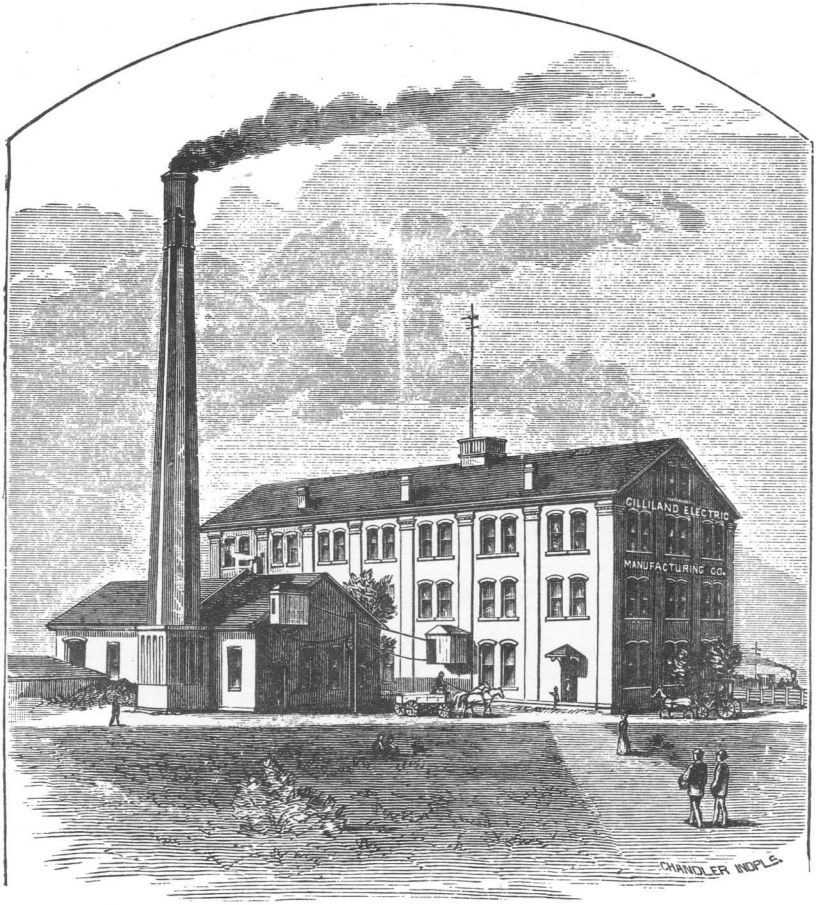
WESTERN ELECTRIC COMPANY.

NEW YORK ✦ CHICAGO ✦ INDIANAPOLIS

LICENSED BY

AMERICAN BELL TELEPHONE CO.



INDIANAPOLIS FACTORY.

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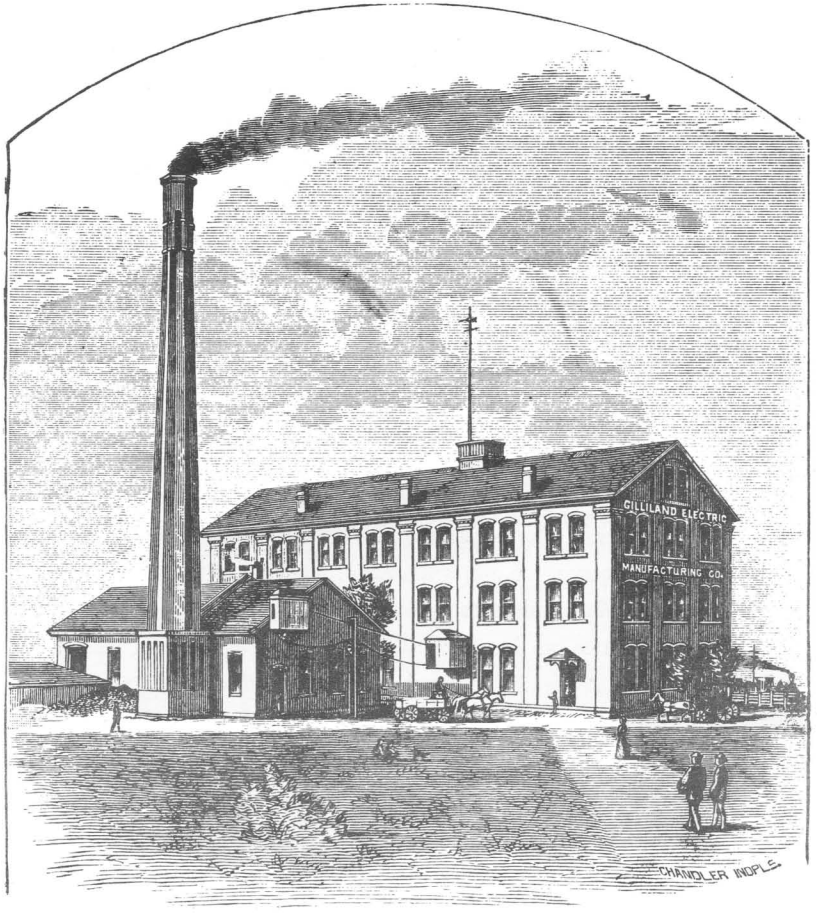


INDIANAPOLIS FACTORY.

INTRODUCTION.

THE WESTERN ELECTRIC COMPANY, having acquired the manufactory and business of the Gilliland Electric Manufacturing Company, at Indianapolis, now controls the three largest shops in America employed in the manufacture of telephone apparatus and supplies, and has about five hundred names on its different pay-rolls.

The Chicago factory succeeded by purchase or consolidation to the business of the Caton Instrument Factory of the Western Union Telegraph Company at Ottawa, Ill., and to that of Gray & Barton, and Bliss, Tillotson & Co., and Geo. H. Bliss & Co., of Chicago, and of the Electric Improvement Co., of Galesburg, Ill.

