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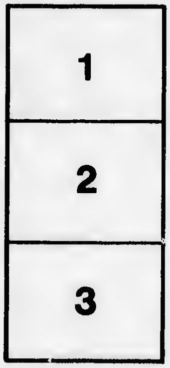
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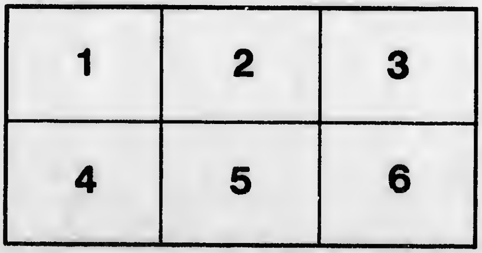
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Canadian Society of Civil Engineers.

SESSION 1888.

TRANSACTIONS.

25th October, 1888.

JOHN KENNEDY, Member of Council, in the chair.

Paper No. 21.

INCEPTION OF ELECTRICAL SCIENCE AND THE EVOLUTION OF TELEGRAPHY.

By F. N. GISBORNE, M.CAN.SOC.C.E.,
F.R.S.C., &c., &c.

Six hundred years B.C., Thales of Milete noted the electrical phenomena developed by friction upon Amber; two hundred years later Plato theorized upon Electricity; and A.D. 1522, Martinigo (a Venetian), the engineer in defence of Rhodes, applied one end of a drum head at the end of his counter mine, to discover the vicinity and direction of the enemy's underground galleries, and thus, by utilizing the molecular disturbance of the earth in sound waves, conceived the basis of telephony. It was not, however, until A.D. 1690, that Von Guerick made the first machine for generating frictional electricity, nor until A.D. 1726, that Wood recorded the fact that frictional electricity would pass through a considerable length of wire, and could therefore be utilized for the transmission of signals. To Wood of England is therefore due the honor of first suggesting the feasibility of electric telegraphy.

A.D. 1745. Murschenbrok, Germany, invented the Leyden jar, by which means frictional electricity could be stored for experimental purposes. A.D. 1747, Dr. Watson, England, erected the first telegraph line between Shooters Hill and London; and A.D. 1753, C.M. (believed to be the initials of Charles Mathews) published the manner in which he had indicated the letters of the alphabet through a system of 26 wires, by frictional electricity. During the latter half of the eighteenth century inventors of all nations endeavored, by means of two or more wires and *frictional* electricity, to transmit intelligence between distant places; but it was not until A.D. 1800, when Volta proclaimed his own and Galvani's prior experiments in the production of *chemical* electricity, that electric telegraphy, as now developed, became practicable.

A.D. 1819. Oersted (Denmark) discovered that a freely suspended magnetized needle would move to the right or left, in accordance with the polarity of a current of electricity through an adjacent wire.

A.D. 1820. Arago (France) discovered that when a bar of soft iron was wound with a copper or insulated iron wire, it became a magnet whenever a current of electricity traversed the wire, and was immediately demagnetized (or nearly so) when the wires were disconnected from the source of the current.

A.D. 1832. Faraday (England) discovered that when a coil of insulated wire was placed adjacent to, but not connected with, another coil of wire, through which an intermittent current of electricity was passed, induced currents of increased intensity and alternating polarity were developed in the unattached coil. Also that the movement of a permanent bar magnet within a coil of wire, or the movement of an electro-magnet near the poles of a permanent magnet, would develop currents of electricity.

To the foregoing rudimental *discoveries* of Galvani and Volta, Oersted, Arago and Faraday, is the world indebted for the numerous subsequent *inventions* which have developed electric telegraphy, plating, illumination, transmission of power, and other valuable results attained during the 19th century.

The purport of the present paper is, however, necessarily limited to the *Evolution of Telegraphy*, in its several branches of *Material*, *Construction* and *Apparatus*, for the transmission of intelligence between distant places, and to the "*Survival of the Fittest.*"

First in order under the heading of *Material* are the *Poles;* underground wires being commented upon in conjunction with submarine cables.

Throughout Canada and the Northern United States, the red and white cedar (Thuya Occidentalis) poles are the most durable of all woods. Standard poles, say 25 feet in length, 6 inches diameter at top, and averaging 10 inches diameter at butt, if cut during the winter months before the sap rises, or in summer and *dried* with the sap in, will continue serviceable for 25 years, and if placed near the sea coast 5 years longer. Hacmatac, *i. e.*, Juniper or Larch (Larix Americana) will last 14 years; black spruce (Abies Nigra) 10 years, and poplar (populus tremuloides) barely 3 years.

In tropical climates, where white ants and other fibre-devouring insects are prevalent, even chemically prepared wood is rapidly destroyed and iron posts or tubes have been substituted with economical advantage. Upon the treeless prairies of the North West Territory where fires, rage, and where travellers and teamsters are apt to utilize telegraph poles for fuel, the "Gisborne" tubular iron poles have been erected, with economy in cost of maintenance. It may here be stated that the "G" iron tube is of wrought iron, galvanized, 18 to 20 feet in length, 1¼ in. diameter inside at top, 2½ at bottom, and weighs complete 80 to 85 lbs., the special merit of such poles being their bed and grip plates, which render them immediately and permanently stable, although planted but three feet deep in the ground, *versus* the five feet necessary for wooden poles.

The next item for consideration is the *Wire.* Galvanized iron and copper are the metals in general use. In order to convey a clear understanding of the experimental and practical results obtained during the last decade or two, it is essential that the values of the definite units for electrical measurements, as adopted at the International Congress of Electricians, A. D. 1881, should first be explained.

Electricity by whatever means generated is the result of the expenditure of energy; and, as the measurement of energy involves space, matter, and time, the three fundamental units adopted were the centimetre for length, the gramme for mass, and the second for time; technically known as the "C.G.S." system; and upon these fundamental units all practical electrical units are based, viz.:—

1st. *The Volt* represents the unit of *electro-motive-force* or *potential.* It is about 8 per cent. less than the E.M.F. of a standard Daniell cell, and is analogous to the *head* or *pressure* of water in a cistern.

2nd. *The Ohm* represents the unit of electrical *resistance.* It is about equal to that met with in a length of 232 feet of No. 18 guage pure copper wire (=100 standard at 60° Fah.), and is analogous to the *frictional* resistance to water as it passes through a pipe.

3rd. *The Ampère* represents the unit of *current.* It is equal to a Volt of E.M.F. passing through an ohm of resistance, and is analogous to the *flow* of water through a pipe.

4th. *The Coulomb* represents the unit of *quantity.* It is the quantity given by an Ampère of current in a second, and is analogous to the *volume* of water passing through a pipe.

5th. *The Farad* represents the unit of *capacity.* A condenser has a capacity of one Farad, when a difference of E.M.F. of one Volt between its two sets of plates charges each of them with one Coulomb, and is analogous to the capacity of a cistern.

6th. *The Watt* represents the unit of *power.* It is equal to the power developed by an Ampère of current, in a circuit whose ends differ in E.M.F. by a Volt, and is analogous to the *power* of water, estimated at 10 ergs or $\frac{1}{746}$ part of one horse power.

Each one of the foregoing established units represents approximately 10 C.G.S. units, viz., 10^8, 10^9, 10^1, 10^1 10^9 and 10^7 respectively.

Reverting to the item of *Wire,* a careful selection of ores and admixture of metals has resulted in greatly increased tensile strength with diminished resistance; the standard for the No. 6 galvanized iron wire adopted by the Canadian Government being 570 lbs. weight per statute mile, 1700 lbs. breaking strain, 18 twists within 6 inches of length, without break or split of fibre, and 8 ohms maximum resistance per mile. Phosphor bronze, silicate and hard drawn copper wires have the advantage of less electrical resistance, but the cost is much greater, tensile strength less, and resistance increases after use. Steel wire coated with pure copper combines strength with minimum resistance, but from the unequal expansion and contraction of the two metals under varying temperatures and other causes, its conductivity rapidly deteriorates. As an experiment the Baltimore and Ohio Telegraph Co. erected several hundred miles of 200 lbs.-to-the-mile hard drawn copper wire, at a primary cost of $44 per mile, the resistance being $4\frac{44}{100}$ ohms, and tensile strength 572 lbs., but within 3 or 4 years such wire elongated 1.28 per cent., and the strength was reduced to 530 lbs. The subject of copper wire will be further commented upon under the item of underground and submarine conductors.

Insulation: The difficulties attending all attempts to convey intelligence by electricity during the 18th century were greatly increased by the high intensity of frictional currents, but the Galvani-Volta discovery of chemically produced electricity of low intensity rendered insulation, either by an external coating of the wire or by its suspension from non-conducting substances, both inexpensive and practical. Wood, vegetable gums, glass or porcelain have all been utilized in various forms and patterns for aerial wires, the latter material being preferable.

