessary to keep it as nearly as practicable up to date, and never more than six months in arrears.

Tampering with wires prohibited

Rule 9.—Any person who shall wilfully tamper with, or make any unauthorized changes in, or connections to, any part of the electrical circuits or apparatus in, or used in connection with a mine, whether such circuits are alive or not, or who shall wilfully cause any other person to come in contact with any live electrical circuits, shall be deemed guilty of a misdemeanor.

Allaying dust in coal mines

Rule 10.—In any bituminous coal mine where the special rules applying to gaseous mines are not observed, precautions, such as sprinkling or other effective means, must be taken to prevent dangerous accumulation of coal dust.[9]

SECTION 2.—TRANSMISSION LINES AND CABLES

Switching apparatus at mine entrance

Rule 11.—Where the generating station under the control of the owner or superintendent of the mine is not within one thousand (1,000) feet of the mine entrance, a switch box or boxes efficiently

[8] See Note E.

[9] See Note F.

inclosed, or a switch house, shall be provided near the mine entrance for cutting off the supply of electricity to the mine. In all mines the power for electric hoists which are regularly used for lifting miners from the workings, and in all coal mines the power for fans, must be supplied by separate feeders run from any convenient distributing point, so that power may be kept on either or both of these circuits when all other circuits in the mine are cut off.

Protection of machine terminals

Rule 12.—All terminals and live metal on machines over low pressure, below ground, shall, where practicable, be protected with insulating tape or other suitable insulating covers, or with metal covers connected to earth.

Lightning arresters

Rule 13.—If the transmission lines from the generating station, or substation, to the mine entrance are overhead, they shall be properly secured to insulators and have lightning arresters at the mine entrance, if the overhead line exceeds 400 feet in length.

Minimum height of wires on the surface

In the case of high-voltage wires, they shall be maintained at least twenty (20) feet from the ground, except where they enter the mine or transformer station, in which case they shall be adequately protected. All medium and low voltage wires shall be maintained at least six and one-half feet above the ground at the lowest point, except where they enter the mine.

Covering of wires and cables

Rule 14.—All high-pressure wires in underground roadways shall be in the form of lead-covered cables, which may be either armored or unarmored. The insulation of these cables must be non-hygroscopic and as nearly acid proof as possible, so that a defect in the lead sheath will not give rise to an immediate breakdown of the insulation.[10]

In nongaseous sections of mines, medium or low pressure wires may be bare. If insulated, they must be covered with high-class insulation that is as nearly moisture and acid proof as possible. All high and medium pressure wires, unless metal covered, must be adequately protected where there is danger of men or animals coming into contact with them.

Protection of cable terminals

Rule 15.—The exposed ends of cables where they enter the terminals of switches, fuses, and other appliances shall be properly protected and finished off so that moisture can not creep along the insulating material, or so that the insulating material, if of an oily nature, can not leak out of the cable.

Joints

Rule 16.—All joints must be electrically efficient, mechanically strong, and where practicable should be soldered. All joints,

[10] See Note G.

except in trolley wires, should be taped or otherwise suitably insulated to protect them from corrosion.[11]

Shaft cables

Rule 17.—All cables used in shafts must be highly insulated and substantially fixed. Shaft cables not capable of sustaining their own weight shall be properly supported at intervals, according to the weight of the cable. Where the cables are not completely boxed in and protected from falling material, space shall be left between them and the side of the shaft, so that they may yield when struck, and thus lessen the blow given by the falling material.

Protection of cables in roadways

Rule 18.—Where the cables in main haulage roads, where persons are hauled into or out of the mines, can not be kept at least 18 inches from any part of the car, they shall be specially protected.

Supporting of wires and cables

Cables and wires, unless provided with metallic coverings, shall not be fixed to walls or timbers by means of non-insulating fastenings.

Metal covered or any multiple conductor cables underground, when suspended, shall be supported flexibly in such a manner as to allow of their readily breaking away when struck before the cables themselves can be seriously damaged.

Protection of cables while blasting

Where main or other roads are being repaired, or where blasting is being done, temporary protection must be used, so that the cables are protected from damage.

Trailing cables

Rule 19.—Trailing cables for portable motors shall be especially flexible, heavily insulated, and protected with extra stout braiding, or other equally effective covering.

Connection of trailing cable to motor

Rule 20.—The twin trailing cables, supplying power to coal cutter motors, shall be divided at the motors, but only for such a length as is necessary for making the connection to the motor, and the twin cable, with its outer covering complete, shall be securely held by a suitable clamp on the frame of the motor, in such a manner as to protect the trailing cable from injury, and to prevent any mechanical strain being borne by the terminals making electrical connection with the motor.

Operation of trailing cables

Rule 21.—In the event of the trailing cable in service breaking down or being damaged, or of its inflicting a shock upon any person, it shall at once be put out of service, and shall not be used again until it has been repaired and tested by the mine electrician or assistant mine electrician.

The trailing cable shall be kept disconnected from the machine while it is being loaded upon or unloaded from the truck, unless electric power is necessary for such loading or unloading.

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[11] See Note H.

Location of wires in roadways

Rule 22.—In underground roads, the trolley wires shall be placed as close to the side as practicable, and in a straight line, and securely supported at frequent intervals. In all roads where it is necessary for men to travel on foot, all wires, except signal wires, must be placed on the same side of the roadway. Signal wires should where practicable be placed on the opposite side of the roadway from other wires.

Protection and illumination of wires at crossings

At all landings, turn-outs, partings, or crossings, or other places where it is necessary for men to pass near the wires, a suitable protection shall be placed around the wires, or the pressure must be cut off when such places are used for traveling on foot. Sufficient illumination shall be provided at all points where men are liable to come in contact with power wires.

Automatic trolley switches and danger signals

Every branch trolley shall be fitted with an automatic trolley switch, or section insulator and line switch, or some other device that will allow the pressure to be cut off from such trolley when not actually in use.[12] Danger signals, consisting of no fewer than two red lights in parallel, and as many in series as may be necessary, shall be connected at suitable intervals to all branch trolley circuits to indicate when the current is on. A notice shall be posted at the entrance to all roadways carrying exposed power wires, warning persons against the dangers of carelessly carrying metal tools such as drills, picks, etc., which may come in contact with the wires.

Erection of lighting and signal wires

Rule 23.—Small wires for lighting or signal circuits shall either be conveyed in pipes or casings, or they may be suspended from porcelain or glass insulators or securely tied to them, so that they do not touch any timbering, coal, or metal. On no account shall staples be used. If metallic pipes are used, they must be grounded, and if not electrically continuous, every section must be grounded. If separate uncased wires are used, they shall be kept at least three (3) inches apart, and not brought together, except at lamps or fittings.

SECTION 3.—SWITCHES, FUSES, AND CIRCUIT BREAKERS

Adjustment and replacing of fuses and circuit breakers

Rule 24.—Fuses and automatic circuit breakers should be so constructed or adjusted as to open the circuit when the current through them exceeds, by 100 per cent, the working current in the case of motors, or the permissible current of the cables which they protect. Fuses shall be stamped or marked, or shall have a label attached indicating the current at which they are

[12] See Note I.

intended to fuse, or, where fuse wire is used, each coil shall be so stamped and labeled. Fuses shall be adjusted or replaced only by a competent person, authorized by the mine foreman.

Construction and location of switches, fuse blocks, etc.

Rule 25.—All switches, circuit breakers, and fuses must have bases of marble, slate, or porcelain, or other suitable incombustible material, free from metallic veins, and shall be placed in as dry a situation as practicable.

Sectionalizing switches and branch cut-outs

Rule 26.—Wherever branch electric circuits leave a main or secondary feeder, switches shall be provided for disconnecting the branch line from the supply line, and all main and distributing feeders shall be provided with sectionalizing switches at distances not exceeding one mile.[13]

Connection of branch circuits to supply line

All circuits that are to be made or broken underground shall be fitted with proper switches. If connection is made to the supply line by means of hooks or other temporary connections, the switch must be open when such connection is made or broken.

SECTION 4.—MOTORS

Auxiliary appliances for motor

Rule 27.—Every underground motor, together with its starting resistance, shall be protected by a fuse or circuit-breaking device, in accordance with rule 23, and by switches capable of entirely cutting off the pressure. The switches shall be placed in a convenient position near the motor.

Bushing for cable boxes, etc.

Rule 28.—Where unarmored cables or wires pass through metal frames or into boxes or motor casings, the holes shall, where practicable, be substantially bushed with insulating collars.

Precautions in the operation of coal cutters

Rule 29.—No person shall be permitted to take charge of an electric coal-cutting machine in a mine who is not a competent person, capable of determining the safety of the roof and sides and of detecting the presence of explosive gas.

In order that the roof may be carefully examined, a coal-cutter motor shall not be kept continuously in operation for a length of time exceeding half an hour, unless otherwise specified in writing by the mine foreman.

Rule 30.—The person in charge of a coal-cutting or drilling machine shall not leave the machine while it is working, and shall see that the pressure is cut off from the trailing cables before leaving the working place.

Shot-firing regulations

Rule 31.—Electricity from light and power circuits shall not be used for firing shots in a mine except where the electrical connection to such light or power circuit is made within an inclosed

[13] See Note J.

switch room, which shall be kept securely locked and shall be accessible only to the authorized shot firer. If electricity from light or power cables is used for firing shots in a mine, no shots shall be fired until all the men are out of the mine.

Special precautions must be taken to prevent accidental contact between shot-firing cables or wires and power and lighting cables.

Only persons authorized in writing by the mine foreman or superintendent are permitted to fire shots electrically in a mine.

Rule 32.—All apparatus used for firing shots electrically shall be of a type approved by the inspector for the conditions under which it is to be used.

Rule 33.—Where battery or magneto exploders are used, they shall be inclosed in a suitably constructed box, fitted with a removable connecting plug or key without which the circuit can not be closed. This plug or key shall be detached when not required for firing and shall not under any conditions pass from the personal custody of the shot firer while on duty. Exploders shall be frequently tested by the shot firer to insure that they give the necessary pressure and current.

The exploder shall not be connected to the shot-firing cable until all other steps preparatory to the firing of the shot have been completed and all persons have removed to a place of safety.

Immediately after the firing of the shot, the firing cable shall be disconnected from the exploder, and no person shall approach a shot that has been attempted to be fired by electricity and has failed to explode until the firing cable has been so disconnected and an interval of five minutes has elapsed since the last attempt to fire the shot.

Rule 34.—All proper precautions shall be taken to prevent electric wires from coming in contact with other electrical conductors, whether insulated or not.

Construction of signal systems

Bells, wires, insulators, contact makers, and other apparatus used for electrical signaling in connection with the working of a mine shall be of substantial and reliable construction, and shall be erected in such a manner as to reduce the liability to failures or false signals to the minimum.

Telephone systems. When required. How installed

Rule 35.—All coal mines from which exit is by shaft only, and all others in which the working places extend more than one mile from a place of exit, shall be provided with telephone systems, provided the number of men employed at any one

time on the regular working force exceeds twenty-five.[14] The system shall be of approved construction, and of such extent that no working place shall be at a greater distance than three-fourths mile from a telephone, and all places where there are permanent attendants shall be provided with telephones. If more than one hundred men are employed at any one time on the regular working force inside the mine, the telephone lines shall, if possible, be introduced through drill holes so that falls of earth and explosions will be less likely to interrupt the working of the telephone system. All main telephone cables shall be insulated with water-proof insulation, and, unless run through metal pipes or casings, they shall be protected by a continuous lead sheath.

SECTION 5.—SPECIAL RULES GOVERNING THE USE OF ELECTRICITY IN GASEOUS MINES

Rule 36.—In all mines which generate any appreciable quantity of explosive gas and in which electricity is employed below ground, every working place shall be examined daily by an authorized fire boss before any men are permitted to go to work in the mine, and if explosive gas is found in any part of the mine in sufficient quantities to permit its detection by an approved type of safety lamp, the test being made under normal conditions of ventilation, no electrical pressure shall be permitted on any circuits for a period of twenty-four hours in that part of the mine in which gas is found or in any other part of the mine in the return air course from said gaseous part.[15]

Rule 37.—If any mine generates a sufficient quantity of expolsive gas to render necessary the use of locked safety lamps in any part or parts of the mine, those parts of the mine in which locked safety lamps are necessary shall be subject to the following rules in addition to those provided for other mines.

Stoppage of ventilation

Rule 38.—In any part of a mine in which locked safety lamps are necessary, if, for any reason, the normal ventilation is stopped for a period exceeding fifteen minutes, the pressure shall be switched off from all direct-current motors in the same air course, which are not provided with explosion proof casings, except such motors as may be used for driving the ventilating fans or removing men from the mine, and the pressure shall not again be switched on until normal ventilation has been resumed and tests have been made to show that the mine is free from gas.

[14] See Note K.

[15] See Note L.

High pressure prohibited

Rule 39.—No pressure higher than a medium pressure shall be used, and no bare wires other than signal wires shall be permitted.

Mine electrician required to be on duty

Rule 40.—The mine electrician or assistant mine electrician shall be on duty in the mine at all times when the electric power being used for the production of coal in a gaseous part of a mine exceeds twenty-five (25) horsepower.

Main cables, location of

Rule 41.—Main cables shall be taken into the mine only by way of the intake air way, or through separate openings provided especially for the purpose, and so situated as always to be free from explosive gas.

Operation of trailing cables

Rule 42.—Each trailing cable shall be examined daily by the machine boss for abrasions and other defects.

The machine man shall also be required to observe carefully the trailing cable while in use, in order to detect defects, and in the event of any defect becoming apparent, notice of the same shall at once be given to the mine electrician or assistant mine electrician.

Switches

Rule 43.—The use of hooks or other makeshifts for making or breaking a circuit is forbidden, and all switches, circuit breakers, and fuses, shall be inclosed in explosion-proof boxes or break under oil.

Drying motors

Rule 44.—Where the insulation of a motor is found to become damp during a stoppage, suitable steps shall be taken to insure that the insulation shall be dry before the working of the motor is resumed.

Explosion-proof casings required on direct-current motors

Rule 45.—All direct-current motors, unless placed in rooms separately ventilated by intake air, shall have all their current-carrying parts, switches, starters, terminals, fuses, and connections completely inclosed in explosion-proof casings,[16] which shall be of sufficient strength to resist the force of an internal explosion, and which shall be provided with special outlets so designed that the escaping gases shall be cooled to such an extent that they can not communicate the explosion to the outer atmosphere. Such inclosures shall not be opened except by an authorized person, and then only when the pressure is switched off. The pressure shall not be switched on or off while the inclosures are open. All alternating current motors shall be operated only by inclosed, oil-break switches.

Oil switches required with A. C. motors

Apparatus for testing gas must be provided for

Rule 46.—A safety lamp or other suitable apparatus for the detection of explosive gas shall be provided for the use of the

[16] See Note M.

attendant of all electrical apparatus underground, and should any indication of explosive gas appear on the flame of the lamp, or other apparatus used, the person in charge shall immediately stop the machine, cut off the pressure at the nearest switch, and report the matter to the mine foreman, who shall see that, as soon as practicable, the pressure shall be cut off from the wires or cables leading to that part of the mine. The pressure shall not again be switched on until at least twenty-four hours have elapsed since the last appearance of gas.

Procedure when gas is found

Rule 47.—Before an electric coal-cutting machine is brought within twenty (20) yards of the working face in a gaseous part of a mine, the machine man shall make an inspection for gas in the place where the machine is to work, unless such examination is then made by some other competent person authorized or appointed for that purpose by the mine foreman. If any explosive gas is found in the place, the machine shall not enter therein.

Test for gas must be made before beginning to cut coal

No coal-cutting machine shall be continued in operation for a longer period than half an hour, unless otherwise specified in writing by the mine foreman, without an examination being made for gas, as described above, and if gas is found, the current shall be switched off the machine at once, and the trailing cable shall forthwith be disconnected from the feed wire.

Procedure when gas is found

The person finding gas shall at once erect a danger signal to warn persons against entering the place. The trailing cable shall be removed from such place, and shall not be brought back, nor shall the machine be again started until the fire boss, or a person duly authorized by the mine foreman, has examined it and has pronounced it free from gas, and has removed the danger board.

The person finding gas shall forthwith report the same to the mine foreman, and at the end of the shift he shall make and sign a written report in a book kept at the mine for the purpose.

Sparking or arcing outside of inclosed motors

Rule 48.—If any sparks or arcs appear outside the casing of any inclosed motor, or about the cables or rails, the machine shall be stopped, and shall not be worked again until the defect has been repaired, and the occurrence shall be reported to the mine foreman or assistant mine foreman.

Inspection of inclosed motors

Rule 49.—All inclosed motors used underground shall be opened and inspected at least once a week by the mine electrician or his assistant, and, where necessary, shall then be cleaned and repaired. Inclosed switches shall be opened and inspected at least once every month.

Trolley wires prohibited

Rule 50.—Electric haulage on the trolley wire system shall not be allowed in any part of a mine where locked safety lamps are necessary. If storage battery locomotives are used in such places, the rules applying to motors shall also be deemed to apply to the boxes containing the cells.

Storage cells must be inclosed

Electric lighting

Rule 51.—In any part of a mine where there is danger of igniting gas or coal dust, electric lamps, if installed, must be of the inclosed vacuum type, and they shall be inclosed by gas-tight fittings of strong glass and shall have no flexible cord connections. Electric lamps shall be replaced only by an authorized person.

In all machine rooms and other places in gaseous mines where the failure of electric light is likely to cause danger, some safety lamps or other proper lights, not fewer than the number to be prescribed for such place by the inspector, shall be kept for use in the event of such failure.

Electric relighting of safety lamps

Rule 52.—Wherever safety lamps are to be lighted underground by electricity, the mine foreman shall select a suitable station or stations not in the return airway, and where there is not likely to be any accumulation of explosive gas, and no electric relighting apparatus shall be used in any other place. All electric relighting apparatus shall be securely locked, and shall not be available for use except by persons authorized by the mine foreman to relight safety lamps, and such persons shall examine all safety lamps brought for relighting before they are reissued.

Limiting pressure on signal circuits

Rule 53.—In any part of a mine where safety lamps are necessary the pressure used for signaling shall not exceed 50 volts, and bare wires shall not be used for such purposes except in haulage roads.

Carrying capacity of conductors

Rule 54.—All conductors shall have a rated carrying capacity in accordance with the requirements of the National Electric Code.

SECTION 6.—THE INSPECTION OF THE ELECTRICAL EQUIPMENT OF MINES

Appointment of Examining Board

The governor shall appoint, within three months after the passage of this act, three (3) citizens of this Commonwealth of good repute, to be known as the Examining Board for Electrical Mine Inspectors and Mine Electricians, whose duty it shall be to examine applicants for the office of electrical inspector of mines of this Commonwealth and to examine persons who desire to receive certificates of competency as mine electricians. The chief of the department of mines shall be ex officio chairman of this Board,

Personnel of Board

and the other two members shall be, one a mine superintendent, and one an electrical engineer. They shall be at least 30 years of age, and shall have had at least five years' experience in the practice of their respective professions. The chairman of this board shall receive no other compensation than his salary as chief of the department of mines. The other two members of the Examining Board shall each receive the sum of ten ($10) dollars a day for each day actually employed in discharging their duties according to the provisions of this act and all necessary expenses incurred in performing the duties imposed upon them by this act. Any vacancy that may occur in the membership of the Examining Board shall be filled by the governor according to the provisions of this act.

Compensation

Vacancies, how filled

The Board after being duly organized shall, before proceeding with its duties, go before any proper officer authorized to administer oaths and each member shall be duly sworn to faithfully perform the duties of his office without fear or favor.

Members of Board to be sworn

The oaths of the members of the Examining Board shall be kept on file in the office of the department of mines as public documents.[17]

The Examining Board shall be convened by the chief of the department of mines at such time as circumstances may require, for the purpose of examining applicants for the office of electrical inspector of mines, or for preparing questions and formulating rules for conducting examinations, or for performing any other duties made necessary by the provisions of this act. The Examining Board shall also meet regularly once each year, and oftener if necessary, for the purpose of examining applicants for the certificate of competency as mine electrician.

Meetings of Board

Every examination shall be publicly advertised throughout the mining district for a period of at least thirty (30) days prior to the date of the examination, and the time and place of the examination and the conditions of eligibility shall be fully stated in the advertisement.

Examinations to be advertised

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[17] The following form of oath is suggested:

We, the undersigned, do solemnly swear (or affirm) that we will perform, to the best of our ability, the duties of examiners of applicants for appointment to the office of electrical inspector of mines, and of persons desiring to secure certificate of competency as mine electricians, and that in judging such applicants we will be governed solely by the evidence of their fitness to perform the duties of electrical inspector of mines and of mine electrician, in their respective classes, as imposed by this act, and that we will refuse to certify all who fail to show proper evidence of their fitness for such duties.

Qualifications of candidates for office of electrical inspector

All applicants for appointment to the position of electrical inspector of mines shall certify to the Examining Board that they are citizens of the State of . . . . . ; that they are not pecuniarily interested in any of the mines of the State; that they are men of personal integrity, of temperate habits, and of good repute; that they are in good physical condition; and that they are between the ages of thirty (30) and forty-five (45) years. Provided, however, that any person who has served as electrical inspector under this act before reaching the age of forty-five (45) years shall be eligible to reappointment at the discretion of the Examining Board.

Applicants must further show that they have had at least five years of practical experience in the operation of electrical apparatus devoted to power purposes, at least two years of which must have been in connection with the electrical equipment of mines.

Nature of examination

The examination shall be in writing and shall be of such a nature as to show that the applicant possesses sufficient theoretical and general practical knowledge of the application of electricity to mining, of the dangers attending its use, and the safeguards that should be employed. Each applicant must also show that he possesses a full knowledge of the code of the Underwriter's National Electrical Association, of the rules of the American Institute of Electrical Engineers, and of the rules governing the use of electricity in mines as prescribed in this act.

Grading of applicants

The Examining Board shall grade each applicant according to his merit. In determining the grade, the previous experience and record of service of the applicant together shall have equal weight with the written examination, and only those who receive a grade as high or higher than that previously determined upon by the board shall be eligible to appointment. The examination sheets of all applicants, together with the complete list of questions and their correct solutions, shall be kept on file in the office of the department of mines as public documents. The Examining Board shall certify to the governor and to the department of mines the name and grade of all successful candidates and shall issue to every candidate a statement of the result of his examination.

Appointment of inspectors, number, etc.

The governor shall, from the names certified to him by the Examining Board, commission as many electrical inspectors as the conditions of the service may require, but at least one electrical inspector must be appointed for each five inspection districts of the State. Provided, that if in any district the regular inspector

of mines is also a qualified electrical inspector, such district need not be counted in determining the number of electrical inspectors necessary. When appointments are made, those persons standing highest in percentage on the examination shall be given preference over those of lower percentage. Provided, that any person who has not been certified as hereinabove provided within a period of ten years, shall not be deemed eligible for appointment or reappointment to the office of electrical inspector of mines until he shall have been again examined and certified by the Examining Board according to the foregoing provisions of this act.

Length of term of electrical inspectors

All appointments to the office of electrical inspector of mines shall be for a full term of six years, but in case of a vacancy the governor may commission for the unexpired term the person having the highest grade on the certified list.

Salaries of electrical inspectors

Electrical inspectors on first appointment shall receive a salary of three thousand ($3000) dollars per year, which shall be increased to thirty-five hundred ($3500) dollars per year after the inspector has served for six years.[18] Each electrical inspector may incur traveling expenses and such other expenses as may be necessary for the proper discharge of his duties under this act, which shall be paid quarterly by state treasurer on warrant of state auditor issued upon presentation of vouchers sworn to by the inspector and approved by the chief of the department of mines.

Duties of electrical inspectors

The electrical inspector shall inspect the electrical equipment used in, or in connection with, all of the mines within his jurisdiction as often as possible. Within five (5) days after completing the inspection of a mine, the inspector shall prepare a printed report setting forth fully the condition of the electrical equipment of said mine, the copy of this report shall be sent to the office of the department of mines, where it shall be kept on file as a public document, and another copy shall be sent immediately to the superintendent of the mine to be posted by him in a conspicuous place near the workings.

Procedure in case orders of electrical inspector are not complied with

If the inspector discovers any violation of any of the provisions of this act, or any conditions which, in his opinion, may be contrary to the spirit of this act, he shall at once notify the super-

[18] In some of the more important coal mining States the responsibilities of the electrical inspector of mines are so great that the salaries here suggested appear to be very moderate. In other States, as, for example, in the metal mining States or those States in which the coal mining industry is not of great magnitude, a smaller salary would be indicated.

intendent or manager of the mine in which such condition is discovered and order the immediate removal of the defect. If the superintendent or manager fails to remove at once such condition,[19] the inspector shall immediately report the matter to the chief of the department of mines, who shall promptly designate two other inspectors who shall accompany said electrical inspector to the mine wherein said dangerous condition is alleged to exist. If after a full investigation the inspectors agree that the condition is one of grave danger, they shall direct the superintendent of the mine in writing to remove the dangerous condition immediately, and if the superintendent fails to do so, the inspectors shall at once apply to the proper court for a writ of injunction to enjoin the immediate suspension of all work in or about any part of the mine which the inspectors believe to be jeopardized by the dangerous condition. Whereupon the court shall proceed immediately to hear the case, and if the cause appear to be sufficient he shall issue a writ of injunction restraining the working of said mine until it can be shown to the satisfaction of the court that the provisions of this act have been complied with.

