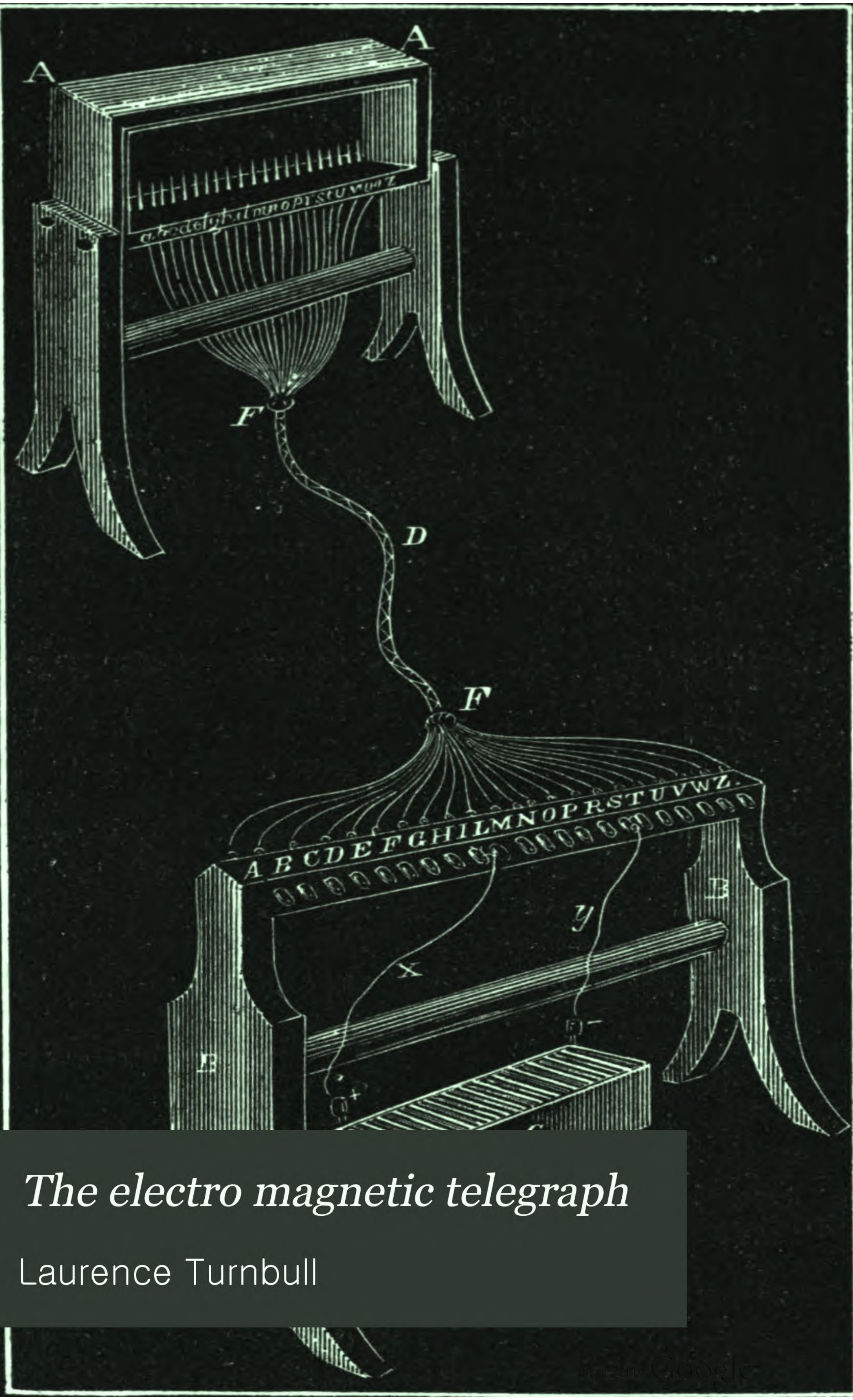

The electro magnetic telegraph

Laurence Turnbull

Plate II

BRETT'S
Electric Printing Telegraph.

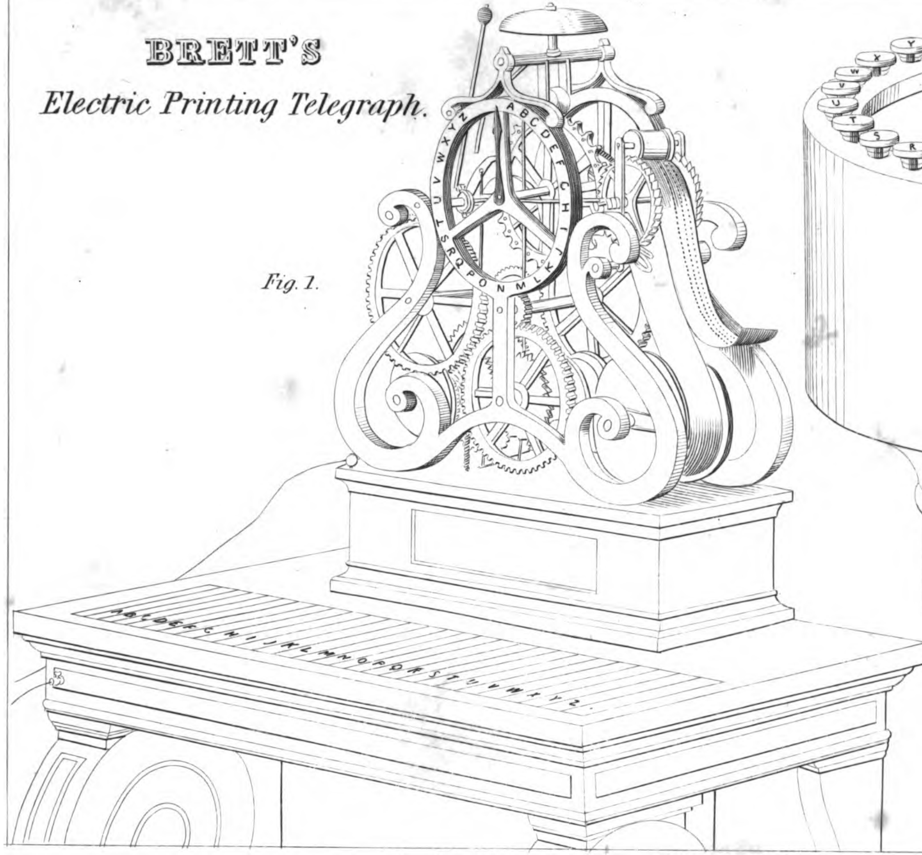

Fig. 1.

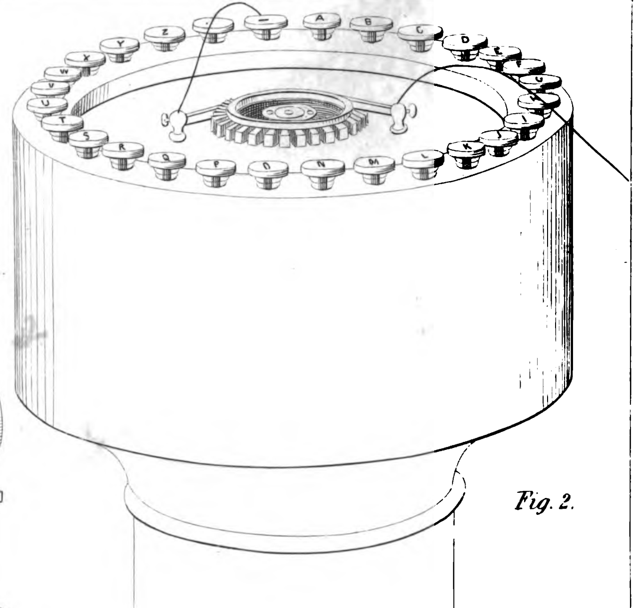

Fig. 2.

THE

[illegible]AGNETIC TE[illegible]

WITH

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[illegible] THE EFFEC[illegible]NG.

[illegible]ER WITH AN

A[illegible]NDIX,

[illegible] IMPORTANT [illegible]

BY

LAURENCE TURNBULL, M.D.,

[illegible] CHEMISTRY AT THE FRANKLIN [illegible] OF THE STATE OF PEN[illegible]

Second Edition, Revised and Improved.

ILLUSTRATED [illegible] NUMEROUS ENG[illegible]

PHILADELPHIA:
A. HART, LATE CAREY AND HART.
1853.

B.

Electr. Printin

THE
ELECTRO-MAGNETIC TELEGRAPH:

WITH AN

HISTORICAL ACCOUNT

OF ITS

RISE, PROGRESS, AND PRESENT CONDITION.

ALSO,

PRACTICAL SUGGESTIONS IN REGARD TO INSULATION,

AND

PROTECTION FROM THE EFFECTS OF LIGHTNING.

TOGETHER WITH AN

APPENDIX,

CONTAINING

SEVERAL IMPORTANT TELEGRAPHIC DECISIONS AND LAWS.

BY

LAURENCE TURNBULL, M. D.,

LECTURER ON TECHNICAL CHEMISTRY AT THE FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA.

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PREFACE

TO THE SECOND EDITION.

A NEW edition of the author's lectures on the telegraph having been called for, he has embraced the opportunity to add many new facts gleaned from various sources within his reach. He has added an outline of the views of Henry, Baumgartner, and Steinheil, with reference to the action of atmospheric electricity upon the telegraph, accompanied by descriptions and illustrations of the means to be employed to obviate the disastrous results from this source. In consequence of the injurious action of lightning, poles, wires, and magnets, and, in a late case, the entire telegraph office have been destroyed.

A chapter has also been added on the subject of insulation, so important to the satisfactory working of telegraphic lines, and their entire reliability in all weathers. For some of the suggestions upon this point he is indebted to Professor Robert Hare, of this city.

He has freely availed himself of important facts found in the works of De la Rive, Walker, Breguet, Jones, and Highton, received since the publication of the first edition of this work, as also in the pages of the *American Telegraphic Magazine*, and the *National Telegraph Review*, publications of great value to the telegraphic world. To J. W. Norton, Esq., proprietor of the extensive Telegraphic Depository in New York, and to his accomplished assistant, Charles T. Chester, Esq., he is under obligations for a valuable communication, containing descriptions of various improvements in telegraphic apparatus, which will be found under their appropriate heads.

For the new cut of the House Machine, and other favors, he is indebted to the politeness of J. W. Philips, Esq.

He has also added to the Appendix several new and important telegraphic decisions, the telegraph laws of Pennsylvania, New York, Indiana, Illinois, and Louisiana, with the liability of telegraph companies for errors in dispatches, cutting telegraph wires, and a verdict against the New Orleans telegraph for personal injuries by the wires of the line having fallen across the road.

To show the increasing prosperity of the telegraph in the far west, the author extracts the following information from a letter to him from H. S. Bishop, Esq., late superintendent of the Lake Erie Telegraph line, dated Cleveland, Ohio, April 19, 1853, which will fitly close this brief preface.

"That the telegraph in this country is infantile in its operations as yet, cannot be denied. But its capacity, even in its present state, may, in a measure, be seen by the following statement: In two consecutive days we received and sent out at Cleveland, on a single line, 36,980 words, exclusive of repetitions and corrections, attendant upon a poorly insulated line and a great lack of experienced operators; these 36,980 words being equal to 1849 messages of ten words each per day, not counting addresses, signature and check.

"Even this large amount of business will give way to yet larger, as the telegraph is made reliable in construction, management, and general working."

This will assist to indicate the rapid improvement made in the course of eight years, for at the beginning of that time a report of one hundred words was considered a good day's work for an operator. What then may we not expect in the next eight years from the genius and invention of man!

PHILADELPHIA, *September*, 1853.

INTRODUCTION.

THE Electric Telegraph has excited and is still exciting much interest over all the enlightened parts not only of this country, but of the world. No one can view the extensive lines, and hear of and see its wonderful, nay, magical effects, without a strong desire to become better informed of its history and mode of operation. Like every other branch of science, it has a history, a beginning, and a gradual advance to its present perfect state. It has required a long series of years to develop and perfect it; it is not the invention of one man or of any set of men, nor of one nation, but of many nations, each adding its mite to the noble structure. Its history is based upon two of the most interesting of the physical sciences, those of electricity and magnetism. Had not these sciences been fully investigated, and thousands of laborers spent centuries upon them, we should never have seen an electric telegraph. Had not such men as Œrsted, Ampère, Arago, Faraday, and our own Franklin, spent their days in experimenting, and nights in studying, we should never have reaped the rich reward of their labors.

In this country, it becomes us to be proud of the electro-magnetic telegraph, having in operation a greater number of miles than all the known world; and yet, many of our people are as little acquainted with it as if they never knew its name, although its lines of iron wire pass before their very doors, and extend even into the most distant wilds of our country.

It was this knowledge, coupled with a strong love for its kindred branches of science, that induced me to select it as the subject of a course of lectures before the Franklin Institute of this city, for the session of 1850 and 1851, and it received the approbation of the Committee of Instruction of that useful institution.

The interest and attention with which they were there received, induced me, after the conclusion of my course, to continue the investigation of the subject, and finding there was no work at that time in the English language on the electro-magnetic telegraph, with the exception of Mr. Vail's, which is now out of print, and not to be had in this city, I concluded either to translate the work of Dr. Schelling, published in September, 1850, from the German, or the work of Abbé Moigno, published in French; but as there had been many new and important matters scattered throughout the many Journals devoted to the physical sciences, and as in the United States the subject has been brought to its most perfect state, I considered it better to write a work than to translate one.

I have received from the operators and proprietors of our telegraphic lines every assistance, by the use of drawings, apparatus, and advice, and am, therefore, under many obligations to them; I have also the pleasure of being able to give a correct list of the telegraphic lines of the world, for which I am in part indebted to the work of Dr. Schelling, and the second edition of the work of Abbé Moigno, 1852, for telegraphic lines in Europe; and to E. Cornell, Esq., President of the Erie Telegraph Company, New York, and J. H. Wade, Esq., of the Wade Telegraph Office, Columbus, Ohio, for the principal information in regard to the extent of the telegraphic lines in the United States. I have also received valuable assistance in the materials of the work, from the interesting trials which have taken place between Messrs. Morse and House, and also between Messrs. Morse and Bain, and which have caused the historical part of the electric telegraph to be very completely investigated. Every work, too, upon the subject of electricity and magnetism, or that treated of telegraphing, has been obtained from the libraries of our own country, and many of the important works from Europe.

The French works comprise the original productions of Ampère, Arago, also those of the distinguished Germans, Schweigger, Ohm, Steinheil, Fechner, and Gauss and Weber, with the masterly productions of the lamented Œrsted, of Copenhagen, the discoverer of the first link of that beautiful chain of the reciprocal action of electric and magnetic phenomena. Nor can I omit the great English physicists, Wheatstone, Cooke, Daniell, Grove, Davy, and Faraday, whose writings and experiments have added much that is new and important to our knowledge of the subject of electricity and magnetism.

But it is to an American experimenter, Prof. Henry, that we are indebted for the corner-stone by which the electro-magnetic telegraph received the most important and completing part, namely—the use of a long circuit of wire, the proper form of wire and magnet to be employed, and those masterly experiments of his which made his name known throughout Europe and his native land, as one worthy of being honored. It is to the joint labors of Prof. Morse, and Profs. Henry and Gale, that we are indebted for one of the best forms of telegraph the world has ever produced.

Still more recent is the most interesting of all the forms of telegraph, that of Mr. House, which, so far as I am aware, has never been described before so much in detail. It will add a new laurel to the brow of the American people, and, for beauty of design and utility, will strike at once even those uninitiated in the mysteries of electric telegraphing, by placing in their hands communications from their friends thousands of miles off, in the course of a few minutes, printed in Roman letters, which require no translation. This wonderful piece of mechanism is worthy of the study of those interested in the physical sciences, as it combines principles of mechanics, as well as the reciprocal action of electric and magnetic currents.

I have, in the succeeding pages, arranged my subject under three heads, namely—common, or statical electricity applied to telegraphing; secondly, galvanic or chemical electricity; and, thirdly, electro-magnetism applied to telegraphing.

In an Appendix, I have given the decision of Judge Kane, in the case of French *vs.* Rogers; also that of Judge Woodbury, in the case of Smith *vs.* Downing, tried at Boston, 1851.

In regard to rival claims for the first discovery of the electro-magnetic telegraph, I have endeavored to follow the rule of its first publication, as, for instance, although Steinheil's telegraph is stated to have been in operation in the early part of the year 1837, still there was no published account of it until July, 1837, so that I have placed Prof. Morse's as the first electro-magnetic telegraph—his publication being in April, 1837. In 1851, during the publication of my articles in the Journal of the Franklin Institute, I received a work styled "Book of the Telegraph," a popular account of it, published by Mr. Daniel Davis, of Boston; but although in the English, it does not contain all the important points connected with electric telegraphing. I have also received the work of Brockman, published in Germany, and the original papers of Siemens, of Berlin, presented to the Academy of Sciences of Paris, from all of which I have culled whatever I thought would be useful in a work devoted to the subject of the telegraph.

"Telegraphing, in this country, has reached that point, by its great stretch of wires and great facilities for transmission of communications, as to almost rival the mail in the quantity of matter sent over it. It has become indispensable to many business transactions, and an interruption of the communication between cities is severely felt by the business community. Nearly seven hundred messages, exclusive of those for the press, were sent in one day over the Morse Albany line. The Bain line at Boston, a few days after, sent and received five hundred communications, exclusive of reports for the press. These facts show how important an agent the magnetic telegraph has become in the transmission of business communications. It is every day coming more and more into use, and every day adding to its power to be useful."

September, 1852.

THE

ELECTRO-MAGNETIC TELEGRAPH.

THE term Telegraph is derived from the two Greek words τηλε (*tele*) and γραφω (*grapho*), meaning, "I write afar off." It is the name given to any mechanical contrivance for the rapid communication of intelligence by signals. Of late years, the term semaphore (from sema (σημα), *a sign*, and phoreo (φορεω), *I bear*), has been introduced by the French, and frequently adopted by English writers.

Although the art of conveying intelligence by signals was practised in the earliest ages, and was known even to the rudest savages, and although its importance is not only obvious, but continually felt, wherever government is established, it has been allowed to remain in its original state of imperfection down almost to the present day. The first notice of any method of this kind of communication is to be found in the 6th chapter and 1st verse of the prophet Jeremiah. He says: "O, ye children of Benjamin, gather yourselves to flee out of the midst of Jerusalem, and blow the trumpet in Tekoa, and set up a *sign* of *fire* in Beth-haccerem."

The proposed object of the telegraphic art is to obtain a figurative language, the characters of which may be distinguished at a distance. Barbarous nations employed torches, fires on the tops of distant hills, hoisting of flags, carrier-pigeons, drums, speaking-trumpets, &c. More recently, since the invention of gunpowder, cannon and sky-rockets have been applied to the same use.

The first description of a telegraph universally applicable, was given by Dr. Hooke, in the *Philosophical Transactions* for 1684. The method which he proposed (for it was not carried into effect) consisted in preparing as many different-shaped figures, formed of deal, as, for example, squares, triangles, circles, &c. as there are letters in the alphabet. He exhibited them successively, in the required order, from behind a screen, and proposed that torches or other lights, combined in different arrangements, should supply their place by night.

About twenty years later, Amontons, of Paris, exhibited some experiments before the royal family of France and the members of the Academy of Sciences, by which the practicability of the art was de-

In 1729, Mr. Grey and Mr. Wheeler observed the instantaneous discharge of electricity through some hundreds of feet of wire.

In 1746, Winckler, at Leipsic, and Nollet Lemonnier, at Paris, made numerous experiments on the transmission of electricity through water, earth, &c.; in one case, wires of more than two miles in length were employed. (*Philosophical Transactions*, 1746.)

In July, 1747, Dr. Watson, Bishop of Llandaff, together with several other electricians, ascertained the passage of electricity through water, by sending shocks across the Thames; experiments which they subsequently repeated on a still larger scale through the New River, at Newington; and in August, 1747, they transmitted shocks through two miles of wire, and two miles of earth at Shooter's Hill. The passage of electricity through water excited a great deal of interest, and these experiments were repeated in 1748, by Franklin, across the Schuylkill, at Philadelphia; and in 1749, by De Luc, across the Lake of Geneva.

Though electricity is the agent used in common by all telegraph operators, its mode of application has been as manifold as the number of laborers in this most interesting combination of science and art. Those now in use, and before described by historians, can be included in three divisions;—taking them in the order of discovery and application, we have first the electric, in which simple frictional electricity was alone used; next the galvanic, where voltaic electricity was employed; and last, the electro-magnetic, combining the agencies of electricity and magnetism. The first was used during the period from 1745 to 1800; the second from 1800 to 1825, the third from 1825 to the present time. From 1820 to 1850, there have been no less than sixty-three claimants for different varieties of telegraph.

The first electric telegraph appears to have been made about the year 1786; though long before that time the vague idea of a magical magnetic telegraph appears to have been entertained; for the Roman Jesuit Strada, who lived from 1572 to 1649, in a curious book, dated 1617, entitled *Prolusions*, describes a fabled contrivance of two magnetic needles, attached to dials, bearing a circle of letters, and which possessed the property of always indicating the same letter, so that when one needle was made to point to any particular letter, the other needle, however distant at the time, placed itself so as to point to the same letter. An account of this curious idea will be found in the *Spectator*, 241, and *Guardian*, 119.

The first real attempt which seems to have been made to render electricity available for the transmission of signals, is described by Moigno, in his *Traité de Telegraphie Electrique*. It is that of Lesage, a scientific Frenchman, who, in 1774, established an electric telegraph at Geneva, composed of 24 metallic wires, separated from each other, and immersed in a non-conducting matter. Every wire corresponded with a particular electrometer, formed of a small ball of elder, suspended by a wire. By placing an electrical machine in communication with either of these wires, the ball of the electrometer which corresponded to it was repulsed, and the movement designated the letter of the alphabet, or whatever conventional signal it was wished to transmit.

In the first volume, page 42, of Arthur Young's *Travels in France*, during the year 1757, will be found the following description of an electric telegraph:—

"Mr. Lomond has made a remarkable discovery in electricity. You write two or three words upon paper; he takes them with him into a chamber, and turns a machine in a cylinder case, on the top of which is an electrometer, having a pretty little ball of pith of a quill suspended by a silk thread; a brass wire connects it to a similar cylinder and electrometer in a distant apartment, and his wife, on observing the movements of the corresponding ball, wrote the words which it indicated. From this it appears that he had made an alphabet of movements; and as the length of the brass wire made no difference, you could correspond at a great distance, as for example, with a besieged city, or for purposes of more importance."

Electricity was generated and retained by the common machine and a Leyden phial. Having but one movement, and using an apparatus extremely delicate, we must suppose this mode of communication to be limited and dilatory.

In *Voigt's Magazine* for 1794, vol. ix. p. 183, there is a letter from Reusser, of Geneva, in which he describes an electric telegraph. In this contrivance, a number of strips of tinfoil were fastened on a glass plate, each strip having a different letter marked on it, and connected by carefully insulated wires inclosed in glass tubes, with a corresponding glass plate at a distance. Thus there was a separate wire for each letter, and one return wire for the whole series. Signals were transmitted by sending electric shocks through the different wires, and noting down the letters attached to the strips of tinfoil, where the sparks were observed. The attention of the observer at a distant station was drawn by firing an inflammable air pistol attached to the apparatus, by means of an electric spark.

"A similar and yet more practical proposition was soon after made by Professor Boeckman. He proposed to choose as the signals the sparks passing at the distant station, using only two wires, by which first one and then, after certain intervals, more sparks being combinedly grouped," indicating the particular letter, so as to get rid of the large number of wires used by Reusser, and also the twenty-six glass plates; in the same manner as the alarms of fire are indicated by our State House clock.—*Dr. H. Schellen's Electro-Magnetic Telegraph*, p. 46, 1850.

The *Madrid Gazette* of November 25, 1796, states, that the Prince de la Paix, having heard that M. D. F. Salva had read to the Acadamy of Sciences, a memoir upon the application of electricity to telegraphing, and presented at the same time an electric telegraph of his own invention, desired to examine it; when, being delighted with the promptness and facility with which it worked, he presented it before the king and court, operating it himself. After these experiments, the Infanta Don Antonio desired another more complete telegraph, and occupied himself in testing the quantity of electricity that would be required by the telegraph at different distances, whether on land or water.

Some useful trials were made and published in *Voigt's Magazine.* Two years after, the Infanta Don Antonio constructed a telegraph of great extent on a large scale, by which the young prince was informed at night of news in which he was much interested. He also invited and entertained Salva at court. According to Humboldt, a telegraph of this description was established in 1798, from Madrid to Aranjuez, a distance of 26 miles. Other writers affirm, that M. Betancourt established a line of telegraph between the same places in 1787, and worked it with frictional electricity.

M. Cavallo published some experiments which he had made on the transmission of signals in 1795. (4th edition, *Traité de Electricitie* published 1798, vol. iii. page 285.) The most important of these consisted in firing gunpowder, phosphorus, and hydrogen, by electric sparks, at a distance of a few hundred feet. He adds, that the same might be done at the distance of many miles.

The next electric telegraph in order of dates, was that of Mr. Francis Ronalds, who in 1816 constructed one, by means of which he was enabled to send signals with considerable facility and rapidity, through a distance of eight miles, using frictional electricity. He published a work in 1823, describing his telegraph, and illustrating it with plates; also several other electrical instruments of his invention. This plan was very simple; at either end of the wires was a clock, carrying a light paper disk, on which were marked the letters of the alphabet, and certain words and numbers. By means of a perforated cover, only one letter and figure were visible at a time, and, as the clock continued to go, every letter in turn was presented at the aperture to the view. As the clocks kept accurate time, it is evident that the same letter would always be visible at both clocks, and therefore that if an electric discharge were sent from one station to another, when a particular letter was exhibited on the dial, the observer at the other station would readily know the signal intended. The wires were buried under ground, in dry and well insulated glass tubes. The attention of the observer was, at the outset, drawn to the instrument by an inflammable air gun fired by an electric spark, and the subsequent signals indicated by the divergence of two small pith balls suspended in front of the revolving disks, a distance of eight miles along a wire.

Fig. 1 shows the form of the apparatus used at either end of the telegraph. *A*, the air pistol; *B*, the dial, exhibiting one letter only through a slit; *C*, pith ball electrometer; *D*, conducting wire. Fig. 2, the dial without the slit, showing the letters and numbers upon it.

Harrison Grey Dyer, an American, constructed a telegraph in 1827–8 at the race-course on Long Island, and supported his wires by glass insulators fixed on trees and poles. By means of common electricity, acting upon litmus paper, he produced a red mark, and then passed the current through the ground as a return circuit. The difference of time between the sparks indicated different letters arranged in an arbitrary alphabet, and the paper was moved by the hand. —*Bell's Evidence in House's Case.*

Like many preceding it, this instrument appears to have been little more than a philosophical toy—frictional electricity being too easily dissipated, rapid and incontinuous in action, confined with great diffi-

Fig. 1.

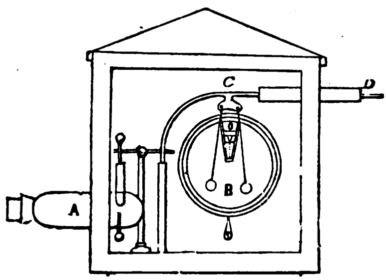
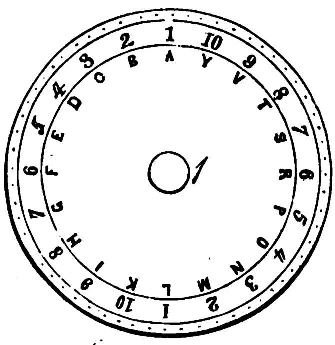


Fig. 2.



culty to conductors, and devoid of that dense, energetic, yet almost imperceptible force which renders galvanic electricity so available in this art. His instrument is far inferior to that of Söemmering, invented twenty years before, and indicates a want of proper regard for, or information of, the discoveries of Galvani, Œrstead, Ampère, and a host of others.

Before considering the individual galvanic telegraphs, it will be proper to state the most important phenomena and laws of galvanism; also the principal forms of voltaic apparatus.

The first instrument of importance was the voltaic pile of Professor Volta, of Pavia, a description of which is published in the *Philosophical Transactions* of 1800; although the discovery of galvanism is due to Galvani, Professor of Anatomy at Bologna, who found that, by forming a chain of conducting substances between the outside of the muscles of the leg and the crural nerve of a frog, convulsions might be produced. Galvani previously entertained the idea, that the contractions of the muscles of animals were dependent on electricity.

The invention of the pile by Volta, was the result of profound thought on the development of electricity at the surface of contact of different metals.

The galvanic pile of Volta consisted of an equal number of silver coins and pieces of zinc of the same form, with circular disks of card soaked in salt water; of these, he formed a pile or column by placing them alternately. If the uppermost disk of metal, either copper or silver, be touched with the finger, previously wetted, while a finger of the other hand is applied to the lowest disk, a distinct shock is felt, which is increased with the number of plates. Instead of the moist conductor we now use liquids of various kinds, and electricians have devised various forms of batteries, but all based on the important principle discovered by Volta.

"By the voltaic pile, I mean such apparatus or arrangement of metals as contain water, brine, acid, or other aqueous solutions or decomposable substances between their plates; decomposition is an essential chemical part of every voltaic battery."—*Faraday's Researches.*

It was Volta who removed our doubtful knowledge. "Such knowledge is the early morning light of every advancing science, and is essential to its development; but the man who is engaged in dispelling that which is deceptive in it, and revealing more clearly that which is true, is as useful in his place, and as necessary to the general progress of science, as he who first broke through the intellectual darkness, and opened a path into knowledge before unknown."—*Ibid.*

According to Professor Faraday, the supply of electricity is due to chemical power in the voltaic pile, metallic contact not being necessary for the production of the voltaic current; and farther, that electricity is only another mode of the exertion of pure unmixed chemical forces. It is proportional in its intensities to the intensities of the affinities concerned in its production, and its quantity to the quantity of matter which has been chemically active during its evolution. It is the union of oxygen of the water which determines the current; and though the acid is essential to the removal of the oxide so formed, in order that another portion of zinc may act on another portion of water, it does not by combination with that oxide produce any sensible portion of the circulating electrical current; for the quantity of electricity is dependent on the quantity of zinc oxidized, and is scarcely, if at all, affected by the use of either strong or weak acid. Galvanic differs from frictional electricity in its low degree of intensity; the larger amount set in motion, the greater constancy, more perpetual reproduction, less tendency to escape, and better conduction along metallic substances without being dissipated. The unequal character of all the batteries previous to the one introduced by the late Prof. Daniell, of King's College, London, was a serious obstacle to telegraphic operations; they are familiar to most persons who have taken any interest in this important matter, and I will therefore omit them.

Prof. Daniell was the first to invent a battery capable of constant and steady action, and thus overcame the defects of those previously in use. The defects which cause the electromotive action to subside rapidly and soon to cease altogether, are: 1. The sulphuric acid becomes saturated with the oxide of zinc. 2. The hydrogen adheres to the surface of the metals, and thus prevents their perfect contact with the water. 3. By the chemical action of the battery, the zinc contained in the sulphate of zinc which is formed, is reduced to the metallic state at the surface of the copper, and deposited upon it in the form of a crust, where it acts locally and impairs the conducting power. 4. Electricity is carried off and dissipated by the escaping hydrogen. 5. Impurities on the surface of the zinc form small circuits, by which the electricity is conducted back into it, without going through the fluid to the copper, and then returning by metallic connection.

The adhesion of hydrogen to the zinc plate, does not take place when that metal is pure or amalgamated with mercury. Prof. Daniell, therefore, employs a cylindrical rod of zinc, amalgamated with mercury, instead of a plate of the common and impure metal. The amalgamation has also the effect of preventing the small local electric circuits, by covering up the impurities which exist on its surface. This was first introduced by Sturgeon. But the peculiar and most valuable feature of this battery is the use of a porous partition, which may be formed of animal membrane, earthenware, plaster of Paris, paper, or any similar substance. This divides the vessels containing the metals into two cells, one of which, the zinc cell, is filled with dilute sulphuric acid, in the proportion of ten parts water to one of acid, and the other with an acid solution of sulphate of copper. The partition freely transmits the electrical current, but prevents the passage of the sulphate of zinc to the copper plate, and thus remedies the third of the above-mentioned defects. The sulphate of copper is decomposed into sulphuric acid and protoxide of copper. The sulphuric acid passes through the partition into the zinc cell, there to act upon the oxide of zinc, while the oxide of copper is again decomposed into oxygen and metallic copper. The oxygen unites with the nascent hydrogen formed in the oxidation of the zinc to form water, and the metallic copper is deposited on the copper plate, keeping the plate constantly bright, and thus making it a better conductor. The hydrogen being consumed in the formation of water, it cannot interfere with the action of the conducting plate, nor convey away electricity. A little frame is fitted to the top of the cell, in which crystals of sulphate of copper are placed, in order that the strength of the solution may remain unimpaired.

Another form of battery, proposed by Prof. Grove, of London, is an improvement upon Prof. Daniell's, in respect to amount of force generated in a small space, and has been adopted in most of the telegraphic offices of this country. A platinum plate is substituted for the copper one of Prof. Daniell, and instead of sulphate of copper, strong nitric acid is used, which furnishes oxygen to unite with the hydrogen. The oxygen in nitric acid is held by very slight affinity, and many chemical substances reduce the nitric acid to hypo-nitrous and nitrous acid, which contains one and two equivalents less. The increase of power in Grove's battery over Daniell's battery, for the same amount of zinc dissolved, is equal to the difference of affinity between oxygen for nitrous acid and oxygen for zinc. The force of Grove's battery is, therefore, equal to the affinity of oxygen for zinc, minus the affinity of oxygen for nitrous acid. The energy of a galvanic arrangement depends to some extent upon the difference in the affinity for oxygen of the metals employed, which in the case of platinum and zinc, is at a maximum, zinc being most readily oxidized, and platinum least so. The zinc plate, as in Daniell's, is amalgamated and surrounded by sulphuric acid, diluted with eight parts of water, while the nitric acid is placed in the platinum cell. A Grove battery, exposing a surface of zinc equal to twenty square inches, was found by its magnetizing power, to afford a current of greater quantity than a Daniell battery exposing 210 inches of zinc. The intensity of the current is also considered three times as great as Daniell's, and is remarkable for its constancy. The escape of nitrous acid red fumes from this battery, renders it disagreeable and unsafe to a careless experimenter. They are irrespirable, and injurious to nice apparatus, which may be exposed to them. By placing a wooden box over the battery, and allowing the gases to escape through an orifice stuffed with cotton, wet with a little alcohol, these may be to some extent neutralized. The intensity of the current depends on the chemical affinities which are concerned, and on this account there is a gain in Grove's battery over Daniell's. Prof. Callan, of Maynooth College, Ireland, has invented a galvanic battery, cheap in its construction and use, yet powerful. He substitutes cast-iron for the outer copper cell, and a flat piece of zinc for the inner one, with equal parts of nitric and sulphuric acids for the outer cell, and a mixture of two parts of nitric acid, five of sulphuric acid, and forty-five of water, for the inner one.

Bunsen's constant battery is a modification of Grove's, made by the substitution of carbon for platinum; it is found to be constant for a longer time, but is less energetic in its effects than Grove's. It is much used in Germany. The substitution arose essentially from the high price of platinum.

The original Bunsen's pile has hollow cylinders of carbon; this it has been found difficult to make, so that now a more convenient arrangement has been contrived by M. Bonijol of Paris, who employs instead of hollow cylinders, solid cylinders of carbon, in the top of which is thrust a stout copper wire or rod, bent so as to be put into communication, by means of a cup filled with mercury, with a similar rod soldered to each zinc. The top of the carbon cylinder around the place in which the copper rod is inserted, is covered with a coating made of wax, prepared so as to penetrate to a sufficient depth into the pores of the portion of the carbon which it covers, and to which it adheres strongly. The consequence of this is, that the nitric acid cannot ascend as far as the copper rod. The amalgamated zinc is outside the carbon, being a hollow cylinder plunged into a glass vessel that is filled with diluted sulphuric acid; a porous tube is placed in the interior of the zinc cylinder, and it receives the carbon and pure or diluted nitric acid into which the latter must be plunged.

The preparation of the carbon is difficult when hollow cylinders are employed. For this purpose it is necessary to have iron moulds, and then coke in fine powder (a mixture of ordinary gas coke and gas coal), which is brought by one or two operations to a high temperature after having been mixed with sugar or molasses to cause a cohesion that gives consistency to the whole. In Bonijol's pile, the cylinders may be prepared of carbon in the same manner, which is the easier, as they are solid. But the most simple plan is to procure pieces of well-baked coke of good quality and of sufficient dimensions. They are cut (by a common two-handled cross-cut saw, and water must be frequently thrown on it) into the form of cylinders; as to the exact form it is not of much importance.

This form is now made in Paris, in which the carbon is perfectly cylindrical, made according to the process spoken of.

By a very simple arrangement the contact is effected between the carbon or zinc of each pair; and to attach the pairs themselves upon fixed frames in such a manner that, in order to put the battery in action, it is only necessary to raise a wooden table that sustains the vessels filled with their liquids, and into which the carbon and the zinc are to be plunged, each in that which appertains to it.

The following is the account of Bunsen's battery as given by M. Reizet, from *Les Comptes Rendus.* "A single pair has power to melt a thin iron wire, and can be advantageously employed in galvano-plastic and gilding experiments. The decomposition of water is obtained with two elements.

M. Bunsen has compared the intensity of the current of the carbon battery with Grove's, by employing two apparatuses of equal dimensions, and he is hence led to conclude that the maximum of the current of Grove's battery, all things else being equal, is hardly three-hundredths superior to that of the carbon battery; a difference which amounts to nothing in practical applications. He has concluded, moreover, that the carbon battery has the advantage of being more constant, and does not cost above one-fourth of the Grove's in construction, being at the same time as elegant, and much more commodious. He paid about two shillings English for an excellent cylinder of carbon, having 20 to 21 square inches of inner surface. The height of his ordinary cylinder is five inches, and its diameter two; for uniting the pairs copper clamps are found better than screws, on account of the acid vapours.

The effect of the galvanic current on the nerves and muscles of animals, is essentially the same as that produced by frictional electricity, modified, however, in some degree, by the continuous action of it. They are also characterized by the presence of some chemical influence, which excites the organs of taste and sight in a remarkable manner. Very small batteries are adequate to excite the organs of taste and sight, but a large apparatus is needed to produce any perceptible influence on the sense of touch, so as to cause the muscles of the human body to contract, when it forms part of the circuit. Galvani, in his fundamental experiment, touched the nerves of a dead frog's spine and the muscles of one of his thighs with two different metals, and then forming a circuit by a wire between them, the leg became violently contracted. When the nerves of vision are made to form part of the voltaic connection, peculiar luminous flashes will appear before the eyes. The excitement of the organ of hearing under similar circumstances is not less interesting, a roaring sound being heard as long as the wires are kept in place. On closely observing the effect of galvanic electricity upon the muscular and nervous system, three distinct stages in the process are readily seen. First, when the circuit is completed, an electric shock is experienced; next, the continued action of the current causes a series of contractions rapidly succeeding each other; and lastly, when the connection is broken, a less violent shock than before is felt. The shock of the voltaic battery differs from that of common electricity, as the latter is felt far less deeply, affecting only the outer part of our organs, and being exhausted in a moment. The voltaic shock, on the contrary, penetrates farther into the system, passing along the entire course of the nerves. The influence of the galvanic current on the nervous system, has been successfully applied to the restoration of persons in whom animation was suspended. By means of it, Aldini set in motion the feet of a corpse, caused the eyes to open and shut, and distorted the mouth, cheeks, and the whole countenance. Ure, by completing the circuit through the body of a man recently hung, caused the muscles of the face to acquire a frightful activity, so that rage, despair, and anguish, with horrid smiles, were successively depicted on the countenance.—*Peschell's Elements of Physics.*

The chemical effects of galvanism are perhaps the most important of all that come under our observation. Prof. Faraday's investigations have recently added most materially to our knowledge on this subject, and it is to him that we are indebted for detecting most of its laws. To produce these effects, the electrical current must be conducted completely through the substance which is to be decomposed; as soon as the circuit is completed, the elements are set in operation, and so continue until the connection is broken. The bodies to be resolved must be conductors of electricity, and also be in a liquid condition, that their particles may move freely among each other. The circuit may be completed through the fluid, by dipping into it the metallic wires which connect with the poles of the battery. These extremities of the wire are commonly termed *poles*, from an idea that they exert attractive and repulsive energies towards the elements of the decomposing liquid, just as the poles of a magnet act towards iron; and each is farther distinguished by the term positive and negative, according as it affects an electrometer with positive or negative electricity. Now Prof. Faraday contends, and has proved by experiment, that these poles have not any attractive or repulsive energy, and act simply as a path, or door, to the current; he hence calls them electrodes, from *electron*, ελεκτρον, electricity, and *odos*, ὁδος, *a way*. The electrodes are the surfaces, whether of air, water, metal, or any other substance, which serve to convey an electric current into and from the liquid to be decomposed. The surfaces of this liquid which are in immediate contact with the electrodes, and where the elements make their appearance, are termed anode, and cathode, from *ana*, ανα, upwards, and *odos*, ὁδος, the way in which the sun rises, and *kata*, κατα, downwards, the way in which the sun sets. The anode is where the positive current is supposed to enter, and the cathode where it quits, the decomposing liquid; its direction, when the electrodes are placed east and west, corresponding with that of the positive current, which is thought to circulate on the surface of the earth. To electrolyze a compound is to decompose it by the direct action of galvanism, its name being formed from *electron*, ελεκτρον, and *luo*, λυω, to unloose or set free. An electrolyte is a compound which may be electrolyzed. The elements of an electrolyte are called ions from *ion*, ιον, going, neuter participle of the verb *to go*. Anions, are the ions, which appear at the anode, and are usually termed the electro-negative ingredients of a compound, such as oxygen, chlorine, and acids; while the electro-positive substances, as hydrogen, metals, alkalies, &c. which appear at the cathode, are cations. Whatever may be thought of the necessity of some of these terms, the words electrode, electrolyze, and electrolyte, are peculiarly appropriate.—*Faraday's Experimental Researches.*

Water, the first agent decomposed in this way, was electrolyzed by Messrs. Nicholson and Carlisle, soon after the discovery of the voltaic pile. From its low conducting power, water requires a powerful current for its decomposition, unless it be slightly acidulated. In 1803, Berzelius and Hissinger ascertained the power of the galvanic battery to resolve many other substances into their elements; that these elements observed regular laws in their resolution into more simple form, as oxygen and acids accumulated about the positive pole; while hydrogen, alkaline earths, and metals appeared at the negative one. Sir H. Davy communicated to the Royal Society his celebrated Lecture on some chemical agencies of Electricity, in 1806; and, in 1807, he announced the grand discovery of the decomposition of the fixed alkalies. Faraday's masterly productions on this subject were elicited in the period from 1831 to 1840, some of which important results have been mentioned.

It is an interesting matter to obtain a fixed rule or law, by which we can estimate the amount of projectile force needed by a galvanic current to pass over a certain length of telegraphic wire; though all such rules must be more or less inconclusive, from the number of contingent circumstances on which they depend; still, from experiment and observation, we can obtain those which may be useful in making what are termed rough calculations. To make such a computation, we must on the one hand find all the sources which give motive power, and, on the other, seek those agencies which offer resistance to that power, obtain the sum of each, and then institute a comparison. The power is that electricity of intensity which a single galvanic cell is capable of generating. This, multiplied by the number of cells, gives us the whole amount of electrical power. The resistance is that obstruction the electricity meets in the conducting metal and the liquid of the cells. Find the amount of obstruction in a single cell; this, multiplied by the number of cells, affords the total sum of a battery. Then divide the whole sum of power by the total amount of resistance in the conducting wire and liquid of the battery cells, and the quotient will be the effective power of the battery.

The electromotive force of an electric current may be ascertained by the following important law of Ohm, which was discovered in the year 1827, being applicable under all circumstances, referring to all the causes which tend to impede the action of the battery. "It is, that the intensity of an electric current, where a battery is in action, is directly as the whole electromotive force in operation, and inversely as the sum of all the impediments to conduction. It may, therefore, be expressed by a fraction whose numerator is the electromotive force, and its denominator the sum of the resistance of all its parts. Let I be the intensity of the current; E the effective electromotive force in the battery; R its constant retarding influence, and r the variable retarding influence in the connecting wires; then

$$I = \frac{E}{R + r}.$$

If, according to Ohm's formula, we put the intensity of the current in a simple voltaic arrangement whose excited surface is I,

$$1.\ I = \frac{E}{R + r}.$$

Then the intensity of a current from a battery of n pairs of plates or cups will be,

$$2.\ I' = \frac{n\,E}{n\,R + r},$$

and in a single voltaic arrangement whose surface is n times greater than I, the resistance to conduction being diminished inversely as the area of its transverse section, the intensity becomes

$$3.\ I'' = \frac{E}{\frac{R + r}{n}} = \frac{n\,E}{R + nr}."$$

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The resistance to an electric current in a conducting wire is in proportion to the length of the wire, and inversely as its sectional area. That is, the longer the wire the greater the resistance, and the larger the wire the less the resistance. If the wire be many miles long, the resistance to the electrical current varies arithmetically as the wire increases in length geometrically. Arithmetical progression is constant addition, while geometrical progression is constant multiplication, and the ratio would stand thus:—

Resistance,	1 : 3 : 5 : 7 : 9 : 11 : 13 : 15, &c.
Length,	1 : 2 : 4 : 8 : 16 : 32 : 64 : 128, &c.

The resistance of the liquid in the cells is in direct proportion to the amount and thickness of that fluid, and in the inverse proportion to its conductibility. Or the greater the thickness of the fluid, the more resistance it will oppose to the galvanic current; while, on the other hand, the greater the conducting power of the fluid, the less obstruction is presented.

Thus it will be seen that the data for such an estimate are numerous, and require much scrutinizing experiment to afford a system for practical deduction.

Professors Wheatstone, of London, Steinheil, of Munich, and Jacobi, of St. Petersburg, appear to have been foremost among those who have endeavored to ascertain the velocity of the electrical current. Its rapidity, previous to their labors, was supposed incalculable; simple observation had impressed experimenters with the opinion that it was instantaneous; but, like the other imponderable agents, it has not only been shown to be progressive, but also, under peculiar circumstances, of much less celerity than light. It is greatly modified by the incidents connected with different trials. Not only the kind of electricity employed, but the nature and size of the conductor, temperature, and electrical tension of the atmosphere, dissimilar means and instruments used by different operators for arriving at results, may perhaps account for the very discordant opinions of practical physicists on this topic. Prof. Wheatstone, making a current of frictional electricity pass along copper wire, and noting the intervals of reflected sparks from a revolving mirror, estimated the speed at 288,000 miles in a second. Our ingenious and distinguished townsman, Mr. Saxton, devised the instrument with which Prof. W. determined these facts. Some truly practical and indefatigable trials have been recently made under the direction of Prof. S. C. Walker, of the United States Coast Survey, which, like the rest, present a heterogeneous mass of probable velocity; taking the whole of them, he deduces the "resultant as 15,890 miles per second, as the most probable value." (*Silliman's Journal*, March, 1851.) He used galvanic electricity, and conductors of wire known in trade as No. 9.

Professor Mitchell, of the Cincinnati Observatory, experimented with a sidereal clock on the common telegraphic line, and inferred the velocity at 30,000 miles per second. And again, Messrs. Fizeau and Gounelle, in a paper published in the *Comptes Rendus* of April last, make their result as 111,886 miles per second in copper wire, and 62,159 in iron.—*Journ. Frank. Ins.* vol. xx. p. 62.

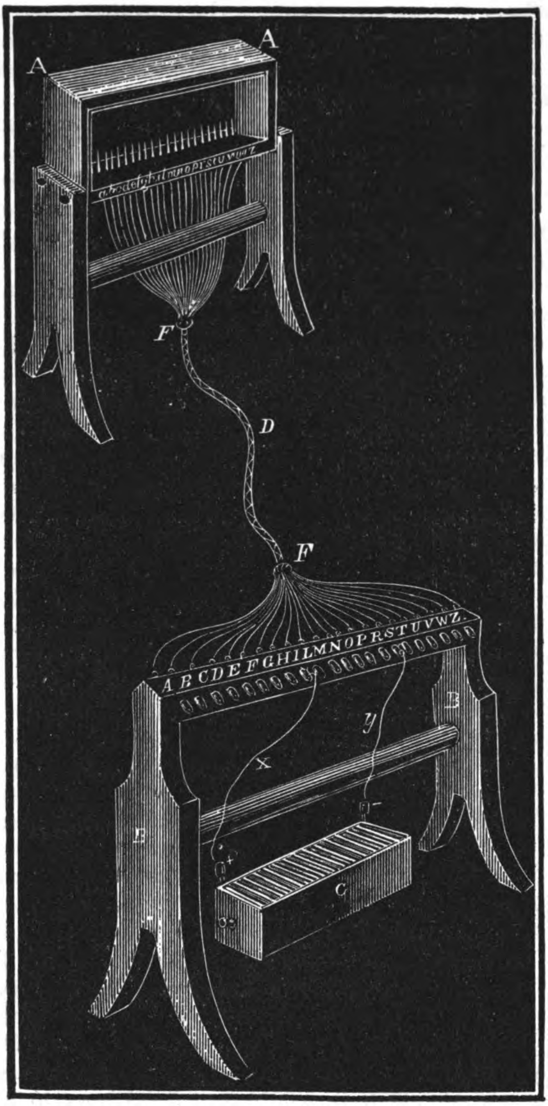
Here are very many discrepancies, that may be perhaps ascribed to the variable contingencies attending the experiments. Matteucci, Baumgartner, Kirchoff, Ridolphi, and Smauren, are and have been prominent investigators of this subject.

Many trials were made at an early period, on the transmission of galvanism through water and soil. In 1803, experiments were made by F. H. Basse, on the Weser, a distance of 4,000 feet being included in the circuit (*Gilbert's Annalen*, xiv. p. 26), by Erman, in the Havel, near Potsdam (*Gilbert*, xiv. p. 385), and by Aldini, at Calais, across about 200 feet of sea-water.

Prof. Steinheil, in 1837, first employed the earth as a return portion of the circuit between telegraphic stations, and nearly all the telegraph lines are now arranged on this principle. Much speculation has arisen as to the mode in which the electrical impulse is conveyed through the earth between the termini; though it is as much under our control as when transmitted through wire conductors, it is difficult to conceive the passage of the fluid in these cases as similar. In all our experiments we find the earth a vast receptacle and source of electricity, and from this fact modern physicists suppose no impulse communicated, but that electricity given to the earth at one end of the line increases the whole amount of it, and the equilibrium is restored by the escape of the redundant fluid into the other extremity of the wire. Baumgartner inferred from experiment, that the geological structure of the intervening earth had some effect upon the time required for the appearance of the electrical impulse at the termini; this, if correct, is strong evidence in favor of conduction of electricity by the earth.

Application of Galvanism to Telegraphing.—"Mr. S. T. Sömmering, of Munich, first applied galvanism to telegraphing; in 1809, he constructed an apparatus, which, by decomposing water, enabled him to give signals. At the station where the news was to arrive, were arranged thirty-five small glass test-tubes, filled with water, and reversed in a reservoir also containing that fluid. Into each one of these test-tubes, projected through the bottom of the reservoir the gilt end of one of thirty-five wires, that came from the transmitting station. Each wire at the termini of the line was connected to its own distinct brass plate or cylinder. These plates were arranged in a row and perforated at one extremity: by introducing two conical metallic pins connected with the poles of a voltaic battery into these perforations, a

Fig. 3.

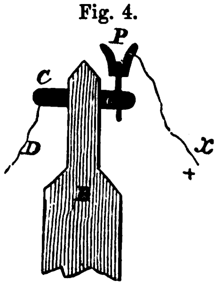


circuit was established. Each glass tube was marked with one of the 25 letters of the German alphabet, and 10 numerals, and the plate connected to it by wire at the other station, was stamped with the same. The circuit being established, the water in two of the tubes was decomposed, the gaseous constituents of which rising gave two signs, whose succession was determined by considering the letter over the evolved hydrogen at first. Decomposition of water gives twice the volume of hydrogen that it does of oxygen, and thus no mistake could well be made in distinguishing them. The conducting wires, well insulated, after passing some distance from the apparatus, were wound into a rope to go on to their destination. Fig. 3 represents Sömmering's telegraph; *AA* water-receiver. The points protruding into it are shown, the glass tubes are removed. *BB*, the apparatus to close the circuit. *C*, the voltaic battery. Single wires coming from the wire rope *D*, have connection with the plates or cylinders. Into the perforations of these plates, the metal pencils connected with the closing wires *Xy* fit exactly; they are kept clean and free from oxidation in order that they may do so.

If the rod or pencil of the positive pole is put into the plate *L*, and that of the negative one into the plate *S*, the circuit is closed. Coming from *X*, the current goes into the wire in connection with *L*, then to *l*, at the other station, through the receiver to *S*, thence into the conducting wire to *S* at the first station, through *y*, to the negative pole of the battery. Oxygen rises from the positive pole in the glass *l*, and hydrogen from the negative one in the glass *s*, and thus a signal is given which reads *s l*.

The mode of completing the connection is exhibited in the small Fig. 4, by a lateral view of the instrument: *B*, standard to support the frame of cylinders; *C*, a single cylinder; *a*, orifice in it where the rod *P* is introduced; *X*, wire connecting with the positive pole of the battery; *D*, wire leading to the opposite station.

Fig. 4.



Especial signals are used to denominate the same letter used twice in succession, or to designate the end of a word. Sömmering connected with his instrument a curiously constructed alarm, to call the attention of the operator. It consisted of a two-armed lever, the longer arm having the shape of a spoon, while the shorter supported a rolling brass ball. The arrangement was easily moved, and it was necessary to poise it after each telegraphic operation. The hollow end of the long arm stood over the end of one of the wire points, and at the commencement of an operation received the hydrogen that was evolved at this point. After one half a minute, sufficient gas was evolved to carry upward in its ascent the long arm of the lever, depress the shorter one, and by this depression permit the ball to fall through a tube on a lever connected to an alarm-stop, set it loose, and thus put the alarm in active operation. Though very ingenious, the expense of so many wires, and their insulation, precluded the use of this instrument on a large scale; likewise, the necessity of constant attention on the part of the attendant to watch the evolution of gas in two of the thirty-five tubes, was a strong objection to it.

On the publication of this apparatus in his *Journal*, Schweigger proposed the use of two wires, which he considered sufficient, if two voltaic batteries, one strong and another weak, were used, and the time being taken into consideration partly during the evolution of the gas, and partly that which elapsed between the two evolutions following each other.—*Schellen's Elec. Mag.* p. 53.

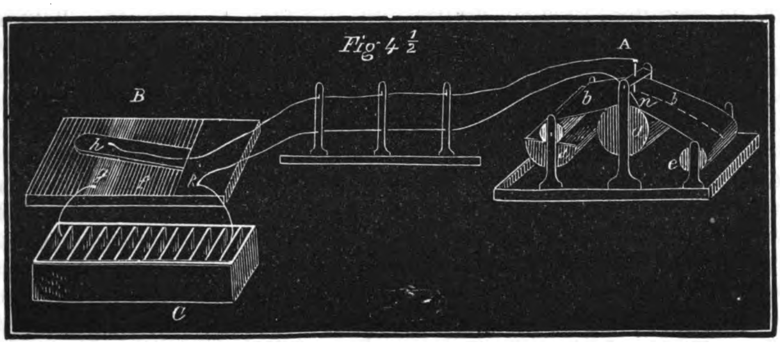
We find the following in *Thomson's Annals* for 1816, from the pen of Dr. J. R. Coxe, then Professor of Chemistry in the University of Pennsylvania. This hoary-headed veteran in the cause of knowledge is still living in our midst. Though long since withdrawn from the active duties of teacher in the oldest medical school of this country, the mementos of his labors remain emblazoned among the records of science. Speaking of galvanism, he says: "I have contemplated this important agent, as a probable means of establishing telegraphic communications with as much rapidity, and perhaps less expense, than any hitherto employed. I do not know how far experiment has determined galvanic action to be communicated by means of wires; but there is no reason to suppose it confined as to limits, certainly not as to time. Now, by means of apparatus fixed at certain distances, as telegraphic stations, by tubes for the decomposition of water, metallic salts, &c., regularly arranged, such a key might be adopted as would be requisite to communicate words, sentences, or figures, from one station to another, and so on to the end of the line. As it takes up little room, and may be fixed in private, it might in many cases of besieged towns, &c., convey useful intelligence with scarcely a chance of detection by the enemy. However fanciful in speculation, I have no doubt that, sooner or later, it will be rendered useful in practice. I have thus, my dear sir, ventured to encroach on your time with some crude ideas that may serve perhaps to elicit some useful experiments in the hands of others. When we consider what wonderful results have arisen from the first trifling experiments of the junction of a small piece of silver and zinc in so short a period, what may not be expected from the farther extension of galvanic electricity! I have no doubt of its being the chief agent in the hands of nature in the mighty changes that occur around us."

Next in order of those depending on the galvanic principle solely, is the physiological telegraph of Vorzleman De Haer. He proposed the instrument on a small scale in 1839, basing it on the property of galvanism to produce physiological effects on the nerves and muscles, and making sensation the means of receiving the signals. He employed ten wires after Messrs. Steinheil and Morse had succeeded with only one, and experience has also taught us that many repeated shocks render the operator insensible; the workmen in the gutta percha manufactory of Fonropert and Pruckner, at Berlin, engaged in proving insulated tubes, lose sensibility in their hands and forearms after a day's work. One constructed by a skilful organ-builder, was exhibited in January, 1839, at a sitting of the Physical Society of Deventer. The keys have a similar arrangement to those of the piano-forte, and connection is established by depressing them into a cup of mercury; no extensive use has been made of this instrument.—*Schellen's Elec. Mag.* p. 66.

Mr. R. Smith, Lecturer on Chemistry, Blackford, Scotland, invented an Electro-Chemical Telegraph; a paper containing an account of which was read before the Royal Scottish Society of Arts, on the 27th of March, 1843, reported on by a committee, and approved the 12th June following. Since that time, many trials have been made, and various improvements in its construction have also been introduced by the inventor. The following is a description of it in its present improved form:—

In the annexed wood-cut, *A* represents the indicating portion of the telegraphic apparatus; *a* is a leaden cylinder fixed upon a spindle, which is supported so as to revolve freely, by two standards attached to the bottom plate of the apparatus; *b b* is a piece of calico in the form of a ribbon coiled upon the roller *c*, placed in the trough *d*, its contrary extremity being attached to the second roller *e*, revolving loosely in standards attached to the opposite end of the bottom plate; *B* is the communicator, or that portion of the apparatus through which any given signal is communicated to the indicator *A*; *f* is a block of wood having a brass plate *g* attached to it; *h* is a slip of wood hinged to the block, and slightly raised above the surface of the brass plate *g* by means of a spring placed beneath it. The brass plate *g* is connected by the wire *k* with the positive end of the voltaic battery *C*, the negative end of which is connected with the wire *l*, which passes along to the indicator *A*, where it is attached to the leaden cylinder *a*. The other wire, *m*, is attached to the finger-board *h*, through which it passes, projecting slightly on the lower surface, its contrary end being attached to the impress wire *n*, which is supported loosely by a cross-beam on the top of the centre-standards of the indicator, its lower end resting upon the calico ribbon on the leaden cylinder beneath.