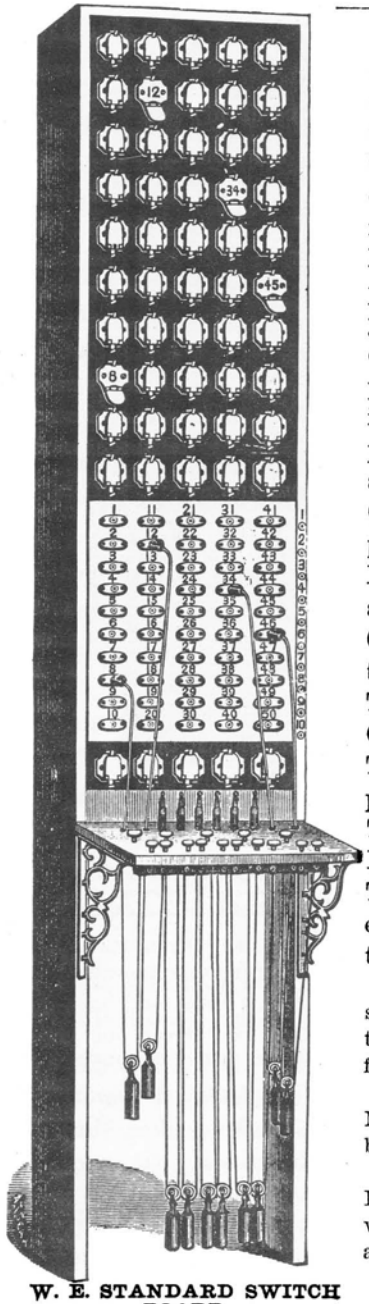
The New York factory was long and favorably known as the instrument shop of the Western Union Telegraph Co., and was acquired by this Company April 1, 1879. Since that time several departments and much special machinery have been added to the business, increasing greatly its capacity and efficiency.

The Indianapolis factory, under the management and creative ability of Mr. E. T. GILLILAND, has taken rank as *the largest establishment in the world* making an exclusive specialty of telephone apparatus. This factory will still be under the control of Mr. GILLILAND, and its aim will be in the future, as in the past, to perfect and introduce the newest and best of everything in the line of telephone appliances. With our facilities for general telegraphic and electric work, and our special resources in the line of telephone appliances, we confidently believe that we can offer superior inducements to the telephone trade, both in the perfection of our apparatus, excellence in workmanship, and reasonable price, and thereby secure a large proportion of this trade.

For convenience we have, in the following pages, used the terms "Gilliland" and "W. E." to indicate that certain apparatus originated at the Indianapolis or at the Chicago and New York factories.

Telephone Switch Boards.

W. E. STANDARD SWITCH BOARD.



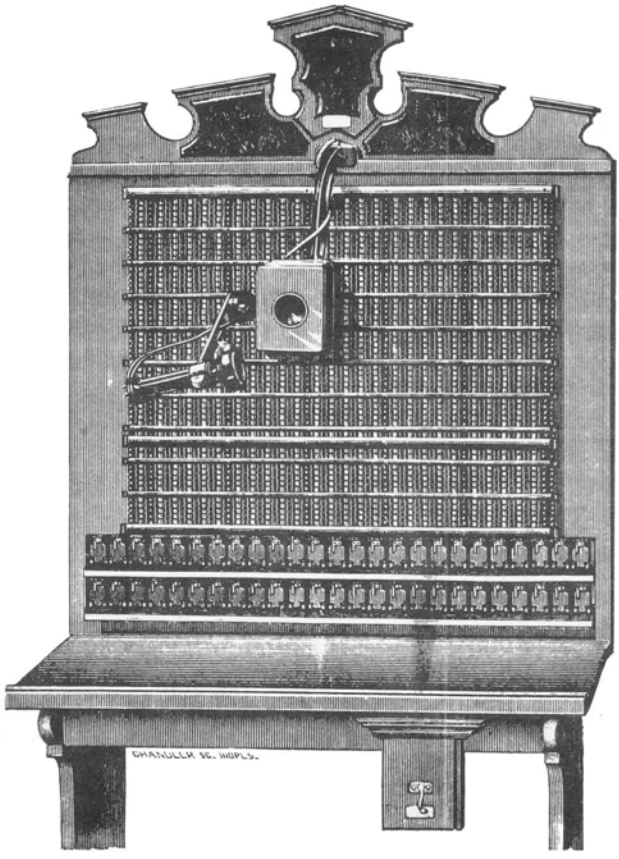
W. E. STANDARD SWITCH BOARD.

This is a cord board, with annunciator, drops and automatic switches and keys for calling and connecting telephone to subscribers' circuits. In this board the movements necessary to connect and disconnect subscribers are reduced to a minimum, and it is believed to be the simplest and most expeditious in manipulation of any board yet devised. It is now in practical operation in over two hundred telephone exchanges in this country, and is used on about forty thousand telephone lines. It is the standard board adopted by the Western Telephone Co., Central Telephone Co., Midland Telephone Co., Missouri Telephone Co., Iowa and Minnesota Telephone Co., and Iowa Telephone and Telegraph Co., and is extensively used by such telephone corporations as the Bell Telephone Co., of Buffalo, Central Ohio Telephone Co., the Connecticut Telephone Co., Empire State Telephone and Telegraph Co., Evansville Telephone Exchange, Metropolitan District Telephone Co., Northwestern Telephone Exchange Co., Southwestern Telephone and Telegraph Co., and the Wisconsin Telephone Co.

By the use of superior stock in the construction of our cords, and with weights to take up the slack of cords, the trouble from this source is reduced to a minimum.

Our boards are 14 inches wide. The No. 1 board rises 73 inches, and the No. 2 board rises 60 inches from the floor.

A complete description of this Switch Board is given in our Catalogue No. XIV, which we send free to telephone people on application.



THE GILLILAND SWITCH BOARD.

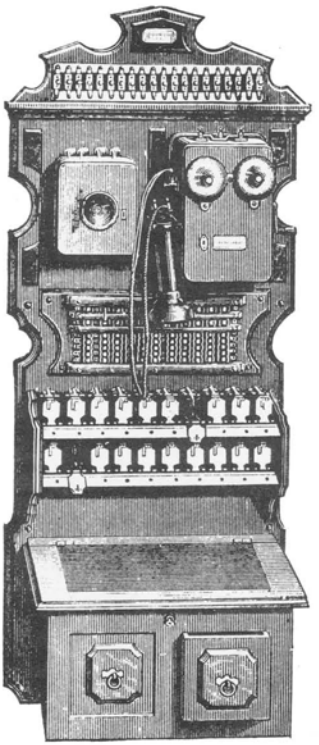
This board is a peg board, and is arranged for table operators. It has met with the most favor of any board of this class, and has had a very extensive sale in this country and for Europe. Over one thousand boards have been made, having a capacity for over fifty thousand telephone lines. Among the principal cities using it are Boston, Buffalo, Chicago, Denver, Louisville, Memphis, Milwaukee, Montreal, New Orleans, Omaha, and Salt Lake. Recent improvements have been made in the details, including the drops and the cabinet work. It continues to hold its own as the foremost peg board of the country. We make two kinds of these boards—designated as number one and number two board.

THE MULTIPLE SWITCH BOARD.