If the court shall sustain the decision of the inspectors, the costs of the proceeding shall be paid by the owner or agent operating the mine, but if the court shall not sustain the decision of the inspectors, the costs shall be paid by the county.

Electrical inspector subordinate to chief of department of mines

The electrical inspector shall work under the direction of the chief of the department of mines, and shall perform such duties and make such reports from time to time as he may direct.

Powers of electrical inspectors

If at any time the electrical inspector shall discover any condition of so grave a character that, in his opinion, any delay might be disastrous to life, he shall have the power to withdraw temporarily all persons from such dangerous place until the foregoing provisions of this section can be carried out.

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[19] In a proposed code recently prepared by the department of mines of Pennsylvania and presented to the state legislature, the procedure is briefly as follows:

In case of disagreement between inspector and mine owner or operator, the owner or operator shall appeal to the chief of the department of mines, who then appoints two other inspectors to accompany the inspector of the district to make a further examination into the matter in dispute. If the inspectors agree their decision shall be final unless the owner or operator shall appeal within seven days to the proper court. The court must then appoint three persons as referees to investigate the matter, and if they sustain the decision of the inspectors, their decision shall be final unless a bill of exception is filed by the owner or operator within ten days, in which case the court shall proceed at once to hear the case, and his decision shall be final and conclusive.

Additional powers and duties of electrical inspectors

The electrical inspector shall have the right to enter any mine within his jurisdiction at any time for the purpose of making examinations or obtaining information. In case of accident, resulting directly or indirectly from the use of electrical apparatus in or about the mine, the electrical inspector shall be required to make a full and complete investigation into the nature and cause of the accident, and to enable him to do this he shall have power to summon witnesses and administer oaths. He shall make a full report of every such investigation to the chief of the department of mines.

Trial of electrical inspector

When written charges of incompetency or gross neglect of duty, or malfeasance in office, shall be brought against any electrical inspector, and signed by not less than 15 coal miners, or by one or more mine owners or operators (and accompanied by a bond in the sum of five hundred ($500) dollars, payable to the State and signed by two or more responsible freeholders, and conditioned for the payment of all costs and expenses arising from the investigation of such charges) the governor shall convene a board of examiners to investigate the case, which board shall consist of three members, one of whom shall be a member of the electrical inspector's examining board, one a mining engineer, and the third the attorney-general of the State or a presiding judge of the district court, said board to be convened at such time and place as the governor may deem best, giving ten days' notice to the inspector against whom the charges are made, and also the persons who have made the charges. The board when so convened, and having been first duly sworn truly to try and decide the charges made, shall summon any witnesses desired by either party to the case, and examine them on oath which may be administered by any member of the board, and depositions may be read on such examination as in other cases; and the board shall examine fully into the charges and report the result of the investigation to the governor. If the board shall sustain the charges made, the governor shall at once declare the office of the said electrical inspector vacant, and shall proceed to fill the same in accordance with the provisions of this act, and the costs of said investigation shall be paid by the county. If, however, the charges shall not be sustained, the said electrical inspector shall stand exonerated, and the costs of the examination shall be paid by the persons signing the bond.

Costs of trial

Qualifications of candidates for post of mine electrician

Applicants for the mine electricians' certificate of competency shall be required to give satisfactory evidence that they are at least 21 years of age, that they are of temperate habits and of good repute, and that they are in good physical condition. They must further show that they have had at least two years' practical experience either as assistant mine electrician or in the operation of electrical systems devoted to power purposes, in which case their experience must include both wiring and the operation and repair of electric motors. They must give evidence that they possess a practical knowledge of electric wiring, the making of joints, bonding of tracks, and testing for faults in wires, cables, and motors. Also, that they have a due appreciation of the dangers attendant upon the use of electricity in mines, and a knowledge of the proper safeguards. They must show also that they possess a sufficient knowledge of the rules of the American Institute of Electrical Engineers, and of the rules and regulations provided by law for governing the use of electricity in mines in the State of . . . . . .

Duties of mine superintendent, etc.

It shall be the duty of the mine superintendent, mine foreman, or other official in responsible charge of the mine at the time of any serious accident, at once to give notice of such accident to the inspector of the district in which the accident occurred.

Penalties

Any person who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding one hundred ($100) dollars, or by imprisonment for a term not exceeding three months, or by both such fine and imprisonment, at the discretion of the court.

Any mine owner, superintendent, mine foreman or mine electrician who shall wilfully permit any violation of any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding two hundred ($200) dollars, or by imprisonment for a term not exceeding six months, or by both such fine and imprisonment, at the discretion of the court.

Liability of employers

If any employee shall receive any injury, occasioned by the violation of any of the provisions of this act by the owners, operators, or any responsible employee of said owners or operators, a right of action shall accrue to the injured party against said owner or operator, for any injuries he may have sustained thereby. And in case of loss of life by reason of such violation aforesaid, a right of action shall accrue to the widow or lineal heirs of the deceased for the recovery of damages.

III. SOME EXPLANATORY STATEMENTS IN REGARD TO THE PROPOSED CODE OF RULES GOVERNING THE USE OF ELECTRICITY IN MINES

In the accompanying code there are a number of proposed rules in regard to which there appears to be considerable diversity of opinion. It has seemed wise therefore to accompany these proposed rules with a few explanatory notes setting forth the principal considerations that have led to the adoption of certain of the proposed rules about which there may be some question.

NOTE A

Rule 1 (second paragraph).—This rule requires that the frames and bedplates of generators, motors, and transformers, and the metallic coverings of cables, switches, etc., shall be grounded.

Four objections are usually brought against grounding as herein required, viz:

(1) It produces greater strain on the insulation.

(2) A single fault in the insulation requires the shutting down of the machine or cable.

(3) Such a fault may develop a short circuit and the flash which results may ignite gas, should the latter be present.

(4) Difficulty is often experienced in making a good ground, especially for coal-cutter motors.

The first of these objections can be justified only on the ground of economy in the initial installation. It is true that a somewhat cheaper machine can be built where the insulation strains can be kept low, but in the case of low or medium voltage machines for mining work the severe mechanical strains that are put on the insulation due to severe overloads, mechanical shocks, etc., require that the insulation be of such strength and quality that the additional voltage strain that would be caused by grounding the frame would be of relatively small consequence. The difference in cost would therefore be of such slight importance that it would be hardly worthy of consideration in comparison with the much more important question of safety.

As regards the second objection, that a single fault in the insulation makes it necessary to shut down the machine, it must be said that this is true only in case one point of the electric circuit is grounded, and even then it can hardly be regarded as a disadvantage. A machine which has developed a fault in its insulation should never be continued in operation in a mine even though such operation may be possible. Any machine that has developed a fault in its insulation is obviously more likely to develop another than one in which trouble has never occurred, because the appearance of the first fault often indicates a bad condition of the insulation as a whole.

Hence it is more dangerous to operate a machine that is grounded through defective insulation than to operate one in which the frame is intentionally connected to earth. Moreover, either through overlooking the defect, or owing to the inevitable tendency of the operator to keep the machine in operation, even after the first defect is discovered, this condition of greater danger would frequently arise.

The third objection mentioned carries practically no weight for the reason that the rules prohibit the operation of electric machines where gas in explosive quantities is present, and the possibility of a short circuit developing during the interval between the appearance of gas and the shutting down of the machine is very remote.

The last objection is not serious since the ground wire need not be of large current carrying capacity, hence a small flexible wire can be run to any convenient ground plate or other suitable ground, either back along the trailing cable or separately as the case may require. Since this wire is not alive its presence can not be regarded as materially objectionable and the question of insulation does not arise at all.

On the other hand we have the unquestionable fact, supported by numerous authentic records, that persons have frequently been killed by coming in contact with the ungrounded frame of a motor or coal cutter which had accidently become alive even from a lower stage circuit; whereas such accidents are rendered absolutely impossible by the thorough grounding of the frames of such machines.

It would seem therefore that the doubtful advantage of ungrounded machine frames can hardly be regarded as comparable with the positive safety from shock assured by the thorough grounding of such machines.

Grounding of machine frames, cable sheaths, etc., is required by law in Great Britain, Cape of Good Hope, and New South Wales.

NOTE B

The grounding of three-wire direct current systems and all alternating current systems of low or medium voltage is deemed of great importance as a measure of safety. The large number of deaths from electric shock from low and medium voltage circuits has proven beyond a doubt that the danger even from low voltage circuits is serious and should be guarded against wherever possible. Three-wire systems are rarely installed in mines for lower than medium voltages, and since the grounding of the neutral of such a system reduces the normal working pressure between either line and ground to one-half what it would if one side were grounded, it is desirable that the neutral point be grounded wherever possible.

In alternating current systems the danger from shock arises from two sources, viz, from the normal working pressure of the circuit, and in the case of secondary circuits, from the high pressure of the primary circuit due to accidental contact between primary and secondary system. Danger from the latter source is eliminated by grounding any point of the secondary system. If one side of the secondary be grounded, however, there would still remain the danger of shock from the normal working pressure of the secondary circuit, while if the neutral or middle point of the secondary winding of the transformer be grounded, a person standing on the ground and

touching either wire would receive only half of the normal working pressure between lines in the case of a single-phase system. Here, again, therefore, the neutral should be grounded wherever possible. Most companies are now prepared to supply standard types of transformers, in which the neutral can readily be grounded when working at pressures of 220 or 440 volts, so that this presents no difficulty. In three-phase systems two cases have to be considered, viz, the Δ and Y connected secondaries. In the latter the common connection of the three phases is commonly called the neutral and this point should always be grounded, since by so doing the voltage between any line and ground is reduced to about 58 per cent of what it would be if one line were grounded. In case the secondary is connected in Δ there is no neutral point as in the case of the Y connection. In this case the neutral point of one phase, and one only, should always be grounded, as in this case the pressure between two of the lines and ground is reduced to one-half of the normal working pressure between lines, and that between the third line and ground is reduced to about 86 per cent of the normal line voltage. It is apparent, therefore, that grounding a proper neutral point on any system greatly reduces the danger of shock. It may be noted that the delta-connected system gives a somewhat less satisfactory condition in this respect, but inasmuch as this connection is sometimes preferable in practical operation, it does not seem desirable to prohibit its use.

NOTE C

Rule 3.—The prohibition of pressures higher than 600 volts on portable motors and the moving parts of machines is justified by the fact that with these high voltages the question of insulation becomes a very important one and the necessity for maintaining thorough insulation is imperative. It has been demonstrated by experience that the insulation of moving armature coils and of flexible trailing cables, especially the latter, is much more difficult to maintain than in the case of stationary armatures and fixed cables. Moreover, portable motors and cables require much more handling than stationary motors and hence the liability to shock becomes greater.

In the excessively damp atmosphere that prevails in many mines the use of an air blast for cooling transformers seems certain to give rise to serious insulation troubles. Oil insulated, oil or water-cooled transformers have demonstrated their reliability and comparative safety under all conditions of service, and it is therefore believed that a maximum degree of safety will result from their use.

The limitation of high-voltage motors to 20 horsepower or over is advisable for several reasons: In the first place, it is very difficult to provide ample insulation for the coils in the small space available in motors of less than 20 horsepower without making an unduly large and expensive machine; and further, since small machines usually receive less care and attention than large machines, trouble is more likely to develop. Again, the use of high voltage is desirable only for the sake of securing economy of copper in the transmission line, and its importance therefore depends on the amount of power to be transmitted. In the case of very small powers, the total charge for copper with medium voltage would be small and hence the saving

by the use of high voltage would not be sufficient to justify the increased hazard which must accompany its use, and its use in such cases should therefore be discouraged.

It seems advisable to make a distinction between the danger signals to be used on high and medium voltage systems for the reason that men, as a rule, have a tendency to disregard danger signals if they are too common, and this would be especially true if the same signals are used on the high-voltage circuits as are used on the low-potential circuits. By making a distinction between the two classes, the high-voltage circuits at least, which are admittedly the most dangerous, are more likely to be avoided.

It has been argued that the tendency of men to disregard danger signals is so great that it is useless to provide them in any case. It can not be denied, however, that there are many men who desire to avoid danger and would do so if they were warned of its presence, and in justice to such it appears that the least that can be done is to point out that the wires are dangerous, and also as near as may be, indicate the degree of the danger.

Not a few persons consulted have opposed the provision requiring that low-pressure circuits be marked with the word "Caution." Our records show, however, that in the aggregate a large number of persons have been killed by coming in contact with low-voltage wires, and we believe that some sort of warning is necessary.

NOTE D

Rule 4.—In the matter of leakage, it seems necessary to make a distinction between cables of two or more wires, or those with metallic sheaths, and those wires that may give rise to leakage over exposed surfaces. In the former case any leakage that may exist must of necessity pass through the insulation, and a relatively small amount of leakage would indicate a defective condition of the insulation which might at any time develop serious consequences. On the other hand, in the case of wires which depend on their supports for insulation, such as trolley wires, there is the possibility of leakage over exposed surfaces, and in general owing to accumulations of damp coal dust and dirt, which may contain considerable acid, the leakage will be much greater. The leakage current will, as a rule, be distributed over a great many insulators, and further since it indicates, as a rule, only a temporary condition that can be readily removed by cleaning the insulators, it is not to be regarded as being as serious as leakage from cables, and hence much larger leakage may be permitted in such cases.

NOTE E

Rule 5. Examination of mine electricians.—The post of mine electrician is one of considerable importance, since it has much to do not only with the economy and reliability of operation of the electrical system, but also with the safety of the miners. Great care should therefore be exercised in choosing a man for this place.

We believe that mine electricians should be required to pass an examination along the lines indicated in section 6 of the proposed code, for reasons which will appear from a careful consideration of the qualifications which

such persons ought to possess. A mine electrician must be, among other things, a person capable of exercising sound judgment. In order to do this, he must have had ample experience, since no inexperienced person can judge soundly in regard to technical matters. He must also have a thorough knowledge of the state laws governing the use of electricity in mines, in order that he may know when the laws are being complied with. An examining board, properly constituted, can determine with certainty in regard to the two latter of these requirements, and it can also form a pretty accurate judgment in regard to the first; and, in determining this much in regard to the men, the board could be of very great assistance to nontechnical mine operators in the selection of a man for this important post.

As to the other principal requirement of the mine electrician, viz, that he be sufficiently industrious to exert himself to use his abilities in the proper discharge of his duties, the board probably could not determine so definitely, but even here it could be of considerable assistance by inquiring into the previous record of service of the applicant. We have obtained expressions of opinion from a number of mine electricians in regard to this matter, and in the vast majority of cases they are unqualifiedly in favor of the proposal where the character of the proposed examination is explained to them. An examination carried out along the lines indicated in section 6 would be an eminently practical one and free from political favor or bias, and it would eliminate few, if any, men who are really competent to carry the responsibilities of a mine electrician. It would, however, eliminate from the list of possibilities not a few incompetent persons who, through some form or other of personal favoritism, might in some cases be given responsibilities that they are not properly qualified to carry. We do not see how such an examination could ever result in lowering the efficiency of mine electricians, while it appears certain that in many cases at least it would tend materially to raise the standard.

NOTE F

Rule 10.—It is a well-known fact that bituminous coal dust in considerable quantity is violently explosive in the presence of air, even though no explosive gas whatever is present. Further, a quantity of gas too small to be explosive in itself, or even to be indicated on the cap of a safety lamp, may, in the presence of a small quantity of coal dust, produce a violently explosive mixture. There are many mining engineers who believe that coal dust is more frequently the cause of explosions than gas. Inasmuch as numerous electrical phenomena, such as short circuits, blowing of fuses, arcing of air-break switches, etc., are capable of igniting any coal dust that may be present, it seems necessary that special precautions be taken to remove or keep down coal dust, or else the special rules applying to gaseous mines should be observed.

NOTE G

Rule 14.—All high-voltage wires inside of a mine should be thoroughly insulated for the reason that it is impracticable to maintain insulating supports so as not to give rise to excessive leakage over the surface when subjected to high voltage, and also to reduce the danger of electric shock.

Owing, however, to the excessively damp and acid atmosphere in most mines, all insulations at present available for commercial insulation of cables deteriorate much faster than under ordinary conditions above ground, and in time become practically worthless, and even a menace, since their presence may engender a false sense of security and actually increase the danger of electric shock. The only remedy for this is to use metal-covered cables. This would be more expensive, of course, in first cost, but the greatly increased life of the cable, together with greater freedom from trouble, would probably make it the more economical in the end, and if the lead sheath be grounded it eliminates entirely the danger of electric shock.

It seems advisable also that even with lead-covered cables the insulation should be nonhygroscopic and as nearly as possible proof against the action of mine acids, because there is always the possibility of a defect appearing in the lead sheath, either through a defective joint or through electrolytic action, or otherwise; and if paper insulation is used, even a small opening of this sort may admit enough moisture to destroy the insulation at that point and cause a breakdown. The use of nonhygroscopic insulation protected by a lead sheath seems therefore to offer the most reliable protection and should be used in all cables that are of sufficient importance to demand the use of high voltage.

NOTE H

Rule 16.—Whenever two dissimilar metals are joined together, as at the contact of a soldered joint, there exist local differences of potential which, in the presence of an excessively moist atmosphere, will give rise to more or less local electrolytic corrosion, which in time may destroy the joint. This can be largely prevented by taping or otherwise insulating the joint in such a way as to protect it from moisture. The expense of this protection is so slight as to be of no consequence, and it should therefore be applied in all cases where bare wires are used except, of course, in the case of trolley wires where it is obviously impractical.

NOTE I

Rule 22 (third paragraph).—Every overhead trolley wire is a source of danger when the pressure is on, whether the same be in use or not, but inasmuch as most branch trolley wires are actually in use only a small part of the time, it would greatly reduce the probability of electric shock if the pressure were cut off when not actually needed. If this be done, however, some sort of signal should be provided to indicate when the pressure is on, and in the dark recesses of a mine, lamps would appear to be the only suitable signal for this purpose. A number of lamps should therefore be permanently connected in series across the trolley circuit, the number depending on the voltage of the line, and the lighting up of these lamps would indicate that the trolley wire is alive. Owing to the liability of the lamps to burn out, and further since the burning out of one lamp extinguishes all those in series with it, a single circuit of this kind might sometimes, by its failure to light up, give a false signal indicating that the trolley wire is dead even when the pressure is on, which would obviously be worse than if no signal

at all were provided. To prevent this at least two such sets of lamps should be connected to the trolley circuit at every entrance to the branch roadway, so that the failure of one lamp would not cause a failure of the signal.

NOTE J

Rule 26.—Sectionalizing switches are necessary both for disconnecting certain sections of the line in cases of emergency, such as fires, short circuits, etc., and for purposes of periodic testing of the insulation.

NOTE K

Rule 35.—The question of communication between the surface and the workings of large mines is one which has not, in most cases, received as much attention as its importance deserves. Many mine managers who have expressed themselves on this subject agree that an adequate telephone system in a large mine will be worth much more than its cost merely as an aid to the regular routine operation of the mine. The delay in its general introduction may be due in part to the peculiar physical conditions which prevail in most mines, which render it difficult to maintain in proper working order, a telephone system installed on lines similar to those generally employed above ground. At the present time, however, several firms are prepared to furnish telephone systems designed especially for mining conditions, and such systems may be depended upon to give satisfactory and reliable service, provided sufficient care be taken to insure good construction of the line. Such a system would be of value not alone in facilitating the regular operation of the mine, but it might often prove to be a valuable agent in preventing mine disasters, or in reducing their severity. In order to be most effective in doing this, however, it is necessary that the construction be such as to give rise to the fewest possible interruptions. This condition is difficult to attain if the wires are placed along the side or roof of the roadways, because owing to the falls of earth, fires, explosions, and other causes, the lines might become useless when most needed. It seems probable that the most reliable working could be attained by introducing the telephone cables into the mine by way of suitably placed drill holes. In this case the main lines would be free from interruption due to falls of earth and most explosions, and fires of short duration, and might often be used to advantage in rescue work when such disasters occur.

Such a construction would generally be the most reliable one in cases of emergency, when the lives of the miners are at stake, and the great importance of this feature would seem to give ample warrant for this type of construction.

NOTE L

Rule 36.—There are some who believe that electric circuits and apparatus of all kinds should be entirely excluded from mines in which the liability of the appearance of gas is such as to render necessary or advisable the use of safety lamps. In view, however, of the great economic importance of electricity in coal mining, care should be exercised not to restrict or hamper its use more than is rendered neccssary by considera-

tions of safety to life and property. There can be no question but that all types of electrical apparatus which, during normal operation give rise to sparks, arcs, or flashes, such as direct-current motors, arc lamps, trolleys, etc., are very dangerous whenever there is any great probability of the appearance of gas, and it will be generally agreed that such apparatus should be prohibited wherever conditions are such as to render necessary the use of safety lamps. With other apparatus, however, such as explosion-proof motors, polyphase motors of proper design, and well-installed circuits conveying power to such apparatus, there is comparatively little danger of igniting gas even if it should be present in explosive quantities. In fact, the ignition of gas by such apparatus is impossible except under certain comparatively rare conditions of abnormal operation—conditions which can usually be anticipated and prevented by proper periodic testing and inspection of the apparatus. It does not seem wise therefore to prohibit the use of such apparatus where gas does not exist merely because there is a possibility of its appearance. But because of the possibility of danger when gas is actually present it has been deemed wise to require the immediate shutting down of all electrical apparatus as soon as gas is found to be present in dangerous quantities. It is believed that this requirement practically eliminates the danger of an explosion arising from this source because, in view of the fact that such apparatus may often operate for days or even weeks in the actual presence of explosive gas without causing an explosion, the danger of the ignition of gas during the brief interval between its appearance and the shutting down of the apparatus seems very remote indeed.

Another rule (Rule 46) provides for cutting the pressure off from polyphase and other motors when gas actually appears.

NOTE M

Rule 45.—In many foreign laws provision is made that electric motors, switches, etc., working in gaseous mines shall be provided with flame-tight casings. Experience has shown, however, that such casings are inadequate, since it is practically impossible to maintain them in such a way as to prevent the accumulation of explosive gases within them, when such gases appear in considerable quantity in the air outside. The necessity for providing means for opening such casings for inspection, together with frequent changes in temperature caused by ordinary working, with the consequent changes in internal pressure, contribute to the difficulty of maintaining such casings free from gas. Cases have actually occurred in which explosions of gas have been caused by opening a so-called flame-tight switch. Experiments have shown that the only practicable way to operate motors, air-break switches, fuses, etc., in an explosive atmosphere is to make the casing explosion proof. In so doing it is not necessary that the case be made gas-tight, and no care need be taken to prevent gas from entering freely within the casing. The essential thing here is to make the casing of sufficient strength to resist the internal pressure developed by an explosion, and to provide an exit for the gases which will at the same time cool them to such an extent that they can not communicate the explosion to the atmosphere. This is usually accomplished by causing the gases to pass out

through a somewhat elongated passageway, across which are placed a number of fine metal gauzes, preferably of copper. In passing through these gauzes the gases are cooled successively, and by providing a sufficient number of the gauzes the temperature of the gases can be readily reduced below the flash point of the gases which are found in the mines. Other and equally effective means have been proposed, so that the requirements can be easily met by the manufacturers.

Section 6.—It is recognized that, wherever possible, the duties of the electrical inspector as set forth in the proposed code should be performed by the regular inspector of mines, and provision is made for this wherever the regular inspector is qualified to perform such duties. In many cases, however, the regular inspectors may not possess, at the outset, sufficient familiarity with electrical apparatus to inspect the electrical plant as efficiently and thoroughly as it should be done, and in most cases considerable time is necessary to acquire the requisite experience. In such cases some provision seems to be necessary for providing proper inspection of the electrical apparatus by a qualified expert until such a time as the regular inspector may acquire sufficient experience with electrical machinery and appliances to enable him to properly and safely exercise the authority of electrical inspector.

Administration of the law.—The form in which the present proposed code is drawn places the authority and responsibility for enforcing the laws in the hands of the chief of the department of mines. Such departments of mines are now in existence in most of the leading mining States, but in some States no such department exists, the supervision of mining work, where such supervision exists at all, being placed with some other branch of the state government, such as the geological survey, bureau of labor, etc. In such cases, of course, the details of that part of the law relating to its enforcement would be changed accordingly.

Liability of employers.—In inserting the clause in regard to liability of employers, it is recognized that many States now cover this point with a general liability law which includes mining within its scope, in which case this provision would not be required in the mining law. This is not always the case, however, and the importance of this provision appears to be such as to justify its inclusion here by way of suggestion.