To put this apparatus in action, the cells of the battery *C* are filled with water, and the trough *d* with a solution of ferro-cyanate of potass, to which have been added a few drops of nitric acid. The roller *e*, to which the indicator cloth is attached, is next put in motion by clock-work, and thus the cloth, wet with the solution contained in trough *d*,



is caused to pass uniformly over the leaden cylinder *a* below the point of the impress wire.

The apparatus is now ready for signaling, which is done by pressing down the finger-board *h*, so as to bring the end of the wire *n* in contact with the brass plate *f*, thus completing the electric circuit. The impress wire *n* now becomes the positive electrode, and the cylinder *a* the negative one, and a blue mark is printed upon the cloth, by the electric fluid decomposing the ferro-cyanate of potass, thus forming cyanate of iron. If the circuit is formed and broken rapidly, a succession of dots will be printed upon the cloth; if formed and broken at long intervals, the result will be a series of marks. In this manner long and short spaces and corresponding lines will be formed according to the duration of the opening or closing of the circuit, and the speed with which the cloth is caused to pass beneath the metallic pen. An arrangement of these various marks thus forms the telegraphic alphabet, from which sentences may be composed, embracing any information which it may be necessary to transmit. For instance, a single dot may be taken as the index for *A*, two for *B*, three for *C*, and a dot and line for *D*, &c.

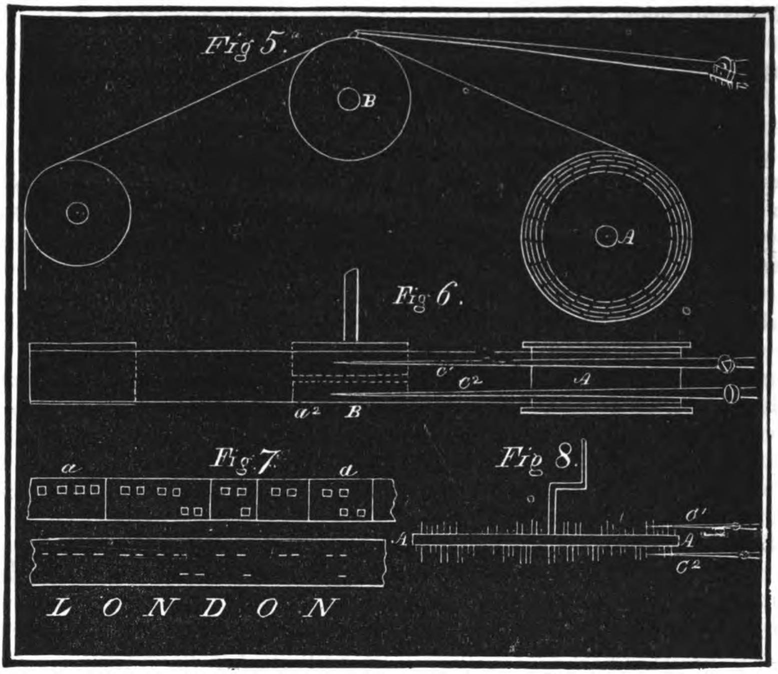
The species of battery which is the best adapted for producing the electro-chemical indications, consists of forty repetitions of charcoal and zinc plates; the charcoal plates being composed of three parts pulverized charcoal, two of pulverized coke, and one of wheaten flour, mixed together with water; when formed, the plates are allowed to dry, and are then placed in an earthen crucible, in the lid of which is an aperture for the escape of the gases; in this they are heated to redness. This battery will keep up a uniform and energetic current for a considerable time, the cells being merely filled with water; the only attention which it requires subsequently, being to wash off any oxide which may be deposited upon the plates, and supply fresh water. The battery employed for making the electro-magnetic telegraph is a calorimotor or single circle; the electricity generated by this battery has a tendency to weaken in its progress, so that the defect must necessarily be provided for by placing batteries at different distances, according to the desired amount of power; this objection is completely removed in the voltaic apparatus. Experiment has proved that the electric energy from the intensity battery, in producing the electro-chemical effects, *increases* instead of diminishing in regard to distance. Faraday ascertained that the quantity of electricity required to decompose a single drop of water, is equal to that of a powerful flash of lightning, while from the largest single circuit ever constructed, not the slightest chemical effect can be exhibited. On the other hand, a small single circle composed only of a few square inches of copper and zinc, will temporarily magnetize a large bar of iron, while a powerful voltaic trough will not magnetize a lady's sewing-needle. Throughout the whole of the practical details of the electro-magnetic apparatus, a far greater amount of carefulness of workmanship is required than in those of the voltaic one. Thus, the whole of the joinings of the conducting wires require to be in perfect metallic contact, and carefully isolated, whilst the electro-chemical communications may be transmitted through the medium of a wire fence. The inventor lately exhibited an experiment which proves the practicability of this application.

In this case, the communicator and indicator were attached to the contrary extremities of an iron wire fence of a length of 1,868 yards, when a number of signals were dispatched with the greatest facility. This economical adaptation will doubtless render it worthy of the attention of railway proprietors, as a metallic fence may in this manner be rendered doubly useful.—*Prac. Mech. and Eng. Mag. Glasgow*, vol. i. 2d series, pp. 36, 239.

Succeeding this in our chronological series, comes the instrument of Alexander Bain, a native of the northern part of Scotland. Mr. Bain's instrument, dated December 12, 1846, in patent specifications, depends for its efficiency on electro-chemical action, and consists of a transmitting apparatus at one end of the line, with a recipient one at the other terminus. Figure 5 is an elevation, and Fig. 6 is a plan of so much of a transmitting apparatus as is necessary to show its mode of action. *AA* is a thin roller of wood upon which is wound a long strip of paper, previously perforated with holes *a a a*, in the manner represented in Fig. 7. Each group of holes, as divided by cross lines, represent letters, numerals, words, or sentences, as may have before been fixed upon. From this roller *A*, the end of this slip of paper is passed between another roller *B*, and two metallic springs C^1 C^2. The roller *B* is composed of metal pieces a^1 a^2, mounted upon wood inside, so that their contiguous edges shall be some distance apart; and the roller is moved by clock-work, whose velocity is regulated by a ball governor. The receiving apparatus at the other end of the line is the same as the transmitting one, except, that instead of the strip of perforated paper, there is wound on the roller *A A*, a strip of colored paper. This is first soaked in diluted sulphuric acid, and afterwards in a solution of prussiate of potassa; while wet it is wound on the first roller *A*, where it forms part of the galvanic circuit, and must be kept damp while the message is being sent. When the machines at both ends of the line are thus arranged, and connected together by wire, with the metallic springs $C^1 C^2$, attached to a galvanic battery, the operator at the transmitting end sets it in motion, like the lock which governs the striking of a clock; this lifts a detent in the receiving apparatus at the other end of the line, and puts that in operation. Thus, the two machines unroll their strips of paper at the same time, and as long as the contact between the springs C^1 C^2, and the second roller *B*, of the transmitting machine, is prevented by the paper which has no holes in it passing between them, the circuit is broken. As soon as the spring C^1 comes over one of the holes in the paper, the circuit is re-established, and the electric current flowing through these holes, passes along the connecting wire to the wet roll of paper at the receiving end of the line. The electricity passing through the wet paper destroys its color by chemical action in those parts which it enters, and thereby makes as many legible spots on the wet roll of paper as there are holes in the dry roll at the other end of the wire. Thus, by alternately renewing and breaking contact by means of the holes in the transmitting roll, as many corresponding letters, numerals, &c. are made on the receiving roll.

An exemplification of the alphabetical characters employed by Mr.

Bain is given in Fig. 7, which represents at once the perforations which would be made in the transmitting paper, and the correspond-



ing marks which would be made in the colored or recipient paper to express the word LONDON. When it is desired that the attendant at the receiving station should not know the contents of the message sent, the receiving roll is wet in diluted acid, passed through the machine, and afterwards immersed in the solution of prussiate of potassa, which makes the words plain. The holes are made in the paper by means of a separate machine worked by hand; the paper passes between two rollers, one of which is a small punch, which cuts the holes in the paper, and works by the slightest touch. After the holes are made in the paper, it then has to be wound on the transmitting roller. The rapidity of this mode of communication depends on the number of holes which a clever hand can punch in a given time, which is about 100 per minute; after the holes are made, the machine will transmit from 500 to 1000 impressions in a minute. Mr. Bain has lately remodelled this machine, by changing the rollers of the receiving apparatus into a revolving disk, in the periphery of which, there are a number of metallic rods or wires of equal length, which may be made to slide towards one side of the disk, or the other, at pleasure.

Fig. 8 is a plan of this modification. *A* is the edge of the disk; *b b* the wires; and C^1 C^2 springs, similar to those marked with the same letters in other figures. It will be obvious that, when the disk *A* is made to rotate, the springs C^1 C^2 will successively be brought in contact with the wires *b b*, on one side or on the other; and that as they are made the means of establishing the metallic connection between the two ends of the line of communication, the effects produced upon the chemical substance will be the same as before described. In this case, the wires *b b* serve the purpose of the holes in the strip of paper, Fig. 7.—*London Mechanics' Magazine*, vol. xlvi. p. 591.

"In this form of telegraph," he remarks, "I have rejected magnetism altogether, and caused the pulsations of the electric current to be transmitted through groups of perforations, forming signs, which are recorded at the receiving station by pulsations of the electric current acting on chemically preparèd paper, in the manner described and shown; so that the circuit is completed, and interrupted, by the operation of the composed communication itself, without the electric current having to produce any mechanical motion, and without any manipulation of the operator, in forming the intermittent pulsations of the electric current; thereby effecting the transmission of a communication to one or a plurality of distant receiving stations, with far greater rapidity than by any other mode."

This may be true in theory, but it will require more time than the simple passage of the current in practice. For in every case decomposition of the fluid will take place, and time is required for the operator to see the mark. If the paper should become dry, as it is known to do, the mark then becomes very indistinct from the want of proper conducting material; and as the wire is not of platinum, by becoming oxidized it prevents that proper metallic contact, so that it will require an intense and constant current, which cannot be produced and kept up in the form of battery described by Mr. Bain, namely, zinc and copper battery. There is also the inconvenience arising from the fumes from the chemicals employed in preparing the paper.

S. F. B. Morse's Electro-Chemical Telegraph, patented in May, 1849.—"The nature of my invention consists: First. In the application of the decomposing effects of electricity produced from any known generator of electricity, to the marking of the signs for numerals, or letters, or words, or sentences, invented and arranged by me, and secured by patent, bearing date June 20, 1840; reissued January 15, 1846, and again reissued, June 13, 1848, or their equivalents, through a single circuit of electrical conductors.

"Second. In the mode of applying this decomposition, and the machinery for that purpose.

"Third. In the application of the bleaching qualities of electricity to the printing of any desired characters.

"In applying the decomposing effects of electricity upon any known salts that leave a mark, as the result of the said decomposition, I use—

"*Class A*. A class of salts that produce a *colored mark* upon *cloth, paper, thread*, or *other material*, under the action of electricity.

"First. Iodide of tin in solution.

"Second. Extract of nutgalls, and sulphate of iron in solution, making an ink which colors white cambric cloth a uniform gray.

"Third. Acetate of lead, and nitrate of potash in solution.

"Fourth. Iodide of potassium in solution.

"Into either of these I dip a strip of cloth or thread, which is kept properly moistened. All these give a black mark upon the cloth, thread, or other material under the action of electricity.

"*Class B.* A class of salts which color the cloth, paper, thread, or other material, and are *bleached* by the action of electricity.

"First. Iodide of tin in solution.

"Second. Iodine dissolved in alcohol.

"Into either of these I dip a strip of cloth, paper, thread, or other material; and if in solution *second*, I also dip them into a solution of sulphate of soda, the cloth or other material, in these cases, becomes of a purple color more or less dark. The electricity in these cases, when a metallic point or type is pressed upon, or comes in contact with, the moist cloth or other material, *bleaches* it, and leaves the point or the type impressed in white characters upon the material.

"*Class C.* A class of salts that produce a mark upon metal, through the intervening cloth or other material, and not upon the material, under the action of electricity.

"First. Sulphate of copper in solution.

"Second. Chloride of zinc diluted with water.

"Third. Sulphate of iron in solution.

"Into either of these solutions I dip the cloth, thread, or other material, and if into the third, I afterwards dip it into muriate of lime in solution. The electricity in these cases causes a dark mark upon a bright metal plate beneath the moistened material, but not on the material itself.

"The mode of applying this decomposition by electricity, is by the use of so much of my machinery previously described in the schedule referred to in the Letters Patent, granted to me, and bearing date June 13, 1848, being the reissue of the original patent of April 12, 1846, as is employed in regulating the motion of the paper, substituting, however, for the common paper therein used, the cloth, thread, metal, or other material, chemically prepared.

"*Operation.*—I consider the discoloring process better than the bleaching process, and for the discoloring process I consider the iodide of potassium in solution, as the best of the substances I have mentioned for the preparation of the cloth, paper, or other material. I wish it to be understood that I do not confine myself to the use of the substances I have mentioned, but mean to comprehend the use of *any known substance already proved to be easily decomposed by the electric current.*

"*Claims.* What I claim as my own invention and improvement, and desire to secure by letters patent, is: 1st, the use of the *single circuit* of conductors for the marking of my telegraphic signs already patented, for numerals, letters, words, or sentences, by means of the decomposing, coloring, or bleaching effects of electricity, acting upon any known salts that leave a mark as the result of the said decomposition, upon paper, cloth, metals, or other convenient and known markable material.

"2d, I also claim the combination of machinery as herein substantially described, by which any two metallic points or other known conducting substances, broken parts of an electric or galvanic circuit, having the chemically prepared material in contact with and between them, may be used for the purpose of marking my telegraphic characters already patented in Letters Patent, dated 20th of June, 1840; in the first issue, 25th January, 1846; and second reissue, 13th June, 1848."

The marking instrument of Morse is a platina disk, and is described fully in the patent. As this apparatus has not been used practically, I have noticed it here more to keep up the chain of Galvanic Telegraphs, and I am surprised that Mr. Morse should have taken out a patent for a telegraph so far inferior to the one he has in operation since 1840, as there cannot be a doubt that the Chemical Telegraph, according to the opinion of the best operators, is far inferior to the Electro-Magnetic in regard to trouble, expense, and uncertainty in operation.

"The last patent of Mr. A. Bain is one taken out in connection with Robert Smith, Lecturer on Chemistry, Perthshire, Scotland, October, 1849.

"These improvements consist—

"Firstly. In the peculiar mode of arranging the several parts herein described of our marking instruments of Electro-Chemical Telegraphs.

"Secondly. In a mode of constructing a style or point-holder, so as to afford a ready and convenient mode of regulating the pressure of the style or point on the surface of the chemically prepared paper or other suitable fabric.

"Thirdly. In a mode of applying a weight for regulating the pressure of an upper on a lower revolving wheel, or roller, in motion, so as to grasp the strip of chemically prepared paper, or other suitable fabric, and insure its being drawn continually forward.

"Fourthly. In a mode of arranging the marking instruments, keys, wires, and batteries, in a single circuit, and in branch circuits, connected therewith, so that a copy of a message sent from any station may be marked upon the chemically prepared paper, or other fabric, at any desired number of stations in communication therewith, and also, if required, at the transmitting station.

"We would here state, that the paper, linen, or other suitable fabric, may be prepared by being equally and thoroughly moistened by the following chemical compound, viz.: Ten parts, by measure, of a saturated solution of prussiate of potash, which will be best made in distilled water, and we prefer to use the yellow prussiate for this purpose; two parts, by measure, of nitric acid, of the strength of about 40° by Baumé's scale; two parts by measure of muriatic acid, of the strength of about 20° by Baumé's scale.

"To keep the paper, or other fabric, in a sufficiently moist state, favorable for the action of an electric current, we add about one part by measure of chloride of calcium; this mixture is to be kept stirred about with a glass rod until the chloride of calcium is in complete solution. In connection with this compound, it is proper to observe that we have found that prussiate of potash, combined with almost any acids, will give mark under the decomposing action of an electric current, but no other mixtures act so quickly, or give such permanent marks with feeble currents of electricity, as that herein described. The principal use of the chloride of calcium is, that it absorbs moisture from the atmosphere, and thereby keeps the prepared fabric in a proper state to be acted upon by an electric current in all states of the weather."

"The system of correspondence made use of consists of *dots* and *lines*; the number, dimensions, and relative positions of which form an intelligible code of signals, as is well understood.

"We do not claim as our invention the train of wheels constituting the motive part of the marking instruments; neither do we claim or confine ourselves to any particular form of battery or other generator of electricity, which may be of any suitable form, several of which are well known and in common use.

"We desire it to be understood that what we claim as new and of our invention, is:—

"Firstly. The modes of arranging the several parts of our marking instruments for Electro-Chemical Telegraphs, substantially as herein-before described.

"Secondly. We claim the mode of adjusting a style or point-holder, as herein-before described and shown, so as to afford a ready and convenient mode of regulating the pressure of the style or point upon the surface of chemically prepared fabric.

"Thirdly. We claim the mode of applying a weight, for the purpose of regulating the pressure of a wheel or roller in motion, so as to grasp the strip of prepared paper, and insure its being drawn continually forward.

"Fourthly. We claim the mode of arranging the marking and transmitting instruments, wires, and batteries, in a single circuit, and in branch circuits connected therewith; so that a copy of a message sent from any one station may be marked upon chemically prepared paper, or other fabric, at one or any desired number of stations in communication therewith, and also, if required, at the transmitting station, without requiring the use of any secondary current."

On the 28th of May, 1850, Messrs. Westbrook and Rogers, the former of Washington, the latter of Baltimore, secured a patent for the "Electric Metallic Telegraph." In their Specification, they state that: "The nature of our invention consists in recording telegraphic signs on a metallic surface, connected with the earth by a wire conductor at one end, and to a galvanic battery and the earth at the other end of the circuit, by the use of the acidulated water or other fluid interposed between the point of the usual wire conductor leading from the operating apparatus, connected with the galvanic battery of the ordinary construction and the metallic surface, by which the use of paper is dispensed with; time also being saved, in not having to moisten the chemically prepared paper when it becomes too dry for use, and in having the telegraphic signs more clear and distinct on the metallic surface than on the paper; in avoiding the inconvenience arising from the fumes from the chemicals employed in preparing the paper, and evils arising from the corrosion of instruments, and annoyance to operators in preparing and using chemical paper, and other inconveniences."

The metallic recording surface, after being filled and transferred, is simply cleaned by the application of a sponge or other soft substance saturated with acidulated water. The wire conductor has the form of a tubular pen, of which the fluid flows by means of a barrel valve or sponge and porous substances, such as glass or ivory, open at both ends, through which the acidulated water or other fluid passes to the metallic surface, on which the telegraphic signs are to be made.

Before concluding the subject of electro-chemical telegraphs, I would bring before my readers a communication from the distinguished French philosopher, the Abbe Moigno, author of the *Traité de Telegraphie-Electrique*, although not agreeing with the sentiments expressed in my former communication; but I have introduced it in justice to Mr. Bain, and from respect to the opinion of M. Moigno.

Communication on the Electric Telegraph.—The President of the Society for the Encouragement of National Industry (Session May 8, 1850) announced that Mr. Bain had arranged in the hall his ingenious system of electric telegraphing, of which M. Sequier had during a previous session given a description, which greatly interested the members of the Society.

The Abbe Moigno was invited to give an explanation of this apparatus, to which invitation he quickly responded.

"In this consists the ingenious mechanism of this apparatus, to which the author has given the name of electro-chemical telegraph, to distinguish it from the electro-magnetic telegraphs now in use, provided it be deprived of the magnet.

"The message wished to be transmitted, is written on a piece of long narrow paper by cutting, with the aid of a punch, the letters of a very simple alphabet composed of points and horizontal lines. This band is rolled on a wooden cylinder, and then unrolls itself with the aid of a crank, so as to pass on a second metallic cylinder, which supports four little springs which communicate with the conducting wire of the telegraphic line; the metallic cylinder is connected with the pole of a battery of small volume and very simple construction.

"The band of paper presents in turn a covered part and a vacant space; this last represents the letters of the alphabet, whilst the covered parts are of paper, that is to say, an insulating substance. When the small springs rest on the covered parts, the circuit is not formed and the current does not pass; but so soon as the springs touch an empty place, they are in contact with the cylinder; from that time the communication is established, the current circulating, and arriving instantaneously at the station. There a small style is attached to the conducting wire of the line; below this style turns a metallic plate, which is covered with a disk of paper, chemically prepared by dipping it at first in a solution of sulphuric acid, and afterwards in a solution of prussiate of potash. The plate and the damp disk with which it is covered, communicate with one of the poles of the battery at the station of arrival. The current is afterwards completed through the earth.

"The dispatch is transmitted in the following manner: At a given signal, the style is applied to the chemical paper; at every empty space on the band of paper, which is unrolled by the crank, the current passes, and under its influence the point of the style, by the chemical action which it exercises, traces a point or a little line of a very dark color, which is the faithful representation of the letter which must be reproduced at a distance.

"The band on which an entire page is written unrolls itself with extreme rapidity; the plate, drawn by a clock-like movement, turns also with great quickness. At 45 seconds, the 1,200 letters composing this page appear very neatly drawn on the disks of the chemical paper, and were thus faithfully reproduced, and would have gone two or three hundred leagues farther without any difficulty. The movement printed on the plate is a spiral one, so that the successive lines do not supersede each other, but remain entirely distinct.

"These are the advantages which the author attributes to his system of electro-chemical telegraph: 1st, more economy and simplicity in the primitive construction; 2d, more rapidity in the transmission of the dispatches; a single wire with a good insulator can transmit 1,200 letters a minute, or 20 letters a second, that is, ten times more than is customary; 3d, an electric current more feeble than is ordinary suffices to cause the apparatus to work, and is consequently less exposed to the chances of interruption by the imperfection of the insulation, which results sometimes from the vicissitudes of the weather and other circumstances; 4th, more simplicity and economy in the correspondence and superintendence; 5th, fewer chances of error in the dispatches sent.

"Bain's telegraph is in operation in England, from London to Manchester, and from Manchester to Liverpool, over an extent of 300 kilometres (186½ miles), and in America on a line of 2,000 kilometres (1,242⅛ miles).

"The President begs Mr. Bain to receive the congratulations of the Society on his system of electric telegraphing, and he renders to M. Abbe Moigno the thanks of the Society for the complaisance with which he has given clear and precise explanations on the mechanism and play of this system."—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, May 8, 1850, p. 236.

Before giving an account of the various forms of electro-magnetic telegraphs, it will be proper to give a brief account of the science which investigates the relations subsisting between the electric, galvanic, and magnetic fluids; as all the forms of telegraph I am about to describe, depend on the power of the electric current to deflect a magnetic needle, or the power of the current to impart temporary magnetism to iron, or to produce electric currents by magnetic induction.

Electro-Magnetism.—The power of lightning to destroy and reverse the poles of a magnet, and to convey magnetic properties to iron, which did not previously possess them, was noticed at a very early period of electrical science, and led to the supposition that common electricity and galvanism would produce the same effect. Attempts were made to prove this fact, but no important results were obtained, until the late Prof. Œrsted, of Copenhagen, published in *Thomson's Annals of Philosophy*, for October, 1820, the important discovery he had made in the winter of 1819, which laid the foundation of the science of electro-magnetism. He ascertained that, when a wire conducting electricity is placed parallel to a magnetic needle properly suspended, the needle will deviate from its natural position, which is thus expressed in Ampère's brief and universal terms: "*That the north pole of a magnet is invariably deflected to the left of the current which passes between the needle and the observer, who is to have his face towards the needle, the electric current being supposed to enter near his feet, and to pass out near his head.*" Likewise, that this deviation follows a regular law, which can be stated in four general rules: 1st. If the needle is above the conducting *wire*, and the electricity passes from right to left, the north pole of the needle will be moved *from* the operator. 2d. If the needle is below the wire, and the electricity passes as before, the north pole of the needle will be turned towards the observer. 3d. If the needle is put in the same horizontal plane with the wire, and is between the observer and the wire, the north pole of it will be elevated. 4th. If the needle is in like manner placed on the opposite side, the north pole will be depressed. To exhibit this effect well, the needle must be very near the wire. Other new and important facts were soon after discovered by Ampère and Arago, in France; Davy and Faraday, in England; and Prof. Henry, then of Albany, New York. Ampère satisfactorily referred all the observed phenomena to the laws which govern the mutual actions of electrical currents, by means of a very ingenious hypothesis—that magnetism consists in electrical currents, revolving around the minute particles of a magnet, in planes perpendicular to its axis. This branch of science is also named electro-dynamics, which simply means electricity in motion, while electricity at rest, is called statical electricity. The laws of electro-dynamical attraction and repulsion, experimentally established by M. Ampère, and which serve to explain all the known phenomena, may be plainly stated in a few general propositions.

Proposition 1st. Parallel currents (Fig. 9), flowing in the same direction, attract each other, where *a b c d* are the currents, whose directions

Fig. 9.

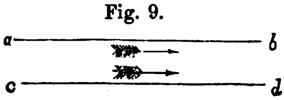


Fig. 10.

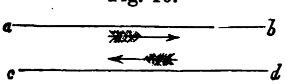
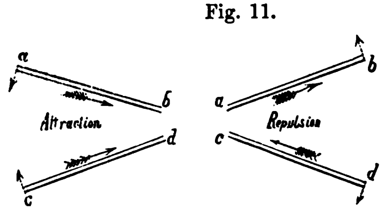


Fig. 11.



are indicated by arrows. They mutually repel, when their directions are opposite, as in Fig. 10, *a b c d.*

Proposition 2d. Two currents attract each other, when they both flow towards or from a certain point, if they are not in the same plane, as in Fig. 11. And they repel each other, if one approaches and the other recedes from that point, as in Fig. 11.

If two rectilinear currents, *a b* and *c d*, Fig. 12, cross each other, then, by the preceding case, they will attract each other between the vertical angles *x* and *y*, and repel between *z* and *w*. The result will be that both conductors will endeavor to take up a position in which the currents that flow through them may have a similar direction.

Proposition 3*d*. These attractive forces vary in their intensity in the inverse ratio of the square of the distance—or, as the distance increases, so their force diminishes.

Fig. 12.

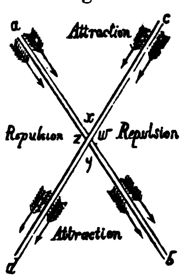
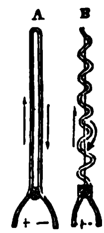


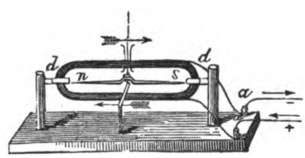
Fig. 13.



Proposition 4*th*. The attraction or repulsion exerted by a current passing through a tortuous conductor, no matter how numerous its windings may be, is exactly equal to that which is produced by the same current when it follows in a straight line between the points, as shown in Fig. 13. A magnetic needle is a galvanoscope, by which the existence and direction of an electric current may be detected. It was early employed with this intention, by Ampère, but, as the deflection took place only when the opposite ends of the battery were in connection, and ceased when the circuit was broken, he inferred that electricity passes uninterruptedly through the battery itself when the circuit is closed, and that there is no action in the interrupted circuit.

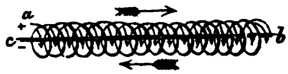
A magnetic needle will not only indicate the existence and direction of an electric current, but may serve by the degree of deflection as an exact measure of its force. When used for this purpose it is called a galvanometer, the first example of which was invented by Professor Schweigger, of Halle, in 1820, soon after the discovery of electro-magnetism, and was called by him an electro-magnetic multiplier; an example of this form of instrument is seen in Fig. 14. Various forms have been given to this instrument, as it is the basis of all the needle telegraphs.

Fig. 14.



A current of galvanic electricity not only determines the position of a magnet, but renders steel permanently magnetic. This was observed nearly at the same time, by M. Arago and Sir H. Davy, who found that, when needles are placed at right angles to the conducting wire, permanent magnetism is communicated to them. Sir H. Davy succeeded in producing this effect, even with a shock of electricity from a Leyden jar. M. Arago, at the suggestion of M. Ampère, made a galvanic conductor in the form of a helix, or coil, into the axis of which he placed a needle, as seen in Fig. 15. This helix was simply a spiral coil of wire, the extremities of it being connected to the opposite poles

Fig. 15.



of a battery, thus permitting an electrical circuit to pass through it. By this arrangement, the current is almost at right angles to the needle, and as each coil adds its effect to that of the others, the entire action of the spiral helix is extremely powerful. In this way a needle can be completely magnetized in an instant, and this is the method now principally employed by artisans in the manufacture of compass needles.

When the conductors of a galvanic battery are brought near, or in contact with a quantity of iron filings, the filings will be attracted towards the conductors, and place themselves in the form of a ring around it. This action takes place while a current of galvanism is sent through the conductor, but as soon as that current is broken they fall off. By observation of this fact, M. Arago was led to the important discovery of what is termed magnetic induction by electrical currents; namely, that a current of electricity passing through a conductor will induce, or make sensible, magnetic action in those bodies near it, which are capable of being magnetized. Arago was then the first to form a temporary magnet. That this property is magnetic, and not simply electrical, is shown by the fact, that the filings of other metals are not attracted in the same way. It likewise renders steel needles permanently magnetic when placed in the axis of the spiral helix or coil.

The word induction is here used to express that power which electricity has to make magnetic action apparent to our senses. That the effect of the galvanic current upon the iron filings and needles is one of magnetic induction, is proved by the reality that they acquire this property without contact with, and even at a distance from, the conducting wire.

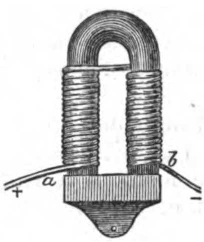
When the conjunctive wire is made of a non-magnetic metal, such as copper, it is well known that iron filings will adhere when brought in contact with it. This fact has been generally attributed to temporary magnetism, induced in the wire, whereby it attracts the filings. Dr. Bache, the eminent Professor of Chemistry in the Jefferson College, Philadelphia, however, has shown that this alleged attraction does not take place, and that the filings adhere to the wire because the particles of the iron become magnets, and, adhering together, form a ring around the wire, which ring supports them in their position. When the upper side of the ring of filings is broken, they immediately fall off.

Mr. Wm. Sturgeon, a native of London, about the year 1825, discovered that when wires of soft iron were placed within the coil of a conducting wire, they were rendered intensely magnetic.—*Annals of Philos.* vol. xii. p. 359.

Our knowledge of this subject was afterwards greatly extended during the period from 1828 to 1831, by the researches of Professor Henry, Secretary of the Smithsonian Institution, at Washington.

Though soft iron does not retain magnetism, its magnetic properties, while under the influence of a galvanic current, are very surprising. A piece of soft iron, about a foot long and an inch in diameter, is bent in the form of a horseshoe; an insulated copper wire is twisted round the bar at right angles to the axis, and an armature or keeper of soft iron, to which a weight may be attached, is fitted to its extremities; as may be seen in this instrument, Fig. 16. On connecting the ends of the wire with a simple galvanic circle, the soft iron instantly becomes a powerful magnet, and will support a weight of 50, 60, or even 70 pounds. As soon as the galvanic circuit is broken, the iron immediately loses its magnetism and the weight drops. When the number of coils is increased, they give great additional power. The wire used for making the helix must be wound with waxed or silk thread, to insulate it, so as to prevent the current from skipping along the contiguous parts of the coil, and thus taking a shorter route for its circuit, instead of traversing around the bar.

Fig. 16.



The instrument first used by Prof. Henry, in 1828, to illustrate electro-magnetic action, consisted of an iron bar, two inches square, twenty inches long, bent in a horseshoe form, and weighing 21 pounds. The keeper weighed 7 pounds, and 540 feet of insulated copper wire were wound in nine coils of 60 feet each around the horseshoe-shaped bar of soft iron. From the experiments which he made with it, he proved that a small battery is capable of producing great magnetic effects, if the spirals of the coil are numerous, and the resistance to the passage of electricity is not very great. He also showed the effect of varying the lengths of the conducting wires and the intensity of the current, and found that six short wires were more powerful than three of double the length. When the current was made to pass through all of the nine coils, the magnet raised 750 pounds.

After all his investigations, he concluded that we can use long or short wires as the case may require. Where we use long wires, the galvanic battery must have a number of plates, in order to give projectile force; on the contrary, a single pair of plates will answer for short wires.

"May it not also be a fact that the galvanic fluid, in order to produce the greatest magnetic effects, should move with a small velocity, and that, in passing through one-fifth of a mile, its velocity is so retarded as to produce a greater magnetic action.

"But be this as it may, the fact that the magnetic action of a current from a trough is, at least, not sensibly diminished by passing through a long wire, is directly applicable to Wm. Barlow's project of forming an electro-magnetic telegraph, and also of material consequence in the construction of the galvanic coil. From these experiments, it is evident that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require; in the first case, our galvanic combination must consist of a number of plates so as to give projectile force; in the second, it must be formed of a single pair.

"The wire used was 1,060 feet (a little more than one-fifth of a mile) of copper wire, of the kind called bell wire, .045($\frac{45}{1000}$) of an inch in diameter, were stretched several times across the large room of the Academy."—*Silliman's Journal*, vol. xix. January, 1831.

He afterwards endeavored to ascertain the best form of iron to receive magnetism, but did not succeed satisfactorily. However, he found that magnetic power resided wholly on the surface of iron bodies, though a certain thickness of metal is necessary for its complete development. Hence the larger amount of iron surface we have, the more powerful will the magnet be, when all other things are alike. This is the reason that a bundle of wires will exhibit greater magnetic effects than a solid bar, containing much more iron. Bachhoffner, of Germany, and Sturgeon, of London, were the first who noticed this fact.

In 1830, Prof. Moll, of Utrecht, made some experiments of the same nature, and noticed particularly the sudden destruction and reproduction of magnetism when the current is reversed.—*Bibliothèque Universelle*, 1830, p. 19.

Subsequently, Prof. Henry constructed two of the largest and most powerful instruments of this kind at present known. One now in the cabinet of Yale College, weighing 59½ pounds, which sustained a weight of 2,063 pounds; another, belonging to the cabinet of Princeton College, N. J., of 100 pounds' weight, which could support 3,500 pounds, or one and a half tons.

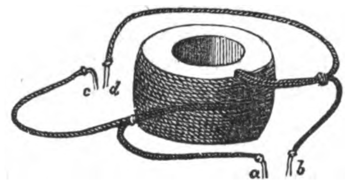
According to our present knowledge of the matter, the power of an electro-magnet depends on five important conditions, viz.: 1. The intensity and tension of the electric current. 2. The number of coils around the magnet. 3. The quantity of iron composing the magnet. 4. The structure of the iron, the purest, softest, and most homogeneous receiving the most magnetism. 5. The form of the magnet, as cylinders were found to support greater weights than solid bars, and bundles of wires more than cylinders.

Magneto-Electricity.—The power which electricity of tension possesses of causing an opposite electrical state in its vicinity has been expressed by the general term induction, which, as it has been received into scientific language, may also, with propriety, be used in the same general sense to express the power which electrical currents may possess of inducing any particular state upon matter in their immediate neighborhood, otherwise indifferent; this is the meaning given to it by Professor Faraday, in his *Experimental Researches.* Previous to the experiments of this distinguished philosopher, certain results of importance had been obtained by Ampère, showing the induction of electrical currents by his experiment of bringing a copper disk near to a flat spiral; also his repetition of Arago's experiment, and the wonderful effects produced by Sturgeon, Moll, and Henry. Still, Faraday remarks, it appeared unlikely that these could be all the effects which induction by currents could produce.

These considerations, with their consequences, stimulated him to investigate experimentally, with the hope of obtaining electricity from ordinary magnetism.

Though baffled in his early attempts, he at last succeeded in laying open a new branch of electro-dynamics, which vies in interest and importance with the fundamental discovery of Œrsted. "A copper wire, 203 feet long, was passed in the form of a helix around a large block of wood, and an equal length of a similar wire was wound on the same block, and in the same direction, so that the coils of each helix should be interposed, but without *actual* contact, between the coils of the other. The two ends of one of the helices, *a* and *b*, as in Fig. 17, were connected with a galvanometer, and those of the other, at *c* and *d*, with a strong galvanic battery, with a view of ascertaining whether the passage of an electric current through one helix would create or induce a current in the adjoining helix. It was found that the galvanometer needle indicated a current to have been elicited in the under wire, at the moment of completing and breaking the circuit, but that, in the interval, no deflection took place. And likewise, the induced currents readily magnetized a sewing needle, while the electric current along the inducing coil was in the act of beginning or ceasing to flow, but at no other period. An electric current transmitted from a galvanic battery through a conducting coil, does not induce a current in an adjoining coil, except at the moment of making or breaking the circuit. When the circuit is closed, the direction of the induced current is opposite to that of the inducing one, but when it is broken, the direction of both is the same." To this phenomenon Professor Faraday gave the name of volta-electric induction. The power of magnetism, to induce or create an electric current in an adjoining body, is greater than that of electricity itself. One of the most convenient of Professor Faraday's arrangements to represent this action consisted of a hollow cylinder of pasteboard, around which two compound coils were adjusted. On connecting one of these coils with a galvanic battery, the other coil moved the needle of the galvanometer, and magnetized steel needles, as in the experiment just described. But when a cylinder of soft iron was introduced into the pasteboard case, and a galvanic current transmitted as before, the effect on the galvanometer was much greater. This effect results from the induction of magnetism in the bar of iron, which magnetism causes the increased amount of electricity in the coil connected with the galvanometer. To the phenomena in the last experiment, Professor Faraday gave the name of magneto-electricity. With such an instrument, he caused convulsions in the leg of a frog, and when the ends of the induced wire were armed with charcoal points, sparks of electric light were obtained at the moment the galvanic circuit was broken, and closed through the inducing wire. When a permanent magnet is placed in a coil of wire, a current of electricity is set up in the wire. While the magnet remains in the coil at rest, no action is perceptible; but, on removing it, another current is perceived. The currents move in opposite directions. These singular phenomena, which establish such new and intimate relations between galvanic and magnetic action, and supply additional evidence in favor of Ampère's beautiful theory

Fig. 17.

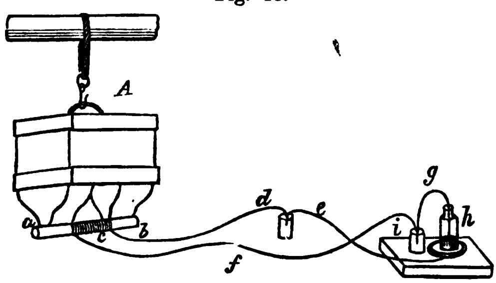


of magnetism, have led to an experiment by which, at first view, an electric spark appeared to be derived from the magnet itself.—*Faraday's Researches*, Nov. 1831.

Ampère's theory was, that all magnetic properties of bodies can be referred to currents of electricity circulating around each particle of those bodies.

After Professor Faraday had announced his experiment of obtaining sparks from the induced wire, other attempts were made to effect the same object with a magnet, without the aid of galvanism. The first person who succeeded in Great Britain was Professor Forbes, of Edinburgh, who operated with a loadstone, which had been presented to the University of Edinburgh by Dr. Hope. A helix of copper wire was formed around the middle of a cylinder of soft iron, which was of such length that its extremities reached from one pole of the loadstone to the other. On applying and withdrawing the soft iron cylinder to and from the poles of the loadstone, magnetism was alternately created and destroyed within it. At these periods of transition, electric currents were induced in the helix surrounding the soft iron; and when, at these instants, metallic contact between the conducting wires of the helix was broken, an electric spark was visible. The arrangement of the apparatus is shown in Fig. 18. *A* is the magnet, *a b* a cylindrical collector of soft iron passing through the axis of the helix *c*, and con-

Fig. 18.



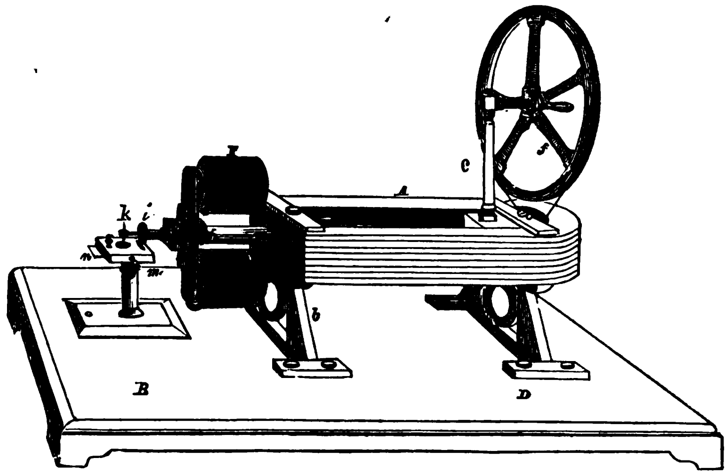
necting the poles of the magnet. The one termination *d e* of the wire passed into the bottom of a glass tube *h*, half filled with mercury, in which the wire terminated. The other extremity *f*, of the helical wire, communicated by means of the cup of mercury *i* with the iron wire *g*, the fine point of which may be brought by the hand into contact with the surface of the mercury in *h*, and separated from it at the instant when the contact of the connector *a b* with the poles of the magnet is effected. The spark is produced in the tube *h*.

In this experiment, therefore, the electricity was obtained from the helix, and was induced in it by the soft iron, while in the act of acquiring or losing magnetism. (*Phil. Trans. of Ed.* 1832.) The same experiment was performed by Professor Faraday, with a loadstone belonging to Professor Daniell; and shortly before the experiment of Mr. Forbes, Nobili and Antinori succeeded with an ordinary steel magnet. M. Pixii, of Paris, performed this experiment in 1832, with great effect.

He caused a strong horseshoe magnet to revolve horizontally upon an axis, so that its poles should pass, in rapid succession, in front of a soft iron armature or keeper of the same form. (*Ann. de Chem. et de Phys.*) Mr. Saxton, a native of Philadelphia, but at that time residing in London, made an important improvement upon the apparatus of Pixii.

At the meeting of the British Association, at Cambridge, in June, 1833, Mr. Saxton exhibited his improvement, which consists in making the keeper, the lighter body, revolve, while the magnets remain at rest; and, secondly, the interruptions, instead of being produced by the revolution of points, were made by bringing one of the ends of the wire over a cup of mercury, and depending on the jerks given to the instrument by its rotation for making and breaking the contact with the mercury. Fig. 19 represents the complete machine. *A* is a compound horseshoe magnet, composed of six or more bars, and supported on the rests *b*, *e*, which are screwed firmly on the board *B D*, into the rest; *e* is screwed on the brass pillar *c*, carrying the large wheel *f*, hav-

Fig. 19.



ing a groove in its circumference, and a handle by which it can readily be revolved on its axis; a spindle passes from one end of the magnet to the other between the poles, and projects beyond them about three inches, where it terminates in a screw at *h*, to which the armatures, to be described immediately, are attached; at the farther extremity is a small pulley, over which a catgut band passes, by means of which, and the multiplying wheel *f*, the armatures can be revolved with great velocity. The armatures, as seen at *F*, are nothing more than electro-magnets; two pieces of round iron are attached to a crosspiece, into the centre of which the spindle *h* screws; round each of these bars is wound in a continuous circuit a quantity of insulated copper wire, one end being soldered to the round disk *i*, the other connected with the copper wire passing through, but insulated from it by an ivory ring. By means of the wheel and spindle, each pole of the armature is brought in rapid succession opposite each pole of the magnet, and that as near as possible without absolutely touching. The two armatures differ from one another. The one termed the quantity-armature is constructed of stout iron, and covered with thick insulated wire. The other, the intensity-armature, is constructed of slighter iron, and covered with from 1,000 to 2,000 yards, according to the size of the instrument, of fine insulated wire.—*Lond. & Ed. Phil. Mag.* vol. ix. p. 360.

The quantity-armature is for exhibiting the magnetic spark, inducing magnetism in soft iron.

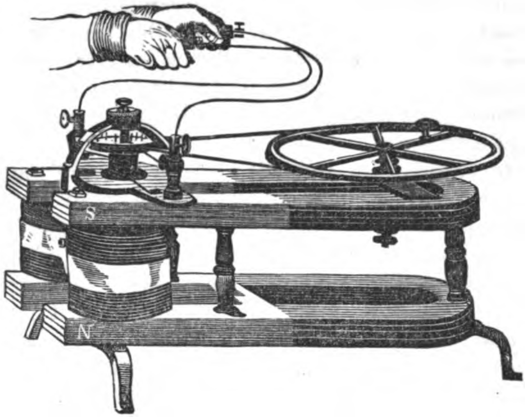
The intensity-armature is employed for medical purposes, and for effecting chemical decomposition. This arrangement of armatures was an improvement by William Clark, of London, and was based upon the discoveries of Professor Henry, of this country, who found that an electrical current of quantity would induce a current of intensity, and, on the other hand, that a current of intensity would make sensible a current of quantity.

According to Faraday, in the wire of the helix of magneto-electric machines (as, for instance, in Mr. Saxton's beautiful arrangement), an important influence of the principles of these actions of induced currents is evidently shown. From the construction of the apparatus, the current is permitted to move in a complete metallic circuit of great length, during the first instants of its formation; it gradually rises in strength, and is then suddenly stopped by the breaking of the metallic circuit; and thus great intensity is given by induction to the electricity, which at that *moment* passes. This intensity is not only shown by the brilliancy of the spark and the strength of the shock, but also by the necessity which has been experienced of well insulating the convolutions of the helix, in which the current is formed; and it gives to the current a force at these moments very far above that which the apparatus could produce, if the principle of the inductive action of a current were not called into play.—*Experimental Researches*, Dec. 8, 1834, vol. i. p. 343.

Another important improvement, or modification of the magneto-electrical machine, was made in 1838, by Prof. Page, of the United States Patent Office. According to Dr. Page's plan, two straight keepers, surrounded by coils of insulated copper wire, revolve between two powerful horseshoe magnets, though much shorter keepers are used now than those he introduced. The steel magnets are fixed, with the south pole of one above the north pole of the other, at such a distance as just to allow the armatures to pass between them. The keepers are mounted on each side of a vertical shaft, in such a manner that both keepers shall be passing between the opposite poles at the same time. They revolve in a horizontal direction around this shaft, while those before in use revolved vertically around a horizontal axis. A little instrument, called a pole changer, was invented by Dr. Page, of Washington. It is composed of two semi-cylindrical pieces of silver, fixed on the axis upon which the keeper revolves, but insulated from that axis, and from each other. To each of the segments is soldered one end of the wire composing the coil. Two silver springs press upon these segments, and convey the electricity to the screw cups or point desired, by means of wires attached to them. The pole changer on the shaft conveys the alternating currents in a constant direction to the screw cups, with which some metallic handles can be put in connection for the purpose of giving shocks, &c. His improved form of the machine is represented in Fig. 20, made by Mr. D. Davis, Jr., of Boston, for Prof. Franklin Bache, of this city.

"Respecting the efficacy of this machine, the following is the substance of a statement in a letter from Dr. W. F. Channing, of Boston,

Fig. 20.



to Prof. Hare, of this city. The unmitigated shocks from this machine are insupportable. When the wires which break the shocks are removed, the current becomes sufficiently uniform to be competent for electrolysis, or imparting magnetism to iron, included in a long helix of fine wire, comprised in the circuit of the helices of the machine. When sent through a circuit of a mile, the current from this machine was found abundantly competent to work the telegraph of Prof. Morse." —*Hare on Electro-Magnetism*, p. 131.

In Liebig's *Annual Report* (vol. iii. part 1, p. 146), it is stated that considerable improvements have recently been made in the magneto-electric machine.

Sinstedem (*Pogg. Ann.* lxxvi. 29, 195, 524) and Stöhrer (*Ibid.* lxxvii. 467) have published instructive suggestions for rendering them more perfect. Stöhrer has employed these machines, as it appears, with a satisfactory result, for the purposes of the electric telegraph (*Ibid.* 485). Dujardin, of France, has also used this instrument before the Committee on Electric Telegraphs, appointed by the legislative assembly; the circuit he employed being 140 leagues, by uniting two telegraphic wires at Paris and Lille, and employing a single magneto-electric machine, he caused his telegraphic machine to work with complete success, transmitting and printing, under the eyes of the committee, eighty-two letters a minute.

Many observers who have availed themselves of the magneto-electric apparatus for the production of electric currents, have observed that the excitation of the current does not keep pace, as might have been supposed, with the velocity of rotation. In numerous cases, indeed, a maximum of the current-force has been observed to attend a certain velocity of rotation. This deportment has been explained by assuming that the production and disappearance of the magnetism in the iron cores requires a certain time. This explanation has, however, been proved by Lenz (*Petersb. Acad. Bull.* vii. 257) to be sufficient for those cases only in which the induction-currents set up are of a very low intensity, when, for instance, they have to pass through a great length of wire in addition to the coils in which they are developed. On the other hand, in the case of currents which have only to surmount comparatively slight external resistances, their force increases for equal velocity of rotation the more slowly, and, as this velocity increases, attains a maximum the sooner the smaller the external resistance.

Lenz accounts for this phenomenon by the reaction of the induced currents upon the iron cores, by which magnetism is reproduced in the latter; the maximum of this magnetism coincides with the maximum of the current-force; not, however, for that very reason, coinciding with the maximum of the primary magnetism of the iron cores induced by the magnet, it consequently causes a deviation of those points of the rotation in which the induced current-force is at zero, or a maximum. The amount of deviation increases with the force of the current, and consequently with the velocity of rotation. It is therefore clear why, in the commutators of the machine, which are empirically adjusted for the development of the greatest current-force (always in the same direction), the change does not take place at the moment when the iron cores are opposite to the poles of the magnet; if the matter be only superficially examined, this is the instant at which the iron cores might be supposed to have attained the greatest possible degree of magnetism, and at which the induction in the copper wires would be at zero.

Electro-Magnetic Telegraphs.

When Œrsted's splendid discovery was announced, and it was seen that feeble electric currents would produce a variety of magnetic actions, electrical telegraphing received a new impulse, and numerous forms of telegraphic apparatus were proposed, of which I will now endeavor to give an account, describing each step in the progress of discovery, and commencing with

Ampère's Telegraph.

In 1820, Ampère, in consequence of a suggestion of La Place, was led to devise the first telegraph, employing the deflection of the magnetic needle, by the agency of the galvanic fluid, which, however, it appears that he did not carry out practically. His plan was to have as many magnetic needles as there are letters of the alphabet, which might be put in action by the passage of currents through metallic conductors, made to communicate successively with the battery, by means of keys, which could be pressed down at pleasure, and might give place to a telegraphic correspondence that would surmount all distance, and be as prompt as writing speech to transmit thought.—*Ann. de Chem. et de Phys.* xv. 73.

The second telegraph was suggested by Peter Barlow, F. R. S., in 1825, that an instantaneous telegraph might be established by means of conducting wires and compasses.—*Edinburgh Philos. Journ.* vol. xii. p. 105.

In 1828, Victor Triboaillet de Saint Amand proposed to establish a telegraphic line from Paris to Brussels, by a metallic wire, about a line or a line and a half in diameter. He recommended to cover the wire with shell-lac, upon which was to be wound silk, very dry, which should be covered with a coating of resin. The whole was then to be put into glass tubes, carefully luted up with a resinous substance, and secured by a last envelop, then varnished over and hermetically sealed; then, by means of a powerful galvanic battery, he would communicate the electricity to the conducting wire, which would transmit the current to the opposite station, to an electroscope, destined to render sensible the slightest influence, and left to each one to adopt, at pleasure, the number of motions to express the words or letters which they might need.—*Report of Academy of Industry, Paris*, from *Vail's E. M. Telegraph*, p. 138.

Fechner's Telegraph.

Fechner, of Leipsic, in 1829, in his handbook of galvanism, remarks that there is no doubt that, if the insulated wires of twenty-four multipliers, corresponding to the several letters of the alphabet, and situated at Leipsic, were conducted under ground to Dresden, at which place the battery were situated, we could thus obtain a means, probably not very expensive, comparatively speaking, of transmitting intelligence from one place to the other, by means of signals properly agreed on beforehand.

I confess, it is a very seductive idea, to imagine that by future development of a system of such connections at some time, a communication between the central point and the parts of a country can be established, which shall consume no time, like communication between the central point of our organism and its members by means of the nerves, by what appears to me a very analogous arrangement.—*Lehrbuck des Galvanismus*, p. 269.

"Dr. Ritchie, in a lecture at the Royal Institution, London, in 1830, endeavored to illustrate the suggestion of Ampère, and exhibited a model of a telegraph constructed after his description; the arrangement was, however, very complex from the number of wires employed, &c., and Dr. Ritchie was not sanguine as to the ultimate practicability of the scheme."—*Journal of the Royal Institution*, p. 183.

Schilling's Telegraph.

In 1832 and 1833, Baron Schilling, of Caunstadte, a Russian Counsellor of State, had occupied himself with an electro-magnetic telegraph. The Baron, who was attached to the Russian embassy, at Munich, at the time when Sömmering was engaged with his galvanic telegraph, already described, was much interested in the experiments of the latter, and shortly after Œrsted's discovery of the deflection of the magnetic needle, Schilling was led to devise a needle telegraph, which consisted in a certain number of platinum wires, insulated, and united in a cord of silk, which put in action, by the aid of a species of key, 36 magnetic needles, each of which was placed vertically in the centre of a multiplier. Schilling was the first who adapted to this kind of apparatus an ingenious mechanism, suitable for sounding an alarm, which, when the needle turned at the beginning of the correspondence, was set in play by the fall of a little ball of lead. An improved form of his instrument was exhibited at the Bonn meeting of naturalists, by Dr. Munke, in 1835 (*Isis. Nog.* 1836), and is described in detail in *Gehler's Physikalisches Wörterbuch*, 1838, vol. ix. iii. In this improved instrument, light disks of card-board, attached to magnetic needles inclosed in galvanometer coils, are moved by the galvanic or magneto-electric current. Five similarly prepared magnets, arranged so that the round disks of card-board were only seen edgewise, were connected by wires with the distant source of electricity; according to the direction in which the current was sent, the magnet was deflected to the right or left, in the one case showing to the observer the one side, in the other case, the reverse of the card-board disk; thus, then, separate signals were obtained, which, by reference to a telegraphic dictionary, gave any required number of signals.

"Professor Henry, Secretary of the Smithsonian Institution, Washington, says, that in 1832, nothing remained to be discovered in order to reduce the proposition of the electro-magnetic telegraph to practice. I had shown that the attraction of an armature could be produced at any distance, and had designed the kind of a battery and coil around the magnet to be used for this purpose. I had also pointed out the fact of the applicability of my experiments to the electro-magnetic telegraph. I make a distinction between the terms discovery and invention. The first relates to the development of new facts; the second to the application of these or other facts to practical purposes." —*House Case*, p. 93.

Gauss and Weber Electro-Magnetic Needle Telegraph.

Counsellor Gauss and Professor Weber, two of the most illustrious philosophers of Germany, to whom the science of magnetism is deeply indebted, entered nobly into the lists in establishing, by means of electricity, telegraphic communication between the Astronomical Observatory, Physical Cabinet, and Magnetic Observatory at Gottingen, the first notice of which is found in *Göt. Gel. Anz.* 1834, 1273, and in 1836, *Schumacher Jahrbuch*, pp. 38–39. It consisted of a double line of wire carried over the houses and steeples at Gottingen. It was constructed chiefly for the purpose of being able to make investigations respecting the laws of the force of galvanic currents on a large scale, under different circumstances. The circuit employed in 1833 was about nine thousand feet; and in 1834 or 1835, at least fifteen thousand, but part of this wire was reeled. The form of wire employed was mostly copper, of the size known in commerce as No. 3, of which a length of one metre weighs eight grammes; the wire of the multiplier in the Magnetic Observatory was of silvered copper, No. 14, of 2.6 metres to the gramme. They first employed galvanic electricity by employing small sized plates, and found that the action was much increased by adding to their number. They repeated and perfected their first form of telegraph by applying the phenomenon of magnetic induction, discovered by Prof. Faraday. The divers movements or the slow oscillations of magnetic bars, caused by the passage of the currents, and observed by the aid of a glass, furnished to Gauss and Weber all the signals which they wished in corresponding, but the number of signals which could be transmitted was few, and the time occupied by each considerable.

The main apparatus was a magneto-electric machine, and to this Counsellor Gauss adapted a peculiar arrangement, by which the direction of the current can be reversed by a single pressure of the finger.

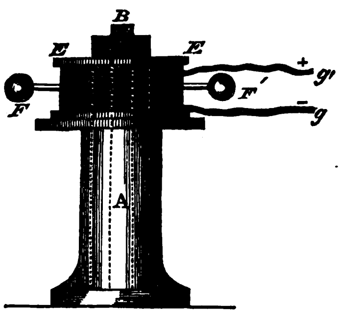
Professor Weber had a delicate apparatus for setting off an alarm of a clock, placed at the side of the magnet in the physical cabinet, by means of the current conducted from the observatory.

The telegraphing apparatus consisted of the following parts:—

1. The apparatus for generating the galvanic current.
2. The apparatus for observing the given signal.
3. The apparatus for the sudden reversing of the current, or the commutator (*pole changer*).

In the column *A*, Fig. 21, are two or three strong magnet bars (each of 25 pounds) united in one strong magnet—their poles of the *same name* (like poles) are visible at *B*. Over these bars the reel *E* is placed (of course having a hole for the bars to pass through), and around its external surface a copper wire (insulated by silk winding) is wound.

Fig. 21.

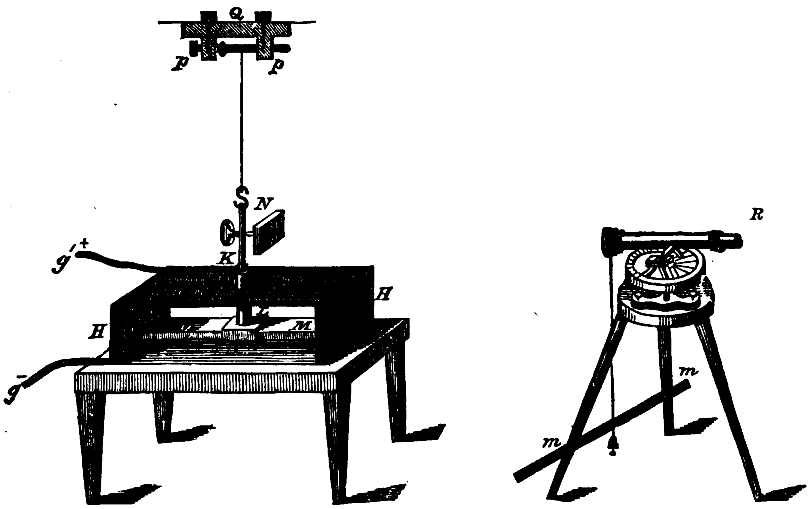


At the first arrangement, Gauss gave the reel 1,050 coils; by a late arrangement, he increases the number of coils to 3,537, with a length of wire of about 3,600 feet; and still later, he used a reel with 7,000 coils with a length of wire of more than 7,000 feet.

