DYNAMO TENDERS' HAND-BOOK.

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DYNAMO TENDERS' HAND-BOOK,

WITH SEVENTY ILLUSTRATIONS.

BY

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PREFACE TO THE FIRST EDITION.

EACH company manufacturing electric light apparatus furnishes special directions for its care and management, and hence a general knowledge of the principles governing the construction and operation of electric light installations has been obtainable only by a practical observation of the features of each system or by study of books so technical in character as to be beyond the comprehension of those not possessing an academical or collegiate education.

Therefore, in the preparation of DYNAMO TENDERS' HAND-BOOK, the author has striven to lay down, as the results of an extended experience, general rules for the care and operation of electric light installations and discarding entirely the use of technical phraseology and scientific terms and formulæ, has endeavored to confine his use of words to those very plain, simple and elementary in character.

To dynamo tenders, engineers, linemen and others who wish to familiarize themselves with the principles underlying the care and operation of electric light installations, this hand-book is offered with the hope that the author's intentions have been carried out to the full.

To those who wish to pursue the study of the principles of electric lighting into deeper channels, the author cordially recommends "Elementary Lessons in Electricity and Magnetism," by Silvanus P. Thompson; "Electric Light Arithmetic," by R. E. Day; "Magneto Electric and Dynamo Electric Machines," by Dr. H. Schellen; Munro & Jamieson's "Pocket-Book of Electrical Rules and Tables."

PREFACE TO THE SECOND EDITION.

THE great demand for the DYNAMO TENDERS' HAND-BOOK has compelled the author to prepare a second edition. He has corrected several errors of the first edition, and added the new Rules and Regulations for Overhead Conductors for Electric Light and Power established by the Board of Electrical Control of New York, and attached the Lamp Lighting schedule for 1889.

F. B. BADT.

Chicago, Ill., December, 1888.

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ELEMENTARY DATA.

CHAPTER I.

The Electric Current.

In order to understand the action of what is called the electric current, we will consider two reservoirs of water connected by a pipe, Fig. 1. The electric current may be likened to the flow of water through this pipe from the higher to the lower level.

The unit of current strength, also called the rate of flow, or intensity, is the ampere. In the illustration we would

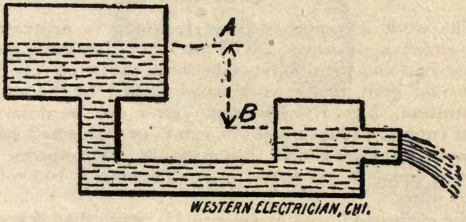

FIG. 1. — RESERVOIRS OF WATER.

say the water is flowing through the pipe at the rate of one gallon per second. In speaking of the electric current we would say it has a strength of, say, one ampere.

The unit of electromotive force, also called electrical pressure, or tension, or difference of potential, is the volt. In the illustration the head of water, or the difference between the levels *A* and *B* is similar to the electromotive force.

The unit of resistance is the ohm. Resistance may be compared with the friction of the internal surface of the pipe offered to the water. It follows that the more cross-section the less friction, and the less cross-section the more friction, for the same volume of water flowing through the pipe in a given time.

In the following, only the terms, current strength, electromotive force—frequently written e.m.f.—and resistance, will be used.

CHAPTER II.

Ohm's Law.

Ohm's law expresses the relation of current strength, electromotive force, and resistance, to each other. It says: Current strength equals electromotive force divided by resistance. We can write this $C = \frac{E}{R}$, C standing for current strength, E for electromotive force, and R for resistance.

CHAPTER III.

Work.

The work accomplished by electricity is expressed in volt-amperes or watts. The product of so many gallons per second and the difference between the two levels *B* and *A*, would give us the work accomplished by the water in illustration, Fig. 1. The same work can be done with great current strength and low e.m.f., or with small current strength and high e.m.f. For instance, 100 amperes × 10 volts = equals 1,000 watts; or, 10 amperes × 100 volts = 1,000 watts.

One electrical horse power equals 746 watts; hence the electrical work of a dynamo may be expressed:

$H.\ P. = \frac{\text{amperes} \times \text{volts}}{746.}$. The number of mechanical horse power necessary to drive a dynamo is generally 10 to 20 per cent. higher than the electrical horse power yielded by the dynamo.

CHAPTER IV.

Conductors and Insulators.

Bodies in which the current moves freely are called conductors, and those in which it does not move freely are called insulators. Examples of conductors: Metals, solutions of chemical salts, moist earth, etc. Examples of insulators: Porcelain, rubber, gutta percha, sealing wax, dry wood, etc.

CHAPTER V.

Direction of the Current.

For convenience sake we assume that the electric current flows from the positive pole of a galvanic cell or any other generator of electricity, through the external circuit back to the negative pole. In order to find the direction in which the current is passing through the wire, we place a pocket compass, Fig. 2, *under* the wire, Fig. 3. The north-seeking pole of the needle, called the north pole, and dis-

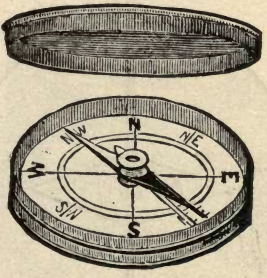

FIG. 2. — POCKET COMPASS.

tinguished either by a different color—blue, for instance—or by a little brass rivet, will be deflected to t e *left* when the current flows in the direction of the arrow, Fig. 3. Or, in other words, the positive electricity enters at *A* and leaves at *B*.

When the compass is held *above* the wire the north pole of the needle will be deflected to the *right*.

General rule: Think yourself swimming in the current always facing the needle. The positive current entering at your feet will cause the needle to deflect to your left.

Another general rule: Think of the word Snow. With the wire over the compass the current flowing from the South to the North will deflect the needle to the West; in other words, from S-outh to N-orth O-ver W-est.

The compass should be tested before these trials are made, as the polarity may have been reversed by the proximity of dynamo electric machines or other powerful magnets.

The binding post of the dynamo electric machine or battery from which the current starts is called the positive and is marked +; the opposite binding post is called the negative and is marked —. All indicators, lamps and other apparatus which are connected in the electric circuit must be

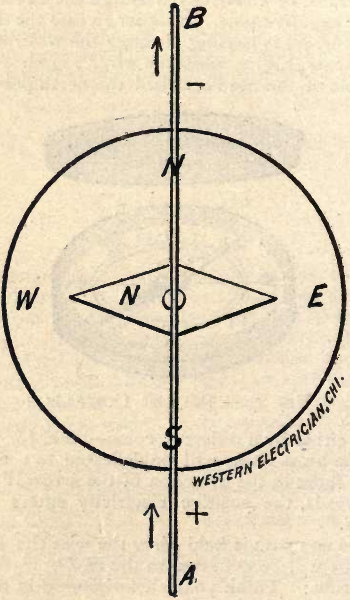

FIG. 3.—COMPASS UNDER THE WIRE.

marked accordingly; the binding post which should be connected with the positive binding post of the dynamo with + and the other with —. There are quite a number of instruments and electrical apparatuses, such as incandescent lamps, for instance, which may be inserted in the circuit either way. These, of course, need not be marked at all.

CHAPTER VI.

Detector Galvanometer and Magneto Bell.

The detector galvanometer, Fig. 4, in connection with the galvanic cell, Fig. 5, is used for testing the insulation of the wires and apparatus and for locating other faults. The detector galvanometer is a compass mounted on a coil of wire. An electric current passing through this coil will deflect the needle of the compass, as has been explained in Chapter V. Of course, a coil will cause a greater deflection of the needle than a single wire as the current is forced to pass a number of times under the needle.

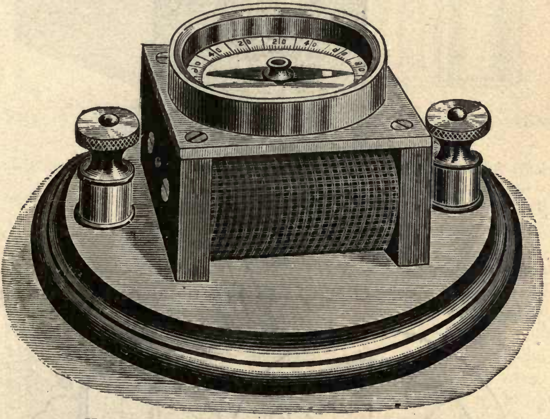

FIG. 4. — DETECTOR GALVANOMETER.

In order to test for insulation with the galvanometer, connect the galvanometer and the galvanic cell in series, that is, tandem—one behind the other, Fig. 6—and connect one wire starting from binding post *A* to a ground—gas pipe or water pipe — and the other starting from *B* to the wire to be tested for insulation. If the needle deflects, the wire is grounded; if it remains in its position the insulation is in good condition. It is well to connect wires *A* and *B* for a minute before testing, and see whether cell and galvanometer are in good condition. In connecting the wires the insulation must be carefully removed and the wire perfectly cleaned by scraping with a knife or by rubbing with a piece of emery cloth. Connections must always be made with clean metallic surfaces. In the same way a break in the circuit can be found. Cut the circuit in several sections and connect the ends of

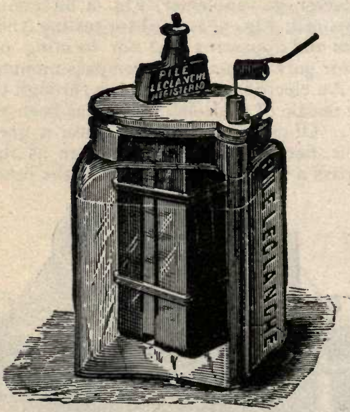

FIG. 5. — GALVANIC CELL.

each section to *A* and *B*. When the needle deflects, there is no break in the circuit; if it does not deflect, the circuit is open.

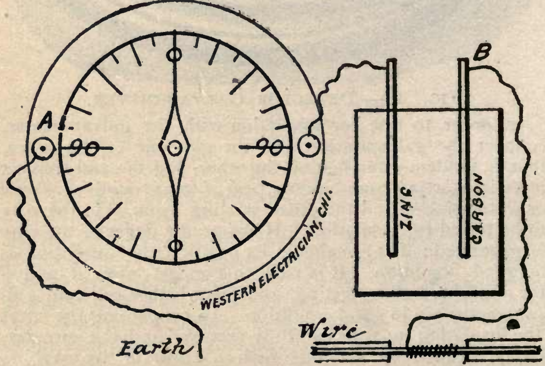

FIG. 6.— GALVANOMETER AND CELL CONNECTED.

Fig. 7 shows one form of portable galvanometer, combining galvanometer, battery and wire.

Very often a magneto bell, Fig. 8, similar to that used as a call for telephones, is employed for testing. When the bell rings the circuit is closed; if it does not ring the circuit is open. This is all it can tell, while the detector galvanometer, if properly handled, can tell very much more. A detector galvanometer can be carried in the pocket and rarely gets out of order, and a galvanic cell can be had almost anywhere. A magneto bell is a bulky apparatus and liable to get out of order at any time. The use of the galvanometer is preferable.

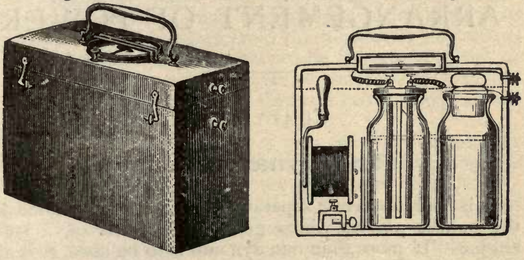

FIG. 7. — PORTABLE GALVANOMETER, BATTERY AND WIRE.

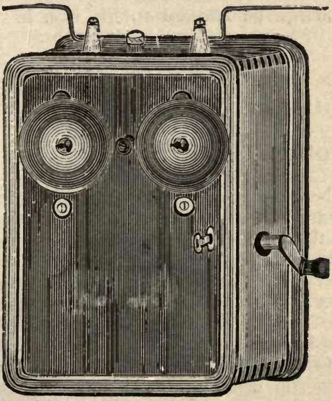

FIG. 8. — MAGNETO BELL.

A test with a cell and an ordinary electric bell cannot be considered reliable. Such a bell will ring only through a very low resistance, while a good magneto bell will ring through from 10,000 to 20,000 ohms resistance and a high resistance galvanometer with a powerful battery will deflect through millions of ohms of resistance.

ARRANGEMENT OF POWER.

CHAPTER VII.

The Dynamo Room.

It is best to have a separate room for the dynamo and the motive power, which generally consists of a steam engine. If more than one dynamo is to be used, it is also preferable to have them all in one room, as one man can more readily attend to them. The place where the dynamo is to be located should be dry and free from dust. A turning lathe should not be allowed near a dynamo, nor should the man in charge be allowed to file iron in its proximity.

CHAPTER VIII.

Motive Power.

The main thing to be considered in selecting an engine for an electric light plant is uniform speed. Any fluctuation in the speed of the engine will show in the lights. Incandescent lights are more sensitive in this respect than arc lights. It is preferable to have an extra engine for the electric light machinery. If other machinery is connected with the engine, the sudden throwing on and off of machines will cause an irregular speed of the dynamo and very disagreeable fluctuations in the lights. The best power so far known to run electric light machinery is the modern automatic cut-off steam engine. The regulation of water motors, turbine wheels, etc., and gas motors, is generally not very satisfactory for electric light plants.

A good instrument for indicating the speed of a shaft or a dynamo at all times is the tachometer. It will show variations even within a small fraction of a minute.

CHAPTER IX.

Shafting and Pulleys.

The number of shafts should be reduced to a minimum. It is very convenient to use friction pulleys, if more than one dynamo is to be driven from the same shaft ; by means of friction pulleys any dynamo can be thrown in or out at will. In calculating the diameter of the pulleys, it should be borne in mind that there is always a loss in speed caused by the slippage of the belt.

It is safe to allow about 2 per cent. for slippage for each belt. It is advisable to have the distance between the driving shaft and the shaft of the dynamo not too short.

A long belt will generally give better results than a short belt. The bearings will keep cooler, less oil will be used, and even with comparatively slack belts there will be little slippage.

On the other hand, short belts must be drawn very tight to prevent slippage. The boxes will heat, oil will be consumed faster, and the belts will be short lived.

Vertical belts must not be allowed ; horizontal belts give the best results. Arrange the shafting to get the belts at an angle of at least 40 degrees with a vertical line.

If possible arrange to have the slack side of belt on top.

CHAPTER X.

Foundations for Dynamos.

A dynamo should be solidly set. Vibration caused by the rotation of the armature on a poor foundation may cause damages to dynamos in various ways. Especially larger dynamos, say from twenty-five horse power upwards, should be set on a solid brick or stone foundation.

The iron frame of a dynamo should be properly insulated from such foundations ; this is generally done by a dry wood base plate. The upper surface of this brick or stone foundation should be at least one foot above the floor; this will enable the engineer or dynamo tender to keep the machine free from dirt, and will facilitate the inspection of the bearings, the commutator, and other important parts.

In a place where the noise caused by dynamos and engines would be objectionable, it is of importance to keep the foundations away from the foundation walls of the building. The counter-shafts must be set on the floor, and the floor above the dynamo room should be deadened.

Most dynamos are provided with a frame and a belt-tightening apparatus, which can be set on the foundation without any further preparations.

CHAPTER XI.

Belts.

The best belt to drive dynamo electric machinery is a light, double, endless, and rivetless leather belt. A single belt may be used for small dynamos, say, under ten horse power. Belts should always be made endless. A laced joint will show a fluctuation in the light every time it passes over the dynamo pulley.

It is advisable to run a new dynamo a day or two with a loose belt. In taking the measurement for a belt, the dynamo should be moved by means of the belt-tightener as near the driving pulley as possible; when this is done, it will be possible to utilize the whole length of the belt-tightener screw to stretch the belt. A belt should never be tightened any more than enough to prevent an excess of slippage. Any belt will slip a little, but this slippage should not exceed 2 per cent.

DYNAMO ELECTRIC MACHINES.

CHAPTER XII.

Description of the Dynamo.

A dynamo consists of the field and the armature. The field consists of the magnets, which are solidly connected with the iron frame. The magnets are iron cores, on which layers of insulated wire are wound. These magnets belong to the class of electro-magnets, as they become magnetic only when the current is passing through their coils. Between the poles of the magnet the armature rotates. The armature consists of an iron or steel shaft, to which a number of coils of insulated wire are affixed.

Metal plates or bundles of wire called brushes conduct the current generated in the armature to the lamp circuit.

The two main types of dynamos are:

A, *The continuous current dynamo.* The current generated in this dynamo always flows in the same direction. The armature of this dynamo has a commutator from which the current is taken off by the brushes.

B, *The alternating current dynamo.* The current generated in this machine flows at rapid intervals first in one and then in the other direction. This dynamo has no commutator but simply a collector consisting of two metal rings on which the brushes rest. The magnets of the alternating current machine require, however, a continuous current for excitation. This current is generated by an extra continuous current machine of small size, which is called the exciter.

CHAPTER XIII.

The Continuous Current Dynamo.

A, *The series dynamo*, Fig. 9. Magnet, armature and lamp circuit are connected one behind the other, that is, in series; that is to say, the current generated in the armature passes in equal strength through field magnets and lamp circuit. These machines are mostly used for arc lighting.

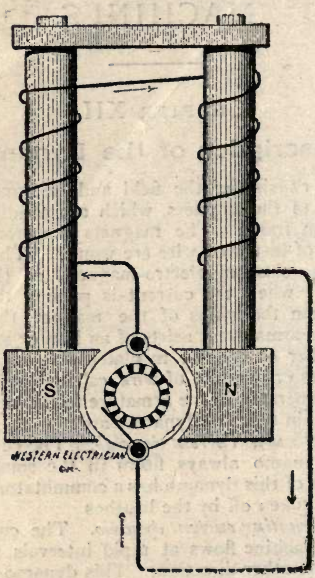

FIG. 9. — THE SERIES DYNAMO.