The article in the next section on the dangers of electric wires has been prepared for the information of the mine workers, many of whom are unaware of the possibilities of accidents due to contact with wires or the short circuit of two wires. It is intended to reprint this article as a separate circular, perhaps in several languages, and to furnish copies to mine superintendents on request, to distribute among the employees of their mines. It is hoped that in justice to the mine workers an effort will be made to get this information into the hands of the men for whom it is intended.

IV. DANGERS OF ELECTRIC WIRES, AND HOW TO AVOID THEM

Electric wires used for power purposes in mines are dangerous to human life and should always be approached with caution. Deaths occur every year from electric shock, and yet in most cases these accidents could have been prevented if proper care had been exercised to prevent contact with the wires. Some men accustomed to working near electric wires grow careless, and it is largely because of this carelessness, and a lack of knowledge of the dangers involved, that so many deaths from electric shocks occur.

Special precautions are necessary in mines even where low or medium voltages are used. Everybody knows that high-voltage wires, carrying 1000 volts or more, are dangerous, and such wires are carefully avoided. But many think that circuits carrying only a few hundred volts are not dangerous. This is a serious mistake, because many deaths from electric shock occur from pressures of 300 volts or less. A considerable number of deaths have occurred from contact with circuits of less than 200 volts.

Electric circuits in mines are, as a rule, more dangerous to life than similar circuits above ground. This is sometimes due to the lack of space, which increases the liability of contact with the wires, but mainly to the damp condition of most mines. In order to receive an electric shock a man must place his body between two conductors of different electric pressures, or between one conductor and the ground. If the earth be dry, a man standing on the ground and touching the wire would receive a lighter shock than if he stood on wet ground and touched the same circuit, because dry earth is a poor electrical conductor, while wet or moist earth is a good conductor. When the skin is dry it also affords protection against low voltages, but when the skin is wet it becomes a better conductor and gives no protection. Hence, wires which might be touched with safety at one place where the ground is dry may be highly dangerous at a near-by place where the ground is moist. It is not safe, therefore, to assume that because one has touched a circuit before, or has seen some one else touch it without injury, that it is safe to touch it again. Men have frequently been killed by coming in contact with a circuit that they have often handled without harm, because, owing to different conditions of the ground, or poorer insulation of the circuit, or to a different manner of contact with the wire, the circuit is more dangerous at some times and in some places than in others. Especial care should be taken not to touch wires when standing on an iron rail or in water, as the danger is usually greatest under such conditions.

All power wires in mines of whatever voltage should be regarded as dangerous and avoided whenever possible. Insulated wires should be avoided as carefully as bare wires. Under the conditions that exist in many mines, the insulating coverings of wires become practically worthless as a protection from electric shock. Defective insulation can not always be detected by inspection, even by an expert electrician, and an insulation that appears

perfectly good to the eye may be defective, and, if touched, a severe, or perhaps a fatal, shock may result. Even lead-covered cables should be avoided, because unless the lead sheath be thoroughly grounded, which is often not the case, a shock may be received.

Special attention is called to the danger of carrying metal tools, such as drills, picks, shovels, etc., in roadways in which there are live electric wires. It is difficult to carry such tools in the limited space afforded by roadways without permitting them to come in contact with the wires. When a person holds such a tool and permits it to touch a live wire, the result is generally much more dangerous than if he had touched the wire directly with his hand, because of the fact that if he has a firm grip on the tool there is a better contact with the circuit. A large proportion of the deaths due to electric shock in mines result from carrying tools along roadways where there are exposed wires. The practice of carrying long metal tools along such roadways should therefore be avoided whenever possible, and when it becomes necessary to do so, the greatest care should be taken to keep the tools clear of the wires.

Cans of powder should never be permitted to come near to electric wires of any kind. The slightest contact of the can with the wires may often result in an explosion.

Very low voltage wires that are not likely to inflict severe shocks should, nevertheless, be regarded as dangerous. If the two wires are brought together, or if a piece of metal be connected across them, it forms what is known as a short circuit, and a blinding flash follows. This may often be so severe as to seriously injure the eyes of any person standing near, or it may inflict severe and sometimes fatal burns. Serious damage to the generating machinery may also result from such short circuits. Only experienced electricians should undertake to handle wires or operate electrical machinery.

Fires may be started as the result of a short circuit, and explosions of gas or coal dust may start in that way. It is very important, therefore, not to break an electric wire so that it may fall upon another, nor to touch the wires with any piece of metal, even when they carry the lowest voltages used in mining work.

The practice of playing with electric wires or disturbing them in any way, or of playing practical jokes, such as connecting a wire from an electric circuit to a doorknob, or to a tool for the purpose of inflicting a shock on a fellow-workman, is a dangerous practice and should never be indulged in even with very low voltage wires. Cases have been known in which the victims of such jokes have lost their lives as a result of the shock thus inflicted. Never tamper with electric circuits or apparatus in any way.

Never try to remove a wire that is found lying about or across the roadway or working places, until authorized to do so by the mine electrician or some other responsible person. It may be alive and dangerous.

Observance of the simple precautions pointed out above will serve to prevent a large proportion of accidents that would otherwise occur.

Electricity is a very useful agent in mining as in other industries. Used for haulage, coal cutting, lighting, hoists, signals, and other purposes it is of great value, and decreases the discomforts of mining. If it is properly used and the machines and wires are avoided by those not authorized to handle them, it is safe and a benefit to the miners.

V. ELECTRICAL MINING LAWS IN EFFECT IN VARIOUS STATES AND FOREIGN COUNTRIES

Up to the present time there has been very little legislation in America in regard to the use of electricity in mines. A few States have recognized the necessity of providing some sort of regulation, and have provided a few rules governing certain portions of the electrical equipment, but no law that covers the subject in anything like an adequate manner is in effect in any State. Ohio has, however, made considerable progress in its new law which has just gone into effect. Recently the department of mines in several States, notably Pennsylvania and West Virginia, have been quite active in proposing and urging legislation with a view to regulating the use of electricity in mines, but there has been a lack of concerted action between the different States, and as yet little legislation has actually been secured. In a number of foreign countries, on the other hand, a great deal has been accomplished in this direction, and comprehensive laws have been in effect for several years.

The following compilation of the electrical mining laws of the different States that have done anything in this direction, and of the principal foreign countries, has been made with a view to assisting those who are interested in the subject of regulating the use of electricity in mines, especially the departments of mines and the legislatures of the various States.

UNITED STATES

WEST VIRGINIA

There has been no law passed by the legislature of West Virginia governing the use of electricity in mines, but the department of mines has prescribed a code of rules which apply to the federal mine until such a time as the legislature may provide a general law. The department of mines has also prepared a code of rules relating to mine wiring, which it has recommended to the legislature for passage. The provisions of both of these codes are given below:

CHAPTER I.—REGULATIONS GOVERNING THE INTRODUCTION OF ELECTRICITY IN THE FEDERAL MINE PENDING A GENERAL ACT OF THE LEGISLATURE COVERING THE INTRODUCTION OF ELECTRICITY AND ITS USE IN COAL MINES IN THE STATE OF WEST VIRGINIA

1. Nothing in these regulations shall be construed as giving the sanction of the West Virginia mine inspectors to the use of any apparatus or device installed hereunder after the same has been condemned by any subsequent act of the legislature, and all rules and regulations herein mentioned and apparatus installed hereunder are to apply alone to the installation of electricity at the federal mine until such time as a general act of the West Virginia legislature shall definitely prescribe regulations covering the installation and use of electricity in coal mines and at which

time the Federal Coal & Coke Company will make its plant installed hereunder conform to the provisions of such an act.

2. The current used inside the mine will be low tension 250 volt direct current.

3. All electrical apparatus and conductors shall be sufficient in size and power for the work they may be called upon to do and so installed, worked, and maintained as to reduce the danger through accidental shock or fire to the minimum, and shall be of such construction and so worked that the rise in temperature caused by ordinary working will not be greater than demanded by fire underwriters' rules governing such installation in surface structures.

In any part of the mine where safety lamps are used the wiring shall be so hung and the insulators so constructed that there will be no danger of firing gas by short circuiting, sparking, or arcing of the current.

4. The insulation of every complete circuit other than signal or telephone wires used for the supply of energy, including all machinery, apparatus, and devices forming part of or in connection with such circuit, shall be so maintained that the leakage current shall, so far as is reasonably practicable, not exceed $\frac{1}{1000}$ of the maximum supply current, and suitable means shall be provided for the immediate localization of leakage.

5. In every completely insulated circuit, earth or fault detectors shall be kept connected up in every generating and transforming station to show immediately any defect in the insulation of the system. The reading of these instruments shall be recorded daily in a book kept at the generating or transforming station or switch house.

6. Main and distribution switch and fuse boards must be made of incombustible insulating material, such as marble or slate, free from metallic veins, and be fixed in as dry a situation as practicable.

7. Every subcircuit must be protected by a fuse on each pole. Every circuit carrying more than 5 amperes up to 125 volts, or 3 amperes at any pressure above 125 volts, must be protected in one of the following alternative methods:

(*a*) By an automatic maximum cut-out on each pole.

(*b*) By a detachable fuse on each pole, constructed in such a manner that it can be removed from a live circuit with the minimum risk of shock.

(*c*) By a switch and fuse on each pole.

8. Fire buckets filled with clean, dry sand shall be kept in electrical machine rooms, ready for immediate use in extinguishing fires.

No repair or cleaning of the live parts of any electrical apparatus, except mere wiping or oiling, shall be done when the current is on.

Gloves, mats, or shoes of india rubber or other nonconducting material shall be supplied or used where the live parts of switches or machines working at a pressure exceeding the limits of the low pressure, have to be handled for the purpose of adjustment.

9. A competent person shall be on duty at the mine when the electrical apparatus or machinery is in use; and at such time as the amount of electricity delivered down the mine exceeds 200 brake horsepower, a competent person shall be on duty at the mine above ground and another below ground. Every person appointed to work any electrical apparatus shall have been instructed in his duty and be competent for the work that he is set to do.

10. No person shall wilfully damage, interfere with, or without proper authority remove or render useless any electric line or any machine, apparatus, or part thereof used in connection with the supply or use of electricity.

11. Instructions shall be posted up in every generating, transforming, and motor house containing directions as to the restoration of persons suffering from electric shock.

12. Direct telephonic or other equivalent means of communication shall be provided between the surface and the pit bottom or main distributing center in the pit.

13. Within three days after the introduction of electricity into the federal mine, notice in writing must be sent to the chief of the department of mines of the State of West Virginia that the plant is ready for inspection.

14. A plan shall be kept at the mine showing the positions of all permanent electrical machinery and cables in the mine, and shall be corrected as often as may be necessary to keep it up to a date not more than three months previously.

15. There shall be a passageway in front of the switchboard of not less than 3 feet in width, and if there are any connections at the back of the switchboard, any passageway at the back of the switchboard shall not be less than 3 feet clear. This space shall not be utilized for a storeroom or a lumber room, or obstructed in any way by resistance frames, meters, or otherwise. If space is required for resistance frames or other electrical apparatus behind the board, the passageway must be widened accordingly.

No cable shall cross the passageway at the back of the board except below the floor, or at a height of not less than 7 feet above the floor.

The space at the back of the switchboard shall be properly floored, accessible from each end, and, except in the case of low pressure switchboards, must be locked up, but the lock must allow of the door being opened from the inside without the use of a key. The floor at the back shall be incombustible, firm, and even.

16. Every generator shall be provided with a switch on each pole between the generator and the bus bars.

Where continuous current generators are paralleled, reverse current cut-outs shall also be provided.

Suitable instruments shall be provided for measuring the current and pressure of each generator.

Every feeder circuit shall at its origin be provided with an ammeter.

17. If the transmission lines from the generating station to the pit are overhead there shall be lightning arresters in connection with the feeder circuits.

18. Automatic cut-outs must be arranged so that when the contact lever opens outward no danger exists of striking the head of the attendant. If unclosed fuses are used they must be placed within 2 feet of the floor, or be otherwise suitably protected.

19. No person other than an authorized person shall enter a machine or motor room, or interfere with the working of any machine, motor, or apparatus connected therewith.

20. All conductors (except as hereinafter provided) shall in every case be maintained completely insulated from earth, but it is permissible to use the concentric system with unearthed outer conductor, if proper arrangements are made to reduce the danger from shock or fire to the minimum, but it is not intended that any burdensome expense shall be placed upon the federal mines requiring it to exercise more than a reasonable amount of care in the present installation of cables pending the general act of the legislature heretofore mentioned.

21. The exposed ends of cables where they enter the terminals of switches, fuses, and other appliances, must as far as is reasonably practicable be properly protected and finished off, and encased in flame proof weather proof covering.

22. All joints must be mechanically and electrically efficient, and preference given to soldered joints and in parts of the mine where safety lamps are used, flame proof joint boxes shall be installed with conductors connected by metal screw clamps. In making soldered joints in parts of the mine where safety lamps are used, the space shall first be tested for the presence of gas by the fire boss and the dust in the neighborhood dampened by water.

23. Overhead bare wires on the surface must be efficiently supported upon insulators, and clear of any traffic, and provided with efficient lightning arresters.

24. All cables used in shafts must be highly insulated and substantially fixed. Shaft cables, not capable of sustaining their own weight, shall be properly supported

at intervals varying according to the weight of the cables. Where the cables are not completely boxed in and protected from falling material, space shall be left between them and the side of the shaft that they may yield, and so lessen a blow given by falling material.

25. When feeder cables or other cables than trolley wires are strung in haulage roads and can not be kept at least one foot from the mine cars in transit, they shall be specially protected, and where possible, carried down other parallel entries. At this mine the trolley wires will be strung upon the upcast air courses and feeder wires will be taken in the downcast. This plan, however, can be reversed at the option of the inspectors.

26. Trailing cables for portable machines shall be specially flexible, heavily insulated and protected with armoring of steel wire or extra stout braiding or other effective covering. These cables shall be examined at least once a shift by the person in charge of the machine, and defects promptly repaired.

27. Fuses and automatic cut-outs shall be so constructed as effectually to interrupt the current when a short circuit occurs, or when the current through them exceeds the working current by 200 per cent. Fuses shall be stamped or marked, or shall have a label attached, indicating the current with which they are intended to be used, or where fuse wire is used each coil in use shall be stamped or labeled. Fuses shall only be adjusted or replaced by an authorized person.

28. All live parts of switches, fuses, and cut-outs not in machine rooms, or in compartments specially arranged for the purpose must be covered. These covers must be of incombustible material, and must be either nonconducting or of rigid metal, and, as far as practicable, clear of all internal mechanism.

29. All points at which a circuit other than those for signals has to be made or broken shall be fitted with proper switches, and should this occur in parts of the mine where safety lamps are used, said switches shall be inclosed in flame-tight boxes.

30. All motors, together with their starting resistances, where used in any part of the mine in which safety lamps are used, shall be protected by switches capable of entirely cutting off the pressure and fixed in a convenient position near the motor and shall be inclosed in a flame-tight case, and where unarmored cables or wires pass through metal frames or into boxes or motor casings, the holes must be substantially bushed with insulating bushes which shall be gas-tight and can not become displaced. Terminal boxes must be securely attached to the machine and a safety lamp shall be provided for use with each such machine when working, and should any indication of fire damp appear on the flame of the safety lamp the person in charge shall immediately stop the machine, cut off the current and report the matter to an underground official of the mine.

31. The current for electric locomotives shall not exceed 250 volts and the rooms in the mine shall not be wired for the electric current and no heading shall be wired to within 25 feet of the heading brattice. The locomotives shall be in all cases gas proof as to motors, controllers, etc., and in all parts where sparking can occur except the trolley wheel and as soon as a sparkless trolley is devised or other suitable device invented that will prevent sparking at the trolley, that device shall be at once installed in this mine. The gathering locomotives shall be equipped with double cables. The bare trolley wires may be strung and insulated in the best manner practiced in other mines in the Fairmont district pending the general act of the legislature, but nothing in this clause shall permit the Federal Coal & Coke Co. to install any device in a manner not workmanlike or recognized as dangerous by the recognized standards now in force for wiring in coal mines.

32. Arc lights shall be used only at the shaft bottom if at all, and vacuum incandescent lamps at all other places in the mine. Lighting wires shall be strung as carefully in the mine as insurance rules demand for house wiring on the outside and where practicable shall be kept off the haulage entries.

33. There shall be an automatic governor switch attached to the fan shaft in such a manner that when the speed of the fan is reduced to one-half its normal number of revolutions the electric current entering the mine shall be automatically cut out at the switchboard.

34. At all times the current of air shall be made to brush each working place, and not less than two hundred (200) cubic feet of air per minute shall be furnished for each person employed in the mine.

35. No bare electric wire shall be strung or conducted through or in close proximity to any abandoned or worked out part of the mine which is not efficiently ventilated.

Approved in accordance with letter of this date.

(Signed.) J. W. PAUL.

PITTSBURG, PA., *September 9, 1908.*

The following set of rules in regard to mine wiring has been recommended to the legislature for passage:

GENERAL RULES FOR MINE WIRING

1. All power circuit mine wiring must be done with approved mine type insulators and pine, 20 to 25 feet apart where the roof is low, and where the roof is sufficiently high to permit it, 30 to 35 feet apart.

2. One wire only must be placed on an insulator, securely tied with at least five turns of No. 4 copper tie wire on each side of the insulator.

3. Where conditions are such as not to permit the hanging of wire on roof, cross timbers not smaller than 3 by 4 inches must be used, placing them so as to bring all insulators as near as possible to one height.

4. The cold or negative wire must be put up and maintained with the same care as the positive, and in no instance thrown down along the entry or placed underneath road or track. All wires, when erected, must be put up with care and pulled up snug and taut, so as to remove all kinks and slack and not allowed to touch slate, coal, or timbers, but must be erected and maintained at a safe distance therefrom and not less than 10 inches apart. The practice of wedging insulators between wires or between wire and coal, etc., will not be permitted.

5. Butt entries must be wired with the same care as face and main entries and provided with two S. P. switches of approved design, of not less than 200 ampere capacity. No breakers or fuses will be permitted at these points.

6. Where face entry wires leave main line, switches must also be used.

7a. Where entries advance beyond the limit of the machine cable, No. 4 copper wire should be used for a distance of about 600 feet, or the length of a longer roll of wire. This wire is to be replaced with wire of larger size as soon as the entry has advanced sufficiently to allow the use of a complete coil without it being cut.

7b. Under no conditions are live coils to remain hanging at head of entries or at the ends of any wires and a No. 4 wire must not be employed for a greater distance than 800 feet, but must be replaced promptly with wire of larger size.

8a. No rooms or working places are to be wired.

8b. Entries must not be wired beyond the last break-through.

8c. Power circuits will not be permitted in return air-courses.

8d. The amount of wire in mines must be minimized as much as possible and where circuits are no longer necessary, the wire must be disconnected at once and removed as soon as possible.

8e. The practice of leaving wiring remain in old break-throughs, crosscuts, etc., must be discontinued and old tie wire, broken bonds, scrap wire, old cables, and coils of wire must be gathered up and kept in an orderly manner under lock and key where it may not be accessible to everyone. All scrap wire, etc., must be disposed of promptly and not allowed to accumulate in quantity.

9. The terminal ends of all large wires must be securely anchored and thoroughly insulated with a turn-buckle and strain insulator. The practice of dead ending on wood cross pieces or posts without the use of an insulator will not be permitted.

10. Whenever there is danger of the wires being touched, as, for example, where it crosses an entry, the roof should be trenched at least 10 inches deep and wire securely placed on insulators. The trench should then be covered by 1-inch boards, fastened to wooden pegs driven into the roof. The wires must not touch the board, but must be thoroughly insulated and well separated from it.

11. The practice of using jumpers will not be permitted.

12. All wire joints 2/0 or larger must be made with brass sleeves thoroughly and neatly soldered. For smaller sizes use regular Western Union joints with no less than six turns on each side, and thoroughly solder.

13a. Where wires go through wooden or brick brattice work or other partitions, they must be thoroughly protected with porcelain tubes. The tubes, if in wood partitions, must be held in place with tape; if in brickwork, they must be cemented so that they can not be moved.

13b. Where partitions, brattices, etc., are built after wires have been erected, split tubes must be used to avoid the cutting of wires.

14. In wiring entries where grounded circuit is used, care must be taken that the positive or hot wire is always placed next to the rib, the negative or cold wire being placed 10 inches on the outside of the hot wire.

15. The practice of hanging wires on nails, whether wire is insulated or not, will not be permitted and wood cap pieces, etc., must not be used to keep wire away from the ribs under any circumstances.

TROLLEY WIRE AND BONDING

1. Trolley wire may be suspended inside the mine on hangers, lag screwed to cross timbers, or, where roof will permit, on wooden blocks 3 by 4 by 18 inches, bolted to roof.

2. All new trolley will be of the standard grooved pattern; care must be taken that no kinks, sharp turns or dents from come-alongs are made in it.

3a. The center of each hanger should be plumbed 7 inches outside the outer edge of rail. Hangers should be placed about 20 feet apart on straight entries in low coal and 35 feet apart in high coal. Considerable latitude will have to be allowed, as no specific rule can be made for distance apart of hangers, but the above is a fair average when wire is erected and maintained properly. On curves, the distance should be 8 feet to 10 feet apart and strain of wire from pulling the hanger sidewise. Use No. 6 steel wire to guy the strain ear and spherical strain insulator. On sharp curves, curve ears can be of great assistance in holding wire.

3b. Barn hangers are provided with four holes, while two holes diametrically opposite are sufficient. Use a ½ by 2½ inch gimlet point lag screw, drilling holes for same with three-eighths twist bit. Do not use track spikes or nails for fastening hanger bodies to timbers.

4. Frogs should be placed 10 feet to 12 feet back from point of latch and held in horizontal position by properly placing hangers on line near frogs. Guys of No. 6 galvanized steel wire will assist materially in relieving the strain on frog and holding it in proper position. Insulate guy at frog by use of spherical strain insulator.

4b. Frogs must be placed at each point where branches leave main trolley and when properly placed will not necessitate the holding of pole when passing over frog at ordinary speeds.

5. Automatic trolley switch and signal lights must be placed at all partings where mules will pass under the trolley. Automatic switches are not expected to sustain severe strains and should be relieved of such by proper disposition of strain ears and hangers.

6. The ends of trolley wire must be securely anchored and thoroughly insulated with turn-buckle and strain insulator. A three-bolt galvanized clamp should be used for fastening end of wire when wire is bent back on itself through strain insulator.

7. Care must be taken that the trolley wire clears the roof, so that wheel will not touch roof at any time.

8. Where feeders are necessary they must be erected the same as main lines and tapped in at proper intervals by means of feeder ears. The practice of hooking a jumper around an ordinary hanger must not be allowed.

9. At end of motor road where machine lines ground to rail or at points where rail circuit returns to plant, it is well to use several bonded wires leading to return and to bond each individual wire into rail in more than one hold; also provide cross bond at this point.

10a. Bond both sides of track, using nine-sixteenths inch channel pins and No. 0 soft copper wire only.

10b. Be careful to drill holes to exact size, using nothing other than nine-sixteenths inch twist drills.

10c. Bonds must be placed on outside of rails and extended at least 3 inches beyond fish plates and cut to such lengths as will allow removal of fish plates without disturbing bond.

10d. Cross bonds every fifth rail, making bond of sufficient length that it may be bent down below top of ties so as not to be interfered with.

MINE LIGHTING

1a. Where it is necessary to wire partings, slopes, curves, pump houses, etc., use receptacle and No. 12 triple braid, weatherproof wire and No. 4 porcelain knobs.

1b. No rosettes, snap switches, or ordinary sockets can be used in interior of mine.

2. No switches or fuses will be required. Where a large number of lights are used fuses and switches can be used to advantage.

3a. The practice of hooking ends of light wires over power circuits must be discontinued and connections made in such a manner that vibration of line will not form arcs, burning large wire.

3b. Where it is necessary to turn lights on and off frequently in interior of mine, knife switches should be used.

OHIO

The following law was in effect in Ohio until June 10, 1910:

An Act to protect the lives of persons employed in the mines of Ohio against the dangers of electricity and machinery and providing penalties for violation.

Be it enacted by the General Assembly of the State of Ohio:

Insulating electric wires; guarding wires not insulated; certificate of inspector

Section 1. That after three months from the passage of this act, in all mines in this State where electricity is or hereafter shall be used as a part of the system, power, or means of mining and producing the coal from any of said mines, that the owner or operator of every such mine shall cause all wires conducting electricity in and about said mines to be carefully and thoroughly insulated or protected in a safe manner as may be authorized by the state mine inspector or his deputy, so that persons or animals coming in contact therewith will not be injured thereby. Provided, however, that trolley wires or other wires not capable of insulation shall be guarded by being placed at least three (3) inches deep within a groove or in such other manner as may be authorized by the state mine inspector or his deputy, whose duty it shall be, upon the written request of any mine owner, operator, or person employed in such mine, to investigate all such wires that may be incapable of insulation and determine upon any proper method of guarding said wires other than by means of the aforesaid groove.