The two ends, *g g'*, of this reel *E* (which on account of their inductive action are called *inductors*), are in connection with a commutator (pole changer), and through that with the two principal conducting wires of the telegraph. If the inductor is taken by the two handles *F F'*, and suddenly drawn off the magnet bars on which it rests, and immediately, without turning it round, replaced in its former resting-place, there result two induction currents, one immediately after the other, in opposite directions, passing through the conducting wire; the duration of these currents is very short. Their intensity depends upon the strength of the united magnets in *A*, upon the number of coils in the inductor *E*, and upon the distance these coils are from the magnets.

Fig. 22 represents the *observing apparatus.*

Fig. 22.



Whilst the inductor is set up at the station whence the signal is to be telegraphed, the observing apparatus is placed at the station where the communication is to be received.

It consists of a strong *multiplicator H H*, that is to say, of a copper frame, around which an insulated wire is coiled. The two ends of the wire *g g* are connected with the two chief conducting wires coming from the other station, so that the multiplicator wire forms with the wire coiled on the inductor *E*, Fig. 21, a single closed wire circuit.

At first the multiplicator had 270 coils of wire, 2,700 feet long; in later trials it had 610 coils of wire, more than 6,000 feet long.

In the coils of this multiplicator there hangs for a magnetic needle a magnetic bar *M M*, of at most four pounds in weight (later, 25 lb. magnetic bars were used), which is suspended by a thread easily movable in the *little ship L.* This thread consists of 200 parallel silk threads, and is fastened to a wooden screw *p p*, near the ceiling of the room, by which it can be raised or lowered.

On the brass rod *K*, which passes through the copper frame *H H*, there is a vertical mirror *N*, which turns with the magnet, and is directed in such a manner towards the *cipher scale*, *m m*, fastened at the foot of the stand of the spy-glass *R*, that the image of the parts of the scale can be seen in the mirror through the spy-glass.

The apparatus contrived by Gauss for the rapid change of the direction of the current was somewhat complicated; but any other simple *commutator* can be used for the same purpose.

The following is the mode of using this telegraph: At the station from which a communication is to be sent, the inductor *E*, Fig. 21, is suddenly drawn off, and again, without turning it round, thrust down upon the magnet pole *B*, by which means two induction currents of opposite directions are passed through the conducting wire.

By means of the first current, the magnet in the observing apparatus, Fig. 22, at the other station, through the action of the multiplicator's coils, is made to diverge in a determined direction, for example, to the right. By means of the second current in the opposite direction it is immediately stopped, so that the magnet can make no farther *excursions*, but only, in consequence of the two opposite currents, makes a little lively vibration to one side, and then immediately remains quite still.

These small motions of the magnet are observed through the spy-glass *R*, Fig. 22, in the mirror *N*.

In a state of rest, the image of the null point of the scale, *m m*, is visible through the spy-glass; by the motion of the magnet the mirror is also moved, and reflects to the spy-glass another part of the scale. In this manner the smallest motion of the magnet is perceptible by the spy-glass.

Accordingly as the commutator (which is directly attached to the inductor) is fixed, the *first* induction current passes in one or the opposite direction through the conducting wire—and therefore, by a sudden drawing off and thrusting down of the reel *E*, Fig. 21, a magnetic vibration to the right or left at the other station can be produced at pleasure.

By an ingenious combination of several magnetic motions, to form a signal, Gauss and Weber were able to make all requisite signs (letters and ciphers) with these two *motions* (*first blows*).

The following are the alphabetical signs as arranged:—

r = a	*r r r* = c k	*l r l* = m	*l r r r* = w	*l l r r* = 4
l = e	*r r l* = d	*r l l* = n	*r r l l* = z	*l l l r* = 5
r r = i	*r l r* = f v	*r r r r* = p	*r l r l* = o	*l l r l* = 6
r l = o	*l r r* = g	*r r r l* = r	*r l l r* = 1	*l r l l* = 7
l r = u	*l l l* = h	*r r l r* = s	*l r r l* = 2	*r l l l* = 8
l l = b	*l l r* = l	*r l r r* = t	*l r l r* = 3	*l l l l* = 9

The variations of the magnetic needle signify a letter; *l* denotes a variation to the left, and *r* to the right, and by the combined deflection of the needle, words and sentences may be transmitted.

Experiments of Messrs. Taquin and Ettieyhausen.

Messrs. Taquin and Ettieyhausen made experiments with a telegraphic line over two streets in Vienna, 1836. The wires passed through the air and under the ground of the Botanic Garden.—*Polytechnic Centra. Journal*, 1830; *Vail Electro-Magnetic Telegraph*, p. 189.

MORSE'S ELECTRO-MAGNETIC TELEGRAPH.

In the latter part of the year 1832, Samuel F. B. Morse, an ingenious American artist, while on a voyage homeward from Europe, conceived the idea of an electric or electro-chemical telegraph, and devised a system of signs for letters, to be marked by the breaking and closing of the electric or galvanic current.

Dr. C. T. Jackson, of Boston, a fellow-passenger, well versed in the science of chemistry and electricity, and having witnessed numerous experiments during a recent visit to Paris, afforded him considerable assistance.

The following is a brief account of the methods proposed:—

1*st.* That electricity might be made visible in any part of the circuit by dividing the wire, when a spark would be seen at the intersection.

2*d.* That it could be made to perforate paper if interposed between the disconnected wires.

3*d.* Saline compounds might be decomposed, so as to produce colors on paper.

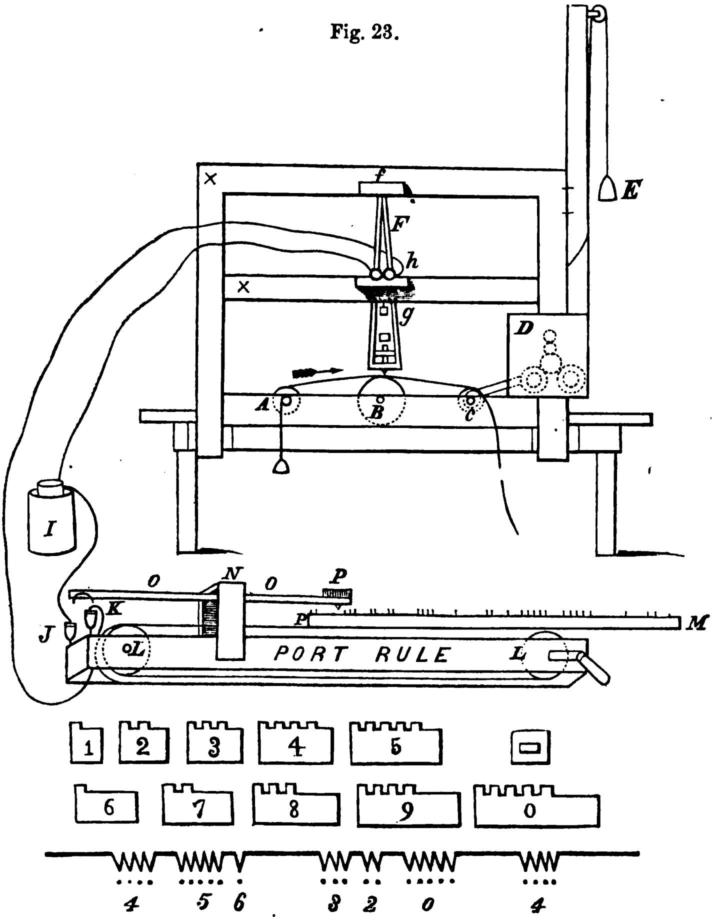
The 2d and 3d projects were adopted for future trial, since they would furnish permanent records. The saline substances mentioned, were the acetate and carbonate of lead, which, when decomposed by the galvanic current, left black marks on the prepared paper; again, turmeric paper, moistened in a solution of sulphate of soda, left brown marks on the passage of the current, produced by the disengaged alkali. Platina points were also proposed to effect the changes in color.

Mr. Morse experimented for some time after arriving in New York, independent, however, of Dr. Jackson. While on board the Sully, Dr. Jackson doubtless materially aided Mr. Morse in his conception of the electric telegraph, though they do not appear to have had any subsequent connection, nor was the instrument they devised brought into practical use.

From a careful examination of all the evidence given by the passengers on board of the packet ship Sully, the telegraph devised by Morse and Jackson was not an electro-magnetic telegraph, but an electric or electro-chemical telegraph (see letters of Dr. Jackson to Mr. Morse, and Mr. Kendall's pamphlet, and letters of J. Francis Fisher, Esq., of Philadelphia). Mr. Morse cast some type in 1833, but from limited circumstances was compelled to desist from farther experiment, until his appointment to a professorship in the University of New York, in 1835, when he formed the annexed mechanical arrangement, which is interesting from the fact, that it is the basis on which a long series of improvements have been made to bring the instrument to its present unique construction. He exhibited it in January, 1836, to Mr. L. D. Gale, a colleague professor in the University of high scientific attainment, who afterwards joined Mr. Morse in his enterprise, and made some useful suggestions for its improvement. But becoming satisfied that the electro-magnetic power was more available for telegraphic purposes, as exemplified by the experiments of Prof.

Henry and his own trials, he directed his attention to that agent. Mr. Gale gives the following description of the instrument, in his evidence in the case of F. O. J. Smith *versus* Hugh Downing.

Fig. 23.



"A train of clock wheels were used to move a strip of paper, one half an inch in breadth. *A*, *B*, and *C*, are cylinders; the paper is unrolled from passing over the cylinder *B* to *C*, where it is connected to the clock-work *D*, moved by the weight *E*. *F* is a wooden triangular-shaped pendulum, suspended from the pivot *f*, over the centre of the cylinder *B*; its vibrations were across the paper, or at right angles to the motion of the latter. Through two cross-pieces in its lower part was fixed a pencil-case, containing a pencil moving readily up and down, but kept in contact with the paper by a light weight *g*. An electro-magnet was fixed on the shelf *h*, which projected from the frame *XX*; this magnet attracted an armature affixed to the pendulum. One of the conductors of the magnet helix passed to the single plate galvanic battery *I*, while the other joined the cup of mercury at the port rule *K*. The other pole of the battery was connected by a wire to the other cup of mercury *J*. The lower table represents a port rule; it consists of a rude frame containing two cylinders *L L*, two inches in diameter and two inches long, one turned by a crank, and that turning the other by a band one and a half inches in width.

"*M* is a rule or composing stick, made of two small thin rules, two feet long, placed side by side, separated sufficiently far to form a trough for the type; the tops or cogs of the latter are seen rising above the top of the rule *M*. A lever *O O* is suspended from the united top of two standards that rise from the sides of the long frame of the port rule, on one end of which is a fork of copper wires that plunges, when the lever is depressed, into the two mercury cups *K* and *J*. A weight is attached to the other extremity to keep it down, and beneath this is a tooth, similar to the keys of a hand-organ. There were eleven types one-eighth of an inch thick, having from one to five projections called cogs, save one that was used for a space. The first five numbers consisted from one to five cogs respectively, followed by a space, while the second five were the same, only having a long space double that of the first.

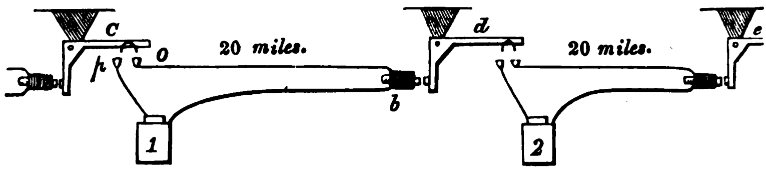
"If, as an example, it was desired to send the number 456, the types 4, 5 and 6, with a space to separate them from the successive ones, were set up in the port rule *M*, which was placed on the bands of the port rule and sent forward by turning the crank; the cogs of the type operating the lever *O O*, broke and closed the circuit at the battery *I*; this being done, the magnet *h* attracted the pendulum *F*, and moved the pencil *g* about one-fourth of an inch; the pencil being in contact with the paper while it was moving, a continuous straight line was marked on it if the pendulum was stationary either at one or the other limit of its motion; but, when attracted by the magnetic force, it marked a V-shaped point, as seen in the drawing; the points were marked on the moving paper as there shown by the successive breakings and closings of the circuits through the cogs of the type; the extremities of the V-shaped marks were recognized for the figures by their number."

A dictionary was prepared, in which words were arranged in a manner that the numbers would represent them.

Mr. Morse found himself unable to make use of his instrument for great distances, from the resistance to, and dissipation of, the electrical current along the conductors. To overcome the difficulty, he adopted, in the spring of 1837, a receiving magnet and a relay or repeating circuit.

The one used by Mr. Morse is represented in the accompanying diagram. By means of the receiving magnet, the current of one battery was employed to set off that of a second, the second a third, and so on, the last circuit being as strong as the first. 1 is a battery at one terminus of one line of conductors representing twenty miles in length; from one pole of which the conductor proceeds to the helix of an electro-magnet at the other terminus (the helix forming part of

Fig. 24.



the conductor); from thence it returns to the battery and terminates in a mercury cup *O*. From the contiguous mercury cup *p*, a wire proceeds to the other pole of the battery.

When the fork of the lever *O* unites the two cups of mercury, the circuit is complete, and the magnet *b* is charged, and attracts the armature of the lever *d*, which connects the circuit of the battery 2 in the same manner, which again in turn operates the lever *e*, twenty miles farther, and so on.

Publicity was given to it through the columns of the *New York Observer*, on the 15th of April, 1837, in consequence of an announcement that Messrs. Gour and Servell had produced an instrument of miraculous capacity, to transmit information, which was, however, only an example of the visual telegraph; it was likewise noticed in the *New York Journal of Commerce* of April 27, 1837.

In September of the same year, an exhibition of the instrument working through 1,700 feet of wire, was given at the New York University, to numerous visitors, among whom were some eminent scientific gentlemen. An account of this was given in the *New York Journal of Commerce* of that date.

The ability of the instrument was so skilfully displayed, that Messrs. George and Alfred Vail were induced to "interest themselves in the invention, and furnish Prof. Morse with the means, material, and labor for an experiment on a larger scale." At this time operations were commenced at the Speedwell Iron Works, near Morristown, New Jersey.

On the 10th of March, 1837, the Hon. Levi Woodbury, then Secretary of the Treasury, issued a circular, requesting information in regard to the propriety of establishing a system of Telegraphs for the United States. Prof. Morse sent three replies to this circular, containing an account of his invention, its proposed advantages, and probable expense, with a description of the kind of conductors required; two of these letters, dated respectively September 27, 1837, and November 28, 1837, were included in a report of the Secretary to the House of Representatives, on the 6th of December, 1837. In this report, Mr. Woodbury gave a favorable view to the subject of telegraphing.

Some extracts from Prof. Morse's letters will show how far real progress has exceeded his expectations at that time, and the modifications that have since been made.

September 27, 1837.—"The principal expense will be the first cost of the wire, or metallic conductors (consisting of four lengths), and the securing them against injury. The cost of single copper wire $\frac{1}{16}$

of an inch in diameter (and it should not be of less dimensions), for 400 miles was recently estimated in Scotland to be £1,000 sterling, including the soldering of the wires together, that is, $6 per mile for one wire."

"Iron tubes inclosing the wires, and filled in with pitch and resin, would probably be the most eligible mode of securing the conductors from injury, while at the same time it would be the most costly." "Iron tubes of 1½ inch diameter, I learn, can be obtained at Baltimore at 28 cents per foot. The trenching will not be more than three cents for two feet, or about $75 per mile." "If the circuit is laid through the air, the first cost will doubtless be much lessened." "Stout spars of some thirty feet in height, well planted in the ground, and placed about 350 feet apart, would in this case be required, along the tops of which the circuit might be stretched. Fifteen such spars would be wanted to a mile. This mode would be as cheap, probably, as any other, unless the laying of the circuit in the water should be found the most eligible." "I presume that five words can be transmitted in a minute; for, with the imperfect machine I now use, I have recorded at that rate, at the distance of half a mile."

November 28, 1837.—"We have procured several miles of wire, and I am happy to announce to you that our success has, thus far, been complete. At the distance of five miles, with a common Cruikshank's battery of 87 plates (4 by 3½ inches each plate), the marking was as perfect on the register as in the first instance of half a mile. We have recently added *five miles more*, making in all *ten miles*, with the same result, and we have no doubt of its effecting a *similar result* at *any distance.*"

The instrument was partially described in Prof. Silliman's *Journal* of October, 1837, which was afterwards copied in the November number of the *Journal of the Franklin Institute* of the same year, and the *London Mechanics' Magazine* of February, 1838.

A model, inclosing a circuit of ten miles of insulated wire wound upon two reels, was finished in the latter part of the year 1837, and intended for an exhibition before Congress. This was soon after shown in the hall of the Franklin Institute of this city, where it was subjected to the inspection of a committee appointed to examine it; its operation was eminently satisfactory to them, and they did it the honor to give the subjoined favorable report:—

"The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred, for an examination, an electro-magnetic telegraph, invented by Prof. F. B. Morse, of the city of New York, report: That this instrument was exhibited to them in the Hall of this Institute, and every opportunity given by Mr. Morse and his associate, Mr. Alfred Vail, to examine it carefully, and to judge of its operation. * * * * * * *

"As exhibited to us, it was very satisfactory. The power given to the magnet at the register, through a length of wire of ten miles, was abundantly sufficient for the movements required to make the signals. The communication of this power was instantaneous. The time required to make the signals was as short at least as that necessary in the ordinary telegraphs. It appears to the Committee, therefore, that the possibility of using telegraphs on this plan, in actual practice, is not to be doubted, though difficulties may be anticipated which could not be tested with the trial made with the model.

"One of these relates to the insulation and protection of the wires, which are to pass over many miles of distance, to form the circuits between the stations. Mr. Morse has proposed several plans; the last being to cover the wires with cotton thread, then varnish them thickly with gum elastic, and inclose the whole in leaden tubes. More practical and economical means will probably be devised; but the fact is not to be concealed, that any effectual plan must be very expensive. Doubts have been raised as to the distance to which the current of an ordinary battery can be made efficient; but the Committee think no serious difficulty is to be anticipated on this point. * * * *

"An experiment is said to have been made on the Birmingham and Manchester railroad, through a circuit of thirty miles in length.

"It may be proper to state, that the idea of using electro-magnetism for telegraphic purposes has presented itself to several different individuals, and that it may be difficult to settle among them the question of originality.

"The celebrated Gauss has a telegraph of this kind in actual operation, for communicating signals between the University of Gottingen and his magnetic observatory in its vicinity. Mr. Wheatstone, of London, has been for some time also engaged in experiments on an electro-magnetic telegraph. But the plan of Prof. Morse is, so far as the Committee are informed, entirely different from those devised by other individuals, all of which act by giving different *directions* to magnetic needles, and would therefore require several circuits of wires between all the stations.

"In conclusion, the Committee beg to state their high appreciation of Prof. Morse's telegraph, and the hope that means may be given him to subject it to the test of an actual experiment made between stations at a considerable distance from each other. The advantages which this telegraph would present, if successful, over every kind heretofore used, make it worthy of the patronage of the government. These are, that the stations may be at a distance asunder far exceeding that to which other telegraphs are limited, and that the signals may be given at night, and in rains, snow, and fogs, when other telegraphs fail.

"By order of the Committee.

"WILLIAM HAMILTON, *Actuary*.

"PHILADELPHIA, *February* 8, 1838."

It was subsequently taken to Washington, and kept in successful operation for several months in the room of the House Committee of Commerce, where it was visited by multitudes of people.

The examining committee were propitious to it, and in a warm and ardent report made on the 6th of April, 1838, urgently advised that it should be subjected to an adequate trial.

Prof. Morse sent in a caveat to secure his invention in October, 1837, filed his specifications, and made application for a patent in April, 1838, but withdrew them afterward, that he might be enabled to obtain patents in the European countries. Hon. F. O. J. Smith, a member of Congress, from Maine, was so interested in it, and sure of success, that he left his seat there, and joined Prof. Morse in a trip to Europe, in May, 1838. From the peculiar construction of the English patent laws (which require that the instrument should not have been published), he was unable to obtain a patent there, and though he secured one in France, it afforded him no profit, as his funds were too limited to bring it into operation within two years—the time specified in their patent regulations.

Though he failed at that time to remunerate himself as a momentary speculator, the instrument attracted the attention of scientific men in both countries, who accorded him much merit for the skilfulness of the invention.

It was put in operation at a meeting of the French Academy of Sciences, September 10, 1838, and a description of it published in their weekly journal, the *Comptes Rendus*. On account of the disordered financial condition of the country, and his own restricted means, no farther advancement was made after his return, until June, 1840, when he secured his first patent, which was given on the specifications of April, 1838, for the rude instrument already described, including a second electro-magnet used to give an alarm, without the improvement up to the former date.

Unable to proceed farther on a more extensive scale of experiment, he procured the support of prominent scientific men in a petition to Congress during the December session of 1842.

In respondence to his petition, Congress appropriated $30,000 for the purpose of testing its practical application. Thus enabled to prosecute his favorite theme with a freer element and more liberal spirit of investigation, he had the great gratification to exhibit to the American people his invention, working in an eminently successful manner, for a distance of forty miles, between the cities of Baltimore and Washington, in the month of June, 1844.

Prof. Morse has obtained for his instrument several distinct patents; the first was dated June 20, 1840; there were many important modifications introduced, such as a signal lever key substituted for the port rule, and a lever in the register in place of the pendulum, when it was exhibited before Congress, in 1838; this was reissued January 15, 1846. A second patent was taken out on the 11th of April, 1846, containing the above alterations, with the addition of a local circuit and register, receiving magnet and adjuster, self-regulating break, the metal pen points, and grooved rollers for them to work in.

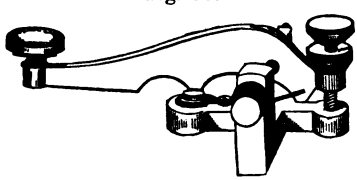
The device of the local circuit in the Morse Telegraph was founded in part upon the experiments of Prof. Henry, who had, previous to this, "opened the circuit of a large quantity magnet at Princeton, when loaded with several hundred pounds, by attracting upwards a small piece of movable wire, by means of a small intensity magnet, connected with a long wire circuit and an intensity battery."

The reissued patent of January 15, 1846, and the patent of April 11, 1846, were both reissued on the 13th of June, 1848, and another patent, containing improvements in the electric telegraph, was taken out on the 1st of May, 1849:

The line between Baltimore and Washington is the only one constructed under governmental patronage, the remainder having been projected by private enterprise; the patentee being allowed one-half the stock for the use of the patent, as his share of the investment; the capital invested in them up to January 1, 1850, was nearly $400,000, exclusive of the patent right, upon which Prof. Morse, up to that time, had received some $30,000. The machine at present in use consists of three main portions, the transmitting and receiving apparatuses with the connecting circuit.

The spring lever key, as at present used in the Morse office, has received various modifications. In Fig. 25, we have a view of its present improved form; it consists of a nicely balanced lever, supported on standards raised from a small block of mahogany; thumb screws are fixed to each extremity of it, that on the longer arm being used for the operator to play upon, and the shorter one to adjust the distance of the connecting surfaces; on the short arm is attached a spring to keep those surfaces apart when not pressed together by the operator; the connecting surfaces called the hammer and the anvil, the former on the lower surface of the long arm of the lever, the latter on the mahogany support, are faced with platinum; they are respectively connected with the opposite poles of the galvanic circuit, and by their contact or separation, the circuit is united or broken.

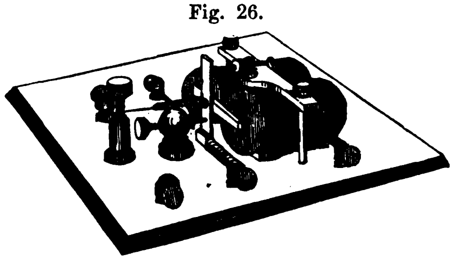
Fig. 25.



If this key is at an intermediate station, by means of the screw on the short arm the surfaces are kept together; the circuit may be closed when not in use; this permits communications to be sent through the office between stations on each side of it, or rather it keeps the main circuit continuous; when operating, if they are merely touched, a point is made at the receiving station; if kept together any time, a line is produced whose length is governed by the period of contact. The circuit connections are beneath, one below the anvil, the other under the screw.

The receiving magnet is an intensity one, surrounded by a helix of very fine wire, 3,000 feet or more in length, having the horseshoe form, and fixed in a horizontal position. The main circuit passes through this helix unbroken to the next station; an armature is fixed to a vertical movable standard, opposite the poles of this magnet, in such a manner that, by means of a spring and adjusting screws, it cannot come in actual contact with the mag-

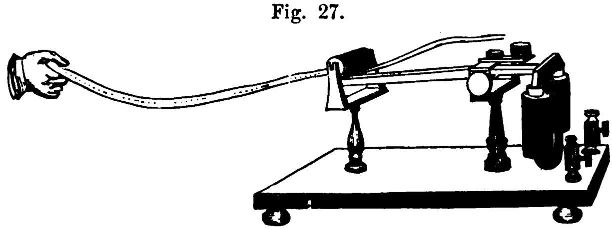
Fig. 26.



net, nor yet is it so far removed as to be beyond its influence; the object of this delicate suspension, is that the armature may be approached to or withdrawn from the magnet's influence, according to the intensity of the current; much of the operator's skill depends on the management of this adjuster, as the varying electrical agencies of the atmosphere and generating forces of the batteries are constantly operating to increase or diminish its intensity.

The support of this armature forms part of the local circuit, the horizontal rod above another part, and that circuit is closed, by the attraction of this armature to the poles of the magnet, through the horizontal rod above, terminating in a platinum face, opposite another one fixed on the horizontal support above the magnet; the connections of the local circuit are through screws seen on the right; when the current flows through the main circuit, the receiving magnet attracts the armature, and thus closes the local circuit, the only place where it is open being above the horizontal bar over the helix; the local circuit is confined entirely to the office where it belongs, passing through the local battery and the helix of the register magnet, being distinct from the main; the registering apparatus has, or should have, a quantity magnet of a horseshoe form, fixed vertically, the open extremity upward; the object being to indent impressions upon paper; force, rather than delicacy, is requisite. The figure from Davis's *Manual of Magnetism* represents the mechanical action of the instrument. Above

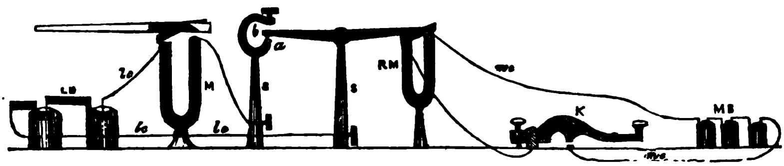
Fig. 27.



the poles of the magnet is an armature, attached to one end of a movable lever, which has on the upper surface of the other end a metal point, which fits into a groove of a roller above it; the passage of the galvanic current making the magnet attract and depress the armature, raises the points at the other extremity, and makes an impression on the paper in dots or lines, according to the duration of the current; a spring is used here to withdraw the armature from the magnet after the cessation of the current, which must be so arranged as not to carry the armature too far from the magnet, or let the points too deep into the groove; a lead pencil was first used, afterwards a pen with an ink reservoir, which was laid aside for the hard steel points; the impressions on the paper resemble the raised printing for the blind. The connection with the local battery is made through the screw caps on the right hand.

"Fig. 28 represents the arrangement and relations of the magnets, batteries, and circuits: R M representing the small magnet, *m c* the main circuit of indefinite extent, M B the distant battery, K the key which breaks and closes this extended circuit; *l c* and L B represent the local circuit and battery, M the helices of the register magnet included in the circuit, which, as the standards S S are metallic, is broken

Fig. 28.



only at the points *a b*. Now, the least possible space between these points effectually interrupts the current, and as they are covered with platinum, a very slight contact is sufficient to establish the connection. The little instrument is so delicately adjustable, that often, when the breath would stop the vibrations of the lever, the circuit is broken and closed with certainty and regularity; this is also shown on a larger scale in Fig. 29."

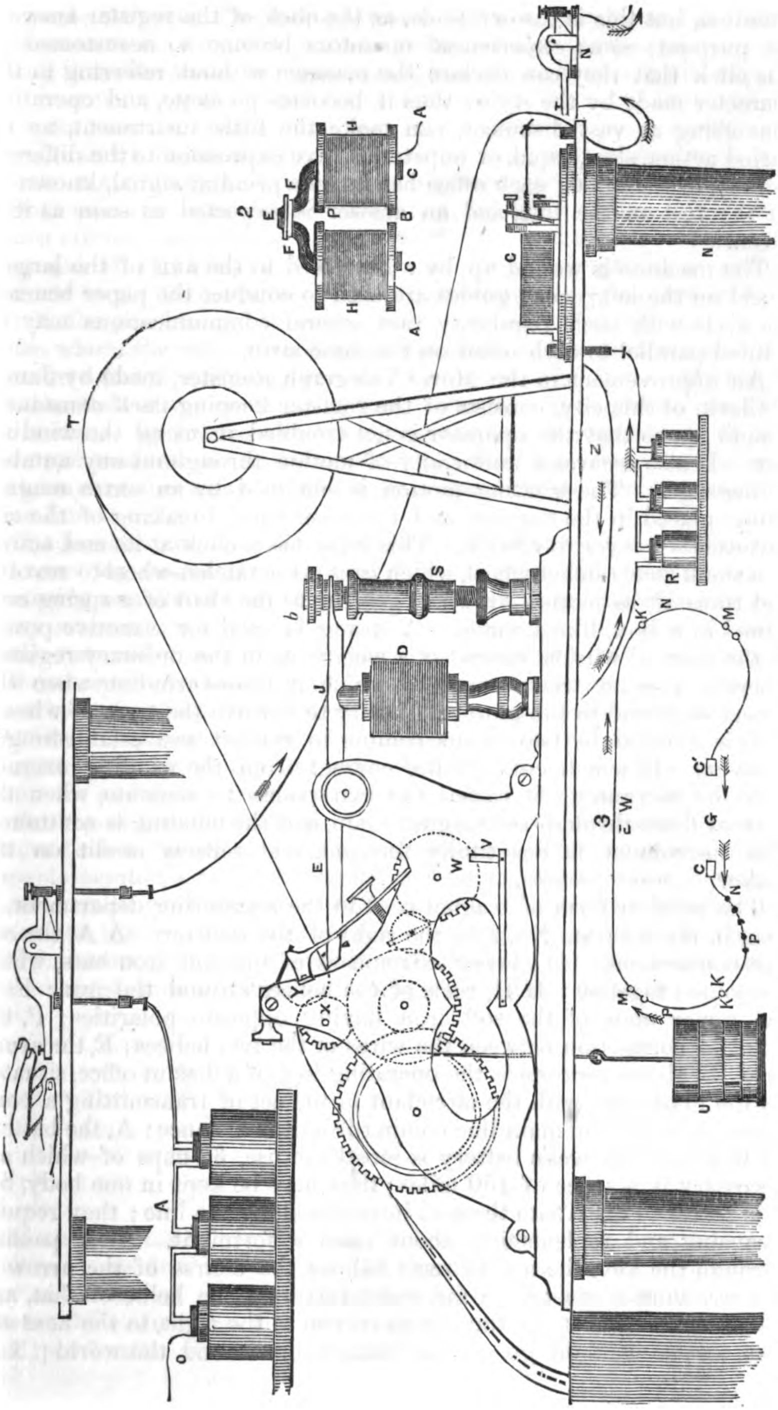
Many forms of this instrument have been devised, some with the levers vertical; in others, the magnet was attached at one end, and the style at the other end of a shaft working through a horizontal tube.

The figure (29) represents the whole combination of the registering apparatus and its connections with the main and local circuits, together with the distant and local operating keys. The register occupies the centre of the picture, being supported on two standards: T is a spool carrying a roll of paper; this paper is prepared by manufacturers for this especial use, by winding it into large rolls, and dividing it into smaller rolls of one inch or more in width by a knife, while it is revolving in a lathe; from this spool the paper is drawn between the two rollers X and Y, which are turned by means of the weight U, moving the clock-work above it; D is the register magnet, E the lever, having J the armature at J, and its axis or fulcrum to the left of it; also at the extreme left, the style, playing in a groove of the lower surface of the wheel Y; S, on the right, is a screw to limit the motion of the style, a distance of one-eighth of an inch being usually allowed; it also contains a spiral spring below, to separate the armature and magnet; the paper is dealt off steadily from the spool, and a momentum is prevented by springs fixed on the axis of the spool between the latter and its standards; formerly a break was suspended from the lower surface of the lever upon some of the clock wheels below, to permit and arrest their motion, but this is now supplied by the small jack V setting into the cogs of the wheel W, the swiftest one in the train; this the operator pushes down immediately on the reception of a signal, and the weight U sets the whole in motion, drawing the paper off the spool between the rollers X and Y, the style impressing on it the required characters, and it rolls finally into the vessel on the left, ready to be read at the convenience of the receiver.

In the earlier forms, an alarm was appended to call the attendant's

Fig 29.

B



attention, but this is thrown aside, as the click of the register answers the purpose; some experienced operators become so accustomed to this click that they can declare the message without referring to the character made by the style; thus it becomes phonetic, and operators conversing at vast distances, can make the little instrument, by its varied action, slow, rapid, or impetuous, give expression to the different feelings of the mind; each office has its own peculiar signal, known to all the rest on the line, and an answer is expected as soon as it is given.

The machine is wound up by a key fixed to the axis of the largest wheel on the left; some guides are used to conduct the paper beneath the style with such regularity that several communications may be printed parallel to each other on the same strip.

An improvement in the Morse Telegraph Register, made by James J. Clark, of this city, consists of the register keeping itself constantly wound up, so that the operator is not troubled in using the winding key. It also secures a uniformity of motion throughout any number of messages. The winding motion is obtained by an extra magnet being placed in the register, and the closing and breaking of the circuit causes a lever to vibrate. This lever has a click at its end, acting in a small steel ratchet-wheel, which causes the ratchet-wheel to revolve and transmit its motion by wheel gearing to the shaft of a spring contained in a box, like a watch. A spring is used for a motive power to the train of wheels, instead of a weight, as in the ordinary register. There is also an arrangement by which it ceases winding when the spring is wound to the power necessary to revolve the train of wheels. This is effected by two points coming in contact and establishing a cross-current, which cuts off the current from the winding magnet, until, by its running, it causes the two points to separate, when the current flows through the magnet again, and the winding is continued. The instrument is beautifully finished, and reflects credit on the maker.

The peculiar form of magnet used in the registering department, is seen in the diagram No. 2, to the right of the register. A A, the circuit connections; C C, lower extremities of the soft iron bars, which are joined together; H H, reels of the helices around the iron; F F, the upper ends of the soft iron, having opposite polarities; P, the point of connection between the wires of the two helices; E, the armature. B, above, represents the operating key of a distant office, situated on the main line, with the attendant in the act of transmitting a communication; O, the main line coming from the distance; A, the battery on that line. Groves's battery is mostly in use, 30 cups of which are necessary in a space of 150 miles; they may be kept in one body; but it is better to distribute them at intervals along the line; they require cleansing and replenishing about once a fortnight. After passing through the key, the main circuit follows the course of the arrow to the receiving magnet C on the right, traverses the helix of that, and issues again from it, continuing its course to the right, to the next station, and so it might go on indefinitely, or around the world; N is the local operating key through which the line passes in the same manner as at B; this is the entire relation of the main circuit to an office; it makes the receiving magnet close the local circuit, and it will do it not only at one station, but at all on the same line, and at the same time; so that an operator in Philadelphia can transmit his message to St. Louis, and drop it at all the intermediate stations at one and the same moment; this has actually been performed.

Only one wire is now used on the main line, the earth affording the return circuit; No. 3 shows it very well; one end of the line may be supposed at Philadelphia, the other at New York; M M, receiving magnets of the two stations; K K, the operating keys respectively; P and N, the positive and negative poles of a battery on the line; C C, plates where the wires terminate in the ground: the connection of the wires to a gas-pipe will answer every purpose; the arrows represent the direction of the current; G, that portion of the ground forming the circuit. By having two wires, one connected respectively to the keys and magnets of the different offices, communications may be sent both ways at the same time, but only one current can traverse the same line at once.

The local circuit Z is short, simple, and effective, being closed by the receiving magnet C; the current starts from the local battery R, consisting usually of from two to three cups, that must be cleansed every morning for efficient operation, runs through the helix D, back to the receiving magnet in the course of the arrow to the local battery; this causes the style to raise and make an impression on the paper; the whole operation then is very simple; the key depressed at a distant city or station, B, causes the receiving magnet C, at Philadelphia, to close the local circuit: the iron of the helix D is made instantly magnetic, and the style goes against the paper, and stays there as long as the key is kept down at B. A simple contact makes a dot (.), a longer time a line (—). Considerable experience is requisite to make a good operator, either to transmit or read messages; some, however, become quite proficient after three months' tuition; the interval between the times of contact is regarded as well as the letter, for by its length, letters, words and sentences, are distinguished from each other; the adjoined table contains the Morse telegraphic characters.

A	- —	J	— - — -	S	- - -	Numerals.		9	— - - —
B	— - - -	K	— - —	T	—	1	- — — -	0	———
C	- - -	L	——	U	- - —	2	- - — - -		
D	— - -	M	— —	V	- - - —	3	- - - — -		
E	-	N	— -	W	- ——	4	- - - - —		
F	- — -	O	- -	X	- — - -	5	— — —		
G	— — -	P	- - - - -	Y	- - — - -	6	- - - - - -		
H	- - - -	Q	- - — -	Z	- - - -	7	— — - -		
I	- -	R	- - -	&	- - - -	8	— - - - -		

If an operator at Philadelphia wishes to send a communication to Baltimore, he first breaks the main circuit by opening the operating key at his station. All the receiving magnets in that circuit cease to attract their armatures, the spring draws them away from the magnets, and thus breaks all the short office circuits. The Philadelphia operator then makes the signal for Baltimore, by tapping on his key the proper number of times; this produces a clicking of the registers, which is heard and understood in all the offices on the line, though none but the Baltimore operator pays any regard to it.

Then the Baltimore operator opens his transmitting or operating key, and breaks the main circuit in another place, so that the Philadelphia operator cannot operate his main circuit, which the latter discovers by the silence of his own receiving magnet when he operates his key; he then closes his key to permit the operator at Baltimore to return an answer.

The Baltimore operator closes his key, sets his clock-work in motion, and returns word that his Philadelphia correspondent may send his communication, which the latter hears, and goes to work accordingly.

If the Philadelphia operator wishes to telegraph his message to several or all the stations on the line, he makes in succession all the signals of those offices, and awaits their replies; after receiving them all, he commences to operate, and the communication is received by every one of them at the same moment.

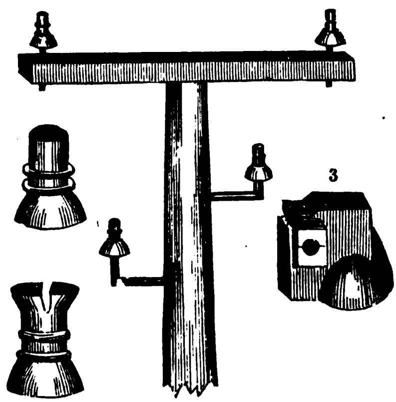
The daily performance of this machine is to transmit from 8,000 to 9,000 letters per hour. There are a number of attendants needed about an office transacting much business, each one of whom has his respective department; they are divided into "copyists, book-keepers, battery-keepers, messengers, line inspectors and repairers." The usual charge of transmission is 25 cts. for ten words sent one hundred miles; the messages vary in value from 10 cts. to $100. The amount of business which a well conducted office can perform, and the net proceeds arising therefrom, may well excite our surprise; a single office in this country with two wires, one 500, the other 200 miles in length, after spending three hours in the transmission of public news, telegraphed, in a single day, 450 private messages averaging 25 words each, besides the address, sixty of which were sent in rotation, without a word of repetition.

The public journals, however, often contain notices of errors committed by the operators on these lines, which, from their importance, have been the cause of considerable complaint among business and newsmen. This is variously attributed to careless attendants, disarrangement of the circuits, or the alphabetic combination, which renders the best receivers and copyists liable to mistake; this is not all, for instances can be cited where messages sent immediately, as the clerks promised to do, would have answered the desired end, but being delayed three hours, were utterly valueless.

Several important things are necessary to the successful operation of the instrument; skilful manipulators, good batteries and machines, and more than all, thorough insulation of the conductors. The latter can never be completely accomplished, as the best non-conductors will conduct in a slight degree. Copper wire, first employed, has, on account of expense, been laid aside for iron, of which 300 lbs. are required to a mile; the method of insulation consists in winding them around glass knobs, passing them through caps of the same material, or inclosing them throughout with gutta percha.

"The figure shows the methods of attaching them to glass caps, by supporting the wire from their side, or resting them in a groove on the top; these caps fit over wooden or iron pins, which are fastened on the top of horizontal crossbars, or driven into the side of the post; two blocks of glass in the form of a parallelopiped, and dovetailed together in such a manner as to let a wire, without any other fastening, slide through a central opening, the glass being surrounded and protected by wood; the most recent method consists of glass blocks, fitted in cast-iron caps, and supported on the peg by a heavy glass tube (3). The caps, of whatever form, are either upon crossbars, or supported by iron staples driven into the post."

Fig. 30.

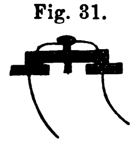


Notwithstanding these precautions, by the contact of wires blown about by winds, moisture, &c., connections are made through the ground or otherwise, and a short circuit is formed, instead of going the entire route of the line, or part of the current, of greatly diminished intensity, pursues the latter course.

The following method of ascertaining the existence of a break, or forming connections with different offices at will, is well described by Mr. Charles T. Chester, of New York, in *Silliman's Journal*, vol. v. 2d series. It has been found that the intermediate offices on a main line are of great utility in determining the situation of the breach.

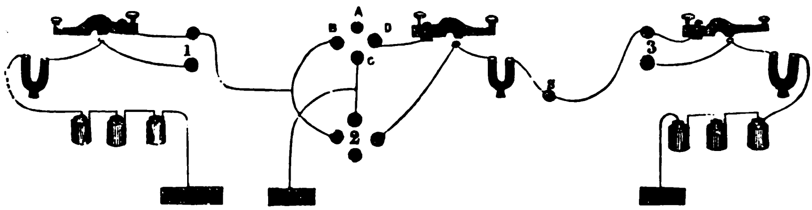
"If the circuit is broken on one side, a current is at once obtained from the battery of the unbroken side, and the accident found is repaired. The diagram shows how to apply this test, and the method of dividing the long line into sections. The black dots, A B C D, in Fig. 32, represent brass terminations of conductors, sunk on a level with the surface of the operator's table; a metallic button, Fig. 31, plays over their surface. This button connects each brass stud with its opposite, and a change in its position changes the direction and channel of the current at pleasure. Thus, the intermediate operator wishes to break and close the through circuit (this is synonymous with main circuit), he turns his button, bringing B in contact with D; the course of the current can be easily traced. But again, cutting off his left hand neighbor, he wishes to converse with his right, the button changed so as to connect A with C, the current passes directly to the ground through his instruments. Supposing a binding

Fig. 31.



screw at S, the left or right-hand wire may thus be brought in connection with the ground. The buttons 1, 2, and 3, are simply used as convenient duplicate keys, or circuit closers, when the operator is receiving."

Fig. 32.



When the line is found deranged at an intermediate office, by the evidence of a current unnaturally strong or weak, the impression is that the wire is broken at one or both sides of the office. Supposing the wire continuous from one end of the line to the other, and a battery at each, the current passes through the intermediate magnet without interruption, and the circuit established is termed a "through circuit." When a derangement is perceived, the intermediate operator alters the through circuit, and by connecting with the ground, makes two short circuits.

Several methods have been devised to obviate the disastrous consequences that sometimes result from violent electrical action during thunderstorms, such as the melting or breaking of wires, total destruction of long distances of the circuit, injury to office furniture or the operators connected with it; among the most important of which are those that combine the readiest communication with the ground to convey away the superabundant fluid; one is to have the circuit closer of a receiving magnet, employed for this sole purpose, pass into the earth; another is the metallic connection with the surface of a brass ball, surrounded by a ring situated in and forming part of the circuit, from the inner circumference of which minute metallic points project towards, but do not quite touch the ball; both of these, however, are inefficient at times.

Professor Morse has deservedly received the highest approbations of the American people for the invention that not only calls forth wonder at its accomplishments, but has proved itself an invaluable agent in political economy. Excepting efficient and economical batteries, most of the discoveries in this department of science had been made, which were essential to a proper foundation of his invention; some hand was necessary to elicit the remaining facts, combine and give them a mechanical arrangement and application, and then to thrust it before a distrustful public, to solicit the attention and patronage of the government for the proper attestation of its merits.

It was novel to the American people; no one had projected the thing here successfully, though many had thought of, and some tried it; through Professor Morse's indefatigable perseverance, the adjuvant resources of science were united in the form of utility; though dependent for most of his information upon others, he had the confidence in its final success, to master opposing obstacles, and bring to his aid those who had labored honorably and prosperously in the progress of knowledge.

Professor Morse has received numerous testimonials of the high appreciation in which his form of telegraph is held in Europe, one of the most recent of which was "the State medal" from the King of Wurtemberg, with the information that his form of telegraph will be adopted in that kingdom. The Grand Sultan of Turkey, also, did Professor Morse the same honor, followed by the King of Prussia, with the adoption of his form of telegraph for great distances.

And their scientific men have not withheld their high estimation of its simplicity and utility. Professor Steinheil, the Administrator-in-chief of the Austrian telegraphs, although himself the inventor of an electric telegraph, which has procured for him a world-wide and well-deserved fame, with a magnanimity which does him high honor, has given his opinion in favor of adopting the American system in Germany.

The following is a translation of the official act:—

"Extract from the Protocol of the Convention of Deputies from the German Governments which met at Vienna in the month of October, 1851, for the establishment of a German Austrian Telegraphic Union, &c.:—

"The Governments of this Union give their mutual assurance to bring into operation, at the latest, on the 1st of July, 1852, the direct transmission of telegraphic communications between the central stations of the respective governments, so that transfers upon intermediate stations will be no longer required, whenever the lines are not previously occupied, so that each of the central stations can enter into communication with every other.

"To accomplish this, all the Governments of the Telegraph Union adopt for the International Correspondence upon each line, for the present, Morse's Telegraph, with receiving magnets, registers, and uniform alphabet."

Morse Telegraph Convention.

A Telegraph Convention assembled at Washington on the 5th day of March, 1853, to confer together for the purpose of establishing regulations among the various Morse Telegraph Companies, so as to increase the farther usefulness of this means of transmission, and to perfect the system to its greatest capacity of good.

The Committee on Resolutions reported on the following points, which were adopted in detail by the Convention:—

First. All words in the body of a message should be counted. Proper names, such as the names of persons, steamers, cities, &c., shall be counted as many words as there are capitals used.

Second. Better means recommended to secure answers to messages sent, and to give priority to messages of inquiry between offices on business.

Third. A reciprocal rule for refunding on lost messages, making the line at fault responsible.

Fourth. To protect the telegraph from abuse by unworthy and unqualified operators, requiring suitable evidence of integrity and capability.

Fifth. A uniform system of numbers and signal letters.

Sixth. The recommendation to decline adopting new letters in the Morse alphabet, but agreed to the transposition of the letters "C" and "K," requiring the dash, dot and dash to be used as "C," and the spaced letter "C" to be used in future as "K."

Seventh. Refusal to adopt any periodical for an official organ of the Convention or Telegraph.

Eighth. Refusal to adopt the general term of National Telegraph, considering it as a name applied to associated lines.

Ninth. The extension of the patent of 1840 was considered the legitimate business of the patentee.

Tenth. Declined to reduce the tariff of charges by an increase of words.

Eleventh. The appointment of a Committee of Correspondence, to serve until the next Convention, to attend to such matters relative to the general interest of Telegraph Companies as may be deemed necessary.

Twelfth. No message to be transmitted by any line unless prepaid, except answers to messages, checked "answer paid."

Thirteenth. Recommending the abolition of the practice of sending free messages, except for those actually engaged in the business, and on telegraph business.

Fourteenth. Against the employment of persons without good testimonials of integrity, &c.

Fifteenth. The Convention agreed to meet annually, and in Washington, March, 1854.

Sixteenth. Recommending offices in same cities to unite, and have one office, common to all.

Much important business was transacted with great unanimity.

The Convention in a body called and paid their respects to the President of the United States, at the Executive mansion, and were courteously received by him. The members composing the Convention represented about four-fifths of the Telegraph lines of America.

The Convention adjourned *sine die* at 7 o'clock P. M.

Wheatstone and Cooke's Needle Telegraph.

In 1834, Professor Wheatstone published a beautiful series of experiments on the velocity of electricity, which I noticed in the first of these lectures on the Telegraph. This seems to have had an influence in directing his attention to the subject of the Electric Telegraph. During the month of June, 1836, in a course of lectures delivered at King's College, London, he repeated his experiments on the velocity of electricity, but with an insulated circuit of copper wire, the length of which was now increased to nearly four miles; the thickness of the wire was $\frac{1}{16}$ of an inch.

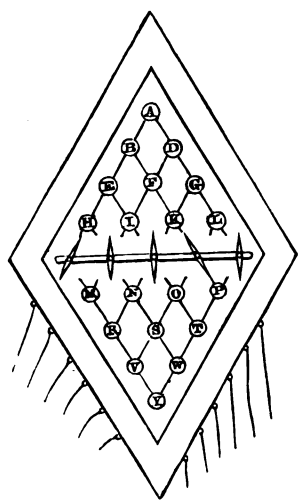
When machine electricity was employed, an electrometer placed on any point of the circuit diverged, and wherever the continuity of the circuit was broken, very bright sparks were visible. With a voltaic battery, or with a magneto-electric machine, water was decomposed, and the needle of a galvanometer deflected in the middle of the circuit. Prof. Wheatstone gave a sketch of the means by which he proposed converting his apparatus into an electrical telegraph, so that, by the aid of a few finger stops, it would instantaneously and distinctly convey communications between the most distant points. The apparatus, as it is at present constructed, is capable of conveying thirty simple signals, which, combined in various manners, will be fully sufficient for the purposes of telegraphic communication.—*Mag. Pop. Sci.* 1836.

This was Prof. Wheatstone's first telegraph, and, having matured his plans, he took out a patent on the 12th of December, 1837, which was sealed on the previous 12th of June, 1837, in conjunction with Mr. W. F. Cooke, who had devoted much of his time and attention to the practical application of the Electric Telegraph.

The principle on which this telegraph depended, was that of combining several peculiarly constructed galvanometer needles. It was an application of the famous discovery of Prof. Œrsted of the deflecting influence of an electric current upon a magnetic needle, which I have already explained in a previous lecture.

A signal board was employed, having five vertical galvanometers with double needles, the lower ends of each being slightly the heaviest, so as to insure at all times a vertical position, except when deflected by the current. From the ends of these needles lines were drawn, both above and below, as in Fig. 33, and at the points where these lines intersected, letters and numbers were placed. When an electric current was transmitted so as to deflect at the same time two of the needles, they indicated, by their convergence, one or other of the letters marked on the signal board. Thus, if the first and fifth needles converged above, they pointed to A; if below, to Y; or if the first and fourth converged above, they indicated B, and so on.

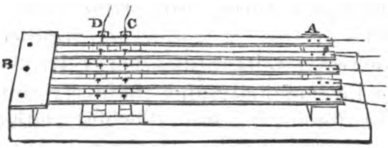
Fig. 33.



The signal boards were placed at either end of the line of telegraph, having a battery and keys so arranged as to render it easy to deflect at pleasure any of the five galvanometer needles at the distant station; the two sets of galvanometers being connected by six wires, one for each separate needle, and one as a return common to them all. The keys used to connect these wires with the battery were very simple, and at the same time perfectly efficient.

The arrangement consisted of five copper bars, thin enough to be elastic, fastened to a crosspiece of wood, as at A, Fig. 34, and connected with the five wires of the telegraph, whilst their other ends pressed slightly (but so as to be in good metallic contact) against a crosspiece of copper, B. The terminal wires of the voltaic battery were attached to two small bars of metal, C D, and in the five longer bars, just where they crossed the battery bars C D, there was a row of small metal pins, terminated with little ivory knobs. When it was desired to deflect any of the needles in the signal boards, all that was necessary was to press the ivory knobs above those bars, in connection with the needles to be deflected; the slight pressure, by bending down the bars, insulated them for the time by breaking the contact at B; and the metal pins, by coming in contact with the crossbars C and D, became connected at once with the battery. By this simple arrangement the keys, though always ready for immediate use in sending a signal, were not any obstacle to receiving one, as the bar B always completed the circuit of all the wires, except at the moment of using the telegraph, and then, by the contrivance just described, it was thrown out of connection. The wires of this first telegraph were insulated in tubes by means of a mixture of cotton and India rubber; then the prepared wires are all passed with certain precaution through iron pipes, which on some parts of the line were buried beneath the ground, and in others raised above it. It was afterwards elevated on wooden posts, as the moisture affected the wires, and destroyed the insulation. The battery employed by them was that of a vessel of copper, with plates of zinc, and acidulated water.

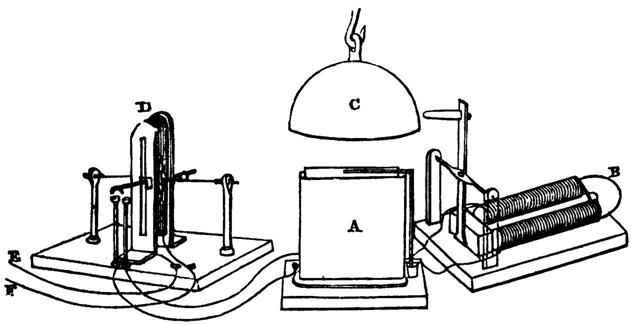
Fig. 34.



In order that the telegraph could be practically used, it was essential that some simple means should be employed to call the attention of the operator when a message was about to be sent, as the movement of the needles made no sound.

In order to overcome the difficulty presented by the very small amount of power which would be transmitted to a long distance, and which was not sufficient to make an electro-magnet of any power, and thus discharge an alarum, he placed a second battery at the distant station, having wires connected with a powerful electro-magnet attached to an alarum, or arranged so as to strike a bell as soon as the battery was brought into operation. But, as the circuit was broken, the battery, though charged with acid, and therefore ready to act, could not exert its magnetizing power on the electro-magnet unless the circuit was completed. The current of electricity from the distant station from whence the intelligence was to be transmitted, though not powerful enough to make an electro-magnet, was abundantly powerful enough to complete the circuit of the second battery, thus waiting to be called into action. This was effected by a small piece of copper wire attached to a crosspiece fastened to a delicately suspended vertical galvanometer; when the latter was deflected by even a feeble electric current, the copper wire, by having its ends plunged into two cups of mercury, completed the circuit of the secondary battery, causing the electro-magnet to attract its keeper, and thus let off the alarum to ring the bell. The general form of the arrangement is represented in Fig. 35, which I have taken from a published lecture by Professor E. Solly, of London, on the telegraph, which drawing proves correct on comparing it with the original in the patent.

Fig. 35.



E F are the wires conveying the electric current from the distant station; D, the vertical galvanometer deflected by its influence; A, the secondary battery thus brought into action, and B, the electro-magnet which is made to act on the bell C.

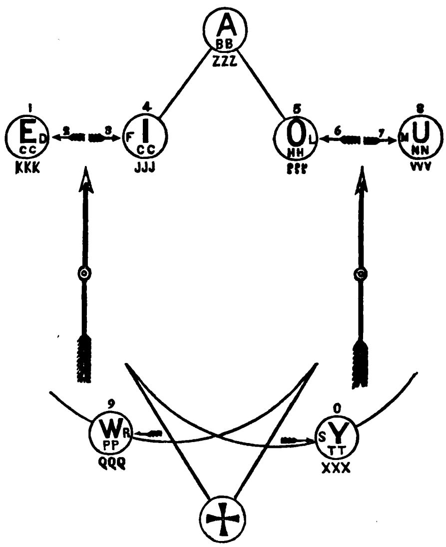
The line of telegraph upon the Great Western Railway was finished in July, 1839, and had been in operation above seven or eight months. Thirty signals may be conveniently made in a minute. According to Professor Wheatstone, on his examination before a Parliamentary Committee on Railways in 1840, he states: "I have been confining the attention of the Committee to the telegraph now working on the Great Western Railway, but having lately occupied myself in carrying into effect numerous improvements which have suggested themselves to me, I have, conjointly with Wm. Cooke, who has turned his attention greatly to the same subject, obtained a new patent for a telegraphic arrangement, which I think will present very great advantages over that which at present exists. This new apparatus requires only a single pair of wires to effect all which the present one does with five, so that three independent telegraphs may be immediately placed on the line of the Great Western; it presents in the same place all the letters of the alphabet according to any order of succession, and the apparatus is so extremely simple, that any person without any previous acquaintance with it can send a communication and read the answer."

Mr. Saunders, the secretary of the Great Western Railway, states the expenses of constructing the electrical telegraph on the line of that railway to have been from £250 to £300 a mile; whereas, the old form of telegraph in use between London and Portsmouth, independent of the original outlay, costs about £3,300 a year; and the lines of telegraphic communication to Plymouth, to Yarmouth, and to Deal, were abandoned in the year 1816, on account of the expenditure for their maintenance.—*Civ. Eng. and Arch. Journ.*

According to the *Tyne Mercury*, the electric telegraph on the South-Western Railway, from London to Gosport, cost about £24,000.

Professor Wheatstone specified a second patent for improvements, in the name of Mr. Cooke, Oct. 18, 1838, still making use of the deflection of needles as the signals employed, and using only two wires instead of five, and a combination of the two elementary instruments. It has two pointers, each worked by its distinct handle, and gave eight single signals, and a sufficient number of compound ones to admit of the twenty-six letters of the alphabet being used. By farther conventional signs, those letters are made to represent figures; and by blending both systems, a mixed sentence, consisting of passages from a code, spelling and figures, could be telegraphed together. The general form of the dial is shown in Fig. 36. Behind this dial a magnet is fixed on the same axis as the needle, so that both move together. A portion of the conducting wire is coiled many times longitudinally round a frame in which the magnet moves; by this contrivance, the magnet is subjected to the multiplied deflecting force of the voltaic current. The motion of this magnet is limited by fixed stops placed at both sides. The simple signals are given by the movement of the needles, either singly or combined. Thus the left-hand needle moved to the left gives E, to the right I; the right-hand needle moving to left gives O, and to right gives U. If both converge upward at the same time, their combined indication is A, and if they converge downwards it is +. If the pointers are made to rest parallel to each other in one direction, W is meant, and in the other direction they indicate Y. The consonants most in use are given by two movements of the needle, and those rarely required, such as J, Q, X, Z, by three movements. C and U are generally used for K and V, but not necessarily.