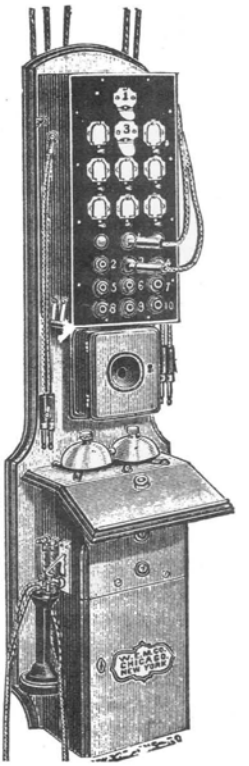
It is becoming generally recognized that the Multiple Switch Board is the switch board which will solve the problem of large exchanges. It is now in use in Indianapolis with 900 subscribers, in Columbus, Ohio, with 600 subscribers, and in Toledo, Ohio, with 500 subscribers. A 600-wire board is being set up in Nashville, and several other exchanges are considering the question of its adoption. It is a fact, that with this system two thousand or more subscribers can be handled in one office just as promptly and as satisfactorily to the subscribers as one or two hundred can be by any other system. At Indianapolis, with 900 subscribers in one office, the average time in making connections is *ten seconds*, counting from the time the drop falls; and this rate can be maintained with any number of subscribers which can be got into one exchange. We believe that we control the broad principles and the general details of construction of all multiple systems. Our inventions comprise all the work in this line of the following gentlemen: L. B. Firman, C. H. Wilson, C. C. Haskins, C. E. Scribner, M. G. Kellogg, J. I. Sabin, E. T. Gilliland, Geo. M. Phelps, Jr., and F. E. Kinsman.

Having for some time believed in the great utility of this system, we have, by the purchase of patents and the encouragement of invention, aimed to secure to the licensees of the American Bell Telephone Company the exclusive use of the invention. We ask the careful investigation and consideration of the merits of the system by all such licensees who may now have over five hundred subscribers, or who expect that their exchanges will grow to that number. By adopting the system now, the service may be improved at once, and at the same time the necessity may be avoided of purchasing apparatus which may in time require to be abandoned. To those who do not plan for a large number of subscribers, we of course recommend our other forms of board.

PONY SWITCH BOARDS.



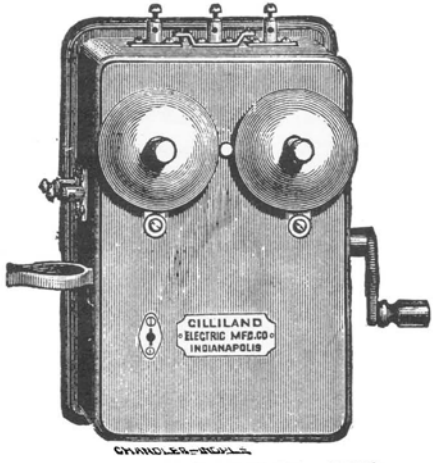
GILLILAND PONY SWITCH BOARD.



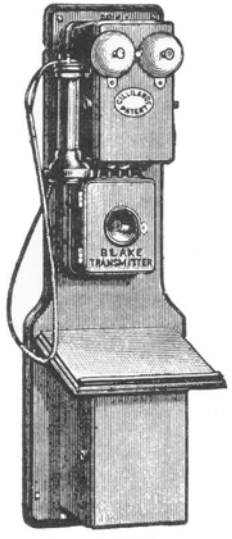
W. E. PONY SWITCH BOARD.

For small exchanges, and in private establishments, asylums, hospitals, schools, and other public buildings, the want is felt for small switch boards, to accommodate a limited number of lines. To meet this want, we make complete exchange outfits of from ten to twenty-five connections, which are called Pony Switch boards. These Pony Switch Boards are as perfect for their use as the regular or standard 50-wire boards. Institutions fitted up with them can be connected with regular exchanges in the ordinary way by means of trunk lines.

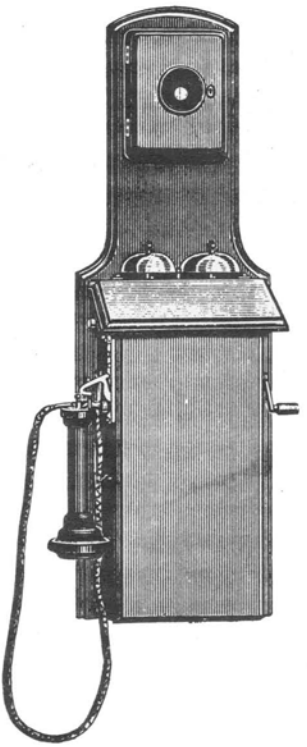
Magneto-Call Bells.



GILLILAND MAGNETO - BELL.



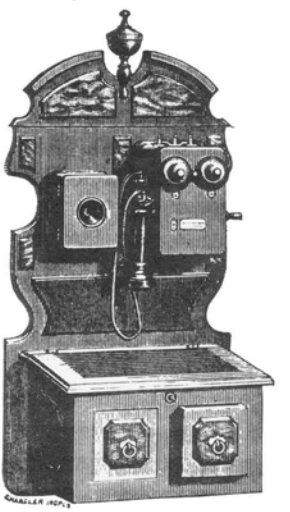
GILLILAND
MAGNETO - BELL WITH
BATTERY BOX.



W. E. MAGNETO-BELL.

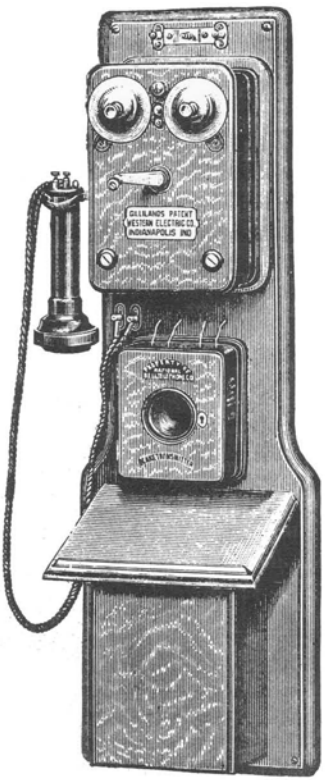
The generators of all these magneto-bells are made at the Indianapolis factory, and by the systems and according to the patents of Mr. E. T. GILLILAND, which secure great strength and durability of construction. The copper wire is insulated with two separate coverings of silk, giving a complete insulation, and avoiding the danger of the coil becoming short-circuited. All our magnetos have *perfectly reliable* automatic shunt devices. The W. E. Magneto-Bell is provided with cut or toothed gear, and is furnished with either the wedge or the gravity switch. The switch alternately *shunts* the telephone and the bell, so that the circuit can never be left open through the box.