And said inspector shall thereupon issue a certificate to the owner or owners of said mine setting forth the method to be employed in the guarding of said wires, and keep a record of the same; thereupon, within thirty (30) days from date of the certificate, it shall be the duty of the mine owner or operator to guard such noninsulated wires in the manner required in said certificate.

Shield for mining machines

Sec. 2. In all mines where mining machines are used, each of said machines shall be equipped and provided with a sufficient shield as may be authorized by the state mine inspector or his deputy, for the protection of those employed in or about the use and operation thereof; and said shield shall be kept in use constantly while said machine is under operation.

Penalty

Sec. 3. Any corporation or person violating the provisions of section one of this act shall be fined not more than five hundred dollars nor less than one hundred dollars; and for the violation of section two of this act not more than one hundred dollars.

FREEMAN T. EAGLESON,
Speaker of the House of Representatives.
JAMES M. WILLIAMS,
President of the Senate.

Passed May 9, 1908.
Approved May 9, 1908.

ANDREW L. HARRIS, *Governor.*

A new general mining law recently passed by the Ohio legislature, and which went into effect June 10, 1910, contains the following provisions in regard to the use of electricity:

Sec. 947. The owner, lessee, or agent of a mine in which electricity is used as a means of power, shall observe the following in the application thereof:

All trolley wires shall be carried at least 6 inches outside of and parallel with the track rail on the side the trolley wire is located. When regular height is less than 6 feet 6 inches from top of rail, the lower side of trolley wire must not exceed 6 inches from the roof or cross timber with hangers now in use, with hangers not to exceed 25 feet between centers, and the tension sufficient to keep all wires from sagging and to prevent trolley wheel from coming in contact with roof or cross timbers. All new hangers hereafter installed shall not exceed 5 inches in depth from lower side of the trolley wire to the roof or cross timbers.

All trolley and positive feed wires crossing places where persons or animals are required to travel, shall be safely guarded or protected from such persons or animals coming in contact therewith.

All trolley and positive feed wires shall be placed on opposite side of track from refuge holes or necks of rooms.

No trolley wire shall be extended into or maintained in any room while being used as a working place; no trolley or feed wire shall be extended into any entry beyond the outside corner of the last break-through.

Switches or circuit breakers shall be provided to control the current at the mine, and at all important points in the mine.

All machine feed wires shall be placed as near the rib and roof or cross timbers as practicable; the positive wire to be carried not to exceed 3 inches from the rib and roof or cross timbers, measured at the insulators, which shall be so placed as to keep the wire at least 6 inches outside of the track rail on the side the wire is located. Insulators shall be placed not exceeding 50 feet apart, and all wires shall be carried so that same will be not less than 6 inches outside of the track rail at any point on the side the wire is located. All positive wires shall be carried on glass or porcelain insulators, or insulators equally efficient. All negative wires shall be carried on suitable fixtures, and when carried in same entry as the positive wire, shall be carried

on the same side of the entry as the positive wire, and as close to it as practicable. When machine or feed wires are carried in same entry as trolley wire, they shall be placed on the same side as the trolley wire, between trolley wire and rib. Nothing in the foregoing shall require negative wires being carried in same entry with positive wire.

When necessary to carry wires down shafts or slopes used as traveling ways, the wires must be thoroughly cased or protected, so that persons can not be shocked therefrom.

Positive machine feed wires, when extended into rooms, shall be placed not nearer than 4 feet of the track, where the room is of sufficient width, and the same shall only be connected to the positive wire or wires on the entry while in actual use. The material used for making such connection shall be of sufficient length to reach across the entry, and when same is disconnected, it shall be kept with the machine operating at such point or working place. No electric wires shall be extended into any room unless a 150-foot cable will not reach the face of the room, and then not beyond the outside corner of the last break-through.

All terminal ends of positive wires shall be guarded so as to prevent persons inadvertently coming in contact therewith.

The bonded track, the negative wires and metallic pipe lines, when coming near each other, may be connected together at intervals not exceeding 500 feet, and any track used as the return or earth system shall be properly bonded. In no case shall a pipe line, or any part thereof, be used exclusively as the return, and when connected to the earth system, the negative wire or bonded track shall be of ample capacity, exclusive of the pipe line, to carry the current.

The trolley wire shall be carried upon hangers or other fixtures which will properly insulate it from contact with the roof or other substances, and so the trolley wheel can trail without the necessity of being constantly attended for that purpose, and no trolley shall be run on any wire not so carried. No locomotive shall be operated by means of a person holding and sliding upon or frequently making contact with the positive wire with any device attached to the cable as a substitute for a trolley, but these provisions shall not prohibit the operation of a locomotive by means of a cable without the use of the trolley, provided the cable be connected to and disconnected from the positive wire when the locomotive is not in motion. Means shall be provided by which machine runners may readily carry the machine cable from the machine to the feed wires on one side of the entry, either under or over the track rails, in the entry where such wires are located, and so the cable will not come in contact with such track rails, thereby reducing the danger of shock to persons or animals required to travel such entry to the minimum.

Sec. 948. The owner, lessee, or agent of a mine at which electricity with a pressure or potential of more than 325 volts, or alternating current, is used shall, in addition to the provisions of the preceding section, observe the following:

At each mine equipped with electric power after the passage and approval of this act, the current used to operate gathering locomotives, mining machines, shearing machines, drills, and other machinery used in or about the working places of the mine, shall not exceed in pressure or potential 325 volts, direct current, as shown at the nearest switchboard, and the wires conducting the power from the nearest switchboard shall not carry a higher pressure or potential.

At each mine equipped with electric power after the passage and approval of this act no alternating current shall be used under ground to operate any machinery other than that necessary to convert the alternating current to direct current, and no wires carrying alternating current shall be used under ground except same be carried in an entry or passageway where persons and animals are not permitted to travel.

At each mine equipped with electric power after the passage and approval of this act, when the current used to operate haulage locomotives, pumps, and other machinery not located in or about the working places of the mine is of a pressure or potential in excess of 325 volts, direct current, the entry or passageway where such wires are carried shall not be designated or permitted to be used as the principal traveling way, and when designated or used as the escapement way, the wires shall be protected so that persons required to travel near same in emergencies will not inadvertently come in contact therewith. No pressure in excess of 650 volts at the switchboard shall be used under ground.

At each mine equipped with electric power prior to the passage and approval of this act, where the pressure or potential is in excess of 325 volts, direct current, or where alternating current is used, and the conditions surrounding the use of same are such, in the opinion of the chief inspector of mines, that the provisions of the preceding section do not provide the required protection from shock to persons employed therein, such additional safeguards shall be employed as may be required by the chief inspector of mines and the district inspector of mines, jointly.

IDAHO

The mining laws of Idaho make but brief reference to electricity. The two following clauses are the only ones that have any bearing on this subject:

Every working adit or cross-cut tunnel entrance, where wooden buildings exist at or near the portal of same, shall be provided with a fire door not less than 50 feet in from the earth portal of the tunnel. This door shall be hung and so adjusted that upon being released it will close of its own accord, either by its own weight when hung from the top of the tunnel or by means of suspended weights when hung from the side. The door shall be held open by a rope passing over a pulley, terminating outside of any of the buildings at the mouth of the tunnel, and shall be so fitted that when closed it will cut off the circulation of air as completely as possible. Where electric haulage is used in said adit or cross-cut tunnel, a door consisting of two doors hung from the sides and closing tightly can be used.

Electric power cables, where used under ground, shall be thoroughly insulated; and where electric haulage is used underground, the trolley wires must be protected by inverted U-shaped guards, placed along the trolley wires, opposite any hand-loading chutes.

MONTANA

In the Montana laws it is provided that if electricity is used for shot firing the voltage must not exceed 250 volts. It is also required that if telephone systems are used they must be inspected daily; and where electric bells are used a simple code of signals is prescribed.

MISSOURI

The Missouri mining laws contain the following provision:

Electric blasting in shafts.—At all mines where 10 or more men are employed on any shift, all holes in the shaft must be fired by an electric battery placed above ground, and in no case shall caps and fuse, or any other method than electric blasting, be employed for exploding holes in shaft.

KANSAS

The only law relating to electricity in mines in Kansas is the following:

No powder shall be delivered by hauling the same in any car hauled by an electric motor unless the car in which the powder is hauled for delivery is thoroughly insulated.

PENNSYLVANIA

The following code of rules has been prepared by the state department of mines of Pennsylvania. It was presented to the state legislature in 1909 for passage, but failed of enactment.

ARTICLE IX.—SPECIAL RULES FOR THE INSTALLATION AND USE OF ELECTRICITY

The following rules shall be observed, as far as is reasonably practicable, in the mines:

Definitions

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and earth, as read by a volt-meter, and,

(*a*) Where the conditions of the system are such that the pressure at the terminals where the electricity is used can not exceed two hundred and fifty volts, this shall be deemed a low-pressure system.

(*b*) Where the conditions of the system are such that the pressure at the terminals where the electricity is used between any two conductors, or between one conductor and earth, may at any time exceed two hundred and fifty volts, but can not exceed five hundred and fifty volts, this shall be deemed a medium pressure system.

(*c*) Where the conditions of the system are such that the pressure at the terminals where the electricity is used between any two conductors, or between one conductor and earth, may at any time exceed five hundred and fifty volts, this shall be deemed a high-pressure system.

The expression "the minimum" signifies the least reasonably possible to be attained by the proper use of the means from time to time known and available, so as to secure safety with efficiency.

Section I

Rule 1.—All electrical apparatus and conductors shall be sufficient in size and capacity for the work they may be called upon to do, and so installed, worked, maintained, and safeguarded, as to reduce the danger from accidental shock or fire or over heating to the minimum, and shall be of such construction, and so worked, that the rise in temperature caused by ordinary working will not injure the insulating materials.

In any mine, or any part of a mine where safety lamps are used, the covering of motors or cables shall be so constructed that there is no danger of firing gas by sparking or flashing which may occur during the normal or abnormal working of the apparatus.

All metallic coverings or armoring of cables, and the frames and bedplates of generators, transformers, and motors, other than portable motors, shall be efficiently grounded if the pressure at the terminals where the electricity is used exceeds the limits of low pressure.

Rule 2.—Where a medium pressure system is used for power purposes, or for arc or incandescent lamps, the conductors which form the connection to the motors, transformers, or lamps, or are otherwise used in connection with the system, shall be completely inclosed in strong armoring or metal casing, or they shall be fixed at such a distance apart, or in such a manner, that danger from fire or shock shall be reduced to the minimum. This rule shall not apply to trailing cables, which are dealt with under rules 27 to 32.

Rule 3.—Motors of coal-cutting and other portable machines, shall not be used at a pressure higher than a medium pressure.

Rule 4.—A higher pressure than a medium pressure shall not be used under ground, except for transmission or for application to transformers or other apparatus in which the whole of the high pressure circuit is stationary.

All high pressure machines, apparatus, and lines, shall be so marked by the use of the word "Danger" at frequent intervals, or by red paint properly renewed when necessary, or in some other conspicuous manner, as to indicate clearly that they are high pressure and dangerous.

For work under ground, when furnished with current at a pressure higher than medium pressure, a transformer shall not be of less normal rating than 5 kilowatts, nor shall a motor be of less normal rating than 20 brake horsepower.

Rule 5.—In any mine, or any part of a mine, where safety lamps are used, a higher pressure than a medium pressure shall not be transmitted beyond the last cut-through of the intake entries, and all motors, transformers, and other apparatus connected with such high pressure system, must be placed in suitable chambers ventilated by intake air.

Rule 6.—In every completely insulated circuit ground detectors shall be kept connected in every generating station to show immediately any defect in the insulation of the system. These instruments shall be inspected daily by a competent person or an automatic recording instrument shall be used.

Rule 7.—Main and distribution switch and fuse board in the mines shall be made of incombustible, insulating material, such as marble, or slate free from metallic veins, and be fixed in as dry a situation as practicable.

Rule 8.—No repairing of the live parts of any electrical apparatus, except cleaning or oiling, shall be done when the current is on.

Where the live parts of switches, or machines working at a pressure exceeding the limits of low pressure, may have to be handled for the purpose of adjustment, or for such wiping or oiling, insulating gloves, or mats of india rubber or other suitable material, shall be supplied by the operator and shall be used by the attendants.

Rule 9.—At every gaseous mine where electricity is used below ground for power, there shall be employed a competent mine electrician who shall be subject to the authority of the mine foreman and superintendent, and shall have full charge of all electrical machinery and apparatus in the mine. The mine electrician, or an assistant mine electrician, shall be on duty at the mine when the electrical apparatus or machinery in use for the production of coal requires more than 25 horsepower.

After the expiration of twelve months from the passage of this act no person shall be allowed to act as a mine electrician, or as an assistant mine electrician, in a gaseous mine unless he shall be the holder of a certificate of competency issued by the department of mines.

Every person appointed to operate any electrical apparatus in a mine shall have been instructed in his duty by the electrician or mine foreman.

Rule 10.—Fire buckets filled with clean dry sand shall be kept in the mines where stationary electrical apparatus is located ready for immediate use.

Rule 11.—Instructions shall be posted at the mine entrance and in every generating, transforming, and motor house for the resuscitation of persons suffering from electric shock. All employees working in connection with the electrical apparatus shall be required to acquaint themselves with these instructions.

Rule 12.—A plan on a scale not smaller than 200 feet to the inch shall be kept at the mine showing the position of all permanent electrical machinery and fixed cables or conductors in the mine, and shall be corrected as often as may be necessary to keep it as nearly as practicable up to date, and never more than three months in arrears. Such plan shall, so far as is consistent with this rule, be subject to the same conditions as are provided by article one of this act in relation to the plan therein mentioned.

Rule 13.—Every personal accident occurring in connection with the operation of electrical equipment shall be promptly reported by the person injured, or by some other person on his behalf, to the mine foreman, and shall be recorded by him at the office of the mine.

Rule 14.—In the event of a breakdown of, or damage or injury to, any portion of the electrical equipment in a gaseous mine, or of overheating, or of the appearance of sparks or arcs outside of inclosing casings, or in the event of any portion of the equipment (not being a proper part of the electrical circuit) becoming alive, every such occurrence shall be promptly reported to the mine foreman.

Section II.—*Generating stations and machine rooms*

Rule 15.—Where the generating station under the control of the owner or superintendent of the mine is not within 500 feet of the mine entrance, a switch box or boxes, efficiently inclosed and locked, or a locked switch house, shall be provided near the mine entrance for cutting off the supply of electricity to the mine.

Rule 16.—All terminals and live metal on machines over medium pressure above the ground, and over low pressure under ground, shall, where practicable, be protected with insulating covers, or with metal covers connected to earth.

Rule 17.—If the transmission lines from the generating station to the mine are overhead, and exceed 500 feet in length, there shall be lightning arresters in connection therewith at the mine entrance.

Section III.—*Cables*

Rule 18.—All high pressure wires used inside of the mines shall be in the form of insulated, lead-covered or armored conductors, subject to insulation tests, and with carrying capacity according to the rules of the American Institute of Electrical Engineers.

Except in gaseous mines, all medium or low pressure conductors may be bare or with high class insulation. If bare wire is used all feed wires must be shielded and properly protected at all points where there is danger of men or animals coming into contact with them. In gaseous mines no bare conductors shall be used in rooms, or in room entries, or beyond the last cut-through in other intake entries.

Rule 19.—The size of the conductor (except in the case of overhead wires upon the surface) shall be determined in accordance with the table showing maximum current for copper conductors as designated by table prepared by the American Institute of Electrical Engineers.

Rule 20.—One side of all grounded circuits must be efficiently insulated from earth.

Where lead-covered or armored cable is used the lead or armor shall be earthed and shall be electrically continuous throughout.

Rule 21.—The exposed ends of cables where they enter the terminals of switches, fuses, and other appliances, shall be properly protected and finished off so that moisture can not creep along the insulating material within the waterproof sheath, or insulating material, if of an oily nature, leak out of the cable.

Rule 22.—All joints must be mechanically and electrically efficient and, where practicable, must be suitably soldered.

Rule 23.—Overhead bare wires on the surface shall be properly secured to insulators, and clear of any traffic, and provided with lightning arresters.

Rule 24.—In any mine, or any part of a mine, where safety lamps are used, the main cables shall be taken into the mine by way only of an intake airway.

Rule 25.—All cables used in shafts must be highly insulated and substantially fixed. Shaft cables not capable of sustaining their own weight shall be properly supported at intervals varying according to the weight of the cable. Where the

cables are not completely boxed in and protected from falling material space shall be left between them and the side of the shaft that they may yield and thus lessen a blow given by falling material.

Rule 26.—Where the cables in main haulage roads where persons are hauled into or out of the mines can not be kept at least one foot from any part of the car they shall be specially protected.

Cables and wires, unless provided with metallic coverings, shall not be fixed to walls or timbers by means of uninsulated fastenings.

Cables under ground, when suspended, shall be supported flexibly in such a manner as to allow of their readily breaking away when struck before the cables themselves can be seriously damaged.

Where main or other roads are being repaired or blasting is being done temporary protection must be used so that the cables are protected from damage.

Rule 27.—Trailing cables for portable machines shall be specially flexible, heavily insulated, and protected with extra stout braiding, hose pipes, or other equally effective covering.

Rule 28.—The joints, if any, made in trailing cables, shall be soldered. Clamps of any kind must not be used for this purpose.

Rule 29.—The two cables of the twin trailing cable shall be divided at the motor, and only for such a length as is necessary for the making of connection to the motor, and the twin cable, with its outer covering complete, shall be securely held by a suitable clamp on the motor frame in such a manner as to protect the trailing cable from injury, and to prevent any mechanical strain being borne by the single ends making electrical connection with the motor.

Rule 30.—In the event of the trailing cable in service breaking down or being damaged in any way, or of its inflicting a shock upon any person, it shall be at once put out of service and another cable shall be substituted therefor. The faulty cable shall not be used again until it has been repaired and tested by the mine electrician.

Rule 31.—In gaseous mines each trailing cable in use shall be examined daily by the machine boss for abrasions and other defects.

The machine man shall also be required to observe carefully the trailing cable while in use in order to detect defects, and in the event of any defect becoming apparent notice of the same shall at once be sent to the mine electrician or the assistant mine electrician.

Rule 32.—The trailing cable shall be kept disconnected from the machine while it is being loaded on to, or unloaded from, the truck, unless the construction of the machine is such that the electric power is necessary for its unloading or reloading. Sections twenty-seven, twenty-eight, twenty-nine, thirty, thirty-one, and thirty-two do not apply to electric gathering locomotives.

Section IV.—*Fuses, circuit breakers, and switches*

Rule 33.—Fuses and automatic circuit breakers shall be so constructed as to open the circuit when the current through them exceeds by 100 per cent the working current in the case of motors, or the permissible current of the cables which these devices protect. Fuses shall be stamped or marked, or shall have a label attached, indicating the current at which they are intended to fuse, or where fuse wire is used each coil in use shall be so stamped and labeled. Fuses shall only be adjusted or replaced by a competent person authorized by the mine foreman, except in case of coal-cutting machines and electric locomotives, when the machine runners and motormen shall be permitted to adjust or replace them.

Rule 34.—All switches, circuit breakers, and fuses must have incombustible bases of marble, slate, or porcelain, or other suitable incombustible insulating material.

Rule 35.—All points at which a circuit (other than those for signals or portable motors) has to be made or broken shall be fitted with proper switches. In any mine, or any part of a mine, where safety lamps are used the use of hooks or other makeshifts is prohibited, and switches, circuit breakers, and fuses (except as provided for in rule 41 hereafter) shall not be of the open type, but must either be inclosed in gas-tight boxes or break under oil.

Section V.—*Motors*

Rule 36.—Every stationary underground motor, together with its starting resistance, shall be protected by a fuse or circuit-breaking device in accordance with rule 34, and by switches capable of entirely cutting off the pressure. The switches shall be fixed in a convenient position near the motor and every stationary motor of 100 brake horsepower or over underground shall be provided with a suitable ammeter to indicate the load on the machine.

In any mine, or any part of a mine, where safety lamps are used all mining machines, with their cables, shall be protected against overloads or excessive currents by a completely inclosed and flame-proof fuse.

Rule 37.—Where unarmored cables or wires pass through metal frames, or into boxes or motor casings, the holes shall be substantially bushed with insulating collars and, where necessary, with gas-tight bushings which can not readily become displaced.

Rule 38.—The terminal of connections, or cables for portable motors, shall be securely attached to the machine.

Rule 39.—Where the insulation of a motor is found to become damp during a stoppage, suitable steps shall be taken to insure that the insulation shall be dry before the working of the motor is resumed.

Rule 40.—In any mine, or any part of a mine, where safety lamps are used, all motors, unless placed in such rooms as are separately ventilated with intake air, shall have all their current-carrying parts, also their switches, starters, terminals, and connections completely inclosed in such a manner as to prevent the escape of sparks or flame into the gaseous atmosphere, the inclosures to be made of incombustible material and of sufficient strength to escape damage in the event of an explosion of fire damp occurring in the motor, and such inclosures shall not be opened except by an authorized person, and then only when the current is switched off. The pressure shall not be switched off while the inclosures are open.

Rule 41.—In any mine, or any part of a mine, where safety lamps are used, a safety lamp or other suitable apparatus for the detection of explosive gas shall be provided for the use of the attendant of stationary electrical apparatus, and should any indication of explosive gas appear on the flame of the safety lamp or other apparatus used the person in charge shall immediately stop the machine, cut off the current at the nearest switch and report the matter to the mine foreman.

Rule 42.—The mine foreman shall not place a man in charge of a coal-cutting machine in a gaseous mine who is not a competent person capable of determining the safety of the roof and sides and detecting the presence of explosive gas.

Rule 43.—In any mine, or any part of a mine, where safety lamps are used, before a coal-cutting machine is brought within 20 yards of the working face, the machine man shall make an inspection for gas in the place where the machine is to work unless such an examination is then made by some other competent person authorized or appointed for that purpose by the mine foreman. If any explosive gas is found in the place, the machine shall not enter therein.

No coal-cutting machine shall be continued in operation for a longer period than half an hour without an examination as above described being made for gas, and if gas is found the current shall at once be switched off the machine and the trailing cable shall forthwith be disconnected from the feed wire.

The person finding the gas shall at once erect a danger signal to warn persons against entering the place. The trailing cable shall be removed from such place.

This cable shall not be brought back nor shall the machine be again started in such place until the fire boss, or a person duly authorized by the mine foreman, has examined it and has pronounced it free from gas and has removed the danger board.

The person finding gas shall forthwith report the same to the mine foreman, and at the end of the shift he shall make and sign a written report in a book kept at the mine for the purpose.

Rule 44.—In order that the roof may be carefully examined, a coal-cutter motor shall not be kept continuously at work for a length of time exceeding half an hour.

Rule 45.—The person in charge of a coal cutting or drilling machine shall not leave the machine while it is working, and shall, before leaving the working place, see that the pressure is off from the trailing cables. No repairs shall be made to any portable machine until the pressure has been cut off.

Rule 46.—In gaseous mines, if any sparks or arcs appear outside the casing of a coal-cutting or other portable motor, or about the cables or rails, the machine shall be stopped and shall not be worked again until the defect has been repaired, and the occurrence shall be reported to the mine foreman or to the assistant mine foreman.

Rule 47.—All inclosed motors used underground shall be opened and inspected by the mine electrician or his assistant at least once a week and, where necessary, shall then be cleaned and repaired. Inclosed switches shall be opened and inspected at least once every month.

Section VI.—*Electric locomotives*

Rule 48.—Electrical haulage by locomotives on the trolley wire system shall not be allowed in that part of a mine where locked safety lamps are used.

Rule 49.—In underground roads the trolley wire shall be sufficiently guarded, or the pressure must be cut off from the wires at all times when such roads are used for traveling on foot. The hours during which traveling on foot therein is permitted shall be clearly indicated by notices and signals placed in conspicuous positions at the ends of, and at all entrances into, the roads. At other times no one except a duly authorized person shall be permitted to travel on foot along such roads.

Rule 50.—On underground roads the trolley wires shall be placed as close to the side, and as near in a straight line, as practicable, and securely supported at frequent intervals. On any part of the trolley system where it is necessary for men to cross under the trolley it shall be so guarded that the possiblity of contact will be reduced to a minimum, and lights shall be placed at all such crossings.

At all landings, turn-outs, or partings, and such other places as men are required to work near or pass under the wire, a suitable protection shall be placed. This protection may consist of channeling the roof, placing boards along the wire which shall extend 3 inches below, or the use of other approved devices that afford protection, or the wire may be placed 6 feet above the top of the rail. All branch trolley lines shall be fitted with an automatic trolley switch, or section insulator and line switch, or some other device that will allow the current to be shut off from such branch headings. Lights shall be placed along the branch headings to indicate when the power is on.