Fig. 36.



Wheatstone's telegraph cost per mile £100. (*Mech. Mag.* 1838.)

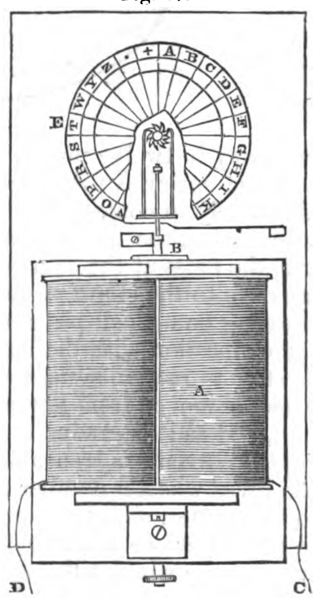
This telegraph, which is the useful and scientific invention of Mr. Cooke and Professor Wheatstone, has now been in operation for nearly twelve months; all the wires are inclosed in hollow tubes, not more than about an inch in diameter.—*London Mining Journal* for 1840.

The American patent for Electro-magnetic Telegraph, Charles Wheatstone and Wm. Fothergill Cooke. Patent for fourteen years from 12th June, 1837, that being the date of the English patent.—*Franklin Inst. Journ.* 3d series, vol. ii. p. 120, August, 1840.

The American patent was of no benefit to the patentees, as it was never practically employed in the United States, Prof. Morse's instrument being the chief one in use from 1844 to 1846.

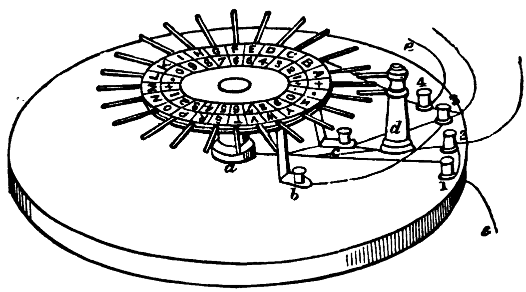
The defects in the practical working of his first and second telegraph led Prof. Wheatstone to devise a new form of telegraph, called by him an electro-magnetic telegraph, in January, 1840. The principles employed in this new instrument are well exhibited in Fig. 37 (*Daniell's Elements*). "It consisted essentially of an electro-magnet surrounded with a long and fine wire A, and a keeper of soft iron B, prevented from coming in complete contact with poles of the magnet, but so near as to be within reach of the attractive power of the magnet when the latter is under the influence of the current.

Fig. 37.



The motion of the keeper was made use of in various ways to communicate signals. In Fig. 37, it is represented as acting by a species of clock escapement on a small ratchet-wheel, and thus causing the rotation of a light disk of paper or mica, E, on the circumference of which the letters of the alphabet, or other signals, are marked. In the diagram, part of this disk is represented, which resembles very much the signal dial of Mr. Ronalds, and is on the same plan. It is in part cut away to show the position of the ratchet-wheel behind. The ratchet-wheel resembles one invented by Burgengeiger, a German, to which he had attached an electric clock, as described in the *Morgan Blatter*, of September 23, 1815, and quoted by Mr. Ronalds in his work on electricity, published in 1825. Every time that an electric current is transmitted from a distance by the wires C D, and they may be made to succeed each other with great rapidity, the disk is advanced one tooth of the wheel, and consequently another letter; and when the electric current is interrupted, the keeper being no longer attracted, is drawn up again to its original position by a spring, and the disk advanced another letter. The whole instrument is inclosed in a case, having an aperture in front, which only permits one letter at a time to be seen. In using this telegraph, the instrument is always placed at the commencement with the sign of a cross only visible, which is before the letter A, on the round disk; if it is then wished to indicate the letter H, it is necessary to transmit four separate electric currents, in order to attract the keeper four times, and so cause the disk to move round eight divisions, the letter H will be exhibited. The transmission of the currents is managed by a little instrument represented in Fig. 38. It consists of a horizontal brass wheel, divided and marked on its upper surface like the disk of the telegraph, with which it perfectly corresponds; the circumference of this wheel is

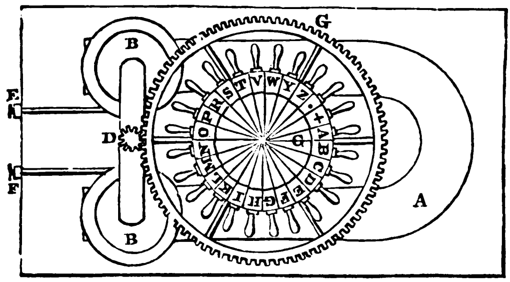
Fig. 38.



cut away in twelve places, and filled with small pieces of ivory. A metallic spring *b*, pressing against the circumference of the wheel, is alternately in contact with the metal of the brass wheel and the ivory pieces when the wheel is turned round. When the instrument is not in use, the cross at the commencement of the alphabet is always placed opposite to the stop *d*, as in this position alone the metallic spring *c*, by pressing on a small piece of metal connected with the stand *a*, cuts off the connection with the battery, and therefore leaves the telegraph in a fit state to receive signals from the distant station. As soon as the wheel is moved from this position, the battery is brought into connection, and as it is gradually turned round, the required number of interrupted currents is transmitted to the magnet. In the circumference of the brass wheel a number of iron pins are inserted, one corresponding to each letter, and, therefore, by taking hold of the pin corresponding to the letter we wish to indicate at the distant station, and rapidly turning the wheel till stopped by the crosspiece at *d*, we cause the letter disk of the telegraph to revolve the required amount.

The preceding is one of the simplest forms of this telegraph, but the power is applied in many ways; thus, in place of moving the letter disk it may remain stationary, whilst a light hand or index only is caused to revolve; or, in place of an electro-magnet being used, the mere deflection of a vertical galvanometer may be employed for the same purpose. But as it was found that a telegraph of this kind, though excellent for short distances, was not so suitable for long ones, a modification was adopted, in which the power required was greatly diminished, and the delicacy of the telegraph much increased. In this form a powerful clock movement, acted on by a strong spring, was employed to rotate the disk or index, the attraction of the keeper being only used to regulate the escapement, every current releasing a single tooth, and so allowing the clock movement to advance the disk one letter. He employed a magneto-electric machine instead of the battery, also doing away with the "communicator." Fig. 39 shows a vertical representation of one of the machines used for this purpose, consisting of a permanent magnet A, an armature of soft iron B, surrounded with coils of copper wire, and connected with the binding screws E F. The armature can be made to revolve by the action of the larger wheel C, on the pinion D, which is thus caused to revolve just so many times by one revolution of the wheel C, as will give rise to the number of currents requisite to turn the telegraph disk once

Fig. 39.



round. The whole of this instrument is inclosed in a box, and the axis of C, which rises through the top of the box, carries a solid brass wheel G, having handles corresponding to the letters of the alphabet, and signals of the telegraph disk. I extract from the *London Artisan*, vol. iii. p. 247, for Nov. 1849, an account of the present condition of this telegraph in England, by Francis Whishaw, Esq.

The construction of the telegraphs chiefly used in England, may be thus described: Along the sides of the various railways (for by this system it is wise to have the telegraph wires protected, as far as possible, by a constant supervision) wooden vertical posts of fir timber are ranged at convenient distances. Each post is furnished with an insulator of earthenware, through which the wires are drawn, to prevent their connection with the wooden posts. The wires are of stout galvanized iron, which are carried from one end of the railway to the other, except in passing through tunnels, or under bridges. In such cases, the insulators are attached to the brickwork; and thus the wires are prevented from being in contact with the brickwork. Each post is furnished with a lightning conductor, and is also capped with a wooden roof, with dripping eaves to throw the rain-water from the wires. At each end of the telegraphs, the line wire is connected with an earth battery, consisting of a large plate of zinc or copper, buried in the earth—the object of which is to avoid the necessity of a return wire, which in the first telegraphs in England was made use of. At the various stations, one or more of Cooke and Wheatstone's needle instruments are set up, being connected with the line wires and batteries by wires of smaller size, generally covered with silk or cotton, which is easily destroyed by the alterations of weather, and, therefore, is objectionable. Each telegraph on this plan has two wires. The batteries used are of the most simple form, consisting of a trough, divided into any number of cells, according to the power required. Alternate plates of zinc and copper are connected throughout the pile, which dip into sand, saturated with dilute sulphuric acid—the use of the sand being to prevent waste of the acid in the battery, when required to be sent from one station to another ready charged. The signals are given by means of the needles, placed in front of a dial, on which are written or engraved the letters of the alphabet, being moved either to the right or to the left. Each needle in *front* of the dial is placed on the same axis as a magnetic needle *behind* the dial, which latter is suspended freely in a space surrounded by a coil of wire, through which coil, when the current is transmitted either in one direction or the other, the needle is deflected either to the right hand or to the left, as may be desired; so that, by a certain number of movements of each needle, and by the combination of the movements of both, every letter of the alphabet, or any numeral, is given. As many as thirty letters, under ordinary circumstances, are thus transmitted in a minute; but by expert manipulators many more. Although the requisite movements are easily learned, yet it requires many weeks for a telegraphist to work the needle instrument sufficiently well to be intrusted with a communication of any value, whether for railway or commercial purposes; moreover, it is requisite that the two persons communicating with each other should be equally advanced in the required manipulations. Some of the boys employed by the Electric Telegraph Company, have acquired wonderful rapidity in the transmission of messages; while I have known many persons give up the occupation altogether, although having no other employment to resort to. In case of a telegraphist attending the needle instrument being suddenly disabled by illness or otherwise, great inconvenience must be experienced, by reason of no one being at hand to take his place; whereas, by other instruments, as that of Siemen's, &c., which can be worked by man, woman, or child, at five minutes' notice, this inconvenience is done away with. The exposure of the wires to atmospheric influence—to storms of snow, as lately experienced on the South Eastern Railway—to the destructive effects of trains running off the way, and to the destruction of the wires by malicious persons (rewards for whose apprehension have frequently been offered), are all fatal objections to the present English system ever becoming universal. Moreover, the expense to railway companies and others is a sad drawback to the farther extension of this system in Great Britain and Ireland—for the railways of which alone an extension of at least 2,000 miles is still required. The average charge for an electric telegraph with two wires, as hitherto furnished to the various railway companies in England, may be stated at not less than 150*l*. per mile; added to which an annual sum must be calculated on for keeping it in order, and reinstating, when necessary, the wooden posts, &c. The charge for transmission of communications by the Electric Telegraph Company's telegraphs in England, is at the rate of one penny per mile for the first fifty miles, and one farthing per mile for any distance beyond one hundred miles. The South-Eastern Railway Company's charges for telegraphic communications are even much higher than those of the Electric Telegraph Company. Thus twenty words, transmitted eighty-eight miles, is charged the large sum of 11*s.*; whereas the same length of communication for the distance of 100 miles is only charged 6*s.* 3*d.* by the Electric Telegraph Company.

If we judge by the following remarks, some of the English journals appreciate the advantages of this form of telegraph.

"We have heard of things being done 'in less than no time,' and always looked on the phrase as a figure of speech signifying great dispatch. The paradox seems, however, to have been actually realized in the invention of Wheatstone's Great Western Telegraph, a message having been sent in the year 1845, and received in the year 1844! It appears that directly after the clock had struck twelve, on the night of the 31st of Dec. last, the superintendent at Paddington signalled to his brother at Slough, that he wished him a happy New Year; an answer was immediately returned, suggesting that the wish was premature, as the New Year had not yet arrived at Slough. Such, indeed, was the fact, for 'panting' Time was matched against the telegraph, and beaten by half a minute."

On the London and Portsmouth Electric Telegraph (88 miles), "Her Majesty's speech, on the opening of Parliament was transmitted by the telegraph to Portsmouth, and published there almost as soon as in London. The speech contained 3,600 letters, and was printed off as it arrived. It occupied about two hours in the transmission, being at the rate of about 300 letters per minute."—*Mech. Mag.* Feb. 1, 1845.

Steinheil's Electro-Magnetic Needle Printing Telegraph.

The next telegraph in order of date of publication is that of Professor Steinheil, the first published notice of which I find in a letter from Munich, dated December 23, 1836, published in the third volume of the *Magazine of Popular Science*.

"Prof. Steinheil has fitted up a telegraph here according to the plan of Prof. Gauss, and similar in principle to that which connects the Observatory and Cabinet of Natural Philosophy at Göttingen." This telegraph was in operation previous to July, 1837, but was not published and described until August, 1838. "His Memoir was communicated for the *Comptes Rendus* July 19, and published in September, 1838." According to the authority of Prof. Morse, Steinheil's telegraph was adopted by the Bavarian Government, and was in actual operation during his visit to Europe in 1838. According to the same authority, in 1838, "Professor Steinheil's telegraph was the only European telegraph that professed to write the intelligence."—See Letter of Professor Morse to the Hon. C. G. Ferres, *Vail's Electro-Mag. Telegraph*, pp. 95, 97.

In the work of Dr. Schellen, published in Germany in 1850, it is stated that Steinheil's telegraph was in operation in 1837.

This is the first telegraph which I find on record, in which the earth was employed as half of the circuit—a most useful application of knowledge, gained at great labor, and not patented, but published freely to the world. His experiments are thus described by Dr. Schellen, in his work on the telegraph:—

"Gauss had already conceived it possible to make conductors of the rails of a railroad, when Steinheil, in 1838, make the experiment, insulating the chairs of the rails by tarred felt; this was, however, imperfect insulation, as the circuit would not extend beyond thirty rails. To test the matter more thoroughly, he had some new rails constructed; but the points of contact were so numerous, and the establishment of a metallic connection between the two rails by the wheels and axles of the cars passing over them so complete, that the current lost its force, and all idea of the measure was given up. This experiment, demonstrating the conducting power of the earth, induced Steinheil to think of that as a means of return circuit, and thus dispense with one-half the wire. The fact by experiment he found verified, and immediately arranged his apparatus on this plan. This was a discovery of vast utility, and has contributed much to the extension of telegraphing. Steinheil says, you can make conductors of earth and water, as well as of wire, if you increase their size in proportion to the non-conductibility of the substance. Water was 100,000 times worse as a conductor than copper, and therefore the conducting surface should be made 100,000 times greater; in order to obtain this large conducting medium, it is necessary that the wires should terminate in submerged plates of the required dimensions to include that medium between them. The same idea was afterwards brought forward by Dr. Coxe, of this city, in regard to the use of railroads for telegraphic purposes, in September, 1845."

Steinheil's alphabet is one of great beauty and simplicity, displaying the man of learning and refinement; as, for example, his musical bells, producing sounds which, striking upon a cultivated ear, conveyed a telegraphic language in imitation of the human voice. But he did not confine himself to the production of evanescent sound; he also employed the simple dot, so as to fix them permanently upon paper, that they could be recalled again. This form of telegraph is a combination of the successive fundamental discoveries of Professors Œrsted and Faraday, with the multiplicator of Schwigger.

I extract from the original paper of Steinheil, published in the *London Annals of Electricity*, March and April, 1839, an account of his telegraph, being the most complete which I can find on record:—

To Gauss and Weber* is due the merit of having, in 1833, actually constructed the first simplified galvano-magnetic telegraph. It was Gauss who first employed the excitement of induction, and who demonstrated that the appropriate combination of a limited number of signs is all that is required for the transmission of communication. Weber's

* Gott. gel. Anz. 1834, p. 1273, and Schumacher's Jahrbuch, 1837, p. 38.

discovery that a copper wire 7,460 feet long, which he had led across the houses and steeples at Göttingen from the Observatory to the Cabinet of Natural Philosophy, required no especial insulation, was one of great importance. The principle was thereby at once established of bringing the galvanic telegraph to the most convenient form. All that was required was an appropriate method of inducing or exciting the current with the power of changing its direction without having recourse to any special contrivances for that purpose. In accordance with the principles we have laid down, all that was required in addition to this was to render the signals audible, a task that apparently presented no very particular difficulty, inasmuch as in the very scheme itself a mechanical motion, namely, the deflection of a magnetic bar, was given. All that we had to do, therefore, was to contrive that this motion should be made available for striking bells or for making indelible dots. This falls within the province of mechanics, and there are therefore more ways than one of solving the problem. Hence the alterations that I have made in the telegraph of Gauss, and by which it has assumed its present form, may be said to be founded on my perception and improvement of its imperfections, in harmony with what I had previously laid down as necessary for perfect telegraphic communication. I by no means, however, look on the arrangement I have selected as complete; but as it answers the purpose I had in view, it may be well to abide by it till some simpler arrangement is contrived.

As an inductor or exciter I employ a rotating apparatus whose construction, speaking in a general way, is similar to those of Clarke, of London. The multipliers of which my inductor is composed, consist of a vast number of turns of fine insulated copper wire; and this arrangement is necessary in order that the resistance offered by the thicker wire completing the circuit, even should it be many miles long, may be but little increased. Of the galvanic influence excited during the entire half-turn of the rotating double multiplier, only a small portion is employed, and that when it is at the maximum of its energy. By this means the duration of the current is but very short, an arrangement which therefore, in a manner, can cause merely a momentary deflection of the little magnetic bars employed for giving the signals. In order to heighten the action of these indicators as much as possible, they are surrounded by powerful multipliers. Small detached magnets are so placed near these indicators, that they are thereby brought back to their original position immediately that the induced current ceases, or, in other words, as soon as the deflection has taken place: I thus am enabled to repeat signals in very rapid succession. The same indicator can be brought with ease to make five deflections in a second, succeeding each other as fast as the sounds of a repeater when striking. Hence if bells are placed at the proper striking distance from these indicators, they will ring at every deflection produced, and as it is quite immaterial at what part of the wire, completing the circuit, the multiplier containing the indicator is inserted, we have it in our power to produce the sign excited by induction at any part of the course the wire takes. Should it be desired that the indicator instead of producing sounds should write, it is merely required to adapt to one end of the little magnetic bar a small vessel filled with a black color, and terminating in a capillary tube. This tube, instead of striking on a bell, thus makes a black spot upon some flat surface held in front of it. If these spots are to compose writing, the surface upon which they are printed must keep moving on in front of the indicator with a uniform velocity, and this is easily brought about by means of an endless strip of paper which is rolled off one cylinder on to another by clock-work. As far as the employment of this telegraph is concerned, it may be fairly said to perform all that can be reasonably required of it. The excitation of the current is produced by half a turn of the indicator, and is equally available at all times. The sounds of the bells close to the person making the signals, and which being produced at the other station too are also audible there, become, by practice, intelligible as a language. Should they, however, be overheard or misunderstood, the communication presents itself simultaneously written down. This can be done with closed doors, without any but the parties concerned being aware of it; the communication may be made at any distance, and either by day or night, without any appreciable loss of time. There is, therefore, every reason to be content with the performance of the instrument.

It is not, however, to be denied, that the establishment of certain conditions indispensable to its action is, nevertheless, a matter of some difficulty. We allude to the connecting wire joining the stations.

It has been stated above that Ampère required more than sixty such wires, whereas thirty or so were sufficient for Sömmering. Wheatstone and Cooke* reduced their number to five; Gauss, and, probably in imitation of him, Schilling, as likewise Morse† in New York, made use of but a single wire running to the distant station and back. One might imagine that this part of the arrangement could not be farther simplified; such, however, is by no means the case. I have found that even the half of this length of wire may be dispensed with, and that with certain precautions its place is supplied by the ground itself. We know in theory that the conducting powers of the ground and of water are very small, compared with that of the metals, especially copper. It seems, however, to have been previously overlooked, that we have it within our reach to make a perfectly good conductor out of water or any other of the so called semi-conductors. All that is required is, that the surface that its section presents should be as much greater than that of the metal as its conducting power is less. In that case the resistance offered by the semi-conductor will equal that of the perfect conductor; and as we can make conductors of the ground of any size we please, simply by adapting to the ends of the wires plates presenting a sufficient surface of contact, it is evident that we can diminish the resistance offered by the ground or by water to any extent we like. We can, indeed, so reduce this resistance as to make it quite insensible when compared to that offered by the metallic circuit, so that not only

* La France Industrielle, 1838, April 5, p. 3.

† Mechanics' Magazine, No. 757, p. 332. Silliman's Journal for October, 1837. Annals of Electricity, &c. vol. ii. p. 116.

is half the wire spared, but even the resistance that such a circuit would present is diminished by one-half. This fact, the importance of which in the erection of galvanic telegraphs speaks for itself, furnishes us with another additional feature in which galvanism resembles electricity. The experiments of Winckler, at Leipsic, had already shown us that with frictional electricity the ground may replace a portion of the discharging wire. The same is now known to hold good with respect to galvanic currents.

The inquiry into the laws of dispersion, according to which the ground, whose mass is unlimited, is acted upon by the passage of the galvanic current, appeared to be a subject replete with interest. The galvanic excitation cannot be confined to the portions of earth situated between the two ends of the wire; on the contrary, it cannot but extend itself indefinitely, and it became, therefore, now only dependent on the law that obtained the excitation of the ground and the distance of the exciting terminations of the wire, whether it was necessary or not to have any metallic communication at all for carrying on telegraphic intercourse.

I can here only state in a general way that I have succeeded in deducing this law experimentally from the phenomena it presents; and that the result of the investigation is, that the excitation diminishes rapidly as the distance between the terminal wires increases.

An apparatus can, it is true, be constructed in which the inductor, having no metallic connection whatever with the multiplier, by nothing more than the excitation transmitted through the ground, will produce galvanic currents in that multiplier sufficient to cause a visible deflection of the bar. This is a hitherto unobserved fact, and may be classed among the most extraordinary phenomena that science has revealed to us. It only holds good, however, for small distances. It must be left to the future to decide whether we shall ever succeed in telegraphing at great distances without any metallic communication at all. My experiments prove that such a thing is possible up to distances of 50 feet. For distant stations we can only conceive it feasible by augmenting the power of the galvanic induction, or by appropriate multipliers constructed for the purpose, or, in conclusion, by increasing the surface of contact presented by the ends of the multiplier. At all events, the phenomenon merits our best attention, and its influence will not perhaps be altogether overlooked in the theoretic views we may form with regard to galvanism itself.

To sum up in a few words what are the results of what we have here brought forward respecting telegraphic communications, we see that with the present arrangement of the apparatus, no principle can be brought into competition with the galvanic telegraph, but that the establishing the metallic connection indispensable to its action, although now materially simplified, still presents great difficulties in practice. Indeed, such a connection is only practicable where it can be constantly watched, as, for instance, in the vicinity of railroads.

For very considerable distances without intermediate stations, galvanic or electric excitation must, on account of its rapidity, be always the best power to have recourse to. For less distances, it yet remains open to inquiry whether, with proper modifications, some of the other methods we have pointed out would not be preferable, as they dispense with a metallic connection.

Dr. Steinheil's Magnetic Telegraph.

This telegraph is composed of three principal parts. 1. A metallic connection between the stations. 2. The apparatus for exciting the galvanic current. 3. The indicator.

1. *Connecting Wire.*—The so called connecting wire may be looked on as the wire completing the circuit of a voltaic battery extended to a very great length. What applies to the one holds good of the other. With equal thicknesses of the same metal, the resistance offered to the passage of the galvanic current is proportional to the length of the wire. With equal lengths of the same metal, however, the resistance diminishes inversely with the section; but the conducting power of metals is very different. According to Fechner, copper conducts six times better than iron, and four times better than brass. The conducting power of lead is even lower, so that the only metals which can well vie with each other in their technical use are copper and iron. But now, though iron is about six times as cheap as copper, it will be requisite to give the iron wire six times the weight of a copper one, to gain the same conducting power with equal lengths. We thus see, that as far as the expense is concerned, it comes to the same thing whichever of these metals is chosen. The preference will, however, be given to copper, as this metal is less liable to oxidation from exposure to the atmosphere. This latter difficulty may nevertheless be surmounted by simple means, namely, by galvanizing it. It would even appear that the simple transmission of the galvanic current when the telegraph is in use, is sufficient to preserve the iron from rust; such at least is observed to be the case with the iron portion of the wire used for the telegraph here, and which has already been exposed in all weathers.

If the galvanic current is to traverse the entire metallic circuit without any diminution of intensity, the wire during its whole course must not be allowed to come into contact with itself; neither should it be in frequent contact with semi-conductors, inasmuch as a portion of the power called into action takes its course by the shortest way in consequence thereof, whereby the remotest parts are deprived of a portion of the power.

Numerous trials to insulate wires, and to conduct them below the surface of the ground, have led me to the conviction that such attempts can never answer at great distances, inasmuch as our most perfect insulators are at best but very bad conductors. And since in a wire of very great length, the surface in contact with the so-called insulator is uncommonly large when compared with the section of the metallic conductor, there necessarily arises a gradual diminution of the force, inasmuch as the out and the home wire, although but slightly, yet *do* communicate in intermediate points. It would be wrong to think that this difficulty would be got over by placing the out and the home wire very far apart. The distance between them is, as we shall see in the sequel, almost a matter of indifference. And as we shall never succeed in laying down conductors that are sufficiently insulated beneath the surface of the ground, which is always damp, there is but one other course open to us, namely, leading the wire through the air. Upon this plan, it is true, the conductor must be supported from time to time; it is liable to be injured by the evil disposed, and is apt to suffer from violent storms, or from ice which forms upon it. As we, however, have no other method that we can avail ourselves of, we must endeavor by suitable arrangements to get the better of these, not immaterial, faults, in the best way that we can.

The conducting chain of the telegraph erected here consists of three parts: one leads from the Royal Academy to the Royal Observatory, at Bogenhausen, and back, and the total length of its wire is 32,506 feet. The weight of the copper wire employed amounts to 260 pounds. Both wires (there and back) are stretched across the steeples of the town, at a distance of four feet one inch. The greatest distance from support to support is 1,279 feet; this is undoubtedly far too great for a single wire, inasmuch as the ice that forms upon it materially increases the weight of the wire itself, and considerably augments its diameter, so that it thus becomes liable to be torn asunder by high winds. Over those places where there are no high buildings, the connecting wire is supported upon tall poles forty or fifty feet long, which are let five feet into the ground, and to the top of which the wire is fastened to a crossbar. At the point where the metal rests there is simply a piece of felt laid, and the wire is made fast by twisting it round the wooden bar. The distance from pole to pole ranges between 640 and 650 feet; but this is far too great, for experience has shown that the wires become considerably stretched by high winds and other causes, and have, in consequence, had to be taken up more than once.

All these evils would be overcome by making the connection by at least a triple strand of metal, and not by a single wire supporting it at intervals of 300 feet, and giving it a tension not exceeding one-third of what it will bear without giving way. This, however, in the experimental telegraph erected here, was not practicable, for reasons into which we cannot enter.

The conducting wire thus mounted is by no means completely insulated. When, for example, the circuit is broken at Bogenhausen, an induction shock given in Munich ought to produce no galvanic excitation whatever in the parts of the chain then disconnected. Gauss's galvanometer, however, even then gives indication of a weak current; measurements, indeed, go to show that this current goes on increasing as the point at which the interruption of the stream is made recedes from the inductor. The absolute amount of this current is not constant. Generally it is strongest when the weather is damp. When there are heavy showers of rain, it may be fairly said to be five times as strong as when the weather is settled dry. At moderate distances of a few miles, this small loss of power is of almost no importance, and that the more as the construction of the inductor places currents of almost any strength we choose at our command. When the distance, however, amounted to upwards of 200 miles, the greatest part of the effect would be dissipated. In such cases much greater precaution must be taken with regard to the points of support of the metallic circuit.

When thunderstorms occur, atmospheric electricity collects on this semi-insulated chain as upon a conductor, but the passage of the galvanic current is not at all affected thereby. An occurrence may be mentioned here as a warning for the future. During a severe thunderstorm on the 7th of July, 1838, a very strong electric spark darted at the same instant through the entire conducting chain, and there was simultaneously produced at the indicator, that is fitted up in my room, a sound like the cracking of a whip. At the same time the lower toned bell of the indicator emitted a sound owing to the deflection of the needle, and the blow was so hard that the points on which the magnetic bar plays were injured. The same phenomenon was observed at one of the other stations. As the deflecting power of frictional electricity is very inconsiderable with respect to magnets, the above occurrence indicates the presence of a vast quantity of electricity. It can only have arisen from the electricity of the earth having at that moment made its way to that collected in the wire. Whether this was brought about through the lightning conductors in the neighborhood, or the imperfect insulation of the points of support, cannot be well made out.

Quite recently, I made the discovery that the ground may be employed as one-half of the connecting chain. As in the case of frictional electricity, water or the ground may with the galvanic current form a portion of the connecting wire. Owing to the low conducting power of these bodies, compared with metals, it is necessary that at the two places where the metal conductor is in connection with the semi-conductor, the former should present very large surfaces of contact. Taking water, for instance, to conduct two million times worse than copper, a surface of water proportional to this must be brought in contact with the copper, to enable the galvanic current to meet with equal resistance, in equal distances of water and of metal. For instance, if the section of a copper wire is 0.5 of a square line, it will require a copper plate of 61 square feet surface in order to conduct the galvanic current through the ground, as the wire in question would conduct it. But as the thickness of the metal is quite immaterial in this case, it will be always within our reach to get the requisite surfaces of contact at no great expense. Not only do we by this means save half the conducting wire, but we can even reduce the resistance of the ground below what that of the wire would be, as has been fully established by experiments made here with the experimental telegraph.

A second portion of the conducting chain leads from the Royal Academy to my house and observatory in the Lerchenstrasse. This conductor is of iron wire; its length, there and back, is 5,745 feet, and it is stretched over steeples and other high buildings, as has already been described. Lastly, a third portion of the chain, running through the interior of the buildings connected with the Royal Academy, leads to the mechanical workshop attached to the cabinet of Natural Philosophy. It is composed of a fine copper wire, 958 feet long, let into the joinings of the floor, and in part imbedded in the walls. These three portions together compose a line, returning into itself, and into which the apparatus for generating the galvanic current, and also the indicator, are inserted.

2. *Apparatus for Generating the Galvanic Current.*—Hydro-galvanism, or the galvanic current generated by the action of the voltaic pile, is by no means fitted for traversing *very long* connecting wires, because the resistance in the pile, even when many hundred pairs of plates are employed, would be always inconsiderable compared with the resistance offered by the wire itself.

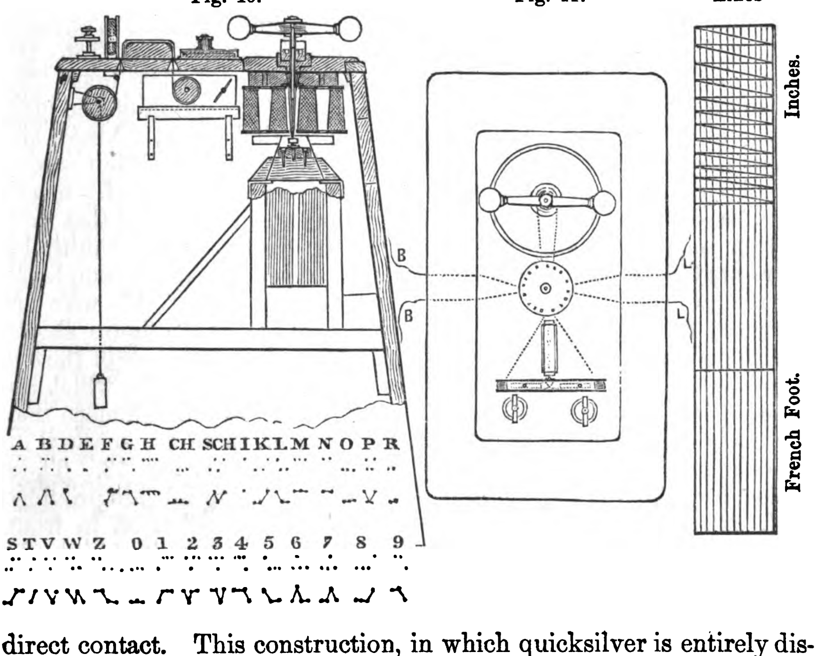
The principal disadvantage, however, attendant on the use of the pile or trough apparatus, is the fluctuations of their current, joined to the circumstance of their becoming very soon quite powerless, and requiring to be taken to pieces and put together again. The extremely ingenious arrangement of Morse is likewise subject to this inconvenience. (All these inconveniences have been obviated by Morse's local circuit and the improved form of battery employed since Steinheil's, experiments.—T.) All this, however is got over when one, to generate the current, has recourse to Faraday's important discovery of induction, that is to say, by moving magnets placed in the neighborhood of conducting wires. The better way, however, is, not to move the magnets as Pixii does in his electro-magnetic apparatus, but rather to give motion to the multipliers placed close to a fixed magnet. The arrangement that Clarke has given to the multiplier is the one which, with some modifications, has been adopted. Assuming on the part of our readers a general knowledge of the principles of the apparatus, we here confine ourselves to explaining how it has been adapted to purposes of telegraphic intercourse.

The magnet is composed of 17 horseshoe bars of hardened steel. With its iron armature its weight is about 74 lbs., and it is capable of supporting about 370 lbs. Between the arms of the magnet there is fastened a piece of metal, supporting in its centre a cup provided with adjusting screws, and which serves as a support for the axis of the coils of the multiplier. The coils of the multiplier have in all 15,000 turns of wire. A metre (3 feet 3.3708 inches English) of this wire weighs 15½ grains, and it is twice bespun with silk. Its two ends, which are insulated, are passed up through the interior of the vertical axis of the multiplier, and then terminate in two hook-shaped pieces, as may be seen in Plate I. Figs. 8 and 9. In order to secure perfect insulation, the vertical axis, Fig. 8, was bored out hollow. Into this hole there are let in from above two semicircular rods of copper, which are prevented touching by a strip of taffeta fastened between them with glue; and these again are kept from touching the metallic axis by winding taffeta round them. In each of these little strips of metal there is, above and below, a female screw cut. In the lower holes small metal pins are screwed in, to which the ends of the multiplier are soldered securely on. While in the upper holes, as may be seen distinctly in Figs. 9 and 18, there are iron hooks screwed in. These hooks, therefore, form the terminations of the multiplier wires of the coils of the inductor. They here turn down, Fig. 15, into two semicircular cups of quicksilver, that are separated by a wooden partition. From these cups of quicksilver there proceed connections, J J, Figs. 8 and 13, towards the wires, and they therefore may be considered as forming part of the chain. The quicksilver, owing to its capillarity, stands at a higher level in these semicircular cups than are the partitions, so that the terminal hooks of the wires of the multiplier pass over these partitions without touching them when the multiplier is made to turn on its axis. One sees that the hooks thus are brought into other cups of quicksilver at every half turn of the multiplier, in consequence of which the galvanic current preserves its sign as long as the multiplier is turned in one direction, but it changes its sign on the motion being reversed. This commutation, which it may be remarked may be established without the use of mercury, by the contact of strips of copper that act like springs, is found to answer completely. There are, besides, two other arrangements which we must not allow to pass unnoticed.

The galvanic current, as we shall see in the sequel when treating of the indicator, should only be permitted to be in action during as short a period as possible, but during that interval should have the greatest intensity we can command. The terminal hooks of the wires dip into the quicksilver only at the place where it forms pools that advance towards each other at the centre, and where the current is at its greatest intensity (see Figs. 13, 14, and 15). Fig. 15 shows the position that the inductor has when the terminal hooks first dip into the cups. In all other positions of the inductor it should, however, form no part of the chain, otherwise the signals made at the other stations will be repeated by its own multiplying wire; and this becomes of the more moment the greater the resistance in the inductor is. In order, therefore, to cut off the inductor when in any other position than shown at Fig. 15, there is a wooden ring adapted to the axis of rotation of the inductor (see Figs. 11 and 12). This ring is encircled with a copper hoop, and into this latter two iron hooks are screwed. These hooks dip down into the semicircular cups of quicksilver, as shown at Fig. 14. At the moment, however, that they are passing across the wooden partition, the hooks of the inductor, which are at right angles to them, dip into the cups. When the hooks of the multiplier are in contact with the quicksilver, the connection with the hooks for diverting the current is broken. In every other position the connection through the hooks of the multiplier is interrupted, while it is established through the others; whence it naturally follows that the current, on being transmitted from any other station, passes directly through the latter hooks, or, in other words, crosses directly from one quicksilver cup to the other, and is not forced to traverse the wire of the inductor for that purpose. In order to put the inductor in motion without trouble, there is a fly bar terminating in two metal balls fastened horizontally on to its vertical axis (annexed cuts), Figs. 40 and 41. To prevent the quicksilver being scattered about, owing to the motion of the hooks as they dip into it when the multiplier is turning rapidly, a glass cylinder is fitted on to this part of the apparatus, Fig. 1. At every half turn is seen the passage of the spark, as the hooks of the multiplier leave their cups of quicksilver.

If we choose to give up the phenomena of these sparks, a thing noways necessary to the employment of the instrument as a telegraph, the inductor will admit of a far more simple construction. It will then merely be necessary to place the commutator directly above the anker, and to let the axis of rotation pass farther up in the neck, in the direction of the fly bar. It then becomes unnecessary to bore the axis out, but the ends of the multiplier are at once fastened by twisting on to two plates of copper, and these copper plates are let into a wooden ring directly opposite each other. The wooden ring is placed upon the vertical axis, and made fast to it by clamps. Externally this ring is, in addition to the above-mentioned plates, provided with an arc of copper let into it, which acts as a contact-breaker, and two ends of the chain that the current has to traverse have the form of permanent springs, that keep pressing against the wooden rings directly opposite each other. By this means, with this arrangement also, the ends of the inductor are in metallic communication with the chain only during a small portion of each revolution, while during the rest of the time the connecting arc brings the ends of the chain into

Fig. 40. Fig. 41. Lines

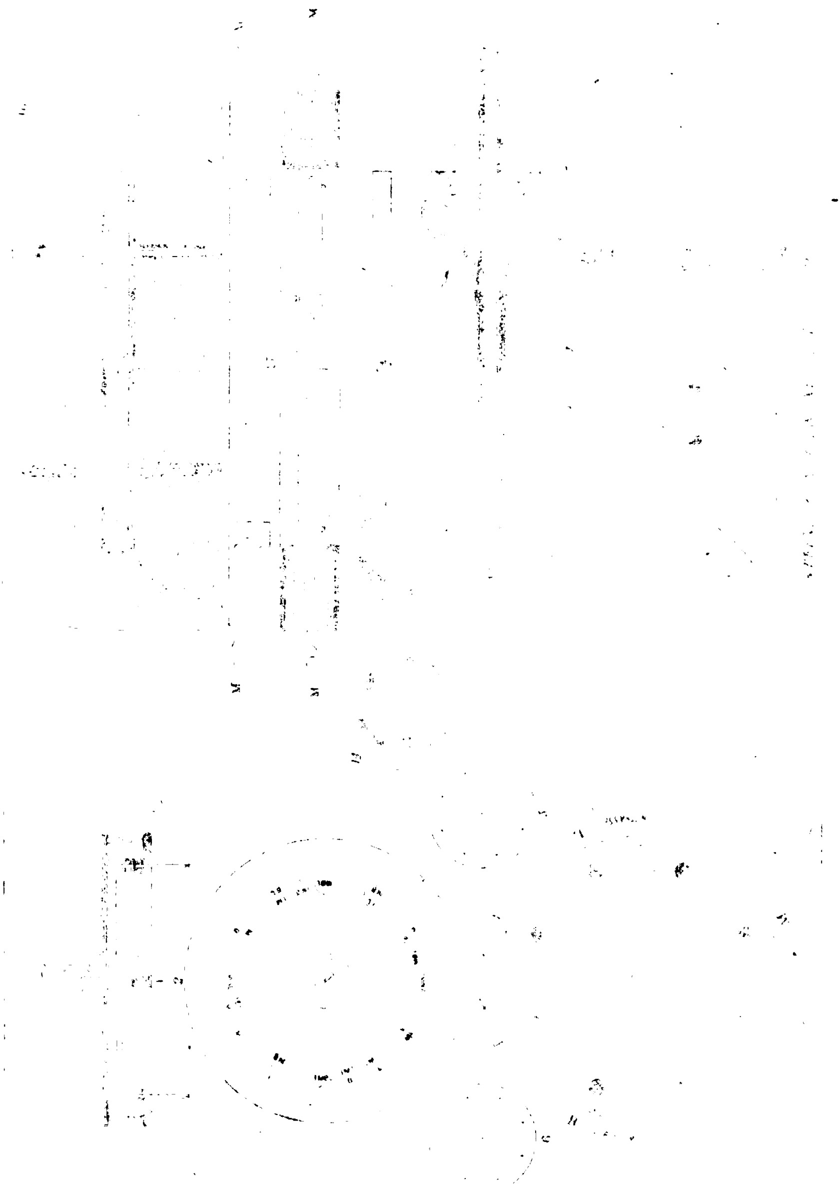


direct contact. This construction, in which quicksilver is entirely dispensed with, is, on account of its greater simplicity and durability, preferable to the arrangement first described. The apparatus of the stations at Bogenhausen and in the Lerchenstrasse are thus constructed.

3. *The Indicator.*—We have shown in the preceding paper, that our

aim is so to employ the current developed by the inductor and led through the conducting chain, that when passed across magnetic bars that are delicately suspended, it may cause them to be deflected, as was discovered by Œrsted. These deflections, if we wish to give the signals in quick succession, must follow each other with the greatest rapidity, and should therefore be powerful. This points out to us the size we should give the magnetic bars we wish to deflect. They must not, however, be made too small, as in that case the mechanical force arising from their deflection is not strong enough to be directly applied to striking upon bells, or any other similar purpose. The deflections are, as is well known, taking the force of the current to be the same, the stronger the greater number of turns in the multiplier, or, in other words, the oftener the wire is led along the magnetic bar. The size of the diameter of the separate turns, as we know, only exerts an influence inasmuch as it adds to the entire length of the connecting wire. The indicator therefore is a multiplier, whose two ends connect it with the conducting chain, and within which the bar to be deflected is placed. It must be borne in mind, that the thinner the wire of the multiplier is, the larger its coils are; and the more turns they make, the greater is the resistance to the current throughout the entire chain.

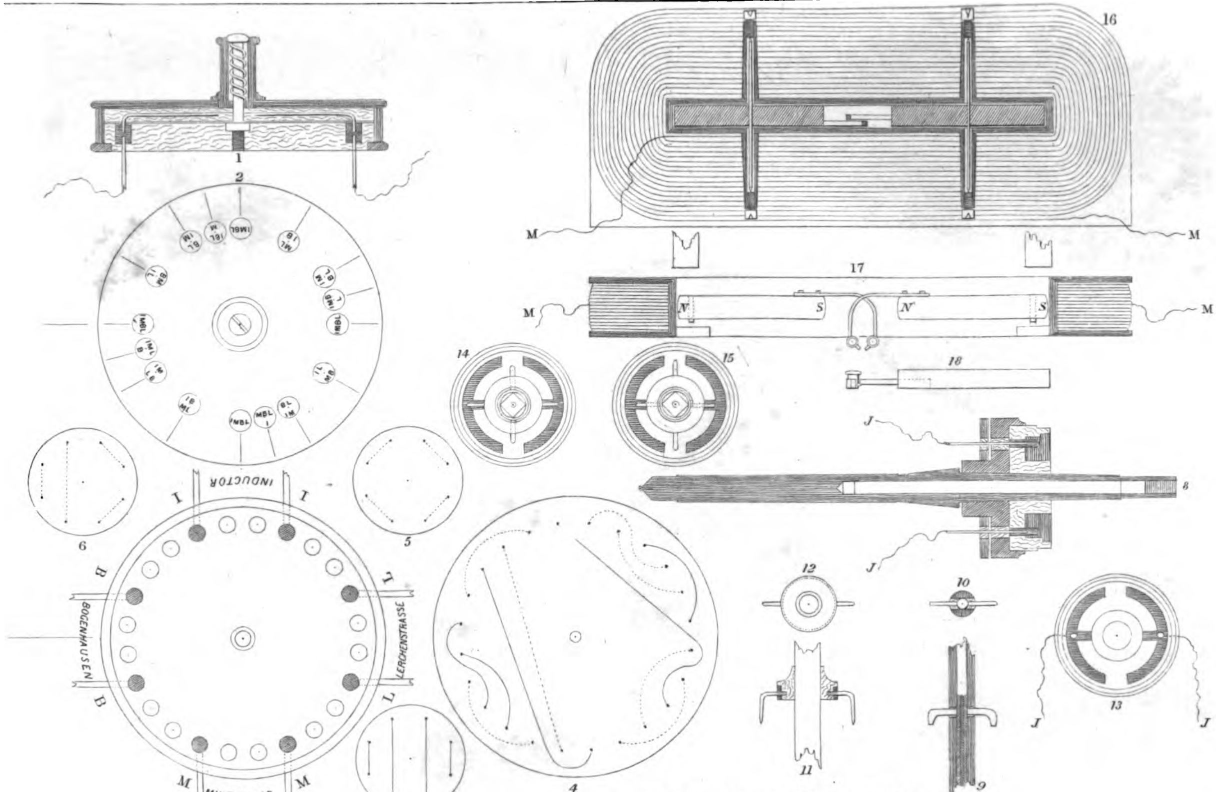
Figs. 16 and 17, Plate I., represent the vertical and horizontal sections of an indicator containing two magnets, movable on their vertical axis, and which, from their construction, are applicable both to striking bells and also to noting down a type composed of dots. Into the frames of the multiplier, which are made of soldered sheet brass, Fig. 16, there are soldered two smaller cases for the reception of the magnets, and which allow of the free motion of their axes. Above and below they have threads cut in them for the reception of four screws in holes, on the ends of which the pivots of the axes turn. By means of these screws the position of the bars may be so regulated that their motion is perfectly easy and free. In the frames of the multiplier there are 600 turns of the same insulated copper wire as was employed for the inductor. The commencement and the end of this wire are shown at *M M*, Fig. 16. The magnetic bars are, as the figure shows, so situated in the frame of the multiplier, that the north pole of the one is presented to the south pole of the other. To the ends which are thus presented to each other, but which, owing to the influence they mutually exert, cannot well be brought nearer, there are screwed on two slight brass arms supporting little cups, Figs. 17 and 18. These little cups, which are meant to be filled with printing ink, are provided with extremely fine perforated beaks that are rounded off in front. When printing ink is put into these cups, it insinuates itself into the tube of these beaks, owing to capillary attraction; and, without running out, forms at their apertures a projection of a semi-globular shape. The slightest contact suffices, therefore, for noting down a black dot. When the galvanic influence is transmitted through the multiplying wire of this indicator, both magnetic bars make an effort to turn in a similar direction upon their vertical axes. One of the cups of ink would therefore advance from within the frame of the multiplier, while the other would retire within it. To prevent this, two



...by the inductor and ... when passed across magnetic ... may cause them to be deflected, ... if we wish to ... each other with the greatest ... This points out to us the size ... bars we wish to deflect. They must not ... as in that case the mechanical force ... is not strong enough to be directly applied ... purpose. The deflections ... current to be the same ... the multiplier, or, in other ... the magnetic bar. The size ... as we know, only exerts an ... length of the connecting wire ... two ends connected with ... bar to be deflected is ... thinner the wire of the multiplier ... its ... more turns they make, the greater ... resistance ... throughout the entire chain.

... the vertical and horizontal sec- ... magnets, movable on their vertical ... applicable both to striking ... composed of dots. Into the ... of soldered sheet brass, Fig. ... for the reception of the mag- ... of their axes. Above and ... the reception of four screws in ... which ... points of the axes turn. By means of the ... position of the bars may be so regulated that their motion ... easy and ... in the frames of the multiplier ... of the ... copper wire as was employed ... and the end of this wire are ... bars are, as the figure shows, ... that the north pole of the one ... of the other. To the ends which are ... but which, owing to the influence they ... be brought nearer, there are screwed on ... little cups, Figs. 17 and 18. These ... filled with printing ink, are provided with ... beaks that are rounded off in front. When ... these cups, it insinuates itself into the tube of ... capillary attraction; and, without run- ning out, forms ... projection of a semi-globular shape. ... slightest ... therefore, for noting down a black dot. ... transmitted through the multiplying ... indicate ... magnetic bar make an effort to turn ... direction ... vertical ... One of the cups of ink ... therefore ... within the frame of the multi- plier, ... the other ... within it. To prevent this, two

Plate I



STEINHAEL'S GALVANIC TELEGRAPH

plates are fastened at the opposite ends of the free space that is allowed for the play of the bars, and against which the other ends of these bars press. Only the end of one bar can therefore start out from within the multiplier at a time, the other being retained in its place. In order to bring the magnetic bars back to their original position as soon as the deflection is completed, recourse is had to small movable magnets, whose distance and position are to be varied till they produce the desired effect. This position must be determined by experiment, inasmuch as it depends upon the intensity of the current called into play.

If this apparatus be employed for producing two sounds easily distinguishable to the ear by striking on bells, it will be right to select clock bells or bells of glass, both of which easily emit a sound, and whose notes differ about a sixth. This interval is by no means a matter of indifference. The sixth is more easily distinguished than any other interval; fifths and octaves would be frequently confounded by those not versed in such matters. The bells are to be supported on little pillars with feet, and their position with respect to the bars, and likewise their distance from them, is to be determined by experiment. The knobs let into the bars that strike on the bells must give the blow at the place which most easily emits a sound. These hammers, however, are not to be too close to the bells, as in that case a repetition of the signal can easily ensue. A few trials will soon get over this difficulty. If the indicator is to write down the signals, a flat surface of paper must be kept moving with a uniform velocity in front of the little beaks above mentioned. The best way of doing this is to employ very long strips of the so-called endless paper, which is to be wound round a cylinder of wood, and then cut upon the lathe into bands of the suitable width. One of these strips of paper must be made to unwind itself from a cylinder, pass close in front of the cups, run along a certain distance in a horizontal position, so that the dots noted down may be read off, and lastly, wind itself up again on to a second cylinder. This second cylinder is put in motion by clock-work, the regularity of whose action is insured by a centrifugal fly-wheel. A longitudinal section of the entire arrangement is shown at Fig. 40 (p. 97). Fig. 41 represents it as seen from above. At the corners of the frame over which the ribbon of paper is led, there are placed two movable rollers to diminish the friction. This frame moreover admits of being advanced towards the cups or withdrawn from them, so that the most proper position to give it can be ascertained by experiment. It is evident that the same magnetic bars cannot be at once employed for striking bells and for writing, the little power they exert being already exhausted by either of these operations. But to combine them both, all we have to do is to introduce a second indicator into the chain. By thus increasing the number of the indicators, the loudness of the sounds of the bells can be augmented at pleasure; this can, however, only be done at the cost of an increased resistance in the chain. In order that this may be increased by the indicator as little as possible, it would in future be better that its coils should be made of very thick copper wire, or of strips of copper plate.

The above description will enable those who are familiar with such subjects to construct the apparatus for themselves. We have yet to add a few words upon

The Way of putting the Apparatus together.—Fig. 40 (p. 97) represents the longitudinal section of a pyramidal table, standing on the floor of the room, and containing the whole apparatus. Fig. 41 shows the same as seen from above. The wires from Bogenhausen, those from the Lerchenstrasse, the ends of the indicator, and the wires from the quicksilver cups of the inductor, or, in other words, the two ends of its multiplier, all meet together at the centre of the table, as seen at Fig. 41. They are here brought into connection with eight holes filled with quicksilver, made in a disk of wood, as shown at Fig. 3, Plate I. The course that the current we call forth will take, depends upon the respective connection of these eight holes with each other. For instance, supposing them to be connected together by four pieces of bent copper wire, as shown at Fig. 3, the current would pass through the whole apparatus, and also the entire chain. Establishing, however, the connection as shown at Fig. 6, would cut off the Bogenhausen station, and would at once transmit the current direct from the inductor, through the multiplier of the indicator and through the Lerchenstrasse station. Supposing this figure turned round 180 degrees, we should have the Lerchenstrasse station cut off, and the current would pass through Bogenhausen. A third system of connections is shown by the copper wires represented in Fig. 7. In this position of the sketch, the inductor and the multiplier would be in direct communication, while the two stations at Bogenhausen and in the Lerchenstrasse would be cut off. But by turning this figure 90 degrees, we should connect these two stations, while we broke off the station in the Academy. Copper wires, serving to establish these three systems of connection and the combinations, are laid down upon the under surface of the wooden cover of the commutator, as seen at Fig. 4. There are 24 wires projecting downwards from this lid. Only eight of them, however, ever come into use at once, so that there must be sixteen other holes made in the lower disk of wood, for the reception of the wires not in use, and having no quicksilver poured into them. It is thus in our power to direct the course of the current as we choose, and the systems concerned are indicated upon the upper surface of the cover of the commutator by engraved letters, see Fig. 2, Plate I.; this cover containing the different modifications of the systems of connection, as shown at Fig. 4. Changing the position of this cover round the central pin springing from the table, enables us to vary the direction of the current in any manner we like. The use of quicksilver cups in the commutator may of course be replaced by conically turned copper pins. This has indeed been done at the Lerchenstrasse and the Bogenhausen stations.

We shall conclude by a few remarks upon

The Application of this Apparatus to Telegraphic Communication.—We know, from what has preceded, that at every half turn of the fly-bar from right to left, one of the bars is deflected. I have so connected the terminations of the wires, that every time this movement is repeated the high-toned bell should be struck at all the stations. Standing at the side B B, and turned towards the indicator, one immediately perceives the beak imprint a dot upon the ribbon of paper as it moves along. The intervals of time between the successive repetitions of this sign, are represented by the respective distances between the dots that follow in a line upon the paper. On turning the fly-bar from left to right towards the operator, the deep-toned bells ring, and the second ink cup marks down a dot upon the paper as before; not, however, upon the same line with the former dots, but upon a lower one. *High* tones are therefore represented by the *upper* dots, and *low* tones by the dots of the *lower* line, as in writing music. As long as the intervals between the separate signs remain equal, they are to be taken together as a connected group, whether they be pauses between the tones, or intervals between the dots marked down. A longer pause separates these groups distinctly from each other. We are thus enabled, by appropriately selected groups thus combined, to form systems, representing the letters of the alphabet or stenographic characters, and thereby to repeat and render permanent at all parts of the chain, where an apparatus like that above described is inserted, any information that we transmit. The alphabet that I have chosen represents the letters that occur the oftenest in German by the simplest signs. By the similarity of shape between these signs and that of the Roman letters, they become impressed upon the memory without difficulty. The distribution of the letters and numbers into groups consisting of not more than four dots, is shown at Fig. 40 (page 97).

Printing Telegraph of Alfred Vail.

The printing telegraph of Alfred Vail was proposed in September, 1837. It consists of a type-wheel having on its surface the twenty-four letters of the alphabet. On the side of the wheel are twenty-four holes. The type-wheel is moved circularly by means of a spring that the electro-magnetic key causes to advance at each interruption and return of the current. The paper advances under the type-wheel by means of an independent clock movement.

The precision of the operation depends on the exact correspondence of the machinery, situated at the two extremities of the telegraphic lines. It is necessary that the type-wheel present the same letter at both stations, and that the clock move at the same rate. But I believe that this system has never been put in execution. I copy from p. 169 of his work on the telegraph, the conclusions he comes to in regard to this form of telegraph:—

"All electro-magnetic telegraphs require as their basis the adoption of the *electro-magnet*, when recording the intelligence is an object, and it would seem must be applied in a manner equivalent to the mode adopted by Prof. Morse; that is, the application of the armature to a lever, and its single movement produced by closing and breaking the circuit. It is therefore safe to assume that, whatever improvement in one plan may be made to increase the rapidity of the movements of those parts of the telegraph which belong to the electro-magnet, is equally applicable to any other plan, provided too much complication, already existing, does not counteract and defeat the improvement.

"Some plans, however, use an extra agent besides the electro-magnet, which is employed for measuring the time of the revolution of the type-wheel, and the electro-magnet is only called in, occasionally, to make the impression. In such plans the rapidity of communication demands the combined action, alternately, of both magnets. This, of course, increases the complication, and must certainly be considered a departure from other more simple arrangements. Whatever will reduce the inertia of mechanical movements and bring them to act with an approximate velocity, at least of the fluid itself, will increase the rapidity of transmission. The more the instrument is encumbered with the sluggish movements of material bodies, the less rapid, inevitably, must be its operation, even where several co-operating agents are assisting, in their respective spherés, to increase the rapidity of the motion. Such is the case with the several kinds of letter printing telegraphs; very weighty bodies, comparatively speaking, are set in motion, stopped, again set in motion, and along with this irregular motion, other parts perform their functions. There must be a courtesy observed among themselves, or matters do not move on as harmoniously as could be desired. This is not always the case, especially where time is the great question at issue.

"All printing telegraphs which use type, arranged upon the periphery of a wheel, must have, of necessity, these several movements, viz. the irregular revolution of the type-wheel, stopping and starting at every division or letter; the movement of the machinery, called the printer; the irregular movement of the paper, at intervals, to accommodate itself to the letter to be printed; the movement of the inking apparatus, or what is not an improvement in cleanliness, paper of the character used by the manifold letter-writer. So many moving parts are so many impeding causes to increased rapidity, and are, to all intents and purposes, a *complication.*

"The requirements of a perfect instrument are: economy of construction, simplicity of arrangement and mechanical movements, and rapidity of transmission. To use one wire is to reduce it to the lowest possible economy. If there is but one movement, and that has all the advantages which accuracy of construction, simplicity of arrangement, and lightness, can bestow upon it, we might justly infer that it appeared reduced to its simplest form.

"The instrument employed by Prof. Morse has but a single movement, and that motion of a vibratory character; is light and susceptible of the most delicate structure, by which rapidity is insured; the paper is continuous in its movement, and requires no aid from the magnet to carry it.

"The only object that can be obtained by using the English letters, instead of the telegraphic letters, is, that the one is in common use, the other is not. The one is as easily read as the other; the advantage, then, is fanciful, and is only to be indulged in at the expense of time and complication of machinery, increasing the expense, and producing their inevitable accompaniments, liability to derangement, care of attendance, and loss of time."

Alexander's Electric Telegraph.

I copy this account of Alexander's telegraph from the *London Mechanics' Magazine*, of November, 1837, but it was copied originally from the *Scotsman*, a paper published in Edinburgh, perhaps a month before, and a model to illustrate the nature and the operation of the telegraphic machine was exhibited at a meeting of the Society of Arts in Edinburgh, in October, 1837.