B, The shunt dynamo, also called derived circuit dynamo. The coils of wire wound around the field magnets in this machine, Fig. 10, are connected in shunt or parallel to the brushes. Only a comparatively small part of the current generated in the armature is used for excitation of the field coils, while the greater part of the current is conducted from the brushes to the lamp circuit. These machines generally have a resistance box, rheostat or regulator which is connected in the shunt winding of the field. By putting more or less resistance in the field of these machines the e. m. f. at the binding post of the machine can be decreased or increased. Shunt dynamos are mostly used for incandescent lighting. In some systems, however, they are used for arc lighting also.

C, The Compound Dynamo. This dynamo, Fig. 11, combines in its fields the winding of both the series and the shunt dynamo. The magnets are wound with thick

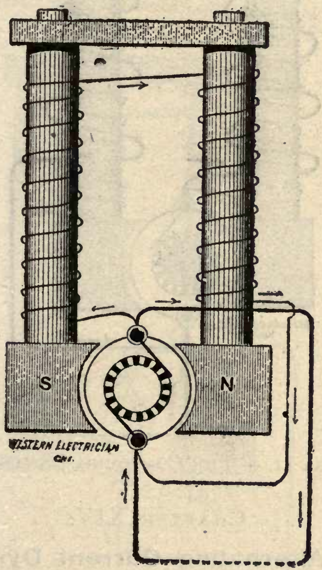

FIG. 10.— THE SHUNT DYNAMO.

wire, which is in series with the armature and the lamp circuit. In addition they have a winding of fine wire, which is in shunt with the brushes. This dynamo generally has a resistance box put in the shunt winding of the fields, for the same purpose as explained under *B*. Compound dynamos are mostly used for incandescent lighting.

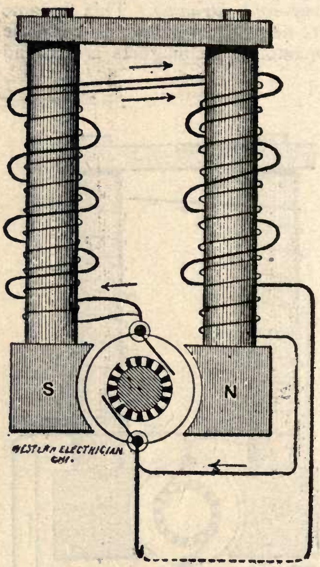

FIG. 11. — THE COMPOUND DYNAMO.

CHAPTER XIV.

The Alternating Current Dynamo.

The field wire coils of an alternating currrent dynamo, Fig. 12, have no connection with the brushes of the dynamo at all. The fields are separately excited, as mentioned in the foregoing, by a little continuous current dynamo, called an exciter The alternating current machines were used formerly for arc lighting mainly — very little, however, in the United States — but recently have been introduced for long distance incandescent lighting by means of transformers or converters.

Chapter XV.

Preparation of a New Dynamo for Operation.

Iron par's which have to be fitted to each other must be carefully cleaned with fine emery cloth. When the armature is put into the dynamo, extra precaution is necessary in order to avoid any injuries to the insulation of the wire and to the commutator. The armature should be carried by a man on each end of the shaft. Heavy armatures

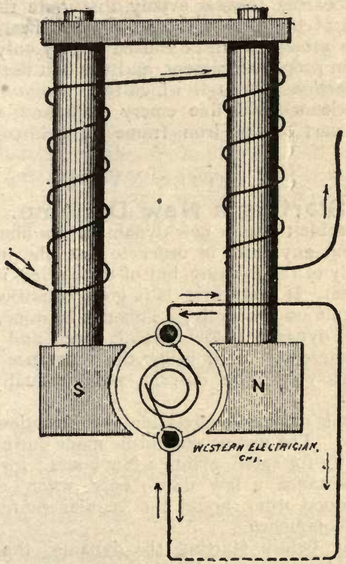

FIG. 12.—THE ALTERNATING CURRENT DYNAMO.

should be supported by a board put underneath the armature, and each end carried by an additional man. Armatures weighing over 500 pounds should be handled by means of a differential block and tackle.

An armature should not be lifted by its commutator.

Some soft material, such as cotton waste or felting, should be put between the armature and the support.

When put in place in the dynamo the armature must not touch the pole pieces and must turn easily. There should be at least from $\frac{1}{16}$ to $\frac{1}{8}$ inch play between its bearings. This play or lengthways motion can generally be regulated by adjusting the collar on the shaft.

It must be borne in mind that the armature will warm and expand not only diametrically but also lengthways. If there should be no play, the armature might get wedged between its two bearings and cause hot boxes and stoppage of the dynamo. A swinging motion of the armature will cause the bearing to wear evenly, distribute the oil from end to end of the bearings, and prevent heating of the boxes. An armature can be caused to play only when the dynamo is in proper alignment and the belt not too tight.

All connections through which the current has to pass should be cleaned with fine emery cloth and should not touch any part of the iron frame or field-coils of the dynamo.

CHAPTER XVI.

Starting a New Dynamo.

It is advisable to run a new dynamo a few hours or even a day without any load, in order to test the lubrication, etc., not only of the dynamo, but of the engine, if it should be a new one. If everything is in good condition the load should be put on gradually. This can be done, either by running the dynamo below normal speed and gradually increasing the speed, or by using the resistance boxes and starting with very little current and gradually increasing it.

The latter is especially advisable for incandescent lamp installations. The testing should be made during the day. It will require for small plants a few hours ; for plants of greater importance a few days ; only when everything operates in good order should the regular running of the installation commence.

Every day before starting the dynamo, the dynamo tender should examine the binding posts, commutator and brushes. If the brushes are allowed to rest against the commutator, the engineer should be careful not to reverse the motion of his engine when starting, as he would spoil the brushes.

Iron nails, bolts and small iron tools should be kept away from the dynamo, as they may be attracted to the machine and damage it.

Oil cans for filling the oil cups of the dynamo should be of non-magnetic material (brass or zinc).

Chapter XVII.

Keeping a Dynamo in Good Order.

The dynamo must be kept scrupulously clean, like any other expensive machine. Any good engineer or dynamo tender will do that without being told.

Copper dust, which will be caused by the friction of the copper brushes against the commutator, should never show; it should be cleaned off the armature and fields by means of a paint brush and a pair of bellows every day. Shafts and pulleys running near the dynamo must be prevented, by means of shields, from throwing oil on the dynamo, especially on the commutator.

A brush should never be lifted off the commutator while the dynamo is running.

Binding posts and other contacts should always be tight. A slight vibration of the dynamo, which will occur even when it is properly set, will loosen these connections in time. Every binding screw should be examined, and, if necessary, tightened every day.

Chapter XVIII.

Brushes.

The setting of the brushes is one of the most important duties of the dynamo tender. The brushes should rest against the commutator with a slight pressure. They should not be rigid, but the brush holder springs should allow a certain amount of spring; this will prevent excessive sparking of the brushes, even if the commutator should be a little uneven.

The contact points for the brushes on the commutator are in most dynamos diametrically opposite each other. In order to find these points quickly it is advisable to cut a little strip of tin, the length of which is just one-half the circumference of the commutator, and use this strip as a gauge when setting the brushes. The brush holders should be carefully kept clean, and should be wiped off every time before the brushes are put in. The brushes must extend from each brush holder at equal lengths. The insulation between the brush holder pins and the quadrant must be in good condition; oil and dirt must be kept out.

Fig. 13 shows the proper positions of the brushes. The point where the brushes are resting on the commutator when the greatest e.m.f. is obtained are called the neutral points, *A*, *B*. When the brushes touch the points *C*, *D*. at right angles to *A*, *B*, no current is obtained.

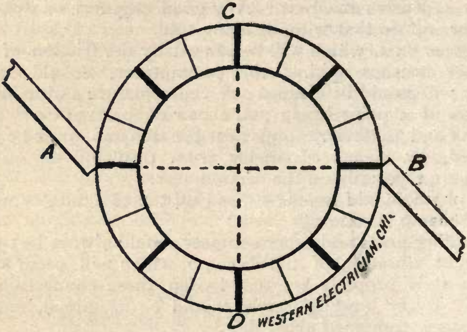

FIG. 13.—PROPER POSITION OF BRUSHES.

If the brush is nearly worn through to the middle of its thickness, it should be turned over and the other side used

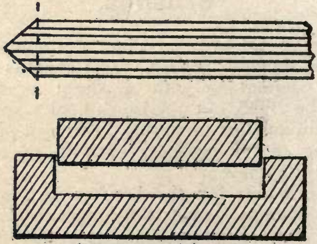

FIG. 14.—WORN BRUSH AND BLOCKS FOR TRIMMING.

on the commutator. When both sides are worn off, as shown in the upper part of Fig. 14, the brushes should be trimmed. In larger stations, little brush cutting machines are used for this purpose; in smaller installations, two blocks of hard wood, lower part of Fig. 14, are used. The brush is put between the two blocks and the whole put in a vise. The end of the brush projecting beyond the wooden blocks is then removed by means of a file.

The brushes should also be in such a position on the commutator that the least sparking will be set up. In some dynamos it is necessary to move the brushes in proportion to the load in order to get little sparking. In other systems, the brushes need not be moved at all, no matter how many lights are turned on or off. In some dynamos, the moving of the quadrant, or, in other words, the moving of the contact points of the brushes on the commutator, is used for increasing or decreasing the strength of the current.

CHAPTER XIX.

The Commutator.

The commutator is the most sensitive part of the dynamo, and should be especially cared for. It must always be kept smooth. If it should get rough from the electric spark, it is necessary to smooth it by pressing a block of wood covered with fine emery cloth against it, after having set the dynamo in motion with the brushes lifted off. If the commutator is so rough that a smooth surface cannot be obtained by the use of emery cloth, it should be filed. In order to do that, it is necessary to take out the brush holders, pins and brushes. After a straight surface has been obtained, the commutator should be smoothed with fine emery cloth.

The disadvantages of using a file on a commutator are the liability of pressing small chips of copper into the insulation between the copper segments, and the impossibility of getting the commutator true. The best way is to turn the commutator off by means of a little lathe, which can be attached to the dynamo, or by taking the armature out of the dynamo and having the commutator turned off in a lathe in a machine shop. This will not only make the commutator smooth but perfectly true. In filing or turning off the commutator while the armature is rotating in the dynamo, it is necessary to reduce the normal speed of the dynamo considerably, as too high a speed would spoil commutator and turning tools.

In new commutators for which fiber is used as insulation between the copper segments, it is very often found that the thin sheets of fiber have absorbed moisture, and extend above the surface of the commutator. If a few days' exposure in a dry warm room does not cause the fiber to shrink and go back to its place, the surface of the commutator must be smoothed first with coarse and then with fine emery cloth.

In most systems it is advisable to put a little oil on the commutator just after starting the dynamo. Very little oil, however, must be used. Dip the point of one finger in one drop of oil, distribute it by rubbing it on the inner surface of the hand and apply what oil remains on the finger tip to the commutator, and take it off with another finger. This will do for at least three hours' run.

If it should become necessary at any time to replace the commutator by a new one, it should be done in the following manner: Take the armature out of the dynamo and put the two ends of the shaft on two wooden horses. Mark the wires leading from the armature to the commutator by attaching little tags with numbers, to make sure of the proper place of each wire after taking off the commutator. Then disconnect these wires from the corresponding copper bars of the commutator, either by unscrewing the set screw, or in commutators which have solid connections, by unsoldering them by means of a hot soldering iron. Take the commutator off, clean the shaft and connections and put the new commutator carefully in its proper position and connect the wires in proper turn to the corresponding copper bars of the commutator by means of set screws, or soldering with hard solder. The greatest care must be observed not to short-circuit any parts of the commutator with drops of molten solder.

Chapter XX.

Repairs.

A, to the Armature.—In most cases repairs to the armature are necessitated by injuries to the insulation of the wire from external mechanical sources or by excessive heat generated in the armature. The first is very often caused by little particles of material dropping in the spaces between armature and pole pieces—for instance, little balls of cotton waste being caught from the end of the dynamo and pressed between armature and pole pieces, thus scaling off the insulation of the wires in some places, or bursting the metal bands. Such injuries can have two different results, either short circuiting some of the coils or bringing different parts of the wire coils in contact with the iron core. These injuries hardly ever extend below the first layer of wire. In most cases it will be possible to carefully lift one wire at a time just high enough to wrap it with silk tape, and thus insulate it. After having wrapped and insulated all the injured parts, drive the wires back into their position by means of a small hard wood block and hammer, and give them two or three good coatings of shellac varnish. If the injuries are below the first layer of the armature, it will be necessary in most cases to have it sent to the factory to be re-wound.

Excessive heat in the armature will very often char the insulation of one or more coils of wire entirely. These coils, of course, must be taken out and replaced with new wire. In most armatures of the so-called Gramme pattern this can be easily done. In armatures of the Siemens drum pattern it will necessitate a re-winding of the whole armature. The over-heating of one or more coils of an armature is very often caused by the short-circuiting of two or more segments of the commutator by means of copper dust which has been allowed to settle back of the commutator, or by excessive sparking of the brushes, forming little bridges of metal across to adjacent commutator segments.

B, to the Field Magnets.—The faults which mostly occur in field magnets consist in short-circuiting coils, or in getting parts of the field wire in contact with the iron core. The field wire should be unwound until the damaged part is reached, and after insulating it properly as described before, it should be wound back on the core. If it should be necessary to take a considerable amount of wire off the field in this way it will be advisable to put the damaged field magnet in a lathe and do the unwinding and re-winding by means of the lathe.

CHAPTER XXI.

Testing the Wire Coils of a Dynamo for Contact Against Iron.

The iron frame of each dynamo must be well insulated from the wire coils of the field, the armature and also from any connection with the earth. If one of these wire coils should get in contact with the iron frame of the dynamo and the latter should be in connection with the earth by means of foundation bolts, etc., it would cause what is called a ground. This ground must be considered the worst enemy of electric light apparatus, and should never be allowed to exist. We have shown how to test for grounds in Chapter VI. The same method can be applied in testing for contact between field wire coils or armature coils and the iron. During the test, any wires leading to the circuits or other apparatus should be disconnected from the dynamo in order to make sure that the fault really lies in the dynamo itself. Another fault sometimes found in the field of the armature is called a short circuit.

A short circuit is a shunt of little resistance between two points of a conductor. Suppose the points *A* and *B*, in Fig. 15, are set in some way in connection. It is clear that the main part of the current will pass through *A*, *B*, and but very little current will pass through the coil. If this should occur in the armature, the coil thus short-circuited in itself will generate currents of great strength, which will destroy the insulation of this coil in a very short time. Generally the dynamo tender will be warned by a smell of burnt cotton and shellac. If this fault should occur in a field magnet it would decrease its power, and thus cause the different magnets of the field to be of unequal strength. It may cause heating of the field in shunt and compound dynamos, while in series dynamos it will simply decrease the current strength generated by the dynamo. In order to test for a short circuit in an armature coil, or a field magnet, it is necessary to disconnect each field coil, or each armature coil, and measure by proper instruments the resistance of each coil. If any magnet coil shows a resistance below the others, it is short-circuited. The use of the necessary testing apparatus can not be described here, as it would go beyond the limits of this little book.

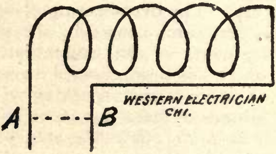

FIG. 15—A SHORT CIRCUIT.

The short circuits in field coils, however, can very often be found without the use of finer testing instruments, simply by the use of the detector galvanometer and the cell. By connecting each field coil in series with galvanometer and cell, and marking the deflection of the galvanometer, the coil which will show the greatest deflection is the one which is short-circuited. A short-circuited field magnet will heat less than a sound magnet when the dynamo is generating current. A break of the field wire can very easily be found by means of the galvanometer, as no deflection would be obtained at all through the broken coil. A break in a wire coil of the armature could only be found by disconnecting all wire coils from the commutator and from each other, and then testing each coil separately in the manner described. This, however, would involve considerable work and delay, and a quicker method may be employed: Set the dynamo in operation; then take a short piece of wire and touch the commutator with the two ends of this wire at a distance of three or four segments apart,

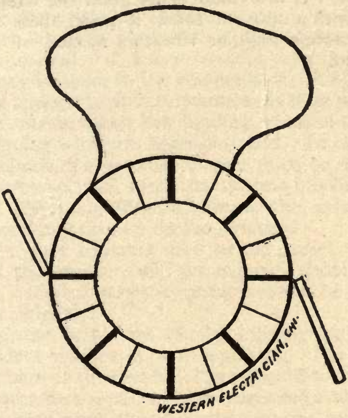

FIG. 16. — TESTING FOR A BREAK IN AN ARMATURE COIL.

Fig. 16. If the machine should commence to generate current, an electric arc will be formed on the commutator between the two ends of this wire, and indicate there is a break in the armature wire. The machine must be shut down quickly, as otherwise it would cause damage in the commutator and armature. The coil of the armature in which the fault lies can be easily recognized by the burns on the corresponding segments of the commutator. Faults of this kind are very often found in poor contacts between two coils, or between a coil and the corresponding copper

bar of the commutator. Poor contacts will cause more trouble than actual breakage of the wire. Such faults will often destroy certain commutator segments, caused by increased sparking of the brushes when passing these points. Hence, if only one or two commutator segments should show rapid destruction from the electric spark, all the connections between these segments to the corresponding armature coils should be well examined, and, if necessary, cleaned and well tightened, or made solid with solder. The poor contact between parts of the field wire coils can be very often discovered by holding a piece of iron, for instance a machine wrench, near the pole piece without touching it. If the contacts are good the wrench will be attracted with a uniform force; if poor, these forces will vary and cause a singular vibratory motion of the wrench in the hand.