Rule 51.—It is recommended that where air or water pipes parallel the grounded return of power circuits, the return be securely bonded at frequent intervals to such pipes to eliminate the possibility of a difference of potential between rails and pipes, and to prevent electrolysis of the pipes. The rail return shall be of sufficient capacity for the current used independent of the capacity of the pipes.

Rule 52.—If storage battery locomotives are employed in any mine or part of a mine where safety lamps are used, the rule applying to motors in such places shall also be deemed to apply to the boxes containing the cells.

Section VII.—*Electric lighting*

Rule 53.—Arc lamps used underground shall be so guarded as to prevent pieces of heated carbon falling from them, and they shall not be used in situations where there is likely to be danger from the presence of coal dust. They shall be so screened as to prevent risk of contact with persons.

Rule 54.—Small wires for lighting circuits shall either be conveyed in pipes or casings, or they may be suspended from porcelain insulators, or securely tied to them so that they do not touch any timbering, coal, or metal. On no account shall staples be used. If metallic pipes are used, they must be electrically continuous and grounded. If separate uncased wires are used, they shall be kept at least 3 inches apart and not brought together except at lamps, or switches, or fittings.

Rule 55.—In any mine or any part of a mine where safety lamps are used, electric lamps, if installed, must be of the vacuum, or inclosed type, and they shall be protected by gas-tight fittings of strong glass, and shall have no flexible cord connections. Electric lamps shall be replaced by a competent person only.

Rule 56.—In gaseous mines, in all machine rooms, and other places under ground where a failure of electric light is likely to cause danger, some safety lamps, or other proper lights, not fewer than a number to be prescribed for such place by the inspector, shall be kept for use in the event of such failure.

Section VIII.—*Shot firing*

Rule 57.—Electricity from lighting or power cables shall not be used for firing shots.

Rule 58.—When shot-firing cables or wires are used in the vicinity of power or lighting cables sufficient precautions shall be taken to prevent the shot-firing cables or wires from coming into contact with the lighting or power cables.

Rule 59.—In gaseous mines only competent persons who have been properly instructed in the work, and duly authorized in writing, shall be allowed to fire shots electrically in any part of a mine.

Rule 60.—The exploder fuses and wires shall be suitable for the conditions under which the blasting is carried out and shall be of an approved type.

Rule 61.—High tension magneto-generators shall be inclosed in flame-tight cases when employed in any mine or any part of a mine where safety lamps are used.

Rule 62.—A primary or secondary battery, when used for shot firing, shall be inclosed in a suitably constructed box fitted with a removable connecting plug or key without which the circuit can not be closed. This plug or key shall be detached when not required for firing, and shall not under any conditions pass from the personal custody of the shot firer while on duty. Such batteries shall be frequently tested by the shot firer to insure that they give the necessary pressure and current.

Rule 63.—The exploder shall be in the charge of the shot firer and shall be fitted with a handle or key which shall be detached when not required for firing, and shall not under any conditions pass from the personal custody of the shot firer while on duty.

Rule 64.—The exploder shall not be connected to the shot-firing cable until all other steps preparatory to the firing of the shot have been completed and all persons have removed to a position of safety.

Immediately after the firing of the shot the firing cable shall be disconnected from the exploder, and no person shall approach a shot that has been attempted to be fired by electricity and has failed to explode until the firing cable has been so disconnected, and an interval of five minutes has elapsed since the last attempt to fire the shot.

The foregoing rules shall not apply to apparatus used for telephone, telegraph, and signal purposes, which are provided for by the three following rules.

SECTION IX.—*Signaling*

Rule 65.—All proper precautions must be taken to prevent electric signal and telephone wires from coming into contact with other electric conductors, whether insulated or not.

Rule 66.—Bells, wires, insulators, contact-makers, and other apparatus used in connection with electric signals underground shall be of substantial and reliable description and shall be erected in such a manner as to reduce the liability to failures or false signals to the minimum.

Rule 67.—In any mine, or any part of a mine, where safety lamps are used, the pressure employed for signaling purposes shall not in any one circuit exceed 50 volts in an intake air way, or 50 volts elsewhere, and bare wires shall not be used for such purposes except in haulage roads.

SECTION X.—*Electric relighting of safety lamps*

Rule 68.—If in any mine, or part of a mine, in which safety lamps are used, they are relighted underground by electricity, the mine foreman shall select a suitable station or stations not being in the return airway and where there is not likely to be any accumulation of inflammable gas, and no electric relighting apparatus shall be used in any other place. All electric relighting apparatus shall be securely locked and shall not be available for use except by persons authorized by the mine foreman to relight safety lamps, and such persons shall examine all safety lamps brought for relighting before they are reissued.

No other States have any laws relating to the use of electricity in mines.

FOREIGN COUNTRIES

GREAT BRITAIN

In 1902 a committee was appointed by the British Home Office to investigate the use of electricity in mines, and this committee made its report in 1904, in which the following set of rules was recommended.

RULES FOR THE INSTALLATION AND USE OF ELECTRICITY IN MINES

DEFINITIONS.

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and earth as read by a hot-wire or electrostatic voltmeter, and

Low pressure (*a*) Where the conditions of the supply are such that the pressure at the terminals where the electricity is used can not exceed 250 volts, the supply shall be deemed a low pressure supply.

Medium pressure (*b*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 250 volts, but can not exceed 650 volts, the supply shall be deemed a medium pressure supply.

High pressure (*c*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 650 volts, but can not exceed 3,000 volts, the supply shall be deemed a high pressure supply.

Extra high pressure (*d*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 3,000 volts, the supply shall be deemed an extra high pressure supply.

Section I.—*General*

Quality of installation

1. The whole of the machinery, material, and workmanship in connection with the supply and use of electricity shall be the best of its respective class, and sufficient in size and power for the work it may be called upon to do.

Installation of machinery

2. All electric machinery shall be installed as far as is practicable in dry, well-lighted, and well-ventilated places.

Apparatus to work without undue heating

3. All electrical apparatus shall be so worked that the rise in temperature will not injure its insulating materials.

Protection of live metal work; complete inclosure of same where gas is liable to be present; earthing of metallic coverings

4. All live metal work, such as commutators, slip rings, resistances, switches, starters, cut-outs, shall be substantially made and effectively covered or guarded so as to avoid danger through accidental shock or risk of fire. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, the covering shall be constructed so that there is no danger of firing gas by any sparking or flashing which may occur during the normal or abnormal working of the apparatus. All metallic coverings shall as far as practicable be effectively earthed where the pressure exceeds the limits of low pressure.

Conditions as to use of medium pressures

5. The pressure of a supply delivered to the motor or other terminals shall not exceed the limits of a low pressure supply, unless the following conditions are complied with:

(*a*) Where a medium pressure supply is used for power purposes or for arc lamps in series:

(1) The frame of every electric motor or transformer shall be efficiently connected with earth.

(2) The wires or conductors forming the connections to the motors, transformers, arc lamps, or otherwise in connection with the supply shall be, as far as practicable, completely inclosed in strong armoring or metal casing efficiently connected with earth, or they shall be fixed at such a distance apart or in such a manner that there shall be no danger from fire or shock.

(3) The supply to every motor, transformer, or arc lamp shall be controlled by an efficient switch, placed in such a position as to be easily handled by the person in charge of the motor transformer, or arc lamp, and connected so that by its means all pressure can be cut off from the motor, transformer, or lamp itself, and from any regulating switch, resistance, or other device in connection therewith.

(4) Switches, efficient fuses, or automatic cut-outs shall also be provided, so as to protect the circuits from excess of current, and these switches, fuses, and cut-outs shall be so inclosed and protected that there shall be no danger of any shock being obtained in the ordinary handling thereof or of any fire being caused by their normal or abnormal action.

(*b*) Where a medium pressure supply is used for incandescent lamps in series:

(1) The wires or conductors forming connections to the incandescent lamps, or otherwise in connection with the supply, shall be completely inclosed in strong armoring or metal casing, and this armoring or casing, together with the switches and lamp holders (if metallic), shall be efficiently connected with earth.

(2) Switches, efficient fuses, or automatic cut-outs shall also be provided, so as to protect the circuits from excess of current, and these switches, fuses, and cut-outs shall be so inclosed and protected that there shall be no danger of any shock being obtained in the ordinary handling thereof or of any fire being caused by their normal or abnormal action.

Prohibition of pressure exceeding medium beyond the main airway

6. No higher pressure than a medium pressure supply shall be taken beyond the in-bye ends of the main air ways.

Conditions as to use of high and extra high pressures

7. No higher pressure than a medium pressure supply shall be used other than for transmission or for motors, and then the following conditions shall be complied with:

(1) No motor or transformer shall be of less normal rating than 75 b. h. p.

(2) The frame of every electric motor or transformer shall be efficiently connected with earth.

(3) The wires or conductors other than overhead lines above ground forming the connections to the motors or transformers or otherwise in connection with the supply shall be completely inclosed in a strong armoring or metal casing efficiently connected with earth.

(4) The machines, apparatus, and lines shall be so marked as to clearly indicate that they are high pressure, either by the use of the word "Danger" at frequent intervals or by vermilion paint properly renewed when necessary.

(5) The motors, machinery coupled thereto, and transformers shall be fixed in proper rooms or inclosures set apart solely for the purpose, and a notice shall be fixed in a conspicuous position at the door of every such room forbidding unauthorized persons to enter.

Test to detect injury to line during installation

8. Every fixed electric line shall be tested for insulation after having been placed in position and before it is used for the purpose of supply, the testing pressure being at least 200 volts. The results of such tests of each line or section of line shall be duly recorded.

Insulation of circuits

9. The insulation of every complete circuit used for the supply of energy, including all machinery, apparatus, and devices forming part of or in connection with such circuit, shall be so maintained that the leakage current shall not under any conditions exceed 1-10,000th of the maximum supply current, and suitable means shall be provided for the immediate localization of leakage.

Special test for circuits above medium pressure before use

10. A high-pressure circuit shall not be brought into use unless the insulation of every part thereof has withstood a continuous application during half an hour of a pressure exceeding the maximum pressure to which it is intended to be subjected in use—that is to say, in the case of every electric line a pressure twice the said maximum pressure, and in the case of every machine device or apparatus a pressure 50 per cent greater than the said maximum pressure. The results of such tests shall be duly recorded.

Earth detectors in generating and transforming stations

11. Earth or fault detectors shall be kept connected up in every generating and transforming station to show immediately any defect in the insulation of the system. The readings of these instruments shall be recorded at least twice daily in a book kept at the generating or transforming station or switch house, and immediate steps shall be taken to rectify any defects.

Construction and arrangement of main and distribution switch and fuse boards

12. Main and distribution switch and fuse boards must be made of incombustible insulating material, such as marble or slate free from metallic veins, and be fixed in as dry a situation as practicable, and be so placed that a fire thereon can not spread to combustible material.

Live metal must be fixed at such a distance from all metal not at the same potential, or be so separated by insulating partitions, that an arc can not be formed between the metal surfaces.

All circuits, switches, and instruments shall be clearly labeled for identification.

Distributing centers and subcenters

13. Conductors must radiate from distributing centers and in large systems from those centers to subcenters. At these centers suitable switchboards shall be fixed, by which the pressure can be cut off from any circuit.

Bunching of conductors

14. No conductor shall be bunched in the same duct, pipe, or groove with one at another pressure of supply unless they are each separately protected by a strong continuous metallic sheathing efficiently earthed.

Provision of switches, and cut-out or fuse

15. Every circuit carrying not more than 3 amperes must be protected on each pole by a fuse. Every circuit carrying more than 3 amperes must be controlled by a switch on each pole and cut out or fuse on each pole. The switch shall be on the live side of the fuse.

Construction and ventilation of machine rooms

16. No portion of the internal surface of any room in which electrical machinery is installed shall be formed of substances easily ignited, and the use of inflammable materials in such rooms shall be reduced to the minimum. Such rooms when underground shall where possible be ventilated by intake air.

17. Fire buckets, filled with clean dry sand, shall be kept in electrical machine rooms ready for immediate use in extinguishing fires. **Fire extinguishing in machine rooms**

18. No repair or cleaning of any electrical apparatus except mere wiping or oiling shall be done when the current is on. **No repairs to be carried out when current is on**

19. Gloves and mats of india rubber or other nonconducting material shall be supplied and used where the live parts of switches or machines working at a pressure exceeding the limits of low pressure have to be handled for the purpose of adjustment. **Use of rubber gloves and mats during adjustment of live parts of switches or machines**

20. The manager shall appoint a competent person or persons to inspect daily all electrical machinery and apparatus, who shall make a true report in writing of the result of such examination before leaving the mine. **Competent person to make daily inspection**

21. A competent person shall be on duty at the mine when the electrical apparatus or machinery is in use; and at such time as the amount of electricity delivered down the mine exceeds 200 brake horsepower, a competent person shall be on duty at the mine above ground and another below ground. **Competent persons to be on duty**

22. No person shall be allowed to work any electrically driven apparatus unless he has been previously instructed in his duty and has been duly authorized by the manager or under-manager. **Appointment and instruction of machine attendants**

23. All persons engaged in or about the mine shall at once report to the management anything unusual observed in the working of the plant. **Immediate report to management of abnormal working of plant**

24. No person shall wilfully damage, interfere with, or without proper authority remove or render useless any electric line or any machine, apparatus, or part thereof, used in connection with the supply or use of electricity. **Prohibition of unauthorized persons interfering with installation**

25. Instructions shall be posted up in every generating and motor house containing directions as to the restoration of persons suffering from electric shock. **Posting of instructions as to treatment of persons suffering from electric shock**

26. Direct telephonic communication shall be provided— **Provision of telephonic communication**

(*a*) Between the generating station and the pit bottom or main distributing center in the pit.

(*b*) Between the generating station and the pit head.

(*c*) Between the pit head and the pit bottom or main distributing center in the pit.

27. Before any electric installation is erected at any mine notice in writing must be sent to H. M. inspector of mines for the district. Notice must also be sent of any existing electric installation at any mine within three months after the coming into force of these rules. **Notice of existing and new installations to be sent to inspector**

28. A plan shall be kept at the mine showing the position of all electrical machinery, apparatus, and lines at or in the mine, and shall be corrected as often as may be necessary to keep it up to a date not more than three months previously. **Plan showing installation to be kept**

29. If fixed storage batteries are used underground they must be placed in well-ventilated rooms or inclosures. **Storage batteries**

Section II.—*Generating stations and machine rooms*

1. Generating sets shall be spaced so that there is ample passage all round them, not less than 4 feet between separate sets or less than 3 feet between any set and the wall. **Generating sets**

For installations of over 200 brake horsepower an inclosure in which the electrical energy is generated shall be fenced off and set apart for that purpose only. It shall contain the engines, dynamos, switchboards, and any other mechanical or electrical apparatus belonging thereto, but shall not contain boilers, feed pumps, haulage engines, or other machinery, or be used as a storeroom or workshop, except for repairing the machines therein.

Provision of switch house where generating station is over 400 yards from pit mouth

2. Where the generating station under the control of the owner or manager of the mine is not within 400 yards of the pit mouth, a switch house shall be provided near the pit mouth, containing switches for cutting off the supply of electricity to the mine. This house shall only be entered by duly authorized persons, and a notice to that effect shall be posted at the door, and the same regulations as to switchboards and their inclosures in generating stations shall apply thereto.

Main switchboard

3. The main switchboard shall be separated from the engine room by a hard-wood rail not less than 3 feet from the front of the board. The space in front of the board shall be a platform raised not less than 6 inches above the floor level, and preferably constructed of wood blocks.

Provision to be made for clear space at back of main switchboards

4. If there are any connections at the back of the switchboard, there shall be a clear space behind the board of not less than 3 feet. This space shall not be utilized as a storeroom or a lumber room, or obstructed in any manner by resistance frames, meters, or otherwise. If space is required for resistance frames or other electrical apparatus behind the board, the passageway must be widened accordingly.

No cable shall cross the passage way at the back of the board except below the floor or at a height of not less than 7 feet above the floor.

The space at the back of the switchboards shall be properly floored, accessible from each end and, except in the case of low pressure switchboards, must be kept locked up, but the lock must allow of the door being opened from the inside without the use of a key.

The floor at the back shall be firm and even, and shall be of hard wood, or be covered with good insulating material.

Provision of automatic cut-out and meters for generators

5. Every generator shall be provided with an automatic maximum cut-out or switch and fuse on each pole between the generator and the bus bars.

Where generators are paralleled reverse current cut-outs shall also be provided.

Suitable instruments shall be provided for measuring the current and pressure of each generator.

Automatic cut-out and ammeter for feeder circuit

6. Every feeder-circuit shall be provided with an automatic maximum cut-out or switch and fuse on each pole and an ammeter.

Arrangement of switchboard where continuous supply is maintained

7. Where the supply is maintained continuously the switchboards shall be arranged in sections, so that all pressure can be cut off from any section for the purpose of cleaning or repairing it.

No work or cleaning shall be carried out on any portion of a switchboard, above the limits of low pressure, while the pressure is on the board.

Lightning arresters for overhead lines

8. If the transmission lines from the generating station to the pit are overhead there shall be lightning arresters in connection with the feeder circuits.

Protection from short circuits with low pressure installations

9. Where the supply is at low pressure the bus bars and any live metal work on the front of the boards must be so spaced or separated by fillets of nonconducting material that there shall be no danger of accidental short circuits, and switches must be provided which will open even on a short circuit without danger to the attendant.

Automatic cut-outs must be arranged so that when opening outwards the contact lever does not fall within 6 feet 6 inches of the floor. If uninclosed fuses are used they must be placed within 2 feet of the floor.

Live metal on front of switchboards at medium pressure and upwards

10. Where the supply is at a pressure exceeding the limits of low pressure, there shall be no live metal work on the front of the switchboard within 8 ft. of the platform and the space provided under rule 4 shall be not less than 4 ft. in the clear.

High pressure meters to be connected through transformers where practicable

11. Where the supply is at a pressure exceeding the limits of medium pressure the instruments should, where practicable, be connected through transformers and worked at low pressure. Where such transformers are not used the metal cases of all instruments shall be either earthed and guarded by efficient earthed metal cages out of reach of the attendant, or be completely protected with insulating covers.

Metal casings, etc., to be earthed

All metal work not in connection with the circuits shall be connected to earth, and all switches shall be operated by long and well insulated levers.

12. The frames and bedplates of all generating machines and transformers at a pressure exceeding the limits of low pressure shall be efficiently connected to earth. **Earthing of machine frames**

13. All terminals and live metal work, where practicable, shall be protected with insulating covers or with metal covers connected to earth. **Protection of live metal**

The brush rockers of machines working at a pressure exceeding the limits of low pressure shall be worked by hand wheels at a safe distance from the brushes. **Brush rockers**

14. Insulating stands or rubber mats must be placed at the commutator or collector side of all open type machines working at a pressure exceeding the limits of low pressure. **Rubber mats**

15. The fencing of generators having collector rings or commutators must be of teak or hard wood or metal. If of metal, that part of the metal which might be touched by a person when wiping commutator or collector rings shall be covered with insulating material. **Fencing of generators**

16. No person other than an authorized person shall enter a machine or motor room or interfere with the working of any machine, motor, or apparatus connected therewith. **Unauthorized persons not to enter motor rooms or interfere with apparatus**

Section III.—*Cables*

1. Except as hereinafter provided, metallic circuits shall in every case be maintained completely insulated from earth. **Prohibition of earthed circuits**

The neutral point of polyphase systems shall not be earthed without notification in writing to the inspector of mines of the district.

2. All continuously insulated cables and wires shall be highly insulated, and the insulating material must be protected from mechanical injury. **Insulation of continuously insulated cables**

The insulating material must be so protected or, as far as is practicable, be of itself of such a nature that it will not deteriorate under the action of water or alternate periods of wet and dry, or at the highest temperature to which it will be subjected. Rubber must not be allowed to exceed 130° F., or paper or fiber insulation 170° F. In specially hot places the conductors shall be so large that the electric heating is almost nil.

3. A continuously insulated cable must be so constructed that when a test piece of it has been immersed in water for twenty-four hours it will, while still immersed, in the case of cables intended for low or medium pressures, withstand 2,000 volts for ten minutes between the conductor and the water, and between cores if there are more than one in the cable. **Tests of continuously insulated cables**

If the cable is intended for high or extra high pressure twice the working pressure shall be taken for this test.

Prior to the immersion the test piece must have been bent six times (three times in one direction and three times in the opposite direction) round a cylindrical surface not more than twelve times the diameter of the finished cable.

4. Continuously insulated cables and wires which are to be used at low and medium pressures must be subjected at the maker's works to a test under water of 2,000 volts for one hour between the conductor and the water, and between cores if there are more than one in the cable, after twenty-four hours' immersion in water, and each drum and coil must be certified to have been so tested. **Certificate of maker's tests**

Where high or extra high working pressures are intended the tests must be made at twice the working pressure.

A written certificate signed by a cable manufacturer or competent engineer of the United Kingdom shall be sufficient evidence that the requirements of this rule have been complied with.

5. Unless fixed in sight and out of reach of injury, all conductors other than lead covered armored cables must further be protected by a strong covering, and this in damp situations must consist of water-tight metal tubes, which shall be electrically continuous throughout, and efficiently connected to earth. Means must be provided to prevent the accumulation within the tubing of water arising from condensation or **Protection of conductors**

other sources. Short bends or elbows must be avoided, corners being turned by smoothbore round bends or suitable boxes.

Protection of exposed ends of conductors entering terminals of switches, etc.

6. The exposed ends of cables where they enter the terminals of switches, fuses, and other appliances, must be properly protected and finished off, so that moisture can not creep along the insulating material within the waterproof sheath, nor can the insulating material, if of an oily nature, leak out of the cable.

Limits of sections

7. The sectional area of a copper conductor must not be less than that of a No. 18 S. W. G. wire, with the exception of the case of flexible cord conductors and wires for fittings, when the sectional area must not be less than that of a No. 20 S. W. G. wire. All insulated copper conductors having a greater area than that of a No. 14 S. W. G. wire must be stranded.

Sectional area of conductors

8. The section of all conductors along which the current is to pass shall be such that if double the normal current were flowing the temperature would not rise to the point at which the insulating material would be damaged or deteriorated.

Current densities

9. If the conductors are of copper they shall be of high conductivity, and when the area does not exceed .2 square inches the current density must not exceed 1,000 amperes per square inch; when the area exceeds .2 square inches, but does not exceed .7 square inches, the current density must not exceed 800 amperes per square inch; and when the area exceeds .7 square inches, but does not exceed 1 square inch, the current density must not exceed 750 amperes per square inch.

Joints not to take strain

10. In every case wires and cables must be so clamped and secured at their joints as to insure that the contact is relieved not only from the weight of the cables, but from any strain that may be put upon them.

Joints

11. All joints must be, as far as practicable, mechanically and electrically perfect to prevent heat being generated. All joints where possible must be soldered. Soldering fluids containing acids or other corrosive substances must not be used. The insulation of all joints in insulated conductors must be most carefully attended to. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, suitable joint boxes must be used.

Joint boxes

12. Joint boxes must be used to connect lengths of cables or conductors equivalent to, or larger than 7-16 S. W. G., and must be so constructed that—

(*a*) The conductors can not be readily short-circuited;

(*b*) The insulation between opposite poles will not readily break or chip;

(*c*) The connections do not heat.

If used in damp places special precautions must be adopted to exclude moisture.

Joints constitute a source of weakness, and they must therefore be accessible, and their positions should be indicated by a conspicuous mark.

Joining of cables in certain places

13. Soldering of joints is prohibited in any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies. In such places conductors must be connected by means of metal screw clamps, connectors, or their equivalent. These connectors must consist of separate clamps on each cable end, with a gap between, which must be bridged across by a link making contact under oil, or in a gas-tight box. The links should be easily removable for dividing the cables when required for testing purposes.

The connectors must be constructed with ample contact surface to prevent any perceptible rise of temperature when carrying twice the full load.

When the separate conductors of cables, at different potentials, such as twin, triple, or concentric cables, are connected in the same box, ample insulation and mechanical protection must be provided between the conductors. On no account may wires, other than signaling wires, or cables be joined by merely twisting them together.

Overhead lines on surface

14. It shall be permissible to use on the surface bare overhead wires under the following conditions:

(*a*) Every overhead line shall be attached to supports at intervals not exceeding 200 feet where the direction of the line is straight, or 150 feet where the line makes an angle at the point of support.

(*b*) Every support for an overhead line shall be of durable material, and properly stayed to withstand forces due to wind pressure, change of direction, or unequal lengths of span, and have a factor of safety of at least ten, calculated from the weight of the wires only. The wires must have a factor of safety of at least five at 32° F.

(*c*) All overhead lines shall be attached to insulators, and shall be so guarded that they can not fall away from the supports.

(*d*) The overhead lines shall at every part be absolutely clear of any traffic going under them.