The model consists of a wooden chest, about five feet long, three feet wide, three feet deep at the one end, and one foot at the other. The width and depth in this model are those which would probably be found suitable in a working machine; but it will be understood that the length in the machine may be a hundred or a thousand miles, and is limited to five feet in the model, merely for convenience. Thirty copper wires extend from end to end of the chest, and are kept apart from each other. At one end (which for distinction's sake we shall call the south end) they are fastened to a horizontal line of wooden keys, precisely similar to those of a piano-forte; at the other, or north end, they terminate closely to thirty small apertures, equally distributed in six rows of five each over a screen of three feet square, which forms the end of the chest. Under these apertures, on the outside, are painted in black paint upon a white ground the twenty-six letters of the alphabet, with the necessary points, the colon, semicolon, and full point, and an asterisk to denote the termination of a word. The letters occupy spaces about an inch sqare. The wooden keys at the other end have also the letters of the alphabet painted on them in the usual order. The wires serve merely for communication, and we shall now describe the apparatus by which they work. This consists, at the south end, of a pair of plates, zinc and copper, forming a galvanic trough, placed under the keys; and at the north end of thirty steel magnets, about four inches long, placed close behind the letters painted on the screen. The magnets move horizontally on axes, and are poised within a flat ring of copper wire, formed of the ends of the communicating wires. On their north ends they carry small square bits of black paper, which project in front of the screen, and serve as opercula or covers to conceal the letters. When any wire is put in communication with the trough at the south end, the galvanic influence is instantly transmitted to the north end; and, in accordance with a well-known law discovered by Œrsted, the magnet at the end of that wire instantly turns round to the right or left, bearing with it the operculum of black paper, and unveiling a letter. When the key A, for instance, is pressed down with the finger at the south end, the wire attached to it is immediately put in communication with the trough; and the same instant the letter A at the north end is unveiled by the magnet turning to the right, and withdrawing the operculum. When the finger is removed from the key, it springs back to its place, the communication with the trough ceases, the magnet resumes its position, and the letter is again covered.

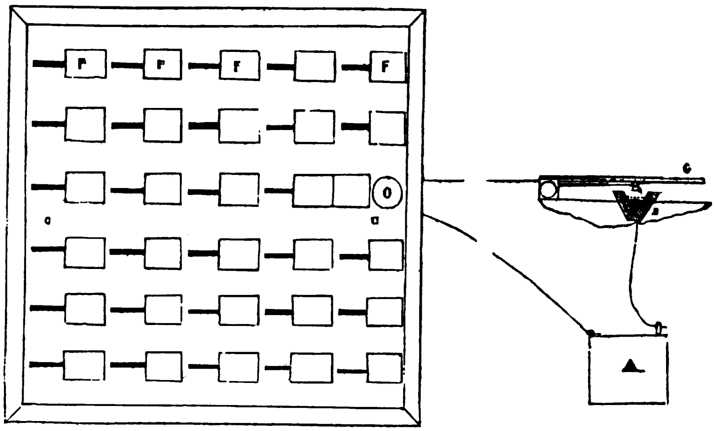
Thus, by pressing down with the finger, in succession, the keys corresponding to any word or name, we have the letters forming that word or name exhibited at the other end; the name *Victoria*, for instance, which was the maiden effort of the telegraph on Wednesday evening. In the same way we may transmit a communication of any length, using an asterisk or cross to mark the division of one word from another, and the comma, semicolon, or full point, to make a break in a sentence, or its close. No proper experiment was made while we were present to determine the time necessary for this species of communication, but we have reason to believe that the letters might be exhibited almost as rapidly as a compositor could set them up in type. Even one-half or one-third of this speed, however, would answer perfectly well.

Galvanism, it is well known, requires a complete circuit for its operation. You must not only carry a wire to the place you mean to communicate with, but you must bring it back again to the trough. (The writer of this communication, and even Mr. Alexander, were not aware of the discovery of Steinheil, that the earth would conduct so as to return the current without the use of the second wire.—L. T.) Aware of this, our first impression was, that each letter and mark would require two wires, and the machine in these circumstances having sixty wires instead of thirty, its bulk and the complication of its parts would have been much increased. This difficulty has been obviated, however, by a simple and happy contrivance. Instead of the return wires, extending from the magnet back to the keys, they are cut short at the distance of three inches from the magnet, and all form a transverse copper rod, from which a single wire passes back to the trough, and serves for the whole letters. The telegraph, in this way, requires only thirty-one wires. We may also mention, that the communication between the keys and the trough is made by a long narrow basin filled with mercury, into which the end of the wire is plunged when the key is pressed down with the finger.

The telegraph thus constructed, operates with ease and accuracy, as many gentlemen can witness. The term model, which we have employed, is in some respects a misnomer. It is the actual machine, with all its essential parts, and merely circumscribed as to length by the necessity of keeping it in a room of limited dimensions. While many are laying claim to the invention, to Mr. Alexander belongs the honor of first following out the principle into all its details, meeting every difficulty, completing a definite plan, and showing it in operation. About twenty gentlemen, including some of the most eminent men of science in Edinburgh, have subscribed a memorial, stating their high opinion of the merits of the invention, and expressing their readiness to act as a committee for conducting experiments upon a greater scale, in order fully to test its practicability. This ought to be a public concern; a machine which would repeat in Edinburgh, words spoken in London, three or four minutes after they were uttered, and continue the communication for any length of time, by night or by day, and with the rapidity which has been described; such a machine reveals a new power, whose stupendous effects upon society no effort of the most vigorous imagination can anticipate.

The principle of Alexander's telegraph is represented in the following illustration from the work of Alexander Bain, Esq., Fig. 42. It consists of but one circuit, so as to make the operation intelligible.

Fig. 42.



A is a voltaic battery; B, a trough filled with mercury; C, a key to be pressed down by the finger of the operator; E is the end of a conducting wire, which dips into the mercury when the key is depressed, and completes the electric circuit; DD is the distant dial upon which the signals are to be shown; F F are screens, thirty in number, each being fixed to a needle, corresponding to the finger keys before described. When no electricity is passing, these screens remain stationary over the several letters, &c., and conceal them from view; but when a current is made to flow by the depression of a key, the corresponding needle in the distant instrument is deflected, carrying the screen with it, and uncovering the letter, which becomes exposed to view, as at O.

In the same magazine, there is an improvement suggested by a correspondent, which is obviously a good one, namely, the use of fifteen wires to represent the whole number of letters, thus: Let each of the letter screens affixed to the movable magnets be wide enough to cover two letters; then the positive end of the galvanic battery being connected with the inducing wire, by a touch of the keys, the magnet and screen will move in one direction and discover one letter. The negative end of the battery being thus connected with the same wire, the magnet will move in the contrary direction, and discover the other letter. There must, of course, be something fixed to prevent the magnet going so far in either direction as to discover both letters. The returning wire connected with all the other thirty, must of course have its connection with the battery poles reversed at the same time as the lettered wire. To prevent oscillation, let each wire act upon two magnets and screens, one magnet and screen moving in one direction, but prevented from moving in the other as now. The current of electricity, if reversed, would, on account of this prevention, not move this magnet and screen in the opposite direction, but it might the other magnet and screen, having a similar stop or prevention, but placed on the other side of the pole.

Davy's Needle and Lamp Telegraph.

This telegraph is called the needle and lamp telegraph, to distinguish it from the telegraph of Edward Davy, which I will describe.

"There is a case, which may serve as a desk to use in writing down the intelligence conveyed; and in this there is an aperture about sixteen inches long and three or four wide, facing the eyes, perfectly dark. On this the signals appear as luminous letters, or combinations of letters, with a neatness and rapidity almost magical. The field of view is so confined, that the signals can be easily caught and copied down without the necessity even of turning the head. Attention, in the first instance, is called by three strokes on a little bell; the termination of each word is indicated by a single stroke. There is not the slightest difficulty in deciphering what is intended to be communicated.

"In front of the oblong trough, or box, described by your correspondent, a lamp is placed, and that side of the box next the lamp is of ground glass, through which the light is transmitted for the purpose of illuminating the letters. The oblong box is open at the top, but a plate of glass is interposed between the letters and the spectator, through which the latter reads off the letters as they are successively exposed to his view. At the opposite side of the room, a small key-board is placed (similar to that of a piano-forte, but smaller), furnished with twelve keys; eight of these have each three letters of the alphabet on their upper surfaces, marked A, B, C; D, E, F; and so on. By depressing these keys in various ways, the signals or letters are produced at the opposite desk, as previously described; how this is effected is not described by the inventor, as he *intimated* that the construction of certain parts of the apparatus *must remain* SECRET.

"By the side of the key-board, there is placed a small galvanic battery, from which proceeds the wire, 25 yards in length, passing round the room. Along this wire the shock is passed, and operates upon that part of the apparatus which discloses the letters or signal. The shock is distributed as follows: The underside of the signal keys is each furnished with a small projecting piece of wire, which, on depressing the keys, is made to enter a small vessel, filled with mercury, placed under the outer ends of the row of keys; a shock is instantly communicated along the wire, and a letter, or signal, is as instantly disclosed in the oblong box. By attentively looking at the effect produced, it appeared as if a dark slide were withdrawn, thereby disclosing the illuminated letter. A slight vibration of the (apparent) slide, occasionally obscuring the letter, indicated a great delicacy of action in this part of the contrivance, and although not distinctly pointed out by the inventor, is to be accounted for in the following manner: When the two ends of the wire of the galvanic apparatus are brought together, over a compass-needle, the position of the needle is immediately turned, at right angles, to its former position; and again, if the needle is placed with the north point southward, and the ends of the wire again brought over it, the needle is again forced round to a position at right angles to its original one. Thus it would appear that the slide or cover over the letters is poised similarly to the common needle, and that, by the depression of the keys, a shock is given in such a way as to cause a motion from right to left, and *vice versa*, disclosing those letters, immediately, under the needle so operated upon." —*London Mech. Mag.* vol. xxviii. 1837.

Masson's Magneto-Electric Telegraph.

In 1837, Prof. Masson, of Caen, addressed a letter to the French Academy, in which he announced that he had made several trials with a magneto-electric telegraph, for the distance of 1,800 feet. He employed, for the development of the current, the magneto-electric machine of Pixii, to produce the deflection of magnetic needles placed at the extremities of the circuits. These trials were repeated in October, 1838, with Bréquet, who was at that time one of the members of the Commission on the Telegraph from Paris to Rouen, but the results obtained were not as satisfactory as those of Steinheil, Morse, and others; afterwards Masson and Bréquet associated themselves together, and invented a new form of telegraph, a description of which is not given.—*Moigno*, *Traité de Telegraphie*, p. 30.

Amyot's Telegraph.

In a letter addressed to the Academy of Science of Paris, in July, 1838, Amyot proposed the construction of a needle telegraph. It was to consist of a single circuit, which would move a single needle, which needle was to write on paper, with mathematical precision, the correspondence which was to be transmitted to the other extremity, by a simple wheel, on which it should be written by means of points differently spaced, the same as they are on the barrels of portable organs, the wheels to be regulated by clock-work.—*Moigno*, p. 31.

Edward Davy's Telegraph.

The next telegraph in chronological order is that of Mr. Edward Davy, of London. The patent for this telegraph was sealed July, 1838, and published in the *Repertory of Patent Inventions*, London, July, 1839. The specifications are very voluminous, and not very intelligible. I have therefore studied it carefully, and have given the important points, and a drawing, which fully illustrates the improvements which Davy proposed, being careful not to omit any vital part of his machine. In this method of treating it, I have followed the examples of Moigno and Shellen, two of the latest writers upon the subject of the history of the telegraph.

In the telegraph of Edward Davy, the decomposing action of the galvanic current is employed to produce marks upon chemically prepared cloth or other material; the cloth preferred by the inventor was *calico*, and the chemical substance employed by him to prepare the cloth was a solution of the iodide of potassium and muriate of lime.

He employed a local battery to produce the telegraphic signs by chemical decomposition. This battery also operated an electro-magnet, whose armature regulated the movement of the registering instrument. This battery is also connected with a short independent circuit, which is closed and opened by the movement of a magnetic needle, surrounded by a coil of copper wire, which forms part of the main circuit. He employed finger-keys to open and close the circuit; his receiving instrument being similar in principle to Cooke and Wheatstone's, only closing his circuit like Mr. Morse, by the contact of solid metals instead of mercury. When the main circuit is closed by the finger-keys the needle is deflected, which closes the short circuit; but when the main current is interrupted, the needle opens the short circuit by returning to its original position.

The cloth or other chemically prepared material is drawn between a metallic cylinder and a series of platinum rings surrounding a wooden cylinder; by these rings the current from a local battery is passed through the chemically prepared cloth to the metallic cylinder beneath, producing signs consisting of simple dashes arranged in six rows. The calico is moved by clock-work, and this clock-work is regulated by a U electro-magnet, with an armature and lever, which at each motion withdraws the stop from a fly-wheel for the space of a semi-revolution, during which a single sign is made upon the calico, the clock-work moving always in proportion to the number of signs transmitted. The platinum rings were so arranged as to be connected separately or together, at will, with the other poles of the battery, but insulated from each other.

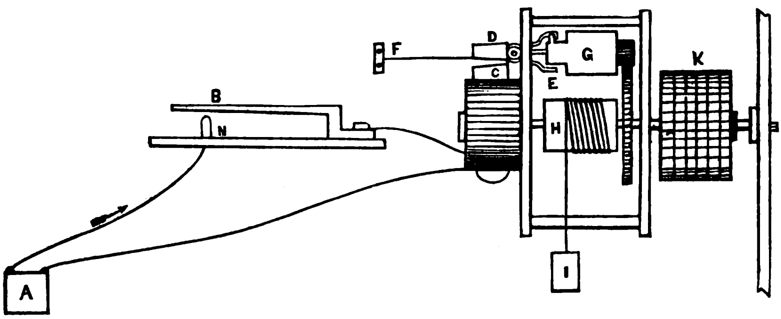
In his patent three telegraphic wires are represented, which are made by means of his commutator to connect a local circuit with either of the six platinum rings, so as to simplify the system of marking necessary to form the signs for the different letters of the alphabet.

There cannot be a doubt that Davy was informed of the telegraphs of Morse and Steinheil, by the following remarks at page 12 of his Specifications:—

"I am aware that it has been proposed to use a marking instrument with lead or ink, by the aid of an electro-magnet, to make a number of dots or marks in immediate succession, to indicate the signification of such communication; I do not, therefore, claim the use of marking instruments generally, but only when they are adapted to make communications by marks across and lengthwise of the fabric which receives them, as above described."

The most ingenious portion is the escapement. The figure represents the principle of the escapement and the electro-magnet. A is the voltaic battery; B, lever; N, metallic button, to which is fixed the wire conductor of the battery; C, an electro-magnet; D, the armature; I is a clock-weight; H, the band of the wheel that carries the revolving cylinder of the signs K; G is a van or regulator of motion; E, a pair of pallets fixed to the armature D. On the side opposite the axis of motion is fixed a spring, F, to separate the armature from the electro-magnet, by which the electric current is broken, and magnetism destroyed. The arrangement is such that, for every revolution of the van G, the cylinder K advances one division, and a letter is impressed. If the lever B rests against the metallic button N, the metallic circuit of the voltaic battery is immediately established, the electric current passes along the conducting wires of the electro-magnet C, which instantly attracts the armature D, forces the superior pallet E to abandon the lever O, and permits the van to turn. As soon as it turns half a revolution, it is arrested by the inferior pallet, against which the lever

Fig. 43.



touches. The contact of this lever being abandoned, the voltaic circuit is instantly broken, magnetism destroyed, and the spring F leaves the armature in its first position. This movement lowers the inferior pallet, sets at liberty the lever O, and the second half of a revolution is performed, bringing it into a new position, and arrests it against the lever O, or superior pallet. For each complete revolution a character successively appears. The operation of successively elevating and depressing the key, gives the cylinder of signs a circular motion, in the same manner that the hand of a clock is made to revolve by means of balancing and escapement. On some cotton fabric are some longitudinal lines, intersected by transverse ones, dividing the surface into little squares. It is impregnated with iodide of potassium and muriate of lime, and wound on a cylinder that turns by a weight at each magnetic pulsation. The current traverses this prepared material, and leaves a well marked trace in the square indicated by the touch of the director. The position of the square in the network marked on the stuff, determines the letter or signal. This mode requires seven or eight lines, and has never been put in practical operation, though patented in January, 1839.

The following are the claims in full, as given in the original publication:—

"First. The mode of obtaining suitable metallic circuits for transmitting communications or signals by electric currents, by means of two or more wires, which I have called signal-wires, communicating with a common communicating-wire, and each of the signal-wires having a separate battery, and, if desired, additional batteries, for giving a preponderance of electric currents through the common communicating-wire, as above described.

"Secondly. I claim the employment of suitably prepared fabrics for receiving marks by the action of electric currents for recording telegraphic signals, signs or communications, whether the same be used with the apparatus above described or otherwise.

"Thirdly. I claim the mode of receiving signs or marks in rows across and lengthwise of the fabric, as herein described.

"Fourthly. I claim the mode of making telegraphic signals or communications from one distant place to another, by the employment of relays of metallic circuits, brought into operation by electric currents.

"Fifthly. The adapting and arranging of metallic circuits in making telegraphic communications or signals, by electric currents, in such manner that the person making the communication shall, by electric currents and suitable apparatus, regulate or determine the place to which the signals or communications shall be conveyed.

"Sixthly. I claim the mode of constructing the apparatus which I have called the escapement, whether it be applied in the manner shown, or for other purposes, where electric currents are used for communicating from one place to another.

"Seventhly. I claim the mode of constructing the galvanometer herein described.

"And lastly. I claim such parts as I have herein pointed out as being useful for other purposes, as above described."—*Repertory of Patent Inventions*, July, 1839.

Bain's Printing Telegraph.

The following extract of a letter is taken from a work entitled "An Account of some Remarkable Applications of the Electric Fluid to the Useful Arts, by Alexander Bain: edited by John Finlaison, Esq., London, 1843," which gives us the date of Mr. Bain's first telegraph.

"PERCIVAL STREET, *Clerkenwell*, Aug. 28, 1842.

"DEAR SIR: I recollect visiting you early in June, 1840, when you showed me a model of your electro-magnetic telegraph.

"ROBERT C. PINKERTON."

In July, 1841, it was exhibited and lectured on at the Polytechnic Institution, London. It consists of three principal parts.

1. The rotary motion given to the type-wheel, step by step motion, like the second-hand of a clock, until the required letter arrives opposite the paper.

2. The means of inking the types, or otherwise making permanent the imprint of the types upon the paper.

3. The motion communicated to the paper, so as to bring a fresh surface under the types, and receive the printed intelligence in a continuous spiral line, until the book is filled.

He uses wire coils freely, suspended on centres, for electro-magnets. These coils, within and in the vicinity of which are fixed powerful permanent magnets, are deflected as long as the electrical current is passing through them; but when the electric current is broken, they are drawn upwards by the force of the spiral springs, the levers are released, and the machinery of the telegraph, worked by main-springs, is left free to rotate. The only battery proposed by Mr. Bain is a pair of copper and zinc plates, one of which is to be buried in the earth at one station, and the other at the distant station, where there is to be a telegraph the exact counterpart of the first.

I have considered it entirely unnecessary to give a drawing of this telegraph, as it never could be of very great service; and as to the form of battery, it was entirely out of the question. The best evidence of this was, that an entire change was made in it by Mr. Bain, in 1846, a description and drawing of which will be found in my article on Galvanic or Electro-Chemical Telegraphs.

I find in the same work the following account of some interesting experiments on the earth as a source of permanent voltaic electricity :—

"In prosecuting some experiments with an electro-magnetic sounding apparatus, in the year 1841, it was found that if the conducting wires were not perfectly insulated from the water in which they were immersed, the attractive power of the electro-magnet did not entirely cease where the circuit was broken. For the purpose of investigating the nature of this phenomenon, a series of experiments took place, with great lengths of wire, in the reservoir of water at the Polytechnic Institution, when similar results were obtained. While reflecting upon these experiments, some few months after they had been performed, Mr. Bain was led to infer, that if a surface of positive metal was attached to one end of a conducting wire, and an equal surface of negative metal to the other end, and the two metallic surfaces put into water, or into the moist earth (the wire being properly insulated), an electric current would be established in the wire."

This proposition was soon tested by experiment. A surface of zinc was buried in the moist earth, in Hyde Park, and at rather more than a mile distance a copper surface was similarly deposited; the two metals were connected by a wire suspended on the railing, and on placing a galvanometer in the circuit, an electric current was produced, which passed through the intervening mass of earth from one plate to the other, and returned by the wire. In the first experiment, the metallic surfaces being small, the electric current produced was feeble; but on using a large surface of metal, a corresponding increase in the energy of the current was obtained, with which an electrotype process was conducted, and various electro-magnetic experiments performed with universal success.

It is essential to success, that the earth wherein the plates of metal are deposited should be of a moist nature. A current has, indeed, been obtained in dry soil, but of such small energy as to be of no practical utility.

A patent was solicited for the application of this mode of producing electric currents to his printing telegraph, and obtained in April, 1841.

This form of battery could never have been of any useful application to great distances, without an increase of the number of plates and of the exciting fluid.

Sturgeon's Electro-Magnetic Telegraph.

In the *Annals of Electricity* for October, 1840, are published a description and drawings of a form of electro-magnetic telegraph proposed by William Sturgeon, of London, a man who has by his numerous experiments and researches into the subject of electricity and magnetism, conferred signal benefits on these important sciences, and has not received the full award of merit even from his own countrymen. The publication of the *Annals of Electricity* alone deserves the thanks of all interested in these important subjects, containing as they do a mass of valuable information not to be found elsewhere in our language.

"In describing a new electro-magnetic telegraph, I am necessarily impelled by a similar feeling to that which urged my predecessors to bring their respective inventions before the public; and I cannot resist the idea that there will be found a peculiar simplicity both in the structure and management of the telegraph I am about to describe. Indeed, I shall point out the structure of two distinct telegraphs, having the sign common to both. Also, a third, differing very materially from the other two.

"In one of these telegraphs I use six soft iron bars, bent into the form of horseshoe magnets, and covered with copper wire spirals, in the usual way, for converting them into occasional magnets by electric currents. To each magnet is a short bar of soft iron for a keeper or crosspiece, which is attached to the shorter arm of a lever of the first order; and to the extremity of the longer arm of the lever is attached a circular card. The arrangement of one of these pieces of apparatus is shown by Figs. 45 and 46, the former being a side view, and the latter an end view of it; *m*, in both figures, represents the magnet, *i* the crosspiece, *a b* the lever, and *f* the fulcrum. The cards at the longer extremities of the six levers are numbered 1, 2, 3, 4, 5, 6, which, individually, and by a series of simple combinations, form all the signals that are required.

"When the levers are in the position shown in Figs. 45 and 46, the magnet is out of action, in consequence of the battery circuit being interrupted. If, now, the battery circuit were to be closed, the magnet *m* would immediately be brought into action, and its attractive force would bring down the crosspiece *i*; which, being attached to the shorter arm of the lever, would raise the longer arm, with its card and sign, into the position of the upper dotted circle, where it becomes visible through a circular opening in the face of the instrument, as at (5) in Fig. 44. When that particular sign has appeared the required

Fig. 44.

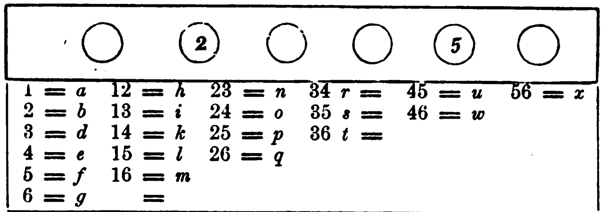


Fig. 45.

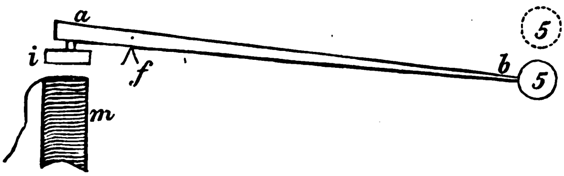
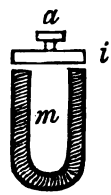


Fig. 46.



time to be observed, that battery circuit is opened, the magnet *m* loses its power, and the longer arm of the lever preponderating, again falls down to its first position, and the card with its sign disappears.

"The face or dial of the telegraph is represented by Fig. 44, which may be either of painted wood or metal, silvered in the manner of clock faces, or barometer scales. On the upper part of the dial there are six circular openings, for the occasional appearance of the cards, with their figures, which are attached to the longer arms of the six levers. (See Fig. 45.) Below the circular openings in the dial-plate, there are arranged the signals which are to represent all the alphabetical letters that are necessary for the spelling of words. The signals are thus continually before the eyes of the operator, and are too simple to miss being understood. These levers, with their magnets, &c., Figs. 45 and 46, are placed behind the dial in a suitable case, and in such a manner that the figures on the cards may appear at the circular openings whenever their levers move upwards by the attractions of their respective magnets at the other, or shorter arms; and to disappear below those circular openings, when the magnets are out of action. To accomplish this latter effect, the face of the crosspiece of iron, which is attached to the short arm of each lever, must be covered by a card, or a film of some non-ferruginous matter, which will prevent close contact of the iron and magnet. By this arrangement of the apparatus, it is a matter of no consequence in what way the magnetic poles are arranged, because the attraction of the crosspieces, attached to the shorter arms of the levers, will take place as well with one arrangement as with another. But for uniformity, we will suppose that the coils on the magnets are all of the same kind, and that the north poles are to be in one and the same direction, towards the left hand,

8

for instance, to a person facing them, then those extremities of all the coil wires which were situated in one direction, might be collected together in one bundle, and either continued to the station where the battery is situated, or soldered to one stout copper conductor, at some short distance from the magnets, which conductor would become a general *fixed channel* between all the magnets at this station, and the battery at the other station. The other six ends of coil wires must be insulated by silk covering, and continued to the battery without metallic contact with each other. At the battery station these six insulated wires are to be attached to six wooden or ivory keys with springs, like the keys and springs of a piano-forte; by the downward motion of which, the extremities of the wires become immersed in a long trough of mercury, connected with the opposite pole of the battery to that which the other conductor is attached to. On the top of each key is to be a conspicuous figure, corresponding to the figure which is to appear in the dial-plate at the other station, so that when one finger is placed on key 2, and another finger on key 5, the magnets 2 and 5 at the other station are brought into play, and by attracting their respective pieces of iron, the figures 2 5 make their appearance on the dial as seen in Fig. 44, and the letter *p* is understood. By these means, twenty-one of the letters of the alphabet can easily be represented without a possibility of error, either in the manipulation at the one station, or in the reading at the other; unless, indeed, there be a deficiency of attention which would incapacitate the attendants for employment at any telegraph whatever.

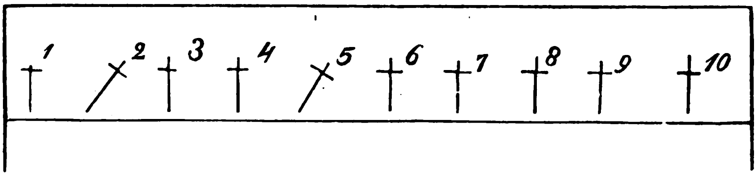
"The keys of this telegraph are sufficiently near to each other to permit the fingers to press on any number of them at one time, and if necessary, the whole of the magnets may be brought into play at once, by the application of three fingers of each hand to the keys. By these means, the numerals may be grouped into combinations of three, four, five, and six, and thus, without the slightest confusion, a considerable number of signals would be obtained, which might represent words, or whole sentences, which would greatly expedite the transmission of intelligence from one end of the line to the other.

"There is a very great advantage in employing the numerals for signals. Not only because they are not so liable to lead to confusion as by the employment of the alphabetical letters when used in combinations or groups, but because the subject of communication may be kept a perfect secret from one end of the line to the other; which is a most essential consideration in government expresses, and very often in those of mercantile affairs also.

"In this telegraph a seventh magnet is employed to ring a warning bell, as first proposed by Professor Steinheil.

"Although in the telegraph already described I employ soft iron magnets and levers to bring the signals into view, I am of opinion that magnetic needles in coiled conductors, or electro-magnetic multipliers, will be somewhat more prompt in their motions than the lever, at great distances from the battery. I therefore propose to make the necessary signals by means of magnetic needles, which can be moved with the same arrangement of conductors as that already described. And although I have only used six numerals for the signals, I am very far from supposing that the working of an electro-magnetic telegraph is facilitated or simplified by using a small number of original signals, or by having a small number of conductors. The simplest method of *spelling* words would be to have a needle for each letter of the alphabet, and the telegraph could be *made* and *worked* as easily by 24 needles as by a smaller number. And the words and sentences, which could be signified by combining them in pairs, or in groups of two each, would afford great facilities for the rapid transmission of ideas from one end of the line to the other. The needles could be placed in three horizontal rows, one above another, on a vertical dial-plate.

Fig. 47.



"I have shown a dial-plate in Fig. 47, on which are placed 10 needles, with their respective figures or signs. As the needles can be deflected in only one direction, viz. with the north end towards the figure which belongs to it, there can be no mistake in understanding what sign is to be understood. I believe that any of these telegraphs will be found much simpler than those already before the public. They are capable of producing many more signs than any other known, and may be made at a less expense."

The House Printing Telegraph.

This instrument has been appropriately termed one of the wonders of the age; its apparent intricacy of construction arises not so much from the use of electricity and magnetism, as from the number of minute physical contrivances, and the various methods by which they are brought into action.

Of the origin and life of the inventor, Mr. Royal E. House, it seems difficult to obtain any definite or conclusive information; while the results of his labors are spread before the public, form a prominent object of its curiosity, and are made subservient in a high degree to its utility, the man himself seems almost a recluse, and veiled, as it were, from the sight of the world. If some tell us that he originated in New York, more authentic sources affirm that he was born and reared among the Green Mountains of Vermont. To the Green Mountain State, then, may we ascribe the honor of having given birth to one who has achieved so much in the progress of American artisanship.

To converse and carry on intelligent discourse at the distance of many hundreds of miles, is not new; nay, it has become common; but to impress with the subtile electric spark through vast space, solid materials with the symbols of our language in the fulness of their proportionate beauty; to make the cold, dull, inanimate steel speak to us in our own tongue, surpasses the mythological narratives of ancient Greece and Rome, throws into the shade the fabulous myths of superstitious Arabia, and sinks into insignificance the time-honored traditions of the Oriental World.

A letter, dated Boston, Dec. 23, 1850, received in reply to some inquiries relative to Mr. House, affords the following interesting information: "Mr. House is a self-educated man, and was engaged nearly six years in perfecting his instrument; he is decidedly scientific, but not learned, having devoted much attention to electricity and its kindred sciences; observing the property of a helix or coil of wire to attract an iron bar to its centre, he proceeded to make some practical application of the fact, and succeeded in constructing what is termed an axial magnet; his principal object then, was the construction of a machine adapted for its use, which he fabricated after many attempts and much perseverance.

"Such is the cast of his intellect, that he could form the entire object in his mind, and retain it there until he had completed its whole arrangement, without committing anything to paper; somewhat abstract in disposition, he is careless about money, little communicative concerning himself, capable of long protracted thought, and completely absorbed in his hobby, the telegraph; to such an extent is this abstraction carried, that he often forgets his most faithful and punctilious business promises, and when sought after to comply with them, is found investigating some interesting object of science, or deeply engrossed in thought; even with particular friends he is very reserved about himself.

"From some affection of the eyes, he was confined to his dwelling during most of the time spent in contriving his instrument; he resides at present in New York. An application was made for a patent in 1845 or '46, but it was refused on the ground that some of the specifications clashed with those of Mr. Morse; one, however, was granted in October or November of 1848, to date from April 18, 1846."

The stations between which communications are conveyed are connected by means of a circuit composed of one conducting wire (see J, Fig. 48) and the ground; the wire is insulated, to prevent escape of the electric fluid; they were formerly made of twisted wire, and wound around glass knobs; thus exposed to the atmosphere, they soon became oxidized, requiring frequent repairs, or the lightning, by striking them, often played many pranks with the machines and their operators; the action of the current was also very unequal, owing to the varying electrical conditions of the atmosphere.

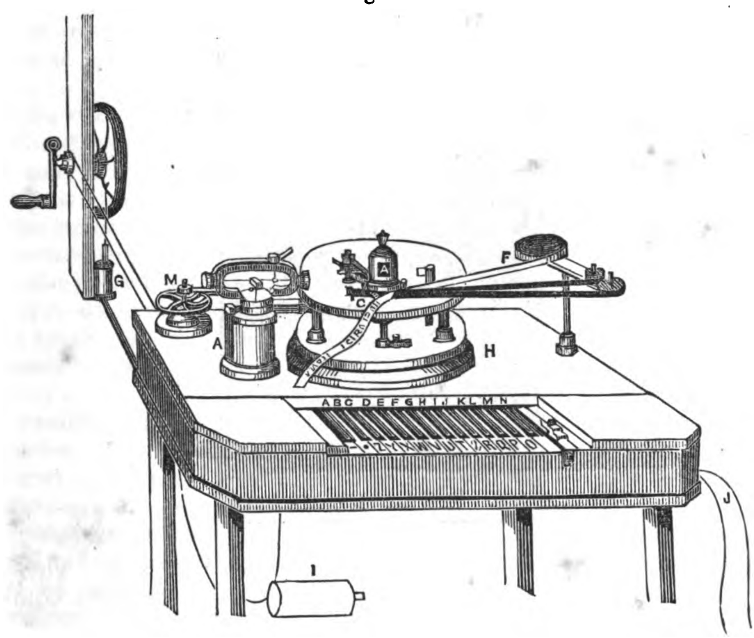
Notwithstanding all their precautions, a severe accident of the above nature occurred to the House Telegraph in this city, on the 29th of May last. During a severe thunderstorm in the afternoon of that day, the lightning, as was supposed, struck the line about six miles from the city; it destroyed nearly three miles of wire, melted off the helix of the magnet here, and terminated with a loud explosion at the battery; several gentlemen were sensibly and severely affected.

The posts to sustain the wire are from 20 to 30 feet in height, set 5 feet deep, nine inches in diameter at the base, four and a half at the top, and about 15 rods distant from each other, that being the medium length which the kind of wire cited will support of itself and be durable; the Grove battery is employed to generate the current, of which about thirty cups are necessary for a distance of 100 miles.

The main constituents of his telegraph are, the composing machine, the printing machine, a compound axial magnet, a manual power which sets the two machines in motion, and a letter wheel or tell-tale, from which messages can be read, should the printing machine get out of order.

A composing and printing machine are both required at every station; the printing apparatus is entirely distinct from the circuit, but

Fig. 48.

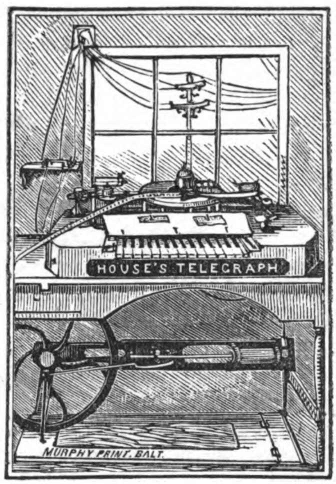


all the composing machines are included in and form part of it; the circuit commences in the galvanic battery of one station, passes along the conductor to another station, through the coil of the axial magnet to an insulated iron frame of the composing machine, thence to a circuit wheel revolving in this frame; it then enters a spring that rubs on the edge of this circuit wheel, and has a connection with the return wire, along which the electricity goes through another battery back to the station from whence it started, to pursue the same course through the composing machine and magnet there, and all others upon the line; thus the circuit is confined to the composing machines, axial magnets, conducting wires, and batteries.

The composing machine, Fig. 48, is arranged within a mahogany frame H, three feet in length, two in width, and six or ten inches deep; the various parts of the printing machine are seen on the top of the same case; both are propelled by the same manual power, which is distinct from the electric current; it is simply a crank, with a pulley carrying a band to drive the machine, and a balance-wheel to give stable motion; one of the spokes of the balance-wheel has fixed to it an axis for the end of a vertical shaft to revolve on, that moves the piston of an air condenser G, fastened to the floor; the air is compressed in the chamber I, fourteen inches long, and six in diameter, lying beneath the mahogany case H; it is furnished with a safety-valve, to permit the escape of redundant air not needed in the economy of the machine.

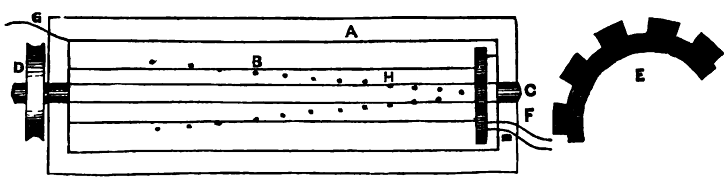
One of the improvements in the "House Printing Telegraph," since the publication of the first edition of my work, consists in the operator being able to work the machine without an assistant, by means of a

Fig. 49.



treadle placed under the instrument, instead of the crank. The cut, Fig. 49, will show this new arrangement, and also the wires coming from the distant station.

Fig. 50.



The composing system has an insulated iron frame, A, Fig. 50, placed immediately below the keys, parallel with the long diameter of the case; this has within it a revolving shaft C; the shaft is inclosed for the greater part of its length by the iron cylinder B; it is made to revolve by a band playing over the pulley D, fixed to the left extremity of it. The cylinder B, Fig. 50, is detached from the shaft, but made to revolve with it by a friction contrivance, consisting of a brass flange fastened permanently to the revolving shaft; the face of the flange and the inner face of the circuit wheel are in contact with a piece of cloth or leather interposed, moistened with oil; the friction is regulated by a spring pressing against the end of the revolving shaft C.

The object of this friction apparatus is to allow the shaft to revolve while the cylinder can be arrested.

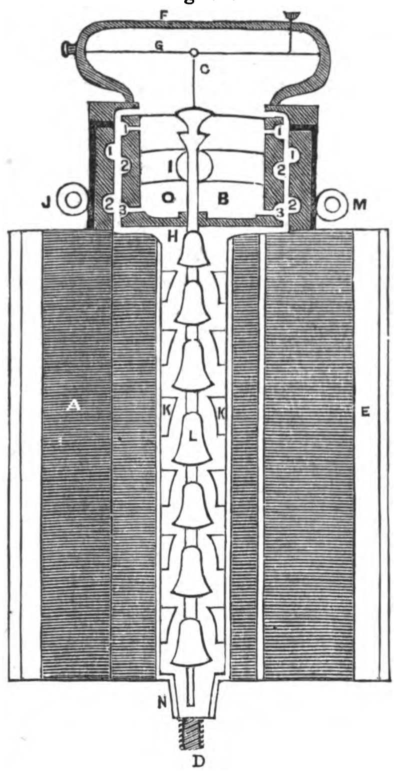
On the right end of the cylinder is fixed the brass wheel E, Fig. 50, four or five inches in diameter, called the circuit wheel, or break; the outer edge of it is divided into 28 equal spaces, each alternate space being cut away to the depth of one-fourth of an inch, leaving fourteen teeth or segments, and fourteen spaces, Fig. 50, E; the revolving shaft and cylinder form part of the electric circuit; one point of connection being where the shaft rests on the frame, the other through a spring F, having connection with the other end of the circuit, pressing on the periphery of the break-wheel E, Fig. 50; G, the other part of the circuit, coming from the axial magnet to the frame A; when the shaft, cylinder, and circuit wheel revolve, the spring will alternately strike a tooth and pass into an open space; in the former case, the circuit is closed, in the latter it is broken.

For the purpose of arresting the motion of the circuit wheel and cylinder, the latter has two spiral lines of teeth H, Fig. 50, extending along its opposite sides, having fourteen in each line, making 28, one for each tooth, and one for each space on the circuit wheel; the cylinder extends the whole width of the key-board above it; the latter is like that of a piano-forte, containing twenty-eight keys that correspond with the twenty-eight projections on the cylinder, and have marked on them in order, the alphabet, a dot, and dash, Fig. 48; they are kept in a horizontal position by springs; there is a cam or stop fixed to the under surface of each key, directly over one of the projections on the cylinder; these stops do not meet the teeth unless the key is pressed down, which being done, the motion of the cylinder is stopped by their contact; by making the circuit wheel revolve, the circuit is rapidly broken and closed, which continues until a key is depressed; that key being released, the revolution continues until the depression of another key, and so on; the depression of a key either keeps the circuit broken or closed; as it may happen to be at the time, so that the operator does not break and close the circuit, but merely keeps it stationary for a moment; from one to twenty-eight openings and closings of the circuit take place between the depression of two different keys or the repetition of the depression of the same one; the object of the composing machine is to rapidly break and close the circuit as many times as there are spaces from any given letter to the next one which it is desired to transmit, counting in alphabetical order.

The rapid electrical pulsations are transmitted by the circuit of conductors to the magnet and printing machine at another station, through the wire J, Fig. 48. The helix of this magnet is an intensity coil contained in the steel cylinder, A, Fig. 48, on the upper surface of the mahogany case; its axis is vertical.

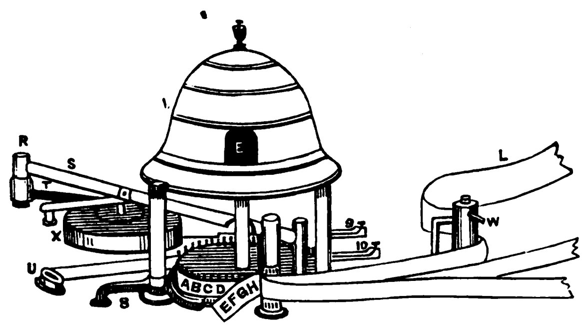
A, Fig. 51, is a brass tube, eight or ten inches long, placed within the helix, and fastened at the bottom by the screw D. To the inner surface of this tube are soldered six or eight soft iron tubes, separated from each other at regular intervals. Above the iron cylinder is an elliptical ring F, through the axis of which is extended an elastic wire, G; two screws are attached to the wire, by which it is made lax or tense, to suit the intensity of the electric current. From this is suspended the brass rod C, that passes down within the small iron tubes before mentioned, and has strung on it six or eight small iron tubes L; these are fastened at equal intervals, and have their lower extremity expanded into a bell-like flanch; the surrounding fixed ones have their upper ends enlarged inwardly in the same manner. The tubes L, and the wire to which they are fastened, are movable, so as to come in contact with the small exterior iron tubes K, Fig. 51, but are kept separate by the elastic spring above. At E, is the brass covering. On the transmission of an electric current through the helix, the tubes become magnetic. Such is the arrangement of their polarities, that they act by attraction and repulsion, overcome the elasticity of the spring, and bring the movable magnets down to the fixed ones—the current being broken, the spring separates them. The two flanches do not come in direct contact, though the movable one acts responsive to magnetic influence. Most of the magnetism exists at the flanches, and the order is such that the lower end of the inner tube has south polarity, the surrounding one above, the same, which repels it, while the top of the surrounding one below has north polarity, and attracts it; this movement is through a space of only one-sixty-fourth part of an inch.

Fig. 51.



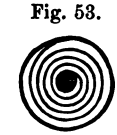
On the same rod, above the movable magnets, is fixed a hollow cylindrical valve, having on its outer circumference the grooves 1, 2, 3, Fig. 51. The plate represents a longitudinal half-section of the valve, magnets, and helix. The valve slides in an air chamber H, which has two grooves, 1, 2, on its inner surface. Air is admitted through the orifice 1, by means of a pipe from the air chamber beneath the case, into the middle groove of the valve. The grooves of the chamber open into the side passages J and M, which connect at right angles with a second chamber, in which a piston moves. The movement of the magnets changes the apposition of the grooves in the first chamber, by which air enters from the supply pipe, through one of the side passages, into the second chamber, at the same time that air on the other side of the piston in the second chamber escapes back into the grooves 1 and 2 of the valve, through the other side passage, and from them into the atmosphere. This causes the piston to slide backward and forward with every upward and downward motion of the valve.

Fig. 52.



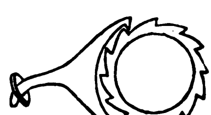
This piston moves horizontally, and is connected with the lever 8, Fig. 52, of an escapement, the pallets of which alternately rest on the teeth of an escapement wheel of the printing machine A, Fig. 52. This part of the apparatus is arranged on a circular iron plate, twelve or fourteen inches in diameter, supported by standards on the mahogany frame H, Fig. 48. The escapement wheel revolves on a vertical shaft that passes through the iron plate, and has fixed on it there a hollow pulley. This pulley contains within it a friction apparatus, consisting of an ordinary spiral clock spring—the inner end of which is fastened to the shaft, and the outer pressing against the inner side of the case. Thus the spring is always about the same strength, and acts upon the escapement wheel, causing it to revolve uniformly when released by the escapement. The pulley revolves constantly, while the shaft and escapement wheel may be stopped. The escapement wheel has fourteen teeth, each one of which causes two motions of the escapement, which will make twenty-eight for a single revolution of the wheel, which is shown in Fig. 54.

Fig. 53.



When in operation, the piston to which the escapement arm 8, Fig. 52, is attached, is subjected, on one side or the other, to a pressure of condensed air; therefore the piston and escapement will only be moved by the escapement wheel when the air is removed from one side or the other of the piston. The position of the valve, Fig. 51, attached to the magnet, regulates the pressure of air on either side

Fig. 54.



of the piston, by opening one or the other of the side passages into the second chamber. By breaking and closing the circuit, therefore, the piston and escapement move backward and forward; thus a single revolution of the circuit wheel at one station opens and closes the circuit twenty-eight times, causing an equal number of movements of the magnets in another station; they carry the valve which alternately changes the air on either side of the piston. This permits the escapement wheel to move the escapement and piston twenty-eight times, and allows one revolution of the escapement wheel for one of the circuit wheel at the transmitting station.

A steel type wheel, Fig. 52, A, B, C, D, two inches in diameter, is fixed above and revolves on the same shaft with the escapement wheel; it has on its circumference twenty-eight equidistant projections on which are engraved in order the alphabet, a dot, and a dash. The fourteen notches of the escapement wheel cause twenty-eight vibrations of the escapement in a revolution, that correspond to the characters on the type wheel. Every vibration of the escapement, therefore, makes the type wheel advance one letter; these letters correspond to those on the keys of the composing machine. If any desired letter on the type wheel is placed in a certain position, and a corresponding key in the composing machine is depressed, by raising that key, and again depressing it, the circuit wheel at one station, and the escapement and type wheel at the other station, all make a single revolution, which brings that letter to its former position. Any other letter is brought to this position by pressing down its key in the composing machine, the circuit being broken and closed as many times as there are letters from the last one taken to the letter desired.

To form the letters into words, it is necessary that the printing and composing machines should correspond, and for this purpose a small break and thumb-screw, 9 and 10, Fig. 52, can be made to stop the type wheel at any letter. In sending messages, they usually commence at the dash or space; if, by accident, the type wheel ceases to coincide with the distant composing machine, the printing becomes confused, the operator stops the type wheel, sets it at the dash, and the printing goes on as before.

Above the type wheel, on the same shaft, is the letter wheel E, Fig. 52, on the circumference of which the letters are painted in the same order with those on the type wheel below. It is incased in a steel hood, having an aperture in it directly over where the letters are printed, so that when the type wheel stops to print a letter, the same letter is made stationary for a moment at the aperture, and is readily distinguished; hence messages can be read, thus making it a visual telegraph.

The type wheel has twenty-eight teeth arranged on the outer edge of its upper surface; near it, on the opposite side from where the printing is done, is the shaft T, Fig. 52, revolving in an opposite direction. A steel cap, X, Fig. 52, two inches in diameter, is so attached to the top of this shaft that friction carries it along with it, but it can be moved in the opposite direction; it has a small steel arm, three-fourths of an inch long, projecting from its side, and playing against the teeth on the type wheel; while the latter is revolving, its teeth strike this arm, and give the cap a contrary motion to its shaft. There is a pulley on this shaft, below the plate, connected by a band to M, Fig. 48; its speed is less than that of the type wheel. When the type wheel comes to rest, the arm falls between the teeth, but it has not time to do so when they are in motion. On the opposite side of the cap to where the arm is attached are two raised edges, called detent pins, against which the detent arm U, Fig. 52, alternately rests, as the position of the cap is altered by the small arm that plays on the teeth of the type wheel.

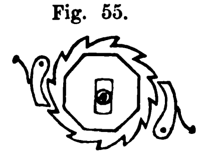
Between the type wheel and cap is a small lever and thumb-screw, 9, Fig. 52, which acts as a break on the cap; its motion can be stopped by it, while the type-wheel revolves; it is used merely to arrest the printing, though the message may be read from the letter wheel.

The detent arm revolves in a horizontal direction about the vertical shaft, which is also driven by a pulley beneath the steel plate; when the type wheel is at rest, the detent arm rests on one of the detent pins, but when it moves, the teeth on its upper surface give the arm and cap a reverse direction to its shaft, which alters the position of the detent points, so that the detent arm is liberated from this first pin, and falls upon the second, where it remains until the escapement and type wheels again come to rest; when this happens, the arm falls between two of the teeth, the cap resumes its first position, the detent is let loose, makes a revolution, and stops again on the first pin.

The shaft that carries the detent arm has an eccentric wheel R, Fig. 52, on it, above the arm; an eccentric wheel is one that has its axis of motion nearer one side than the other, and, while revolving, operates like a crank; from this eccentric is a connecting rod S, which draws a toothed wheel against the type; this toothed wheel is supported in an elastic steel arm (shut out of view by the coloring band), on the opposite side of the type wheel from that of the eccentric, and revolves in a vertical direction; the band E, Fig. 48, carrying the coloring matter to print with, passes between this and the type; the dots seen represent small teeth that catch the paper and draw it along, as the wheel revolves, between itself and a steel clasp, operated by a spring that presses the paper against the teeth and keeps it smooth; the clasp is perforated in such a manner that the type print through it; there are two rows of teeth, one above, the other below the orifice.

The vertical wheel, Fig. 52, is embraced in a ring by the connecting shaft S, and a rotary motion is imparted to it by a ratchet fixed to its lower surface, moving with it, and catching against two poles fastened to the steel plate below it; the poles are pressed against the ratchet by springs, as shown in Fig. 55; the wheel is octagonal, and every revolution of the eccentric turns it through one-eighth of a revolution, and therefore presents a firm, flat surface to push the paper against the type, and advances sufficient for every letter, one being printed each time the detent arm revolves.

Fig. 55.



When the type wheel stops, the detent arm revolves, that carries with it the eccentric, which, through the connecting rod, draws the toothed wheel having the paper and coloring band before it against the type, and an impression is made on the paper; a letter is printed if the circuit remains broken or closed longer than one-tenth of a second; three hundred letters, in the form of Roman capitals, can be accurately printed per minute; the roll of paper L, Fig. 52, is supported on a loose revolving wire framework; on the same standard is a small pulley W, around which one end of the coloring band runs.

In transmitting a message, the machine is set in motion, a signal is given (which is simply the movement of the magnet), and then with the communication before him, the operator commences to play like a pianist on his key-board, touching, in rapid succession, those keys which are marked with the consecutive letters of the information to be transmitted; on hearing the signal, the operator at the receiving station sets his machine in motion; then setting his type at the dash, sends back signal that he is ready, and the communication is transmitted; he can leave his machine, and it will print in his absence; when the printing is finished, he tears off the strip which contains it, folds it in an envelop ready to send to any place desired. The Governor's Message has been transmitted by this instrument, and published entire in New York two hours after its delivery in Albany.

The function of the electric current in this machine, together with the condensed air, is to preserve equal time in the printing and composing machine, that the letters in one may correspond with the other; the electrical pulsations determine the number of spaces or letters which the type wheel is permitted to advance; they must be at least twenty-five per second to prevent the printing machine from acting; the intervals of time the electric currents are allowed to flow unbroken are equal, and the number of magnetic pulsations necessary to indicate a different succession of letters are exceedingly unequal; from A to B will require one-twenty-eighth of a revolution of the type wheel, and one magnetic pulsation; from A to A will require an entire revolution of the type wheel and twenty-eight magnetic pulsations.

On the 28th December, 1852, Royal E. House obtained the following patent for various improvements on the original machine: "I claim, First. The employment of electro-magnetic force, in combination with the force of a current of air, or other fluid, so that the action of the former governs or controls the action of the latter, for the purpose described. Second. I claim the construction of the electro-magnet, as described; that is to say, a series of fixed magnets, in combination with a series of movable magnets, arranged upon a central axis, which axis plays between or through the line of fixed magnets, so as to effect a vibratory movement of said axis by a force multiplied by the number of magnets of both kinds. Third. I claim the combination of the electro-magnet with the valve, for regulating and directing the force of a current of air, or other fluid, acting as a motive power upon the piston, or other analogous device for producing a vibratory motion, as described. Fourth. I claim the endless band, in combination with the cylinder, as an inking machine, for conveying and applying the coloring matter to the paper, at the moment of receiving the impression from the types, as described. Fifth. I claim the combination of the regulating bar with the type wheel, for the purpose of regulating the proper position said wheel should have, in connection with a given position of the key shaft, at the moment of printing any letters or characters."

The first line operating with this instrument was completed in March, 1849, by the New Jersey Magnetic Telegraph Company (now the New York and Washington Printing Telegraph Company), from Philadelphia to New York city. They were incorporated by the Legislature of New Jersey, with a capital stock of $100,000.

"The Boston and New York Telegraph Company, using House's Printing Telegraph; about six hundred miles of wire; two wires. Stations at Boston, Mass., Providence, R. I., Springfield, Mass., Hartford, Conn., New Haven, Conn., and New York. A line being constructed to connect with the Boston line, running from Springfield, Mass., to Albany, New York, there intersect the New York and Buffalo line, using the same instruments, extending from New York to Buffalo, a distance of five hundred and seventy miles. One wire now in operation, connecting with Poughkeepsie, Troy, Albany, Utica, Syracuse, Lyons, Rochester, Albion, Lockport, and Buffalo; and another wire nearly completed, same distance. The same line to continue to St. Louis, Mo., connecting with Cleveland, Cincinnati, Louisville, and St. Louis—forming the longest line in the world, under the direction of one company; whole length being fifteen hundred miles. We learn that the first section of the New York Central, New Jersey and Pennsylvania Telegraph Company (House's Printing Telegraph), is now in successful operation from Easton to Belvidere, connecting with the Morse line at Easton to Philadelphia. This line, when completed, will be one of the most important in this State and New Jersey, connecting Philadelphia, Trenton, Lambertville, Easton, Flemington, Doylestown, &c. &c., via the Central Railroad to New York. The New York and Washington Printing Telegraph Company, using House's instruments, extends from New York via Philadelphia and Baltimore to Washington; two wires, one hundred and thirty-two miles."

Subjoined is a specimen of the form of printing executed by this machine, kindly offered by the principal operator at this station, Mr. W. J. Philips, to whom, and the records of the House trial, I am indebted for most of my information:—

HOUSE'S PRINTING TELEGRAPH.

Submarine Electric Telegraphs.

The first wires for the Submarine Telegraph between England and France were sunk in the British Channel on the 27th of August, 1850. The wire was thirty miles long, with a covering of gutta percha half an inch in diameter, the wire imbedded by leaden clamps of twenty and twenty-five pounds, to the bottom of the sea. The clamps were streamed out at every sixteenth of a mile, and the wire was safely sunk to a depth which was hoped would place it out of the reach of anchors or monsters of the deep; and the other end of the wire was run up the cliff at Cape Grienez, to its terminal station on the French side of the channel, and messages were passed between the two countries.

But, unfortunately for the first effort, in the course of a month the wire received so much injury on a rock off Cape Grienez, as to make it entirely useless, and, upon a careful consideration, the directors of the company determined to lay, instead of one, "four permanent wires."

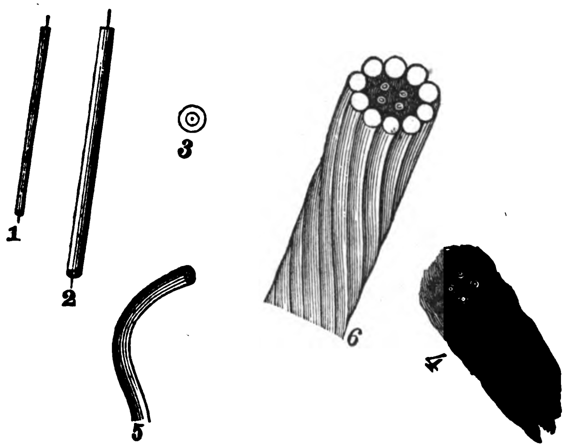
Upon an examination by divers, it has been found that where the rupture of the coil occurred it had rested on a very sharp ridge of rocks, about a mile out from Cape Grienez, so that the leaden weights, hanging pannier-like on either side, in conjunction with the swaying of the water, caused it to part at that point; while at another place, in shore, the shingle from the beach had the effect of detaching the coil from the leaden conductor that carried it up the cape.

The wire, in its gutta percha coating, was consequently cut in two places, representing a remnant of wire of about four hundred yards, which was allowed to drift away, till it came into the possession of a fisherman of Boulogne; and it was no wonder that it was cut, being represented as not thicker than a lady's stay-lace, while it ought to have been as thick as the cable of those placed in the Britannia tubes in position, say eight or ten-inch cable, and to be submerged below five fathoms, by the aid of enormous weights, so as to avoid all currents.

I will now state the present condition of this communication, and the means taken to secure it from accident, and I will then describe the form of telegraph which is employed by Mr. Brett. In *L'Illustration Journal Universel*, for October, 1851, it is stated that in this, the last effort, they had not calculated for the proper amount of cable when first taken across the channel, it requiring a mile more cable, but the accident was soon repaired. The engraving is one taken from that journal, and they remark that it is indeed a wonderful work. The cable of wire in which is inclosed the electrical conductor, was manufactured in the short space of three weeks, by means of a machine, the invention of Mr. Fenwick, an ingenious English engineer. It is hoped that to preserve the conducting wire free from accidents which caused the first experiment to fail, by the present arrangement four wires are enveloped in a double cover of gutta percha, and each re-covered with cable lying at the bottom of the sea; the covers forming, together, a length of ninety-six miles, over which is placed a linen covering prepared in a composition of tar, tallow, &c., and crossing its length the centre of the cable.

No. 1, Fig. 56, is the first covering of gutta percha; No. 2 is the second covering, re-covering the first; No. 3, section of the covering No. 2; No. 4 is the wire in the covering of tarred linen; No. 5 is the simple wire of galvanized iron; the covering is that of zinc; No. 6 is a view of the arrangement of the cable, showing the galvanized iron wire, &c.

Fig. 56.



To recapitulate: The rope is 24 miles long, and consists of four copper wires, through which the electric current will pass, insulated by coverings of gutta percha. These are formed into a strand, and bound round with spun-yarn, forming a core or centre, round which are laid ten iron galvanized wires, of 5-16ths of an inch diameter, each welded into one length of 24½ miles, and weighing about 15 tons. The rope weighs, altogether, about 180 tons; it forms a coil of 30 feet in diameter outside, 15 feet inside, and five feet high, and was in good working order in September, 1851. English papers, received by the arrival of the Niagara, on Friday, December 12, 1851, state that the Submarine Telegraph is working well. Messages, on the same day, have been transmitted from London and Liverpool to Paris, Havre, Vienna, Trieste, Hamburg, and Ostend; and, in one instance, a communication was forwarded to Cracow, to be dispatched thence by mail to Odessa.

The rates are, for a message of twenty words:—

From Paris to Calais	. . . .	7f. 56c.
" " Dover	. . . .	19f. 56c.
" " London	. . . . . .	32f. 81c.
" " Birmingham	. . . . . .	— —

From Paris to Brighton, Cheltenham, Coventry, Gloucester, New Market, Norwich, Oxford, Portsmouth, Southampton, &c., 26f. 03c.

From Paris to Chester, Edinburgh, Glasgow, Holyhead, Liverpool, Manchester, New Castle, Nottingham, Sheffield, York, 29f. 31c.