DISEASES OF DYNAMOS.

CHAPTER XXII.

Non-generation of Current by the Dynamo.

There may be numerous causes for such an occurrence.

First, the residual magnetism in the field magnets of the dynamo may be too weak. Series dynamos can be started in such a case when running at normal speed, by short circuiting the two binding posts with a piece of wire for a fraction of a second; if short-circuited too long, serious damage may be done to the commutator. This operation can not be applied to shunt dynamos, as they will not generate any current when the binding posts of the machine or the outgoing wires are short-circuited. In order to start shunt dynamos, the external circuit must be disconnected from the dynamo, and, after the dynamo has been running at normal speed for about a minute, the external circuit must be suddenly thrown on the dynamo.

Secondly, poor contacts may be the cause. Every connection of the armature and the magnets should be closely inspected. If necessary the contacts should be cleaned and set screws tightened.

Thirdly, the insulation of the binding posts and the brush holders may be in poor condition. For instance, if the metal bars of the brush holders should touch the quadrant, the armature would be short-circuited and no current would be generated. Such faults can be very easily detected by means of the detector galvanometer, as described in Chapter VI.

Fourthly, if one or more field magnets are short-circuited the dynamo will generate current, but the current will not be at normal strength. In this case the dynamo should be examined, as described in Chapter XXI.

Fifthly, shunt dynamos, as mentioned heretofore, will not generate any current when short-circuited. This is especially true for small dynamos. In incandescent lamp installations, for instance, it may happen that two branch wires or two contact points in a lamp-holder, are short-circuited. Even as trivial a fault as this may be sufficient to prevent the dynamo from generating any current at all. By taking out one of the circuit wires and putting an incandescent lamp between the binding posts of the dynamo, it can be very easily discovered whether the fault is in the dynamo or in the external circuit. If the lamp burns properly, the fault is in the circuit. If it does not burn properly, the fault is in the dynamo. If the fault should be in the circuit, insert the circuit wire suddenly in the binding post, and the short circuit will show either by burning out or by fusing a safety plug. Great care should be taken in making this test not to set the building on fire, as considerable sparking and often melting of a small wire may be caused in the place where the short circuit is. If the short circuit should be heavy, the probability is that the belt will fly off the dynamo pulley. In such a case the short circuit must be located by means of the detector galvanometer. It is advisable to watch the belt before inserting the wire in the binding post, in order that it may not be injured by being thrown off. If the belt on the dynamo pulley commences to squeak and the lamp between the binding posts commences to burn dimly, the wire should be pulled quickly back again, and this operation not carried any further, but the fault should be located by means of the galvanometer.

Chapter XXIII.

Excessive Sparking of Commutator and Brushes.

The causes for excessive sparking of commutator and brushes may be classified as follows:

First, poor condition of the brushes and brush holders.

Secondly, faulty adjustment of the brushes [See Chapters XVIII and XIX].

Thirdly, the surface of the commutator may be rough or covered with dirt and grease [See Chapter XIX].

Fourthly, the insulation of one field magnet coil may be injured and the coil short-circuited in itself. If one magnet is more excited than the other, one brush will spark more than the opposite one, in the same way as if the brushes were not properly adjusted.

Fifthly, two or more segments of the commutator may be short-circuited.

Sixthly, the dynamo may be overloaded. This will cause not only an excessive sparking of the brushes but a considerable heating of the armature and fields. The overloading of the dynamo may be caused by poor insulation of the external circuit, thus causing a considerable amount of current to escape from one pole to the other. Grounding of the external wires, which frequently happens in rainy weather, will bring about the same result.

In arc lighting, lamps may be fed by too strong a current, or in incandescent lighting, too many lamps may be put on the leads.

LAMPS.

CHAPTER XXIV.

Arc Lamps.

When an electric current has passed through two carbon pencils in contact with each other and then separated, an electric spark will jump through the short space between the two carbons and produce what is called the electric arc. In continuous current systems the positive carbon will become more incandescent than the negative and burn about twice as fast. When an alternating current is used the two carbons will become equally incandescent and will be consumed at about equal rates.

In continuous current machines the arc lamps are so arranged that the upper carbon must be the positive, and the lower carbon the negative. The upper carbon will form a little crater and reflect the light downward, Fig. 17. It is very important to have the distance between the two carbons kept uniform at all times, in order to have the lamps burn steadily. The lengths of the arcs of the different systems vary from $\frac{1}{32}$ to ¼ of an inch. By the use of dark glasses one can observe the arc without injuring the sight. Systems using the short arc are very often said to employ low tension, while systems using a long arc are said to employ high tension.

Arc lamps with a short arc use a current from 18 to 25 amperes, and an e. m. f. of from 25 to 35 volts, while arc lamps with a long arc use a current of from 7 to 12 amperes, and an e. m. f. from 40 to 60 volts. The feeding mechanism of an arc lamp must keep the arc at a uniform length and allow the positive carbon to feed down at the proper rate. Lamps in which both carbons are feeding towards the arc are called focussing lamps, and are made for the purpose of keeping the arc in one spot, so a projector may be used to advantage.

If more than one lamp is to run from one dynamo a shunt must be provided in the lamp, Fig. 18. These lamps are generally called differential lamps, as the difference between the current strength passing throughout the coarse wire coil S_1, and the current strength passing through the fine wire coil, S_2, operates the feeding mechanism. An arc lamp which is to be run alone from one dynamo has only the coarse wire coil. The current passes from the positive binding post through the coil, thence through a contact to the upper carbon, then passes through the lower carbon and out to the negative binding post.

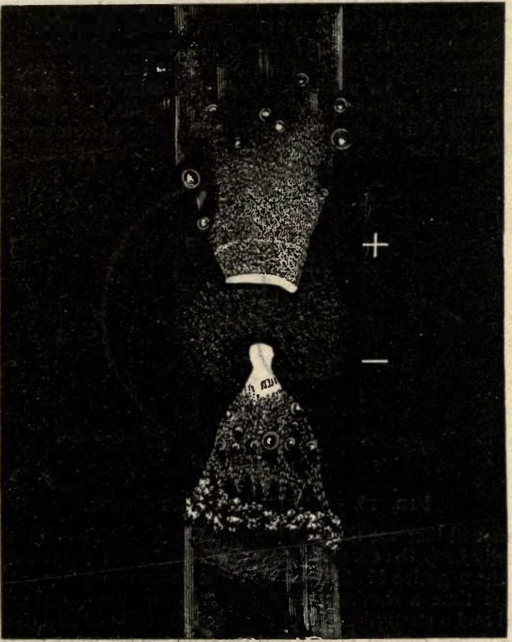

FIG. 17.—ARC LIGHT CARBONS.

The iron armature or core which is connected with the upper carbon holder regulates the arc according to the increase or decrease of the current strength. If the arc elongates too much the current strength in the coil will decrease, and allow the iron core to drop. On the other hand, if the length of the arc should be too short the current strength in the coil will increase and lift the iron core, thus increasing the length of the arc. Fig. 18 illustrates a differential lamp as used when a series of lamps are run from one dynamo. The lamp has, as described heretofore, in shunt with the two binding posts, a fine wire coil which helps to regulate in the following manner: The current through the circuit must be kept at a uniform strength; if there was no shunt coil an increase of the arc of one lamp would decrease the current strength through the whole circuit and make the other lamps dim. This would cause a permanent fluttering of the arcs and no steady light could be obtained. In using a shunt coil each lamp is made practically independent of the other lamps in the same circuit. If the arc should elongate, the flow of the current through the coarse wire coil will decrease, but at the same

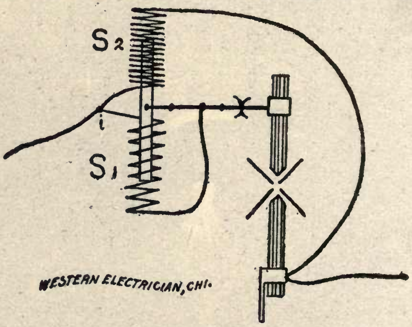

FIG. 18.—SHUNT FOR ARC LAMPS.

time will increase through the shunt coil. This will practically keep the current strength passing from the positive to the negative binding post of the lamp uniform; at the same time a decrease of the strength of the coarse wire coil and a strengthening of the fine wire coil will pull down the upper carbon holder and regulate the arc to its proper length. Each system, of course, will necessarily require certain special instructions which cannot be given here.

Arc lamps are generally connected in series, as shown in Fig. 19. The positive binding post of the dynamo connects to the positive binding post of the first lamp, the negative binding post of the first lamp to the positive binding post of the second lamp, and so on until finally the negative binding post of the last lamp connects to the negative binding pcst of the dynamo.

An ammeter should be connected in the circuit to show at all times the current strength, which must be kept constant in such a system. The e. m. f. between the binding post of the dynamo will depend upon the e. m. f. of each lamp, and the number of lamps in the circuit. If, for instance, one lamp requires 50 volts, and there are ten lamps in the circuit the total e. m. f. between the binding posts of the dynamo would amount to $50 \times 10 = 500$ volts. Besides the ammeter there is generally a hand or automatic regulator connected in the circuit to enable the dynamo tender to keep a constant current strength in the circuit. If one or more lamps should be turned out, the current strength would increase if properly arranged devices did not cut

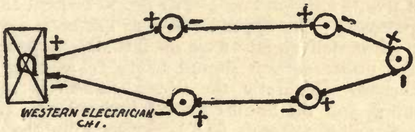

FIG. 19.—ARC LAMPS IN SERIES.

down the e. m. f. of the machine, and thus keep the current strength at its normal.

CHAPTER XXV.

Suspension of Arc Lamps.

Arc lamps should be securely fastened and properly insulated from the point of suspension. When used outdoors a weather-hood should be put above the lamp to protect it from rain or snow. The wires leading to the lamp should be well insulated in order to prevent their getting in contact with any part of the lamp, except the binding posts. The set screws of the binding post should be well tightened.

If cords and pulleys, or counterpoises and flexible cables are used for raising and lowering lamps it is well to examine all these parts carefully every few months, as ropes and flexible cables will wear out, and the lamps or counterpoises may drop, and bring property and human life in danger. For these reasons it is preferable to have the lamps put up stationary, or devices should be used which will take the strain off the ropes or cables when the lamp is in its place.

CHAPTER XXVI.

Trimming and Cleaning Arc Lamps.

Special instructions are given for each system when the plant is put in operation. The following, however, are general rules which will apply to all systems: In putting in the carbons care should be taken that they are well pointed, and that they are not too long. There should be sufficient space to allow the feeding mechanism to separate the carbons at least one-fourth of an inch. The carbon holders and all other parts of the lamp which are exposed should be dusted off every time before putting in new carbons. The carbon rods should be cleaned with a clean rag moistened with benzine or spirits of ammonia every day. Contact points and binding screws are to be kept clean and well tightened. The upper carbon, as has been described, will be consumed about twice as fast as the lower one; hence the upper carbon should be twice as long as the lower carbon. Generally the upper carbon is made 12 inches long, and the lower carbon 6 inches long. One set of carbons will last from 5 to 8 hours according to the current and kind of carbons used. Larger carbons will burn longer than carbons of smaller diameter; but generally lamps will burn more steadily with carbons of smaller diameter than with those of larger diameter. Short-arc lamps use mostly carbons from seven-sixteenths to one-half inch diameter, while long-arc lamps use carbons from three-eighths to seven-sixteenths inch diameter. Carbons should be kept in a dry place.

CHAPTER XXVII.

Incandescent or Glow Lamps.

An incandescent lamp consists of a carbon filament inclosed in a glass globe from which the air has been exhausted by means of an air pump. The electric current passes through the carbon filament, which offers so much resistance that it becomes very hot and glows, or, as we say, becomes incandescent. Most incandescent lamps are made for an e.m.f. of from 50 to 120 volts. Lamps should always be burned at the proper e.m f. If they run above the normal e.m.f., the candle power will be increased, but the life of the lamp will be very much shortened. Incandescent lamps can be connected to the dynamo in various ways; for isolated plants they are generally connected in parallel or multiple arc

Chapter XXVIII.

Multiple Arc System.

Fig. 20 shows the method of connecting lamps to the dynamo in multiple arc. Each lamp is independent, and any number of lamps can be switched in or out without interfering with the other lamps, provided the e.m.f. between the parallel mains is kept constant. Generally lamps of the same e.m.f. are connected in the same system, but

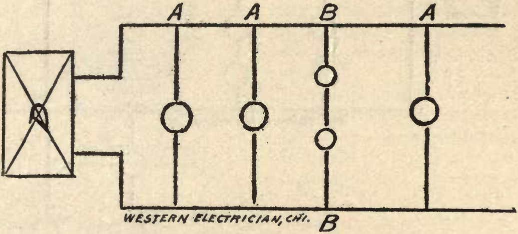

Fig. 20. — Lamps in Multiple Arc.

if, for instance, we should want to use 50 volt and 100 volt lamps in the same system, we would connect the 100 volt lamps direct between the mains, as shown in the drawing; with *A*, and the 50 volt lamps in series of two, with *B*, The two lamps marked *B*, of course, are not independent. if one should break or be switched out, the other lamps would go out also.

Chapter XXIX.

Multiple Series System.

In some cases it is necessary to use dynamos of a higher e.m.f. for incandescent lighting, and in such cases the lamps are connected between the two mains in series, Fig. 21. If, for instance, the electromotive force of the dynamo is 500 volts, and 100 volt lamps should be used, five lamps would have to be connected in series in order to divide the e.m.f. properly. In this system, of course, if one lamp in one series should break, the other lamps of this series would go out also. This has been practically

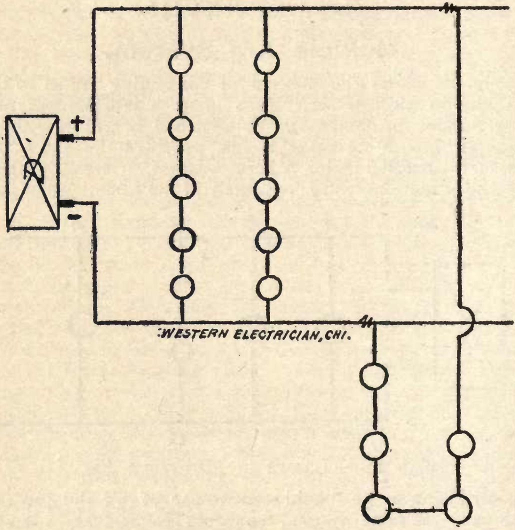

FIG. 21. — LAMPS IN MULTIPLE SERIES.

avoided by providing each lamp, Fig. 22, with a little cut out and connecting in the circuit an extra lamp or a resst-ance coil. If one lamp should break or be switched out, the cut-out will switch into its place an equal resistance. This arrangement will prevent any other lamp in the series from going out, and sustain the same current strength through the whole series at all times. The device is explained by Fig. 23, in which *M* is the magnet, *A* armature, *R* resistance equal to lamp, *C* contact, and *L* lamp.

The current generated by the dynamo in the multiple series system will be in proportion to the number of series burning. The more series switched in, the more current will be required. In this system, as well as in the multiple arc system, a constant e.m.f. is required in the main wires, while the current strength will vary in proportion to the number of lamps or number of series.

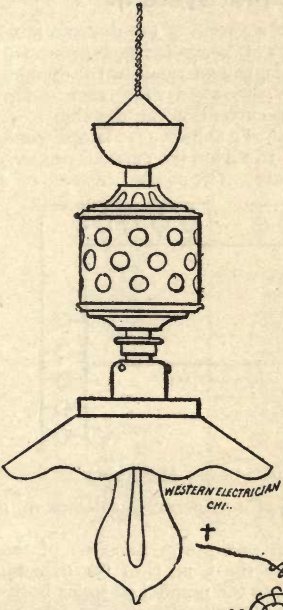

FIG. 22. — LAMP IN MULTIPLE SERIES.

In the multiple series system, of course the switching out of one or more lamps in a group will not result in any saving in the power of the engine or waterwheel; a saving is effected only by switching out one whole series or more at a time. This is a disadvantage in comparison with the multiple arc system, in which the switching out of one lamp means a proportional reduction in the power needed to run the dynamo.

A little saving in power is of no consequence where fuel is cheap or a waterwheel is used.

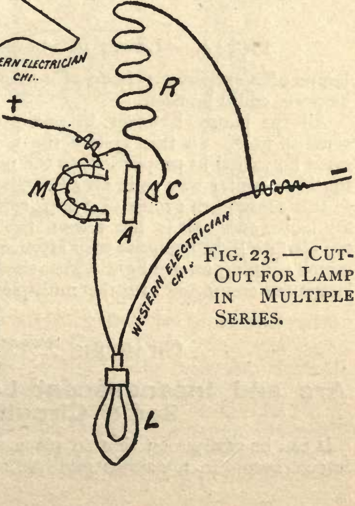

FIG. 23. — CUT-OUT FOR LAMP IN MULTIPLE SERIES.

In larger stores, or places of amusement, where all the lights are required at one time the multiple series system in regard to saving of power stands on an equal footing with the multiple arc system.

CHAPTER XXX.

Series Multiple System.

In this system the current strength of the dynamo must be constant, and the number of lamps for each group will depend upon the current strength generated by the dynamo and the current strength required for each lamp, Fig. 24. For instance, the current of the dynamo is 10 amperes, and each lamp requires 2 amperes; 5 lamps would be connected in each group, to divide the current properly and give each lamp its share. Of course, instead of 2

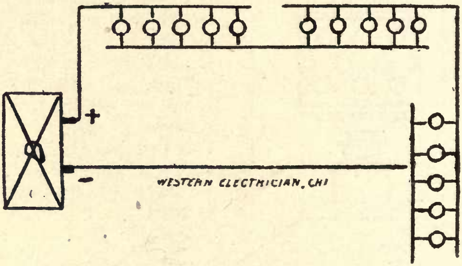

FIG. 24. — LAMPS IN SERIES MULTIPLE.

lamps of 2 amperes, 1 lamp of 4 amperes, or 4 lamps of 1 ampere, could be used.