The "Gisborne" white porcelain insulator, as adopted by the Canadian Government and by the Canadian Pacific R. R. Co., has been designed for strength, facility for clearing, freedom from insects, and maximum insulation during wet and foggy weather. The nominal *standard* for the resistance or non-conductivity of any insulator when dry is 100,000 megohms,—a megohm being 1,000,000 ohms, and for pole suspended wire, during dry weather one megohm; but in wet weather the insulation drops to $\frac{1}{4}$th of a megohm, and during storms and fogs it becomes so low as to require that messages shall be repeated over short sections of line, and hence the importance of the "G" standard insulator, which costs but 7 cents, *versus* glass at 5 cents each.

The resistance of insulating substances used in submarine and underground circuits diminishes with elevation of temperature, and they vary materially; for instance, at 24° centegrade, a cubic centimetre of gutta percha has a resistance of 84×10^{12} ohms, vulcanized rubber $15{,}000 \times 10^{12}$ ohms, while at 46° centegrade ebonite tests $28{,}000 \times 10^{12}$ ohms, and Paraffin wax $34{,}000 \times 10^{12}$ ohms.

Perfection of resistance is however only one of the qualifications required for the insulation of underground and submerged conductors; freedom from absorption of moisture, cracks, etc., being vital elements. Gutta percha and all vegetable gums part with their essential oils, and become brittle when exposed for some time to the atmosphere; and, unless protected by an infusion of sulphur, India rubber liquifies when in direct contact with copper, which metal should for this reason be coated with tin.

To the invention of submarine telegraph cables we are indebted for much practical knowledge, both in conductive and non-conductive materials, for instance, placing the standard of pure chemically precipitated copper at 100 units.

Lake Superior ingots grade	98.8 units.
Australian "Burra-Burra"	88.7 "
British "best selected"	81.3 "
Russian	59.3 "
Spanish only	14.2 "

or little better than iron.

And whereas the copper conductor in the first Atlantic cable proved to be 40 units standard only, the following cable tested 89, and the last one laid 98 units. Purity of metal lessens resistance, and upon long lines a reduction of one ohm per mile signifies fewer battery cells and less perfect insulation required for the transmission of signals.

Perfect insulation is, however, essential for underground and submarine wires and cables, as exemplified by the great number of dead (*i.e.*, useless from imperfections) lines throughout the world.

The disadvantages attending long distance underground wires are, first cost, reduced rate of speed in signals, and difficulty and expense of repairs, which are materially increased where a multiplicity of wires are required. A sample of underground cable manufactured in Germany, and placed experimentally in a trench, through alkali grounds, in the North West Territory of Canada, became defective after two years; but even though imperishable in material, the cost, difficulty and delay attendant upon repairing damage (from frost heaving the soil, or by animals or lightning,) when the ground is frozen and covered with snow, would greatly counterbalance any other advantages over ærial wires; but in towns, where a multiplicity of poles and wires are a source of danger, annoyance and disfigurement, there can be no question as to the practicability, immediate necessity and ultimate advantage to shareholders, of all electric wires, gas and water pipes, being placed in traversable underground conduits, or in troughs in the sidewalks, and that the corporations should charge companies a sufficient rental to cover interest upon cost of construction and maintenance expenditure.

With perfection of material and manufacture, experience in laying, and improved transmitting apparatus, *submarine* cables are now safe and profitable investments, the localization of breaks or faults and the making of repairs being subject to scientific skill.

To the *uninitiated*, the localization of a fault or break in a mid Atlantic cable is incomprehensible, but the following brief explanation of the main feature or original basis of the method may be interesting, although but one of the many items of scientific and professional attainments necessary for detecting the exact locality of either a break or fault.

Suppose the copper conductor of a cable has a resistance of 10 ohms to 1 *mile*, and a bobbin containing 1 *foot* of fine drawn platina wire, which is a bad conductor, to have a resistance of 10 ohms.

The above resistances being equal, if a battery current is passed through both conductors separately and simultaneously, it will divide or split evenly as to quantity, and when connected with a differential galvanometer, the needle will remain steady at zero.

Now, supposing the cable to be broken 10 miles seaward, its conductor to that point will have 100 ohms resistance, and it will require 10 bobbins of platina wire to balance the needle of the galvanometer at zero. By adding up the number of the bobbins you thus note the distance to the break.

The foregoing explanation may be misleading in its simplicity, unless it be added that the true internal resistance of the cable core depends upon its contact with rock, mud, or water only, and that much more delicate tests are required to localize a fault, based upon dialectric resistance, inductive capacity, percentage of electrical discharge, etcetra.

Galvanic cells or batteries, the source of current, must next be considered, the standard for comparative efficiency being the Daniell cell =1.104 E.M.F. and 0.33 ohm internal resistance:—

the E.M.F. of a	Grove cell being	1.93	Resistance	0.15
"	Bichromate	2.00	"	0.25
"	Le Clanche	1.47	"	1.50
"	Gravity	1.05	"	2.00

The efficiency of all batteries in great measure depends upon their E.M.F., constancy, and low internal resistance. Hitherto the high resistance in *dry* cells has militated against their utility; but a new form known as the "Gassner," with an E.M.F. of 1.44, has an internal resistance of 0.32 only, and is admirably adapted for open circuit requirements.

Dynamic and magneto currents are also applicable, and under some conditions economically utilized for the transmission of signals.

From Woods' first conception of an electro-telegraph, A.D. 1726, more than a century elapsed before Cooke and Wheatstone, (England,) A. D. 1837, adapted Oersted's discovery of A.D. 1819, to the *first practical* and *commercially successful* system of what may be termed *visual* electric telegraphy; and some months later Morse and Vail, United States, adapted Arago's discovery of A.D. 1820, to the first system of *recording* electric telegraphy, Vail being the inventor of the dot and dash alphabet.

A.D. 1833. Steinhill, Germany, adapted Oersted's discovery to the first recorded system of sound or *aural* telegraphy, and first utilized the earth in lieu of a second wire or all metallic circuit. It is by no means certain, that there is any electric current flowing through a wire, or that a wave of electricity like the waves of sound traverses it. It is simply a customary expression to indicate a difference in and around a wire to the conditions in which said wire was when no electricity was present in it.

A.D. 1839. Wheatstone invented the step by step alphabetical indicating telegraph; and A.D. 1848, House, England, invented the alphabetical type printing telegraph, which was subsequently improved upon by Hughes, England.

A.D. 1846. Bain, England, invented the chemical dot and dash recording telegraph, which, combined with Wheatstone's automatic transmitter, hereinafter explained, is the most rapid method of conveying intelligence in present operation.

Finally, A.D. 1876, Bell, United States, invented the telephone, and by accomplishing the electrical transmission of speech, thus attained possibly the highest degree of perfection in intercommunication of intelligence.

And now as to the "*Survival of the Fittest,*" regarding which the writer ventures to express his opinion, with a view to inviting discussion for the benefit of the members and students of the Canadian Society of Civil Engineers, viz.:—

That timber poles, preferably of Cedar, duly provided with lightning conductors at every 5th or 10th pole, are best adapted for telegraph lines throughout Canada, excepting through prairie lands, subject to fires, where iron posts are desirable.

That No. 6 galvanized iron wire, per specification herein before cited, is preferable to copper or composite wires, for aerial lines of considerable length and in exposed localities.

That porcelain insulators are the most economical and efficient, under similar conditions.

That gravity batteries are the most reliable for closed circuits, and Gassner's dry cells for open circuits.

That in towns and populous districts all electric wires, gas and water pipes should be placed in traversable underground conduits, or the wires in sidewalk troughs.

That the Morse and Vail system, with sounding apparatus operated by dot and dash signals, is the most effective in the hands of skilled operators, for general purposes.

That the Wheatstone automatic transmitter, by a paper tape or strip previously perforated with dot and dash or all dot lettering, drawn rapidly between contact makers, and reproduced mechanically upon plain, or chemically upon prepared, receiving paper, at the possible rate of 1000, and *practical* rate of 400 or 500 words per minute, is the best combination for the rapid transmission of intelligence.

That the most successful and profitable telegraph companies of the future will abandon the present system of a multiplicity of wires for the transmission of intelligence; and at business centres, and important stations, will employ female labor for perforating, and comparing with the original manuscript, despatches to be forwarded by automatic transmitters; an additional wire or two being operated by Morse sounders for the correction, when needed, of automatically transmitted messages, and also for the requirements of intermediate local business, such additional wire or wires being available for duplex, quadruplex, or multiplex instruments.

DISCUSSION.

The only objection to Mr. Gisborne's paper is, that the subject being one on which experience only can provide material for discussion, the author has gone into it so fully as to preclude criticism. Mr. Lawson.

The placing of telegraph wires underground is an important one. Those of the Telegraph Department of the General Post Office, London, are now nearly *all* underground in that city, and the service has benefited by this to a great extent; breakages and consequent delays in transmission were frequent on the aerial lines, but now are a minimum. Gutta percha insulated wires "drawn in" to iron pipe conduits are the rule; and these conduits are laid as Mr. Gisborne suggests under the curb stones in the streets.