(*e*) Whenever overhead lines are used they must be protected by efficient lightning arrestors.

(*f*) Service lines from overhead lines shall be connected as directly as possible to suitable insulators firmly attached to some portion of the premises which is not accessible to any person without the use of a ladder, and from this point they shall be efficiently inclosed and protected.

Buried lines on surface

15. Cables buried on the surface shall be continuously insulated.

Unarmored cables must be mechanically protected by suitable material. High tension cables must not be placed in the same trough or conduit with low or medium tension cables, unless they are each separately protected by earthed metallic shields.

Shaft cables

16. All cables used in shafts must be highly insulated and substantially fixed. Shaft cables shall be properly supported at intervals, varying according to the weight of the cable. Where the cables are not completely boxed in and protected from falling material, space should be left between them and the side of the shaft that they may yield, and so lessen a blow given by falling material. They shall, if reasonably practicable, be taken down the down-cast shaft and along the main intake air ways.

Underground cables

17. (*a*) As the condition of underground roads is very variable, the manager shall be responsible for placing the cables in positions where they will be least liable to be damaged by falls of roofs or sides, or by tubs or trams passing or getting off the road.

(*b*) Where the cables in main haulage roads can not be kept at least 1 foot from any part of the tub or tram, they shall be specially protected. When single cables are used they shall, if practicable, be fixed on opposite sides of the road.

(*c*) The fixing with metallic fastenings of cables and wires not provided with metallic covering to walls or timbers is prohibited.

(*d*) Cables when suspended shall be suspended by leather or other flexible material in such a manner as to allow of their readily breaking away when struck, before the cables themselves can be seriously damaged.

(*e*) Trailing cables for portable machines shall be specially flexible, heavily insulated, and protected with either galvanized steel wire armoring, extra stout braiding, hose pipe, or other effective covering. Trailing cables shall be regularly inspected, and any defects in them promptly repaired.

(*f*) At points where the flexible conductors are joined to the main cables, a fixed terminal box must be provided, and be of such design that the lugs can be securely clamped without risk of undue heating, and that no live metal can be exposed when the lid is closed. A switch shall be fixed close to or in the terminal box capable of entirely cutting off the supply from the terminal box and motor.

Cables to be protected during repair of roads or blasting

18. Where main or other roads are being repaired, or blasting is being carried out, suitable temporary protection must be used so that the cables can not be damaged.

Section IV.—*Switches, fuses, and cut-outs*

Switches to be of suitable design

1. Every switch must be of such a type and size that it will not overheat when the full current flows continuously; when it is switched off under full load it must not be possible to form an arc, and it must be incapable of remaining in partial contact, and its handle must be insulated and so arranged that the hand can not touch live metal.

Fuses to be of suitable design

2. Fuses must be so proportioned that no overheating can take place in any part when the full current flows continuously. They shall effectually interrupt the current when a short circuit occurs, and also when the current through them exceeds the working current by 100 per cent. Their covers must be of incombustible material, and either nonconducting or of rigid metal lined with insulating incombustible material, and kept clear of all internal mechanism. Fuses must not be placed in wall sockets, ceiling roses, or switch covers.

Material, marking and replacing of fuses

3. Hard metal or soft metal soldered to hard metal lugs must be used for fuses. They shall be stamped or marked with the current for which they are intended to be used, and shall only be changed or replaced by an authorized person. In the event of a fuse melting, its circuit must be switched off before the fuse is replaced.

Inclosure of switches, fuses, etc., not in machine rooms

4. All live parts of switches, fuses, and cut-outs not in machine rooms, or in compartments specially arranged for the purpose, must be covered. These covers must be of incombustible material, and must be either nonconducting or of rigid metal, and, as far as practicable, clear of all internal mechanism.

Makeshift switches not permissible

5. All points at which the circuit has to be made or broken shall be fitted with proper switches. The use of hooks or other makeshifts is prohibited.

Prohibition of open type switches and fuses in certain places

6. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, the use of open type switches, fuses, and cut-outs is prohibited; they must either be inclosed in gas-tight boxes, or break under oil.

Section V.—*Motors*

Switches to be placed near motors

1. All motors, together with their starting resistances, shall be protected by switches capable of entirely cutting off the pressure, and fixed in a convenient position near the motor.

Ammeter for each motor

2. Every motor in a machine room shall be provided with a suitable ammeter to indicate the load put upon the machine.

Motors to be worked without undue heating

3. Motors must not be worked at a heavier load than they can carry for a six hours run, with a maximum rise of temperature attained by any accessible part of the motor of 80° F. as measured by a thermometer.

Protection for cables passing through metal casings, etc.

4. Special care must be taken to insure that the holes, where unarmored cables or wires pass through metal frames or into boxes or motor casings, are substantially bushed with insulating bushes, and, where necessary, with gas-tight bushings, which can not readily become displaced. All the internal machine connections shall be efficiently protected against damage by accident or rough usage.

Provision of flame-tight inclosure of motors, etc., in certain places, which are only to be opened by authorized persons

5. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, all motors, unless placed in such rooms as are separately ventilated with intake air, shall have all their current carrying parts, also their starters, terminals, and connections, completely inclosed in flame-tight inclosures, made of uninflammable material, and of sufficient strength as not to be liable to be damaged should an explosion of fire damp occur in the interior, and such inclosure shall not be opened except by an authorized person, and then only when the current is switched off. The pressure shall not be switched on while the inclosures are open.

Current to be switched on gradually

6. When starting a motor the switch block shall not be moved across the contacts with one rapid movement, but with a slow movement until the armature has attained its proper speed, and care must be taken that the strain is put on the machine gradually.

Inclosure of portable motors

7. Portable motors which are fed by flexible cables must be provided with strong terminal boxes for making secure mechanical and electrical contact with the cable lugs, as provided in Sec. III., rule 17 (f); the boxes must entirely inclose all live metal, and the lids must be firmly screwed down. These boxes must be securely attached to the machines, or be designed to form a part thereof.

Motors to cease working if fire damp is present

8. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, a safety lamp or other suitable apparatus for the detection of fire damp shall be provided for use with each machine when working, and, should any indication of fire damp appear on the flame of the safety lamp or other apparatus used for the detection of fire damp, the person in charge shall immediately stop the machine, cut off the current at the gate end or nearest switch, and report the matter to an official of the mine.

Current to be cut off at motor if machine is jammed

9. In cases were the cutter of a coal-cutting machine becomes jammed, the current shall be immediately cut off from the motor, and the tension holding the machine up to the face shall be released. The machine shall not be re-started until the increased load upon the cutter has been removed.

Manager to specify length of period of continuous work of coal-cutter

10. A coal-cutter motor shall not be kept continuously at work for a period of time exceeding a maximum period, which shall be specified in writing by the manager.

Casing of portable motors to be opened once a week

11. The casing of all portable motors shall at least once a week be opened by a competent person appointed by the manager, and the parts of the motor so inclosed shall be cleaned, and all dust and dirt be removed before the casing is replaced.

Daily examination of portable machinery and accessories

12. All portable machines, when in use, and their trailing cables, with switches, fuses, and other appliances, shall once in every twenty-four hours be examined by a competent person or persons appointed by the manager.

Authorized person to be in charge of portable machines

Current to be cut off at close of work

13. The person in charge of a coal-cutter or drilling machine shall be a thoroughly competent man duly authorized by the manager; he shall not leave the machine while it is working, and shall, before leaving the working place, see that the current is cut off from the trailing cables. He must not allow the cables to be dragged along by the machine.

No repairs to portable machines while current is on

14. No repairs shall be made to any portable machine until the pressure has been cut off from the trailing cables.

Portable machines to cease working when out of order

15. Should any sparking or arc be produced outside a coal-cutting or other portable machine, or by the cables or rails, the machine shall be stopped, and the occurrence reported to an official of the mine, and the machine shall not be worked again until the defect is repaired.

Manager to fix interval between wedges in holing

16. Wedges or blocks shall be systematically inserted into the holing cut as the cutter progresses, and at a distance apart to be fixed by the manager. Where the holings left by the machine are found to be sufficient to act in place of wedges, wedges need not be inserted.

Section VI.—*Electric locomotives*

Electric locomotives only permissible in certain places and then with medium and low pressures only

1. Electric haulage by locomotives by the trolley system is not permissible in any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies. On this system no pressure exceeding the limits of medium pressure may be employed.

Protection from danger of stock

2. The cab of the locomotive and all trucks used to convey persons shall be so roofed that persons riding are efficiently screened from contact either with the trolley wires or the roof of the road.

Position of trolley wires and conditions of working

3. In drifts and underground roads the trolley wires must be placed so that they are at least 7 feet above the level of the road or track, or the pressure must be cut off from the wires during such hours as the roads are used for traveling on foot. The hours during which traveling on foot is permitted shall be clearly indicated by notices and signals placed in a conspicuous position at the ends of the roads. At other times no one other than a duly authorized person shall be permitted to travel on foot along the road.

System of returns

4. On this system either insulated returns or uninsulated metallic returns of low resistance may be employed.

Separate generator to be employed for locomotives

5. In order to prevent any other part of the system being earthed, the current supplied for use on the trolley wires with an uninsulated return shall be generated by a separate machine, and shall not be taken from or be in connection with electric lines used for any other purpose.

Protection of storage battery locomotives in certain mines

6. If storage battery locomotives are used in any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, the rules applying to motors in such places shall also be deemed to apply to the boxes containing the cells.

Section VII.—*Electric lighting*

Lampholders, switches, etc., not to be directly fixed to metal or timbering.

1. Lampholders, switches, or other fittings must not be directly fixed to the timbering or metal work, but to hard wood, or incombustible, nonhygroscopic, insulating base blocks.

Use of arc lamps

2. All arc lamps shall be so guarded as to prevent pieces of ignited carbon or broken glass falling from them, and shall not be used in situations where there is any danger from the presence of coal dust. They shall be so screened as to prevent risk of contact with persons.

Pressure for lighting

3. For lighting purposes only low pressure electricity shall be used, unless the conditions set out in rule 5, Section I, are complied with.

System of wiring

4. Small wires for lighting circuits must be either conveyed in pipes or casings, which, if underground, shall be noninflammable, or suspended from porcelain insulators, or tied to them with some nonconducting material which will not cut the covering, and so that they do not touch any timbering or metal work. On no account must staples be used. If metallic pipes are used they must be electrically continuous and earthed. If separate uncased wires are used they must be kept at least 2 inches apart, and not brought together except at lamps or switches or fittings.

Wires not to be subjected to mechanical strain

5. No wire carrying a current shall be used underground to support a lamp, or be otherwise subjected to mechanical strain.

Vacuum lamps only permissible in certain places

6. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, vacuum lamps must alone be used; they shall be inclosed in gas-tight fittings of strong glass, and have no flexible cord connections. The wires must be protected by a strong continuous metallic sheathing efficiently earthed.

Lamps to be changed only by authorized persons and when current is off in certain places

7. Lamps underground shall only be changed by a duly authorized competent person. While lamps are being changed on any circuit in any place or part of a mine as mentioned in rule 6, the supply must be switched off from that circuit.

Other lights to be provided at certain places in case of failure of electric light

8. At every entrance between the top and bottom of the shaft and at the shaft bottom, and in all machine rooms and at other places, where the failure of electric light is likely to cause danger, a sufficient supply of safety lamps or other suitable lights shall be maintained for use in the event of a failure of the electric light.

Section VIII.—*Shot firing*

Shots to be fired electrically in places to which the explosives in coal mines orders apply

1. All shots in places to which the explosives in coal mines orders apply shall be fired by electricity, and only by such persons as are duly authorized in writing. High tension magneto-generators shall be inclosed in flame-tight cases when used in such mines.

Firing cable to be not less than 25 yards in length

2. The shot-firing cable shall be of such length as to enable the shot firer to be out of danger from projected material, and shall in no case be of less length than 25 yards.

Method of connecting up for firing

3. The shot-firing cable shall be first connected to the detonator or fuse wire by the shot firer, and not connected to the electric firing apparatus until all persons in the vicinity have taken cover.

4. The handle or key of a magneto shot-firing apparatus shall be detached when not required for firing, and shall under no conditions pass from the personal custody of the shot firer whilst on duty. Magneto machines must be frequently tested to insure that they give the necessary pressure and current.

Detachable key or plug of magneto generators to be in custody of shot-firer

Primary or secondary batteries when used for shot firing shall be provided with a removable connecting plug or key, without which the circuit can not be closed, and this plug or key shall be detached when not required for firing, and shall under no conditions pass from the personal custody of the shot firer whilst on duty. Such batteries must be frequently tested to insure that they give the necessary pressure and current.

Detachable plug of cell batteries to be in custody of shot firer. Batteries to be tested for efficiency

6. Electricity from lighting or power cables shall not be used for firing shots, except in sinking shafts or stone drifts, and then only when a special firing plug, button, or switch is provided, which plug, button, or switch shall be placed in a fixed locked box, and shall only be accessible to the authorized shot firer.

Electricity from light or power mains not to be used except under certain conditions and then only in sinking shafts, etc.

The firing cable or wires shall not be connected to this box until immediately before it is required for the firing of shots, and shall be disconnected immediately after the shots are fired.

7. No person shall approach a shot which has been attempted to be fired by electricity and failed to explode until the firing cable or wires have been disconnected from the apparatus.

Cable to be disconnected before any person approaches missed shot

8. When shot-firing cables or wires are used in the vicinity of power or lighting cables, sufficient precautions shall be taken to prevent the shot-firing cables or wires from coming in contact with the lighting or power cables.

Firing cable not to be in contact with other cables

Section IX.—*Signaling*

1. All proper precautions must be taken to prevent electric signal and telephone wires from coming into contact with other electric conductors, whether insulated or not.

Signal wires not to come into contact with other wires

2. Contact makers or push buttons of electric signaling circuits shall be so constructed and placed as to prevent the circuit being accidentally closed.

Prevention of circuit being accidentally closed

3. In any place or part of a mine to which general rule No. 8 of the coal mines regulation act, 1887, applies, bare wires shall not be used for signaling circuits except in haulage roads, and the pressure shall not exceed 10 volts in any one circuit. If the length of line would otherwise necessitate a higher pressure, suitable relays must be provided.

Limit of pressure where bare wires are used, in certain places

Section X.—*Electric relighting of safety lamps*

1. In mines to any place or part of which general rule No. 8 of the coal mines regulation act, 1887, applies, when safety lamps are relighted underground by electricity, the manager shall select a suitable station or stations, which are not in the return airway, and in which there is not likely to be any accumulation of inflammable gas; and no electric relighting apparatus shall be used in any other place. The relighting apparatus shall be securely locked so as not to be available for use except by persons authorized by the manager to relight safety lamps, and who shall examine all safety lamps brought for relighting before they are reissued.

Authorized person to be in charge of relighting apparatus, and to examine lamps before reissue in certain mines

2. All such apparatus shall be inclosed in a flame-tight casing, and shall be provided with a suitable switch or safety plug so that no sparking can occur except between the terminals provided for the purpose inside the safety lamp.

Apparatus to be inclosed in flame-tight case

Section XI.—*Exemptions and miscellaneous*

1. Notwithstanding anything contained in these rules, any electrical works or apparatus installed or in use before the coming into force of these rules may be continued in use unless an inspector shall otherwise direct or subject to any conditions that he may prescribe.

Exemption for existing installations with inspector's leave

Exemption from rules in special cases

2. An inspector may by writing, signed by him, dispense with any of the above rules in any case in which the special circumstances appear to him to render such exemption necessary or desirable.

Sec. 42 of C. M. R. A., and sec. 18 of M. M. R. A.

3. In case any difference of opinion shall arise between an inspector and an owner as to any requirement or exception under this section, the same shall be settled as provided in section 42 of the coal mines regulation act, 1887, or in section 18 of the metalliferous mines regulation act, 1872.

. The foregoing proposed set of rules was considerably modified and the following code was put into effect by the British Home Office in 1905:

SPECIAL RULES FOR THE INSTALLATION AND USE OF ELECTRICITY IN MINES

Definitions

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and earth as read by a hot wire or electrostatic voltmeter, and

(*a*) Where the conditions of the supply are such that the pressure at the terminals where the electricity is used can not exceed 250 volts, the supply shall be deemed a low-pressure supply.

(*b*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 250 volts, but can not exceed 650 volts, the supply shall be deemed a medium-pressure supply.

(*c*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 650 volts, but can not exceed 3,000 volts, the supply shall be deemed a high-pressure supply.

(*d*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 3,000 volts, the supply shall be deemed an extra high-pressure supply.

Section I.—*General*

1. (*a*) All electrical apparatus and conductors shall be sufficient in size and power for the work they may be called upon to do, and, so far as is reasonably practicable, efficiently covered or safeguarded, and so installed, worked, and maintained as to reduce the danger through accidental shock or fire to the minimum, and shall be of such construction, and so worked that the rise in temperature caused by ordinary working will not injure the insulating materials.

(*b*) In any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, the covering shall be constructed so that, as far as is reasonably practicable, there is no danger of firing gas by sparking or flashing which may occur during the normal or abnormal working of the apparatus.

(*c*) All metallic coverings, armoring of cables, other than trailing cables, and the frames and bedplates of generators, transformers, and motors other than portable motors, shall, as far as is reasonably practicable, be efficiently earthed where the pressure at the terminals where the electricity is used exceeds the limits of low pressure.

2. Where a medium-pressure supply is used for power purposes, or for arc lamps in series, the wires or conductors forming the connections to the motors, transformers, arc lamps, or otherwise in connection with the supply, shall be, as far as is reasonably practicable, completely inclosed in strong armoring or metal casing efficiently connected with earth, or they shall be fixed at such a distance apart, or in such a manner

that danger from fire or shock may be reduced to a minimum. This rule shall not apply to trailing cables.

3. Where a medium-pressure supply is used for incandescent lamps in series, the wires or conductors forming connections to the incandescent lamps, or otherwise in connection with the supply, shall be, as far as is reasonably practicable, completely inclosed in strong armoring or metal casing efficiently connected with earth, or they shall be fixed at such a distance apart or in such a manner that danger from fire or shock shall be reduced to the minimum.

4. Motors of coal cutting and such other portable machines shall not be used at a pressure higher than medium pressure. No transformer used for supplying current at a pressure higher than medium pressure, and no motor using such current shall be of less normal rating than 20 b. h. p. for use underground.

No higher pressure than a medium pressure shall be used in any place or any part of the mine to which the general rule No. 8 of the coal mines regulation act, 1887, applies.

5. No higher pressure than a medium-pressure supply shall be used other than for transmission or for motors, and the wires or conductors other than overhead lines above ground forming the connections to the motors or transformers or otherwise in connection with the supply shall be completely inclosed in a strong armoring or metal casing efficiently connected with earth, or they shall be fixed at such a distance apart or in such a manner that danger from fire or shock shall be reduced to the minimum.

The machines, apparatus, and lines shall be so marked as to clearly indicate that they are high pressure, either by the use of the word "Danger" at frequent intervals or by red paint properly renewed when necessary.

6. The insulation of every complete circuit other than telephone or signal wires used for the supply of energy, including all machinery, apparatus, and devices forming part of or in connection with such circuit shall be so maintained that the leakage current shall, so far as is reasonably practicable, not exceed $\frac{1}{1000}$ of the maximum supply current, and suitable means shall be provided for the immediate localization of leakage.

7. In every completely insulated circuit earth or fault detectors shall be connected up in every generating and transforming station to show immediately any defect in the insulation of the system. The readings of these instruments shall be recorded daily in a book kept at the generating or transforming station or switch house.

8. Main and distribution switch and fuse boards must be made of incombustible insulating material, such as marble or slate, free from metallic veins, and be fixed in as dry a situation as practicable.

9. Every subcircuit must be protected by a fuse on each pole. Every circuit carrying more than 5 amperes up to 125 volts or 3 amperes at any pressure above 125 volts must be protected in one of the following alternative methods:

(*a*) By an automatic maximum cut-out on each pole.

(*b*) By a detachable fuse on each pole, constructed in such a manner that it can be removed from a live circuit with the minimum risk of shock.

(*c*) By a switch and fuse on each pole.

10. Fire buckets filled with clean, dry sand shall be kept in electrical machine rooms ready for immediate use in extinguishing fires.

No repair or cleaning of the live parts of any electrical apparatus except mere wiping or oiling shall be done when the current is on.

Gloves, mats, or shoes, of india rubber or other nonconducting material, shall be supplied and used where the live parts of switches or machines, working at a pressure exceeding the limits of low pressure, have to be handled for the purpose of adjustment.

11. A competent person shall be on duty at the mine when the electrical apparatus or machinery is in use, and at such time as the amount of electricity delivered down the mine exceeds 200 b. h. p. a competent person shall be on duty at the mine above ground and another below ground. Every person appointed to work any electric apparatus shall have been instructed in his duty and be competent for the work that he is set to do.

12. No person shall wilfully damage, interfere with, or without proper authority remove or render useless any electric line or any machine, apparatus or part thereof, used in connection with the supply or use of electricity.

13. Instructions shall be posted up in every generating, transforming, and motor house containing directions as to the restoration of persons suffering from electric shock.

14. Direct telephonic or other equivalent means of communication shall be provided between the surface and the pit bottom or main distributing center in the pit.

15. Within three months after the introduction into any mine of electric motive power, notice in writing must be sent to His Majesty's inspector of mines for the district. Notice must also be sent of any existing electric motive power installation at any mine within three months after the coming into force of these rules.

16. A plan shall be kept at the mine showing the position of all permanent electrical machinery and cables in the mine, and shall be corrected as often as may be necessary to keep it up to a date not more than three months previously.

Section II.—*Generating stations and machine rooms*

1. Where the generating station under the control of the owner or manager of the mine is not within 400 yards of the working pit mouth, an efficiently inclosed locked switch box or boxes, or a switch house shall, where reasonably practicable, be provided near the pit mouth for cutting off the supply of electricity to the mine.

2. There shall be a passageway in front of the switchboard of not less than 3 feet in width, and if there are any connections at the back of the switchboard, any passageway behind the switchboard shall not be less than 3 feet clear. This space shall not be utilized as a storeroom or a lumber room, or obstructed in any manner by resistance frames, meters, or otherwise. If space is required for resistance frames or other electrical apparatus behind the board, the passageway must be widened accordingly.

No cable shall cross the passageway at the back of the board except below the floor, or at a height of not less than 7 feet above the floor.

The space at the back of the switchboards shall be properly floored, accessible from each end, and, except in the case of low-pressure switchboards, must be kept locked up, but the lock must allow of the door being opened from the inside without the use of a key. The floor at the back shall be incombustible, firm, and even.

3. Every generator shall be provided with a switch on each pole between the generator and the bus bars.

Where continuous-current generators are paralleled, reversed current cut-outs shall be provided.

Suitable instruments shall be provided for measuring the current and pressure of each generator.

Every feeder circuit shall at its origin be provided with an ammeter.

4. If the transmission lines from the generating station to the pit are overhead, there shall be lightning arresters in connection with the feeder circuits.

5. Automatic cut-outs must be arranged so that when the contact lever opens outward no danger exists of striking the head of the attendant. If uninclosed fuses are used, they must be placed within 2 feet of the floor or be otherwise suitably protected.

Where the supply is at a pressure exceeding the limits of medium pressure, there shall be no live metal work on the front of the main switchboard within 8 feet of the

floor or platform, and the space provided under rule No. 2 of this section shall be not less than 4 feet in the clear. Insulating floors or mats shall be provided for medium-pressure boards where live metal work is on the front or back.

6. All terminals and live metal on machines over medium pressure above ground, and over low pressure underground, where practicable, shall be protected with insulating covers or with metal covers connected to earth.

7. No person other than an authorized person shall enter a machine or motor room, or interfere with the working of any machine, motor, or apparatus connected therewith.

SECTION III.—*Cables*

1. All conductors (except as hereinafter provided) shall in every case be maintained completely insulated from earth, but it is permissible to use the concentric system with earthed outer conductor, if proper arrangements are made to reduce the danger from fire or shock to the minimum, but the neutral point of polyphase systems and the middle wire of 3-wire continuous-current systems may be earthed at one point.

2. Unless fixed as far as is reasonably practicable out of reach of injury, all conductors, other than armored cables, must further be protected by a suitable covering. Where lead-covered cable is used the lead shall be earthed and electrically continuous throughout.

The exposed ends of cables where they enter the terminals of switches, fuses, and other appliances must as far as is reasonably practicable be properly protected and finished off, so that moisture can not creep along the insulating material within the waterproof sheet, nor can the insulating material, if of an oily nature, leak out of the cable.

3. All joints must be mechanically and electrically efficient, and, where reasonably practicable, must be suitably soldered. In any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, suitable joint boxes must be used, and the conductors connected by means of metal screw clamps, connectors, or their equivalent, constructed in a safe manner. Provided, that in any place or part of a mine where a shot may be fired, joints may be soldered by or in the presence of a person authorized in that behalf by the manager, but the same precautions in regard to examination and removal of workmen as are prescribed by paragraphs (*f*) and (*i*) of general rule No. 12 shall be observed in all cases, and where the place is dry and dusty, also the precautions as to watering prescribed by paragraph (*h*). Wires, other than signaling wires or cables, must not be joined by merely twisting them together.