All the lamps, however, in one group must be of the same e. m. f. In this system the e. m. f. of the dynamo must be varied in proportion to the number of series burning in a similar way as in an arc light circuit. In fact, in in this sense each group of lamps can be considered as an arc lamp, and this is the reason that persons engaged in the electric light business very often speak of incandescent lamps running on arc light wires, simply meaning that the lamps are connected in series multiple, as explained.

CHAPTER XXXI.

Arc and Incandescent Lamps on the Same Circuit.

It can be easily seen that in place of a group of incandescent lamps in the series multiple system, as described, an arc lamp may be inserted, Fig. 25. Such a combination, however, is neither advisable nor practical as the fluctuations of the arc lamps will show in the incandescent lamps.

In this system, as well as in the series multiple system, a similar disadvantage to that described in Chapter XXIX, will occur if one of the lamps should break. The lamps,

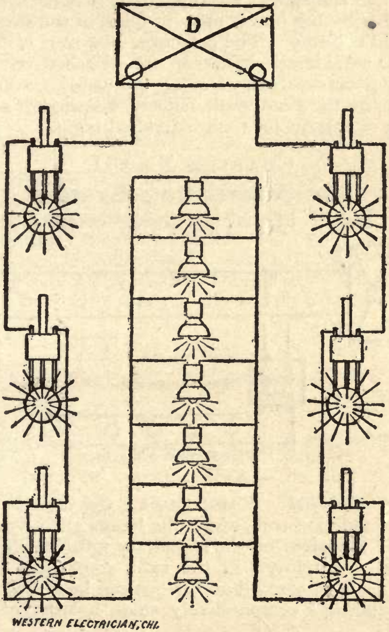

FIG. 25.—ARC AND INCANDESCENT LAMPS ON THE SAME CIRCUIT.

of course, will not go out, but if one lamp should break, the remainder of the lamps in the same group will brighten up considerably and thus injure the life of the lamps. If not discovered in time, more lamps may break and finally the whole series may go out and break the circuit entirely. The breakage of the last lamp in the series might cause considerable damage to property, as owing to the high e. m. f. of the dynamo, a considerable arc may be set up which may destroy the lamp fixtures and set fire to the building. The disadvantage can be overcome by the same cut-outs as described in chapter XXIX, so that if one lamp should break or be switched out, an equal resistance will be shunted in and an even distribution of the current among the lamps will be kept up. In some systems one single distributing box is used in place of the single resistances and cut-outs. The principle, however, is the same. If one or more lamps break or are switched out, a resistance is put between the wires of the series automatically, thus causing the same result, namely, keeping up a constant strength of current for each individual lamp.

CHAPTER XXXII.

The Alternating System.

In this system, Fig. 26, alternating currents of high e.

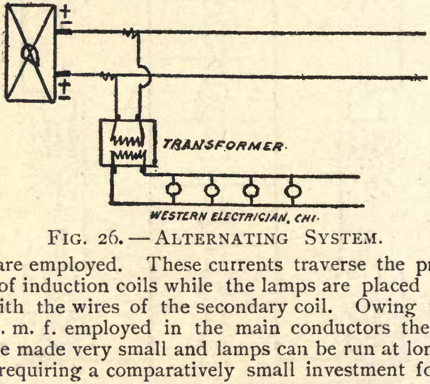

FIG. 26.—ALTERNATING SYSTEM.

m. f. are employed. These currents traverse the primary wires of induction coils while the lamps are placed in circuit with the wires of the secondary coil. Owing to the high e. m. f. employed in the main conductors the latter may be made very small and lamps can be run at long distance requiring a comparatively small investment for copper wire.

The induction coils called converters or transformers are connected in multiple arc with the mains. The incandescent lamps are also connected in multiple arc with the wires starting from the secondary coil. Each lamp in this system is independent of the others and may be switched in or out at will.

Arc lamps may be run in this system at the same time with incandescent lamps.

INSTRUMENTS.

Chapter XXXIII.

Current Indicator or Ampere Meter.

This apparatus is to indicate the current strength at all times. It should be put up in each case where a constant current strength is required as in arc light circuits or in the series multiple system of incandescent lighting. The instrument must be connected in series with the arc lamps or with the groups of incandescent lamps in the series multiple system. It is also used in the multiple arc or multiple

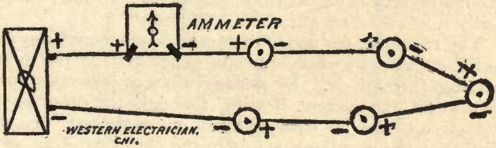

Fig. 27.—Position of Ammeter.

series system and is always put in one outgoing wire of the dynamo, Fig. 27.

Chapter XXXIV.

Pressure or Potential Indicator, or Voltmeter.

This instrument is absolutely necessary on dynamos which must be kept at a constant e. m. f., as in the multiple arc or multiple series system of incandescent lighting. The instrument is connected in parallel with the lamps, as shown in Fig. 28.

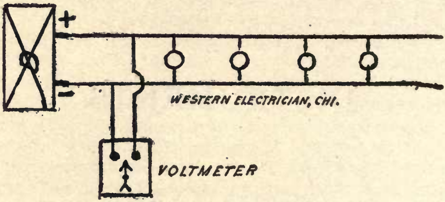

FIG. 28.—POSITION OF VOLTMETER.

CHAPTER XXXV.

Current Regulator.

This instrument, also called rheostat or resistance box, consists of a box which contains wire or some other resistance and which can be switched in or out of the electric circuit by means of a crank. If this is to be done by hand, the instrument is called a hand regulator ; if done automatically it is called an automatic regulator.

The regulator for series dynamos is connected anywhere in the circuit, the whole current generated by the dynamo passing through it. By putting more or less resistance in the circuit, the current flowing through the other parts of the circuit can be strengthened or weakened. In shunt dynamos the regulator is put in the shunt winding of the

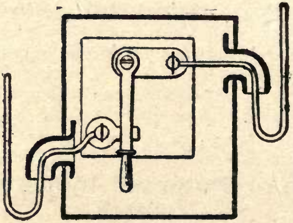

FIG. 29.—SWITCH.

field. Putting in or taking out the resistance decreases or increases the strength of the field magnets and thus controls the current generated in the armature. In some arc light dynamos the regulation of the current is effected by putting more or less resistance in shunt with the field circuit, and in others by automatic devices for shifting the brushes. The movement of the latter towards the neutral point will increase the current, while moving them in an opposite direction will decrease the current strength. [See Chapter XVIII, Fig. 13.]

CHAPTER XXXVI.

Switches.

A switch is an instrument to break or make circuit, or, in other words, to cut off the current in certain places for a number of lamps or cut them in again. The switches should be constructed so that they will open and close very quickly and not show very much sparking. [See Fig. 29.] This is accomplished by having the switch so arranged

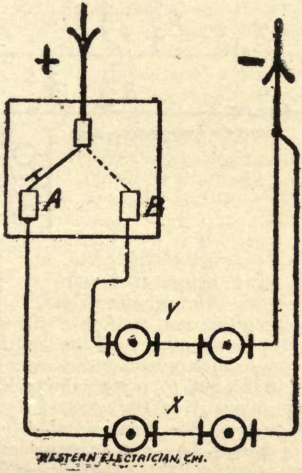

FIG. 30. — TWO-WAY SWITCH.

that the human hand will start it, while a powerful spring throws the switch open or closes it immediately. The contact should be sufficient to prevent any heating at these points.

Two-way switches are used in various ways; for instance, for two different sets of lamps. If one set of lamps is not required, the handle, as shown in Fig. 30, is moved from *A* to *B*, and the lamps marked *X* will go out, while those marked *Y* will be started.

CHAPTER XXXVII.

Safety Devices.

Strips of an alloy which fuses at a low temperature are used as safety devices, or plugs, in incandescent wiring. The cross-section of the plug must be of such size

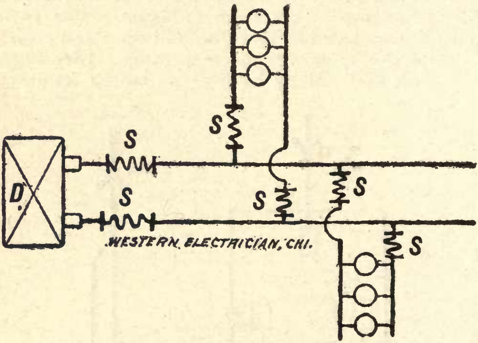

FIG. 31. — POSITION OF SAFETY PLUGS.

that it will melt before the wire it protects gets dangerously warm. Hence, the diameter of the safety plug depends upon the cross-section of the wire to be protected and not upon the number of the lamps. The safety plug is not supposed to protect incandescent lamps from an excess of current, but to protect the building from fire by preventing any part of the electric light conductors from getting too hot. The marking of safety plugs with the number of lamps they can carry has misled many an employe of an electric light company to think that the plugs are put in for the protection of a certain number of lamps. The marking of the plugs simply expresses their carrying capacity in 16 candle power lamps instead of in amperes. See Fig. 31, in which safety plugs are marked *S*.

The blowing out of safety plugs is very often caused, not by an excess of current, but by poor contact between safety plug and safety plug holder. A poor contact, of course, will generate heat, which will gradually fuse the metal on one end. It is best to have double pole safety plugs.

Chapter XXXVIII.

Lightning Arresters.

Where electric light lines are put up outside of buildings they are liable to be struck by lightning. To meet such a contingency, the dynamo and station apparatus are protected by a lightning arrester. Fig. 32 shows the simplest form of a lightning arrester; *D* represents the dynamo; *A* and *B* are brass plates, through which the two outgoing wires pass, and *C* is a brass plate connecting to moist earth. The space between the toothed sides of *A* and *B* and the center plate *C* is adjusted to the thickness of a piece of card board. If lightning should come in on one of the wires, it would leap over this narrow space and run into the ground without doing any serious mischief. Such an arrester will keep the lines discharged, and very often during a thunder storm the atmospheric electricity will continuously leap across these plates in the form of blue sparks. These discharges may sometimes cause the center plate to fuse to one or even both toothed plates. In the latter case, the current of the dynamo may follow the arcs which are simultaneously set up between *A*, *C* and *B*, *C*. If the center plate should be fused to both toothed plates the dynamo would be short-circuited through *A*, *C*, *B*, and the belt would be thrown off or the armature, and possibly some of the instruments in the circuit, might be burned.

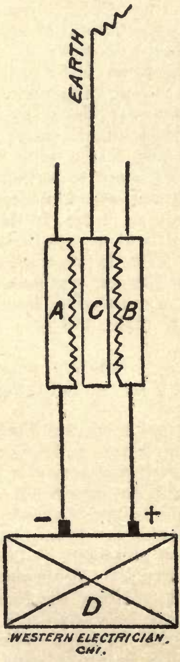

FIG. 32.—LIGHTNING ARRESTER.

In order to prevent such an accident, numerous devices have been designed to operate in connection with the lightning arrester. They may be classified as follows :

First, Safety fuses inserted between the dynamo and the strips *A* and *B*. They will fuse when the dynamo is short-cuited, break the current and thus save the armature.

Secondly, Electro-magnets which are energized when the dynamo is short-circuited and open the circuit.

Thirdly, Devices which will extinguish any electric arc that might be formed between *C* and *A* or *C* and *B*. Such devices are based on the principle that a magnet will attract the electric arc and pull it away from the plates *A* and *C* or *B* and *C*.

Whatever devices are used, one important point should not be overlooked. This is the absolute necessity of a good earth contact. The wire leading from *C* to earth should be at least a number 4 Brown & Sharpe copper wire. This wire should be solidly connected and soldered to a galvanized iron plate at least ⅛ inch thick and having an area of at least ten square feet on each side. If a pipe is used instead of a plate, the internal area is not to be considered, but twenty square feet of external area is necessary. This earth plate should be sunk so deeply in the earth that even during a dry season it will always be in moist ground. A well or a stream of water is preferable. The earth wire should also be connected to water pipes or gas pipes if they are near by. Such a connection, however, is not a substitute for the earth plate, which is a necessity under any circumstances.

The conductor of the lightning rod of a building must not be connected with the earth wire of a lightning arrester.

All connections underground must be soldered and then painted with asphaltum to prevent corrosion and poor contacts. Poor connections with the earth are very often the cause of the unsatisfactory working of lightning arresters.

It should be borne in mind that no lightning arrester is an absolute safeguard against the freaks of lightning. Very long circuits, especially those not protected by tall buildings or trees, are very liable to be struck by lightning. In such cases extra devices at some points along the line must be put up as an additional protection.

The jaws of the lightning arrester should be kept clean and at a proper distance. It is advisable to run a cardboard between the plates every day to make sure that the jaws are at a proper distance from each other.

CHAPTER XXXIX.

Ground Detector.

It is absolutely necessary to test electric light circuits frequently, and this means at least once a day, for grounds. In incandescent light installations which run continuously, arrangements to indicate a ground while the dynamo is running should be made. A simple form of ground detector is shown in Fig. 33. Two lamps are connected in series

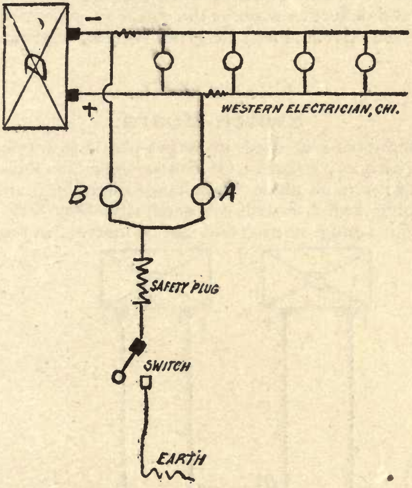

FIG. 33. — GROUND DETECTOR.

between the mains near the dynamo. A wire leading to earth is connected between the two lamps; a safety plug and a switch are put into the earth wire. If there is no ground on the line the two lamps will burn very dimly but at equal candle power. If a ground should occur anywhere in the circuit, say on the positive pole, the earth wire and the ground will form a shunt of low resistance to the lamp nearest the positive wire; the result will be that lamp *A* will dim down and lamp *B* will brighten up. Sometimes it may occur that both poles of a circuit are grounded and that the grounds are of about equal resistance. In such a case the two lamps will burn equal y dimly. By switching out one lamp, however, it can be seen whether the lines are grounded or not If the other lamp also goes out the lines are not grounded, but if the other lamp continues to burn the lines are grounded on both poles. To make this test one lamp should be provided with a socket with key.

Instead of two lamps a galvanometer with two coils connected in the same manner as the two lamps may be used. The needle will stand at zero when there is no ground on the line and deflect as soon as the wire gets grounded. Any grade of sensitiveness may be given such an instrument.

CHAPTER XL.

Switch-Board.

A switch-board is used in larger plants to connect any dynamo with any circuit. Of course only dynamos of the same kind can be made interchangeable. For arc lamp plants, plug switch-boards are generally employed. Short cables with a plug on each end can be inserted in the differ-

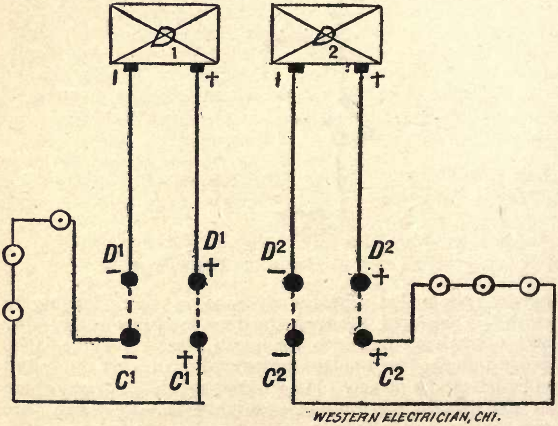

FIG. 34. — SWITCH - BOARD.

ent sockets. The latter are marked with + or —, and with *D* (dynamo), *C* (circuit). In addition, they are marked with a number. For instance, *D* 1 (meaning dynamo number 1) can be connected to *C* 2 (circuit number 2), and so on. Fig. 34 is a diagram showing the arrangement of a switch-board.

In incandescent plants large lever switches are generally used, as large enough plugs could not be conveniently made to carry the heavy currents of incandescent circuits.

CIRCUITS OR LEADS.

CHAPTER XLI.

Outdoor Leads for Arc Lighting.

The wire used for outdoor circuits is mostly what is called underwriters' standard. It consists of a copper wire which is braided with cotton and painted with asbestos to make it uninflammable. This wire is fastened to glass insulators on poles or houses in a way similar to that in which telegraph wires are usually run. Insulated wire, and not bare wire, should be used for tie wire, as the common non-insulated tie wire will cut the insulation of the line wire and possibly cause leaks. The size of arc light conductors varies between numbers 6 and 4, Brown & Sharpe gauge, number 6 being the smallest wire which can be used, according to the rules of the National Board of Fire Underwriters. If the return wire is fastened on the same poles, the positive and negative wires should be kept sufficiently far apart so they can not touch each other when swung by wind. It must be understood that the insulation called underwriters' standard is only an insulation when perfectly dry, and when wet is hardly any insulation at all. If, therefore, the positive and negative wires exposed to rain or moisture of any kind should come in contact with each other or with the ground, a short circuit would be caused. This may cut a number of lamps suddenly out and cause damage to the dynamo. Such an accident, for instance, may burn out the armature or throw off the belt. In very cold weather such occurrences are rare, as frost may make out of a circuit of the poorest insulation one of very high insulation, while on the other hand a thaw or rain may cause all kinds of disturbances. If these disturbances occur during a thunder storm accompanied by rain, lightning is often unjustly accused of having done the mischief, while in fact the poor insulation of the wires is the prime cause.