Our Magneto-Bell with Cabinet Set is a very ornamental as well as useful piece of furniture, and meets with great favor for use in fine residences and offices where a telephone set of a decidedly ornamental character is wanted.

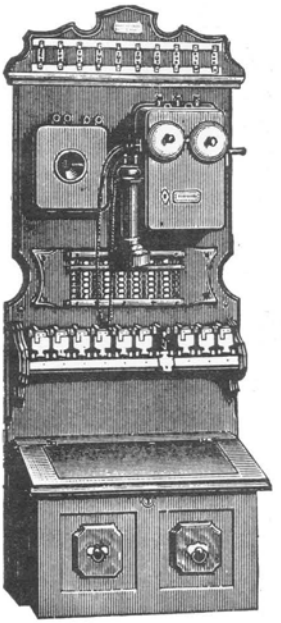


MAGNETO-BELL WITH CABINET SET.

This cut represents a form of Magneto-Bell recently devised by Mr. E. T. Gilliland, and which is believed to have points of decided merit. We expect within a short time to be able to furnish this bell to all who may desire it.

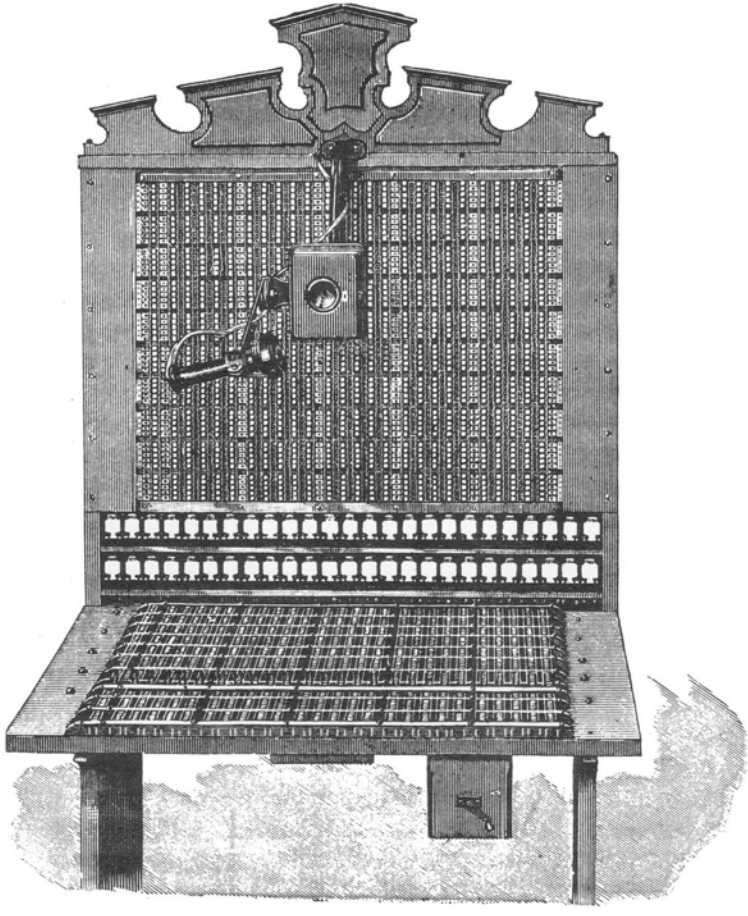


NEW GILLILAND MAGNETO BELL.



GILLILAND 10-WIRE PONY SWITCH BOARD.

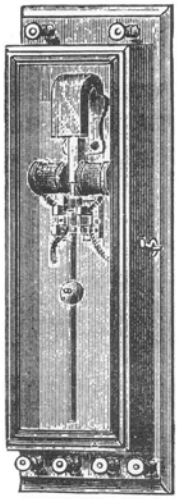
This cut represents a ten wire Gilliland Pony Switch Board, the cut on page 6 representing a board for 20 wires. We make these boards of various sizes.



No. 1 GILLILAND SWITCH BOARD.

This cut represents the No. 1 Gilliland Switch Board, and the cut on page 4 the No. 2 board. The general features of the two boards are the same, but there are some variations in details.

Central Office Calling Apparatus.

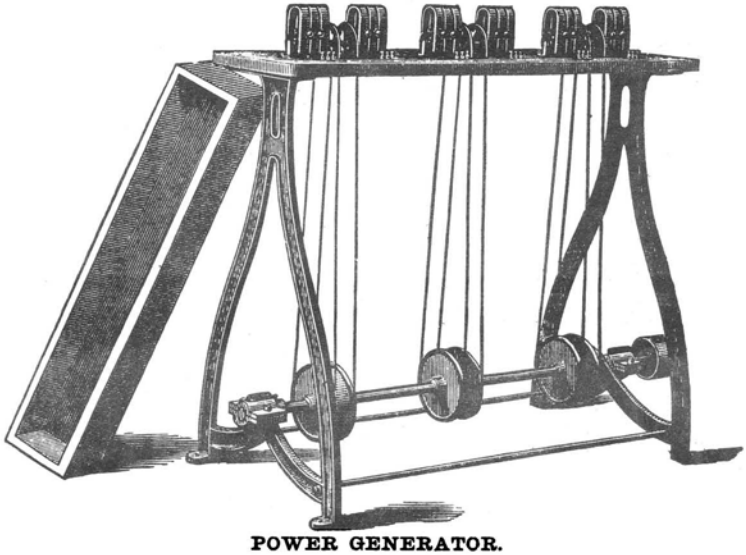


AUTOMATIC POLE CHANGER.

An AUTOMATIC POLE-CHANGER has come to be almost a necessity in the outfit of a telephone exchange. We first devised and introduced such a Pole-Changer, and have furnished practically all that are in use, our product having been over four hundred. We have recently introduced decided improvements in its construction, and it will be found to be thoroughly reliable, and a very durable form of apparatus.

HAND GENERATOR.

In a small exchange a HAND GENERATOR is often used instead of a pole-changer. In a large exchange it is convenient to have a generator at hand, ready for use in case of any accident to the pole-changer or battery. Our hand generator is constructed so that one impulse on the crank may cause several revolutions of the armature, and quicker work can be done with it than with any other form of hand generator.

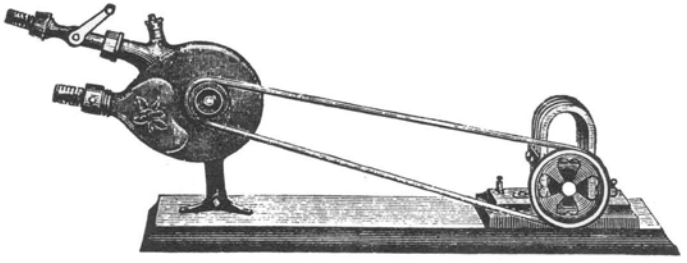


POWER GENERATOR.