In submarine cables, gutta percha is supposed to be the best all round insulator and is the one most used. An objection to it is that in shallow and warm waters the teredo which does not touch India Rubber cores, attacks it, and destroys the insulation of the line; but this has been provided against by Clifford and by Siemens, who have put a muntz-metal sheathing over the core before closing, and all cables recently laid in shallow waters in the Mediterranean, Red Sea and Indian Archipelago are thus protected.

It would be interesting to know if Mr. Gisborne has found any trouble caused by the teredo on the Pacific Coast Canadian cables, as the speaker has observed its ravages on wood piles in the wharves at Vancouver and Victoria; and having in view the proposed Pacific cable (Vide Mr. Gisborne's Appendix No. 1), it is a subject of peculiar interest.

As to conductivity, Mathiessen's standard for copper is too low, and for proof, it may be stated that some lengths of Atlantic cable supplied by Siemens Bros., and laid by the "Faraday," tested about 100·25 the conductivity of pure copper according to Mathiessen's standard.

One thing which might interest members of the Society would be a table of depths of water in which cables have been "hooked," as it would give some idea of the perfection to which submarine telegraph laying has attained. For example it may be mentioned that in the repairs of the Brazilian cable,—Lisbon-Madeira section—by the "Seine," the depth was 2¾ miles, of the Atlantic cables, by the "Great Eastern" and "Scotia", 2 to 2½ miles, and of the West India and Panama cables by the "Dacin" 3 miles.

As a sample of fine testing an experiment by F. A. Hamilton, Electrician of the Anglo-American Telegraph Co., may be mentioned. By his tests of a fault—not a total break,—Captain Trott placed the "Minia" in position, and grappled for and hooked the cable at less than half a mile from the fault, which was distant from the Nova Scotia shore about 800 miles.

It is of importance that the transactions of our Society should contain a full discussion or further papers on "Phonoplex" working, "Long Distance Telephony," and other kindred subjects.

An omission from the list of batteries is De la Rue's chloride of silver battery now much used for cable testing.

For electric lighting no difficulty really prevents the placing of *all* wires underground except first cost.

Many stations in large cities have the conductors for incandescent lights underground, and in Europe, notably in Rome and Milan, no trouble has been experienced with cables made by Siemens Bros. & Siemens & Halske, which carry alternating currents of 2,000 volts. It is simply a question of proper insulation and chiefly a question of paying for it.

Mr Kimball. Mr. Gisborne's paper is so complete and comprehensive a disquisition upon the telegraphic industry of the present day, and covers the ground in so practical a manner, that we are forced to accept his conclusions without question.

The rise and progress of the science of Electricity—for it surely has risen to the dignity of a science,—may be compared to a tiny stream which originated in the discovery of the properties of Amber and the Leyden jar, and which as it trickled along was increased and strengthened by the revelation of that mysterious connection between magnetism and electricity, discovered and applied by Oersted, Arago, Faraday and others, until the little stream has grown to such dimensions, that men have embarked upon its surface and risked their fortunes in such enterprises as the Telephone and Telegraph and the Electric Light, and the volume of this on-flowing river is constantly increasing, and its banks widening, and already we can see it opening into an ocean that is boundless.

The undergrounding of conductors for the purposes of electrical distribution has probably taken up as much of the attention of electricians as any one problem connected with their vocation.

The recent exhaustive report of Mr. S. S. Wheeler, of the New York Board of Electric Control, while stating that considerable progress has been effected in the burying of telephone and telegraph wires, the placing underground of electric light wires has been carried out successfully in but a few places, so far as the arc lighting systems are concerned.

The Edison system of underground conductors is one of the most complete, but the history of many of the stations using this underground system, will be found to be a chapter of accidents, as great care must be taken in the construction and maintenance of these tubes, to avoid trouble.

Although electrical apparatus which is simply perfect in action, has been invented and constructed, the first cost and expense of maintenance are still as great as can be borne by the user, and any increase in the expense of maintenance or first cost must revert back upon the consumer.

Any practical system of underground conductors, to take in the electric light wires, must at present be expensive.

There are some companies, however, which would go to the necessary expense could they be assured that such a system would be reliable, but experience has shown that it is a doubtful undertaking, and that where some have succeeded more have failed from an economical point of view, and that the best insulator is that fluid which surrounds the globe, and which, acording to Dr. Otto A. Moses, of New York, we have only to "open our mouths and breathe in."

Mr. Thornberry said, that if it would be interesting to the Society, he would explain the underground system in use in New York. He had been there recently, and also in Boston, and had carefully studied the subject. In Boston their original system is still adhered to, and is Mr. Thornberry. thought the best. In New York, a pitch and asphaltum concrete conduit pressed into form, is used, as many ducts being made as are required for the lines. They are laid in sections of 4 or 5 ft. in length, and are cemented together with tar. They are found to be successful but not so favorable for the purpose as an iron pipe.

Manholes are inserted every 300 to 400 feet,—the interval depending on street intersections—for use in drawing in or repairing cables.

The least expensive material of all would be creosoted wood conduits laid with as many ducts as are required, in lengths of from 10 to 15 feet, the length being governed by the lumber and the weight of the ducts. The creosoted wood is largely adopted by the companies which could not go to the expense of laying iron tubes and by companies doing their own work. Creosoted wood has been found to last 15 to 20 years. It would probably last longer, but we cannot say from experience, as we do not know the quality of the wood nor how the creosoting has been done. The creosoted wood ducts present greater advantages for drawing in cables than any other after they are laid, and perhaps for this reason they are more in favor. First cost is the primary object. He also stated, in relation to a non-conducting metal, that Major Williams of Boston had been directing his attention, for three or four years back, to the manufacture of a wire which shall have a covering of non-conducting metal. He had combined manganese with steel, with some remarkable results. The iron being compounded with manganese is almost wholly diamagnetic; it can not be magnetized. Should his experiments turn out successfully it would be a great advance in electrical science.

With regard to batteries, he had tested the Gassner and LaClanché, and was not in favor of the former for heavy work as it would not last. The fluid battery gave better results. He had put all the batteries under a test by running them constantly through 20 ohms resistance. The Gassner battery was a failure, and the Law battery he found much worse. The LaClanché battery depends upon the material put into it. If first class material is used in its manufacture, a first class battery is the result. Referring to the writing telegraph, he remarked that when he happened to be in Rochester about two years ago, the telephone people had formed a combination, and many schemes were introduced to effect communication outside the telephone,—among others the writing telegraph. He tried to write with the machine, but could not recognize his own hand writing. He had difficulty in forming some of the letters. The writing was done with a style on a piece of moving paper. A moving tape makes it very awkward to form letters with loops in them. The man exhibiting the arrangement was quite expert and wrote very nicely. A great many people purchased the machines, but they have never been used to any great extent.

Mr. St. George

Mr. St. George having been asked, in connection with Mr. F. N. Gisborne's paper on Telegraphy, to describe the underground system now in use in the United States, submitted the following account of a visit to the cities of Boston, New York, Brooklyn, Philadelphia, Chicago and Detroit, where the underground systems have been adopted.

The successful work of underground conductors for Telephone and Telegraph service appears to be decided; the electric light underground system is still somewhat in doubt, although so far, it is working in Philadelphia successfully. The experience gained in the practical working of underground systems in the cities visited points to the probable development of no serious difficulties, at least within the limits of an ordinary Telephone line.

The conduits or subways, of whatever kind or construction, merely protect the enclosed cables or conductors from injury.

The character and mode of construction of the subways or conduits should be determined by the local conditions in which they may be placed.

The principal systems of electrical subways may be classified: First, as to their material composition, and second, as to their mechanical construction and the manner in which the wires are laid in them.

The material composition of subways is :—

1st. Insulating material, such as wood, glass, asphalt, concrete, etc.

2nd. Conducting material, as iron.

The different subway systems are :—

1st. Tunnel system.

2nd. Drawing-in system.

3rd. Solid system.

In the *tunnel system* sufficient space is provided underground, irrespective of the cost of construction, to allow of the passage of men to and fro, to place wires therein.

In cities like Paris, where large sewers exist in most of the streets, such a plan is practicable, but is not to be considered in such cities as Toronto and Montreal.

The *drawing-in system,* or that in which manholes are provided in the streets and are connected by tubes or pipes, through which the wires or cables can be drawn, are next to the tunnel system in convenience.

In Boston, at first, wrought iron pipes, 2½ inches in diameter, were laid in concrete, and then creosoted wooden boxes with from 12 to 6 ducts in them. Also in New York, Brooklyn, Philadelphia, Chicago and Detroit, iron and wooden pipes were used, and also the wooden box conduits,—the latter system being the most general.

The *solid system* is that in which the wires are permanently embedded in insulating material and are incapable of being reached, except by tearing up the streets and the insulation. It is, or was, in use to a certain extent in Chicago and Washington, and about half a mile of it was laid in Montreal three years ago.

This system has not been extensively adopted, and the mere statement of its character appears to indicate inherent defects, and a lack of flexibility as compared with the drawing-in system.

The report of the Board of Commissioners of Electrical subways for the city of New York states that:—" Leaving out of consideration all " tunnel systems as too expensive, we must also discard any system " which calls for the simple laying of insulated cables in the earth.