Now that the English Channel has been crossed in so substantial a manner, and with such perfect success, the crossing of the Irish Channel must follow; for the same Company will perform this important work.

By their act of incorporation they are styled "The Submarine Telegraph Company between England and France, between England and Ireland, and the European and American Printing Telegraph," all proposed by Mr. Jacob Brett, in 1851.

The Submarine Telegraph Company, between France and England, has declared a dividend of 2½ per cent. on the operations of the first six months. The capital account shows a receipt of £100,000 on so many shares of £1 each, and an expenditure as follows: By amount paid to the *concessionaires* and *entrepreneurs*, under the terms of Article 9 of the *Acte de Société*, cost of experimental wire, cost of existing cable, and amount paid on account of the wires in connection with the submarine cable at Dover, £70,233 7 | 3; candon money in the hands of the French Government, £2,000; amount paid for office furniture, £216 12 | 19. Total, £72,450. The balance of £27,550 is composed of £2,550 value of shares held in the hands of the Company, and £25,000 shares unallotted.

The revenue account shows that £3,546 8 | 5 have been received for messages transmitted from Nov. 30, 1851, to June 30, 1852: The expenses at the London, Dover, Calais and Paris stations, including printing, stationery, postage, and other incidental charges, were £238 12 | 9; salaries and wages, £805 17 | 1; rent and taxes (London, Paris and Dover), £170 6 | 10; directors' allowance (half a year under Article 10 of the Act of Society), £3,000. Total, £1,514 16 | 8, giving a net profit of £2,031 11 | 9.

Since Nov. 15, 1851, the Company has transmitted 9,045 messages from London to Calais, for which it has received £6,889 13 | 9. Two thousand seven hundred and ninety-four of these pounds have been paid to the South-eastern Railway.

The Submarine Telegraph Company is already receiving nearly £450 a week for messages, or £22,000 a year, which is 15½ per cent. on the capital. London, May, 1853.

The following is a description and *Plate* of the form of Telegraph employed by this Company.

Description of Brett's Printing Telegraph, Plate II.

Suppose at one extremity of *a single line* of telegraphic wire, a small key-board, containing a row of ivory keys, marked with the letters of the alphabet, and other characters or words; and that it be connected by the said wire to the printing machine at the other extremity. This machine contains a type wheel, having on its circumference corresponding letters, words, or signs; a slight electric power is sufficient to regulate the motion of the whole, so that the instant a key representing any word, letter, or sign, is pressed down by the person at the key-board at one end of the line, the corresponding word, letter, or sign of the type wheel prints, and the signal bells ring at the other end of the line of telegraph, without limit as to distance. The communications are printed on paper supplied from a scroll of unlimited length, from which any portion of the correspondence may be cut off at pleasure.

The motive power is simple; it being that of a weight, which sets in motion the key-shaft and governor of the key-board; and the circuit wheel in connection with the shaft being put in contact with the wire of the galvanic battery, or other generator of electricity, according to the velocity of motion and manipulation at the key-board, so will the motion be fast or slow at the printing end of the telegraph; the type wheel of the telegraph is set at liberty by means of an escapement, and weights in connection with it, so as to print with a like velocity, in combination with a hydraulic or pneumatic regulator, which admits of the desired letter *only* being printed, by checking and releasing an eccentric arrangement; a rod from thence unites with the cylinder on which the paper is printed, in various modes, as may be desired, either in paragraphs—on a sheet of paper—upon a long strip of ribbon or paper—or, if for government dispatches and the like, it can be printed line by line, like the column of a newspaper, of an unlimited length.

Fig. 2 represents a separate key-board, of a circular form, from which communications can be forwarded to any or every station in connection with it, the letters, words, or characters being arranged round it on the keys; and these, if depressed by the fingers, will check the motion of a pin, or shaft, and also of the circuit wheel fixed to the same axis, at such given point or key, by which means the operator may make or break the circuit of conductors at such letter or point.

The distance actually proved to act by this telegraph in one continuous line has been 230 miles, and 340 miles apart, at the rate of 100 letters per minute. This is a modification of the House Printing Telegraph.

Messrs. Carmichael and Brett have contracted with the Belgian Government for the formation of a submarine telegraph between Belgium and England. They are to have a monopoly of ten years, and the governments are to have priority of all messages.

Submarine Telegraph in the Mediterranean.—The *Genoa Mercantile Courier*, of the 4th inst., contains the following important announcement: A convention has been concluded between the Piedmontese Government, the French Government and the English Submarine Telegraph Company, for the immediate execution of an electric telegraph between Genoa and Cagliari, in Sardinia. The English steamer conveying the India mail from Malta, will call in at Cagliari.

On the 6th July, 1853, a cable of seventy miles, in one entire length, was laid down between England and Belgium with complete success, and communications were instantly transmitted over 500 miles of submarine and subterranean line, with two of 24-plates battery only. The Mediterranean Electric Telegraph Company propose to unite Europe with Africa by continuing the electric wires, which now run without interruption between London and Genoa, to Spezzia. From the latter port they will cross the Mediterranean to Africa, passing by the islands of Corsica and Sardinia. It is farther proposed to construct a subterranean line from Algeria, along the coast of Africa to Alexandria; and, with the support of the British Government and the East India Company, it will be easy to prolong the wires to Bombay, where they will meet the great line of 3,000 miles now in course of construction by the East India Company. The farther end of this chain may ultimately be carried to Australia.

The work has already been commenced, and the line has been made from London to Genoa. The writer adds: "The government of this country has also just entered into a contract with Mr John Brett, who represents a large company of British capitalists—the same which carried the line across the British Channel—for carrying it on from the main land at Spezzia to the farther extremity of the Island of Sardinia, in the midst of the Mediterranean; and France will see that it is continued thence to the province of Algiers, on the coast of Africa. The interest that England has in its continuance to her rich possessions in the East is obvious enough, without specification.

"The company has engaged to have the line from Spezzia to the island completed within eighteen months at its own risk and expense, and the government gives it a monopoly for fifty years, when it will become the property of the State. The cost is estimated at $600,000.

"It is provided, among the details of the contract, that the government shall have the free use of the line for its dispatches, and a certain small interest in the income of the business, for which it guarantees to the company an interest of 5 per cent. on the capital, or cost of the work. The price of all dispatches is fixed at 50 cents for 20 words.

"The whole line from Spezzia, the nearest point of the main land, to the termination on the island (port of Cagliari), will be 414 miles, of which 83 will be under water, and 331 over land, including the intermediate French Island of Corsica, thus—

From Spezzia to Corsica	76	miles.
Across Corsica	128	"
Across the Straits of Bonifacio . . .	7	"
Across the Island of Sardinia . . .	203	"
Total	414	"

"Thus you see that within eighteen months we are to have the benefit of a telegraph line from London to the very bosom of the Mediterranean. France, it is understood, will bear her share in the work on the Island of Corsica. The distance between Constantinople, Algiers, Egypt, the islands of the sea, distant India and China, and the seats of European civilization and commerce, for all purposes of correspondence, will thus be greatly diminished, which will be a great achievement, even if the projected work should go no farther. But it will not stop there, unless the course of things is unfortunately changed by war."

It is stated, in relation to the law just passed for the establishment of electrical telegraphic communication between France and Algeria in the northern coast of Africa, that by agreement with the Government of Sardinia, the wire is to cross the Mediterranean in three leaps. The first will be from Spezzia, on the Italian coast near Genoa, to Corsica; the second, from Corsica to Sardinia; and the third, from Sardinia to Bone, on the coast of Africa; thence along the shore to Algiers and Oran. The submarine telegraphic cable, connecting Sardinia with Bone, will be of one piece, 200 kilometres (124¼ miles) in length; and there will be on the whole line a total of 450 kilometres of submarine wire.

Mr. Brett has arrived at Turin to make preliminary arrangements for the submarine telegraph from La Spezzia to Sardinia and Algeria. Operations are to commence at the Straits of Bonifacio, between Sardinia and Corsica; and about 500 workmen are to proceed to Sassari.

The Submarine Telegraph between Great Britain and Ireland.

This important line of communication has at length been successfully effected by a submarine cable, manufactured by Messrs. Newall & Co., of Gateshead, and laid down by that firm in July, 1853, between Donaghadee and Portpatrick. The cable consists of six communicating wires insulated in gutta percha, and protected in the usual manner by an outer covering of iron wire. It could not be laid, as was intended, during the previous week, owing to the gales from the east preventing the opening of the dock gates at Sunderland to let the vessel containing it pass out. As several previous attempts to lay a submarine telegraph across the Irish Channel had failed, every care was taken to insure the successful termination of the present attempt; and the expedition, consisting of the screw steamer *William Hutt* (with the cable and apparatus on board), the *Conqueror*, and the *Wizard*, left the Irish coast, having landed the end of the cable at a point about two miles to the south of Donaghadee harbor, and commenced the submersion of the cable, under the guidance of Captain Hawes, R. N., specially appointed by the Admiralty, who rendered great assistance in determining and directing the exact course to be pursued. The cable was landed on Wednesday morning, in a sandy bay (called Mora Bay), a little to the north of Portpatrick.

Submarine Telegraph.

The submarine telegraph to connect Nova Scotia to Newfoundland has not made much progress, the Nova Scotia House of Assembly having refused a charter to the opposition company across that province. This act almost seals the fate of the submarine telegraph. A submarine section of ten or twelve miles had been laid under the strait between Prince Edward Island and the main land, which short section was intended as a portion of the "one hundred and forty miles of submarine telegraph" which was designed to connect Newfoundland with the American continent.

The Dutch Electric Telegraph.

The electric telegraph, constructed between La Haye and Brussels, and between La Haye and Scheveningen, has been opened to the public.

The Submarine Cable for Denmark.

It is stated that the submarine cable, 13 miles long, that was to be sunk across the Great Belt to Nyburg, has failed in its manufacture.

The line of telegraph proposed to be laid down from the Hague to the English coast, has already been carried from the Hague to Scheveningen; but the submarine wire will not be thrown across the channel until 1853, owing to the boisterous state of the weather. It is stated that the line will terminate at Lowestoft, and not at Harwich, as at first intended. Mr. T. Allen, of Edinburgh, proposes to place the exterior protecting iron wires of submarine cables longitudinally, instead of spirally, as is done in the Dover and Calais rope, as it will cost less and give greater security against longitudinal strain.

Any of our telegraphic operators who are desirous of examining a portion of the Dover and Calais rope, can have an opportunity by calling at the Franklin Institute of this city, where there is a piece, brought by my friend, Mr. J. V. Merrick, from London.

Submarine Telegraph at Paducah.

"The great submarine telegraph cable, on the St. Louis and New Orleans Telegraph Line, was laid across the Ohio River at this place on Monday last, the 26th inst. We examined this strange piece of mechanism a few days previous to the time it was deposited in its watery abode, and were not a little astonished at its wonderful strength.

"It is composed of a large iron wire, covered with three coatings of *gutta percha*, making a cord of about five-eighths of an inch in diameter.

"To protect this from wear, and for security of insulation, there are three coverings of strong *Osnaburg*, saturated with an elastic composition of *non-electrics;* and, around this, are eighteen large iron wires, drawn as tight as the wire will bear, and the whole is then spirally lashed together with another large wire, passing around at every ¾ of an inch. The whole forms a cable of near two inches in diameter, and it is much the largest and most substantial cable of the sort in the known world.

"We are told that the great cable across the channel from England to France, is inferior in size to this, and by no means as well insulated for electrical application; while in point of strength, it will not compare at all with the one at this place. The British wire across the channel is surrounded by *eight* wires only, while ours has *eighteen.* Ours is spirally lashed, while the British is not. The electric wire in the British cable has but one coating of gutta percha, while ours has *three*, and is altogether superior in every particular.

"This stupendous wire, which now conducts the lightning from shore to shore, beneath the bed of the majestic Ohio, is 4,200 feet in length, and the longest one to be found in the United States. It has been constructed by that amiable and accomplished gentleman, Tal. P. Shaffner, Esq., late President of the company, and now Secretary of the American Telegraph Confederation, assisted by J. B. Sleeth, Mechanical Engineer. These gentlemen have made improvements in the construction of cables, both scientific and mechanical, which will entitle them to letters patent, and the country may well be proud of them, as men of skill and ability, in whatever they may undertake.

"The wires on this line, we understand, have been exceedingly troublesome and expensive to the company, upwards of $20,000 having been expended in unsuccessful efforts to cross the rivers in such a manner as to secure them against accidents; but this great effort has accomplished the object, and there can be no future loss sustained on account of breakage of mast, wires, &c."

Telegraphs from 1847 *to* 1853.

From the year 1847 to that of 1852 there have been so many fancied improvements made in electric telegraphs, that it is unnecessary to consume time in describing them. The most important I have noticed in full; but in the majority, I have only described a new claim, or a good modification of an old arrangement.

Three of the most interesting telegraphs which have been devised in that time, are those of Henley and Foster, of England; Siemens, of Berlin, and Allen, of Edinburgh. I have arranged them chronologically, and have given a list of the publications where they may be found, especially in the instances where the description given here is limited.

Nott's Improvement in Electric Telegraph, January 20, 1846.—Novel arrangement of apparatus, by which audible and visible signals can be given, through the agency of electro-magnetism.—*Rep. Pat. Inventions*, 1847, p. 97.—(Irish.)

Hatcher's Improvements.—First, consisting in arranging and disposing of magnets in such a way that when an electric current is transmitted through them, gives a step by step motion. The second relates to the means of forming the metallic connections. Third, in regulating a number of clocks. Patent dated March 23, 1847.—(English.)

Reid's Electro-Telegraphic Improvements.—Better insulation of the wires, by laying them in channels under ground, and covering them with gutta percha, marine glue, or tar; using a modified galvanometer to sound an alarm, and earthenware insulators. Patent dated Nov. 23, 1847.—(English.)

Henry Mapple, Wm. Brown, and James Lodge Mapple, Telegraphic Machine, June, 1847.—They magnetized a steel dial by electricity, and thereby made a steel pointer to move over it.—*Rept. Patents*, Feb. 1848.

Barlow and Foster's Improvements in Electric Telegraphs, April 27, 1848.—1st. Coating the telegraphic wires with a compound, consisting of one part by weight of New Zealand gum, and one part of milk of sulphur, added to eight parts of gutta percha, by little and little, while in a kneading trough, at a temperature of 120° Fahr. The coating is effected as follows: Two pairs of rollers are made to revolve by means of suitable gearing, at one uniform speed, and each pair is provided with a pipe, fitted steam-tight, to one end of their axis, through which pipe steam is admitted at pleasure, which serves to bring the rollers to a temperature sufficient to soften partially two bands of gutta percha, passed between them. Then, there is another pair of rollers, which have their surfaces cut with semicircular grooves; the grooves of the one roller corresponding or falling right over those of the other. The wires to be covered are wound upon reels, from which they pass between the second pair of rollers. The bands or fillets of gutta percha are passed between the first pair of rollers (and are so brought into an adhesive state), and the two bands of gutta percha, with the wires between them, are in this state passed between the second pair of rollers, by which the fillets of gutta percha are made to adhere together, and consequently to envelop the wires.

2d. The governing the currents of electricity, so as to cause each pulsation thereof, separately or conjoined, to indicate different signs or symbols.

3d. The patentees describe an electric telegraph apparatus for indicating the passing and time of passing of a railway train.

A dial is pierced with fifty holes at regular distances, in which holes small plugs are placed. This dial is made to revolve once every hour. A metal spring presses against the face of the dial, and has the effect of thrusting back any plug that may have been protruded. Above the dial is an electro-magnet, which attracts, on the passing of an electric current from the station which the train has just passed, one end of a lever, the other end of which protrudes the plug immediately underneath beyond the face of the dial, so that the attendant is enabled, by looking at the dial, to see whether the train has passed the station, and what time has elapsed since it passed.—*London Mech. Mag.* No. 1319, Nov. 18, 1848.

C. F. Johnson, Oswego, Tioga County, New York. Improvement in Electric Telegraphs, May 16, 1848.—Claim: First, forming signs for telegraphic purposes, by the dropping of balls upon an endless belt moving with a uniform velocity. Second, I claim the taking off impressions on paper, from balls as dropped substantially in the manner described.—*Franklin Institute Journal,* vol. xvii. 3d series, p. 310.

John Lewis Recardo, Lownds Square, Middlesex, England, Sept. 18, 1848.—1st, "Improvement" to a mode of insulating wire for electro-telegraph purposes; and 2d, to an apparatus for suspending them.—*Mechanics' Magazine,* March, 1849.

Edward R. Roe, Improvements in the Machine for Operating or Manipulating Morse's Electro-Magnetic Telegraph, May, 1849.—The invention consists, 1st, of movable metallic types as conductors of electricity or galvanism; 2d, a metallic type bed upon which they are to rest (which is also movable to and fro, somewhat in the manner of a common printing press); and 3d, a movable board, which is also a conductor, and is made to traverse the face of the types, thereby making, continuing, or breaking the galvanic circuit, according to the form of the types.

Claim. "What I claim as my invention is, 1st. The combination of the body, the socket, the spiral ring, and the wand, with its conducting point and its non-conducting inclined planes, the whole constituting the traverser.

"2d. I claim the manner of giving the proper motion to the traverser, by the combination and action of the traverse wheel, the pulley, and the cord which plays in it, the teeth upon the traverse wheel and the brakes operated by the type bed, in the manner set forth.

"3d. I claim the combination, for telegraphic purposes, of the types, arranged in the manner described, with the traverse and its wand, and its conducting point guarded by non-conducting inclined planes."—*Franklin Institute Journal*, vol. xvii. 3d series, p. 320.

Charles Shepherd, London. Improvements, April 16, 1849.—1st. The employment in chronometers, of apparatus actuated by electro-magnetism, for winding up the remontoir escapement, which is retained by a detent.

2d. Giving audible signals in chronometers by means of a locking plate, and apparatus connected therewith, worked by electro-magnetism.

3d. An arrangement of apparatus for making and breaking the circuit.

4th. A peculiar arrangement and adaptation of apparatus, worked by electro-magnetism to chronometers.

5th. The combination in chronometers and telegraphs, of two pallets and detents for giving the step by step motion.—*Lond. Mech. Magazine*, Oct. 20, 1849.

L. G. Curtis, Ohio. Improvement in Indicating Telegraph, January 16, 1849.—"The basis of the American Indicating Telegraph invented by me, is upon these principles, viz: Electro-magnetism, machinery, figures and signs, and their combinations.

"This end is obtained by means of a revolving disk or dial-plate, marked with successive series of numerals, 0 1 2 3 4, arranged in a circle or otherwise, said dial-plate being revolved by degrees, as the galvanic current is completed and broken by the alternate vibration of the lever, to which the pallets, armature and springs are attached."—*Franklin Institute Journal*, vol. xviii. 3d series, p. 280.

Caleb Winegar, New York. Improvement in Magnetic Telegraphs, March 20, 1849.—Claim: "Moving the paper on which telegraphic marks are made, into and out of contact with a stationary pen, by which means I avoid the danger of dispersing the ink, which happens when the pen is rapidly agitated.

"I also claim operating the magnet which effects the movement of the paper.

"I also claim the arrangement for conveying ink to the stationary pen," &c. &c.—*Franklin Institute Journal*, vol. xviii. 3d series, p. 361.

M. Dugardin. Method of Insulating the Metallic Wires intended for Subterranean or Submarine Telegraph.—"This process consists of two operations. The first is the wrapping of ribbon of caoutchouc $\frac{4}{10}$ of an inch wide, and $\frac{5}{100}$ of an inch thick, around a metallic wire, so that each turn of the wrapping shall cover about one-half of the preceding one. The second consists in wrapping spirally, and $\frac{4}{100}$ thick, so that the edge of each turn shall touch the former, but without lapping over it. The leaden envelop serves to protect the caoutchouc from blows." (*Comptes de l'Académie des Sciences*, for January 2d, 1849.)—*Franklin Institute Journal*, vol. xvii. 3d series, p. 284.

Henry G. Hall, Ohio. Improvement in Posts for Telegraphs, &c., Sept. 19, 1848.—Preventing the posts from rolling, by combining the cast-iron or artificial stone shoes with the posts.—*Franklin Institute Journal*, vol. xxiii. 3d series, p. 102.

Improvements in Electro-Telegraphic Apparatus and Machinery. Wm.

Thomas Henley and David George Foster, of Clerkenwell, London, January 10, 1849.—The invention consists, *Firstly*, in certain improved arrangements of electric apparatus, whereby a visible index hand or pointer is directly acted upon by a single magnet suspended within the sphere of influence of an electro or other magnet, having each of its extremities converted or resolved into two or more poles.

Secondly. Our invention consists in keeping the magnetic bar, needle, or pointer, in one position for any length of time, or imparting to such bar, needle, or pointer, any number of distinct deflections or movements, by means of the current or currents derived from magneto-electricity, and also in making use of the residual magnetism to act upon the needle on its return to its stationary position, instead of the force of gravity; that is to say, in moving the needle in one direction by the induced current, and bringing it back to its stationary position by the action of the reversed inductive current, whereby the motions of the needles are increased in rapidity, and rendered much more marked and distinct than heretofore.

Thirdly. Our invention consists in certain improved arrangements of the magneto-electro apparatus used in electric telegraphs, whereby two distinct currents may be derived from the same magnet, and the reversed current can be made of equal intensity with the primary induced current, and single or double currents may be sent, as required, through any required number of instruments at different stations.

Fourthly. Our invention consists in the improved apportionment of the signs or symbols used in electric telegraphs. [The object of this new apportionment is to reduce the number of movements requisite, and it seems very successfully carried out. We pass over the details, which would occupy more space than we can afford to them.]

Fifthly. Our invention consists of an improved compound of gutta percha, suitable for the insulation, covering, and exterior protection of wire and other metallic substances employed to transmit currents of electricity. We mix the gutta percha nearly in equal portions, by weight, with sand which has been ground or pounded to a degree of fineness exceeding that of the finest natural sand, or with the siftings of glass paper manufactories, or glass fragments and particles of any sort, reduced to a similar degree of fineness, and this either by mixing the pulverized sand or glass with the gutta percha in a state of solution, or while in a plastic state.

Sixthly. Our invention consists in the employment of a current reverser of a peculiar construction, whereby we are enabled to dispense with the use of magneto apparatuses for the purpose of deriving currents of electricity in the manner before described, and to substitute in lieu thereof, voltaic batteries, such as are commonly in use for the purpose of transmitting currents of electricity along metallic conductors, such reverser completing the circuit twice during its motion, by the transmission of a reversed current, in the manner of the magneto machines.

Seventhly. Our invention consists in the employment, in manner following, of currents of electricity to regulate and govern the motions of time-keepers, whether the same be influenced by a current from a distant station or otherwise. We make use for this purpose of the currents of either magneto or voltaic electricity; but obtained in the latter case without the aid of soft iron from two hollow coils of insulated wire affixed to the pendulum of the regulator, and surrounding the poles of two permanent horseshoe magnets which coils vibrate in the direction of their length alternately, off one pole on to the other, a current being induced at each vibration, but in opposite directions.

Claims.—1. We claim in respect to electric telegraphs, and to all machines or machinery, to the moving of which electricity is or may be applied, the different arrangements of apparatus described under the first head of this specification, in so far as respects the division of each pole of the magnet into two or more poles, and the direct action on the index hand or pointer, or other recipient of the magnetic influence.

2. We claim the mode of causing the index hand or pointer to be permanently deflected (that is for any length of time required) in one direction, and bringing it back by the reversed current to its original stationary position, and keeping it there, as before described.

3. We claim the three several magneto-electric apparatuses described under the third head of this specification, in so far as regards the peculiar arrangements and combinations, whereby two distinct currents are obtained from the same magnet; the reversed current is obtained of equal intensity with the primarily induced current, and either single or double currents may be sent as required through any number of instruments at different stations.

4. We claim the improved system of visible symbols suitable for electric telegraphs, before described and exemplified.

5. We claim the employment in electric telegraphs, and in all other machines and machinery to the moving of which electricity is applied, of the peculiar compound of gutta percha, before described, for purposes of insulation and protection.

6. We claim the improved current reverser, before described, in so far as respects the effecting by a single depression of the lever or key, the completing, reversing, and breaking of the electric current.

7. We claim the application of currents of magneto-electricity to regulate the motion of time-keepers in the peculiar manner described under the seventh head of this specification; that is to say, in so far as regards the obtaining of the currents from the inductive action of permanent magnets and coils of insulated wire without the aid of soft iron. And—

8. We claim the application to the regulating of time-keepers of currents of electricity (whether magneto or voltaic) transmitted from a primary or standard clock by the improved apparatuses and instruments, and by the peculiar modes before described, that is to say, in so far as regards the alternate transmission of the current in opposite directions, and the different mechanical arrangements whereby that is effected.—*London Mech. Mag.* vol. l. p. 148.

Henley's Magneto-Electric Telegraph.—An experiment has been made under the direction of the French Government, to test the efficacy of Mr. Henley's Magneto-Electric Telegraph, which is worked without batteries of any kind, and at a fraction of the cost of the voltaic system. The line of railway assumed for the trial was that from Paris to Valenciennes. The persons present at the two stations were the Director of the French Telegraph, a commissioner appointed by the Belgian Government, and a few others. The distance is 180 miles, being the longest telegraph line in France. After a most satisfactory series of trials on the single distance, first with full power, and afterwards with one-twentieth of the power, the wires were connected so as to treble the total length of wire, making 540 miles to and from Paris and back; the magnetic message being communicated through the first wire, back by the second, through the third, and back again by the earth. It was not anticipated that the magnet could possibly work through this resistance; but, in fact, it is alleged it was worked as directly and rapidly as when only made to traverse the 180 miles with full power. The ordinary telegraph, with battery power, used by the French Government, was then put in requisition, but not the slightest effect was produced. On the single distance, even, a signal was not obtained for several minutes, owing, it is said, to some fault in the batteries. The government officers and others inspecting the working operation, expressed themselves thoroughly satisfied with the series of trials.—*London Mining Journal*, 1850.

Highton's Improvement in Electric Telegraphs.—On February 7, 1850, Mr. Edward Highton, Engineer, Middlesex, England, patented the following arrangement of telegraphic circuits: "Two or more signalizing instruments, and to each instrument two batteries are connected, so placed in regard to their poles as to work in opposite directions. A method of working electric telegraphs by the inductive influence of electro-magnets, making the dials, which carry the letters or characters, movable, instead of the pointers. As many of his claims are old, I only notice such as are important. He incloses his wires in flexible materials, such as lead; this was done in 1844, by Prof. Morse. The protecting the telegraphic wires by enveloping them in masonry; also, enamelling the exterior surface with gutta percha, rubbing the surface over with naphtha, or other solvents, and then smoothing it down by a cushion or brush.

A method of constructing the supporting posts out of a number of planks firmly united together, instead of out of one piece of timber, cut taperingly, as has hitherto been the custom.

Removing the atmospheric electricity which is collected during storms or other atmospheric disturbances, by causing the line wire, or a bar of iron connected thereto, previously inclosed in bibulous paper, or other fabric, to pass through a mass of iron filings.—*London Mech. Mag.* No. 1413, Sept. 1, 1850.

Brown and Williams's Improvements in Electric and Magnetic Telegraphs, March 17, 1850.—The only new claim is a method of protecting the conducting wires of electric telegraphs by strands of hemp put on by a braiding engine, and then coating the whole by gutta percha. And a method of connecting the transmitting wires by screwing one end of a wire into a nut formed on the corresponding end of the next wire.—*London Mech. Mag.* March 7, 1850.

W. S. Thomas's Improvements in Electric Telegraphs, patented Feb. 12, 1850.—Claim: What I claim as new is, the making of signals or marks for telegraphic purposes by the agency of heat, generated, induced, or controlled by a current of electricity passed along attenuated conductors, wires, or points; the signals being the flashes of light emitted by the heated conductor or points, are manifest to the eye of the operator; the marks being produced on the paper by the heated point or conductor are the record of the message.—*Journ. Frank. Inst.* Sept. 1850.

Mr. J. L. Palvermacher, C. E., of Vienna. Improvement in Galvanic Batteries, in Electric Telegraphs, and Electro-Magnetic and Magneto-Electric Machines.—I only notice his improvements in electric telegraphs, that is to say, in so far as regards, 1st. A method of varying the intensity of the current, either by increasing or diminishing the number of elements employed, or by interposing more or less powerful resistance to the current. 2d. The imprinting letters or signs by one completion of the current. 3d. The substitution of a letter cylinder for the letter wheel ordinarily employed, and a method of arranging the letters and signs on each cylinder. 4th. The application of a double escapement, each capable of assuming four directions, and each producing effects different from those produced by the others. 5th. The employment of four electro-magnets, to act on two soft iron bars, and thereby render a weak galvanic current available in two directions, and productive of two separate and distinct effects. And, 6th. The method of gradually detaching the keeper from the electro-magnet, by causing the springs which act upon the keeper magnet to come only successively into operation.—*Lond. Min. Journ.* vol. xx. p. 323, July, 1850.

Mitchell's Electric Telegraph.—At a recent meeting of the Philosophical Society of Glasgow, Alexander Mitchell, in a lecture on the electric telegraph, introduced some improvements stated to have been made by him in the general arrangement of the instrument, in the use of only one wire, and in the great facility by which the instrument can be worked. As given in a Glasgow paper, it appears that letters are arranged in a segment in front of the operator, and corresponding ones inscribing on keys similar to those of a piano-forte. On pressing down a key, the corresponding letter is immediately pointed to by a needle, a similar movement taking place at every station throughout the circuit. We know not if Mr. Mitchell was the first constructer of this kind of telegraph, but we do know that a similar one was exhibited two years since at the Society of Arts; and we also know that several inventors of telegraphs have been content to use only one wire, employing the earth for the return circuit.—*London Mining Journ.* vol. xx. April 13, 1850.

Austin F. Park's Improvements in Electric Telegraph Manipulators, Troy, New York, August 27, 1850.—"The nature of my invention consists in arranging machinery for closing and breaking an electric telegraph circuit in transmitting intelligence, whereby the operator, by giving a finger key one instantaneous touch, as distinguished from the prolonged touch applied to the key in ordinary machines, closes and breaks the electric circuit, at and during such times as is required to signal or record a telegraphic sign for a letter, figure, or other character."—*Journ. Frank. Inst.* vol. xx. p. 245.

The machine is stated to be ingenious, but unfortunately it is too complicated. The advantages of its use are to prevent mistakes from being made by telegraphic operators. I have not given the claims, as they could not be understood without a drawing.

Charles S. Bulkley's Improvements in Repeaters for Electro-Magnetic Telegraphs, Macon, Bibb Co., Georgia, Nov. 12, 1850.—Claim: "What I claim as my invention is, the manner of connecting two galvanic circuits with the two electro-magnets (in the said repeater), each of the said galvanic circuits, as it passes through my said telegraphic repeater, embracing in its course the armature of the opposite electro-magnet, in the said instrument, previous to its passing through the helices in the electro-magnet, embraced in its own respective circuit.

"In combination with the above, I also claim the connecting the points with the galvanic battery (or batteries), when the said points are placed in such positions in relation to the armatures of the electro-magnets in my said telegraphic repeater that, when either one of the said electro-magnets is charged, it will, by attracting its armature against one of the points, close the poles of the galvanic current in which the opposite electro-magnet (in the instrument) is in connection, and thereby throw the battery into said circuit."—*Journ. Frank. Inst.* vol. xxi. 3d series.

The object of this repeater is for the purpose of repeating or recording a communication in several places at once along a line, and at the same time allowing the galvanic circuit to remain open when the line is not in use.

Siemens's Improvements in Electric Telegraphs.—Ernst Werner Siemens, of Berlin, patented in England, April 23, 1850, the following improvements.—Claims: "1st. The constructing electro-magnets for telegraphic purposes, of longitudinally divided tubes of iron or other magnetic metal, or of bundles of wire of iron or other magnetic metal.

"2d. The construction of instruments for obtaining motion for telegraphic purposes, by means of one or two electro-magnets revolving on their axes within the fixed coils, by which they are rendered magnetic, or mounted on a transverse axis, and vibrating from side to side within the coils, by which they are magnetized.

"3d. The construction of instruments for producing motion for telegraphic purposes by means of metallic spiral coils or bands traversed by electric currents, and attracting or repelling each other; also producing motion in such spirals by the proximity of permanent magnets, which at the same time serve to produce electric currents by induction for working telegraphic apparatus.

"4th. The construction of the conducting contact pieces of alloys of platinum, iridium, or palladium with gold or silver, whether such alloys be farther alloyed by the admixture of other metals or not.

"5th. The construction of electric telegraphic printing apparatus in such manner that the magnet, which works the step by step motion, breaks and restores the circuit by the oscillation of the armature, or of the moving magnet itself.

"6th. The combining of electric telegraphic printing apparatus in the same circuit with indicating apparatus, when the magnets which work the step by step motion of either or both instruments break and restore the circuit by the oscillation of the armatures, or of the magnets themselves.

"7th. The impression of the types on the paper at the instant that the type wheel stops, by arranging the electro-magnet which acts on the hammer, so that the short intermittent currents which work the electro-magnet of the type wheel traverses the coils of this magnet without producing motion of the armature, which, however, is set in motion when the current is rendered continuous by the stoppage of the type wheel.

"8th. The arrangement of the magnet which acts on the hammer in electro-telegraphic printing apparatus, so that its own circuit is broken by the magnet itself towards the end of its stroke.

"9th. The arrangement of apparatus in electric printing apparatus in such manner that the printing is effected by pressing the type against paper, in contact with an inked roller.

"10th. An arrangement for retaining the moving piece which breaks and restores the electric circuit in its respective positions.

"11th. The application of a small pin for preventing the overrunning of the ratchet-wheel in electric telegraphic apparatus, with the step by step motion.

"12th. The arrangement of a transmitting apparatus with an indicating or printing electric apparatus worked by step by step motion, or with both together, in such manner that the transmitting apparatus breaks and restores the circuit of the telegraphic apparatus, which reciprocally breaks and restores the circuit of the transmitting instrument.

"13th. The combination of a self-acting alarum, with a transmitting apparatus.

"14th. The combination of a self-acting alarum with a transmitting instrument, which breaks and restores the circuit of the alarum magnet, which in its turn reciprocally breaks and restores the circuit of the transmitting instrument.

"15th. The combination of one or two cylinders carrying pins, with a series of springs and keys, for making contacts for transmitting a distinct determinate succession of electric currents in one or both directions by the depression of each key.

"16th. The employment of an implement of the nature of a plough, and revolving cutters for making trenches or channels to receive underground line wires.

"17th. The application of the propelling power of a locomotive engine to giving motion to such implements.

"18th. Conducting under-ground line wires into the ground, by means of suitable guides, which either form part of, or immediately follow, the cutting instruments.

"19th. The following improvement in the manufacture of coated wire for electric telegraphic purposes; 1st, an arrangement of machinery for coating the wire, with two cylinders and pistons, by which the pressure of the semi-fluid mass against the wire is equalized; 2d, arranging these cylinders (or cylinder when only one is used), so that they may be removed and replaced by others, while the former are being discharged; and 3d, the consolidating of gutta percha or its compounds, within these cylinders in vacuo.

"20th. The testing of coated wire for telegraphic purposes, by passing it through water, with which is connected an apparatus capable of producing electric shocks, so that the circuit may include the person of the operator, and may be completed by the passage of the electricity through the defects in the coating in the wires.

"21st. The covering of insulated under-ground line wires with strips of sheet lead.

"22d. Establishing a direct communication between under-ground line wires and the earth, by means of a thin wire of German silver, or some other imperfectly conducting substance, so that the resistance to the passage of the electricity may be capable of being regulated at pleasure."—*London Mechanics' Magazine*, No. 1421, Nov. 2, 1850.

An interesting report of M. Siemens' telegraph to the Academy of Science, Paris, will be found in vol. xxi. third series, of this Journal, pp. 209 and 215, 1850.

The commission conclude their report of M. Siemens's apparatus in the following words: "The commission have examined M. Siemens's apparatus with great interest, and remarked, throughout, an evidence of a perfect intelligence of the theory, as M. Siemens appears to have taken into account all the complicated phenomena which are manifested in the conductors and electro-magnets, especially when the actions are of short duration.

"M. Siemens's system, if worked with care and attention, appears to possess incontestable superiority over all other apparatus of the like nature, that is to say, the ordinary arrangement of alphabetic apparatus, as the latter do not work with the same degree of precision and accuracy. With regard to speed, the commission are led to believe that M. Siemens's apparatus surpasses all other alphabetic apparatus; their opinion is, also, that M. Siemens's improvements in the construction of electro-magnets will prove advantageous."

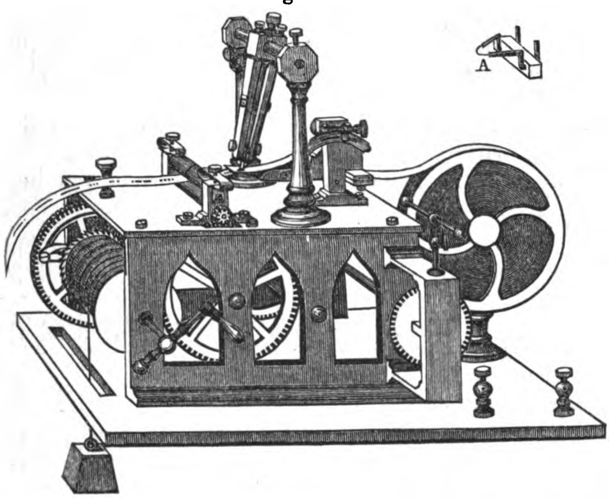
Horn's Igniting Telegraph, patented June 25, 1850.—The register invented by G. H. Horn, of Boston, employs a principle, namely, the heating or igniting effect of electricity. When an electrical current flows through a fine platinum wire, it ignites it, or brings it to a red heat. If this wire is bent, as at A, in Fig. 57, so as to be in contact, for a short distance, with a moving fillet of paper, it will burn a hole through the paper when the current passes. This can be done with great rapidity, so as to represent, probably, a hundred linear letters per minute.

The greater part of this instrument consists of the clock-work, spool, &c., required for moving the paper. Above the clock-work are two pillars, supporting an axis, upon which is the adjustable wire-holder, the lower extremity of which is seen touching the fillet of paper. By means of the connections and insulations of the pillars, axis, and wire-holder, the platinum wire, which passes over a little slip of porcelain at the end of the wire-holder, becomes part of the circuit, with which the two screw-cups on the right of the base-board are connected. When the wire needs adjustment, the wire-holder can be turned upon its axis. The bed supporting the fillet of paper is also adjustable, so as to regulate the contact between the wire and the paper.

This register requires a quantity current to produce the effect of ignition, and therefore needs a receiving instrument and local battery, to be operated by the telegraphic circuit.—*Book of the Telegraph*, p. 37.

This telegraph is the same in principle with that patented by Wm. S. Thomas, Feb. 13, 1850.

Fig. 57.



Batchelder and Farmer's Pyrographic Telegraph Register.

The record is made upon various kinds of paper, by means of a heated wire, which is moved to or from the paper by a deflecting needle, the marking wire being heated by a spirit-lamp, or other convenient generator of heat. We find that the pink tissue paper, made from linen stock, is the best for the purpose, the straw-colored mark being very legible on the pink ground. The paper is used dry, and may be in the form of a fillet, or in a large sheet, which may be filed and preserved for reference. The slightest contact of the heated wire with the paper is sufficient to produce a distinct mark, so that we make the record without using a local or branch circuit.—*Boston*, 1853.

The Telegraph of Brett and Little, of London.—The magnet employed in this telegraph is in the form of a ring or horseshoe, and is suspended in the centre of helices of copper wire, which are double and of a circular form. This magnet is deflected either to the right hand or to the left, according to the direction of the current. The indicators are not magnets, but are moved by the agency of the magnets, by which a distinct and certain indication is insured.

Another modification of this instrument has been made by Mr. Little, which is as follows: The patent instrument is of the form of a disk of mahogany, about 1 foot high by 8 inches broad, standing in a vertical position on a pedestal; the only appliances at the back being the metallic buttons, or binding screws, necessary to convey the galvanic fluid from the battery to the indicators. Two tubes of glass, about one-fourth of an inch in diameter and 3 inches high, are placed in front of the disk, with the alphabet engraved on a metallic plate placed between them, with the number of deflections required to express each letter, stated in plain figures. On the top of each of these tubes, which contain spirits of wine, is a small but powerful cylindrical magnet about one-fourth of an inch in diameter, from the bottom of which are suspended, by magnetic attraction, two needles with the points upwards.

On completing the galvanic circuit, these needles are deflected with equal rapidity with one on an axis; and, on breaking connection, the needle is instantly arrested in its fall to the perpendicular by the density of the fluid, with almost as dead a stop as the seconds hand of a watch, avoiding the vibration so annoying in the old system, which tends so much to puzzle and mislead.—*Lond. Mining Journ.* vol. xxi. p. 183.

Bakewell's Electric Telegraph.—This is a modification of the instrument of Alex. Bain, Esq., noticed under the head of Electro-chemical Telegraph, employing the same chemical agent, but instead of holes cut in paper, the message to be sent is written on a sheet of tinfoil with sealing-wax varnish; this is placed on the transmitting cylinder; all the lines of the non-conducting varnish serving to break the connection. On the receiving cylinder, a sheet of paper moistened with acidulated ferro-prussiate of potash is placed. When the connection is completed, electro-chemical decomposition is effected; and where any interruption occurs, no change takes place.

Improvements in Electric Telegraphs, by John McGregor.—In No. 1409 of the *London Mechanics' Magazine*, for 1850, there is a notice of a patent for some improvements in Electric Telegraphs, and amongst the abstract of claims is the following:—

"8. An arrangement for sounding one out of a number of alarums."

It is impossible, of course, to infer from this brief notice what are the particulars of the invention, and I am not aware of the mode at present adopted. If there be none, by which one only out of a number of stations may be signalled, then I would propose for consideration a plan for effecting this desirable object which occurred to my mind some time ago.

Let the accompanying figure represent a wheel, with marks 1, 2, 3, and 4, at equal distances on the circumference, and corresponding in number to the whole number of stations, say 60, connected by telegraph.

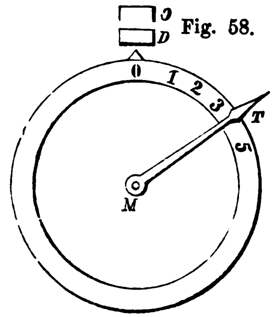


Fig. 58.

Let the axle of this wheel be made to turn once in a minute by clock-work, and the wheel be so placed on the axle that so long as a detent *D* rests on a projection *P* (opposite to the mark *O*), the wheel shall be at rest; but when *D* is lifted (by electricity), the wheel shall have sufficient friction-hold on the axle to cause it to turn round in the same time—that is, once in a minute. Now let *R* be a radial arm, capable of being placed at any of the marks 1, 2, 3, &c., and furnished with a projection *T*, which shall always pass free of *D*, but be caught by a catch *C*, provided that catch descends when *T* is within a certain distance on either side of the line *C M*. The catch *C* is supposed to be moved by electricity, and if it falls so as to strike *T*, the wheel will be stopped, a certain circuit be completed, and a bell rung; but if *C* does not fall on *T*, it will be wholly inoperative on the machine.

A wheel similar to that described should be at every station, and in general the radial arm *R*, at each station, should be left opposite to the particular number denoting that station.

Thus the arm *R*, at No. 2 or No. 27, will be at angles at the line *D N*, particularly representing such stations respectively.

Supposing magnets, circuits, and bells to be so arranged that the bell of each station shall be set ringing only when a current is completed through *C* and *T*, we may describe the action of the instrument as follows:—

If station No. 20 *requires to correspond with No.* 35, *then*—

1. Put the arm *R* opposite the mark 35 on the rim.

2. Send a current along the wire which will release the detents *D at all the stations*, and all the wheels will commence moving (at nearly the same rate).

3. When the point *T* comes under *C* (that is, in 35 seconds), the similar point at station No. 35 will then be beneath its catch; therefore send another current along the line, which will affect only wheels No. 35 and No. 20, and will ring the bell of 35.

4. After the communication of the message, return the wheels 20 and 35 to their original position. All the other wheels will have gone round for *one minute*, and will *themselves* have come into the exact position they were in at first.

By this means, the average time (in the above supposed circumstances) required to signal one station would be half a minute; but if that should be thought too long (!) the wheels might move at double the proposed rate, and the convenience of this plan will depend on the time of revolution of the wheels, and the amount of margin which can be permitted on either side of a perfect agreement of their motions.

We shall see that a comparatively inaccurate adjustment would not impair the usefulness of this simple apparatus; for if the catch *C* were made of such a breadth as to operate on *T*, when it is at the distance from the line *M C* represented by *nearly* half an interval on either side of that line, an error of nearly half a second in a minute may be allowed without deranging the instrument.

Henry Haighton, of England, secured a patent in September, 1844, for certain improvements in electric telegraphs.

The object of this invention being to adapt a system of telegraphing to common or frictional electricity, the inventor uses for this purpose a Leyden battery charged with Armstrong's hydro-electric, or other powerful electric machine. For the purpose of regulating the number of discharges sent, the nature of the charges as to positive and negative, and the times at which the discharges are transmitted, an instrument is employed which admits of various modifications according to circumstances. By this invention, it can be shown that in ten discharges any signal out of a number of sixteen thousand may be made; and by thirty discharges, any one of more than a thousand millions.

"The method of reading the signals at the terminal point is by means of two wires, one communicating with the point of transmission, and the other with the earth; they are placed at right angles to a sheet of paper which is moved along by machinery, so that each discharge may traverse the surface, and penetrate the substance of the paper close to the wire giving out the negative fluid. The paper is colored with chromate of lead, and moistened with sulphuric acid, to expedite the passage of the spark; and by this means the sparks leave upon the paper a register of the signals that have been made."—*Lond. Mech. Mag.* vol. xlii. p. 122.

ON THE

TELEGRAPHIC LINES OF THE WORLD.

UNITED STATES.

In giving an account of the number of telegraphic lines, it will be proper to place the United States as first on the list, from the number and extent of the lines, and from the extensive use made of them in every department, both for business and pleasure. Still, it will be but an approximation to the number, for they are like the spider's web, forming a complete network over the length and breadth of the land, from the extreme north-eastern point to the western boundary of Missouri, adjoining the Indian territory. A continuous line of telegraph now extends from the verge of civilization on the western frontier (east of the Rocky Mountains) to the north-eastern extremity of the United States; and the time is not far distant when we shall have a telegraph from the Mississippi River to San Francisco. This is no fancy sketch, as the route is already selected for the California line, and a most interesting report was presented to the Senate of the United States in the session of 1851, by the Committee on Post Offices and Post Roads.

"The route selected by the committee is, according to the survey of Captain W. W. Chapman, U. S. Army, one of the best that could be adopted, possessing as it does great local advantages. It will commence at the city of Natchez, in the State of Mississippi, running through a well settled portion of Northern Texas, to the town of El Paso, on the Rio Grande, in latitude 32°; thence to the junction of the Gila and Colorado rivers, crossing at the head of the Gulf of California to San Diego, on the Pacific; thence along the coast to Monterey and San Francisco. By this route, the whole line between the Mississippi River and Pacific Ocean will be south of latitude 33°; consequently, almost entirely free from the great difficulties to be encountered, owing to the snow and ice on the northern route, by the way of the South Pass, crossing the Sierra Nevada Mountains in latitude 39°. The whole distance from the Mississippi to San Francisco will be about 2,400 miles."

The great benefits to be derived the report fully and ably sets forth, whether in a military, commercial, or social point of view.

"In a commercial point of view, the line in question assumes a gigantic importance, and presents itself not only in the attitude of a means of communication between the opposite extremes of a single country, however great, but as a channel for imparting knowledge between distant parts of the earth. With the existing facilities, it requires months to convey information from the sunny climes of the East to the less favored, in point of climate, but not less important regions of the West, teeming as they do with the products of art and enterprise. Let this line of wires be established, and the Pacific and Atlantic Oceans become as one, and intelligence will be conveyed from London to India in a shorter time than was required ten years since to transmit a letter from New York to Liverpool.

"Nor does the importance of the undertaking claim less interest, when regarded in a social point of view. California is being peopled daily and hourly by our friends, our kindred, and our political brethren. The little bands that a few centuries since landed on the western shores of the Atlantic, have now become a mighty nation. The tide of population has been rolling onward, increasing as it approached the setting sun, until at length our people look abroad upon the Pacific, and have their homes almost within sight of the spice groves of Japan. Although separated from us by thousands of miles of distance, they will be again restored to us in feeling, and still present to our affections, through the help of this noiseless tenant of the wilderness."

In the Congressional *Globe* of April 6, 1852, Mr. Douglass presented the memorial of Henry O'Reilly, proposing a system of intercommunication by mail and telegraph, between the Atlantic and Pacific States. All he asks is permission to establish a telegraphic line from the Mississippi Valley, where the wires now terminate, to the Pacific Ocean, and to be protected by a line of military posts, so that he can keep up the communication for the benefit both of the government and of the public. Mr. O'Reilly states in this memorial, that, within two years from this time, with this line completed, he would be able to deliver the European news on the shores of the Pacific within one week from the time it left the European Continent. The motion was referred to the Committee on Territories.

I am happy to state that in August, 1853, the project of telegraphic communication with the Pacific is rapidly becoming feasible. The vast plains which, not many months ago, were only inhabited by wild Indians, who would be no respecters of telegraph wire, are now the highways over which thousands of emigrants are constantly passing and repassing towards the great regions which border upon the Pacific. In view of the necessity of this important matter, the Pacific Telegraph Company is now organized. Mr. H. O'Reilly, with a capital of five millions of dollars, the bold projector of the scheme, who has been urging it for some years, has been appointed President, and Tal. P. Shaffner Secretary. Long before the railroad track to the Pacific is graded, the iron highway of thought will be open to all who desire to avail themselves of its important privileges.

The authorities of Newfoundland have granted to Mr. H. B. Tibbatts and associates, of New York, the exclusive right to construct and use the magnetic telegraph across that island, for the period of thirty years. The grant is designed to facilitate Mr. Tibbatts in his scheme for the establishment of steam and telegraphic communication between New York and Liverpool or London *in five days*. The telegraph is to extend from New York to St. Johns, from whence a line of steamers is to run to Galway, where another line of telegraph is to commence, extending to London. This latter line will, it is said, be completed during the current year. The distance from St. Johns to Galway is 1,647 miles, or about five days, by steam.

I am very sorry to state that "the Nova Scotia House of Assembly have defeated, by a vote of 67 to 16, a bill chartering an Opposition Telegraph Company across that province. This act probably seals the fate of the Submarine Telegraph from Newfoundland. The object of the projectors of that line was to get this charter, with a view to an exclusive line from St. Johns, Newfoundland, into the United States. This refusal of the Nova Scotia Legislature to grant them a charter, quashes for the present their efforts, and we presume will arrest the construction of the line."

Advices from Newfoundland state that the work upon the telegraph line has been suspended, and that Mr. Gisborne, the superintendent, has left the province:—*Halifax, N. S.* August 22, 1853.

I cannot but regret that the only feasible plan of uniting the United States and Europe has been abandoned; yet I still hope that the company which are owners of the regular line from Halifax will take it in hand and carry it out, so that there may be communication between Great Britain and the United States within five days.

"*Telegraph between Europe and America.*—The idea of connecting Great Britain and the United States by telegraph, is revived in London on a grand scale. The proposition is to extend the line from Scotland by way of the Orkney, Shetland and Faroe Islands to Iceland, and thence to Greenland; thence across Davis's Straits to Labrador and Quebec. The entire length of the line will be 2,500 miles; and the submarine portion of it from 1,400 to 1,600. From the Shetland Islands it is proposed to carry a branch to Bergen, in Norway, connecting it there with a line to Christiana, Stockholm, Gottenburg and Copenhagen; from Stockholm a line may easily cross the Gulf of Bothnia to St. Petersburg. The whole expense of this great international work is estimated considerably below £500,000."

There are numerous lines in actual and successful operation under the title of Morse, House, and Bain, each giving every facility to the business man.

"Three Morse wires run to Boston, three to Buffalo, five to Philadelphia, four to Washington, and two on to New Orleans; on the western and Canada routes there is generally but one."

New York and Boston Magnetic Telegraph Company, from N. York to Boston, about 250 miles; three wires, one passing through Providence, R. Island, the other through Springfied, Mass., using the Morse patent.

Union of Telegraphs.—The lines of the Rhode Island Telegraph Company, extending from Worcester to Providence, Fall River, Taunton, New Bedford, Warren and Bristol, have been sold to the New York and New England Union Telegraph, which is the Morse and Bain line united. The price paid is $5,000. The cost of the lines sold, including the patent, was about $20,000. March 1, 1853.

Merchants' Telegraph Company, from New York to Boston, about 250 miles; two wires passing through Providence, using Bain's patent.

Boston and Portland Telegraph Company, from Boston to Portland, 100 miles; one wire, using Morse's patent.

The Merchants' Telegraph Company have one wire from Boston to Portland, 100 miles; Bain's patent.

The New York and Boston Telegraph Company, and Merchants' Telegraph Company, between New York and Boston, have consolidated and formed one company under the title of N. York and N. England Union Telegraph Company; Boston and Portland are also included in the new company, which extends from New York to Portland.

Maine Telegraph Company, from Portland to Calais, Maine, about 306 miles; one wire; Morse's patent.

St. Johns and Halifax line, from Calais to Halifax, about 400 miles; one wire; Morse's patent.

There is a line of Bain Telegraph from Boston through N. Hampshire to Burlington, Vt., thence to Ogdensburg, New York; about 350 miles; one wire.

New York, Albany, and Buffalo line, from N. York to Buffalo, through Albany and Troy; 513 miles long; three wires, using Morse's patent.

New York State Telegraph Company, from N. York to Buffalo, via Albany, two wires; 550 miles long; with a branch from Syracuse to Ogdensburg, via Oswego; about 150 miles; one wire; also a branch from Troy to Saratoga, 36 miles; one wire; use Bain's patent. There is also a Morse line from Syracuse to Oswego, about 40 miles.

House Telegraph Company, from N. York to Buffalo, via Albany, 550 miles; two wires; use House's patent.

New York and Erie Telegraph, from New York to Dunkirk, via Newburg, Binghamton, and Ithaca; 440 miles, one wire; Morse's patent.

New York and Erie railroad Telegraph, for railroad use, along the line of N. York and Erie Railroad, 460 miles; Morse's patent.

Magnetic Telegraph Company, from New York to Washington, via Philadelphia; seven wires, 260 miles; Morse's patent.

House line from New York to Philadelphia, 100 miles, one wire; House's patent.

Troy and Canada Junction Telegraph Company, from Troy to Montreal, through Burlington, Vt., 260 miles; one wire; Morse's patent.

Erie and Michigan Telegraph Company, from Buffalo to Milwaukie, via Cleveland, Detroit, and Chicago; one wire all the way; second wire from Buffalo to Cleveland; 800 miles long; Morse's patent.

Cleveland and Cincinnati Telegraph Company, from Cleveland to Cincinnati; 250 miles long; two wires; Morse's patent.

Cincinnati to St. Louis, via Indianapolis, 400 miles long; one wire; Morse's patent.

Cleveland and Pittsburg Telegraph Company, from Cleveland to Pittsburg, 150 miles, one wire; Morse's patent.

Cleveland and Zanesville line, from Cleveland to Zanesville, 150 miles; one wire; Morse's patent.

Lake Erie Telegraph Company, from Buffalo to Detroit, via Cleveland, 400 miles; one wire; Morse's instrument, built under O'Reilly's contract with Morse, with branch from Cleveland to Pittsburg, 150 miles; one wire.

Cincinnati and Sandusky City line, about 200 miles; one wire; Morse's patent.

Toledo to Terre Haute, via Fort Wayne, about 300 miles; one wire; Morse's patent.

Chicago to Dayton, one wire; Morse's line.

Chicago to St. Louis, via Peoria, about 400 miles; one wire; Morse's patent.

Milwaukie to Green Bay; 200 miles; one wire; Morse's patent.

Milwaukie to Galena, via Madison, about 250 miles; one wire; Morse's patent.

Chicago to Janesville; one wire; Morse's patent.

Buffalo and Canada Junction Telegraph Company, from Buffalo to Lewiston; one wire; connecting with a wire in Canada that runs to Toronto, about 200 miles.

There are three companies, if not four, owning the line from Boston to Halifax; from Portland to Calais, Maine, one company using the Morse instrument; from Calais to Halifax, the Morse instrument is used; the line in each province is owned by separate companies, organized under charters from their respective legislatures.

The first American telegraphic line was established in May, 1844, between Washington and Baltimore, over a length of 40 miles.

The line from Washington to Baltimore was then extended to Philadelphia and New York, over a distance of 250 miles. It reached Boston in 1845, and became the great line of the North, from which branched two others: one, the length of 1,000 miles, from Philadelphia to Harrisburg, Lancaster, Pittsburg, Ohio, Columbus, Cincinnati, Louisville (Kentucky), and St. Louis (Missouri); the other, the length of 1,300 miles, from New York to Albany, Troy, Utica, Rochester, Buffalo, Erie, Cleveland (Ohio), Chicago (Illinois), and Milwaukie (Wisconsin).

A fourth line goes from Buffalo to Lockport, Queenstown, the Lakes Ontario and Erie, the Cataract of Niagara, Toronto, Kingston, Montreal, Quebec, Halifax, and the Atlantic Ocean, over an extent of 1,395 miles.

Two lines south; one from Cleveland to New Orleans, by Cincinnati; the other from Washington to New Orleans, by Fredericksburg, Charleston, Savannah, and Mobile. The first is 1,200 miles long, the second 1,700 miles. This line has been extended west to Independence, Missouri.

The entire length of the line from New York to New Orleans, via Charleston, Savannah, and Mobile, is 1,966 miles; and this distance was not worked in one circuit, nor can it be with either of the existing systems with the best mode of insulating in use. The only instance of direct communication was secured by dividing the line into several circuits, probably five or six, and connecting those circuits through the agency of an instrument termed a connector, the effect of which is to cause one circuit to work the other through the entire series, thus producing a result similar to working through the entire line in one circuit. The connector is an instrument first invented and applied by E. Cornell, Esq., of New York, on the New York, Albany, and Buffalo line, at Auburn, N. Y., to work a branch line from Auburn to Ithaca, for the purpose of taking news reports at Ithaca; at the same time they were being transmitted from New York to Buffalo on the main line; this was adopted in the year 1846; it was found to work admirably, and he afterwards modified it so as to make it applicable to working both ways in a main line, or, in other words, to make it capable of working a number of series of circuits in a main line; the instrument was adopted for this purpose on the New York and Erie, and Erie and Michigan lines, in the year 1848, and has been in constant use ever since; by it they having frequently worked direct from New York to Milwaukie, 1,300 miles. The instrument used on the New Orleans line, which is described in my *Lectures on the Telegraph*, was adopted by Mr. Chas. Bulkley, the then superintendent of the line, who claims it as his invention, made in 1850 or 1851.