POWER GENERATOR.

Power Generators are very convenient in large exchanges where power is available. They can be located at some distance, if necessary, from the exchange, where power can be had, or can be driven by water power on the premises.

We furnish Water Motors at manufacturers' prices.



We also furnish a generator mounted with a small Tuerk Water Motor, as represented in the cut above.

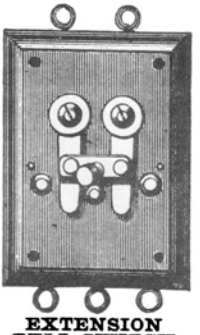
EXTENSION BELL.

EXTENSION BELL.

Our Extension Bell is simply the bell of a magneto call-box mounted separately. An extension bell is very convenient for prolonging the call-box circuit, and giving the signal at some point distant from the telephone. It should be connected in the circuit of the call-box bell—not in the line circuit.

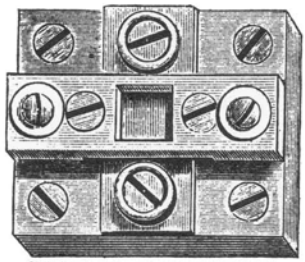
Our EXTENSION BELL SWITCH is a double lever switch, mounted on polished rosewood, with binding posts on the front, and it has all the connections run ready for use.

With a slight change of connections, this switch is also a pole-changing switch.



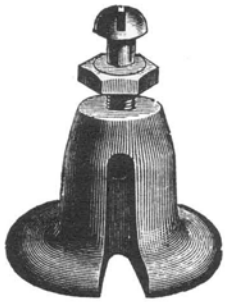
EXTENSION BELL SWITCH

Lightning Arresters and Window Connectors.



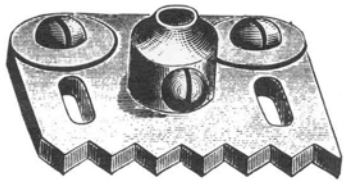
STATION LIGHTNING ARRESTER.

We keep this form of Station Lightning Arrester in stock, and it is found a very desirable form of arrester where extra protection is wanted. It is nickel-plated. We also keep the same form of arrester in strips of ten, in brass finish for tower use.



WINDOW CONNECTOR.

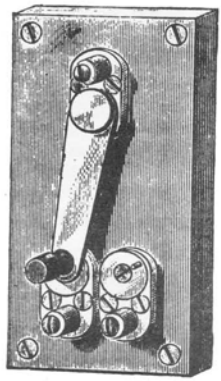
A cheap, safe and convenient connector.



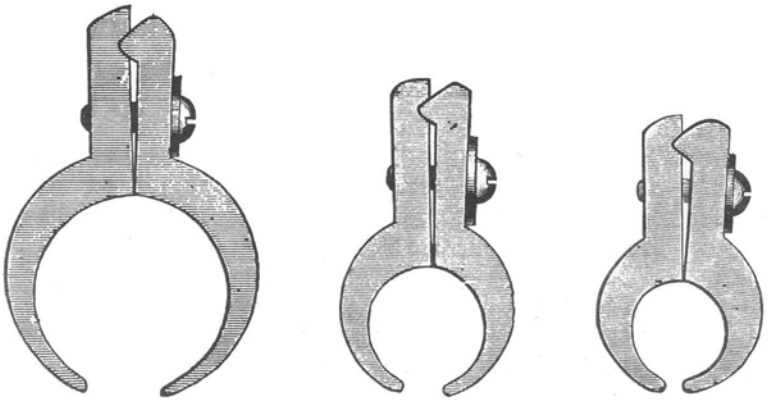
TOWER LIGHTNING ARRESTER AND WINDOW CONNECTOR COMBINED.

This is intended to be screwed in proximity to a ground plate. It will be found to be a great convenience in telephone work, both for exchanges and for private lines.

We are now selling a LIGHTNING ARRESTER GROUND SWITCH, shown in the cut, which, when properly connected to the ground plate of the Central Office Lightning Arrester System, according to the plan of our Mr. Scribner, makes a very efficient and reliable test for all the Lightning Arrester Plates of the Central Office.



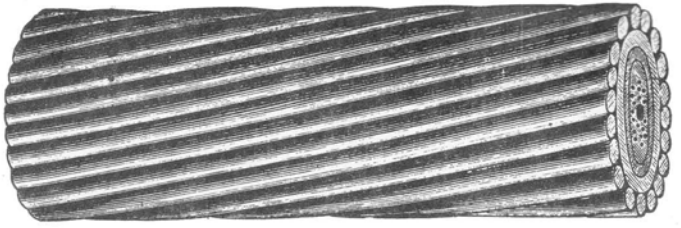
LIGHTNING ARRESTER GROUND SWITCH.



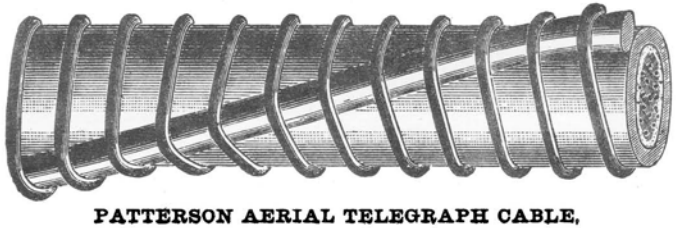
Ground Wire Clamps.

Ground Wire Clamps are furnished in sizes corresponding to gas and water pipes. One of the greatest sources of trouble in the telephone business arises from imperfect ground wire connections due to corrosion, and that, unless soldered, a perfect contact is almost impossible. With our clamp, a reliable and positive connection can be neatly made, and its cost saved in the time required over the old style of connecting.

Underground, Aerial and Submarine Cables.



PATTERSON SUBMARINE TELEPHONE CABLE.



PATTERSON AERIAL TELEGRAPH CABLE.

This Cable is manufactured and sold by us under the *Patterson Patents.* It consists of insulated conductors in a lead pipe, the space between the pipe and conductors being filled with hard paraffine wax, forming the best possible insulator for the purpose. The wax is forced into the Cable when hot, and, by a patented process, is prevented from contracting in cooling. As the pipe is *completely filled* in this way with solid matter, there is no danger whatever of deterioration on account of air or moisture getting into the Cable.

For TELEGRAPH purposes, the Cable is made with large conductors and heavy insulation, and each Cable may contain from one to twenty conductors.