" They would not stand the chemical action of the gases and acids; " the streets would be continually torn up for new connections and re-

"pars. We are thus confined to the question of electrical subways or "conduits in which the wires or cables, insulated or otherwise, must be "placed, and which, once laid down, shall meet all the requirements of "the present and near future. Of conduits, it may be safely predicted "that, so far as the experience of this (New York) and other cities is a "test, some form or other of a drawing-in system is most convenient. "The life of the best cable is by no means satisfactorily decided, and of "any particular cable, to predict how long it would last would be purely "speculation. Of wires not contained in cables, it may be said they are "more uncertain in their length of life and usefulness. At all events, "for purposes of distribution, it is desirable that the wires should "be easily approached at frequent intervals, and the commission cannot "countenance any plan that looks to the disturbance of pavements more "than is absolutely necessary. It may be, that through lines of wires would "be better protected if laid in permanent beds of insulating material; but "a drawing-in conduit system allows space to be provided for new wires "without the frequent tearing up of pavements. The commission can, "therefore, give their approval to a drawing-in system with frequent "manholes, as the general form of subways best adapted to meet the "requirements of the electrical service of the present."

The question is narrowed down to the consideration of the material and form of the drawing-in system.

Conduits of the drawing-in system have been constructed and are in use in various cities, formed of a variety of materials, including asphalt, cement, glass, iron and cement, tiling and wood. Regarding cement, glass or tile conduits, the laborer's pick has been one of the great objections to these, and they are now nowhere seriously considered; consequently, asphalt, iron and wood, as materials, remain to be considered.

The New York commissioners' report above referred to, has adopted asphalt for certain reasons. The report says:

"While it appears that any kind of conduit which will protect the "insulated wires will answer; and on the other hand, that no conduit "has yet been found which works perfectly, or is an ideal one; "it may be said with confidence, that the weight of evidence before "the commission is towards the use of an insulating material for con- "duits; and of insulating materials, asphalt or bituminous concrete has "certain advantages over all others, viz.:

"1st. It is cheap.

"2nd. It is durable.

"3rd. It is capable of standing harsh treatment.

"4th. It can be easily and closely jointed.

"5th. It can be made absolutely free from moisture, and free from "contraction and expansion.

"6th. It is a bad conductor of heat as well as electricity."

In reply to the above points, we may say that in Montreal:

1st. All such conduits would have to be imported and would obviously cost more than wood.

2nd. Its durability is unquestioned, but being of a composite character, we are of the opinion that it is open to the pick axe objection, which therefore raises a question of harsh treatment.

3rd. The joinings of wooden or iron conduits can be made tightly.

4th. It could be hardly kept free from the deposition of moisture in this extreme climate, any more than wood or iron; its freedom from expansion and contraction is no doubt perfect as compared to iron.

5th. Wood is also a bad conductor of heat and also of electricity. With reference to the employment of iron as a material, it may be stated that in the cities of New York, Philadelphia, Chicago and Detroit, iron pipes are principally used.

In Brooklyn, wood alone is used. In Boston, in 1882, iron was used at first, and afterwards wooden boxes. Mr. Joseph P. Davis, vice-president of the Metropolitan Telephone Co. and Telegraph Co., says: "As "regards an iron conduit, I had three years experience with one in "Boston. The longest line was about 1500 feet, and the moment "the wires were put in use, the subscribers complained and pro-"tested that they could not hear. This was caused by retardation. "They could not get their voices through. A greater conductivity in "the wires could not remedy this. You could use a much longer line "in a conduit that is an insulator than in one that is a conductor. No "amount of insulating material around the wire could make it work as "well in an iron as in an insulated conduit."

The question of retardation is a very serious one, and the use of the iron is undoubtedly a great disadvantage. The durability of iron pipes, of such a thickness as could be conveniently used for conduits, would not compare favourably with creosoted wooden conduits, unless thoroughly coated with asphalt, varnish or some similar substance, and in no instance should they be laid without being enclosed in a creosoted wooden box filled with asphalt or cement. Necessarily iron must cost more than wood.

Wood is therefore cheaper than iron and equally durable and better as an electrical non-conductor.

Mr. Starr. Mr. Starr said that it gave him much pleasure to be present and listen to Mr. Gisborne's most interesting paper. It was not generally known that the world was under great obligations to Mr. Gisborne. He had been personally acquainted with him for a number of years and knew something of his history. To Mr. Gisborne he knew we were indebted for the Atlantic cable. What gave Mr. Gisborne his original idea was the success of the first cable laid between England and France—but he had publicly advocated an Atlantic cable before, the news from England was landed in despatches at Cape Race, and by a line (constructed by himself) transferred via Cape Ray, by cable, to Cape Breton and thence to New York. Other people had received the credit of the institution of the Atlantic cable, but he believed that it was really due to Mr. Gisborne. (See Appendix No. 3.) He was pleased to hear that there was some hope of an independent cable for Canada before long. He himself had been residing on the other side of the Atlantic for two or three years, and a few weeks ago read an article in the *London Standard,* telegraphed from New York, purporting to be the result of a meeting of the Dominion Cabinet. It reported that Mr. Thompson, Sir H. Langevin, and others were intent upon war with the United States, but that Sir John MacDonald pronounced the matter all moonshine. Now, when the press people sent such arrant nonsense as that across the water, it was quite time that we had an independent cable and an independent press association of our own.

It might be interesting to the members of the Society to know that there were many new inventions coming out on the other side, connected with electrical and metallurgical matters. It came under his notice a few months ago that a new composite metal had been discovered in France. It was a combination of nickel and iron, and possessed some extraordinary merits. It was said that wire made with a certain proportion of nickel was one of the best conductors for electricity known, better even than copper, and that a different proportion of nickel made the iron a perfect non-conductor and perfectly inoxidizable. Some of the wire had recently been sent to Mr. Preece, the Engineer of the Post Office and Telegraph in England, for a practical test, and before long the public would know the result. If it proved to be all that was claimed for it, it would answer the purpose which Mr. Gisborne thought so desirable,—of having one metal that was a perfect non-conductor to cover one that was a good conductor.

Mr. Gisborne. Mr. Gisborne stated in reply to Mr. Thornberry, that for a large Telegraph company, where they were working the whole time, and practically upon a closed circuit, the gravity cell would of course be preferable; but for home use, telephones, electric bells, etc., where the current was taken off for a few minutes, and then had time to recuperate before again being used, he thought the open circuit cell was better. There was a vast difference between the uses of an open circuit and a closed circuit battery. The question was whether the Gassner dry cell was the best form for open circuits, where the Leolanche cell was now in use, and from very careful experiments made at his office, he was prepared to adopt the dry cell improvement.

In the course of his paper, Mr. Gisborne also made the following supplementary and explanatory remarks:

He was not sure that a pole, cut with the sap in and dried before it was put up, was not better than a pole cut in the winter.

When in Prince Edward Island, about four years ago, he noticed the stumps of some juniper and black spruce poles which he had planted along the coast, near Souri, thirty-six years ago, but there were no remains of those erected further inland.

From experience in the North West, where there is no cedar, the polar poles had to be renewed every two or three years, so that it wase decided to experiment with some iron ones. The expense of transportation was greater than the original cost of the poles themselves, but he had put up 100 miles of iron poies across the Prairie between Battleford and Fort Pitt, where they had withstood heavy gales of wind and blizzards, and of course had not been burnt down and utilized by teamsters for fuel. Between Moose Jaw and Wood Mountain, where 90 miles of cedar poles obtained from Rat Portage had been erected, he had this year to put in 30 new ones to replace those stolen by teamsters, and 25 or 30 to replace others destroyed by lightning.

The iron poles were not affected by lightning. It would therefore be understood that although the first cost of iron poles were double those of wood, they would probably last some 25 years, besides being free from the dangers referred to; he believed therefore that it would be economical to adopt iron throughout the North West, and had recommended the government to give them a fair trial for two or three years, in order to ascertain what would be the effect of the alkali ground upon the galvanized iron, and if it did not act upon them injuriously, then undoubtedly the iron poles would be used in future.

Respecting the iron poles now upon trial, Mr. Gisborne stated that they were wrought iron galvanized tubes, tapering from 1¾ inches at top to 2¾ inches at bottom, 16 feet in length and weighing 42 lbs. only; and that by adding 3 feet to their length and a little more weight of metal, he would be able to use fewer poles and have an improved line. The light weight of the poles erected proved, however, that if they would stand the test of sleet and gale, an 85 pound pole would assuredly be a perfect success.

If a heavy man were sent up a wooden pole when first planted, say, 5 feet in the ground, the pull, when stringing the wire, would move it several inches from the perpendicular, and it would have to be re-tamped, and again the following year, before it was firmly settled; whereas the iron pole, although planted but 3 feet in the ground was at once perfectly fixed, so that it would break off at the surface rather than move, and under strain would bend like a fishing rod, but come up straight again when the wire was finally adjusted. The patented peculiarity and merit of the Gisborne iron pole was in the underground fastening device. The bed plate was made of galvanized boiler plate 8 inches square and ¼ inch thick, with its four corners turned up and its centre punched up for a tongue, with a ¼ inch hole through it.