Accidents from poor insulation of lines are more frequent than damages caused by lightning, though the latter will always be a ready excuse for anything that may have happened. Recently weather and water-proof insulation have come in vogue, and they are much safer than underwriters' standard wire.

In conducting wires into houses, great care must be taken to prevent rain following the wires. The wire should be fastened to the insulator below the point where it is intended to be led through the wall or a window frame, so the rain would have to run up hill in order to follow the wire, Fig. 35.

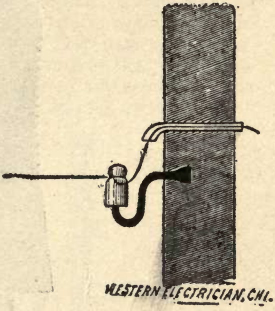

FIG. 35. — PROPER POSITION OF INSULATOR.

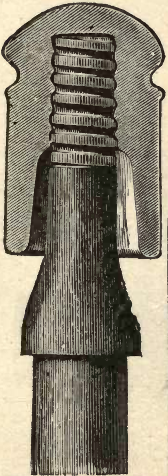

FIG. 36. — WOOD PIN AND GLASS INSULATOR.

FIG. 37.—WOOD BRACKET.

Fig. 36 shows a wood pin and glass insulator, such as are used on cross-arms. The latter are fastened to poles by means of lag screws. Fig. 37 illustrates a wood bracket, which can be spiked to poles or houses and provided with a glass insulator. The glass insulators must always be fastened in a nearly vertical position, the closed end on top, so the space between the pin and glass insulator, Fig. 36, will remain dry in rainy weather and secure perfect insulation.

Fig. 38 shows a rubber hook insulator. This should for the same reason be fastened with the hook downward. A

FIG. 38. — RUBBER HOOK INSULATOR.

hole can be bored with a ⅝ inch bit underneath a cross-arm and the rubber hook screwed in with a wrench.

An extra heavy insulating material, such as rubber hose or hard rubber or porcelain tube, Fig. 39, must be put over the wires where they pass through walls or partitions.

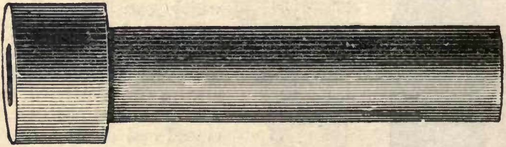

FIG. 39. — HARD RUBBER TUBE.

Poles for lines should be set deep enough in the ground; the depth, of course, will depend upon the soil and the height of the pole. In sand, at least one-fifth of the length of the pole should be buried in the ground, while in rock one-tenth of the length is sufficient. In putting up wires, the season, or, in other words, the temperature, should be taken into consideration, allowing for contraction in cold weather. If, for instance, a wire should be put up very tight in July, it would cause a good deal of damage in breaking off glass insulators and pins as soon as the temperature fell to zero and caused the wire to contract. Corner poles must be braced or anchored to keep them in a nearly vertical position. See Figs. 40 and 41.

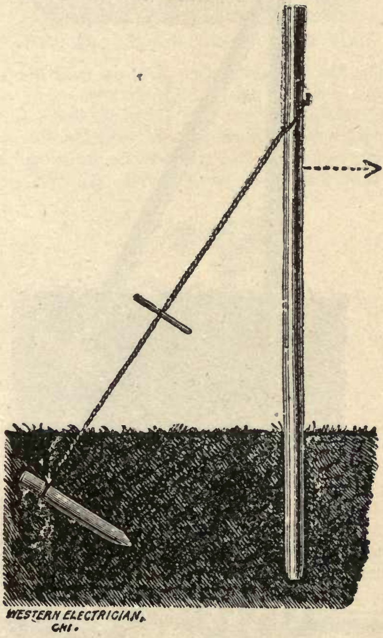

FIG. 40. — CORNER POLE ANCHORED.

When a splice is necessary, it should be made after the fashion of the American telegraph splice, Fig. 42, and should be perfectly clean and solidly soldered and then well taped with insulating tape. In order to prevent the tape from peeling off, it is advisable to fasten the last turns of the tape to the wire with a few turns of bare copper wire, say about number 20. If this precaution is omitted

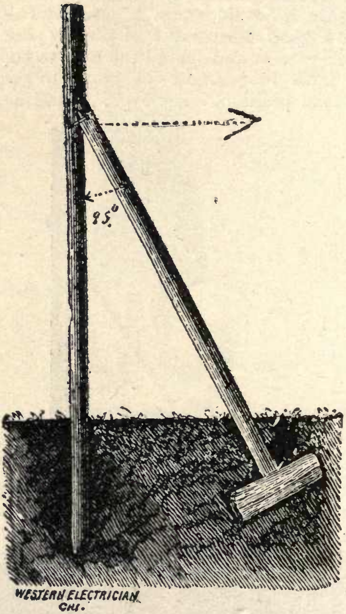

FIG. 41.—CORNER POLE BRACED.

the tape is sure to peel off in time. Most of our electric light lines will show places where the tape is hanging

FIG. 42.—AMERICAN TELEGRAPH SPLICE.

down a couple of feet. Besides, having no insulation on the splice, this, of course, does not contribute to the beauty of overhead wires.

Brass line connectors, Fig. 43, are only allowed for inside work where there is no strain on the wires, The set screws should be well tightened, and the connector be run full of solder and taped. Good soldering and taping

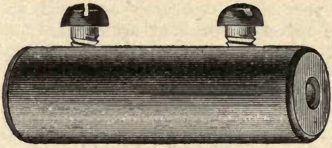

FIG. 43.—BRASS LINE CONNECTOR.

of joints will save at least 50 per cent. of all the troubles that occur in an electric light plant. Joints should never be left unsoldered, even if persons who claim to know all about it should think it unnecessary. The best apparatus for soldering joints on line wire out of doors is the gasoline blow-pipe, Fig. 44. Every trace of acid should be wiped

FIG. 44.—GASOLINE BLOW-PIPE.

off the wire with a moist or oily cloth before taping, to avoid corrosion.

CHAPTER XLII.

Outdoor Leads for Incandescent Lighting.

The rules which were given for outdoor arc light lines can be applied for incandescent light lines. As the wire used will very often be considerably larger than number 4 wire, the poles, cross-arms and other supports must necessarily be heavier to stand the greater strain, and poles should be set closer together. In a low tension incandescent system, very often bare wires are used, and still more care must be taken to prevent accidental contact of the positive and negative wires with each other or with the earth.

CHAPTER XLIII.

Arc Circuits Inside of Houses.

The wires for these circuits should be fastened to porcelain insulators, Fig. 45, and be exposed to view. Owing

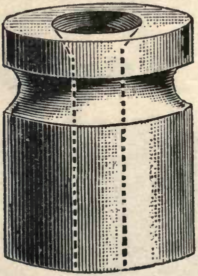

FIG. 45. — PORCELAIN INSULATOR.

to the high tension which prevails in arc light circuits, the concealing of these wires is not permitted by the underwriters. The directions given for splicing and insulating hold good also for inside wiring.

In rooms which are exposed to steam or moisture, as, for instance, in packing houses, wire with a better insulation than underwriters' standard must be used. The moisture which covers insulators and wire would cause considerable leakage, and, besides, would corrode the wire. The use of wood cleats or iron staples instead of porcelain insulators should not be permitted in any case, as they are liable to cause grounds and, in fact, have been the source of mischief in a good many cases in years gone by.

CHAPTER XLIV.

Incandescent Circuits Inside of Houses.

In the low tension systems, wooden cleats or wooden molding are permitted for fastening the wires to the walls and ceilings if there is absolute safety from moisture. Underwriters' wire may be used also under the same conditions. If there is any possibility of moisture getting to the wires, the latter should be first-class waterproof insulation. If any "fishing" has to be done, where wires are to be concealed under floors, above ceilings, or between walls or laths, only waterproof wire can be used. Incandescent wiring inside of houses requires a good deal of skill and experience, and should only be intrusted to reliable and responsible concerns. Unfortunately, any man who ever fastened a piece of wire for a bell-pull, thinks himself an expert also for incandescent wiring ; a good many even important jobs have been done by such men, with the result that, after a great expenditure of money by the owner of the house, the whole system had to be condemned, as not an inch of the wire had been put in properly and could be used.

The joints or connections in waterproof wire should be made waterproof also. This is done in the following way : After having spliced, soldered and cleaned the wires properly, cover the joint with hot Chatterton's compound by molding it between the fingers to almost the total thickness of the insulated wire. Then cover it with kerite tape and give it a second thin coating with hot compound, or hot asphaltum, and then give it a second coat of kerite tape. Hot liquid asphaltum should be used in lieu of compound where there is danger from sewer or illuminating gas that is prevalent in the soil and basements of houses in large cities.

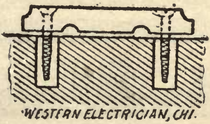

FIG. 46. — WOOD CLEAT.

Figs. 46, 47, 48, 49 and 50 show the use of cleats. Fig. 46 shows a familiar form of cleat. Where the positive wire crosses the negative, an extra protection of rubber tube is required to prevent any danger from short circuits, Fig. 47.

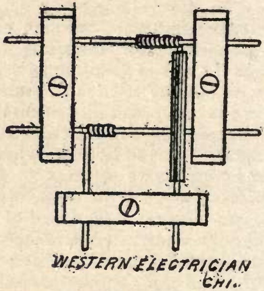

FIG. 47. — PROTECTION OF WIRES CROSSING EACH OTHER.

In passing through a wall, each wire should be inserted in a separate hole, lined with a hard rubber tube, Fig. 48,

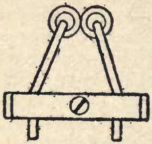

FIG. 48. — WIRES IN SEPARATE HOLES.

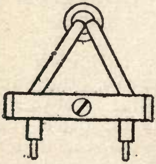

FIG. 49. — WIRES IN SAME HOLE.

or each wire should be covered with soft rubber tubing and both may be drawn through one hole, Fig. 49, lined with a pipe of non-conducting waterproof material.

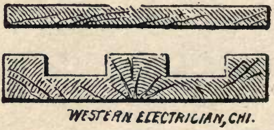

FIG. 50.—WOOD MOLDING.

Fig. 50 is a cross-section of wood molding. The lower part is fastened to the wall or ceiling, the wires put in—

positives in one groove and negatives in the other—and the cover screwed on. Care must be taken that nails or screws do not touch the wires.

The safety plugs are put in the circuit according to the rules of the fire underwriters. They must be of such size that they will fuse before the wire they have to protect can get dangerously warm.

CHAPTER XLV.

Size of Wires for Incandescent Lamp Installations.

The wire for each main or branch must be of such size that it can carry the current to the lamps which are connected to it, without getting very warm. The number of amperes a wire can thus safely carry is called its carrying capacity.

In the table on page 70, the carrying capacity is given in Column XIV. A number 4 B. & S. copper wire, for instance, can carry 50 amperes; its temperature will then increase 18 degrees Fahrenheit. But besides the carrying capacity something else must be taken into consideration. This is the amount of energy which will be allowed as loss in the wires. The larger the wire the less the loss; the smaller the wire the higher the loss. In house wiring not more than 5 per cent. loss should be allowed from the dynamo to the lamp.

For those who want to give this matter more study the following formulas are given. Any one who understands arithmetic will be able to calculate the size of wire for any loss and for any lamp:

n = number of lamps.

d = distance = ½ length of circuit.

$\%$ = energy lost in the conductors, expressed in decimal fractions of 100 as 5% = .05.

r = resistance in ohms.

1. $r \text{ of wire} = \dfrac{r \text{ of lamp hot} \times \%}{n}$
2. Length of wire : 1000 = r of wire : r per 1000 feet.
3. $r \text{ per 1000 feet of wire} = \dfrac{r \text{ of lamp hot} \times \% \times 1000,}{n \times 2 \times d}$
4. $r \text{ per 1000 feet of wire} = \dfrac{\text{constant,}}{n \times d}$
5. Constant = $500 \times \% \times r$ of lamp hot.

EXAMPLE: Find size of wire necessary to carry 40 sixteen candle power lamps ($r = 167$ ohms hot), 500 feet, 10% loss.

Formula 5: Constant $= 500 \times .10 \times 167 = 8350.$

Formula 4: r per 1000 feet $= \dfrac{8350,}{40 \times 500.} = .417$ ohms.

This is the resistance per 1000 feet of the wire necessary to use. Find the next smaller number in Column XI of table on page 70—this is .411.

The number of wire on same line in Column I of the table is the proper size.

In this case No. 6 wire.

If the resistance hot of the lamp should not be known it can be calculated from Ohm's law. $C = \dfrac{E}{R}$ or $R = \dfrac{E}{C}$.

Supposing the e. m. f. = 100 volts and the current $= \dfrac{5}{10}$ amperes, R would equal $\dfrac{100 \times 10}{5}$, or $R = 200$.

CHAPTER XLVI.

Testing.

The circuit should be tested every day for grounds by means of the detector galvanometer or a magneto bell. If a ground is indicated it should be speedily located by disconnecting the circuit in different places and taking each section separately, until the ground is located. [See also Chapter XXXIX.]

CHAPTER XLVII.

Accumulators.

Accumulators, Fig. 51, or secondary batteries, are used for the storage of electricity. They consist generally of glass vessels containing a solution of sulphuric acid and water in which lead plates, insulated from each other, are placed The positive and negative lead plates are called the electrodes. These batteries are usually charged with shunt dynamos. A chemical change in the plates is produced. In discharging, the plates try to return to their first chemical condition and in doing so they generate a current.

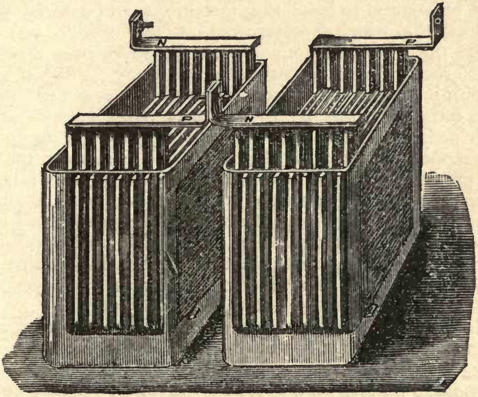

FIG. 51.— ACCUMULATORS.

The e. m. f. of an accumulator is about 2 volts. In order to burn 100 volt lamps, 50 accumulators must be connected in series. The maximum current strength they should be allowed to yield is generally given by the manufacturer. It is in the neighborhood of 35 amperes, which can be yielded for ten hours, or, as it is expressed the accumulators can yield $35 \times 10 = 350$ ampere hours. Hence a battery of 50 accumulators could yield 350 ampere hours at 100 volts pressure. If we had 100 volt 16 candle power lamps requiring $\frac{1}{2}$ ampere each, we could, for instance, burn 70 of these lamps 10 hours, or 35 lamps 20 hours, etc.

SAFETY REGULATIONS.

Rules of the Boston Underwriters' Union.[1]

ARC LIGHT WIRES.

Conducting wires must be seven feet above roofs, and placed so as to avoid ladders of the fire department and fire shutters.

Whenever electric light wires are in proximity to other wires, dead guard wires must be placed so as to prevent any possibility of contact with foreign wires, in case of accident to the wires or their supports. Conducting wires must be secured to insulating fastenings, and covered with an insulation which is waterproof on the outside and not easily worn by abrasion. Whenever wires pass through walls, roofs, floors or partitions, or there is liability to moisture, abrasion, or exposure to rats and mice, the insulation must be protected with rubber, stoneware or some other satisfactory material. Wires entering buildings must be wrapped with tape and bent in such a manner that it will prevent the water entering the building. All wires passing over or under steam, gas or water pipes, must have a good insulation between them and the pipes. Blocks of wood are the most desirable. This rule also applies to foreign wires—they should be treated the same as pipes.

Wires should go over water pipes, where it is possible, so that the moisture will not settle on the wires.

Hard rubber hooks are not desirable as fastenings, and tacks or staples must in no case be used for fastenings or brought in contact with the wire.

In damp places, wires must be run on glass insulators, and kept entirely clear from contact with inflammable material and any substance likely to make a ground connection.

The use of lead covered wires, or wires whose covering contains paraffine, is prohibited.

The use of underwriters' wire will not be passed where it is concealed in any manner. It must be in plain sight, on the walls or ceilings. Wire that is covered with molding must have a water-proof insulation that is approved by this union.

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1 Approved, November 1. 1887.

Joints in wires to be securely made and wrapped with tape ; soldered joints are desirable but not essential. Wires conducting electricity for arc lights must not approach each other nearer than one foot.

Care must be taken that the wires are not placed above each other in such a manner that water could make a cross connection.

Cut-off boxes for arc lights must have the words "On" and "Off" marked on them. They must be placed in a well-protected and accessible place, so that they can be operated by the firemen or police.

ARC LAMPS.

For arc lamps, the frames and other exposed parts of the lamps must be insulated from the circuit. Each lamp must be provided with a separate hand-switch, and also with an automatic switch, which will close the circuit and put the lamp out whenever the carbons do not approach each other, or the resistance of the lamp becomes excessive from any cause. The lamps must be provided with some arrangement or device to p event the lower carbons from falling out, in case the clamp should not hold them securely.

For inside use, the light must be surrounded by a globe, which must rest in a tight stand, so that no particles of melted copper or heated carbon can escape; and when near combustible material, this globe must be protected by a wire netting. Broken or cracked globes must be replaced immediately. Unless a very high globe is used, which closes in as far as possible at the top, it must be covered by some protector, reaching to a safe distance above the light

INCANDESCENT WIRES.

Conducting wires must be seven feet above roofs, and placed so as to avoid ladders of the fire department and fire shutters. All connections must be soldered and wrapped with tape.