For TELEPHONE purposes, as many as seventy-five conductors may be placed in one Cable, and, by a special patented arrangement, the induction between the wires of a Cable is practically eliminated.

Both the TELEPHONE and the TELEGRAPH Cables are furnished in three styles, according as they are to be used, for UNDERGROUND, AERIAL or SUBMARINE purposes.

For UNDERGROUND purposes the plain lead pipe Cable is used, which may be placed in the ground either without other protection or in wooden or other conduits.

For AERIAL purposes, we place one or more wires of No. 4 or 6 iron wire around the pipe in long spiral for strength in suspension; and when extra protection for the pipe is desired, we place finer iron wire, say No. 12, in short spiral around this.

For SUBMARINE purposes we completely cover the pipe with an armor of galvanized iron wires, generally No. 6 or No. 9, according to the character of the place in which the Cable is to be used.

All these styles of Cable are made and finished in our shop, and sent out on reels all ready to be put in place. The Cables are so flexible that they can be coiled on drums two feet in diameter.

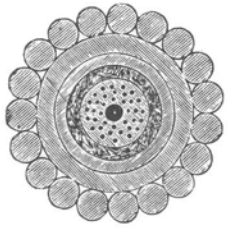
The average insulation resistance which we obtain in telephone cables is about 300 megohms per mile, and in telegraph cables about 1000 megohms per mile. This is many fold the insulation of aerial lines, and of most forms of cable. Low insulation is especially to be avoided in cables, as it shows imperfections in manufacture, and consequently weak points which may develop into serious faults, the dielectric generally used being such that the insulation would always be high if it were not for faults in the cable. The very high insulation which we secure shows the absence of imperfections, and consequently the correct method of our manufacture. The material which we use is not subject to deterioration by age, thus guaranteeing long life to the cable.

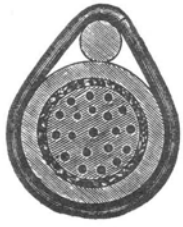
The static capacity of our cable is very low, being, under like conditions, about two-thirds that of gutta-percha cables. As a conse-

quence, the retardation will be much less, and the distance over which conversation can be effected much greater than with other forms of cable. We call attention to the article on Retardation in Cables, published with this, from which it will appear that a telephone cable made according to the Patterson plan may, under like conditions, be worked through about one-half greater distance than a gutta-percha or similar cable with metallic induction sheath (144 to 100).

A feature of this cable to which we wish to call especial attention to the fact that it can be repaired at little expense, if broken, in almost any situation. All that is necessary to be done in case of damage by anchor or otherwise is to take the cable out of the water, splice the broken wires, dry them and pour on hot paraffine, solder on a small section of pipe, and replace the armor.

The following is a list of the parties for whom we have made PATTERSON CABLES during the last year. These include both telephone and telegraph, and alike underground, aerial and submarine. Where more than one cable has been sold to any party the number is indicated in parenthesis. The aggregate of these cables is 71, with 495 miles of conductors.





Australian Telephone Co.
Baltimore & Ohio R. R. Co.
Bell Telephone Co. of Philadelphia. (3.)
Board of Trade Telegraph Co.
Boston & Northern Telephone Co. (2.)
Boston Telephone Despatch Co. (4.)
Buffalo City Fire Alarm.
Buffalo Telephone Co.
Central District and Printing Tel. Co. (3.)
Cincinnati City and Suburban Tel. Co. (2)
Chicago & Western Indiana R. R. Co. (2.)
Chicago Telephone Co. (7.)
Cumberland Telephone Co.
Evansville Telephone Exchange. (5.)
Iowa and Minnesota Tel. Co. (2.)
Lehigh Valley R. R. Co.
London & Globe Telephone Co.
Long Island Telephone Co.
Metropolitan District Tel. Co. (3.)
Midland Telephone Co.
Milwaukee City Fire Alarm.
Mississippi Valley R. R. Co.
Mutual Union Telegraph Co. (11.)
New York, Chicago and St. Louis R. R. Co. (4.)
Port Huron & North Western R. R. Co.
Telegraph & Telephone Construction Co. (5.)
Southern Bell Telephone Co. (2.)
Western Telephone Co.
Wisconsin Telephone Co. (3.)

Insulated Wire & Telephone Cords.

At both our New York and Chicago factories we have departments with the most complete apparatus for the manufacture of insulated wire and conducting cords of all kinds.

Insulated Office and Annunciator Wire.—We make this wire in all styles, both wound and braided, paraffined and polished, and can fill all orders promptly.

Insulated Flexible Cord.—We make such cord for Telephone Switch Boards in two styles. First—with iron spiral around a strong linen cord; and second—with extra heavy gold tinsel conductors. Both kinds of cord are insulated with two coverings, the outside covering of linen, and either red or white, to make the cords easily distinguishable.

Telephone Cords.—We make our telephone cords with the conductors either iron spiral or gold tinsel, as in the flexible cord. The iron spiral telephone cords are tipped with solid metal tips, and the gold tinsel cords are tipped either with solid metal or skeleton tips.

Insulated Line Wire.—For out-door use we insulate iron wire (from No. 10 to No. 14) with cotton yarn and paraffine and polish it similar to office wire. This is a very cheap as well as a durable and satisfactory wire for return circuits, etc. From personal experience, we have known such wire to be in good condition after eight or ten years' use.

Magnet Wire.—All the magnet wire which we use is insulated in our own factories, and with special regard to the purpose for which it is to be used. The wire which we use on our generators is covered with *two* insulations of silk.

Line Material.

Line Wire.—For many years we have handled exclusively the Line Wire made by the Washburn & Moen Manufacturing Company, of Worcester, Mass. We keep a full stock of their wire on hand in Chicago, New York and Worcester, and can fill orders from whichever point the lowest freight rate or the quickest time can be made. For telephone lines, Nos. 12 and 14 iron wire, or Nos. 14 and 16 steel wire, are generally used.

The Washburn & Moen brands of wire are made from the best of stock, and the wire is *thoroughly galvanized.* For the small sizes of wire which are used in telephone construction, the galvanizing is of great importance, as the life of the wire depends almost entirely on it. When the Washburn & Moen wire is purchased, it can be done with entire confidence in the character of the wire, and of the galvanizing. It is this fact which leads us to handle the wire exclusively, and to recommend it to our customers.

WEIGHT AND RESISTANCE PER MILE OF GALVANIZED LINE WIRE.

Number.	Resistance.		Weight.	
	Iron.	Steel.	Iron.	Steel.
12	32.7 ohms.	43.4 ohms.	164	154
14	52.8 "	75.3 "	96	89
16	.....	121.8 "	....	55

Insulators, Pins and Brackets.—We keep in stock at New York and Chicago a full line of the different forms of insulators which are used in telephone construction. Our pins and brackets are made from the best stock of Michigan white oak. We furnish pins and brackets both plain and painted.