The iron tube rested upon this bed plate with the tongue on the inside of it, and a piece of No. 6 wire, passed through both tube and tongue held it loosely in place. It did not signify, therefore, whether this bed plate was put into a perfectly flat-bottomed hole, which would be neces sary if the tube was firmly fixed to its bed plate by a collar and screws, for otherwise if the pole was not perpendicular, the collar would be carried away, or the pole bent, upon endeavouring to plumb it; whereas, after the earth was put upon the bed plate described, the pole could be righted at pleasure and without injury to it; the ends were turned up, so that under pressure, the bed plate would not cut sideways into the ground.

Two feet of earth was then tamped over the bed plate. The grip plate, also of ¼ iron and 8 ins. square, with turned up corners, had a 2½ inch hole in its centre, and was slipped corners down over the top of the pole, another foot deep of earth placed upon the top of the grip plate completed the setting,and the pole was then a permanent fixture. It was also a cheap plan of erecting poles, because to dig the last two feet of a hole costs much more, proportionately, than to dig the first three feet of a five foot hole. In this there was an economy to balance in part the first cost of iron poles. Where there was a sharp angle, a flat ring, pierced with four side holes for wire stays, was slipped over the top of the pole, and its tapering causes it to lodge 3 feet from the top. No. 6 wires were then attached to the ring and to small square iron plates sunk into the ground, and thus a light pole would withstand a very considerable side strain.

Explanatory of the more essential electrical units mentioned in the paper read, he had introduced their comparative analogies to water, so that engineers who were not thoroughly posted in electrical matters would understand their relative value.

There were several other units which electricians had, from time to time, endeavoured to introduce, but if the six he had mentioned were borne in mind, they would be sufficient to understand the subject. They would also notice that the units were all taken from men prominent in electrical engineering science, the "Watt" for instance being chosen to express power.

Just before leaving Ottawa, he had received the following valuable statement from Mr. Carson, M. Can. Soc. C.E., engineer of the Whitecross Manufg. Co., of England,—from whose works the government wire was purchased—to the effect that by a careful selection of ores, etc., they had during the last 20 years, decreased the electrical resistance and increased the tensile strength of iron wire to a remarkable extent.

WARRINGTON, September 29th, 1888.

F. N. GISBORNE, ESQ., Ottawa.

MY DEAR SIR,

But that I have been absent in Spain, the information as to wire which I undertook to supply you with for your paper, would long ago have reached you. I now make such notes as will perhaps afford you a ground for your observations.

The necessities of the telegraphist have been the direct cause of the great improvement in the manufacture of wire which has taken place within the last twenty years. At first commercial wire was used; experience was required to teach the telegraphist the importance of long continuous pieces and low resistances. So, during the twenty years the single piece of 20 lbs., equal to say 80-90 yards of the standard size of 400 lbs. to a mile, has become 112-150 lbs. equal to 500-600 yards, or 3 to a mile.

As every joint is not only a source of weakness, but of loss, and also a possible point of contact during gales, and of collection during snow storms, the importance of this advance cannot be overrated.

This improvement in length has been accompanied by an equal improvement in the character of the material employed, and hence in the conductivity of the line. The theoretical value of wire as a conductor was not even approximated to in the first lines, such a value being obtained as the result of experiments upon material obtained by electrolysis. With the ruder methods of manufacture then practised this was a perfectly illusive standard, but the electricians did not allow the manufacturer to sleep; steady pressure was kept up to improve quality, and the result has been that the Engineer can to day lay down conditions which were considered impossible of fulfilment even a few years ago.

The resistance of an iron wire being in the direct ratio of the proportion of metallic iron contained therein, the difficulty which manufacturers have met with is to reduce the foreign matter as low as is consistent with sound material. It may be said to be like human nature in this respect, that without infirmities, iron is of no use as a practical material. It may be theoretically pure, but unfortunately it will not hold together for any useful purpose. From this arise the difficulties of the manufacturer; impurities, *i. e.*, carbon, silicon (as little of this as may be), manganese, and sulphur, with some phosphorus, must form the constituents, but only so much as will be sufficient to make a malleable material. To balance these ingredients is the business of a successful maker nowadays, and he is successful or otherwise, according to the percentage of conductivity he can provide for the service of the Engineer.

Then much will depend upon the purpose for which the wire is demanded; in England where heavy gales with continuous snow storms are not common, the Engineer can dispense with the condition of great tensile strength, in favour of better conductivity. Thus the British Postal requirement is only some 30 tons per square inch of strain, but what with long circuits and quadruplex instruments, the highest noted conductivity.

The India government, on the contrary, have to build in ice and snow, in all climates, and with sudden variations of temperature, and they are willing to forego somewhat of conductivity in favour of a stronger wire, equal perhaps to 45 tons strain per square inch of section. And these are the conditions which obtain in Canada, where the latter specification has been very widely adopted.

The running sizes, with tests required of the specifications, are subjoined, and it will be seen at once where the differences come in.

Recently, owing to the extreme price of copper, the British authorities have been on the look-out for a material possessing a higher conductivity with greater mechanical strength, and though it cannot be said that this has been generally reached, yet from one firm an approximation has been attained to a more perfect result. A considerable quantity, some hundreds of tons of the standard size of No. 8 (.171 in. diameter, 400 lbs. to a mile), has been erected, having a breaking strain equal to the India Government requirements, with a resistance electrically of only $11\frac{1}{4}$ ohms per mile as a maximum; much of this material showing as little as $10\frac{3}{4}$ ohms resistance per mile. This is represented in the specification as being from 4,300 to 4,500 constant (constant being (W. × R.) where W represents weight per mile in lbs., and R resistance in ohms per mile).

But this is by no means the best that is to be looked for, as the manufacturers of this material assure me that they have now a material on the stocks which shall not exceed a constant of 4,000, with equal mechanical tests to those of the India Government, such as we ourselves insist upon for Canadian work.

But it must be noted that all the care of the manufacturer is thrown away, if the tests which the Engineer lays down, in regard to quality, are not carefully carried out when the material is presented for inspection. When it is stated that a difference of ½ an ohm per mile in the resistance makes a difference in value of something like £2 a ton in the cost of the material, it will be seen at once that if the systematic testing of the material, electrically as well as mechanically, is not conscientiously done before the reception of the wire, the Engineer may not only be paying more for his material than it could be purchased for from the honest maker, but he may be paying the utmost price for what the honest maker would refuse altogether to supply for telegraphic purposes, with conditions of conductivity attached.

In this way the conscientious maker is discouraged, and honesty is no longer the best policy.

If the Engineer wants a cheap line, irrespective of electrical results, let him ask for ordinary fence wire in long lengths; but if his line will warrant him in paying for a lower resistance material, let him above all things, by careful testing, see that he gets what the maker professes to sell him.

This is not difficult when it is remembered that in the works of the three or four leading telegraph wire makers, all the necessary appliances are provided with a competent staff who are at the disposal of the inspecting officer during the inspection.

The percentage for inspection varies according to circumstances, but if all goes well 10 per cent. is usually the lowest proportion. But here the value of a competent man is shewn; a slight falling off in the days work is at once counteracted by an increased percentage of tests, so that a variation is at once traced to an accidental circumstance, or to something more serious, to which the Engineer's attention may be called.

It will be evident that it is of no use to spend money on a line to avoid leakages, to ensure quick and continuous working, and to resist all conditions of weather, unless the Vital Factor, the conductor, is also as good as can be made. And, further, it is of no use to accept the lowest bid of inexperienced makers, when the necessary check of consistent testing is not carried out completely. One constantly hears of Engineers being appealed to against the inspectors result, that the difference is "only half an ohm, what is half an ohm in resistance?" But when it is remembered that this ½ ohm is worth £2 a ton, and that the determination of the skilled manufacturer, when he tendered at a higher price, was to give the specified resistance, not more, and as much less, as possible, and further that if this half ohm had been stated as the specified resistance, the skilled manufacturer in all probability would have supplied at a lower price; it will be evident of what importance proper inspection is, in the erection of a line which shall give the very results which the Engineer designed it should give.

It may be added that the material of which the British Postal wire is obtained has the following percentages of metallic iron:

	4,300 to 4,500	constant	99.85
	4,800	"	99.65
and for theIndia Government wire,	5,400	"	99.50

The accuracy of manipulation which the manufacture of really high class material requires is well shewn in these figures, where not only so near an approach to pure iron is obtained, but also where so small a variation in the percentage of metallic iron causes so great a falling off in conductivity.

I hope you will be able to draw from these remarks so much as will be important in giving your hearers the latest news as to what can be got out of iron wire.

(Signed) Wm. Carson, M. Can. Soc. C. E.