Whenever the electric light wires are in proximity to other wires, dead guard wires must be placed so as to prevent any possibility of contact with foreign wires, in case of accident to the wires or their supports. Conducting wires must be secured to insulating fastenings, and covered with an insulation which is water-proof on the outside and not easily worn by abrasion. Whenever wires pass through walls, roofs, floors or partitions. or there is liability to moisture, abrasion, or exposure to rats and mice, the insulation must be protected with rubber, stoneware or some other satisfactory material. Wires entering buildings must be wrapped with tape, and bent in such a manner that it will prevent the water entering the building. All wires passing over or under steam, gas or water pipes, must have a good insulation between them. Blocks of wood are the most desirable. This rule also applies to foreign wires—they should be treated the same as pipes.

Soft rubber tube is not desirable as an insulator.

Wires should go over water pipes, where it is possible, so that the moisture will not settle on the wires.

Where incandescent wires enter buildings, they must have double-poled safety catches as near the entrance as possible.

The main wires must not be less than two and a half inches apart, except where they are in grooves.

The use of lead covered or wires whose covering contains paraffine is prohibited.

All wires that are fished over the ceiling or in the walls, must have a water-proof insulation satisfactory to this union. This rule also applies to wires covered with molding, or concealed in any manner.

Where underwriters' wire is used, it must be in plain sight on the walls or ceilings

Care must be taken that the wires are not placed above each other in such a manner that water could make a cross connection.

Wires that are run in damp places must be run on glass or porcelain insulators of suitable form.

For incandescent lamps, the conducting wires leading to each building, and to each important branch circuit, must be provided with an automatic switch or cut-off, or its equivalent, capable of protecting the system from any injury due to an excessive current of electricity. These devices must be proportioned to protect the smallest wire in the loop to which they are attached.

On all loops of incandescent circuits, safety catches must be used on both sides of the loop, and switches on such loops should be double-poled.

Ceiling blocks that are used on pendant drops must have safety metals in them where flexible cord is used. Cord should have a knot tied in it with the knot on the top side of the block, so that the strain will come on the knot instead of on the connection ; and where it is possible, a knot should be inside of the socket, the same as the block.

The small wires leading to each lamp from the main wires must be thoroughly insulated, and if separated or broken, no attempt made to join them while the current is in the main wires.

When wires are put on gas fixtures, the fixture must be isolated from the main pipe, and the insulator used for this purpose must be made so that the sediment in the gas will not form a connection over the insulating material.

Chandeliers or brackets attached to any ground connection must have insulating yokes or couplings on them. Individual insulating of lamps at the sockets will not be passed except on brackets in special cases that may be approved by the inspector.

DYNAMO MACHINES.

Dynamo machines must be located in dry places, not exposed to flyings or easily combustible material, and insulated upon wooden foundations. They must be provided with devices capable of controlling any changes in the quantity of the current; and if these governors are not automatic, a competent person must be in attendance near the machine whenever it is in operation.

Each machine must be used with complete wire circuit; and connections of wires with pipes, or the use of ground circuits in any other method, are absolutely prohibited.

The whole system must be kept insulated, and tested every day with a magneto for ground connections in ample time before lighting, to remedy faults of insulation, if they are discovered; and proper testing apparatus must in each case be provided. This applies to both central station and isolated plants.

Testing circuits for grounds with a battery and bell is not considered a reliable test.

Preference is given for switches constructed with a lapping connection, so that no electric arc can be formed at the switch when it is changed; otherwise the stands of switches, where powerful currents are used, must be made of some incombustible substance which will withstand the heat of the arc when the switch is changed.

MOTORS.

Wires for motors should be run exactly as for lamps on similar circuits. On low tension circuits where motors are run in multiple, safety catches must be used on each side of the circuit.

On high tension circuits the same restrictions apply as for arc lamps, and suitable cut-outs must be provided.

Motors must be treated as dynamos as regards insulation, flyings, dampness, etc.

While these rules are intended to be complete, some cases may arise where, in the judgment of the inspector, some deviation from them may be necessary in order to secure safety.

RULES FOR RUNNING INCANDESCENT CIRCUITS FROM ALTERNATING MACHINES.

Outside wires should be treated as arc light wires; inside wires the same as incandescent circuits. Converters on alternating circuits must be outside of buildings, and must be placed high enough from the roof to prevent possible injury to firemen.

RULES TO APPLY TO THE RUNNING OF INCANDESCENT CIRCUITS WORKED FROM ARC CIRCUITS.

The running of incandescent lights or systems on arc circuits should be avoided; but wherever this is unavoidable a proper device or distributor, such as may be approved by this union, must be provided to prevent the possibility of an excessive arc current being thrown on to any one portion of the incandescent system; such device or distribution must have the approval of this union before it is put in operation. It must remain open to inspection at all times, and no change made in any part of the installation after it has been approved, without consent of this union.

Only such wire as has been approved by this union shall be used in constructing lines and circuits.

Wires must be run in plain sight. In damp places they must have a waterproof covering.

The positive wire or wires must be kept at least two and a half inches from the negative wire or wires in running from the distributor or regulator to the fixtures and lamps, and return; except "twin wire" may be used for a single lamp.

No wires should be run through partitions, floors or walls, without being incased in a tube of hard rubber, porcelain, or covered with tape. Soft rubber tube is not desirable as an insulator.

The safety fuses must be so proportioned that they will melt long before the wire is heated to an unsafe degree.

Dust must not be allowed in the distributor-box nor any of the electrical connections.

The contact points should be kept clean, and care should be taken to insure solid electrical connections at all the points of contact, and all parts must be kept free to move easily.

In case any defect should arise in the distributor or regulator, or the wiring thereto, it must be arranged so as to automatically and absolutely shunt off from the arc circuit at once.

In working distributors, the line or circuit current must be kept at its standard amount by tests made by ampere meter, from time to time. In no case must the amount exceed the standard.

Every company shall have a competent and reliable person to examine, daily, every distributor and regulator, or similar device which may in the future be applied to arc circuits.

Where incandescent lights are run on arc circuits, the following named practices are strictly prohibited:

Fastening or attaching electroliers, or lamps, to any gas fixture which may be in electrical connection with the earth.

The running of concealed wires to the electroliers, or lamps, under any circumstances. They must be entirely open to view.

The placing of any distributor box or regulator, electrolier, bracket or lamp in such a position that it may be connected in any way with any other wires, steam fittings, gas pipes, gas fixtures, etc., which may be electrically connected with the earth.

The placing of distributors, electroliers, etc., in any damp location, or in close proximity to any metals or other conductor of electricity.

The building or placing of anything around the distributor or regulator so as to cut off easy access to it, or obstruct the access of air to it.

All joints, after leaving the distributor or regulator, must be soldered, using acid as flux. Resin will not be approved under any circumstances.

All new devices should be submitted to the inspector of the union, and must be approved by him before permission can be given for their use.

While these rules are intended to be complete, some cases may arise where, in the judgment of the inspector, some deviation from them may be necessary in order to secure safety.

THE FOLLOWING FORM SHOULD BE USED IN POLICIES:

Permission is given for the installation and for the use of such wires, lights and apparatus of any electric light or electric power system, located in or on the insured premises, as have been or shall be approved by the Boston Fire Underwriters' union.

English Regulations.[1]

The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by testing or probing with electric currents. They depend chiefly on leakage, undue resistance in the conductor, and bad joints, which lead to waste of energy and the dangerous production of heat. These defects can only be detected by measuring, by means of special apparatus, the currents that are either ordinarily, or for the purpose of testing, passed through the circuit. Should wires become perceptibly warmed by the ordinary current, it is an indication that they are too small for the work they have to do, and that they should be replaced by larger wires. Bare or exposed conductors should always be within visual inspection, and as far out of reach as possible, since the accidental falling on to, or the thoughtless placing of, other conducting bodies upon such conductors would lead to short circuiting, and the consequent sudden generation of heat, due to an increased current, in conductors not adapted to carry it with safety.

The necessity can not be too strongly urged for guarding against the presence of moisture, and the use of earth as part of the circuit tends to magnify every other source of difficulty and danger.

The chief dangers of every new application of electricity arise from ignorance and inexperience on the part of those who supply and fit up the requisite plant.

The greatest element of safety is therefore the employment of skilled and experienced electricians to supervise the work.

I. — THE DYNAMO MACHINE.

1. The dynamo machine should be fixed in a dry place.
2. It should not be exposed to dust or flyings.

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1 Rules and regulations for the prevention of fire risks arising from electric lighting, recommended by the council in accordance with the report of the committee appointed by the Society of Telegraph Engineers and of Electricians, May 11, 1882.

3. It should be kept perfectly clean and its bearings well oiled.

4. The insulation of its coils and conductors should be practically perfect.

5. All conductors in the dynamo room should be firmly supported, well insulated, conveniently arranged for inspection, and marked or numbered.

II. — THE WIRES.

6. Every switch or commutator used for turning the current on or off should be constructed so that when it is moved and left it can not permit of a permanent arc or of heating.

7. Every part of the circuit should be so determined that the gauge of wire to be used is properly proportioned to the currents it will have to carry, and all junctions with a smaller conductor should be fitted with a suitable safety fuse or protector, so that no portion of the conductor should ever be allowed to attain a temperature exceeding 150° Fah.

8. Under ordinary circumstances, complete metallic circuit should be used; the employment of gas or water pipes as conductors, for the purpose of completing the circuit, should not in any case be allowed.

9. Bare wires passing over the tops of houses should never be less than seven feet clear of any part of the roof, and all wires crossing thoroughfares should invariably be high enough to allow fire escapes to pass under them.

10. It is most essential that joints should be electrically and mechanically perfect and united by solder.

11. The position of wires when underground should be clearly indicated, and they should be laid down so as to be easily inspected and repaired.

12. All wires used for indoor purposes should be efficiently insulated, either by being covered throughout with some insulating medium, or, if bare, by resting on insulated supports.

13. When these wires pass through roofs, floors, walls, or partitions, or where they cross or are liable to cross metallic masses, like iron girders or pipes, they should be thoroughly protected by suitable additional covering; and where they are liable to abrasion from any cause, or to the depredations of rats or mice, they should be efficiently encased in some hard material.

14. Where indoor wires are put out of sight, as beneath

flooring, they should be thoroughly protected from mechanical injury, and their position should be indicated.

N. B. — The value of frequently testing the apparatus and circuits can not be too strongly urged. The escape of electricity can not be detected by the sense of smell, as can gas, but it can be detected by apparatus far more certain and delicate. Leakage not only means waste, but in the presence of moisture it means destruction of the conductor and its insulating covering, by electric action.

III. — LAMPS.

15. Arc lamps should always be guarded by proper lanterns, to prevent danger from falling incandescent pieces of carbon, and from ascending sparks. Their globes should be protected with wire netting.

16. The lanterns, and all parts which are to be handled, should be insulated from the circuit.

IV. — DANGER TO PERSON.

17. Where bare wire out of doors rests on insulating supports, it should be coated with insulating material, such as india-rubber tape or tube, for at least two feet on each side of the support.

18. To secure persons from danger inside buildings, it is essential so to arrange and protect the conductors and fittings that no one can be exposed to the shock of alternating currents of a mean electromotive force exceeding 100 volts, or to continuous currents of 200 volts.

19. If the difference of potential within any house exceeds 200 volts, the house should be provided with a switch, so arranged that the supply of electricity can be at once cut off.

Abstract of the Chicago Electric Light Laws.

No plant shall be run without a certificate of inspection from the superintendent of city telegraph. No wire of less conductivity than number 6 B. & S. copper shall be used for arc lights. The conductors shall be fire-proof coated and well insulated, run eight inches apart on insulators along walls and ceilings, well insulated through walls, floors, etc. Lamps must have globes and be protected from accidental contact, and where light, inflammable matters are near, the globes must have wire screen spark protectors. Where dynamos are open to the public they must be protected by rail or screen. Incandescent circuits may be run in moldings, but in all cases soft fusible metal strips of proper size must be placed at each branching of the wire.

The insulation resistance required is one megohm (1,000,000 ohms), and the inspection fee is $1 per horse power used—one ordinary arc light being allowed per horse power, or ten 16 candle power incandescent lamps.

The plant cannot be legally altered after inspection, except by first notifying the city electrician. While the plant remains in the same condition as at the date of the certificate, that document is valid.

Violation of any one of the above requirements subjects the party so transgressing to a fine of from $50 to $100 for each day the infraction is continued.

Overhead Conductors for Electric Light and Power.[1]

I. No two lines of poles bearing conductors of a like class shall be erected on any street or avenue.

II. No two lines of poles shall be erected on the same side of any street or avenue.

III. Poles shall be set in the sidewalk twelve inches from the outside of curb, and no pole shall be placed within ten feet of any lamp post or other pole, except at street corners where necessary in order to support wires running on the cross street.

IV. All poles now standing, or to be hereafter erected, shall be branded or stamped with the initials of the company owning them, at a point not less than five nor more than seven feet from the street surface; and when a pole is occupied by wires belonging to more than one company, each group of cross-arms, or where necessary the support of a single wire of different ownership, must be distinguished by some characteristic paint, mark or fastening.

V. Electric light lamp posts shall be in accordance with the plan adopted by the board.

VI. All poles erected for the purpose of carrying lines of more than two electric light or power wires shall be at least forty-five feet high, uniform in size, straight, and painted from top to bottom—a very dark color from the sidewalk

[1] Rules and Regulations of the Board of Electrical Control, New York.

to a point eight feet high, and a dark green color above that.

VII. All poles for carrying not more than two electric light wires shall be twenty-five feet high, straight, uniform in size, and painted from top to bottom—a very dark color from the sidewalk to a point eight feet high, and a dark green color above that.

VIII. Cross-arms shall be uniform in length, strengthened by braces, and painted the same color as the poles; the cross-arms of each company being distinguished by some characteristic mark.

IX. Each line of poles must be run on one side of the street only, except when absolutely necessary to change to the other side; but this may only be done by the permission of the board or of its engineer or expert.

X. Electric light conductors must not be placed upon fixtures erected or maintained for supporting wires of the other class, namely those for signalling, except by permission of the board.

XI. Poles shall be uniformly spaced, and about sixty to the mile. This requires on the short city blocks of two hundred and sixty feet, alternately three and two poles to the block.

XII. All conductors shall be secured to insulating fastenings, and covered with an insulation which is waterproof on the outside, and not easily worn by abrasion. Whenever the insulation becomes impaired it must be renewed immediately.

XIII. No wire shall be stretched within four inches of any pole, building or other object, without being attached to it and insulated therefrom.

XIV. Every wire must be distinguished by a number plainly marked on each cross-arm under the insulator.

XV. No unused loops from electric light circuits shall be allowed to remain after lamps are taken away, except in cases where it is positively known that the lamp will be required again within three months, and where there is no underground conduit for that class of circuits.

XVI. All arc lamps must be so placed as to leave a space underneath of nine (9) feet clear between lamp and sidewalk.

XVII. All wires must be stretched tightly and fastened to glass or porcelain insulators, approved by the expert, with a strap of the same kind of wire.

XVIII. All connections with lines of electric light conductors shall be made at right angles to the same; and connections to buildings shall be run straight across to the building, and then down the front of the building.

XIX. All joints must be as well insulated as the conductors, and the insulation of joints must be maintained.

XX. Every line entering a building shall be controlled by a cut-off placed near the entrance, in sight, and easily accessible.

XXI. No wires shall hang within twenty feet of the pavement at the lowest point of sag between supports.

XXII. In the construction of lines the insulation to be used must be approved by the expert of the board in writing, and the insulation resistance must be maintained in accordance with a standard to be not less than 1–80 megohm per mile per hundred volts. And under no circumstances shall underwriters' wire be used.

XXIII. All circuits must be tested every hour, and when a ground comes on, effort must be made to remove it at once. Failing in this, the current must be discontinued until the insulation is restored.

XXIV. The insulation must be preserved throughout the entire circuit, and if any portion of a lamp or fixture is a part of the circuit and can be touched, it must be insulated.

XXV. All conductors shall have a resistance uniformly distributed of not more than 30 ohms per mile per ampere, and proportionately less for heavier currents.

XXVI. All existing regulations of the local authorities in regard to the placing of poles and the stringing of wires are to continue in force, except when in conflict with these rules; and the rules and regulations of the New York Board of Fire Underwriters must be strictly observed.

XXVII. The violation of any of the rules and regulations of the board shall operate *ipso facto* as a revocation of the permit held by the company or person guilty of such violation.

XXVIII. Whenever hereafter any company shall be permitted by this board, or its successors, to erect posts or poles, or other fixtures bearing lamps or other devices, for the purpose of lighting by electricity the streets, avenues, highways, parks or public places of the city, the said permission shall be granted only subject to the following provisions, and the same is hereby expressly made a condition of such permits. At any time when, by action of the city authorities, the contract for lighting any such street or other public place shall be given to another company, the company erecting said lamp posts shall, on tender of the first cost thereof, yield possession and ownership of the same to the said other company obtaining the new contract, except in cases where the company owning the lamp posts prefers to remove them.

XXIX. All broken and "dead" wires, and all wires, poles and fixtures not actually in use—subject to Rule XV—must be removed from the streets, avenues and highways of the city. When an old pole is taken down it must be removed from the streets the same day. New poles must not be brought upon any street more than two days in advance of their erection. Any pole that shall lie on any street more than two days shall be removed by the Bureau of Incumbrances of the Department of Public Works, at the expense of the party owning it.

XXX. From and after the first of January, 1889, no company shall do business of arc electric lighting in the city of New York without a certificate of the board granted on the recommendation and after inspection by the expert of the board, to the effect that its lines comply with all the rules and regulations of the board, and that its plant is in proper condition for the doing of its business. The force of the certificate to continue until changes are made, of which the board must be notified and approve, or so long as the plant and conductors remain in the same condition as when inspected.

XXXI. Every lineman must wear a badge in a conspicuous place, giving his number and the name of the company by whom he is employed.