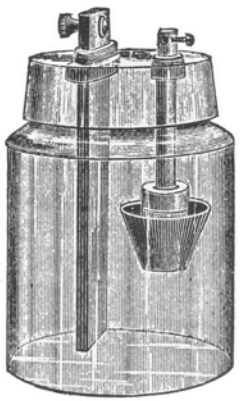
Cross-Arms.—We have an exclusive arrangement for telephone line use with the largest *cross-arm* manufacturer in the country, and can furnish promptly the very best article of cross-arms, in all sizes and quantities, deliverable at either Chicago or South Bend, Ind.

Poles.—We have in stock in our pole yard at Ft. Wayne, Ind., and on the line of the Grand Rapids & Indiana railroad, a limited number of white cedar poles (about 10,000), which can be shipped immediately on receipt of order. These poles vary from twenty-five to seventy feet in length, and are of a choice quality. We solicit the correspondence of parties who want poles *immediately*, either in special or assorted sizes.

Batteries.

We keep in stock a full line of the different forms of batteries used in telephone exchanges, as Le Clanche, Law, Gravity, etc., and also the chemicals usually used in them, as sal ammoniac, blue vitriol, sulphate of zinc, etc.

THE BARRETT BATTERY



BARRETT BATTERY.

is a new form of *open circuit battery*. It will stand for a long time on open circuit without local action or waste of material. Unlike other forms of open circuit battery, however, it will run for days on closed circuit without perceptible polarization or loss of power.

The city of Chicago several months ago replaced with these batteries several hundred open circuit batteries of another form which it was using on its police telephone system, and the BARRETT BATTERY has continued to give the best of satisfaction in that service.

We have tested it for several months in our own work, and find it a very reliable and economical form of battery. We therefore recommend this battery for telephone purposes.

Apparatus for Electrical Measurement.

The practical electrician needs to measure the insulation resistance of circuits, strength of current, internal resistance and electro-motive force of batteries, and to test out the different forms of apparatus and circuits which he meets in his business. The telephone being a new thing, there are new problems connected with it which require to be solved, and the solution of which will, in time, save immense sums of money, which would otherwise be unwisely expended.

The following list of electrical measurement apparatus manufactured by us, embodies, in the best and most approved forms, all that the telephone electrician will require for his use in this respect.

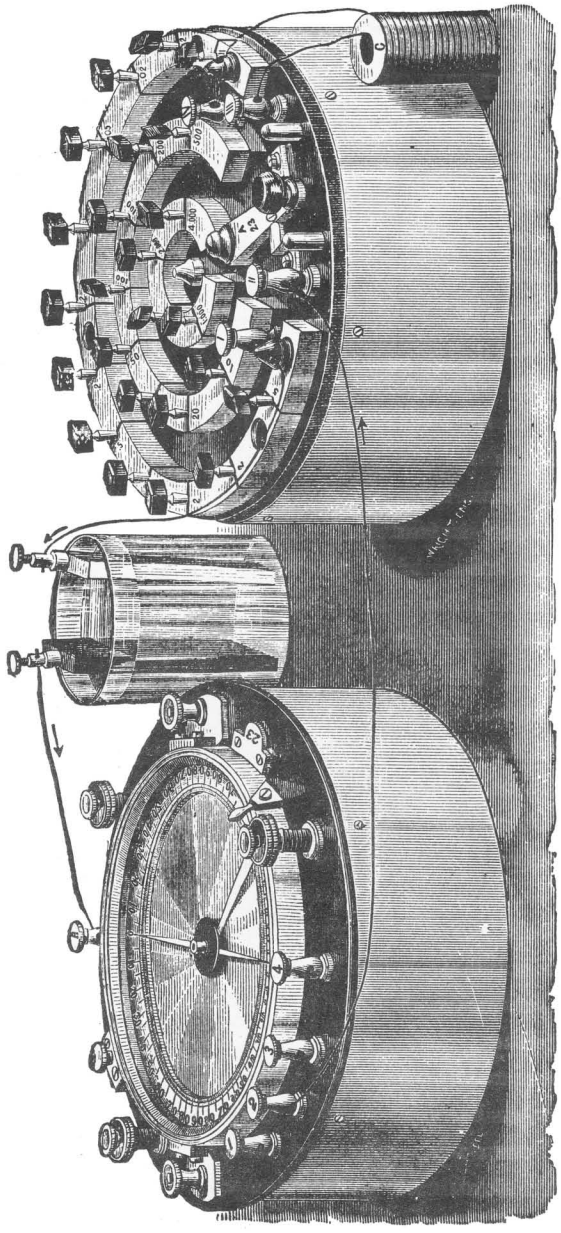
The Dead Beat Reflecting Galvanometer is made after a model furnished us by Sir William Thomson, and embodies his latest and best work in this line. On account of the Dead Beat principle, the measurements can be made with great rapidity. We work under his American patents on reflecting galvanometers.

The Standard Mica Condenser is adjusted from a standard condenser procured from London, and its accuracy can be relied on.

The Wheatstone Bridge and Rheostat is modeled after the English Post Office or Silvertown Rheostat, and is adjusted from standard coils imported by us, and compared with the original standards.

The Bradley Rheostat and Galvanometer, made by us under the patents of Dr. L. Bradley, has for many years, met with great favor and large sales in America. It can be bought with entire confidence in its great utility.

Our Detector Galvanometer is of a new pattern, is neat and compact, and meets with favor.



Bradley's Complete Apparatus for Electric Measurement.

Thomson's Dead Beat Reflecting Galvanometer, 5000 ohms resistance, with lamp stand and scale, and set of shunts, $\frac{1}{3}$, $\frac{1}{99}$, $\frac{1}{999}$ $200 00

Same, without shunts 175 00

100,000 Ohm Rheostat 75 00

100 Cell Testing Battery 50 00

Key Board for Testing 25 00

Wheatstone Bridge and Rheostat, with full set of resistance coils to 10,000 ohms (capacity of measurement, 1,000,000 ohms), with **Galvanometer** 160 00

Same, without Galvanometer 135 00

Bradley Tangent Galvanometer, with three coils of different resistance, and **Bradley Rheostat,** resistance $\frac{1}{100}$ to 2,111 ohms, combined in leather case 125 00

Galvanometer only 50 00

Rheostat only 75 00

Bradley Tangent Galvanometer, with four coils of different resistance, and **Bradley Rheostat,** resistance $\frac{1}{100}$ to 10,111 ohms, combined in leather case 220 00