4. Overhead bare wires on the surface must be efficiently supported upon insulators and clear of any traffic, and provided with efficient lightning arresters.

5. All cables used in shafts must be highly insulated and substantially fixed. Shaft cables, not capable of sustaining their own weight, shall be properly supported at intervals, varying according to the weight of the cable. Where the cables are not completely boxed in and protected from falling material, space shall be left between them and the side of the shaft that they may yield, and so lessen a blow given by falling material.

6. Where the cables in main haulage roads can not be kept at least 1 foot from any part of the tub or tram, they shall be specially protected. When separate cables are used they shall, if reasonably practicable, be fixed on opposite sides of the road.

The fixing with metallic fastenings of cables and wires not provided with metallic covering to walls or timbers is prohibited.

Cables underground, when suspended, shall be suspended by leather or other flexible material in such a manner as to allow of their readily breaking away when struck before the cables themselves can be seriously damaged.

Where main or other roads are being repaired or blasting is being carried out, suitable temporary protection must be used so that the cables are reasonably protected from damage.

7. Trailing cables for portable machines shall be specially flexible, heavily insulated, and protected with either galvanized steel wire armoring, extra stout braiding, hose pipe, or other effective covering. Trailing cables shall be examined at least once in each shift by the person in charge of the machine and any defects in them promptly repaired.

At points where the flexible conductors are joined to the main cables a fixed terminal box must be provided, and a switch shall be fixed close to or in the terminal box capable of entirely cutting off the supply from the terminal box and motor.

Section IV.—*Switches, fuses, and cut-outs*

1. Fuses and automatic cut-outs shall be so constructed as effectually to interrupt the current when a short circuit occurs or when the current through them exceeds the working current by 200 per cent. Fuses shall be stamped or marked or shall have a label attached indicating the current with which they are intended to be used, or where fuse wire is used each coil in use shall be so stamped or labeled. Fuses shall only be adjusted or replaced by an authorized person.

2. All live parts of switches, fuses, and cut-outs not in machine rooms, or in compartments specially arranged for the purpose must be covered. These covers must be of incombustible material and must be either nonconducting or of rigid metal and, as far as practicable, clear of all internal mechanism.

3. All points at which a circuit other than those for signals has to be made or broken shall be fitted with proper switches. The use of hooks or other makeshifts is prohibited, and in any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, the use of open-type switches, fuses, and cut-outs is prohibited. They must either be inclosed in gas-tight boxes or break under oil.

Section V.—*Motors*

1. All motors, together with their starting resistances, shall be protected by switches capable of entirely cutting off the pressure, and fixed in a convenient position near the motor and every motor of 10-brake horsepower or over in a machine room underground shall be provided with a suitable ammeter to indicate the load put upon the machine.

2. Where unarmored cables or wires pass through metal frames or into boxes or motor casings, the holes must be substantially bushed with insulating bushes, and where necessary, with gas-tight bushings which can not readily become displaced.

3. Terminal boxes of portable motors must be securely attached to the machine, or be designed to form a part thereof.

4. In any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, all motors, unless placed in such rooms as are separately ventilated with intake air, shall have all their current-carrying parts, also their starters, terminals, and connections completely inclosed in flame-tight inclosures, made of uninflammable material and of sufficient strength as not to be liable to be damaged should an explosion of fire damp occur in the interior, and such inclosures shall not be opened except by an authorized person, and then only when the current is switched off. The pressure shall not be switched on while the inclosures are open.

5. In any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, a safety lamp or other suitable apparatus for the detection of fire damp shall be provided for use with each machine when working, and should any indication of fire damp appear on the flame of the safety lamp or other apparatus used for the detection of fire damp, the person in charge shall immediately stop the machine, cut off the current at the gate end or nearest switch, and report the matter to an official of the mine.

6. (*a*) A coal-cutter motor shall not be kept continuously at work for a period of time exceeding a maximum period which shall be specified in writing by the manager, so that the roof may be carefully examined.

(*b*) The casing or inspection doors of all portable motors used underground and the casings of their switches and other appliances shall at least once a week be opened by a competent person appointed by the manager, and the parts so disclosed shall be cleaned and examined before the coverings are replaced. In special cases requiring a motor to run continuously longer than one week, the motor shall be examined at the end of the run. A report of such examination shall be entered in a report book.

7. The person in charge of a coal-cutter or drilling machine shall not leave the machine while it is working, and shall, before leaving the working place, see that the current is cut off from the trailing cables. He must not allow the cables to be dragged along by the machine. No repairs shall be made to any portable machine until the pressure has been cut off from the trailing cables.

8. If any electric sparking or arc be produced outside a coal-cutting or other portable motor or by the cables or rails, the machine shall be stopped, and not be worked again until the defect is repaired, and the occurrence shall be reported to an official of the mine.

Section VI.—*Electric locomotives*

1. Electric haulage by locomotives by the trolley-wire system is not permissible in any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies. On this system no pressure exceeding the limits of medium pressure may be employed.

2. In underground roads the trolley wires must be placed so that they are at least 7 feet above the level of the road or track, or elsewhere, if sufficiently guarded, or the pressure must be cut off from the wires during such hours as the roads are used for traveling on foot in places where trolley wires are fixed. The hours during which traveling on foot is permitted shall be clearly indicated by notices and signals placed in a conspicuous position at the ends of the roads. At other times no one other than a duly authorized person shall be permitted to travel on foot along the road.

On this system either insulated returns or uninsulated metallic returns of low resistance may be employed.

3. In order to prevent any other part of the system being earthed (except when the concentric system with earthed outer conductor is used) the current supplied for use on the trolley wires with an uninsulated return shall be generated by a separate machine, and shall not be taken from or be in connection with electric lines otherwise completely insulated from earth.

4. If storage-battery locomotives are used in any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, the rules applying to motors in such places shall also be deemed to apply to the boxes containing the cells.

Section VII.—*Electric lighting*

1. All arc lamps shall be so guarded as to prevent pieces of ignited carbon falling from them, and shall not be used in situations where there is likely to be danger from the presence of coal dust. They should be so screened as to prevent risk of contact with persons.

2. Small wires for lighting circuits must be either conveyed in pipes or casings, or suspended from porcelain insulators, or tied to them with some nonconducting material which will not cut the covering and so that they do not touch any timbering or metal work. On no account must staples be used. If metallic pipes are used, they must be electrically continuous and earthed. If separate uncased wires are used, they must be kept at least 2 inches apart and not brought together except at lamps or switches or fittings.

3. In any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, electrical lamps, if used, must be of the vacuum or inclosed type; they shall be protected by gas-tight fittings of strong glass, and have no flexible cord connections, and shall only be changed by a duly authorized competent person. While the lamps are being changed the current shall be switched off.

4. In all machine rooms and other places underground where a failure of electric light is likely to cause danger, some safety lamps, or other proper lights, shall be kept for use in the event of such failure.

Section VIII.—*Shot firing*

1. Electricity from lighting or power cables shall not be used for firing shots, except in sinking shafts or stone drifts, and then only when a special firing plug, button, or switch is provided, which plug, button, or switch shall be placed in a fixed locked box, and shall only be accessible to the authorized shot firer.

The firing cables or wires shall not be connected to this box until immediately before it is required for the firing of shots, and shall be disconnected immediately after the shots are fired.

When shot-firing cables or wires are used in the vicinity of power or lighting cables, sufficient precautions shall be taken to prevent the shot-firing cables or wires from coming in contact with the lighting or power cables.

The foregoing rules shall not apply to telephone, telegraph, and signal wires, to which the rules of this section only shall apply.

Section IX.—*Signaling*

1. All proper precautions must be taken to prevent electric signal and telephone wires from coming into contact with other electric conductors, whether insulated or not.

2. Contact makers or push buttons of electric signaling circuits shall be so constructed and placed as to prevent the circuit being accidentally closed.

3. In any place or part of a mine where general rule No. 8 of the coal mines regulation act, 1887, applies, bare wires shall not be used for signaling circuits except in haulage roads, and the pressure shall not exceed 15 volts in any one circuit.

Section X.—*Electric relighting of safety lamps*

1. In mines to any place or part of which general rule No. 8 of the coal mines regulation act, 1887, applies, when safety lamps are relighted underground by electricity, the manager shall select a suitable station or stations, which are not in the return air way, and in which there is not likely to be any accumulation of inflammable gas; and no electric relighting apparatus shall be used in any other place. All electrical relighting apparatus shall be securely locked, so as not to be available for use except by persons authorized by the manager to relight safety lamps, and such persons shall examine all safety lamps brought for relighting before they are reissued.

Section XI.—*Exemptions and miscellaneous*

1. Notwithstanding anything contained in these rules, any electrical plant or apparatus installed or in use before the coming into force of these rules, may be continued in use unless an inspector shall otherwise direct, or subject to any conditions affecting safety that he may prescribe.

In case any difference of opinion shall arise between an inspector and an owner under this rule, the same shall be settled as provided in section 42 of the coal mines regulation act, 1887.

2. Any of the foregoing requirements shall not apply in any case in which exemption is obtained from the Secretary of State, on the ground either of emergency or special circumstances, on such conditions as the Secretary of State may prescribe.

BELGIUM

The following law is in effect in Belgium:

ADMINISTRATIVE DIRECTIONS AND RULES REGARDING THE USE OF ELECTRICITY, IN FORCE FROM JANUARY 1, 1909

Brussels, 1909

SECTION C (pp. 70–77)

Supplementary conditions relating to electrical installations placed in the underground workings of mines and quarries, and in their surface premises; in open quarries and establishments regulated by the law of April 21, 1910, and their premises.

A.—General arrangements

ARTICLE 1. When the machines are installed in places not intended for labor, access to those places shall be forbidden to persons who are not called there by their duties.

ART. 2. Wheel and pulley pits as well as moving parts of machines and of accessory apparatus shall be always surrounded by guards having supports fit to protect employees against accidents. Gears, and in a general way, movable pieces which might cause accidents, shall be incased and surrounded in a way to avoid all danger.

ART. 3. It is forbidden to clean or repair machines and gearing while in operation, or to take off attachments for protection against accidents. Also, oiling during operation is forbidden, unless the methods adopted give every desired guaranty of safety.

ART. 4. Manways shall have such width and height that the workmen can not be struck by machines and parts with which they might come in contact.

ART. 5. Illumination shall always be sufficient to permit the distinguishing of machines, transmission devices, and all those parts of the installation that present danger.

ART. 6. It is forbidden to place combustible, inflammable, or explosive materials near electrical machines and their subsidiary apparatus.

ART. 7. At least once a year a competent agent shall make a detailed inspection of all parts of electrical installations and shall measure the insulation resistances, except of those installed in underground workings, for which there are special directions. The results of these visits and of the measurements taken shall be recorded on a special register. This register shall be offered at every requisition of the officials charged with supervision.

ART. 8. Before any electric installation begins work and after any addition or important change to a plant, the visiting agent shall assure himself that it entirely complies with the prescriptions imposed by the permit authorizing it, and shall write, in the register mentioned in the preceding article, the result of his observation. Before each starting of every apparatus the persons in charge shall make sure that everything is in order.

ART. 9. The care and maintenance of electrical apparatus shall not be intrusted to other than experienced agents.

ART. 10. The special rules adopted with a view to assuring safety and the directions concerning first aid to victims of electricity shall be posted on the premises of the electric service.

B.—Special regulations concerning the installation of electric appliances in the underground workings of mines and quarries and their surface premises

UNDERGROUND WORKINGS

I. Places where gas is not to be feared, including gaseous mines of the first and second classes

ARTICLE 1. Bare conductors must not be installed in underground workings, except for electric traction by direct current; and in this case they must be placed *at least two meters above the level of the flange of the rail.* The tension between these conductors and the rail must not exceed 250 volts.

The tension may reach 500 volts in galleries not traversed by the personnel.

ART. 2. Flexible cables, intended to connect removable apparatus, must have an insulation equal to 500 megohms and must be covered by a resistant cover, protected by a close plaiting of steel wire, grounded.

The maximum tension between two conductors in the same cable shall be 250 volts. This regulation does not apply to the armored cables leading to sinking pumps.

ART. —. Cables with single or multiple conductors, intended for lighting, shall have an insulation corresponding to 500 megohms and must be covered by a close plaiting of steel wire, grounded. The maximum tension allowed between the two conductors of these cables is 110 volts.

ART. —. The secondary conductors and the bar forming parts of the switchboards shall be bare. The conductors connecting the machinery with the switchboards and with rheostats or circuit breakers must be lead covered and armored cables.

ART. —. The principal cables must be lead covered and armored by steel wire. The protection of these cables shall be grounded and protected against dampness by an impregnated covering.

Nevertheless, in galleries, the inclination of which does not exceed 45 degrees, the protective cover can be made of hoop iron. The lead cover is not obligatory for the movable cables of shafts that are being sunk. The cables must be tested, after placing, under at least 1.5 times their working tension. An official statement will be made of these tests.

These cables may be put in air shafts or working shafts. In the shafts they must be fastened to metallic supports (grips, jaws, etc.) at maximum distances of 6 meters. Between these supports and the cable split spools of wood or impregnated cloth can be placed.

ART. —. All return of currents by the ground is prohibited, except for traction.

ART. —. In the underground portions of electrical installations the use of fuses is prohibited. This rule may be modified for motors or movable apparatus; also for those intended for temporary use, for motors of the character of accessory appliances (brakes, slowing-down devices, etc.), and for lighting installations. In these cases ordinary fuses can be used, incased in air-tight covers.

ART. 8. In measuring apparatus for alternating current the tension is limited to 110 volts.

ART. —. Incandescent vacuum lamps, the only ones allowed in underground workings, shall be fixed. They must be incased, including their sockets, in thick, hermetically sealed glass globes, these globes being protected by metal wire network. Nevertheless, the use of movable lamps is allowed for the examination of machines, wheel pits, foundations, etc., under condition that the filaments are protected, as previously described, and the cable which feeds them conforms with the regulations of article 2.

II. Places where gas is to be feared. (Gaseous mines of first and second class)

ART. 10. The administration in each particular class will determine the measures to be taken to insure safety in places where gas is to be feared, unless the regulations of Article 11 are not observed there.

III. Mines with instantaneous outbursts of gas, or gaseous mines of the third class

ART. —. The only electrical installations allowed in mines subject to instantaneous outbursts of gas are those which, stripped of all accessories, consist of a motor without commutator directly connected with the cable coming from the surface.

Operating must be done at the surface and ordered from below by telephone.

The room in which the motor is to be placed must be ventilated by a current of fresh air going directly to the up-cast.

The cables must conform to the regulations in article 5. When the cables are placed into the up-cast shafts there shall be no junction boxes in these shafts. These boxes must be eventually placed in galleries taking air directly from the down-cast shafts.

In galleries where the walls are not continuous and incombustible, the cables must be underground at a depth of at least 30 centimeters, in a bed of sand covered with a layer of bricks, if another equivalent arrangement is not adopted.

IV. Ventilation, supervising and maintenance

ART. 12. The electric generator motors and transmitters must be installed in dry and well ventilated places. The temperature of these places must not exceed 25° C.

ART. 13. In conveniently selected places, a sufficient number of ordinary lamps, lighted, or portable electric lamps must be kept, in order to assure, in case of an accidental interruption of the usual electric lighting, the retreat of the workmen and the execution of the various manipulations.

ART. 14. In gaseous mines, ordinary safety lamps shall be placed at the disposal of the personnel at all points where their presence shall be deemed necessary.

ART. 15. The walls of the underground galleries and chambers, where electric apparatus shall be kept, must be rigorously watched and maintained. In gaseous workings the atmosphere must be examined by the watchmen at each round and by the special workmen charged with the operation and inspection of the said apparatus at frequent intervals, in order to assure against the eventual formation of a combustible mixture. If the presence of such a mixture is established, the electric appliances shall stop running.

ART. 16. Underground electrical installations must be inspected at least once every week by a competent employee, who shall satisfy himself that they are in good condition.

At least once a month, the insulation of all the parts of the installation must be measured.

The results of these inspections and of these measurements shall be recorded in a record book kept at the disposal of the officials in charge of the supervision.

ART. 17. In the surface premises of underground workings high tension electric power transmission must be exclusively by lead covered armored cables.

ART. 18. The motors installed in the surface premises mentioned in article 41 of the Royal Edict of April 20, 1885, concerning the police service of mines, shall conform to the regulations of the first paragraph of article 11.

ART. 19. In the same premises, electric lighting can be installed conditional to satisfying regulations of articles 3 and 9, and not placing there any apparatus.

SECTION D.—*Employment of portable electric lamps in gaseous mines*

Portable incandescent lamps shall satisfy the following conditions:

(*a*) The filaments must be surrounded by globes of thick glass, hermetically sealed.

(*b*) The boxes containing the cells must be impermeable.

(*c*) Some arrangement must be made to prevent the removal of the globes and the opening of the boxes within the workings.

(*d*) The contacts must be in a closed box.

(*e*) The binding screws of the batteries shall be situated so as to be inaccessible when the lamp is in service.

ART. 2. Ordinary safety lamps must be placed at the disposal of the personnel at all points where their presence shall be deemed necessary.

ART. 3. The care and maintenance of electric lamps can be intrusted only to experienced workmen, especially assigned to supervision.

NEW SOUTH WALES

The following law is in force in New South Wales:

SPECIAL RULES FOR THE INSTALLATION AND USE OF ELECTRICITY

The following rules shall be observed, as far as is reasonably practicable, in the mine:

DEFINITIONS

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and earth, as read by a hot wire or electrostatic volt-meter; and—

(*a*) Where the conditions of the supply are such that the pressure at the terminals where the electricity is used can not exceed 250 volts, the supply shall be deemed a low-pressure supply.

(*b*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 250 volts, but can not exceed 650 volts, the supply shall be deemed a medium-pressure supply.

(*c*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 650 volts, but can not exceed 3,000 volts, the supply shall be deemed a high-pressure supply.

(*d*) Where the conditions of supply are such that the pressure at the terminals where the electricity is used, between any two conductors, or between one conductor and earth, may at any time exceed 3,000 volts, the supply shall be deemed an extra high-pressure supply.

The expression "the minimum" signifies the least reasonably possible to be attained, by the proper use of the means from time to time known and available, so as to secure safety, with efficiency.

The expression "A gassy place" means any place which is either—

(*a*) Any place, or part of a mine, where general rule 8, of section 47 of the coal mines regulation act, 1902, applies; or

(*b*) Any place or part of a mine where any quantity, however small (capable of being detected by an ordinary safety-lamp), of inflammable gas has been given off within the previous six months; or

(*c*) Any working which is within 20 yards of, or is being advanced toward, any locality where it is doubtful whether or not there may be an accumulation of inflammable gas, or any place in the same district on the return airway side of such working.

GENERAL.

1. All electrical apparatus and conductors shall be sufficient in size and power for the work they may be called upon to do, and efficiently covered or safeguarded, and so installed, worked, and maintained, as to reduce the danger, through accidental shock or fire or over-heating, to the minimum, and shall be of such construction, and

so worked, that the rise in temperature caused by ordinary working will not injure the insulating materials.

In any gassy place, the covering shall be constructed so that there is no danger of firing gas by sparking or flashing which may occur during the normal or abnormal working of the apparatus.

All metallic coverings, armoring of cables, and the frames and bedplates of generators, transformers, and motors other than portable motors, shall be efficiently earthed, if the pressure at the terminals where the electricity is used exceeds the limits of low pressure.

2. Where a medium-pressure supply is used for power purposes, or for arc or incandescent lamps in series, the conductors which form the connections to the motors, transformers, or lamps, or are otherwise used in connection with the supply, shall be completely inclosed in strong armoring or metal casing efficiently connected with earth; or they shall be fixed at such a distance apart, or in such a manner, that danger from fire or shock shall be reduced to the minimum. This rule shall not apply to trailing cables, which are dealt with under rules 34 to 41.

3. Motors of coal-cutting and other portable machines shall not be used at a pressure higher than a medium pressure.

4. A higher pressure than a medium pressure shall not be used underground except for transmission, and shall then be applied only to transformers and induction motors in which the whole of the high-pressure circuit is stationary.

The high-pressure conductors (other than overhead lines above ground) which form the connections of such motors or transformers, or are otherwise used in connection with the supply, shall be completely inclosed in a strong armoring or metal casing efficiently connected with earth; or they shall be fixed at such a distance apart, or in such a manner, that danger from fire or shock shall be reduced to the minimum.

All high-pressure machines, apparatus, and lines, shall be so marked by the use of the word "Danger" at frequent intervals, or by red paint properly renewed when necessary, or in some other conspicuous manner, as to clearly indicate that they are high pressure.

Insulation test and report of same

For work underground, when furnished with current at a pressure higher than medium pressure, a transformer shall not be of less normal rating than 10 kilowatts, nor shall a motor be of less normal rating than 20 brake horsepower.

5. In any gassy place a higher pressure than a medium pressure shall not be transmitted beyond the in-bye ends of the main intake air ways; and all motors, transformers, and other apparatus connected with such higher pressure supply must be placed in suitable chambers ventilated by intake air.

6. A test of the insulation of every complete lighting and power circuit, including all machinery, apparatus, and devices forming part of or in connection with such circuit (either collectively or in parts), shall be taken at least once a month; and a record of such test shall be made and signed by the person making the test, in a book kept for the purpose. The insulation of every such circuit shall be so maintained that the leakage current shall not exceed $\frac{1}{1000}$ of the maximum supply current, and in the event of the leakage current exceeding this maximum, suitable steps shall be taken at once to localize and remedy the leakage.

7. In every completely insulated circuit, earth or fault detectors shall be kept connected up in every generating and transforming station to show immediately any defect in the insulation of the system. These instruments shall be inspected daily by a competent person.

8. Main and distribution switch and fuse boards shall be made of incombustible insulating material, such as marble or slate free from metallic veins, and be fixed in as dry a situation as practicable.

9. Every subcircuit shall be protected by a fuse on each pole, except in the case of the earthed middle wire of a 3-wire system, in which case the fuses may be on the outers only. Every circuit having a current of more than 5 amperes at any pressure up to 125 volts, or 3 amperes at any pressure above 125 volts, must be protected by one of the following alternative methods:

(*a*) By an automatic maximum-current circuit breaker on each pole.

(*b*) By a detachable fuse on each pole, constructed in such a manner that it can be removed from a live circuit with the minimum risk of shock.

(*c*) By a switch and fuse on each pole.

10. No repair or cleaning of the live parts of any electrical apparatus, except mere wiping or oiling, shall be done when the current is on.

Where the live parts of switches or machines working at a pressure exceeding the limits of low pressure may have to be handled for the purpose of adjustment or for such wiping or oiling, gloves, mats, or shoes of india rubber or other non-conducting material shall be supplied by the manager and shall be used by the attendants.

11. Where electricity is used below ground for power or lighting purposes, there shall be employed a competent person, who shall be subject to the authority of the manager, and in his absence the under manager, and shall have charge of all electrical machinery and apparatus in or about the mine and who is in these rules called the electrician.

The electrician or some other competent person shall be on duty at the mine when the electrical apparatus or machinery is in use.

Every person appointed to work any electric apparatus shall have been instructed in his duty and be competent for the work that he is set to do.

12. No person other than an authorized person shall enter a machine room or motor room, and no person shall wilfully damage, interfere with, or without proper authority remove or render useless any electric line, or any machine, apparatus, or part thereof, used in connection with the supply or use of electricity.

13. Fire buckets filled with clean dry sand shall be kept in electrical machine rooms ready for immediate use in extinguishing fires.

14. Instructions shall be posted up at the pit top or mine entrance and in every generating, transforming, and motor house, containing directions as to the restoration of persons suffering from electric shock. All employees working in connection with the electrical apparatus shall be required to acquaint themselves with the instructions in question.

15. In every mine where electricity is used below ground for power or lighting purposes direct telephonic or other equivalent means of communication shall be provided between the surface and the shaft bottom or main distributing center underground.

16. Within three months after the coming into force of these rules, notice in writing of any existing electric installation must be sent to the district inspector of collieries.

17. A plan of a scale not smaller than four chains to one inch shall be kept at the mine, showing the position of all permanent electrical machinery and fixed cables in the mine, and shall be corrected as often as may be necessary to keep it as nearly as practicable up to date and never more than three months in arrear, and the inspector shall be entitled to examine the plan and for official purposes only to make a copy of every part thereof.

Record of electrical accidents

18. Every personal accident occurring in connection with the operation of the electrical equipment (including electric shocks and burns) shall be promptly reported by the person injured or by some other person on his behalf at the office of the mine and shall be there recorded.