The greatest distance that Mr. Cornell has known any lines to work in one circuit, was from Boston to Montreal, via New York, Buffalo, and Toronto, a distance of about 1,500 miles; this, however, was done when the earth was frozen, and the lines thus insulated by the frost much better than man has yet contrived to insulate them without its aid. There are no lines working successfully in *one* circuit more than 550 miles; lines may be so insulated as to work in one circuit under favorable states of the atmosphere from 800 to 1,000 miles.

The House Printing Telegraph has only been in operation since 1846, but even in that short time has spread itself from New York to St. Louis, New York to Boston, and New York to Philadelphia, to Washington, working to the entire satisfaction of our business community, and, wherever found, exciting the admiration of the curious, being able to print in Roman capitals communications in almost every language.

This line consists of the Boston and New York Telegraph Company, using the House Printing Telegraph; about 600 miles of wire, two wires; with stations at Boston, Mass.; Providence, R. I.; Springfield, Mass.; Hartford, Conn.; New Haven, and New York.

A line is being constructed to connect with this Boston line, running from Springfield, Mass., to Albany, N. Y.; there to intersect the New York and Buffalo line, using the same instruments, extending from New York to Buffalo, a distance of 570 miles. One wire is now in operation, connecting with Poughkeepsie, Troy, Albany, Utica, Syracuse, Lyons, Rochester, Albion, Lockport, and Buffalo; and another wire, nearly completed the same distance. This line is to continue to St. Louis, Mo., connecting with Cleveland, Cincinnati, Louisville, and St. Louis, which will be completed the entire distance in 1852; the whole length being 1,500 miles.

The New Jersey Magnetic Telegraph Company, using the House instruments, and the first line of this kind ever put in operation, extends from Philadelphia to New York; two wires, 132 miles. A line also extends south to Baltimore and Washington. For this information, I am indebted to the politeness of William J. Philips, Esq., Telegraphic Engineer on the House line at Philadelphia.

Making the whole number of miles 2,202; rate, 25 cents for the first ten words from Philadelphia to New York.

The Bain line, now a Morse line, Mr. Henry J. Rodgers, General Superintendent from New-York to Washington, has lately constructed, at an expense of $10,000, spars 310 feet high, at the Palisades and Fort Washington, ten miles above the city of New York, for the purpose of sustaining their wires over the river, instead of the method formerly employed, by passing the current through the water, by wires laid across the North River. He considers this method, by means of suspension on spars, as being more permanent and durable. The price of telegraphic dispatches by this line is the same as the others. They have offices in Boston, Providence, New York, Philadelphia, Wilmington, Baltimore, and Washington.

List of the Bain Telegraph Lines in the United States.

	Wires.	Miles.
1. New York to Boston, via Providence, 250 miles each	2	500
2. Boston to Portland	1	100
3. Boston through New Hampshire to Burlington, Vermont, thence to Ogdensburg, New York	1	350
4. Troy to Saratoga	1	36
5. New York to Buffalo (513 miles each)	2	1,026
Total	7	2,012

List of the Morse Telegraph Lines in the United States.

	Wires.	Miles.
1. Washington to New Orleans, by way of Richmond, Va.	1	1,716
2. Washington to New-York, by way of Baltimore and Philadelphia, each 260 miles	7	1,820
3. Harper's Ferry to Winchester, Va.	1	32
4. Baltimore, by way of Pittsburg and Wheeling, to Cumberland	1	324
5. Baltimore to Harrisburg, by way of York, Pa.	1	72
6. York to Lancaster, by way of Columbia, Pa.	1	22
7. Philadelphia to Lewistown, Del.	1	12
8. Philadelphia to Pittsburg, by way of Harrisburg	1	309
9. Philadelphia to Pottsville, by way of Reading	1	98
Carried up	15	5,415

	Wires.	Miles.
Brought up	15	5,415
10. Reading to Harrisburg	1	51
11. New York to Boston, about 250 miles, by way of Providence, Rhode Island, and Springfield Massachusetts	3	750
12. New York to Buffalo, by way of Troy and Albany	3	1,539
13. Syracuse to Oswego, N. Y.	1	40
14. Boston to Portland, by way of Dover	2	200
15. Worcester to New Bedford, by way of Providence	1	97
16. Worcester to New London, by way of Norwich	1	74
17. Portland to Calais, Me.	1	350
18. Calais to Halifax, via St. Johns	1	400
19. Troy to Montreal, Canada, by way of Rutland and Burlington	1	278
20. Buffalo to Queenston, Canada by way of Lockport	1	48
21. Buffalo to Milwaukie, Wis., by way of Cleveland, Detroit, and Chicago; second wire from Buffalo to Cleveland	2	1600
22. Pittsburg to Cincinnati, O., by way of Columbus	1	620
23. Columbus to New Orleans, by way of Tuscumbia and Natchez	1	638
24. New Orleans to Balize, at the mouth of the Mississippi	1	90
25. Cincinnati to St. Louis, Mo., by way of Vincennes	1	410
26. Cincinnati, Ohio, to Maysville, Ky., by way of Ripley	1	60
27. St Louis to Chicago, by way of Alton, Ill.	1	330
28. Alton to Galena, by way of Quincy	1	380
29. St. Louis to Independence, Mo.	1	25
30. New York to New Orleans, by way of Charleston, Savannah, and Mobile	1	1,966
31. New York to Dunkirk, via Newburg, Binghamton, and Ithaca	1	440
32. New York and Erie railroad Telegraph, for railroad use	1	460
33. Cleveland to Cincinnati	2	500
34. Cincinnati to St. Louis, via Indianapolis	1	400
35. Cleveland to Pittsburg	1	300
36. Cleveland to Zanesville	1	150
37. Buffalo to Detroit, via Cleveland	1	400
38. Cincinnati to Sandusky City	1	218
39. Toledo to Terre Haute, via Fort Wayne	1	300
40. Newark to Zanesville, Ohio	1	40
41. Mansfield to Sandusky	1	40
42. Columbus to Portsmouth, Ohio	1	90
43. Columbus to Lancaster, Ohio	1	25
44. Lancaster to Logansport	1	15
45. Cincinnati to Dayton and Chicago (wire in Ohio)	1	100
46. Milwaukie to Green Bay	1	200
47. Milwaukie to Galena, via Madison	1	250
48. Chicago and Janesville	1	100
49. Zanesville to Marietta	1	66
50. New York to Sandy Hook	1	80
51. Camden to Cape May	1	100
52. Camden to Absecom Beach, being constructed		
53. Philadelphia to Mount Holly " "	1	25
54. Harrisburg to Sunbury " "	1	26
55. Cleveland and New Orleans by Cincinnati	1	1200
56. Dunkirk, N. Y., and Pittsburg	1	200
	67	19,963

Whole number of Morse line received;	67 wires, length	19,963
Whole number of House line received;	8 wires, "	2,400
Whole number of Bain line received;	6 wires, "	2,012
Total number of wires	81	
Total number of miles in the United States		24,375

There is an "Erie and Alleghany Telegraph Company," having a line from Dunkirk, N. York, via Warren, Pa., thence to New Castle, Pa., and thence to Pittsburg.

Consolidation of Telegraphs.—We learn from the Cincinnati papers, that all the leading Telegraph lines in the West, and South, and Northwest have been united in business interests. The N. Orleans and Ohio line, extending from N. Orleans to Pittsburg; the People's Line from N. Orleans to Louisville; the two wires, Louisville, Cincinnati, and Pittsburg line, and the Western line from Wheeling and Pittsburg to Baltimore and Washington City are all direct parties to the contract—securing these arrangements.

The union brings the Morse and O'Reilly offices in Cincinnati and all other cities on the lines named together. In Cincinnati the Morse lines are removed to the O'Reilly office, which will hereafter be known as the *National Telegraph Office.* A union has been effected between the Morse and Bain lines between New York and Boston. Also the New York and Erie Telegraph Line, built by E. Cornell and Speed, has been united by a lease to the Morse or Faxton Company.

August 24, 1853.—A new line of telegraph from Indianapolis to Cleveland is to be built, to be finished within ninety days.

"From an Annual Report of the 'Magnetic Telegraph Company,' extending from Washington to New York, just published, we glean the following table of the number of messages sent and the amount of money received for tolls for each month of the year. The business, it will be seen, is steadily on the increase.

		Messages.	Receipts.
July,	1851,	13,463	$4,991.62
August,	"	16,580	5,391.96
September,	"	16,744	4,979.35
October,	"	18,641	6,322.98
November,	"	15,969	5,798.50
December,	"	17,896	7,249.73
January,	1852,	23,962	11,352.97
February,	"	27,880	11,341.75
March,	"	27,934	11,918.63
April,	"	25,523	11,114.01
May,	"	24,933	10,949.75
June,	"	25,298	11,832.03
		253,857	$103,232.37

"The first six months was before the consolidation with the Bain line; the last six was after the consolidation, and includes the receipts of both lines. The business of the several months fluctuates a little, though, by comparing the first six months with the last six, it will be seen that the use of the line is increasing wonderfully. The number of messages sent in the first six months, is 99,313, producing $34,733.14; and in the last six the number was 154,514, producing $68,499.23. It is proper to state, however, that, in January last, the

'Magnetic Telegraph Company' became possessed of the wires of the Bain line, extending from Washington to New York, by which the company's facilities were increased, and its business augmented beyond what it probably would have been without such facilities. The increase of December over July, and of June over January, and the very large business of October and March, the most active business months in the year, show the general and growing use of this wonderful invention by the public generally, as well as by that enterprising class of persons, the merchants, brokers, and bankers. The following table exhibits the annual receipts of this company, which was the first organized in the country, from its commencement to the present:—

From January 27, 1846, to July 1, 1846	$4,228 77
" July 1, 1846, to July 1, 1847	32,810 28
" July 1, 1847, to July 1, 1848	52,252 81
" July 1, 1848, to July 1, 1849	63,367 62
" July 1, 1849, to July 1, 1850	61,383 98
" July 1, 1850, to July 1, 1851	67,737 12
" July 1, 1851, to July 1, 1852	103,860 84
Total amount received up to July, 1852	$385,641 42

DIVIDENDS.

1846 and 1847	none
1848	6 per cent.
1849	9 " "
1850	2 " "
1851	2 " "
1852	9 " "

"The capital of the company is $370,000. It has six wires from Washington to Philadelphia, and seven from Philadelphia to New York. It has offices at Washington, Baltimore, Havre de Grace, Port Deposit, Wilmington, Philadelphia, Trenton, New Hope, Princeton, New Brunswick, Newark, Jersey City, and New York, and employs in its service, including messengers, outside laborers engaged in keeping the line in order, clerks, operators, etc., about one hundred and twenty-five persons. The distance from Washington to New York, by the line of the wires, is about two hundred and seventy-five miles; requiring between nineteen hundred and two thousand miles of wire. The cost for chemicals is considerable, and the amount of stationery quite immense; the single item of envelops for the year reaching in number nearly one quarter of a million. This is the pioneer line of magnetic telegraph in the world, and very large sums have been expended in various experiments, the object all the time being to make it as perfect as possible. It is now, perhaps, all things considered, for its length, the best appointed and most reliable in the country, and probably the most productive in the world. Within the last two or three years, it has undergone thorough renovation, and while under its present management, the public may rest assured it will not suffer deterioration."

I received the following interesting account of the telegraph in Ohio, showing the rapid progress which it is making in the West, for which account I am indebted to the politeness of J. H. Wade, Esq., of the "Wade Telegraph Office," Columbus, Ohio.

	Miles.
Cleveland and Cincinnati Telegraph Company, with two lines on separate routes, with an arm from Newark to Zanesville, and another from Mansfield to Sandusky; length of line	640
Cincinnati and Sandusky Telegraph Company, line from Cincinnati to Sandusky	218
Scioto Valley Telegraph Company, line from Columbus to Portsmouth	90
Columbus and Lancaster Telegraph Company, line from Columbus to Lancaster, 25 miles, and an arm to Logansport, 15 miles	40
Pittsburg, Cincinnati and Louisville Telegraph Company, from Pittsburg to Louisville, two wires on same poles, 280 each (in Ohio)	560
Cincinnati and St. Louis Telegraph Company, from Cincinnati to St. Louis	50
House Printing Telegraph line, from Buffalo to Cincinnati	325
Erie and Michigan Telegraph Company, from Buffalo to Milwaukie, with two wires as far as Cleveland; length of wire in Ohio	260
Lake Erie Telegraph Company, from Buffalo to Detroit, with branch to Pittsburg; length of wire in Ohio	286
Cleveland, Wheeling, and Zanesville Telegraph Company	225
Cleveland and Pittsburg Telegraph Company; length of wire in Ohio	90
New Orleans and Ohio Telegraph Company, from Pittsburg to New Orleans; length of wire in Ohio	260
Ohio, Indiana and Illinois Telegraph Company, from Cincinnati to Dayton and Chicago; length in Ohio, about	100
Line from Zanesville to Marietta	66
Total length of wire in Ohio	3,210

CANADA.

From O. S. Wood, Esq., Montreal Telegraph Company, I have received the list of the lines in Canada.

	Miles.
The Montreal Telegraph Company's Line extends from Quebec to the Suspension Bridge at Niagara Falls; distance	155
British North American Electric Telegraph Association, from Quebec to New Brunswick frontier; distance	220
The Montreal and Troy Telegraph Company, from Montreal to New York State line at Highgate; distance	47
The Bytown and Montreal Telegraph Company, from Bytown to Montreal; distance	115
The Western Telegraph Company, from Hamilton to Port Sarnia, at the foot of Lake Huron; not now working; distance	143
Niagara and Chippewa Line, from Niagara to Chippewa; distance	14
All the above lines have single wires.	
In course of construction, a line from Brantford to Simcoe and Dover; distance	33
Also, a line from Kingston to Hamilton, via Prince Edwards Co.; distance	256
Total length in Canada,	983

ENGLAND.

The English telegraphs come next in extent to those of the United States; they were first established in 1845, and may be divided into two classes, the railway and the commercial. The railway telegraphs are used for the purpose of sending communications relative to railway matters, while the commercial are employed for the transmission of public and private messages at fixed rates of charges. They are mostly built on the railroads, and in some instances a railroad company will construct a line, and give the use of it to a company, and as an equivalent, the telegraph lends its aid to expedite the business of the railroad. The telegraph company between London and Liverpool receives one thousand pounds a year for doing the business of the railroad company, and the railroad people afford them all the facilities for repairing the line, even so far as sending an extra engine, without charge, when there is not a regular train going out soon; and every man employed on the railroad is under instructions to report immediately to the nearest telegraph office, anything he may find to be out of order on the line. In fact, a line of telegraph is almost considered an indispensable part of the equipage of all well regulated roads in England. The instruments principally in use are those of Messrs. Cooke and Wheatstone, Jacob Brett, and Brett and Little. There is a line of Bain's Electro-Chemical Telegraph from London to Manchester, and from Manchester to Liverpool. Also, a line of Bain's Electric Telegraph, connecting Edinburgh and Glasgow, a distance of 46 miles. The whole extent of telegraphic lines is estimated at 2,225 miles. The principal ones are as follows:—

ENGLAND, SCOTLAND, AND IRELAND.

I extract from the Manual of Mr. Walker, telegraphic engineer, a list of the Electric Telegraphs of England, for 1850.

Name of Railway.	No. of Miles.	No. of Wires.
Edinburgh and Glasgow	47½	5
Tunnel Line	1	2
Edinburgh and Northern.		
Dundee Branch	36	3
Perth Branch	6	3
Edinburgh and Granton	3	3
Leith Line	1½	3
Tunnel Line	1	2
North British	58	5
Dalkeith Branch	1¼	2
Haddington Branch	5	2
Tunnel Line	1¾	2
York, Newcastle, and Berwick.		
Newcastle to Berwick	65½	5
York to Darlington	45	7
Darlington to Newcastle	38½	8

Name of Railway.	No. of Miles.	No. of Wires.
Shields Branch	11	3
Sunderland Branch	2¼	3
Durham Branch	2¼	2
Richmond Branch	9	2
Fatfield and South Shields	19	1
Stockton Branch	½	1
York and North Midland.		
Normanton to York	24½	
York to Scarborough	42½	3
Harrowgate Branch	18	3
Hull and Selby	36	5
Hull and Bridlington	33	3
Normanton to Milford Junction	10	2
Manchester and Leeds	51	7
Preston and Wyre	20	3
Liverpool and Southport	13¼	3
East Lancashire	12½	3
Midland Railway.		
Birmingham and Gloucester	53	7
Birmingham and Derby	6½	7 }
" "	34¾	5 }
Derby and Lincoln	48¾	3
Derby and Rugby	24½	7 }
" "	24¾	5 }
Leicester and Peterborough	4¾	3 }
" "	23	5 }
" "	25¼	7 }
Derby and Leeds	73	7
Sheffield Branch	5	3
Leeds and Bradford	11	6
" "	2¾	3
" " Tunnel Line	1½	2 }
Skipton Branch	15¼	3 }
London and North-Western.		
London to Birmingham	5	9 }
" "	107½	7 }
" " Tunnel Line	1	3
" " Camd. Incl.	1¼	6
West London Junction	½	2
Birmingham and Manchester	80	7 }
" "	5	8 }
Ardwick Junction	3¼	8
Manchester and Liverpool	31½	6
" " Tunnel Line	1½	2
South Devon	53	4
Torquay Branch	4	3
Newmarket Railway	17	5
Eastern Union	16¾	5
" " Tunnel Line	2¾	2
London and South-Western.		
London to Southampton	74	4
" "	6	6
Portsmouth Branch	21	4

Name of Railway.	No. of Miles.	No. of Wires.
Gosport Branch	5	4
Southampton and Dorchester	61	3
Poole Branch	2	3
Eastern Counties.		
London to Brandon	88¼	7
London to Stratford	3¾	2
Brick-lane Line	½	2
Enfield Branch	3¼	2
Hertford Branch	7	3
Cambridge and St. Ives	14¾	3
Ely and Peterborough	30	5
March and Wisbeach	9	3
London and Colchester	51¼	5
Forest-gate and Stratford	1¼	1
Maldon and Braintree	12	3
Stratford and Thames Junction	2¾	3
North Woolwich	2¾	3
Norfolk Railway.		
Brandon to Norwich	37¾	7
" "	10¼	1
Norwich and Yarmouth	20	9
Lowestoft Branch	12	5
Dereham Branch	12	3
Dereham and Fakenham	12¼	2
North Staffordshire.		
Stoke to Norton Bridge	10¾	3
Colwich Branch	18¾	2
Stoke to Burton	29½	3
" " Goods Depôt	⅜	2
Stoke to Crewe	14½	3
Harecastle Tunnel Line	1	2
Macclesfield Branch	19½	3
Churnet Valley	27	2
South Staffordshire	9¼	2
" "	2	3
Northampton and Peterborough	47	3
" Extension to Wolverton	10½	4
London and Croydon	8	3
Great Western	19	4
London Street Lines		various
Manchester and Sheffield	2	3
" Woodhead Tunnel Line	3¼	3
Ambergate, Matlock, and Buxton	11½	2
London and Blackwell	3½	
Caldon-Low Quarry Line	3¼	1
Moira Colliery	½	2
Maryport and Whitehaven	½	4
Butterley Iron Company's Line	2½	1
South-Eastern.		
London to Dover	88	
London to Rochester	31	4
London to Bricklayers' Arms	4	2
Tunbridge to Tunbridge Wells	5	3

NAME OF RAILWAY.	No. of Miles.	No. of Wires.
Tunbridge to Hastings Road	1	2
Tunbridge to Laboratory		1
Paddock Wood to Maidstone	10	3
Ashford to Ramsgate	30	3
Minster to Deal	9	3
Ramsgate to Margate	4	3
Total	2,225$\frac{3}{4}$	

Their mode of construction in England is very expensive, amounting in some cases to $600 per mile. Posts of fir are ranged at convenient distances along the side of the principal railways; each post is furnished with an insulator of earthenware, and also capped with a wooden roof having dripping eaves to throw the water from the wires. The latter are made of galvanized iron, two of which are needed on a line working with Cooke and Wheatstone's instruments.

Telegraphs in Great Britain.

In England, the patents of Messrs. Cooke and Wheatstone were bought by the Electric Telegraph Company, in 1846. In the same year this company obtained their act of incorporation. They being the first company in the kingdom, have supplied most of the leading lines with telegraphs upon the principles of their patents. This company paid about $840,000 for their patents. The kind of instrument now generally used by them is the double needle telegraph, a drawing of which has been given.

The average number of words sent by this form of instrument in eleven dispatches for the *Times* newspaper, was nearly 17 words per minute, which would be considered very slow work in this country, as the Morse instrument will transmit at the rate of 30 to 35 words in the same space of time; and the House instrument, which is stated to be slow in its operation, by Mr. Highton, which is a mistake, as its ordinary speed by the improved instrument is at the rate of 30 to 35 words, when written in full; and business messages are sent at the rate of from 200 to 250 letters per minute; 365 letters have been printed in one minute from New York to Utica.

According to the published returns of the old Electric Telegraph Company in 1850, which I have given, there are only 2,215 miles of telegraph lines in operation. Since that period, however, considerable progress, it is stated, has taken place in the construction of electric telegraphs, but up to the present time, 1853, the number has not been published, even in the works on the Telegraph issued in England in 1852. When this telegraph company in England first opened their line, the charges for twenty words were calculated at the rate of 1*d.* per mile for the first 50 miles, ½*d.* per mile for the next 50 miles, and ¼*d.* per mile beyond the first 100 miles.

On the 11th of March, 1850, the charges were reduced, 10*s.* being made the maximum charge for any distance.

On the 20th of March, 1851, a farther reduction was made, and no message of twenty words was to exceed 8*s.* 6*d.*

On the 17th of November, 1851, the tariff was still farther reduced, the charge being 2*s*. 6*d*. for twenty words, if transmitted 100 miles or less, and 5*s*. if more than 100 miles.

Early in 1852, a farther reduction was made, the charge for a message between Manchester and Liverpool being for twenty words 1*s*. instead of 2*s*. 6*d*.

The charges on the South-Eastern Railroad Telegraph, for a message between any two stations on this line, is 5*s*. for twenty words.

IRELAND.

An Irish submarine line telegraph, between Fort Patrick and Donaghadee, was to be opened on the 10th of June.

A line of telegraph has been opened between Dublin and Galway, and was in operation in June, 1852.

PRUSSIA.

The Prussian telegraph system is characterized as simple, substantial, effective, and economical. A royal commission was appointed in 1844, to ascertain the best method of constructing lines; they, after experiment, determined on that of copper wire inclosed in gutta percha, and buried two feet beneath the surface; they are generally made to follow the track of railways, and in passing over bridges or aqueducts, are inclosed in iron piping, or when through rivers, in chain pipes. They use but one wire, which terminates in an earth battery, consisting of a zinc plate 6 feet long, 2½ feet wide, and ⅛th of an inch in thickness. The instruments used are those of Morse, Siemens, Halske, and Kramer, together with Daniell's battery. In the principal offices, a printing and a colloquial instrument are employed, but each in turn is worked by the one wire only, notice being given that one or the other is to be used, according to circumstances. Morse's is the printing telegraph used, and differs but very little from that used in the United States. Those of Siemens and Kramer are both colloquial telegraphs, but Siemens's is chiefly used. The whole cost, as determined from detailed estimates, is less than $200 per English mile. Besides the government lines of telegraph, most of the railway companies in Prussia have also their own telegraphs, which are constructed according to the system in this country by one wire suspended on poles along the railways. All telegraphs now under construction, have the gutta percha covered wire, incased in leaden tube. The average cost of this form of telegraph is about $100 per mile; their whole length is estimated at 1,493 miles, having their central point at Berlin, from whence they radiate as follows:—

Instruments used.	Stations and points passed through.	Distance in miles.
Siemens and Halske's Patent,	From Berlin to Frankfort-on-the-Main, established in February, 1849	350
Kramer's Bell Telegraph,	From Berlin through Cologne to Achen, established in June, 1849	362
	Stations are Potsdam, Magdeburgh, Ochserleben, Brunswick, Hanover, Minder, Haurm, Dusseldorf, Deutz, Cologne.	

Instruments used.	Stations and points passed through.	Distance in miles.
Siemens and Halske's Patent,	From Dusseldorf to Elberfeld . . .	16
Morse's Apparatus,	From Berlin through Minder to Rolu . .	81
Siemens and Halske's,	" " to Hamburg	142
" "	" " Stettin	62
" "	" " through to Oderburgh to Breslau	280
" "	" Halle to Leipzic	17
" "	" Leipzic to Berlin	115
" "	" Leipzic to Frankfort-on-the-Main . .	204
Siemens's Telegraph,	" Berlin to Gross Bercen	
" "	A contemplated one from Berlin to Konigsberg to Dantzic	
Morse Instrument,	From Hamburgh to Cuxhaven . . .	80

The Prussian method of burying the wires beneath the surface protects them from destruction by malice, and makes them less liable to injury by lightning.

AUSTRIA.

The Austrian telegraphs diverge from Vienna in the following manner:—

1, From Vienna through Olmutz to Prague, 237 miles.
2, " " " Bumn " 211 "
3, " " to Presburg, 35 "
4, " " through Prevau to Oberburg, 140 "
5, " " " Bruck, Cilli, Laybach to Trinte, 284 "
6, " " " Lintz to Salzburg, 156 "
7, " Prague to the boundary of Saxony, to connect with the line from Dresden, is nearly complete as far as the boundary of Bohemia, on which Storer's apparatus will be used; on the other, a modification of Morse's by Robinson, printing about 600 words per hour; also, a modification of Bain's needle telegraph, by Ekling, of Vienna, containing an arrangement of 45 needles, averaging about 190 words of six letters each per hour. The Austrians have adopted this system of correspondence, mostly since 1847; their network of telegraphs extends over a space of more than 1,053 miles, having 106 stations, which will be increased to 200 stations, if the present projected lines are constructed. The line from Lintz to Salzburg has a connection with the Bavarian one from Munich to the latter place, and makes use of Stochriss's instrument. A line between Venice and Milan, with its branches, is already commenced.

SAXONY AND BAVARIA.

Saxony and Bavaria have government lines which connect with the Prussian and Austrian lines, and establish a communication with Berlin, Dresden, Munich, and Vienna. Nearly all the railroad companies have private lines for their own use, and preparations are now making which, in no distant future, will include every town of importance throughout Germany in this network of communication.

Those of Saxony extend over 265 miles, the principal of which are annexed: From Leipzig to Hoff, 94 miles; from Leipzig to Dresden, 62 miles; Dresden to Konigstien, 15 miles; Dresden to the boundary of Bohemia; Dresden to Hoff, 94 miles. Stochriss's needle instrument is principally used in this country; likewise, in Bavaria, his bell apparatus. The extent of lines in the latter country is about 455 miles. From Munich to Salzburg, 74 miles, connecting with the Austrian lines of Ling and Vienna; from Munich through Augsburg to Hoff, 226 miles, connecting with the line to Dresden in Saxony; from Munich to Augsburg, 31 miles; one under construction from Augsburg, through Nuremburgh and Bamburgh, to Hoff; from Bamburgh to Wurzburg, Aschappenburg, and Frankfort, 125 miles under construction.

TUSCANY.

The lines in Tuscany number 120 Italian miles, commenced in 1847, under the direction of Matteucci; they also follow the railroad. From Florence to Leghorn; from Empoli to Sienne; from Pisa to Lucca, and from Florence to Patro; which makes in all, 120 Italian miles, or nearly 60 leagues. The total length of the wires is 121 leagues, weighing 70,000 pounds; 2,488 posts.

The expense of placing the wire, which cost at first 400 pounds per mile, is reduced to 30 or 40 francs at present, that the wires are placed by the guardians of the telegraph. The telegraphic apparatus is furnished in part by M. Brequet, and part by the constructor of the University, M. Pierncci; a complete apparatus costs 600 livres.

The following is a table of necessary expense for the establishment of the Tuscan lines:—

	Livres.	Sous.	
Iron wire	23,348	8	
Posts of fir tree	21,426	13	4
Tenders	3,347		
Porcelain shield	2,627	13	
Wooden box	1,772	13	4
Furniture, and supplies of the office .	8,183	18	8
Laying of copper wire, varnish . .	5,314	13	4
Machines and piles	26,043	17	
Timber, cost of posts, administration, studies, and superintendence of work	3,443	3	4
Total . . .	94,507	10	

GERMANY.

The telegraph lines of Germany have chiefly been established within the last three years. Gauss and Weber at Gottingen, and Steinhiel at Munich, had short lines of telegraph in 1834 and 1837; but the railroad companies were the first to make a proper appreciation of them, and establish lines for their own benefit. The first great line along the railway from Mentz to Frankfort, was erected by Fardly, a mechanician of Manheim, with Wheatstone's index apparatus. It was this line that aroused the attention of the Prussian Government, and caused the appointment of a committee to experiment on the matter.

No. 781 of the London *Mining Journal* for 1850, states that 2,000 miles of telegraph are already open in Germany, and that 1,000 more will be added in 1851; it works now from Cracow to Trieste, a distance of 700 miles, and a general union of the Austrian, Prussian, Saxon, and Bavarian lines was soon expected, with a tariff of charges nearly as low as that of the United States.

FRANCE.

The French are inferior in telegraphic enterprise to most of the other European countries. In that country the telegraph is under the control of government officers, and all the government business is done by signals, understood by those only who are in the pay of the government; the tariff is too high, and but little use is made of it, as the existing government does not wish it brought into general use; this is much unlike the republicanism of the United States. The principal instruments in use are those of Brequet and Foy, which print from 10 to 12 signs per minute; this is used along the railroad from Paris to Rouen. Wheatstone's needle telegraph, and also the instruments of Dujardin and Gardiner, are made use of. That of Brett is employed on the connecting line of England and France, between Dover and Calais, and Bain's Chemical Telegraph has more lately been introduced. The lines mostly originate in Paris, from which they stretch northward to Amiens, Arras, Valenciennes, Dowae, Lille, Dunkirk, Calais, and Boulogne. South, they extend to Orleans, Louis, Chevres, Angiers, Blois, Bourges, and Chateauroux; east, to Chalons, on the Marne; west, to Versailles, Rouen, Havre, and Dieppe: the whole extent being from 400 to 600 miles. Another line is about to be, or is opened from Paris to Lyons. In last April, the government published the establishment of several offices on each line which could be used for private correspondence; there were six of these points on the northern line, the same number on the southern, two on the western, and one on the eastern. The committee appointed for the purpose, recommended a general distribution of them on all the lines. The government have adopted the following tariff of charges, for a dispatch of twenty words, including the names of the sender:—

From Paris to	Arras,	4 f.	80 c.	From Paris to	Angers,	5 f.	88 c.
"	Valenciennes,	5	64	"	Bourges,	7	60
"	Lille,	6	36	"	Nevers,	5	88
"	Calais,	6	36	"	Chateauroux,	6	72
"	Dunkirk,	7	56	"	Chalons,	6	24
"	Orleans,	7	32	"	Rouen,	5	70
"	Tours,	4	56	"	Havre,	5	76

To estimate the expense between each of these places, it is only necessary to find the difference of that between them and Paris respectively. For dispatches of more than twenty words, a fourth is to be added for every ten words, so that this tariff will be double for sixty words.

I have translated the following list of the lines of France, from the "*Traité de Telegraphie Electrique*," by Moigno, second edition, 1852.

1st. Line of the North, from Paris to Valenciennes, by Amiens, Arras, Dowae, Lille, with a branch to Dunkirk, Calais, and Boulogne, 90 leagues.

2d. Line of the South, from Paris to Chateauroux, by Orleans, Blois, Tours, Bourges, with a continuation to Bordeaux one way, and another to Nantes.

3d. The line of the East, from Paris to Chalons sur Marne, prolonged to Strasburg, by Vetoy, Nancy, &c.

4th. The line from Paris to Havre, by Rouen and Dieppe.

5th. The line of Montereau to Troyes.

6th. The line of Metz to Nancy, &c.

The entire length of the finished lines form three hundred leagues (about 750 English miles), and according to Moigno, they have committed the irreparable fault of suppressing the old telegraphs.

HOLLAND.

The instrument used in Holland is a modification of Morse's by Mr. Wm. Robinson; this gentleman is an American; he has obtained the privilege of erecting and managing lines of magnetic telegraph, in the United Kingdoms of Norway and Sweden for fifty years. A company of heavy capitalists of this city and Stockholm, have commenced in the work, which is to begin immediately. A similar privilege is expected from the Government of Denmark. Most of the Belgian and Holland Railroad Companies have constructed telegraphs; there is one now in operation from Amsterdam to Rotterdam, and the Holland Government has authorized the construction of one from Amsterdam to the Helder, and one from Rotterdam to Vleissingin.

ITALY.

Considerable progress has been made in the construction of lines throughout the Italian States. By virtue of an ordinance of the Minister of Public Works, the telegraphs which are to connect Rome on one side with Civita Vecchia and the sea, and on the other side with the Austrian boundary at Ferrara, will be established at an early day.

SPAIN.

In Spain, the line from Aranjuez to Madrid is complete, and others are being laid down to Seville, Cadiz, Valenten, Barcelona, and the frontier of France. Before long there will be a general telegraphic communication from one extremity of Europe to the other, and when the connection between Dover and Calais shall have been completed, the people of London will be able to communicate with those of nearly every capital on the continent, extending over a space of nearly 6,000 miles.

RUSSIA.

A Prussian engineer has gone to St. Petersburg, in order to establish electro-magnetic telegraphs throughout the whole Russian monarchy.

The lines of telegraph to connect Petersburg with Moscow, and with the Russian ports on the Black Sea, and the Baltic, are almost complete; other wires stretch from the capital of the Czar to Vienna and Berlin, taking Cracow, Warsaw, and Posen on the way. Two lines by different routes, Olmutz and Brunn, uniting Vienna with Prague.

MEXICO.

A contract has been entered into by the Mexican Government, with Wm. George Stewart, Esq., the Mexican Consul at New York, and Senor Juan de la Grariga, of Mexico, to construct a line from Vera Cruz to the city of Mexico, a distance of three hundred miles; one hundred and twenty of which, as far as El Oge de Argua, was to have been completed on the 1st of May, 1851. Another line will soon be built between Acapulco and the city of Mexico. When both are completed, there will be a magnetic communication between the Atlantic and Pacific.

A letter from Mexico informs us of the progress of the magnetic telegraph in that country. It appears that the party who went from the U. States to that country for the purpose of putting up a line of telegraph from the city of Mexico to Vera Cruz, have finished it from the former city to Napolucan, a distance of about 150 miles, and half way to Vera Cruz. The other half will be finished in two and a half months. The line already up is doing a very fair business; the receipts averaging $35 per day, and the expenses about $15. These receipts will be largely increased when the line is finished to Vera Cruz, as the largest portion of the business transactions of the country is between that city and the city of Mexico, including Puebla and Orizaba. Another line is in contemplation from the city of Mexico to Acapulco, on the Pacific, 300 miles farther, which will connect the Atlantic and Pacific. This will be a highly important connection, considering our California possessions on the Pacific.

In January, 1853, the telegraph was finished from Jalapa to Perote. The line in Mexico has nine offices upon it, viz.: City of Mexico, Puebla, Napolucan, San Andre, Orizaba, Cordova, Vera Cruz, and on the branch from Napolucan, Perote and Jalapa, there are three Americans on the line. The rest of the offices are filled by Mexicans.

They are now building the line between Mexico, Guanajuato, and Leon; distance about four hundred miles.

CUBA.

The Governor General has ordered the publication of the concessions made to companies for the establishment of electric telegraphs through all points, and to the principal cities of Cuba. The lines will be established from Villanueva to Union, crossing several small towns in their way; from Union to Matanzas; from Buerba to Macagua; from Tinguaro to Jucaro; from Navagas to Isabel; from San Felipe to Batabano, and from Rincon to Guanajay, by San Antonio. The companies will be obliged to commence the works six months after the date of the concession, and to establish them with the greatest possible activity.

The Cubaneras have discovered the benefits the magnetic telegraph confers by facilitating business and transmitting communications from one point to another. They are, therefore, setting about establishing telegraph lines throughout the island. Two companies have been formed for this purpose. One of these companies, with a capital of $20,000, propose a line from Havana to Cienfuegos, passing through Isabel, Trinidad, and Manzanillo, to Cuba. From this point it will be extended to Bayams, and thence to Guanagos and Pinar del Rio, ending at San Juan and Martenez. The second line, which also starts from Havana, will communicate with Cardenas, Matanzas, Siena, Morena, Sagua la Grand, San Juan de los Remedios, Neuvitas, Moron, and Halguin, and will end at Cuba, having three branches to Puerto Principe, Sancto Spiritus, and Villa Clara. The same company propose a line from Havana to Hariel, Cubanas, and Bahia Honda; the capital of this company is $300,000. These lines, when completed, will connect the capital with every considerable town on the island.

From *The National Telegraph Review* I extract the following information: "S. A. Kennedy, Esq., has secured the contract to erect a line of telegraph in Cuba, associated with Don Juan Pages and Don Jose Font, Cuban merchants. The whole length of the line will be 1,200 miles, with 51 stations. In all, there will be 17 lines or sections, one main line with sixteen branches, one of which, from Alacranes to P. de Matanzas, has a side line to Calisco. Thus arranged, the line will require, for the use of the first wire erected, 67 instruments, which are to be the beautiful instruments of Mr. House.

16 offices connecting side lines, at which two machines are necessary, ...	32	machines.
Single offices, ...	35	"
	67	

These are contracted for by the government, through Kennedy & Co., at $500 each, net cost being $33,500.

In addition to this, a municipal telegraph is to be erected in Havana, to be worked in part with House machinery, and will connect with a Telegraph school to be established in that city under the tutelage of the government, the management of which will be given to Mr. Kennedy.

The contract made by Mr. Kennedy and associates, is as follows:—

1. The poles to be of either of 15 native kinds of wood, or from the United States lumber, to be sawn yellow pine.

2. Poles to be 20 Spanish feet in length, 4 feet in the ground, and to be 9 inches in diameter at large end, and 4 inches at the other.

3. 30 poles to the mile.

4. The insulation of the first wire to be used by the House line in U. S. (See *Insulation.*) The insulation of the second wire to be similar to the insulation of the New York and Washington line. (See *Insulation.*)

The wire used to be No. 8 galvanized wire, of good quality.

The whole to be completed on or about the 1st of May, 1853. The building of the line is to be commenced at four different points, viz.: Havana, Cardenas, Matanzas, and Batabano.

VALPARAISO.

The telegraph between Valparaiso and Santiago is progressing rapidly. Messages have already been sent over one-third of the line, (from Casa Blanca to this city.) From present appearances, the line will be through in less than forty days, as the poles are already up more than three-quarters of the distance.

INDIA.

This all infusing enterprise has aroused the lethargic inhabitants of the tropical climate. An electric telegraph has been erected in India, and is now in successful operation; the telegraph will soon belt both continents.

In the East Indies, a line of telegraph has been laid down and is now in working order between Calcutta and Kedgeree, a distance of 72 miles. This has been done by a Dr. O. Shaughnessy, an Irish gentleman. It is now proposed by the Governor-General of India, Lord Dalhousie, to unite all the important places in the British possessions in that country by electric cords. This will embrace lines of 8,800 miles long. The line which has been constructed differs entirely from any of our lines in America. The conductor (a wire with us), is laid part of the way under ground, in a cement of melted rosin and sand, and is a five-eighths of an inch iron rod. Part of the way it is carried over ground on bamboo poles, fifteen feet high, coated with coal tar and pitch, and strengthened at various distances by posts of saul wood, teak, and iron wood from America. The bamboo posts are found to resist storms which have uprooted trees the growth of centuries. Though the bamboo soon decays, yet its amazing cheapness makes the use of it more economical than that of more durable and more costly materials. The branch road from Bishlopore to Moyapore passed through a swamp; the country is little less than a lake for five months; the conductor runs on footpaths between the island villages, and for some miles crosses rice swamps, creeks and jeels on which no road or embankment exists. The most difficult and objectionable line was selected to test the practicability of carrying the conductors through swampy ground, and it has been perfectly successful. The Huldee River crosses the Kedgeree line half-way, and varies in breadth from 4,200 to 5,800 feet. A gutta percha wire, secured in the angles of a chain cable, is laid across and under this river, and this chain is found to afford perfect protection from the grapnels of the heavy native boats which are constantly passing up and down.

The advantages of the iron rod as a substitute for the wire, are stated to be complete immunity from gusts of wind, or ordinary mechanical violence; if accidentally thrown down, they are not injured, though passengers, bullocks, buffaloes, and elephants may trample on them; they are not easily broken or bent; owing to the mass of metal, they give so free a passage to the electric currents, that no insulation is necessary; they are attached from bamboo to bamboo without any protection, and they work without interruption through deluges of rain; the thickness of the wire allows of their being placed on the post without any occasion for the straining and winding apparatus, whereas the tension of wires exposes them to fracture, occasions expense in construction, and much difficulty in repairs; the thick rods also admit of rusting to take place, without danger, to an extent which would be fatal to a wire. On several occasions, one village forge, carried by two coolies, has been found sufficient for welding a mile of rods in a working day. The rods, moreover, are not likely to be injured by crows or monkeys. Swarms of kites and crows perch on the lines through the swamps, but they cause no harm; the correspondence flies through their claws without interruption, though on one occasion a flash of lightning struck the wet rod, and killed some scores of them. The importance of this discovery of the superiority of rods over wire will be fully appreciated in a country like India, where the line must often run through a howling wilderness, tenanted by savage beasts, or more savage men. The lines must therefore protect themselves, and this is secured by the use of thick rods.

AUSTRALIA.

Mr. Samuel W. McGowan, late chief operator in the Morse Buffalo Telegraphic Line, goes to the new El Dorado of the Pacific to introduce the magnetic telegraph in that distant region. It is the intention to build a line from Sydney to Melbourne, and afterwards to Adelaide, which will take the wires around the southern coast of that golden island, a distance of about one thousand miles.

TEXAS.

According to a letter in the *American Telegraph Magazine* from L. W. Cady, Esq., constructor of the New Orleans and Texas Telegraph, dated Nov. 1852, states that he was about to embark on the construction of the New Orleans, Opelousas, and Great Western Telegraph, to extend from New Orleans to the north-western Red River country, and from Opelousas to Houston and Austin, in Texas. The lines will reach 650 miles at about $200 per mile, to use the Morse instrument.

CALIFORNIA.

The California Telegraph Company were moving energetically in arranging matters for the completion of their lines between San Francisco and the principal towns in the interior of the State.

An electric telegraph is to be immediately constructed between Lara and Agram, by which means news from the East will reach England two days sooner than at present.

INSULATION.

The discovery of the usefulness of glass as a means of producing electricity, appears to have been made by Hawkesbee, who wrote in 1709. To Gray, who followed Hawkesbee, we owe the remark that the electrical excitement of glass and other electrics was communicable to other bodies when insulated, not only by direct contact, but by wires, or threads of great length. It was first observed by this electrician in conjunction with another named Wheeler, that this property of conducting the electric virtue, belonging to flax or hemp, did not belong to silk; also, that, by the class of bodies in which electricity can be excited, it cannot be conducted; whilst in those by which it may be conducted, it cannot be excited.

Thus were two classes of bodies distinguished, one as electrics, or non-conductors, the other as non-electrics or conductors. It was ascertained, however, that a conductor, if supported by a non-conductor, might receive the electric virtue from an excited electric. A conductor so supported was said to be *insulated.*

According to "modern researches, especially those of Faraday, we are led to conclude that there are really no substances which perfectly conduct or perfectly obstruct electrical action. The *insulating* or *conducting* is, in fact, a difference of degree only; still, as remarked by Harris, the extreme differences are so great, that if classed in relation to these differences, those at the extremes of the series admit of being considered, the one as insulators, the other as conductors; whilst the intermediate terms are made up of substances which may be considered as imperfect, taken as either. *Conversely*, every substance is capable of excitation by friction; yet, the differences in this respect are so great as to admit of some bodies being called electrics and others non-electrics, with an intermediate class between these extremes, which may be termed imperfect electrics.

"The distinguished chemist, Professor R. Hare, of this city, in his new theory of electricity, defines conduction to be a susceptibility of undulatory polarization. Insulation to be insusceptibility of such undulatory polarization.

"Conduction conveys electricity to any point which it could not otherwise have attained with almost infinite speed, while insulation, if it does not prevent all motion, allows it to take place to an insignificant extent.

"The conducting property of bodies appears to depend essentially on their chemical nature; thus, we see all the metals are good conductors; all hydrogenated substances are bad conductors. However, in many cases, the physical constitution, also, exercises an influence upon conductibility; ice does not conduct, while water does conduct; tallow and wax become conductors only when they are melted; it is the same with several salts. Glass is a good conductor when it is heated to redness. M. Matteucci, has, moreover, lately remarked, that sulphur and gum-lac lose a portion of their insulating power by an elevation of temperature incapable of changing their cohesion. Diamond is a perfect insulator, whilst mineral carbon is a good conductor, if it has been strongly heated.

"Carbon in general conducts better or worse, according as it has been more or less baked.

"Air and gases are less insulating as they are more rarefied, which is the same as saying that vacuum is a good conductor of electricity.

"Finally, there is one circumstance, independent of the chemical nature and the physical constitution of bodies, which renders them better or worse conductors; it is their degree of affinity for the humidity of the air. It is well that moist air and gases cease to be insulators. Glass, which is of itself a good insulator, easily becomes a conductor as soon as it is exposed to humidity; it attracts to its surface the aqueous vapors of the atmosphere; they form there a thin film of water, by which the electricity passes away.

"Thus, in order that glass rods shall insulate well the electricity accumulated upon the conductor to which they serve as supports, care is taken to cover them with a thin coat of varnish, made with gum-lac dissolved in alcohol, a coating which protects the surface of the glass against the deposition of moisture, and which at the same time itself insulates very well."

The following is an approximative table of the conducting and insulating faculty of different bodies. This table is composed of two columns; the first contains the conducting bodies, placed in the order of their degree of conductibility, beginning with the best conductors; and the second contains the insulating bodies, placed in the order of their insulating faculty, beginning by the worse insulators. It hence follows, that the second column may be regarded as a continuation of the first.

Conducting Bodies placed in the order of their Conducting Power.	Insulating Bodies, placed in the inverse order of their Insulating Faculty.
All the metals.	Dry metallic oxides.
Well-burnt carbon.	Oils; the heaviest are the best.
Plumbago.	Ashes of vegetable bodies.
Concentrated acids.	Ashes of animal bodies.
Dilute acids.	Many dry transparent crystals.
Saline solutions.	Ice below 13° Fahr.
Metallic ores.	Phosphorus.
Animal fluids.	Lime.
Sea-water.	Dry chalk.
Spring-water.	Native carbonate of baryta.
Rain-water.	Lycopodium.
Ice above 13° Fahr.	Caoutchouc.

Conducting Bodies placed in the order of their Conducting Power.	Insulating Bodies, placed in the inverse order of their Insulating Faculty.
Snow.	Camphor.
Living vegetables.	Some siliceous and argillaceous stones.
Living animals.	Dry marble.
Flame.	Porcelain.
Smoke.	Dry vegetable bodies.
Vapor.	Wood that has been strongly heated.
Salts soluble in water.	Dry gases and air.
Rarefied air.	Leather.
The vapor of alcohol.	Parchment.
The vapor of ether.	Dry paper.
Earths and moist rocks.	Feathers.
Powdered glass.	Hair, wool.
Flowers of sulphur.	Dyed silk.
	White silk.
	Raw silk.
	Transparent precious stones.
	The diamond.
	Mica.
	All vitrifactions.
	Glass.
	Jet.
	Wax.
	Sulphur.
	The resins.
	Amber.
	Gum-lac.

Gutta percha is of all known substances, one of the best insulators; its place, however, cannot exactly be assigned in this table.*

Having thus given the general characters of the class of substances known as insulators, I will now proceed to make some application of the facts to the telegraph.

In the construction of lines of electric telegraph, great care should be employed to secure as perfect insulation as possible. This, we are sorry to say, is one of the great defects of all the lines in this country. It matters not how perfect and reliable our telegraphic machinery may be, still, if the insulation be defective, it will prove one of the greatest sources of annoyance and disappointment. Much, it is true, can be done by increasing the numbers and powers of batteries, or by distributing them along the line where none previously existed; still, by this arrangement, there is always increased expense and great waste of battery power.

The disagreeable fact, however, ought not to be withheld, that in rainy or foggy weather not one of our telegraphic lines in this country is reliable, or, if they work at all, it is only from one short station to another, and that with extreme difficulty. But this is the case, not only in this country, but also in France, Germany, and England, where they require but a weak current to deflect their needle instruments.

Edward Highton, Esq., Telegraphic Engineer, remarks, that owing to this result of imperfect insulation, it has been found impossible for weeks together to telegraph direct, even between London and Liverpool, although the insulation has been changed several times in the course of

* De la Rive.

the last few years. The only way in which the communication could be carried on was by sending the message to an intermediate station, and then, by repeating it at such intermediate stations, to forward it thence to Liverpool.

The December number of the *American Telegraph Magazine* contains the following observations on Defective Insulation:—

"Can the present insulation be materially improved? is a very important question. We answer, it can be so much improved as to secure the perfect working of a line five hundred miles in length during the worst weather. Science has told us, ever since the first mile of telegraph was erected, that we should not rely on glass as an insulator; and yet we have used it almost universally. Every one has observed that, whenever the weather is wet or foggy, every article of glass is covered with a thin film of water, and, of course, each 'insulator' on a line of telegraph is so covered with moisture. Certainly some electricity will escape over each glass insulator so covered (according to De la Rive, glass becomes a conductor as soon as it is exposed to humidity; it attracts to its surface the aqueous vapors of the atmosphere; they form there a thin film of water, by which the electricity passes away), and when we reflect that, on a line of telegraph five hundred miles in length, there are 15,000 such imperfect insulators to conduct the fluid from the wire, we are at no loss to account for the dissipation of all, or nearly all, the galvanism generated by the battery, and the consequent bad working of the line.

"Without, at present, entering very minutely into the subject, we will state our own opinion as to the material which should be used for telegraphic insulation.

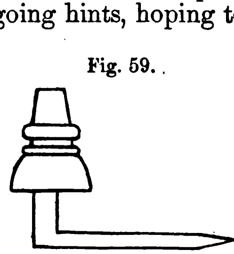
"Inasmuch as glass cannot be so protected as to prevent its surface from being covered with a film of water (unless covered with varnish, in which case the glass itself is unnecessary and useless), some other insulating substance, not liable to that objection, should, if obtainable, be used.

"It is well known that dry wood, as an insulator, is inferior to no other material. Shell-lac is also as perfect an insulator as we have. Now, *saturate* and *cover* dry wood with shell-lac varnish, and we have a cheap and nearly perfect insulator. Moisture does not condense on and cover a varnished surface as it does a glass surface; besides, the greater the extent of insulation, the less electricity will escape over it.

"It will be readily seen that a large surface of wood and shell-lac can be obtained at a much smaller price than it could be of glass.

"We say nothing at present of the *shapes* and forms best adapted for telegraphic purposes, but throw out the foregoing hints, hoping to hear from some of the telegraphic fraternity on the subject."

Fig. 59.



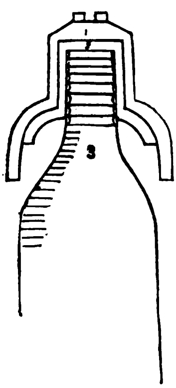
The insulator employed on the Morse line from New York to Washington, is shown in the following cut, Fig. 59.

It consists simply of a glass knob with two rings, between which the wire is simply wrapped; the shank is of iron, and is driven into the posts. From the ease with which moisture settles upon the glass, there cannot be a doubt that a large portion of the current is led into the post in wet weather, and so into the ground, and thus the instrument works with difficulty upon even the slightest shower.

I am somewhat surprised that this company, with its intelligent and public-spirited President, does not make some effort to improve its insulators, and have them protected. It has been found, that with this form of insulator the atmospheric electricity cracks the glass in two pieces, just as if it had been cut with a diamond. Another form of insulator may be seen at Fig. 30, page 75, which also shows the method of attaching the glass caps, of whatever form, either upon crossbars, or supported by iron staples driven into the post.

A better form is seen in Fig. 60, which is the insulator used on the House line of telegraph.

Fig. 60.

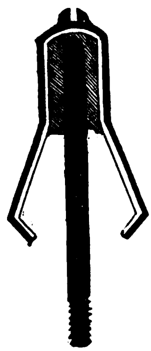


It consists of a glass cap about five inches in length and four inches in diameter, having a coarse screw-like surface cut inside and out. This glass cap (No. 2) is screwed and cemented into a bell-shaped iron cap (No. 1) about from three to four lbs. in weight, projecting an inch before the lower edge of the glass, protecting it from being broken; this is then fitted with much care to the top of the pole No. 3, and is covered with paint or varnish. The conducting wire is fastened to the top of the cap by projecting iron points, and the whole of the iron cap is thus in the circuit, as the wire is of iron and not insulated. To prevent the deposit of moisture, the glass is covered by a varnish of gum-lac dissolved in alcohol, and the ring-like form of the glass is to cause any moisture to be carried to the edge and there drop off.

The chief objections to this form, although an improvement on that employed on the Morse line, is, that it is very expensive, from the large amount of glass and iron used in its construction. It could be made much more effectual if of well glazed stoneware, having an iron hook for the suspension of the wire, and a hood of wood to keep off the rain. Or, not to throw away the glass insulators that are now in use, if, instead of the iron roof, use wood, and instead of the varnish employ the melted shell-lac, heating the glass by radiant heat, and then dipping the glass into it, so that, instead of it cracking and chipping off, it will remain and act as a perfect insulating coating; also fixing a hook with plaster of Paris into the upper part of the glass, and suspend the wire by it.

A third form of insulator has been patented by Messrs. Farmer and Batchelder, of Boston, shown in Fig. 61, which is a vertical section of it. The outer cap shown by the dark line is of cast-iron, which is lined with porcelain; in the interior of this porcelain is fitted a rod with a screw upon its lower end; this rod is held by glass or lead cast around it, and the rod itself is also coated with porcelain. The lower edge of the cap is turned inwards towards the holder, its form being such as to divert the rain downwards and prevent it from entering the inside of the cap. Mr. Batchelder informed me that this form of insulator, which is employed in the Municipal Telegraph in the city of Boston, has been found to insulate well.

Fig. 61.



Having thus noticed the principal forms of insulators employed in this country, I will pass to that of England, as being second, in regard to extent of lines of electric telegraph, to the United States.

In England, most of the electric telegraph lines, after trying glass, wood, and porcelain, have adopted (in 1851) insulators of various forms, "rings, collars, and double cones made of brown stoneware, which, of all substances yet tried, throws off the wet most readily. A stone pitcher, after being plunged into water, is seen to retain scarcely a trace of the immersion beyond a few drops on the surface."

W. C. V. Walker, Telegraphic Engineer, has substituted for the old form of cone, to which it seems there were many objections in practice, a large open-mouthed cone, or rather hollow double cone of well glazed earthenware, so constructed that the wire and the cone should be in contact at the smallest possible surface; also that as the place of contact is as far as possible withinside the cone, it should be as inaccessible as possible to wet; also from its shape, that any wet attaining to the cone would by mere gravity run away from the place of contact; also that the part of the cone, where it is in contact with the wire, should be at the farthest distance from the timber of the pole sustaining all; after suspending the wires, the whole is covered with a roof of wood having sides and ends.

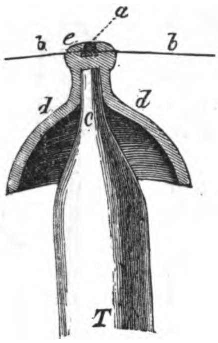
The wires from Red Hill to Shalford, a distance of 19 miles; from Ash to Reading, 19 miles; from Ashford to St. Leonards, 28 miles, are all suspended in this way.

These lines are remarkable for their perfect insulation and good working order. It was feared that the birds would build nests in the roofs, but such has not been the case. "The great practical difficulty to be overcome is to prevent the dampness from entering the point of contact; this has been found accomplished in this form of insulator." —*Report of Jury of London Exhibition.*

Wires passing through railroad tunnels are covered with gutta percha and laid in a grooved board covered in. The grooves are ploughed out by machinery, and the board is also covered with mineral varnish and secured close to the tunnel walls; remaining, when once nailed on, in good working order and in a perfect state of insulation. This grooved board, simple as it is, will doubtless be found a very useful mode of conducting the wires through tunnels, not being in the way of the cars in their passage.

The mode of Insulation in Germany.—In Germany, after numerous trials, they have found the accompanying insulator answer their expectations in regard to its insulating qualities. Fig. 62 presents a telegraphic post *T*, with the insulating cap employed on the telegraphic lines in the Grand Duchy of Brunswick. The pole terminates in a point *c*, an inch and a half in length and about six lines in diameter; this pole is covered with a porcelain cap *d d*, a sort of reversed cup, on its summit *e*; there is a hole *a*, in which the conducting wire *b b* enters inlaid with lead; this insulator is then covered with a roof. This form of insulator is considered by Dr. Schellen as perfect, and even with very intense currents there is no loss of electricity.

Fig. 62.



Mode of Insulation in France.—The posts in France are of pine or fir, from twenty to thirty feet in length, which they inject with sulphate of copper by the Bouchirn process, to lengthen the time of their preservation. They bark them and fix them in the earth, the smallest to the depth of 30 inches, the tallest to the depth of 60 inches; the buried part is perfectly preserved by the sulphate of copper. The insulators used in France are of porcelain, fixed on the sides of the post, and not on the top; the form is either bell-shape or a double oblique cone, fixed to the sides of the post by means of screws, and sealed with sulphur in the interior, the conducting wire passing through a ring support fixed in the interior of the double oblique cone, so that the wire only passes on a point sheltered by the mass of the support.

The great advantage of this system, as stated by Moigno, is that the post is not enfeebled in making it thinner at any point, and that by adding bells of porcelain the number of wires can be indefinitely increased.

To traverse the passage of a level, or to pass above the building of a station, the posts are over 61 feet.

When the conducting wires are to be buried in the soil, like those which pass under the pavements of cities, they are of copper (No. 16). If gutta percha is not employed, they are covered with cotton, saturated with tar, and collected in leaden pipes, in groups of three or four at most; the leaden pipes covered with a pitched cord, and the whole placed in a conducting pipe of iron.

Mr. Highton, to obviate the difficulty where many wires are required to be suspended on the same post or support, proposes, first, to conduct the insulation to a considerable distance from the post, and, secondly, to place between wire and wire a direct communication with the earth, so that any of the electricity transmitted, as it escapes from the wire, may be intercepted by this communication with the earth, and so transmitted direct to the earth, without the possibility of entering an adjoining wire.

In such a case, it will only be necessary, in very great lengths of wire and in very adverse weather, to increase the quantity of electricity transmitted, in order to make due allowance for the quantity that escapes at the points of the insulation. However great such amount of electricity required may be, no portion thereof can reach the adjoining wire, and thereby disarrange the telegraphic instruments connected with such other wires.