Galvanometer only 85 00

Rheostat only 135 00

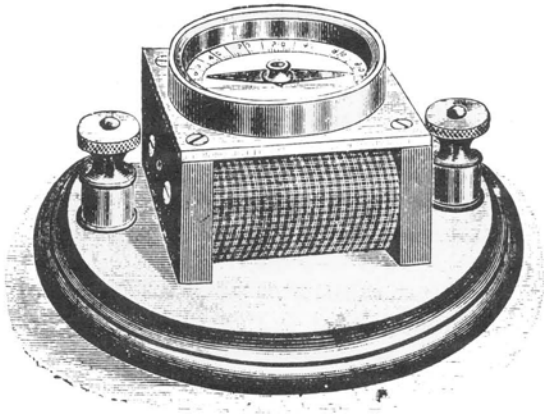
Detector Galvanometer, plain or Astatic Needle, silk suspension, for delicate currents 50 00

Detector Galvanometer, with two coils of low and high resistance 12 00

Same, resistance 100 to 200 ohms 10 00

Same, low resistance 8 00

Standard Condenser, with mica insulation, $\frac{1}{2}$ microfarad, accurately adjusted 100 00



DETECTOR GALVANOMETER.

Retardation in Cables.

The speed of working cables varies as $\frac{1}{r f l^2}$

In which r = resistance of wire per mile.
f = capacity " "
l = length " in miles.

$$f \text{ varies as } \frac{k}{\log. \frac{D}{d}}$$

$$r \text{ varies as } \frac{1}{}$$

In which k = specific inductive capacity.
D = outer diameter of dielectric.
d = inner diameter of dielectric = diameter of wire.

In any two cables the relative speed of working is expressed by the proportion

$$s : s' = \frac{d^2 \log. \frac{D}{d}}{k \quad l^2} : \frac{d'^2 \log. \frac{D'}{d'}}{k' \quad l'^2} \quad (1)$$

To increase the speed of working, or to increase the length of line over which an equal number of electrical pulsations per second can be sent with the same effect at the distant end, we must increase the value of d and $\log. \frac{D}{d}$ and decrease the value of k: that is, increase the conductivity of the wire and the thickness of insulation, and decrease its specific inductive capacity.

We assume through the discussion that copper of the highest conductivity is used, and the only means of increasing the conductivity of the wire is to increase its diameter.

First: *We will determine what effect is produced by varying the specific inductive capacity of a cable.*

In equation (1) we will assume $s = s'$, and find the ratio of the lengths of cables of different materials.

Assuming that $d^2 \log. \frac{D}{d} = d'^2 \log. \frac{D'}{d'}$: that is, that the retarding effects due to size of wire and thickness of insulation are equal, and that the cables differ in material only, we have

$$k\, l^2 = k'\, l'^2. \quad (2)$$

The specific inductive capacity of paraffine is lowered by the presence of cavities and air-bubbles, and in accurate determinations the apparent results need to be corrected. (See Gordon, vol. I., p. 119.) The difference is nearly proportional to the specific gravities, and,

while accurate determinations are wanting, the experiments we have made show that the inductive capacity of paraffine saturated with carbonic acid gas is at least 12 per cent. less than that of pure paraffine. The inductive capacities of different insulators are thus given by different authorities:

	Gordon.	Wöllner.	Schiller.
Paraffine	1.99	1.96	1.68
Gutta Percha	2.46		
India Rubber	2.5		2.94
Chatterton's Compound	2.45		
Glass	3 to 3.8		

Assuming that the ratio of inductive capacities of aerated paraffine and gutta percha and like materials usually employed for insulating wires is as 7 to 10, then equation (2) becomes $10\ k\ l^2 = 7\ k\ l'^2$; from which $l' = 1.2\ l$.

In other words, decreasing the specific inductive capacity of the insulator in the ratio of 10 to 7, other things being equal, increases the length of line that can be worked in ratio of 10 to 12.

Second. *To determine what effect is produced by the use of ground sheaths in reducing the inductive effect between wires.*

To determine what effect is produced by varying the thickness of insulation, we assume that the size of wire remains the same; that is, make $d = d'$: and that the material is the same; that is $k = k'$.

Then equation (1) becomes $$\frac{\log.\frac{D}{d}}{l^2} = \frac{\log.\frac{D'}{d}}{l'^2} \qquad (3)$$

Assuming that the ratio of diameter of wire and thickness of insulation is constant, and, for convenience, that the thickness of insulation is equal to the diameter of the wire, equation (3) shows how much retarding effect is produced by the introduction of ground sheaths around each wire. We will consider the inductive effect of the circle of conductors surrounding any wire to be the same as a cylinder of metal at the same distance.

Then $D = 3d$

$D' = 5d$

Substituting these values in equation (3):

$$l^2 : l'^2 = \log. 3 : \log. 5$$
$$l' = 1.2\ l$$

That is, the removal of the ground sheaths increases the distance through which the same number of electrical pulsations per second can be sent, in ratio of 10 to 12.

Supposing the specific conductive capacity of the insulators to be, as in the previous discussion, in ratio of 7 to 10, $k' = .7\ k$, and

equation (1) becomes $\frac{\log.\frac{D}{d}}{l} = \frac{\log.\frac{D'}{d}}{.7\ l'}$ (4)

Keeping the same ratio between d and D as above,

$$l : .7\ l' = \log. 3 : \log. 5$$
$$l' = 1.45\ l$$

THIRD. *We will determine what change must be made in the diameter of the wires to correspond to a change in the specific inductive capacity and thickness of the dielectric.*

Considering the lengths of cable to be the same, and retaining the same ratios of thickness of insulation and specific inductive capacities, that is:

$$\log. \frac{D}{d} = \log. 3$$
$$\log. \frac{D'}{d'} = \log. 5$$
$$k' = .7\ k$$
$$l = l'$$

Equation (1) becomes $d^2 \log. 3 = 1.43\ d'^2 \log. 5$ (5)

$$d' = .7\ d$$

If	d'	$= .016$	$=$ No. 26
Then	d	$= .023$	$=$ No. 22½
If	d'	$= .05$	$=$ No. 16
Then	d	$= .07$	$=$ No. 13

That is, in cables of a given length and speed of working, if the specific inductive capacity is decreased and the thickness of insulation increased in the above ratios, a wire of No. 26 gauge is equivalent to one of No. 22½, and No. 16 to No. 13, a saving of about 50% in weight of copper.

This Facsimile reproduced in observance of the 100th anniversary of Western Electric Co. Inc.

Originally printed in 1882, this pamphlet is believed to be the first Telephone Supplies Catalogue issued by Western Electric.

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