XXXII. All permits of the board for overhead wires and fixtures are granted only pending the providing of underground accommodations in the neighborhood of the street or avenue for which the permit is granted.

XXXIII. Any member or officer of the board, and every inspector employed by it, as well as every member of the police force of the city, shall be entitled to examine permits under which work of any kind is being done.

XXXIV. No permit shall be granted for the erection of any overhead structure nor for the renewing of any lines already existing in any street, avenue or highway in which underground accommodations for the service have been provided, or are being provided.

XXXV. Every line, pole, fixture, etc., must be kept in thorough order, repair, and conformity with these rules and specifications, upon penalty of forfeiture of all permits granted to the owner by this board.

But the general permit under which these repairs are to be made does not cover the erection in any street, avenue or highway of any new poles or other similar fixtures, and has absolutely no reference whatever to lines which have been ordered underground by the board, and which the mayor has been requested to remove.

In the case of such lines, where notice has been given that underground accommodations have been provided, and the ninety days of notice required by law have elapsed, and the mayor has been requested to remove the same, companies owning or operating said lines are not authorized to make any repairs or connections or to go upon the poles bearing such lines for any purpose whatever, except to remove the said lines of electrical conductors in conformity with the directions of the board.

Any deviation from this rule requires a resolution passed at a regular meeting of the board, attested by the secretary.

XXXVI. Every company or person erecting poles, wires or fixtures must make and leave, at least once each week, at the office of the board, such records of the fixtures, etc., which they are erecting, and of all of the same that they have in use, as are required by the engineer and the electrical expert of the board, and in such form as shall be prescribed by them.

XXXVII. The companies or persons owning or controlling poles in any street or avenue, erected under permits of this board or the Board of Electrical Subways, shall allow the same to be used by other companies or persons operating conductors for similar electrical service when authorized so to do by the board, on tender of proper compensation, to be determined by agreement between the parties interested. In default of such an agreement the amount of such compensation shall be determined by the board. This rule imports a contract on the part of each company or person owning or controlling the poles on any street or avenue, not only with the board but also with each company or person who shall under its terms be qualified to demand the privileges it confers, to permit this joint use of poles.

And in accepting any permit the applicant thereby binds himself to this agreement.

ELECTRIC LIGHT CONDUCTORS.

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
Brown & Sharpe	Diameter.		Square of Diam.	Sectional Area.	Weight.			Length.		Resistance of pure copper wire at 75 degrees F. (23.89 deg. cent.)			Car'y'g c'pac'y **
					Naked.		* Insul.	Naked.	* Insul.				
No.	Mils.	Millimetres.	Mils.	Square millimetres.	Grains per Foot.	Pounds per 1000 ft.	Po'nds per 1000 ft.	Feet per Pound.	Feet per Pound.	Ohms per 1000 ft.	Feet per Ohm.	Ohms per Pound (naked)	Amperes.
0000	460.000	11.684	211600.0	107.219	4475.33	639.33	......	1.56	....	.051	19605.69	.0000798	160
000	409.640	10.405	167805.0	85.028	3549.07	507.01	......	1.97	....	.064	15547.87	.000127	130
00	364.800	9.266	133079.4	67.431	2814.62	402.09	440.6	2.49	2.27	.081	12330.36	.000202	110
0	324.950	8.254	105592.5	53.504	2233.28	319.04	355.9	3.13	2.81	.102	9783.63	.000320	95
1	289.300	7.348	83694.2	42.409	1770.13	252.88	284.8	3.95	3.52	.129	7754.66	.000510	80
2	257.630	6.544	66373.0	33.632	1403.79	200.54	235.3	4.99	4.25	.163	6149.78	.000811	65
3	229.420	5.827	52634.0	26.670	1113.20	159.03	190.5	6.29	5.25	.205	4876.73	.001289	55
4	204.310	5.189	41742.0	21.151	882.85	126.12	158.0	7.93	6.33	.259	3867.62	.00205	50
5	181.940	4.621	33102.0	16.773	700.10	100.01	126.9	10.00	7.88	.326	3067.06	.00326	40
6	162.020	4.115	26250.5	13.301	555.20	79.32	101.7	12.61	9.83	.411	2432.22	.00518	35
7	144.280	3.665	20816.0	10.548	440.27	62.90	85.7	15.90	11.67	.519	1928.75	.00824	30
8	128.490	3.264	16509.0	8.366	349.18	49.88	68.8	20.05	14.54	.654	1529.69	.01311	25
9	114.430	2.907	13094.0	6.635	276.94	39.56	53.8	25.28	18.58	.824	1213.22	.02083	20
10	101.890	2.588	10381.0	5.260	219.57	31.37	46.9	31.88	21.33	1.040	961.91	.03314	17
11	90.742	2.305	8234.0	4.172	174.15	24.88	36.4	40.20	27.46	1.311	762.93	.05269	14
12	80.808	2.053	6529.9	3.309	138.11	19.73	30.9	50.69	32.38	1.653	605.03	.08377	12
13	71.961	1.828	5178.4	2.618	109.52	15.65	25.5	63.91	39.25	2.084	479.80	.1332	10
14	64.084	1.628	4106.8	2.081	86.86	12.41	20.3	89.59	49.21	2.628	380.51	.2118	8
15	57.068	1.450	3256.7	1.650	68.88	9.84	15.8	101.63	63.29	3.314	301.75	.3368	7
16	50.820	1.291	2582.9	1.309	54.63	7.81	14.8	128.14	67.60	4.179	239.32	.5355	6
17	45.257	1.150	2048.2	1.038	43.32	6.19	12.6	161.59	79.58	5.269	189.78	.8515	5
18	40.303	1.024	1624.3	.8230	34.35	4.91	10.8	203.76	92.46	6.645	150.50	1.354	4
19	35.390	.899	1252.4	.6346	26.49	3.78	9.3	264.26	107.83	8.617	116.05	2.277	3
20	31.961	.812	1021.5	.5176	21.61	3.09	9.1	324.00	110.25	10.566	94.65	3.423	3

* The insulation here estimated is the regular D. B. painted Underwriters' approved.
** Wire heated to 10 deg. C. or 18 deg. F. above temperature of surrounding air.

Lamp Lighting Schedule—Moonlight System for 1891.

JANUARY.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	5.10 P. M.	1.......	11.50 P. M.	6.40
2..........	5.10 "	3.......	12.50 A. M.	7.40
3..........	5.10 "	4.......	1.50 "	8.40
4..........	5.20 "	5.......	3.00 "	9.40
5..........	5.20 "	6......	4.00 "	10.40
6..........	5.20 "	7.......	5.10 "	11.50
7..........	5.20 "	8.......	6.20 "	13.00
8..........	5.20 "	9.......	6.20 "	13.00
9..........	5.20 "	10.......	6.20 "	13.00
10..........	5.20 "	11.......	6.20 "	13.00
11..........	5.20 "	12.......	6.20 "	13.00
12..........	5.20 "	13.......	6.20 "	13.00
13..........	5.20 "	14.......	6.20 "	13.00
14.........	9.00 "	15	6.20 "	9.20
15..........	10.10 "	16.......	6.20 "	8.10
16..........	11.20 "	....	.....	7.00
17..........	.....	17.......	6.20 "	
18..........	12.30 A. M.	18.......	6.20 "	5.50
19..........	1.40 "	19.......	6.20 "	4.40
20..........	2.40 "	20.......	6.20 "	3.40
21..........	3.50 "	21	6.20 "	2.30
22..........	4.40 "	22.......	6.20 "	1.40
23..........	No light.	23.......	No light.	0.00
24..........	No light.	24.......	No light.	0.00
25..........	No light.	25.......	No light.	0.00
26..........	5.40 P. M.	26.......	7.50 P. M.	2.10
27..........	5.40 "	27.......	8.50 "	3.10
28..........	5.40 "	28.	9.40 "	4.00
29..........	5.40 "	29.......	10.40 "	5.00
30..........	5.50 "	30.......	11.40 "	5.50
31..........	5.50 "	Feb. 1...	12.40 A. M.	6.50
	Total number of hours,			216.00

The foregoing schedule was calculated on the following basis:

Light one-half hour after sunset and one hour before moonset.

Extinguish one hour after moonrise and one hour before sunrise.

FEBRUARY.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	5.50 P. M.	2.......	1 50 A. M.	8.00
2..........	5.50 "	3.......	2.50 "	9.00
3..........	5.50 "	4.......	4.00 "	10.10
4..........	5.50 "	5.......	5.10 "	11.20
5..........	5.50 "	6	6.10 "	12.20
6..........	5.50 "	7.......	6 00 "	12.10
7..........	6.00 "	8.......	6.00 "	12.00
8..........	6.00 "	9.......	6.00 "	12.00
9..........	6.00 "	10.......	6 00 "	12.00
10..........	6.00 "	11.......	6 00 "	12.00
11..........	6.00 "	12.......	6.00 "	12.00
12..........	9.10 "	13.......	6.00 "	8.50
13	10.20 "	14.......	6.00 "	7.40
14..........	11.30 "	....	.....	} 6.20
15..........	.....	15.......	5.50 "	
16..........	12.40 A. M.	16.......	5.50 "	5.10
17..........	1.40 "	17.......	5.50 "	4.10
18..........	2.40 "	18.......	5.50 "	3.10
19..........	3.40 "	19.......	5.50 "	2.10
20	4.20 "	20.......	5.50 "	1.30
21..........	5.00 "	21.......	5.50 "	0.50
22..........	No light.	22.......	No light.	0.00
23..........	No light.	23.......	No light.	0.00
24..........	No light.	24.......	No light.	0.00
25..........	6.20 P. M.	25.......	8.40 P. M.	2.20
26..........	6.20 "	26.......	9.40 "	3.20
27..........	6.20 "	27.......	10.40 "	4.20
28..........	6.20 "	28.......	11.40 "	5.20

Total number of hours, 178.10

The foregoing schedule was calculated on the following basis:

Light one-half hour after sunset and one hour before moonset.

Extinguish one hour after moonrise and one hour before sunrise.

MARCH.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1	6.20 P. M.	2	12.40 A. M.	6.20
2	6.20 "	3	1.50 "	7.30
3	6.20 "	4	3.00 "	8.40
4	6.20 "	5	4.00 "	9.40
5	6.30 "	6	5.00 "	10.30
6	6.30 "	7	5.30 "	11.00
7	6 30 "	8	5.20 "	10.50
8	6.30 "	9	5.20 "	10.50
9	6.30 "	10	5.20 "	10.50
10	6.30 "	11	5.20 "	10.50
11	6.30 "	12	5.20 "	10.50
12	6.30 "	13	5.20 "	10.50
13	6.30 "	14	5.10 "	10.40
14	10.20 "	15	5.10 "	6.50
15	11.30 "	....	.....	} 5.40
16	....	16	5.10 "	
17	12.30 A. M.	17	5.10 "	4.40
18	1.30 "	18	5.10 "	3.40
19	2.20 "	19	5.10 "	2.50
20	3.00 "	20	5.00 "	2.00
21	3 40 "	21	5.00 "	1.20
22	4.10 "	22	5.00 "	0.50
23	No light.	23	No light.	0.00
24	No light.	24	No light.	0.00
25	No light.	25	No light.	0.00
26	6.50 P. M.	26	8.30 P. M.	1.40
27	6.50 "	27	9.30 "	2.40
28	6.50 "	28	10.40 "	3.50
29	6.50 "	29	11.40 "	4.50
30	6.50 "	31	12.50 A. M.	6.00
31	6.50 "	April 1...	1.50 "	7.00
		Total number of hours,		183.10

The foregoing schedule was calculated on the following basis:
Light one-half hour after sunset and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

APRIL.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1	6.50 P. M.	2	2.50 A. M.	8.00
2	7.00 "	3	3.50 "	8.50
3	7.00 "	4	4.30 "	9.30
4	7.00 "	5	4.40 "	9.40
5	7.00 "	6	4.40 "	9.40
6	7.00 "	7	4.30 "	9.30
8	7.00 "	9	4.30 "	9.30
9	7.00 "	10	4.30 "	9.30
10	7.00 "	11	4.30 "	9.30
11	7.00 "	12	4.30 "	9.30
12	10.20 "	13	4.30 "	6.10
13	11.20 "	....	....	} 5.00
14	....	14	4.20 "	
15	12.20 A. M.	15	4.20 "	4.00
16	1.00 "	16	4.20 "	3.20
17	1.40 "	17	4.20 "	2.40
18	2.10 "	18	4.20 "	2.10
19	2.40 "	19	4.20 "	1.40
20	3.00 "	20	4.10 "	1.10
21	3.20 "	21	4.10 "	0.50
22	No light.	22	No light.	0.00
23	No light.	23	No light.	0.00
24	No light.	24	No light.	0.00
25	7.20 P. M.	25	9.30 P. M.	2.10
26	7.20 "	26	10.40 "	3.20
27	7.20 "	27	11.50 "	4.30
28	7.20 "	29	12.50 A. M.	5.30
29	7.20 "	30	1.40 "	6.20
30	7.20 "	May 1 ...	2.30 "	7.10
			Total number of hours,	149.10

The foregoing schedule was calculated on the following basis:
Light one-half hour after sunset, and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

MAY.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	7.30 P. M	2.......	3.10 A. M.	7.40
2..........	7.30 "	3.......	3.50 "	8.20
3..........	7.30 "	4.......	3 50 "	8.20
4..........	7.30 "	5.......	3.50 "	8.20
5..........	7.30 "	6.......	3.50 "	8.20
6..........	7.30 "	7.......	3.50 "	8.20
7..........	7.30 "	8.......	3.50 "	8.20
8..........	7.30 "	9	3.50 "	8.20
9..........	7.30 "	10.......	3.50 "	8.20
10..........	7.40 "	11.......	3.50 "	8.10
11..........	7.40 "	12.......	3.50 "	8.10
12..........	11.00 "	13.......	3.50 "	4.50
13..........	11.40 "	....	.....	} 4.00
14..........	.....	14.......	3.40 "	
15..........	12.10 A. M.	15	3.40 "	3.30
16..........	12.40 "	16.......	3.40 "	3.00
17.........	1.10 "	17.......	3.40 "	2.30
18..........	1.30 "	18.......	3.40 "	2.10
19..........	1.50 "	19.......	3.40 "	1.50
20..........	2.10 "	20.......	3.40 "	1.30
21..........	No light.	21.......	No light.	0.00
22..........	No light.	22	No light.	0.00
23	No light.	23.......	No light.	0.00
24..........	7.50 P. M	24.......	9.40 P. M	1.50
25.........	7.50 "	25.......	10.40 "	2.50
26..........	7.50 "	26......	11.40 "	3.50
27	7.50 "	27.......	12.30 A. M	4.40
28..........	7.50 "	29.......	1.10 "	5.20
29	7.50 "	30......	1.50 "	6.00
30..........	7.50 "	31.......	2.20 "	6.30
31..........	7.50 "	June 1...	2.50 "	7.00
		Total number of hours,		152.00

The foregoing schedule was calculated on the following basis:
Light one-halt hour after sunset and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

JUNE.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	7.50 P. M.	2.......	3.10 A. M.	7.20
2..........	8.00 "	3.......	3.30 "	7.30
3..........	8.00 "	4.......	3.30 "	7.30
4..........	8.00 "	5.......	3.30 "	7.30
5..........	8.00 "	6.......	3.30 "	7.30
6..........	8.00 "	7.......	3.30 "	7.30
7..........	8.00 "	8.......	3.30 "	7.30
8..........	8.00 "	9.......	3.30 "	7.30
9..........	8.00 "	10.......	3.30 "	7.30
10..........	10.10 "	11.......	3.30 "	5.20
11..........	10.40 "	12.......	3.30 "	4.50
12..........	11.10 "	13.......	3.30 "	4.20
13..........	11.30 "	14.......	3.30 "	4.00
14..........	11.50 "	....	.....	3.40
15..........	.....	15.......	3.30 "	
16..........	12.10 A. M.	16.......	3.30 "	3.20
17..........	12.40 "	17.......	3.30 "	2.50
18..........	1.00 "	18.......	3.30 "	2.30
19..........	1.30 "	19.......	3.30 "	2.00
20..........	No light.	20.......	No light.	0.00
21..........	No light.	21.......	No light.	0.00
22..........	No light.	22.......	No light.	0.00
23..........	8.10 P. M.	23.......	10.30 P. M.	2.20
24..........	8.10 "	24.......	11.10 "	3.00
25..........	8.10 "	25.......	11.50 "	3.40
26..........	8.10 "	27.......	12.20 A. M.	4.10
27..........	8.10 "	28.......	12.50 "	4.40
28..........	8.10 "	29.......	1.20 "	5.10
29..........	8.10 "	30.......	1.40 "	5.30
30..........	8.10 "	July 1....	2.10 "	6.00
			Total number of hours,	134.40

The foregoing schedule was calculated on the following basis:
Light one-half hour after sunset and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

JULY.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	8.10 P. M.	2.......	2.40 A. M.	6.30
2..........	8.10 "	3.......	3.20 "	7.10
3..........	8.00 "	4.......	3.30 "	7.30
4..........	8.00 "	5.......	3.30 "	7.30
5..........	8.00 "	6.......	3 40 "	7.40
6..........	8.00 "	7.......	3.40 "	7.40
7..........	8.00 "	8.......	3.40 "	7.40
8..........	8.00 "	9.......	3.40 "	7.40
9..........	8.00 "	10.......	3.40 "	7.40
10..........	9.30 "	11.......	3.40 "	6.10
11..........	10.00 "	12.......	3.40 "	5.40
12..........	10.20 "	13.......	3.40 "	5.20
13..........	10.40 "	14.......	3.40 "	5 00
14..........	11.00 "	15.......	3 40 "	4.40
15..........	11.30 "	16.......	3.40 "	4.10
16..........	12.00 M.	....	....	3.40
17..........	.....	17.......	3.40 "	
18..........	12.30 A. M.	18.......	3.40 "	3.10
19..........	1.20 "	19.......	3.40 "	2.20
20..........	No light.	20.......	No light.	0.00
21..........	No light.	21.......	No light.	0.00
22..........	No light.	22.......	No light.	0.00
23..........	7.50 P. M.	23.......	10.20 P. M.	2.30
24..........	7.50 "	24.......	10.50 "	3.00
25..........	7.50 "	25.......	11.20 "	3.30
26..........	7.50 "	26.......	11.50 "	4.00
27..........	7.50 "	28.......	12.10 A. M.	4.20
28..........	7.50 "	29.......	12.40 "	4.50
29..........	7.50 "	30.......	1.20 "	5.30
30..........	7.50 "	31.......	1.50 "	6.00
31..........	7.50 "	Aug. 1...	2,40 "	6.50
		Total number of hours,		157.40

The foregoing schedule was calculated on the following basis:

Light one-half hour after sunset and one hour before moonset.