The Canadian Pacific Ry. Co., he believed, had purchased some No. 6 wire from Germany, presumably of the same quality as the Government's wire, but he found that the resistance of such wire was an ohm or more greater than that of the Whitecross wire, thus making a difference in actual value of (as explained by Mr. Carson) £2 or more pounds sterling per ton. It was only of late years that electricians realized that it was essential that wire should be of low resistance, less perfect insulation and less battery power being required with superior conductivity. Electric current, have a natural tendency to escape, and more especially where the insulation is defective.

The ordinary test for wire, the tenacity of which is also a very important *factor* in line maintenance, is readily made by taking a piece of iron wire and drawing an ink mark along the top of it, then by holding it fast between two vices, 6 inches apart, and twisting it around, the ink will show every twist in symmetrical lines which can be counted. The Government test requires that every coil of wire should show at each end, 18 twists within the 6 inch length, without break or division of fibre, and any faulty coil was rejected.

In repairing telegraph lines, you may have to travel some 50 miles to find the break. During that time business is delayed, and horses and men have to be employed at considerable cost, while the stoppage of messages often results in a permanent loss of business to the line, because people would not trust to the telegraph unless it was perfectly reliable. The mere additional cost of £2 or £3 per ton for wire was not therefore to be considered in view of other advantages gained.

With regard to phosphor bronze and silicate metals, he had obtained the best wire made of such material directly from the manufactory in France, and of the same gauge as the iron wire, and strung it across from Gabriola to Valdes Islands in British Columbia, a stretch of about 1000 ft., and each wire from different poles. At the end of the first season the ordinary iron wire was standing, while the composite copper wire had broken.

A great deal had been said in favor of hard drawn copper wire, and of the steel wire coated with copper put up between New York and Chicago; but for the reasons mentioned in his paper, he thus far preferred iron for long distance lines in North America. For small resistance pure copper was advocated by Mr. Preece in England; but our climate is different from that of England. There they were not subject to such heavy falls of sleet and snow and gales of wind, as we were in Canada, and their distances being so much shorter, with railway facilities for repairs, the wires were easily and quickly maintained. The primary cost of even the smaller gauge hard drawn copper wire was at least 4 times greater than that of iron, and irrespective of first cost, copper had to be tightened up every spring, and it would have to undergo the same process every year at the end of three years. It would elongate to the detriment of both its strength and conductivity. This was practical experience against using hard drawn copper wire in our northern climate. He had had a large experience with the different kinds of pole insulators, and when he erected the first line in Prince Edward Island in 1852, experimented with gutta-perch insulators; but they now knew that after a very short time gutta-percha would part with its essential oil (unless placed under water), and the insulators would become like so much old putty, would crack, and were not of the slightest value. He then tried iron insulators. These insulator cups were globular, so as to prevent moisture from internal condensation. The wire was insulated with porcelain, precisely the same as the iron saucepans of the present day. Then the iron pin was coated with porcelain, and fastened within the cup with porcelain ; but they had only been in use one winter when the difference in temperatures, acting precisely the same as he had shown in the case of the steel coated with copper wire, caused the porcelain to crack, almost imperceptibly to the naked eye, but quite sufficiently for the moisture to get to the iron and thus allow the electric current to escape. Other materials had also been tried, but from the experiments he had made he concluded that solid porcelain cups set upon oak pins were the best insulators in this climate. Referring to the white porcelain insulators on the Canadian Pacific Ry. lines, they had probably noticed a number of glass insulators, which had previously been utilized, but across the continent they had one wire suspended from the G insulators, and, if they inquired from their manager, they would be informed that this insulation could be worked through in wet weather over long distances, whereas they had difficulty in working much shorter circuits provided with the glass ones. This again was practical experience. The Canadian Pacific had purchased over 250,000 of them at a primary cost of 7 cents each; this porcelain insulator was open to the light, and did not tempt spiders and other insects to make their nests in it, as was the case with insulators of darker material and more sheltered form.

Referring to the large insulator upon the table, he said it was very much upon the same principle as the smaller ones in general use, but it took a large pin, and before the pole was put up this pin was strapped to the pole by wire. The pole having been raised, the man with the wire on his shoulder mounted it, and readily tilted it over into the slot wher eit was secure until it was drawn tight from below, when he could put the tie wire through the hole which ran parallel with the slot, without risk or exertion.

In the cables that he had laid in the gulf for the government and in British Columbia, he had abandoned gutta-percha in favor of what was called ozokerited rubber insulation. The copper conducting wires were first tinned, then covered with a sticky compound known as Chatterton's, and served with a tape or strip of pure rubber, then served with a tape of partly vulcanized rubber, and again with a rubber tape differently treated with sulphur. It was again the 4th time served with a tape saturated with a rubber compound, and finally immersed in a hot solution of ozokerite,—a natural mineral wax mined in Hungary—by which all the rubber servings are amalgamated into a compact mass, when the insulation is found to be much higher, than the best gutta-percha cores now manufactured.

If gutta percha was not kept wet or cool, it would become plastic like putty, and the result would be that in a bent cable the wire would press through the gutta percha, and come in contact with the fibrous matter serving, placed between the gutta percha and the outside armour wires; and if it was exposed to the heat of the sun, the result would be the same.

In certain cases, the government cables in outlying places are sometimes accidentally exposed to the sun for some days or weeks, and yet the ozokerite rubber insulation remained unaffected.

The great cable manufacturing companies of England were associated either with the original gutta percha company, or had costly manufactories of their own, and they would naturally recommend gutta percha, and impress upon the shareholders of new cables the danger of adopting a new insulating substance, when gutta percha had been proved successful. The Henley and the Hooper companies were the two exceptions.

From his experience, the rubber cable was the best; he hoped we would soon have an opportunity of proving it, as he was satisfied that they were on the eve of having a special cable belonging to Canada, and worked for Canadian interests, when the rubber cable manufacturers would have an opportunity to tender for its construction.

Referring to copper, his friend and associate, the late T. B. Baker, R.N. C.B., chief engineer Chatham Dock Yard, and inspector of machinery for the Admiralty, was, with other engineers and scientists, puzzled by finding that the copper sheathing on vessels did not remain serviceable as long as in former years. Many eminent chemists were called upon to analyse the copper mass, but could not discover what was wrong. Mr. Baker, however, visited the works at Swansea, where the copper was being smelted from the ore, and he noticed the men skimming off the dross from the top of the copper and putting it with some of the surface metal into a separate cauldron. He asked the manufacturers why this was done, and was told that the copper thus skimmed made the best copper tubes; they were, in fact, taking off the cream of the metal, and when it was returned to the copper the sheathing lasted as long as formerly was the case. For this and other good services, Mr. Baker received a special pension.

If two metals were smelted together each of a given resistance, say, copper at 100 and lead at 8, instead of the alloy being of proportionate resistance, say 54 ohms or units, it would probably shew less than half that measurement. It was a curious fact that if you amalgamated any two metals, the resistance of the alloy would almost invariably be greater than that of the pure metals. He had been experimenting with a view to obtaining an unoxidizable alloy of such inferior conductivity, that it might answer as an insulator to cover a copper or other wire of greater conductivity. Such an invention would be of great value, and he would recommend those interested in electrical matters to well consider this subject, because he was sure that in time it would be accomplished. To be able to coat a metal with a metal, so that it would be practically useful for underground purposes, was one of the coming events of the age.

He did not recommend underground wires in all cases. It would be impossible in the Northwest to maintain underground cables. The power of the frost heaving the ground was well known, and if it took hold of a cable, it would be sure to injure it. Then, whenever you come to a brook or river crossing, you had to take it out and carry it across stream and again into the ground. Owing to the cost and difficulty connected with repairs, it would not pay. It might be profitably accomplished if you had a business through a populous country like England, where a great number of wires were required, and you could afford to run the risk of 6 out of 20 being dead, but it would not answer in the Northwest, where one wire is more than sufficient for the whole business of the country, and it would be absurd to lay a wire under long stretches of prairie, where a fault would probably stop the whole business of the country until the return of Spring enabled you to dig it up for repairs.

He exhibited two models of an underground conduit. He was sorry Mr. St. George, the city engineer, was not present, as he had made a report a short time ago upon the different forms of conduits, with their advantages and disadvantages. He had showed Mr. St. George the conduit now before them, which he approved of, on account of its cheapness and effectiveness. It was the same section which was now on the table. The conduit was made of red cedar, and to give them an idea of the great durability of cedar, he might say that a year or two ago a very large tree of Douglass pine was blown down on Vancouver Island, the rings, though not always a safe criterion as to the age of a tree, numbering six or seven hundred, and this tree in going over brought up, firmly grasped by its central roots, a very large log of cedar in a *perfectly sound condition.* The G conduit was supposed to be made of sound cedar boards; the first outside pieces being 1 inch thick and 12 inches, broad; the next 2″, 1½″, 1¼″ and 1″ of reduced breadths and with ½ in. boards between them. They were all then treenailed together, the result being that you have a trough with four grooves or recesses of different depths say for two Telephone Cos., a Telegraph Co., and an Electric Light Co., etc., so that each groove could be got into without disturbing the wires in the adjacent grooves. A connection with any house for any purpose could thus be made without interfering with another company's wires. They could have as many grooves as they liked, and, being placed at the edge of the sidewalk, the distance between the conduit and the house would be only 7 or 8 feet, so that the expense would be very small if a piece of connecting cable, containing more wires than were required, was laid into the building, thus obviating the necessity of taking up the sidewalk for future requirements. India rubber and good copper would stand exposure to heat or cold. Messrs. Henley & Co. were now making him some samples of wire for conduit purposes. These wires would be numbered upon their outside covering, and any one could thus be selected without cutting other wires for electrical testing and identification. This sample form of conduits was cheap, costing about 50c a foot. He was not advocating his own invention, but simply gave it as an idea which may or may not be adopted.