19. In the event of any instance occurring of breakdown of, or damage or injury to, any portion of the electrical equipment in the mine, or of overheating, or of the appearance of sparks or arcs outside the inclosing casings, or in the event of any portion of the equipment (not being a proper part of the electrical circuit) becoming alive, every such occurrence shall be promptly reported in a book kept at the mine for the purpose and signed by the person making such report. Report of breakdowns, etc.

Generating Stations and Machine Rooms

20. Where the generating station under the control of the owner or manager of the mine is not within 400 yards of the shaft mouth or mine entrance, a switch box or boxes, efficiently inclosed and locked, or a locked switch house, shall be provided near the mine entrance for cutting off the supply of electricity to the mine.

21. There shall be a passage way in front of the switchboard of not less than 3 feet in width, and if there are any connections at the back of the switchboard the passage way, if any, behind the switchboard shall not be of less width than 3 feet clear. This space shall not be utilized as a storeroom or a lumber room or obstructed in any manner by resistance frames or meters or otherwise. If space is required for resistance frames or other electrical apparatus behind the board, the passageway must be widened accordingly.

No cable shall cross the passageway at the back of the board except below the floor or at a height of not less than 7 feet above the floor.

The space at the back of the switchboards shall be properly floored, accessible from each end, and, except in the case of low-pressure switchboards, shall be kept locked up; but the lock must allow of the door being opened from the inside without the use of a key. The floor at the back shall be firm and even.

22. Every generator shall be provided with a switch on each pole between the generator and the bus-bars.

Suitable instruments shall be provided for measuring the current and pressure of each generator.

Every feeder connected to the bus bars in the generating station shall be furnished with an ammeter on the main switchboard.

23. Circuit breakers must be arranged so that when the contact lever opens outwards no danger exists of its striking the attendant. If uninclosed fuses are used, they must be placed within 2 feet of the floor or must be suitably guarded.

Where the supply is at a pressure exceeding the limits of medium pressure, there shall be no live metal work on the front of the main switchboard within 8 feet of the floor or platform, and the space provided under rule 21 shall be not less than 4 feet in the clear. Insulating floors or mats shall be provided for switchboards where medium or higher pressure is used.

24. All terminals and live metal on machines over medium pressure above ground and over low pressure under ground shall, where practicable, be protected with insulating covers or with metal covers connected to earth.

25. If the transmission lines from the generating station to the shaft or mine entrance are overhead, there shall be lightning arresters in connection therewith.

Cables

26. All conductors inside the mine, except as hereinafter provided, shall be continuously covered with insulating material, and guarantees shall be obtained from the makers that the cables have been subjected to the following tests:

(*a*) A continuously insulated cable must be so constructed that when a test piece of it has been immersed in water for twenty-four hours it will while still immersed, in the case of cables intended for low or medium pressures, withstand 2,000 volts for ten minutes between the conductor and the water and between cores if there are more than one in the cable.

(*b*) If the cable is intended for high or extra high pressure, twice the working pressure shall be taken for this test.

(*c*) Prior to the immersion the test piece must have been bent six times (three times in one direction and three times in the opposite direction) round a cylindrical surface not more than twelve times the diameter (or the shorter axis, in case the section is not circular) of the finished cable.

27. The size of the conductor except in the case of overhead wires upon the surface and leads inside motors) will be determined in accordance with the table showing maximum current for copper conductors appended to these rules, column 3 of which refers to cables having insulation of Class A, and column 4 to cables having insulation of Class B, according to the following definitions:

(A) A dielectric which is impervious to moisture and only needs mechanical protection ("dielectric" does not include the braiding or taping).

(B) A dielectric which to be effective must be kept perfectly dry, and therefore needs to be encased in a waterproof sheath, generally of soft metal, such as lead, drawn closely over the dielectric.

Below ground, however, column 4 may be applied to cables having insulation of Class A in cases where the atmospheric temperature never exceeds 100° F.

For the purpose of applying the table the current in the conductor must be taken as equal to that required for the maximum number of motors or other current-using apparatus that are at any time used simultaneously on the circuit. Provided that in the case of coal-cutters not in a long-wall working 20 per cent shall be deducted from the normal working current. This rule does not apply to trailing cables.

28. All conductors except as hereinafter provided) shall in every case be maintained completely insulated from earth; but it is permissible to use the concentric system with earthed outer conductor, if proper arrangements are made to reduce the danger from fire or shock to the minimum, and the neutral point of polyphase systems and the middle wire of three-wire continuous-current systems may be earthed at one point.

29. Unless fixed out of reach of injury, all conductors, other than armored cables, must, in addition to the insulation, be protected by a suitable covering. Where lead-covered cable is used, the lead shall be earthed, and shall be electrically continuous throughout.

The exposed ends of cables, where they enter the terminals of switches, fuses, and other appliances, shall be properly protected and finished off, so that moisture cannot creep along the insulating material within the waterproof sheath, or the insulating material, if of an oily nature, leak out of the cable.

30. All joints must be mechanically and electrically efficient, and, where reasonably practicable, must be suitably soldered. In any gassy place suitable joint boxes must be used, and the conductors shall be connected by means of metal screw clamps, or connectors; or some other equally safe construction must be adopted. Provided, however, that, in any gassy place where a shot may be fired, joints may be soldered by or in the presence of the person authorized in that behalf by the manager; but the same precautions in regard to examination and removal of workmen as are prescribed by paragraphs (*f*) and (*i*) of general rule 12 shall be observed in all such cases, and, where the place is dry and dusty, the precautions as to watering prescribed by paragraph (*h*) shall also be observed. Wires, other than blasting wires of cables, must not be joined by merely twisting them together.

This rule does not apply to trailing cables.

31. Overhead bare wires on the surface shall be properly secured to insulators, and clear of any traffic, and provided with efficient lightning arresters.

32. All cables used in shafts must be highly insulated and substantially fixed. Shaft cables not capable of sustaining their own weight shall be properly supported at intervals, varying according to the weight of the cable. Where the cables are not

completely boxed in and protected from falling material, space shall be left between them and the side of the shaft, that they may yield and thus lessen a blow given by falling material.

33. Where the cables in main haulage roads can not be kept at least 1 foot from any part of the tub or tram, they shall be specially protected. When separate cables are used, they shall be fixed on opposite sides of the road, unless it is safer to have them on the same side, in which case they shall be kept as far apart as possible.

Cables and wires, unless provided with metallic coverings, shall not be fixed to walls or timbers by means of metallic fastenings.

Cables underground, when suspended, shall be supported by leather or other flexible material in such a manner as to allow of their readily breaking away when struck, before the cables themselves can be seriously damaged.

Where main or other roads are being repaired, or blasting is being carried out, suitable temporary protection must be used, so that the cables are reasonably protected from damage.

34. Trailing cables for portable machines shall be specially flexible, heavily insulated, and protected with extra stout braiding, hose pipes, or other equally effective covering. Bare metal armoring shall not be used upon any trailing cable carrying current at a pressure exceeding the limits of low pressure.

35. In any gassy place the joints, if any, made in trailing cables shall be soldered. Screw clamps of any kind must not be used for this purpose in any place in any mine.

36. The two cables of the twin trailing cable shall be divided at the motor end only for such a length as is necessary for the making of connection to the motor; and the twin cable with its outer covering complete shall be securely held by a suitable clamp on the motor frame in such manner as to protect the trailing cable from injury, and to prevent any mechanical strain being borne by the single ends making electrical connection with the motor.

37. At points where the flexible conductors are joined to the main cables, a fixed terminal box shall be provided; and a switch and fuses shall be fitted in the terminal box capable of entirely cutting off the supply from the trailing cable, unless the machine is operated on a circuit of its own, either from the power house or some substation, at which point it shall be permissible to place the fuse or circuit breaker.

38. A spare trailing cable shall be kept in each district of the mine where electric coal-cutting machines are in use; and, in the event of the trailing cable in service breaking down, or being damaged in any way, or of its inflicting a shock upon any person, it shall be at once put out of service, and the spare cable shall be substituted therefor. The faulty cable shall not again be used until after it has been repaired and tested, at the surface of the mine, and passed by some competent person.

39. Each trailing cable in use shall be examined daily by a competent person for abrasions and other defects; and the result of such examination shall be recorded daily in a book, kept at the mine for the purpose, and shall be signed by the person making such report.

The machine men shall also be required to carefully observe the trailing cable, while in use, so as to detect defects; and, in the event of any defect becoming apparent, notice of the same shall at once be sent to an official of the mine.

40. All horse traffic shall be suspended on the part of every road along which a trailing cable is extended for the purpose of flitting a machine.

Trailing cables shall at all times be kept clear of the rails and traffic, except when flitting.

41. Each trailing cable shall have a distinguishing number, which shall be clearly indicated on a suitable label securely attached to the cable.

Record of insulation; test of trailing cables

The insulation resistance of each conductor of every trailing cable shall be measured and recorded at least once per month; the resistance being taken between the conductor and the surrounding water after the whole cable, with the exception of the ends, has been immersed for at least six hours.

For this test the manager must supply an instrument suitable for measuring resistances up to at least 5 megohms.

The trailing cable must not be put into service unless the insulation resistance of each conductor measures at least one megohm after immersion.

Fuses, Circuit Breakers, and Switches

42. Fuses and automatic circuit breakers shall be so constructed as effectually to interrupt the current when a short circuit occurs, or when the current through them exceeds by 200 per cent the working current in the case of motors, or by 100 per cent the permissible current of the cables which the fuses protect. Fuses shall be stamped or marked, or shall have a label attached, indicating the current at which they are intended to fuse; or, where fuse wire is used, each coil in use shall be so stamped or labeled. Fuses shall only be adjusted or replaced by a competent person authorized by the manager.

43. All switches, circuit breakers, and fuses must have incombustible bases of marble, slate, or porcelain, or other suitable incombustible insulating material. All live parts of switches, circuit breakers, and fuses, not in machine rooms, or in compartments specially arranged for the purpose, must be covered. These covers must be of incombustible material, and must be either nonconducting or of rigid metal clear of all internal mechanism.

44. All points at which a circuit (other than those for signals) has to be made or broken shall be fitted with proper switches. The use of hooks or other makeshifts is prohibited; provided that, excepting gassy places, hooks may be used if the junctions are completely protected by rubber sleeves; and, in any gassy place, switches, circuit breakers, and fuses (except as provided in rule 50, hereafter) shall not be of the open type, but must either be inclosed in gas-tight boxes or break under oil.

Record of generator circuit breaker or generator fuse opening

45. Fuses shall not be replaced by anyone except the electrician, or some other competent person appointed by the manager. A record of each instance of a generator circuit breaker or generator fuse opening shall be made in a book kept in each generating station or room, and signed by the person making the record.

Motors

46. Every motor, together with its starting resistance, shall be protected by a fuse in accordance with rule 44, and by switches capable of entirely cutting off the pressure. The switches shall be fixed in a convenient position near the motor; and every motor of 10-brake horsepower or over in a machine room underground shall be provided with a suitable ammeter to indicate the load on the machine.

47. Where unarmored cables or wires pass through metal frames or into boxes or motor casings, the holes shall be substantially bushed with insulating collars, and, where necessary, with gas-tight bushings which can not readily become displaced.

48. Terminal boxes of portable motors shall be securely attached to the machine, or must form a part thereof.

49. Where the insulation of a motor is found to become damp during a stoppage, suitable steps shall be taken to ensure that the insulation shall be dry before the working of the motor is resumed, in order that its base may not become alive.

50. In any gassy place, all motors, unless placed in such rooms as are separately ventilated with intake air, or placed on the main intake air courses, shall have all their current-carrying parts, also their switches, starters, terminals, and connections, completely inclosed in flame-tight inclosures, made of incombustible material, and of sufficient strength to escape damage in the event of an explosion of fire damp occurring in the interior; and such inclosures shall not be opened except by an authorized person, and then only when the current is switched off, except for the purpose of adjusting brushes, which may be done subject to the same conditions and precautions as are laid down under rule 30, in the case of soldering. The pressure shall not be switched on while the inclosures are open.

51. In any gassy place, a safety lamp, or other suitable apparatus for the detection of fire damp, shall be provided for the use of the attendant with each stationary machine, when working; and, should any indication of fire damp appear on the flame of the safety lamp, or other apparatus used for the detection of fire damp, the person in charge shall immediately stop the machine, cut off the current at the nearest switch, and report the matter to an official of the mine.

Report of examination for gas

52. In any gassy place, and where coal-cutting machines are flitted by electric power, or the machine men are paid at tonnage rates, a competent person shall make, at least once in the course of each shift, an examination for gas in each place in which an electric coal-cutter is, or is to be, employed during that shift. A report of every such examination shall be made in a book kept at the mine for the purpose, and shall be signed by the person making such examination.

53. The machine man in charge for the time being of a coal-cutting machine must be a competent person, capable of examining the roof and sides and detecting the presence of inflammable gas.

54. In any gassy place, before a coal-cutting machine is brought within 20 yards of the working face, the machine man who is about to operate the starting switch of the machine shall make an inspection for gas in the place where the machine is to work, unless such an examination is then made by some other competent person authorized or appointed for that purpose by the manager. If any inflammable gas is found in the place, the machine shall not enter therein.

No coal-cutting machine shall be continued in operation for a longer period than half an hour without such an examination as above described being made for gas; and if gas is found when the machine is present the current shall at once be switched off the machine, and the trailing cable shall forthwith be disconnected at the junction box.

The person finding the gas shall at once erect a danger fence to warn persons against entering the place.

The trailing cable shall not be reconnected until the deputy has examined such place and has pronounced it free from gas and has removed the danger board.

The person finding gas shall forthwith report the same to the deputy of the district, who at the end of the shift shall make and sign a written report in a book kept at the mine for the purpose.

55. In order that the roof may be carefully examined, a coal-cutter motor shall not be kept continuously at work for a length of time exceeding a maximum period which shall be specified in writing by the manager.

56. The person in charge of a coal-cutter or drilling machine shall not leave the machine while it is working, and shall, before leaving the working place, see that the pressure is cut off from the trailing cables. Special care must be taken to prevent injury to the trailing cables during flitting and during the process of loading the machine on to or unloading it from the power truck. No repairs shall be made to any portable machine until the pressure has been cut off from the trailing cables.

57. If any electric sparking or arc be produced outside a coal-cutting or other portable motor or about the cables or rails, the machine shall be stopped, and shall not be worked again until the defect is repaired; and the occurrence shall be at once reported to an official of the mine.

Weekly report of examination of all portable motors underground

58. The casing or inspection doors of all portable motors used underground, and the casings of their switches and other appliances, shall at least once a week be opened by a competent person appointed by the manager; and the parts so disclosed shall be cleaned and examined before the coverings are replaced. In special cases requiring a motor to run continuously longer than one week, the motor shall be examined at the end of the run. A report of all such examinations shall be entered in a report book, and signed by the person who made the examination.

Electric Locomotives

59. Electric haulage by locomotives on the trolley-wire system shall not be allowed in any gassy place.

60. In underground roads the trolley wires, unless sufficiently guarded, must be placed so that they are throughout at least 7 feet above the level of the road or track, or the pressure must be cut off from the wires at all times when such roads are used for traveling on foot. The hours during which traveling on foot therein is permitted shall be clearly indicated by notices and signals placed in conspicuous positions at the ends of, and at all entrances into, the roads. At other times no one except a person duly authorized by the manager shall be permitted to travel on foot along such roads.

61. Under the conditions indicated in the foregoing rule, trolley wires may be used with current at a pressure not exceeding low pressure; but a pressure not exceeding medium pressure may be used on roads on which traveling on foot is not at any time permitted, except in the case of drivers of locomotives or of persons duly authorized by the management to travel only for purposes of inspection and to effect repairs.

62. In connection with the use of electric locomotives, either insulated returns or uninsulated metallic returns of low resistance may be employed.

63. In order to prevent the earthing of any other electric circuit in the mine, by connection with the trolley system, the current supplied for use on the latter, when the return is uninsulated, shall (except when low pressure is employed or the concentric system with earthed outer conductor is used) be generated by a separate machine, and shall not be taken from, or be in connection with, any electric line otherwise completely insulated from earth.

64. If storage-battery locomotives are employed in any gassy place, the rules applying to motors in such places shall also be deemed to apply to the boxes containing the cells.

Electric Lighting

65. Arc lamps shall be so guarded as to prevent pieces of heated carbon falling from them, and shall not be used in situations where there is likely to be danger from the presence of coal dust. They shall be so screened as to prevent risk of contact with persons.

66. Small wires for lighting circuits shall either be conveyed in pipes or casings; or they may be suspended from porcelain insulators, or tied to them with some nonconducting material which will not cut the covering, and so that they do not touch any timbering or metal work. On no account shall staples be used. If metallic pipes are used, they must be electrically continuous and earthed. If separate uncased wires are used, they shall be kept at least 2 inches apart, and not brought together except at lamps or switches or fittings.

67. In any gassy place, electric lamps, if installed, must be of the vacuum or inclosed type, and, except on the main intake air ways and mechanical haulage roads, being also on the out-bye side of relighting stations, they shall be protected by gas-tight fittings of strong glass, and shall have no flexible cord connections. Electric lamps shall be replaced by a duly authorized competent person only; and, while the lamps are being replaced, the current shall be switched off.

68. In all machine rooms and other places underground, where a failure of electric light is likely to cause danger, some safety lamps or other proper lights shall be kept for use in the event of such failure.

Shot Firing

69. Electricity from lighting or power cables shall not be used for firing shots.

70. When shot-firing cables or wires are used in the vicinity of power or lighting cables, sufficient precautions shall be taken to prevent the shot-firing cables or wires from coming in contact with the lighting or power cables.

71. Only competent persons who have been properly instructed in the work, and duly authorized by the manager in writing, shall be allowed to fire shots electrically in any part of a mine.

72. The exploder, fuses, and wires shall be suitable for the conditions under which the blasting is carried out.

73. High-tension magneto-generators shall be inclosed in flame-tight cases when employed in any gassy place.

74. The exploder shall be in the charge of the shot firer, and shall be fitted with a handle or key; which shall be detached when not required for firing, and shall not under any conditions pass from the personal custody of the shot firer whilst on duty. A primary or secondary battery shall not be used for shot firing.

75. The exploder shall not be connected to the shot-firing cable until all other steps preparatory to the firing of the shot have been completed and all persons have removed to a position of safety.

Immediately after the firing of the shot the firing cable shall be disconnected from the exploder; and no person shall approach a shot which has been attempted to be fired by electricity, and has failed to explode, until the firing cable has been so disconnected and an interval of five minutes has elapsed since the last attempt to fire the shot.

The foregoing rules shall not apply to apparatus used for telephone, telegraph, and signal purposes, which are provided for by the three following rules:

Signaling, Etc.

76. All proper precautions must be taken to prevent electric signal and telephone wires from coming into contact with other electric conductors, whether insulated or not.

77. Bells, wires, insulators, contact makers, and other apparatus used in connection with electric signals underground shall be of a substantial and reliable description, and shall be erected in such a manner as to reduce the liability to failures or false signals to the minimum.

78. In any gassy place the pressure employed for signaling purposes shall not in any one circuit exceed 15 volts in an intake air way or 10 volts elsewhere, and bare wire shall not be used for such purposes except in haulage roads.

Electric Relighting of Safety Lamps

79. If in any gassy place safety lamps are relighted underground by electricity, the manager shall select a suitable station or stations, not being in the return air way, and where there is not likely to be any accumulation of inflammable gas; and no electric relighting apparatus shall be used in any other place. All electrical relighting apparatus shall be securely locked, and shall not be available for use except by persons authorized by the manager to relight safety lamps; and such persons shall examine all safety lamps, brought for relighting, before they are reissued.

EXEMPTIONS AND MISCELLANEOUS

80. Notwithstanding anything contained in these rules, any electrical plant or apparatus installed or in use or contracted to be bought before May 26, 1908, before the coming into force of these rules, may be continued in use or used unless an inspector shall otherwise direct, or subject to any conditions affecting safety that he may prescribe; but an inspector shall not object to the use (if sufficiently earthed) of any bare-armored cables in use or owned or contracted to be bought by any mine on May 26, 1908, on the ground merely of their being bare-armored cables.

In case any difference of opinion shall arise between an inspector and owner, agent, or manager of the mine under this rule, the same shall be settled as provided in section 25 of the coal mines regulation act, 1902.

81. Exemption from any of the foregoing requirements may be granted by the minister, on the ground either of emergency or special circumstances, on such conditions and to such extent as the minister shall prescribe. Such exemption must be in writing, signed by the minister or the under secretary for mines.

Table Showing Maximum Current for Copper Conductors

I	II	III	IV	I	II	III	IV
Number of wires and gauge in S. W. G. or inches	Nominal size of conductors in square inches	Maximum amperes for conductors with Class A insulation	Maximum amperes for conductors with Class B insulation	Number of wires and gauge in S. W. G. or inches	Nominal size of conductors in square inches	Maximum amperes for conductors with Class A insulation	Maximum amperes for conductors with Class B insulation
Gauge	Section	Amperes	Amperes	Gauge	Section	Amperes	Amperes
1/18	.001810	3.2	4.2	37/.072″	.15	96.0	158.0
3/22	.001825	3.3	4.3	19/12	.1595	102.0	166.0
1/17	.002463	4.0	5.4	37/14	.1838	114.0	187.0
3/20	.003016	4.7	6.4	37/.082″	.2	121.0	200.0
1/16	.003217	4.9	6.8	61/15	.2455	142.0	237.0
1/15	.004072	5.9	8.2	37/.092″	.25	145.0	241.0
7/22	.004266	6.2	8.5	37/.101″	.3	166.0	279.0
1/14	.005027	7.0	9.8	61/14	.3029	168.0	282.0
3/18	.005364	7.3	10.3	37/12	.3105	170.0	287.0
7/20	.007052	9.0	13.0	37/.110″	.35	187.0	317.0
7/18	.01254	14.0	21.0	37/.118″	.4	208.0	354.0
19/20	.01912	20.0	29.0	61/.092″	.4	208.0	354.0
7/16	.02227	22.0	33.0	61/.101″	.5	248.0	425.0
19/18	.03399	31.0	47.0	61/12	.5120	252.0	433.0
7/14	.03483	31.0	48.0	61/.110″	.6	282.0	493.0
7/.095	.05	42.0	64.0	91/.092″	.6	282.0	493.0
19/.058″	.05	42.0	64.0	91/.098″	.7	320.0	560.0
19/16	.06039	48.0	75.0	91/.101″	.75	340.0	592.0
19/14	.09442	68.0	108.0	91/.104″	.8	352.0	624.0
19/.082″	.1	71.0	113.0	91/.110″	.9	390.0	688.0
37/16	.1176	81.0	130.0	91/11	.9504	406.0	719.0
19/.092″	.125	84.0	136.0	91/.118″	1.0	424.0	750.0
19/.101″	.15	96.0	158.0	127/.101″	1.0	424.0	750.0

I hereby certify that the above copy of Electrical Special Rules has been shown to my satisfaction to be a true copy of the Electrical Special Rules which are established under the Coal Mines Regulation Act, 1902, for.....Colliery.

.....

Inspector of Collieries.

Date....., 190 .

ACT NO. 33, 1908.

An act to amend the coal mines regulation act, 1902; and for other purposes. [Assented to 24th December, 1908.]

Be it enacted by the King's Most Excellent Majesty, by and with the advice and consent of the legislative council and legislative assembly of New South Wales in Parliament assembled, and by the authority of the same, as follows:

Short title.

1. This act may be cited as the "coal mines regulation (amending) act, 1908," and shall be construed with the coal mines regulation act, 1902, herein referred to as the principal act.

Appointment of electrical inspector.

2. The governor may appoint any person with or without a certificate of competency or service under the principal act as electrical inspector, and such person shall, in relation to the installation and use of electricity, have all the powers vested in an inspector by section nineteen of such act. Except in the case of the electrical engineer of the department of public works or of the holder of a degree in electrical engineering from the University of Sydney, or a person holding a qualification from any other educational body recognized by the department of mines, every person to be so appointed inspector shall be the holder of a certificate of competency as a mine electrician under the provisions of this act.

Penalty upon unqualified person being employed as mine electrician.

3. Any person who, after the twenty-ninth day of May, one thousand nine hundred and nine—

(*a*) not being registered under this act as the holder of a certificate of competency as a mine electrician, or possessing one of the other qualifications mentioned in section two, acts as mine electrician in or about a mine where the output of the generating plant exceeds thirty kilowatts; or

(*b*) knowing that such person is not so registered, employs him as a mine electrician in or about such a mine, shall be guilty of an offense against the principal act.

Certificates of competency as mine electricians.

For the purpose of ascertaining the persons who may be granted certificates of competency as mine electricians examiners shall be appointed by the board for appointing examiners constituted under the principal act, who may hold examinations and examine applicants for such certificates in such subjects as may be prescribed by any rules made by the minister in that behalf.

For all other purposes relating to the examination of applicants and the granting, cancellation, and suspension of such certificates, and the registration of the holders of such certificates, the provisions of the principal act relating to managers' certificates of competency shall, mutatis mutandis, apply and have effect.

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