Extinguish one hour after moonrise and one hour before sunrise.

AUGUST.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	7.50 P. M.	2.......	3.30 A. M.	7.40
2..........	7.50 "	3.......	4.00 "	8.10
3..........	7.40 "	4.......	4.00 "	8.20
4..........	7.40 "	5.......	4.00 "	8.20
5..........	7.40 "	6.......	4.00 "	8 20
6..........	7.40 "	7.......	4.00 "	8.20
7..........	7.40 "	8.......	4.00 "	8.20
8..........	8.20 "	9	4.00 "	7.40
9..........	8.40 "	10.......	4.10 "	7.30
10..........	9.00 "	11.......	4.10 "	7.10
11..........	9.30 "	12.......	4.10 "	6.40
12..........	9.50 "	13.......	4.10 "	6.20
13	10.30 "	14.......	4.10 "	5.40
14..........	11.10 "	....	.....	} 5.00
15..........	....	15.......	4.10 "	
16..........	12.00 A. M.	16.......	4.10 "	4.10
17..........	1.00 "	17.......	4.10 "	3.10
18..........	No light.	18.......	No light.	0.00
19..........	No light.	19.......	No light.	0.00
20..........	No light.	20.......	No light.	0.00
21..........	7.20 P. M.	21.......	9.20 P. M.	2.00
22..........	7.20 "	22.......	9.50 "	2.30
23..........	7.20 "	23.......	10.10 "	2.50
24..........	7.20 "	24.......	10.40 "	3 20
25..........	7.10 "	25.......	11.10 "	4.00
26..........	7.10 "	26.......	11.50 "	4.40
27..........	7.10 "	28.......	12.40 A. M.	5.30
28..........	7.10 "	29.......	1.30 "	6.20
29..........	7.10 "	30.......	2.30 "	7.20
30..........	7.10 "	31.......	3.20 "	8.10
31..........	7.00 "	Sept. 1...	4.30 "	9.30
	Total number of hours,			167.00

The foregoing schedule was calculated on the following basis:

Light one-half hour after sunset and one hour before moonset.

Extinguish one hour after moonrise and one hour before sunrise

SEPTEMBER.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1	7.00 P. M.	2.......	4.30 A. M.	9.30
2..........	7.00 "	3.......	4.30 "	9.30
3..........	7.00 "	4.......	4.30 "	9.30
4..........	7.00 "	5.......	4.30 "	9.30
5..........	7.00 "	6.......	4.30 "	9.30
6..........	7.00 "	7.......	4.30 "	9.30
7..........	7.30 "	8.......	4.30 "	9.00
8..........	8.00 "	9.......	4.30 "	8.30
9..........	8.30 "	10.......	4.30 "	8.00
10..........	9.00 "	11.......	4.40 "	7.40
11..........	9.50 "	12......	4.40 "	6.50
12..........	10.40 "	13.......	4.40 "	6.00
13..........	11.50 "	....	.....	4.50
14..........	.....	14	4.40 "	
15..........	1.00 A. M	15.......	4.40 "	3.40
16..........	2.20 "	16.......	4.40 "	2.20
17...... ...	No light.	17.......	No light.	0.00
18..........	No light.	18... ...	No light.	0.00
19..........	No light.	19.......	No light.	0.00
20..........	6.30 P. M.	20.......	8.40 P M.	2.10
21..........	6.30 "	21.......	9.10 "	2.40
22...	6.30 "	22......	9.50 "	3.20
23..........	6.30 "	23.......	10.30 "	4.00
24..........	6.30 "	24.......	11.20 "	4.50
25..........	6.20 "	26.......	12.20 A. M.	6.00
26..........	6.20 "	27.......	1.20 "	7.00
27.........	6.20 "	28.......	2.20 "	8.00
28..........	6.20 "	29.......	3.20 "	9.00
29..........	6.20 "	30.......	4.20 "	10.00
30..........	6.10 "	Oct. 1....	5.00 "	10.50
			Total number of hours,	181.40

The foregoing schedule was calculated on the following basis:
Light one-half hour after sunset and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

OCTOBER.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	6.10 P. M.	2.......	5.00 A. M	10.50
2..........	6.10 "	3.......	5.00 "	10.50
3..........	6.10 "	4.......	5.00 "	10.50
4..........	6.10 "	5.......	5.00 "	10.50
5..........	6.10 "	6	5.00 "	10.50
6..........	6.10 "	7.......	5.00 "	10.50
7..........	7.00 "	8.......	5.00 "	10.00
8..........	7.40 "	9.......	5.00 "	9.20
9..........	8.30 "	10.......	5.10 "	8.40
10..........	9.30 "	11.......	5.10 "	7.40
11..........	10.40 "	12.......	5.10 "	6.30
12..........	11.50 "	....	....	} 5.20
13..........	.....	13.......	5.10 "	
14..........	1.10 A. M.	14.......	5.10 "	4.00
15..........	2.30 "	15.......	5.10 "	2.40
16..........	No light.	16.......	No light.	0.00
17..........	No light.	17.......	No light.	0.00
18..........	No light.	18.......	No light	0.00
19	5.40 P. M.	19.......	7.40 P. M	2.00
20..........	5.40 "	20.	8.20 "	2.40
21..........	5.40 "	21.......	9.10 "	3.30
22..........	5.40 "	22.......	10.10 "	4.30
23	5.40 "	23.......	11.10 "	5.30
24..........	5 40 "	25.......	12.10 A. M.	6.30
25..........	5.40 "	26.......	1.10 "	7.30
26	5.40 "	27.......	2.10 "	8.30
27	5.30 "	28.......	3.10 "	9.40
28..........	5.30 "	29.......	4.10 "	10.40
29..........	5.30 "	30.......	5.10 "	11.40
30..........	5.30 "	31.......	5.30 "	12.00
31..........	5.30 "	Nov. 1..	5.30 "	12 00
		Total number of hours,		215.50

The foregoing schedule was calculated on the following basis:

Light one-half hour after sunset and one hour before moonset.

Extinguish one hour after moonrise and one hour before sunrise.

NOVEMBER.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H. M.		H. M.	H. M.
1..........	5.30 P. M.	2.......	5.30 A. M.	12.00
2..........	5.30 "	3......	5.30 "	12.00
3..........	5 30 "	4.......	5.30 "	12.00
4..........	5.20 "	5.......	5.40 "	12.20
5..........	5.20 "	6.......	5.40 "	12.20
6..........	7.20 "	7.......	5.40 "	10.20
7..........	8.30 "	8.......	5.40 "	9.10
8..........	9.40 "	9.......	5.40 "	8.00
9..........	10 50 "	....	....	6.50
10..........	.....	10.......	5.40 "	
11..........	12.10 A. M.	11.......	5.40 "	5.30
12..........	1.20 "	12......	5.40 "	4.20
13..........	2.40 "	13.......	5.40 "	3.00
14..........	3.50 "	14.......	5.50 "	2.00
15..........	No light.	15......	No light.	0.00
16..........	No light.	16.......	No light.	0.00
17..........	No light.	17......	No light.	0.00
18..........	5.10 P. M.	18.......	7.50 P. M.	2.40
19..........	5.10 "	19......	8.50 "	3.40
20..........	5.10 "	20.......	9.30 "	4.20
21..........	5.10 "	21.......	11.00 "	5.50
22..........	5.10 "	22......	12.00 "	6.50
23..........	5.10 "	24.......	1.00 A M.	7.50
24..........	5.10 "	25.......	2.00 "	8.50
25..........	5.10 "	26.......	3.00 "	9.50
26..........	5.10 "	27.......	4.00 "	10.50
27..........	5.10 "	28.......	5.00 "	11.50
28..........	5.10 "	29.......	6.00 "	12.50
29..........	5.10 "	30.......	6.00 "	12.50
30..........	5.00 "	Dec. 1...	6.00 "	13.00
			Total number of hours,	221.00

The foregoing schedule was calculated on the following basis:
Light one-half hour after sunset and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

DECEMBER.

Day of Month.	Light.	Day of Month.	Extinguish.	Number of Hours.
	H M.		H. M.	H. M.
1	5.00 P. M	2	6.10 A M.	13.10
2	5.00 "	3	6.10 "	13.10
3	5.00 "	4	6.10 "	13.10
4	5.00 "	5	6.10 "	13.10
5	7.30 "	6	6.10 "	10.40
6	8.40 "	7	6.10 "	9.30
7	10.00 "	8	6.10 "	8.10
8	11.10 "	....	....	7.00
9	....	9	6.10 "	
10	12.20 A. M.	10	6.10 "	5.50
11	1.30 "	11	6.10 "	4.40
12	2 50 "	12	6.20 "	3.30
13	4.00 "	13	6.20 "	2.20
14	No light.	14	No light.	0.00
15	No light.	15	No light.	0.00
16	No light.	16	No light.	0.00
17	5.00 P. M	17	7.40 P. M.	2.40
18	5.10 "	18	8.40 "	3.30
19	5.10 "	19	9.50 "	4.40
20	5.10 "	20	10.50 "	5.40
21	5.10 "	21	11.50 "	6.40
22	5.10 "	23	12 50 A. M.	7.40
23	5.10 "	24	1.50 "	8.40
24	5.10 "	25	2.50 "	9.40
25	5.10 "	26	3.50 "	10.40
26	5.10 "	27	4.50 "	11.40
27	5.10 "	28	6.00 "	12.50
28	5.10 "	29	6.20 "	13.10
29	5.10 "	30	6.20 "	13.10
30	5.10 "	31	6.20 "	13.10
31	5.10 "	Jan. 1, '92	6.20 "	13.10
		Total number of hours,		241.20
		Grand total of lighting hours,		2197.40

The foregoing schedule was calculated on the following basis:
Light one-half hour after sunset and one hour before moonset.
Extinguish one hour after moonrise and one hour before sunrise.

CONSTRUCTION TOOLS.

FIG. 52. — DIGGING BAR.

FIG. 53. — TAMPING BAR.

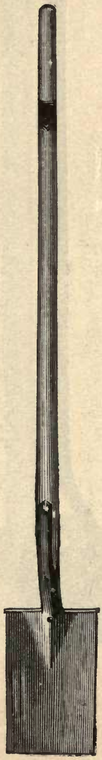

FIG. 54. — SPADE.

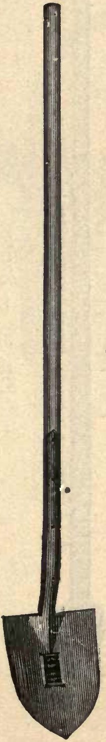

FIG. 55. — SHOVEL.

FIG. 56. — SPOON.

FIG. 57. — POST-HOLE DIGGER.

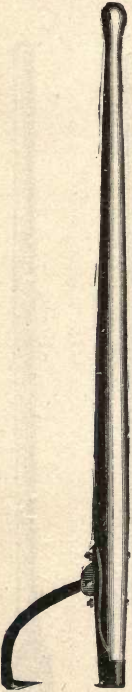

FIG. 58. — CANT HOOK.

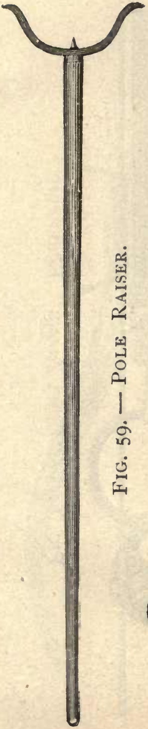

FIG. 59. — POLE RAISER.

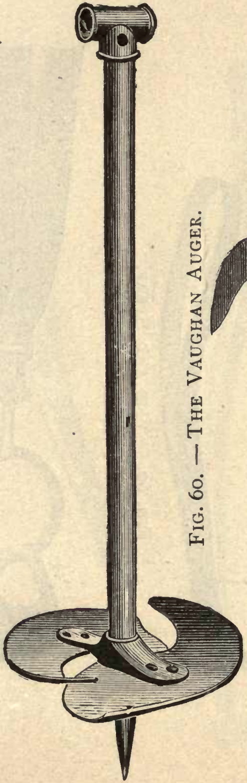

FIG. 60. — THE VAUGHAN AUGER.

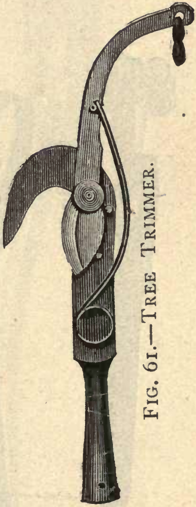

FIG. 61.—TREE TRIMMER.

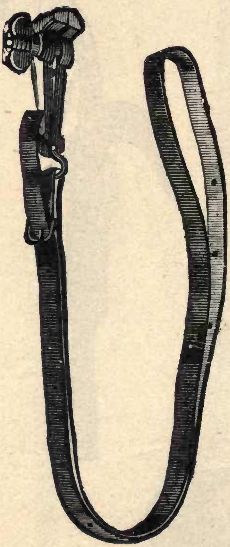

FIG. 62. — VISE AND STRAP.

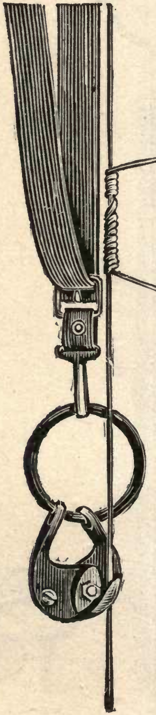

FIG. 63. — "COME ALONG" ECCENTRIC.

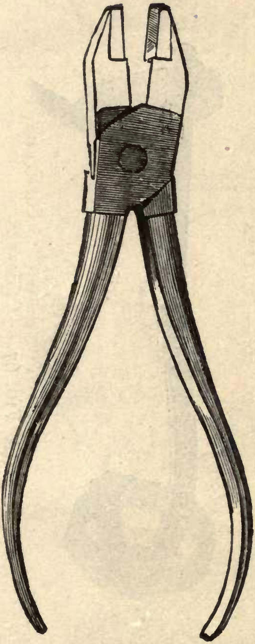

FIG. 64.—SIDE CUTTING PLIERS.

FIG. 65.—SPLICING CLAMPS.

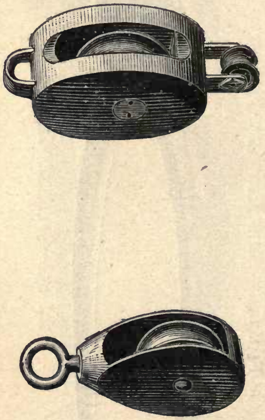

FIG. 66. — PULLEYS.

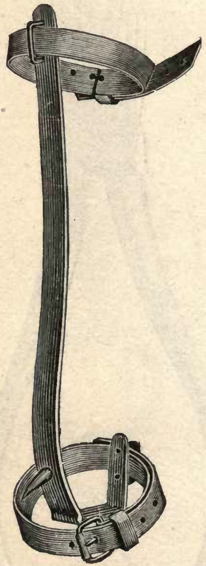

FIG. 67. — CLIMBERS.

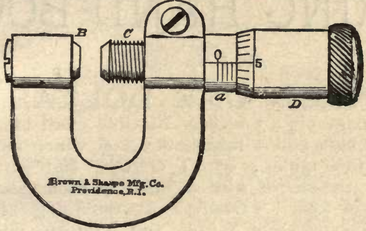

FIG. 68.—MICROMETER GAUGE.

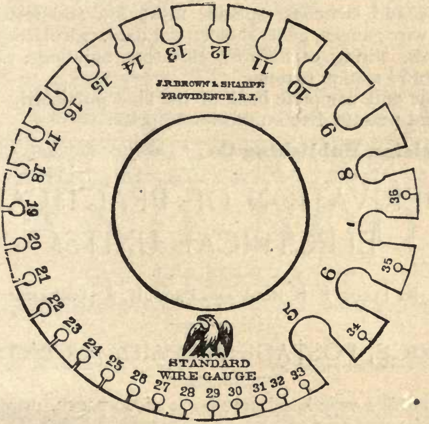

FIG. 69.—STANDARD WIRE GAUGE.

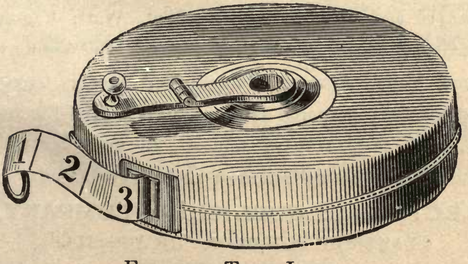

FIG. 70.—TAPE LINE.

TOOLS.

Every Tool required by Linemen, including

Augers,
Crow Bars,
Digging Bars,
Tamping Bars,
Spoons,
Shovels,
Screw-Drivers,
Plain and Guard Pikes,

Branch, 125 W. 6th St., KANSAS CITY, MO.

Factories: ANSONIA, CONN.