It was thought at one time that the life of an Atlantic cable was 10 years. They had been in use 20. Our gulf cables had been down 9 years, and when raised for repairs last summer, no wear at all had been discovered, and they would probably last 10 or 15 years longer with repairs after damaged by ice or anchorage.

The Groves cell was the most powerful battery known to them,—then the Bichromate, but the former gave off unhealthy nitrous fumes and required daily attention, and the latter speedily lost its electro motive force, when in closed circuit. He would now show an improvement in that most useful of all batteries, the ordinary gravity cell used in telegraph offices. Instead of a clamp which held the crow foot form of zinc on the edge of the glass and often broke it, or a tripod resting on the glass, from which the zinc was suspended, this new form (stamped with his name) rests upon two knife edges of zinc, and as every contact with the glass allowed the escape of more or less electric current, and caused more or less creepage of the mineral salts in solution, the improvement was obvious, and had been adopted on the Government and Canadian Pacific Ry. lines.

The Gassner cell, which he also exhibited, had no water in it and no glass to break, the outside case being zinc, and although they had been in use two years, there was very little wearing of the zinc. One wire was fastened to the zinc case and the other to a hollow cylinder of carbon, within the case,which was filled in only between the outer surface of the carbon and the case with a mixture of moist Plaster of Paris, manganese and salammoniac, which is the existing element of the mixture; finally a little wax was run upon the top of the plaster to prevent creepage.

The Electric motive force was greater and the internal resistance less than that of the ordinary LeClanche cell, and after being placed upon short circuit for 3 days, the remaining electro-motive force of the dry cell was greater than that of the wet cell, and he had substituted Gassner for LeClanche cells on the Government lines.

The Sampson battery now exhibited had given good results. The formation of this battery was an outer glass cell, within there was a rod of zinc and a larger central rod of carbon, and just enough of water was introduced minus salammoniac to wet the mineral wool packing. According to the paper he had read the electro-motive force and internal resistance were just about the same as the LeClanche, but he intended to test the cell as to its relative value with the dry battery, and would report result at some future meeting of the Society.

The W. U. Telegraph Co. in New York, had adopted dynamic currents in some of their lines, and with satisfactory economic results. They might answer on Western Union and possibly on the Great North Western main lines, but for lines conveying a moderate amount of business it would be found an expensive substitute for chemical batteries.

Morse was credited with being the inventor of the Morse alphabet, but such was not the case. In a late number of the *Century* there was an interesting article on the subject, where Vail was clearly proved to be the inventor of the dot and dash alphabet which was the principal merit of the Morse system.

It was not generally known that Steinhill used the needle as a sounder, listening to the ticking of the needle. He found this fact in an old German work. In 1847, and for several years afterwards, operators upon the Morse system were not permitted to take messages by sound, but were ordered to transcribe them from recorded marks on paper, but it was found in practice that fewer errors occurred when sound superseded visual signs in telegraphy.

Steinhill also first used the earth to complete an electric circuit, not that a return circuit by the earth was an established fact or that the current was known to flow through a wire, he was inclined to believe that electricity was diffused through a conductor as rays of light were.

Instead of using the earth to complete circuits, if our telephone companies were compelled to take their currents back through a twisted metallic circuit, we should not have all the annoyance we now have from induced currents and sounds in our telephone lines.

The Wheatstone perforator was simply a long strip of paper passing through a stamping machine, by which the dot and dash or all dot characters were punctured through the paper. The paper being a non-conductor. It was then passed between metal rollers over which ran a metal style, and the style dropped into the holes, made contact with the metal roller through which the current passed, and thus automatically reproduced the dots and dashes at the other end of the line, and no matter how rapidly the paper was drawn between the rollers, the style would impress upon the paper at the other end an exact counterpart of the original puncturing.

Thus one hundred words could be transmitted in the course of a few seconds, and as the punctured strips could be used over and over again through a series of rollers connected by different wires to different cities, you will understand how long speeches in parliament and press news generally is so rapidly transmitted to all parts of the world.

Mr. Gisborne concluded his remarks by saying that he had already trespassed too long upon their time and patience, and would, therefore, defer all further reference to cable enterprises (Vide Appendices Nos. 1 3 and 4) and to the different modes of telegraphy until he had again the pleasing gratification of meeting the members, probably about the 30th November, when he would be enabled by colored diagrams and in non-technical terms to explain even to the uninitiated the working of various forms of instruments in general use.

APPENDIX NO. 1

The Proposed Pacific Ocean Cable.—We have received the accompanying amended statement of the suggested routes for the Pacific cable, the proposals for which are now under the consideration of the Imperial, Colonial and United States Governments:—

Landing places.	Distances, nautical miles.	Length of cable.	Estimated cost at $700 per mile, laid.	Average soundings (in fathoms).	Nature of ocean bed.
Route projected by F. N. GISBORNE, *C.E., and Electrician.*					
Vancouver Island, British Columbia, to Unimak, Aleutian Islands	1,350	1,485	$1,039,500	2,000 to 2,800	Ooze, mud and sand.
Unimak to Atton, Aleutian Islands	800	880	616,000	Not sounded. Probably 100 to 200	" " "
Atton to Yezzo, Japan	1,300	1,430	1,001,000	2,700 to 3,000	" " "
Totals	3,450	3,795	$2,656,500		
Route projected by S. FLEMING, *C.E.*					
Vancouver Island, B.C., to Honolulu, Sandwich Islands	2,300	2,530	$1,771,000	2,000 to 3,100	Ooze, mud and clay.
Honolulu to Fanning Island	1,040	1,145	801,500	1,300 to 3,000	" " "
Fanning Island to Vanua Lavu, Fiji Islands	1,674	1,841	1,288,700	2,000 to 3,300	" " "
Vanua Lavu to Brisbane, Australia	1,486	1,634	1,143,800	930 to 2,600	" " "
Totals	6,500	7,150	$5,005,000		
Route projected by C. W. FIELD, *Merchant.*					
San Francisco, Cal., to Honolulu, Sandwich Islands	2,070	2,277	$1,593,500	2,000 to 3,120	Ooze, mud and clay.
Honolulu to Morell Island	1,500	1,650	1,155,000	1,500 to 3,100	" lava and clay.
Morell Island to Nipon, Japan	1,800	1,980	1,386,000	2,700 to 3,000	" mud and clay.
Totals	5,370	5,907	$4,134,500		

N.B.—Actual rate of working speeds attained through existing cables:—

French Atlantic: Brest to St. Pierre, 2,584 miles (nautical), 15 words per minute.

Anglo-American Cables: 1,896 and 1,857 miles (nautical), 17 words per minute, and 25 maximum, experimentally.

The estimated speed of a cable of 1,500 nautical miles being 33 words per minute with a maximum of the highest rate attainable by n operator.

APPENDIX NO. 2.

THE ORIGINATOR OF TRANS-ATLANTIC CABLES.

In an article upon Submarine Cables, of March 30, 1883, we invited Mr. FREDERICK NEWTON GISBORNE to submit any additional evidence at his command in support of our declaration, that to himself belonged the sole credit of having originated trans-Atlantic submarine telegraphy. That gentleman has responded by forwarding to us the annexed copies of certain letters in his possession, and we may add that the public records and leading articles which appeared in the newspapers of the day, 1850-51, coincide exactly with them. The communications in question were addressed to Mr. GISBORNE respectively by the late Hon. JOSEPH HOWE, then Colonial Secretary for Nova Scotia, afterwards Secretary of State for Canada and Lieutenant-Governor of Nova Scotia; and by Mr. JOHN W. BRETT—the latter being the submerger of the first European submarine cable between Dover and Calais in 1851, while Mr. GISBORNE himself submerged the first American submarine cable between Prince Edward Island and New Brunswick, in 1852. Such evidence appears to be complete and unassailable, not a link in the chain being wanting. We therefore now leave all question as to the originality of conception and the practical initiation of the most important enterprise of its day to the impartial judgment of the world at large:—

From the HON JOSEPH HOWE, *Colonial Secretary of Nova Scotia, in* 1848, *and afterwards Secretary of State for Canada, and Lieutenant-Governor of Nova Scotia, to* FREDERICK NEWTON GISBORNE, F.R.S.C., *Engineer and Electrician, and at present* (1888) *Government Superintendent of the Telegraph and Signal Service, Dominion of Canada.*

MY DEAR GISBORNE,—

Without desiring in the slightest degree to undervalue the services rendered to civilization, by the body of eminent men who have just been rewarded for laying the Atlantic cable, I own to some feeling of disappointment in not seeing any mention made of your name, as I have reason to believe you were the first pioneer of the enterprise, as well as the original promoter of electric telegraphy in the Maritime Provinces.

In the winter of 1848 you came to Halifax and interested the Government, of which I was a member, in the subject of telegraphic communication. A bill was introduced, and £4,000 was expended by the Government for construction of lines to connect Halifax with New Brunswick, Canada, and the United States. When that line was completed, you were employed to manage it, under a Commission, of which I was the Chairman, the Hon. George Young and William Murdoch, Esq., being the other members. This line was subsequently purchased from the Government by a Company, which has since extended branch lines to every shire, town and seaport in the Province. In 1850 you discussed with me, and subsequently laid before the Commissioners, a plan for connecting Newfoundland with the Continent of America, and obtained leave of absence to enable you to go to that Island and secure support to the project. My brother commissioners are both dead. On your return you asked leave of absence to go to New York to promote an extension of the line to England, and spoke confidently of being able to extend it across the Atlantic and connect Europe with America. Up to this time I never heard the idea suggested, and though reading the English and American papers, never saw any allusion to the practicability of such an enterprise. As no capital could be got in Halifax, you naturally sought in London and New York for co-operation and assistance. I do not, of course, know what took place abroad, but of this I have no doubt, that until you went to New York nobody had suggested or taken any step towards promoting an Atlantic telegraph. As the original pioneer and projector of this great work, it appears to me, that you ought to place yourself in your true position, and that, if not included among those who are to be honored and rewarded, you should at least endeavor to obtain from your countrymen, and from the world at large, who are to be benefited, the recognition which you deserve as the *originator* and *practical prime mover* of the great enterprise now so happily brought, by a combination of public-spirited and able men, to a fortunate consummation. It ought not to be forgotten that the very line across Newfoundland now used by the Anglo-American Co. was originally, at great pecuniary sacrifice and risk of health, explored by you, and constructed by yourself as Chief Engineer of the New York, Newfoundland, and London Telegraph Company.

Believe me,

Very sincerely yours,

(Signed), JOSEPH HOWE.

London, 25 Savile Row, Feb. 12, 1867.

Extracts from MR. JOHN W. BRETT'S *published letters to* MR. GISBORNE.

LONDON, July 12, 1852.—"Major Carmichael Smith, a friend of your Hon. Mr. Howe, has just called and given me your plan."

LONDON, May 26, 1853.—"Are you now prepared to co-operate in opening up telegraphic communication between Newfoundland and Ireland?"

LONDON, July 8, 1853.—"On my return from Paris I found your satisfactory letter of 4th June. Let me recommend you to secure in our joint names an exclusive privilege for establishing a submarine telegraph between Newfoundland and Ireland for 50 years."

LONDON, April 21, 1854.—I should be glad, therefore, of a line from you, stating clearly whether, as agreed, this is to be carried out between us as Brett & Gisborne's Atlantic Telegraph here, and *vice versa* in America."

From the above it is manifest that Mr. CYRUS W. FIELD and his associates could not have become interested in Mr. GISBORNE'S enterprise before the spring of 1854. This sustains us in our recent view that the pretention of Mr. C. W. FIELD to be the originator of this great project is simply preposterous.—*Shareholder, Montreal.*

APPENDIX NO. 3.
THE WORLD'S
SUBMARINE CABLES IN OPERATION, DEC. 31st, 1887.

OWNED BY GOVERNMENT ADMINISTRATIONS.

NATIONALITY.	Number of Cables.	Nautical Miles.	OWNED BY CORPORATIONS.	Number of Cables	Nautical Miles.
			African Direct	7	2,739
Austria	31	99	Anglo American	15	10,437
Brazil	19	19	Black Sea	1	351
Canada	21	218	Brazilian	6	7,326
Cochin China	3	810	Central and South American	9	3,178
Denmark	36	123	Commercial	6	6,937
Dutch Indies	1	31	Francaize Paris à New York	4	3,409
France	46	3,197	Cuba	3	940
Germany	35	461	Direct Spanish	2	699
Great Britain	104	876	Direct United States	2	2,983
Greece	45	457	Eastern Extension	21	12,035
Holland	20	59	Eastern and South African	5	4,554
India	72	1,873	Eastern	64	21,627
Italy	22	613	Great Northern	20	6,108
Japan	11	55	Hamburg, Helgolander	2	40
New Caledonia	1	1	India Rubber Gutta Percha and T. Works	2	122
New Zealand	3	196	Indo-European	2	14
Norway	236	228	Mexican	2	709
Russia in Asia	1	70	River Plate	1	32
Russia in Europe	5	201	Spanish National	5	1,172
South Australia	5	49	Submarine	10	803
Sweden	9	61	Vereinigte-Deutsche	2	1,119
Spain	3	127	West African	11	2,825
Turkey	8	330	West Coast America	7	1,698
			Western & Brazilian	9	3,801
Total	737	10,154	West Indian and Panama	20	4,119
			Western Union	4	5,537
			Grand Total Governments and Corporations.	979	115,468

N.B.—The longest cable worked in one circuit is, between France and St Pierre and Miquelon, 2,648 knots.

(See The Electrician's Directory.)

Appendix No. 4.

THE WORLD'S CABLE FLEET, 1888.

The following Table gives the Names and other Information concerning Vessels engaged in Cable-laying throughout the World, together with the Companies owning them. (See the Electrician's Directory)

COMPANY, &c.	Steamer.	Gross Ton.	H.P Nominal.	Captain.	Usual Station.
Anglo-American	Minia	1,986	250	S. Trott	Halifax, N.S.
Canadian Government	Newfield	785	90	R. A. Guilford	Halifax, N.S.
Commercial Cable	Mackay-Bennett	1,717 89/100	300	P. Le Fanu	London.
Compagnie Française du Télégraphe de Paris à N. York.	Pouyer-Quertier	1,385	160	Stuart Fossard	Havre.
Chinese (Formosa) Government	Fee Chew	1,034	150	W. R. Lugar	Formosa.
Eastern	Amber	978	160	....	Mediterranean.
Eastern	Electra	1,000	2 00	R. Greey	Lisbon.
Eastern	John Pender	1,213	98	Perkins	London.
Eastern	Mirror	1,500	—	G. Pattison	London.
Eastern	Chiltern	1,304	200	....	Suez.
Eastern and South African	Great Northern	1,352	130	Hales Dutton, R.N.	Zanzibar.
Eastern Extension	Recorder	1,201	250	C. O. Madge	Singapore.
Eastern Extension	Sherard Osborn	1,429	200	W. Fawcus	Singapore.
French Government	Ampère	304, 733	707	....	Brest.
French Government	Charente	747, 821	120	....	La Seyne.
General Post Office, London	H.M.S. Monarch	2,170*	1,040†	R. Draper	Woolwich.
Great Northern	H. C. Oersted	749	120	G. Oersted	Copenhagen.
Great Northern	Store Nordiske	832	120	Einar Suenson	Woosung (Shanghai)
Henley's	Roddam	2,365	200	....	London.
India Rubber, Gutta Percha, and Telegraph Works	Buccaneer	770	220	....	Silvertown.
India Rubber, Gutta Percha, and Telegraph Works	Dacia	1,856	170	....	Silvertown.
India Rubber, Gutta Percha, and Telegraph Works	International	1,380	110	....	Silvertown.
India Rubber, Gutta Percha, and Telegraph Works	Silvertown	4,935	400	....	Silvertown.
Indian Government	H.M.S. Patrick Stewart	1,150	130	W. A. Tindall	Kurachi.
Italian Government	Citti di Milano	1,247	180	Palermo (R.I.N.)	Spezia.
Siemens Bros. and Co	Faraday	4,916	500	P Le Fanu	London.
Submarine	Lady Carmichael	369	165	Batchelor.	Dover.
Telegraph Construction and Maintenance	Britannia	1,524	200	J. Seymour	London.
Telegraph Construction and Maintenance	Calabria	3,321	220	....	London.
Telegraph Construction and Maintenance	Kangaroo	1,773	160	J. Kennedy	London.
Telegraph Construction and Maintenance	Medina	328	45	....	London.
Telegraph Construction and Maintenance	Scotia	4,667	550	W. R. Cato	London.
Telegraph Construction and Maintenance	Seine	3,579	500	H. Manning	London.
Western and Brazilian	Norseman	1,372	200	W. H. Lacy	Pernambuco.
Western and Brazilian	Viking	436	60	W. F. Wardroper	Monte Video.
West Coast of America	Retriever	624	95	W. B. Minhinnick	Callao.
West India and Panama	Duchess of Marlborough	402	80	J. W. Dickinson	West Indies.
West India and Panama	Grappler	868	100	J. Farrier	West Indies.

*These figures indicate the tons displacement. † Effective horse-power.