A very important part of the telegraph is the posts, which in the great majority of cases are of green timber, not even seasoned, which, from the large amount of moisture they contain, are conductors. Even after seasoning or drying for six months, they still contain from 17 to 20 per cent. of moisture. It is also a well established fact that a cubic foot of air-dried wood contains from 457 to 586 cubic inches of air in the pores, which is also a conductor, when moist. How is this to be obviated? By selecting poles of yellow pine, well seasoned, then subjecting them to complete baking by heat, and then forcing into them melted pitch, so that the entire pores of the wood shall be full of a good non-conducting substance. In this way there will be much more perfect insulation, and the cost will pay for itself by the durability of the poles, being perfectly protected from moisture and the depredations of insects. This we consider a matter of the utmost importance to the telegraphic engineer.

According to my distinguished friend, Prof. Robert Hare, the true reason of the difficulty in insulation is in employing the earth as part of the circuit, and depends on the following law: "That each of two bodies, which we necessarily suppose insulated, takes a part of the total electricity proportional to its own surface."

This law explains why an insulating and an electrized conducting body (like the telegraphic wire), when put into communication with the ground, loses its electricity; the electricity that it possesses is really divided between itself and the earth, proportional to their respective surfaces; but its surface being infinitely small in comparison with that of the earth, there must, therefore, remain to it, after contact, infinitely less electricity, or none at all in some instances.

This is the action of the law at all times when applied to the telegraph, but when the air is dry and the posts partially insulated with the dry earth—almost an insulator—there is sufficient current from the battery to work most of our telegraphic instruments; but in moist or foggy weather, when the posts and the earth become almost perfect conductors, the only effectual remedy is to unite two insulated wires going to a distant city, and it will be found that by such an arrangement they will be able to work in rainy or foggy weather, almost as great a distance as in ordinary weather, when using but one wire, connected with the earth. But to make the line independent of all kinds of weather, they must have a perfect conductor all the way, and not use the earth as a conductor for the return current. The wire should also be covered with cotton or wool, and then varnished with pitch or asphaltum, dissolved in coal naphtha or marine glue, and renewed by some arrangement every six months. The insulator should also be made of earthenware or stoneware, and the interior should be lined with the very best insulating substance that is known—gutta percha. I will give a description of gutta percha, and the method of preparing it for insulation, for by its defective preparation it has received a bad name from those not fully acquainted with its physical and chemical characters, and from confounding it with caoutchouc, from which it differs very much. It differs in the first instance from caoutchouc in being a truly fibrous substance, which is not the case with caoutchouc. A strip or sheet of gutta percha may be stretched considerably in one direction, that is, in a line with the fibre; but if you attempt to stretch it across this line, it separates into thin ribbon-like pieces. It is not so with a sheet of caoutchouc, which will stretch equally in all directions. On a careful examination by Prof. Page, of Washington, of thin sheets of these two substances, believed to be ISOMERICAL, a marked difference of texture was at once perceived. The caoutchouc gives little or no change of color, while the gutta percha exhibits a beautiful spectacle. It appears to be built up of prisms of every variety of hue, and, as it were, fused into each other. Friction with a piece of velvet or silk on a dry sheet of gutta percha, will develop a large amount of negative electricity, and in the dark will give off long flashes of electric light.

In 1848, Faraday drew attention to the high insulating power of gutta percha, which not only possesses this property under ordinary circumstances, but likewise retains it under atmospheric conditions, which would make the surface of glass a good conductor. A good piece of gutta percha insulates as perfectly as shell-lac, whether it be in the form of a disk, a stick, or a thread. It is, moreover, tough and pliable in the cold, soft in the heat, and hence preferable in many cases to the brittle shell-lac. In the form of straps or cords gutta percha presents an excellent means of suspension, and in plates it furnishes the best insulating supports. It forms excellent insulating stoppers for the ends of goldleaf electrometers if inclosed in tubes; large stoppers furnish good insulating stuffing for temporary electrical arrangements. Cylinders of half an inch or more in diameter possess great rigidity, and form excellent insulating supports. This good insulation, moreover, fits it admirably for exciting negative electricity. All gutta percha is not found in this good electrical condition.

With respect to that which is not so (and which has constituted about one-half of that which is to be obtained), it has either discharged an electrometer as a piece of paper or wood would do, or it has made it collapse greatly by touching, yet has, on its removal, been followed by a full opening of the leaves again. The latter effect Prof. Faraday has been able to trace, and refer to a conducting portion within the mass covered by a thin external non-conducting coat. When a piece which insulates well is cut, the surface exposed has a resinous lustre and a compact character that is very distinctive; whilst that which conducts has not the same degree of lustre, appears less translucent, and has more the aspect of a turbid solution solidified. As both moist steam heat and water-baths are used in its preparation for commerce, the difference of specimens depends probably upon the manner in which these are applied, and followed by the after process of rolling between hot cylinders. Prof. Faraday, having soaked a good piece in water for an hour, on taking it out and wiping it, and, exposing it to the air for a minute or two, found it insulated as well as ever. Another piece was soaked for four days, and then wiped and tried; at first it was found lowered in insulating power; but after twelve hours' exposure to the air under common circumstances, it was as good as ever. He also found that a week's exposure, in a warm air cupboard, of a piece that did not insulate, made it much better; a film on the outside became non-conducting. But if two fresh surfaces were exposed by cutting, and these were brought into contact with the electrometer and the finger, the inside portion was still found to conduct.

If the gutta percha, either in the good or the bad condition (as to electrical service), be submitted to a gradually increasing temperature, at about 350° to 380°, and is spread out and kneaded, it gives off a considerable proportion of water; being then cooled, the substance which remains has the general properties of gutta percha, and insulates well.

A degree of insulation no less than that of gutta percha is possessed by collodion, the residuary substance obtained by the evaporation of an ethereal solution of gun-cotton. If the clear solution be spread over a glass plate, there remains, after entire volatilization of the solvent, a transparent cuticle, which, by merely passing the hand over it, or, more effectually, by friction with wool, becomes negatively electric, and obstinately retains this electrical state.

The telegraph wire now employed in almost all the lines is that of iron wire No. 8, and in many instances it is not covered, which is wrong, for it soon becomes oxidized and ceases to conduct with facility. It will be seen that oxides themselves are placed in the list of conducting bodies with metallic ores—the sixth after even the worst of the metals in conducting power. It is therefore of the greatest importance that the wire should be galvanized with zinc, as the zinc preserves the iron from corrosion, and that this wire, near cities, should be well painted every six months with marine or zinc paint, for the sulphurous acid given off in the combustion of coal acts upon this galvanized wire so as to destroy it.

Another important suggestion is made by Mr. Reid, in the *Telegraph Review* for July, 1853, which is to erect stronger poles, namely, of iron with a stone base, with a wooden finish on which to plant the insulators. He considers this form to have strong claims to the acceptance of a company able to erect such a line. "It has long been his beau-ideal of the telegraph; a line which time may play with long in vain, and the storm leave, amid its fiercest attacks, scatheless and unharmed."

He also states that we may obtain one of the simplest coating, and perhaps one of the best substances which can be used, of an unconducting character, by first allowing the wire to rust, and then coating it with boiled linseed oil. A paint of the oxide of iron is thus formed, simple, cheap, permanent, and with the merit of an easy application.

ON LIGHTNING PROTECTORS.

ALMOST as soon as the first telegraphic lines were established, it was found that atmospheric electricity collected on the semi-insulated wire, and often produced injurious results to the wire, instruments, and supports. The first instance was that of the electric telegraph laid down at Gottingen, by Gauss and Weber, between the years 1833 and 1834, the wires of which were fused by a stroke of lightning. The second instance is related by Dr. Steinheil as occurring on his telegraph between Munich and Bogenhausen; on the 7th July, 1838, it sounded the bell, and the blow was so hard that the points on which the magnetic bar played were injured. He endeavors to account for the explosive discharge, by supposing that the electricity of the earth may have made its way to that collected in the wire. "Whether this result was brought about through the lightning conductors in the neighborhood, or the imperfect insulation of the points of support, cannot well be made out by him."

Soon after the establishment of the first line of telegraph by Professor Morse, in 1844, the disastrous consequences resulting from the same cause, compelled him to resort to some method to obviate the difficulty by causing the superabundant electricity to be conveyed to the ground. One was to have the circuit closing wire of a receiving magnet, employed for this sole purpose, pass into the earth; another, to have a metallic connection made with the surface of a brass ball, surrounded by a ring situated in and forming part of the circuit, from the inner circumference of which minute metallic points project, but not touching the balls. Both of these means were found, however, inefficient to obviate the difficulty.

At a meeting of the American Philosophical Society, June 19, 1846, the Society received a letter from S. D. Ingham, Esq., of New Hope, Pa., detailing numerous cases in which the telegraphic wires had been struck by lightning, and asking the attention of the Society to questions connected with the mode in which the wires may be affected by electricity. The letter was referred to Prof. Henry, who, after collecting numerous facts and making experiments in reference to the action of atmospheric electricity on the wires of the telegraph, concluded that the effects are produced in several different ways.

1. That the wires of the telegraph are liable to be struck by a direct

discharge of lightning from the clouds, and the discharge given off to a number of poles in succession.

2. That the state of the wire may be disturbed by the conduction of a current of electricity from one portion of space to another, without the presence of a thundercloud, a mere difference in elevation being attended with a change in the electrical state of the atmosphere; for if the line of telegraph pass over an elevated mountain ridge, there will be continually, during clear weather, a current from the more elevated to the lower points of the conductor.

A current may also be produced in a long level line, by the precipitation of vapor in the form of fog at one end, while the air remains clear at the other; or by the existence of a storm of rain or snow at any point along the line, while the other parts of the wire are not subjected to the same influence.

3. The natural electricity of the wire of the telegraph is liable to be disturbed by the ordinary electric induction of a distant cloud. Although currents produced in this way may be too feeble to set in motion the marking apparatus, yet they may have sufficient power to influence the action of the current of the battery, so as to interfere with the perfect operation of the machine.

4. Powerful electrical currents are produced in the wires of the telegraph by every flash of lightning which takes place within many miles of the line, by the action of dynamic induction; which differs (from ordinary electrical induction) in being the result of the influence of electricity *in motion* on the natural electricity of the conductor. The effect of this induction, which is the most fruitful source of disturbance, Professor Henry illustrates by an account of experiments presented to the Society in 1843.

He proposed the following means of preventing the effects of powerful discharges from the clouds of atmospheric electricity, viz.: by erecting, at intervals, along the lines, and aside of the supporting poles, a metallic wire, connected with the earth at the lower end, and terminating above at the distance of about half an inch from the wire of the telegraph. By this arrangement he considered that the insulation of the conductor would not be interfered with, while the greater portion of the charge will be drawn off.

Prof. Henry considers this precaution of great importance, at places where the line crosses a river and is supported on high poles. Though accidents to the operators, from direct discharge, may be prevented by the method he proposes, yet the effect on the apparatus cannot be entirely obviated; the residual current, which escapes the discharge along the perpendicular wires, must neutralize for a moment the current of the battery, and produce irregularity of action in the apparatus.

To obviate this dynamic inductive influence, he proposes to increase the size of the battery (during the season of thunderstorms), and diminish the sensibility of the magnet, so that at least the smaller induced currents may not be felt by the machine. He remarks, that no coating that can be put upon the wire, will prevent the formation of induced currents.

He also considers it not improbable, since the earth has been made to act the part of the return conductor, that some means will be discovered for insulating the single wire beneath the surface of the earth; the difficulty in effecting this is by no means as great as that of insulating two wires, and preventing the current striking across from one to the other.

A wire buried in the earth would be protected, in most cases, from the effect of a direct discharge; but the inductive influence would still be exerted, though perhaps in a less degree.

This form of arrangement of Prof. Henry's has not been found to protect effectually. A better plan is, to place a knob of metal on each wire where it crosses the posts; a second and lower knob is then placed close to the first, but without touching it, and, connected with a wire, led down to moist earth. The lightning discharge will be cut off at the first knob, and then leap across to the lower knob, and thus descend to the ground.

Baumgartner, in March, 1848, made experiments on this subject, which fully confirmed those previously made by Prof. Henry.

At a period at which there was not the slightest appearance of the formation of a thunderstorm, he fixed to the conducting wires of the electric telegraph which extends from Vienna to Prague, a distance of 61 (German) miles, an extremely sensitive multiplicator, and immediately perceived from the deviation of the magnetic needle, that a current of electricity was passing on the wire.

In order to study these phenomena more carefully, a Nobili multiplicator was attached to the conducting wire of the southern telegraph line, and the result was, that the magnetic needle of the multiplicator was nearly always vibrating, and a very short pause of rest occurred.

In this tract (of country) there is, at almost all times, a passing of electricity between the earth and the atmosphere, in consequence of which an electric current is almost constantly passing through the conducting wire, which (current) is, however, generally too weak to set the indicating part of the telegraphic apparatus in motion. On the contrary, if there is a large quantity of electricity in the air, which is generally the case at the beginning of a storm of hail or rain, or after several hot days followed by a sudden change of temperature, these atmospheric currents in the telegraph wires may become strong enough to move the index on the dial. "Often," remarks Baumgartner, "the magnetic needle begins to play, and it seems as if a message from a distant station is to be expected, in order to keep ready for a correspondence; however, the signs have no signification, change irregularly, and occur mostly only in one direction; sometimes the needle places itself for some time in the point of greatest deviation. Through such influences the magnetism of the needle is often ruined, and its polarity reversed, so that it is necessary to change it and magnetize it anew for farther service."

In consequence of the many accidents which have happened through the influence of atmospheric electricity (which my want of space will not permit me even to catalogue), every means has been tried to prevent these injurious results.

Steinheil established, in the year 1846, his lightning conductor, as follows: The main wire was extended over the station building, in which the signalizing apparatus is placed. On the roof of the building the wire is divided, and on each end is fastened a copper plate six inches in diameter. The part of the wire which is fastened to the plate, stands in its middle perpendicular to it. Between the two plates is placed a thin silk cloth, so that the plates do not touch when in contact. In this vertical situation, the plates are fastened through insulated supporters on the roof of the house, and protected from rain by a wooden box.

By this arrangement, the galvanic stream is entirely cut off, as it finds an obstacle in the insulating piece of silk between. It is not so with atmospheric electricity, which, with little effort, can break through the interval between the plates.

To make a perfect connection with the signal machine, the two wires from it are fastened each to the lower corners of the copper plates on the roof.

A galvanic current can, therefore, pass down through the wire to the telegraph in the interior of the building, and through the other wire pass over to the second plate, in order to continue on through the main wire. The atmospheric electricity, however, will break through the small obstacle between the plates rather than pass out of the way, through a thin and long wire, which is in the form of a spiral in the signal machine. It is stated that since the introduction of this protector there has not been observed either sparks or any sounds produced by the atmospheric electricity on the coils of wire or on the signal machine, even with the most vivid flashes of lightning. To prevent the consequences of a discharge of atmospheric electricity, the French electrician Brequet, in March, 1847, proposed that, when the main wire was about 15 or 18 feet distant from the telegraphic station, he would employ a very fine wire connected with the telegraphic apparatus of the station, so that, in case of an electric discharge, it might melt the wires and so save the station.

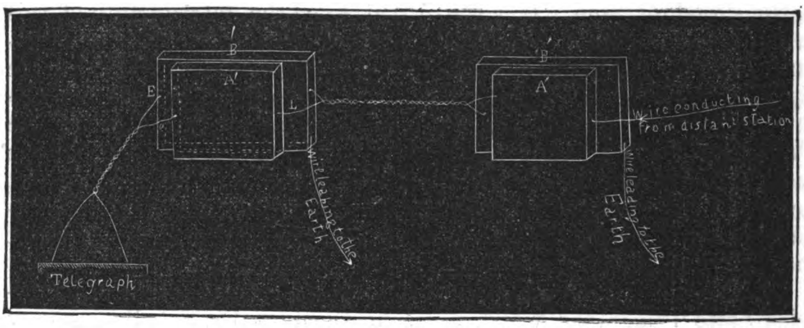
Professor Meiszner established lightning protectors on the Brunswick State Telegraphs, which are considered by Dr. Schellen as very effectual for the protection of persons and apparatus; the main wire coming from the next station on poles insulated by porcelain boxes until in the neighborhood of the building. It is covered by gutta percha, and passes through pipes under the ground, and through the foundation walls of the established telegraphic room; here it is fastened to a copper plate, 8 inches long, 4 wide, $\frac{3}{8}$ths of an inch in thickness, by a screw in the usual manner. From this same copper plate extends a small insulated wire to the telegraphic apparatus, and through the galvanic battery to a second copper plate, and from this screw by a stronger insulated wire to the earth.

The two copperplates are screwed together, but insulated by pieces of ivory or gutta percha one-eighth of a line in thickness; the copperplates are then screwed on a suitable board, insulated, and fastened on the wall of the telegraphic office. The two thin wires, which are covered with silk and twisted together, are once more jointly wrapped till near to the telegraphic apparatus, when they again separate and lead to the fixed cramps of the apparatus.

In ordinary telegraphing, when the wires are only charged with a very moderate galvanic current, it passes from the next station through the main wire to the first plate, through the thin wire to the apparatus and electro-magnet, through this to the galvanic battery, and the second plate over this by the stronger insulated wire to the ground, making a perfect circuit.

But as soon as a certain quantity of atmospheric electricity has collected upon the wire, it passes along to the first plate, and prefers the shortest way to the earth, by a leap over to the second plate, rather than pass through the apparatus which offers a considerable obstacle to the electric stream through the very thin and long wrapt wires of the electro-magnets. Professor Meiszner has become convinced, from numerous trials of this form of lightning protector, that he has found out the way in which a perfect protection for the telegraphic apparatus is insured. His purpose is to make two such lightning protectors, made two or three feet square, of zinc, on account of its cheapness, connected with wires covered with silk one-tenth of a line in thickness, to the apparatus Fig. 63; so the electricity, if it does not go over

Fig. 63.



at the first lightning protector, from the plate A on to the plate B, will go to the second pair of plates from A′ to B′, and thence to the ground; or, in the worst cases, it will burn off the fine twisted wires between the two pairs of plates, leaving the apparatus uninjured.

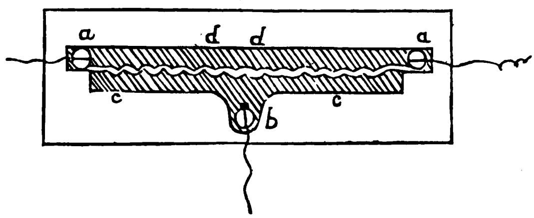
With such arrangements, it will be possible to protect the telegraph officers and apparatus, but the wire conductor itself will always be liable to destruction. According to the experiments made, these protections are not only required with the conductors which are above the ground, but also with those insulated lines by gutta percha, beneath the surface of the ground, as this is done on the Royal Prussian States Telegraph.

The arrangement of these subterranean conductors is analogous to those which are observed in the experiment of the Franklin plate and the Leyden jar. The earth forms the one surface, the wire conductor the other, and the insulated gutta percha the glass. With the known continual fluctuation of the electric condition of the earth and the atmosphere, the above described plate conductors are of great importance in the subterranean wires, because the inside and outside borders are brought through the neighborhood of the plates A and B, so near together that an injurious discharge with ordinary electricity is impossible.

Having devoted considerable space to the means employed in Germany, I will now give a description of the principal forms of lightning protectors now in use. On the telegraph lines in the United States are Bulkley's, Carey's, Barnes's and House's.

Bulkley's protector, Fig. 64, consists of two brass plates, shaped as

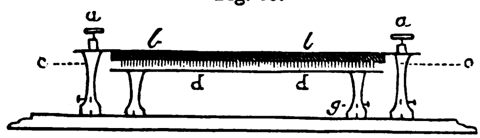
Fig. 64.



in the drawing, upon a mahogany block; one of these (*dd*) is firmly screwed to the block by means of the screws *a a*, which also serve as binding screws (screw cups), and by means of them the main wire passes through the plate *d d*. The binding-screw *b* is so arranged that it binds the other plate, *c c*, to the block, allows it to move to and from the plate *d d*, thus bringing the point or edge of each plate in adjustable proximity. The ground wire is attached to the binding-screw *b*. The operation of this arrangement is too simple to need explanation.

In Carey's protector, Fig. 65, the ground wire enters at *g* and com-

Fig. 65.



municates with the plate *d d*; the upper plate *b b*, has attached to its under surface a strip of card leather *c c*, with its thousand points of fine wire; this upper plate is, by means of the screws *a a*, raised or lowered at pleasure, thus bringing these points more or less near the plate *d d*. The main wire passes through the plate *b b*, by means of the screw connections and its supporting pillars.

Those who have used the Carey arrester find considerable trouble in keeping it properly adjusted. The card teeth being in leather, do not remain true, and hence often cause trouble with the working of the line. This, I think, might be obviated by using a plate of ivory instead of leather.

Barnes's arrester consists of an earthenware flower-pot filled with water. The main line is connected with a fine copper wire, which passes through the water and the opening at the bottom of the pot to the office connections.

This arrangement, simple as it may seem, has been used to a considerable extent on the lines South, and is stated to protect the instrument from injury, the water dissipating the lightning when it comes in contact, often burning the copper wire, and thus preventing contact with the telegraphic instrument.

The House arrester (Fig. 66), consists of an ornamental brass stand-

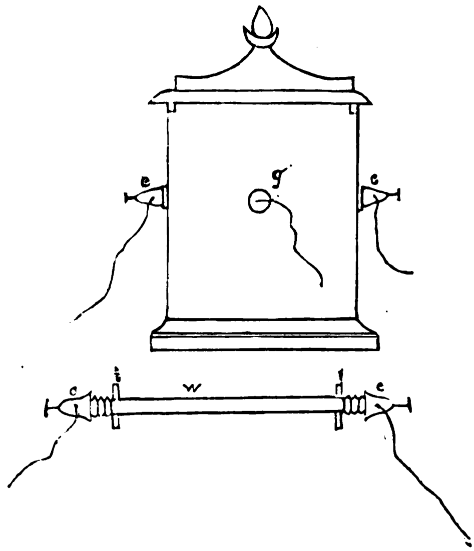
Fig. 66.

ard fixed to a block of hard wood on the left of the standard; the line wire is connected by a brass screw. This standard supports (but is insulated from it by means of paper or silk) a cube of brass one and a half inch long, and three-quarters of an inch in diameter, having an opening through its whole length, through which passes a very fine copper wire insulated with silk, which is attached to the top of the standard by another screw; this wire supports a brass ball a short distance from a brass cup which is fixed to the block of wood; another portion of the same wire is then connected with the office wire on the right; a wire leading to the ground is also connected with the brass cube.

The action of this arrester is as follows: The atmospheric electricity passing along the main wire enters the brass standard, passing by the fine wire to the cube, which has a ground wire connected with it, and may thus pass into the earth, as the ground wire is connected in all the telegraph offices in our large cities with the gas and water pipes; the electricity is thus dissipated over a large surface of metal.

When the atmospheric electricity is sufficiently powerful to injure the helix of a magnet, it will burn the fine wire passing to the cube, and

Fig. 67.



thence pass by the ground wire to the earth, letting the small brass fall into the cup, thus breaking the connection with the instrument in the office until the fine wire is replaced.

These are used in nearly all the offices of the House lines, and are never known to fail.

Another form of lightning protector, made by Mr. Norton, of New York, and called by him the Iron-filing Protector, is seen in Fig. 67. It is a cylindrical brass box of ornamental design, with a cover, by removing which the box is filled with iron-filings. The main current passes through this box by the binding screws *c c* and the wire *w*, as in the lower figure.

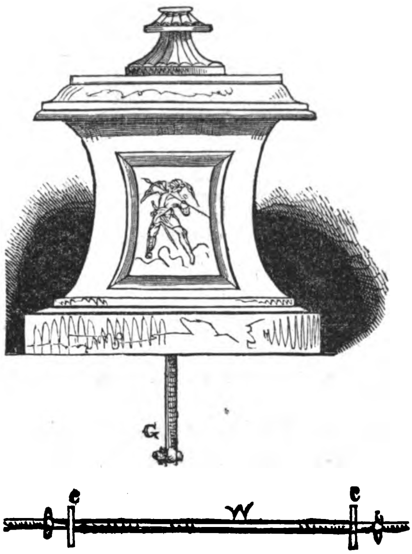
This wire is insulated from the brass box by ivory washers *i i*, and from the iron filings by a thin film of tissue paper. The ground wire connects with the brass box, and, of course, with the iron filings, by means of the screw *g*.

Mr. Edward Highton, who has employed this form of lightning protector, namely, iron filings, and who claims it as his suggestion, makes the following remarks in regard to it in his work on the Electric Telegraph: "The disastrous effects of lightning are now entirely obviated by the following plan pursued by the author, which is as follows:—

"A portion of the wire circuit, say for six or eight inches, is enveloped in bibulous paper or silk, and a mass of metallic filings in connection with the earth is made to surround such covering. This arrangement is placed on each side of a telegraphic instrument at a station. When a flash of lightning happens to be intercepted by the wires of the telegraph, the myriads of infinitesimal fine points of metal in the filings surrounding the wire at a station, and having connection with the earth, at once draw off nearly the whole charge of lightning and carry it safely to the earth. This arrangement at once prevents any damage to the telegraphic instrument; not a coil under the author's charge has been fused where this plan has been adopted. The cheapest method is as follows: Line a small deal box, say six or twelve inches long, with tin plate, and put this plate in connection with the earth; fill this box with iron filings, and then surround the wire (before it enters a telegraph instrument) with bibulous or blotting-paper, as it runs through the centre of the box. All high-tension electricity collected by the wires, will at once dart through the air in the bibulous paper to the myriads of points in the iron filings, and thence direct to the earth, and thus the telegraph instrument will be rendered incapable of being damaged even during the most fearful thunderstorms that may occur."

The objection to this form of protector is, that by the electric discharge, the blotting paper or silk will be destroyed. I would therefore propose the following arrangement, as is seen in Fig. 68, which consists of an ornamental stand of wood, lined inside with copper; passing through the stand is the main wire W, insulated by a coating of gutta percha and by washers, C C, of the same material. The ground wire G should be of copper, insulated in passing through the box, of an inch in diameter, having numerous sharp points in the interior of the stand. It should be near to, but not in contact with the main wire, so as not to conduct any of the galvanic current away from the main wire, terminating in two or more branches leading under the surface of the ground, and, if possible, to moist earth, drains, or springs of water. Under such an arrangement, a discharge of lightning passing along the surface of a wire will be conducted to the earth insensibly, without the possibility of damage to the office or instrument. The following is a description of the protector used on several of the lines in England along the railroads under the superintendence of Charles V. Walker, Esq., Telegraphic Engineer.

Fig. 68.



"This consists of a small hollow metal cylinder connected with the earth. The line wire, in its passage from the railway to the telegraph, passes within this cylinder; traversing which, it is first presented to the inner surface in the condition of a thick wire furnished with spurs, whose points are in the closest possible proximity to the cylinder without being in actual contact; it is then continued on, and presented as a short coil of very fine wire, finer, in fact, than that of the instrument coils wound on a bobbin, the outer convolution of the coil being very close to the cylinder. Thus, a better means of escape is presented to the lightning than is to be found in any part of the instrument; consequently, it always escapes by this conductor, either by the points or by burning the fine wire.

"As yet, no instance has occurred in which these conductors have failed to act, and to preserve the instrument, while instruments in the same office not thus protected have, on several occasions, been damaged."—*Report of Jury of the World's Fair in London.*

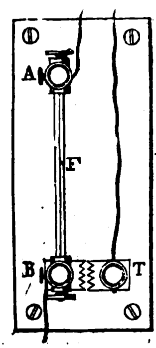
It will be seen, upon a careful examination, that the object to be attained in all these machines, is to bring a number of metallic points in the closest proximity to the main wire, so as to connect as much as possible all the large detached masses of metal in the office, and unite them with a capacious conductor, leading as direct as possible to the moist earth. This conductor should, of course, be metallic, and as metals vary very much in their conducting power, and copper being one of the best, it is to be preferred.

The following is a description and drawing of the apparatus, made by Breguet for the French lines of telegraph, in 1853, to prevent the injurious effects of atmospheric electricity, and he makes the following statement in regard to its merits:—

Since the introduction of this simple apparatus, it has given entire satisfaction, there being no longer danger to the operator nor to the telegraphic apparatus, wherever they have been used, he having made and put up several hundred.

The *paratonnerre* consists of a small square board, Fig. 69, on which are placed two buttons, at a distance of six to seven centimetres, a very fine wire, F, connecting them. This apparatus is inserted in the wire of the line, so that on whatever side the current is directed, it always passes in by the *paratonnerre*. He has chosen iron wire, its conducting power being five or six times less than that of copper of equal diameter, employing wire much finer than that upon the bobbin of the electro-magnetic coil.

Fig. 69.



It will thus allow only a certain quantity of electricity to pass, always less than that necessary to melt the copper wire of the telegraph; but if the quantity of electricity is increased, the iron wire is destroyed, but the telegraphic instrument is saved.

This iron wire is easily replaced, and the apparatus is immediately placed in its original state. This wire is placed in a glass tube, so that it cannot be injured. At each extremity of the glass tube are two copper mountings, A and B, to which the wire is fastened, and which establishes its metallic connection with the two buttons; these two copper mountings are fastened by screws, and in case of accident it is only necessary to insert a new tube.

At the side of the button B is another, T, which is connected with the earth, and these two buttons are joined with toothed plates of copper, of which the points are very close to each other, so that if the wire of the line is charged with atmospheric electricity, it can discharge itself in part by these points to the earth.

As far as regards the safety of the telegraphic operators, he recommends that the large wire should never enter the interior of the telegraphic station, as this may be dangerous, because from a wire three to four millimetres of section, there can escape sparks to a great distance, capable of wounding the operator. He considers it absolutely necessary to stop the wire outside, and only to establish communication with the telegraph by wire of small diameter. When it is possible, it is better to stop the cord from one to two metres from the station.

"H. C. Turner, of Cheraw, South Carolina, has taken measures to secure a patent for an improvement in telegraph apparatus to protect the magnet of a telegraph instrument from being destroyed or injured by lightning, as well as to enable telegraphic operators to continue at work during the prevalence of atmospheric electricity, which often causes great trouble and delay in the southern latitudes.

"The principle of improvement consists in having a medium connected with the ground and telegraph line, which will conduct electricity of great intensity, but not that of low intensity, as generated by the galvanic battery, thus carrying off the atmospheric electricity without interrupting the circuit. He employs two small brass cylinders, each of which has a wire running from a connection screw at the middle, while the circuit wire runs through. Each cylinder is separated at each end by a piece of ivory, or other non-conducting substance, and the only communication with the ground is obtained by some partial conducting substance, such as ground charcoal. With this each cylinder is filled, therefore an intense electric discharge is carried through this medium to the ground, and the magnet is protected. The invention is simple and new to us, and we understand it has been used in the telegraph office at Cheraw for two months, with complete success. It is constructed on scientific principles."

The concluding remarks in regard to this form of lightning protector is by the editor of the *National Telegraphic Review*, from which journal we copied the notice. Its editor, Mr. Reid, is a skilful telegrapher, and superintendent of the Atlantic and Ohio, and the Pittsburg, Cincinnati, and Louisville Telegraph lines. An opinion given by such a practical man should therefore be very valuable. He also adds in a note the following caution: "In all applications of this character, and they are of the highest importance, great care must be taken to keep the apparatus or fixtures free from moisture or accessibility to rain."

ON THE

IMPORTANCE

OF THE

TELEGRAPH ON RAILROADS.

THE recent dreadful accidents which have occurred upon our railroads, have turned the attention of the press and the public to devise some more certain method by which information can be conveyed along the lines of railroad, so as to prevent this awful destruction of life and property which has taken place throughout these United States. I am sorry to state that, within the last eight months, from the first of January, 1853, these have been as follows: Sixty-five casualties, a hundred and seventy-five deaths, and three hundred and thirty-three persons injured on railroads.

The subject is one fraught with much interest to all who travel; and we might well say, Who is there that does not travel? They are to be numbered by millions. In the State of New York alone, during the year 1852, the number of passengers on her railroads was 7,440,653, and of this number, 228 were killed, being one in 286,179.

In Great Britain, the telegraph has been placed along almost all the railroads, and its advantages have been very great, for, although the speed on their railroads is greater, their number of deaths from casualties is less than that of the State of New York. In the year 1852, the whole number of passengers upon the railroads of Great Britain was 89,135,729, and the total number of passengers killed was 216, being only 1 in 2,785,491. This will show at a glance the great inferiority of New York railroad management, and not only New York, but the management throughout the United States; for most of the railroads in the United States are behind New York in this very matter.

The large amount of money spent yearly, for the loss of life on railroads, is shown by the following statement: The New York and New Haven Railroad Company, upon whose road one of the most fearful accidents occurred this season, near Norwalk, paid twenty-one thousand six hundred and seventy-nine dollars last year for personal damages. This year, the amount is likely to be much heavier, in consequence of the catastrophe alluded to, and others.

I am happy to say, that upon a few of the railroads of this country, the telegraph has been introduced, and found of very great benefit in facilitating the business of the road and the prevention of accidents, which is shown by the small number of casualties upon such roads.

"It has been introduced upon the Madison and Indianapolis Road, one of the most successful railroads in the United States. The President of the road, the Hon. John Brough, speaks of the telegraph in the highest terms, and the important benefits derived from it. It has been introduced upon the New York and Erie Road, but has not yet been used to the extent that it could and should be used along this line; and I am very glad to find that the Baltimore and Ohio Road, the Camden and Absecom Road, are about introducing it upon their lines.

The actual cost of building first-rate lines of telegraph, with the best mode of insulation and protection from the effects of atmospheric electricity, so as to secure durability, would not cost much over three hundred dollars a mile; the actual cost of our best built lines now in operation, has not exceeded two hundred dollars a mile. Such a telegraph, well arranged, will return to a railroad company sufficient benefit in the safety of life and property, to counterbalance the whole cost of construction.

Even as an investment it has paid well in England, where capital is abundant and interest is at its lowest point; for the dividends on the South-eastern Railroad have been $1\frac{1}{14}$, $3\frac{1}{2}$ and $3\frac{2}{5}$ per cent. per annum, for the four half years, ending respectively January and July, 1848 and 1849, after all expenses of working and maintenance of the line were paid.

In addition to this statement in regard to the dividends, I cannot do better than quote the advantages which the telegraph has conferred upon the railróad, in the words of the distinguished Superintendent of Electric Telegraph of the South-eastern Railroad Company, Charles V. Walker, Esq., who is well known as an accomplished electrician and telegraph engineer.

"The electric telegraph in England is greatly indebted to the railroads, if not for its existence, at least for the friendly hand they have held out to it, and for the protecting care with which they have guarded it; indeed, the invention would long have remained immatured and void of practical existence, had not the railroad prepared for it a pathway from place to place, along which its capabilities could be tested. Nor has the child been ungrateful to its foster-father; it has made a tenfold return for all the protection that has been extended to it.

"The quiet poles and silent wires, the zinc and the vitriol, the brass, the ivory, the earthenware, and the gutta percha, are far more concerned in the working economy of a railroad than the proprietors may suppose.

"As an illustration of the amount of service it may render to a railroad, take the telegraph work done at Tunbridge station, on the South-eastern Railroad, for the three months from the 1st August to the 31st October, 1848. By referring to the message-book, in which it is the rule that all communications shall be entered, it appears that upwards of *four thousand* messages passed in that interval, which I have roughly classified as follows:—

	Messages.
1. Concerning ordinary trains	1,468
2. " special trains	429
3. " carriages, trucks, goods, sheets, &c.	795
4. " company's officers	607
5. " engines	150
6. " miscellaneous matters	162
7. Messages forwarded to other stations	499
Total,	4,110

"1. To make a full analysis of these seven groups of messages would be tedious; the reader can imagine for himself that, in regard to trains, all which concerns the progress and safety of a train has been at one time or other the theme of telegraph signals, and that from the time it starts until it reaches its journey's end, it 'casts a shadow before,' yes, many miles before, to notify its coming, and leaves 'a track behind' as distinct and as palpable to the mind's eye, as if the eye itself were present to see it. Indeed, this is so realized, that we are in the common habit of saying I just *saw the train pass* this place or that, when all we really saw was the *telegraph signal*. If trains are late, the cause is known; if they are in distress, help is soon at hand; if they are heavy, and progress but slowly, they ask, and have more locomotive power either sent to them or prepared against their arrival; if there is anything unusual on the line, they are forewarned of it, and so forearmed; if overdue, the old plan of sending an engine to look after them has become obsolete; a few deflections of the needle obtain all the information that is required.

"2. *Special trains* are nowhere really *special*, unless on a telegraph railroad. My idea of such a train is, that it can be had for the *asking*, and can have a *clear course* before it. On a railroad like the South-eastern, which is the high-road between the continent and the capital of the British empire, couriers may arrive from abroad, as indeed they do at all hours, and without any previous notice, and require immediate means of reaching London. Should the *Ondine* arrive at Folkstone bearing dispatches for the morning papers, full of eventful news of 'wars, and rumors of war,' of tottering thrones and falling diadems, the courier need not care at having just missed the train, nor fear of being too late in London to save the press for the first edition. If he finds no engine at Folkstone, the telegraph will soon obtain him one from where there is one to spare, and not only so, but when he starts will clear the road before him, and give timely notice to the train in advance to move aside and let him pass. Nor need the traveller by the previous train have any fear, as otherwise he might, on such a line as this, that some ramping, raging engine, conveying a special train, shall rush upon him unawares, with destruction and death upon its wings. The guards in charge of his train are well advised by telegraph of what is following in their wake, and they know the time and place to move aside, and let the coast be clear. Four hundred and odd signals in three months will show how greatly the course of special trains, and the comfort of their passengers, must be regulated by the telegraph.

"3. A given amount of work is accomplished with a less amount of rolling-stock on a well-worked telegraph railroad than elsewhere; and of the stock that is employed, there is much less unnecessary wear and tear in running about to stations where it is not wanted. The money-value of this use of the telegraph is great. It is of daily and almost hourly occurrence, for stations in unexpected want of carriages and trucks, to obtain them by means of telegraph notices from other stations who can spare them; and thus the surplus stock is much less than it must otherwise needs be. About a thousand carriages of various kinds, and sheets for protecting goods trucks, were required by telegraph in the three months before us.

"The urgency of these requests sometimes amounts almost to the ludicrous. To some small station, say Headcorn, an unexpected in-pouring of hops arrives from the neighboring gardens; he has very few trucks, very few sheets, he has just sent his last away; the heavens look black and threatening—big drops begin to fall; his warehouse and his tents are full. He makes known his distress to Ashford in vain; to Canterbury, nearly in vain; to Tunbridge, he gets some trucks, perhaps, but no tarpaulin to cover them; to the goods department, in the Kent Road, London, whence his wants, perhaps, are all supplied. If, again, all this were to be done by letter, conveyed by train, the opportunity would be lost or the mischief would be done before his wants could be supplied; for the letter would first go to head-quarters at London, where probably would be kept the returns of the distribution of the rolling-stock on the morning of the day in question; the officer in charge would know at what station, say Canterbury, there appeared in the morning a good supply. He would write by the next train to Canterbury. But the evening would by this time have arrived, or the stock at Canterbury might now be engaged; or if they could be spared, there might be no ready means of forwarding it.

"Besides these messages, arising out of the daily wants of rolling-stock, there is the plan of furnishing the chief office of the goods department with a telegraph report every morning, from all stations, of the stock at that time at each station.

"4. Six hundred and odd messages, in three months, of communications between the management and the heads of departments, and between the latter and their subordinate officers, is a good illustration of the comparative ubiquity the telegraph confers upon the direction of a railroad. The hours of needless delay and the miles of profitless travelling which are thus saved are great; and anxiety of every kind is mitigated. No small amount of practical confidence is created, from the fact that the management can issue instructions to meet emergencies, and can be consulted by their officers from all parts of the district in any time of need.

"5. We have already remarked that the telegraph communicates the plight of distressed trains to stations provided with spare locomotive power; it also regulates the distribution of engines when any mishap has occurred requiring a fresh supply, or where any undue call has been made upon the ordinary stock.

"But the actual saving, in locomotive power, by enabling the number of pilot engines to be reduced, is, of itself, a most important feature in the economy of the electric telegraph. In the district in question there are certainly two stations, if not three, which once had pilots, but are now without; when required, engines are obtained by telegraph. It would appear that on a part of the line, not yet provided with the telegraph, a pilot might be superseded if the telegraph were there. Now, as the *maintenance and wages* for one single engine amounts to a *larger sum*, weekly, than is required to pay our whole *staff of telegraph clerks* and the *mechanics* and laborers employed in cleaning and repairing the instruments, and maintaining the integrity of the line work, if only one engine be superseded, we have a notable set-off in favor of the telegraph.

"6. All other communications have been classed under the head of Miscellaneous. No matter what the subject or when the hour, the lightning signal is obedient to orders. Passing over the black leather bag which some one, every day, appears to leave in some train, passengers have recovered luggage of a most miscellaneous character, by means of the telegraph. In the trains have been left a pair of spectacles and a pig; an umbrella and *Layard's Nineveh;* a purse and a barrel of oysters; a greatcoat and a baby; and boxes and trunks *et id genus omne* without number.

"7. We appear also to have had just 500 messages to transmit; either to forward on in due course to the smaller groups, or to help on for other stations in times of bad insulation, or of other distress. When to this we add the signals passed on matters essentially connected with the working of the telegraph itself and its maintenance; and our experiments upon the signals and testing, we have no lack of evidence of the great capability of the instruments, and that they are by no means idle.

"In *The Times* of the day on which I am writing, is an illustration of the condition to which a train may be reduced when unbefriended by the telegraph. A 'Constant Reader' has been spending the day at a popular watering place, and, in common with many more, prolonged his visit until the 'last train.' The train arrived, and when all were seated, twenty-seven carriages were filled. The engine had rattled on joyously before this large addition to its load was made, but now, it commenced panting onward with deep asthmatic laborings. 'We proceeded,' writes our friend, 'at a snail's pace, stopping, as usual at the various stations, until we reached the centre of a long tunnel, where we were entirely brought to a stand, and remained almost suffocated by steam and smoke for thirty-five minutes, amidst the screams of the women in the second and third class carriages, who were in total darkness, and sharing with us the fear of the next train, which was considerably overdue, crushing us.' * * * * No very pleasant predicament, assuredly! and he very reasonably asks, in continuation, 'if the train was too long for one engine, why not have had two?' Aye, there was the rub. But there was no getting another then and there.

"The driver may have seen that the great influx of passengers was as much as his engine was equal to, but he had no help for it, he must either do his best, or leave some of the passengers behind; there was no telegraph to call for help.

"As a contrast to this, the very next day, one of the charitable institutions in London gave the children a trip to Tunbridge Wells, and they filled a long special train. The engine which brought them from London was not able, of itself, to take them up the incline where the branch leaves the main line at Tunbridge; and the pilot engine was absent on another equally pressing engagement.

"Quick as thought, the Tunbridge Wells engine was ordered by telegraph to come and help, and it was ready at the junction even before the train that required it.

"On New Year's day, 1850, a catastrophe, which it is fearful to contemplate, was averted by the aid of the telegraph. A collision had occurred to an empty train at Gravesend, and the driver having leaped from his engine, the latter started alone at full speed to London. Notice was immediately given by telegraph to London and other stations; and while the line was kept clear, an engine and other arrangements were prepared as a buttress to receive the runaway. The superintendent of the railroad also started down the line on an engine; and on passing the runaway, he reversed his engine and had it transferred at the next crossing to the up line, so as to be in the rear of the fugitive; he then started in chase, and, on overtaking the other, he ran into it at speed, and the driver of his engine took possession of the fugitive, and all danger was at an end. Twelve stations were passed in safety; it passed Woolwich at fifteen miles an hour; it was within a couple of miles of London before it was arrested. Had its approach been unknown, the mere money value of the damage it would have caused, might have equalled the cost of the whole line of telegraphs. They have thus paid, or in a large part paid for their erection.

"As a contrast to this, an engine, some months previously, started from New Cross towards London. The Brighton company have no telegraphs; and its approach could not be made known. Providentially, the arrival platform was clear: it ran in, carrying the fixed buffer before it, and knocking down, with frightful violence, the wall of the package office."

While I write, August 1853, a most frightful accident has occurred on the Camden and Amboy Railroad, by the collision of two trains, by which four or five valuable lives have been lost, and the maiming and bruising of some twenty others, and the destruction of property to an immense amount. At a meeting of the passengers, some two hundred in number, several resolutions were passed in regard to the bad arrangement of the company, and the following one in regard to the use of the telegraph upon this line:—

"*Resolved*, That the use of a telegraph (so indispensable upon a single track road), might have prevented this sad catastrophe."

If a telegraph line would do nothing more than this for a company, they would be well repaid for the outlay. In conclusion, I would therefore press the important subject upon the attention of all interested in railroads, as a matter of vital importance to their interest, and to the interests of the community at large.

APPENDIX.

INTERESTING AND IMPORTANT TELEGRAPH DECISIONS.

The trial in this important and interesting case occurred in our city in September, 1851, involving important questions relative to the originality of the inventions claimed by Prof. Samuel F. B. Morse. The plaintiffs, who represent the Magnetic Telegraph Company using Morse's patents, allege that the defendants, who represent the "Bain Line" from Washington to New York, have violated the patents granted to Morse.

The following were the counsel engaged on both sides:—

For Plaintiffs—Hon. Amos Kendall, of Washington, St. George T. Campbell, Esq., of Philadelphia, George Gifford, Esq., of New York, and George Harding, Esq., of Philadelphia.

For Defendants—Hon. William M. Meredith, of Philadelphia, Peter M'Call, Esq., of Philadelphia, and Hon. R. H. Gillette, Esq., of Washington.

The Judges on the bench were Hon. R. C. Grier and Hon. J. K. Kane.

On the 3d of November, Judge Kane delivered the opinion of the Court, Judge Grier expressing his concurrence therein.

Opinion of the Court.—This case is before us on final hearing upon the pleadings and proofs.

Professor Morse, under whom the complainants hold, has three patents: the first, dated 20th June, 1840, reissued after surrender on the 25th January, 1846, and again reissued after a second surrender on the 13th June, 1848, which has been referred to in the argument as the Magnetic Telegraph Patent; the second, dated 11th April, 1846, also reissued on the 13th June, 1848, referred to as the Local Circuit Patent; the third, dated 1st May, 1849, referred to as the Chemical Patent. The bill charges that the respondents have infringed all three of these patents; the answer denies the infringements, and controverts the validity of the patents.

I. The objections to the validity of the first patent, that for the Magnetic Telegraph, are stated in the defendants' brief as follows:—

"I. That it does not run from the date of Morse's French patent.

"II. That the Commissioner of Patents had no authority in law to reissue a second time.

"III. That the claims set out in the first reissue are broader than the claims in the original patent; and the claims in the second reissue are broader than those of either of its predecessors, and are not for the same invention."

1. The first of these objections founds itself upon the fact, that Mr. Morse had obtained a patent in France for this same invention twenty-two months before his patent issued here; and it asserts, that under the second proviso of the 6th Section of the Act of 1839, his American patent should in consequence have been limited to the term of fourteen years from the date of the French patent; and that not having been so limited, it is void.

This objection was fully met in the argument of the complainants. Mr. Morse's application for a patent in this country was made in April, 1838, and was filed and acted on in the Patent Office before the 10th of that month; his French patent bears date the 18th of August following. There is therefore no room for the questions, which were argued so elaborately, of the proper interpretation of this proviso in the 6th Section of the Act of 1839, and the 8th Section, second clause, of the Act of 1836, which was also invoked, in any possible bearing upon the case of Mr. Morse. The proviso of 1839 must be interpreted by reference to the enacting words of the section which it limits; and the provisions of both the sections relate only to such patents as are *applied for* here, after the issue of a foreign patent. But Mr. Morse's application here was before his patent abroad—in nowise after it—and his American patent was granted, therefore, under the general enactments of the Act of 1836, not under any special proviso or exception whatever; and its term runs properly from its date.

We do not see the justice of the criticisms upon his application, that the jurat affixed to it is without date of day or month; and that the drawings which accompanied it were not in duplicate. There is no act that requires the jurat to be dated at all; and the supplementary provision of the 6th Section of the Act of 1837, that "the applicant shall be held to furnish duplicate drawings," though directory in its terms, is not a condition; and it has obvious reference in point of time to the issuing of the patent, and not to the filing of the petition for it. Such has heretofore been the interpretation of the Patent Office, announced in the official circulars for the instruction and guidance of inventors; the practice founded on it is both reasonable and convenient; and no act of Congress appears to conflict with it. If Mr. Morse's patent is invalid on this ground, more than half the modern patents for mechanical inventions must probably fall with it.

2. The second objection to the patent is, that the Act of Congress makes no provision for a second surrender and reissue.

The 13th Section of the Act of 1836, which provides in certain cases for the surrender of a defective patent, and its reissue in an amended form, regards the new patent as substituted for the old one, with just the "same effect and operation in law" as if the specification had been filed at first in the form which it takes in the reissue. It is difficult to see why, if the original patent could be amended, its substitute, having all the legal attributes of the original, cannot be amended also.

There is nothing in the words of the act, or in the policy which it proclaims, that limits the correction of errors to such as may have been the first discovered. On the contrary, if it be true, as we have supposed in determining the recent case of Battin *vs.* Taggert, that the patent is granted to the inventor in consideration of some benefit to be derived by the public from his disclosures, and that the reissue is in consideration of some more full or more accurate disclosure than that which he had made in his original specification, or some renunciation on his part of an apparently secured right—it is for the public interest, that the surrender and reissue should be allowed to follow each other, just as often as the patentee is content to be more specific or more modest in his claims.

Besides, it might not be safe to assume too readily that the act was intended to withdraw altogether from the officers of the executive department the power, which they had before, to accept a surrender and grant a reissue, and which would sanction a second reissue quite as readily as at first. The act might perhaps be regarded more justly as affirming the propriety of the usage which had obtained under the former laws, and had been repeatedly recognized by the courts (Morris *vs.* Huntington, 1 *Pain.* 355–6; Grant *vs.* Raymond, 6 *Pet.* 220; Shaw *vs.* Cooper, 7 *Pet.* 315), and as prescribing in addition the conditions and incidents which should attach to it thereafter in certain cases. It is hardly to be supposed that the merely clerical error of an engrossing subordinate, or the accidental inadvertence of the Commissioner himself, is not capable of being rectified or supplied now, just as it was before the passage of the act. And yet the construction, which regards this section as superseding the implied power of the Commissioner, might lead to this, since the act makes no provision for correcting such mistakes on the part of the patent officers.

Still further: it must, as we think, be conceded, that if the Commissioner's power to reissue is so restricted by the act as to be exhausted by a single exercise, his power to accept the surrender must be equally restricted and equally transitory. And the argument then resolves itself only into another form of the question, whether the patent was for any purpose a valid one as it stood after the first reissue; because, if the second reissue was invalid for want of authority to make it, the second surrender was ineffective for want of authority to accept it—and so the patent stands as if it had not been surrendered the second time. The surrender and the reissue, no matter how often they recur, are reciprocal—each in consideration of the other—and forming together but a single act between the parties. It would be unconscientious to retain the consideration, while denying the validity of the grant. See Woodworth *vs.* Hall, 1 *Wood C. & M.* 400.

3. We pass to the third objection, the supposed variance in the reissues.

From the course of some parts of the argument on this point, it might be inferred that the objects as well as the import of the 13th Section of the Act of 1836 had been misapprehended by the learned counsel for the respondents. It is not the meaning of the law, that the patentee who applies for a reissue, must at his peril describe and claim in his new specification, either in words or idea, just what was described and claimed in his old one. His new specification must be of the same invention, and his claim cannot embrace a different subject-matter from that which he sought to patent originally. But, unless we narrow down the correction which the statute contemplates, till it becomes a mere *disclaimer*, it is not possible in any case to frame a corrected specification, which shall not be broader than the one originally filed. To supply a defect, to repair an insufficiency, is to add—either directly or by modifying or striking out a limitation; in either form, the effect is to amplify the proposition; in the case of a specification under the patent laws, it is to amplify the description and enlarge the claim.

There are few things more difficult, even for well educated and practised lawyers, than to describe a new invention clearly, and point out the principle which distinguishes the subject of it from all things known before; and as inventors are rarely experts either in philology or law, it has long been established as a rule, that their writings are to be scanned with a good degree of charity. But it is easy to abuse this liberality to the purposes of fraud. The public has rights to be guarded also; and these exact, that the patentee's specification shall set forth his invention so fully and definitely that it cannot be readily misunderstood.

It is the purpose of the statute to reconcile this seeming conflict; and it effects it by allowing the inventor to amend the mistakes he has honestly fallen into in his description and claim of title, as soon and as often as he discovers them. And there is the more reason for this indulgence, since, under the Act of 1836, Sec. 7, the specification is reviewed by the Commissioner before the patent issues, and is very often modified in accordance with his suggestions, or to obviate objections made by him to its original form. He may be supposed to know, therefore, better than any one else but the patentee himself, what the invention was for which the patent was sought at first, and he may also know whose inadvertence, accident, or mistake it was, that made the first specification inoperative, or invalid. It is not absolutely impossible that it may have been his own: as certainly it had his implied concurrence.

And this consideration furnishes a strong argument for the rule, that the Commissioner's action in ordinary cases of reissue shall have more than a *prima facie* influence in finally deciding the question of identity of invention. Whatever be the extent of that rule; whether it leaves nothing open for discussion before the court, but the issue of fraud, as appears to have been the undivided opinion of the Supreme Court in the case of Stimpson, 4 *How.* 404; or whether we permit ourselves to except from it, as we did in Battin *vs.* Taggert, cases in which the invention claimed in the reissued patent is obviously different from that claimed in the original; or whether, with Judge Story in Allen *vs.* Blunt, 3 *Stor.* 740, and in Woodworth *vs.* Stone, *ibid.* 749, we hold the grant of the amended patent to be "conclusive as to the existence of all the facts which by law are necessary to entitle the Commissioner to issue it, at least unless it is apparent on the face of the instrument itself, without any auxiliary evidence, that he was guilty of an excess of authority, or that the patent was procured by a fraud between him and the patentee;" whatever be the rule, or its limitations, the propriety of the reissue in the case before us can hardly claim a judicial review. There is no want of jurisdiction, either apparent on the face of the proceedings or asserted by the evidence; and there is no fraud imputed, or justly imputable.

Nor is there any flagrant diversity of claim. After a repeated and careful examination of the three specifications, with their respective claims, fully aided by the acumen of highly ingenious counsel, we have not found a material difference of import between any of them. The order in which the subjects of claim are marshalled is not the same throughout; a phrase is more concise in one, in another more popular; in one a scientific term, or a general expression, takes the place of the descriptive or defining language, or the detailed particulars of another; in a word, they are unequal as specimens of artistic writing, and a close examination may detect defects in the first two, which are repaired in the last. But they all describe the same thing essentially; and we should find it easier to argue, that neither the first nor the second specification could be rightfully regarded as "inoperative or invalid" for want of precision and clearness, than that there was an important variance in the second from the first, or in the third from either.

These observations form the answer to the third objection.

Mr. Morse's patent of 1840, in all its changes, asserts his title to two distinct patentable subjects; the first, founded on the discovery of a new art; the second, on the invention of the means of practising it.

1. That he was the first to devise and practise the art of recording language at telegraphic distances, by the dynamic force of the electro-magnet, or, indeed, by any agency whatever, is, to our minds, plain upon all the evidence. It is unnecessary to review the testimony for the purpose of showing this. His application for a patent, in April, 1838, was preceded by a series of experiments, results, illustrations, and proofs of final success, which leave no doubt whatever but that his great invention was consummated before the early spring of 1837. There is no one person, whose invention has been spoken of by any witness or referred to in any book, as involving the principle of Mr. Morse's discovery, but must yield precedence of date to this. Neither Steinheil, nor Cooke and Wheatstone, nor Davy, nor Dyar, nor Henry, had at this time made a recording telegraph of any sort. The devices then known were merely *semaphores*, that spoke to the eye for the moment—bearing about the same relation to the great discovery now before us as the Abbe Sicard's invention of a visual alphabet for the purposes of conversation bore to the art of printing with movable types. Mr. Dyar's had no recording apparatus, as he expressly tells us; and Professor Henry had contented himself with the abundant honors of his laboratory and lecture-rooms.

When, therefore, Mr. Morse claimed, in his first specification, "the application of electro-magnets" "for transmitting, by signs and sounds, intelligence between distant points," and "the mode and process of recording or making permanently signs of intelligence transmitted between distant points;" and when in his second specification he claimed "the making use of the motive power of magnetism, when developed by the action of currents of electricity, as a means of operating and giving motion to machinery, which may be used to imprint signals upon paper or other suitable material," "for the purpose of telegraphic communication;" characterizing his "invention as the first recording or printing telegraph by means of electro-magnetism;" and when, in his third, after again describing his machinery and process, he once more characterized it in the same terms, and claimed "as the essence of his invention the use of the motive power of the electric or galvanic current (electro-magnetism as he now terms it), however developed, for marking or printing intelligible characters, signs of letters at any distance;" through these several forms of specification, claiming and renewing his claim of property in the same invention, as it seems to us—and claiming in each and all of them no more, as it also seems to us, than he was justly entitled to claim—he declared the existence of a new Art, asserted his right in it as its inventor and owner, and, announcing fully its nature and elements, invoked in return the contracted protection of the laws.

From this time, his title was vested as patentee of the art, and other men became competitors with him only in the work of diversifying and perfecting his details. He himself used the *stylus* to impress paper or parchment, or wax-coated tablets, it may be; though he sometimes made a colored record by the friction of a pencil; another substitutes a liquid pigment, or stains his paper with a chemical ink; the next perhaps stains his paper beforehand, and writes on it by decomposing the coloring matter; and another, yet more studious of originality than the rest, writes in a cyclovolute, instead of a straight line, and manufactures his ink as he goes along, by decomposing the tip of his stylus on a chemically moistened paper. They are no doubt all of them inventors; as was the man who first cast types in a mould, or first bent metal into the practical semblance of the gray goose-quill, or first devised sympathetic ink, that the curious in letter writing might veil their secrets from the profane. All these toiled ingeniously and well, to advance and embellish a pre-existing art. But they had no share in the discovery of the art itself, and can no more claim to share the property which its discovery may have conferred on another, than he who has devised some appropriate setting for a gem can assert an interest in the gem itself.

Yet admitting, for the sake of argument, that Mr. Morse's leading invention is correctly designated as a new art; and that he has sought to patent it accordingly, by a compliance with all the requisitions of the statute—it is still contended, and with much of elegant research into the radical meaning of the term, that an art, as such, cannot be made the subject of a patent. But interpreting language as men use it around us and as it reflects ideas, the question can hardly be regarded as doubtful. The constitutional provision, under which our patent laws are framed, looks to the promotion of "useful arts." The act of Congress places "a new and useful art" among the discoveries it professes to protect, and assigns to it the first place on the list. The statute of 21 James I. c. 3, from which the patent system of England has grown up, speaks only of "new manufactures." Yet the Judges of that kingdom find a warrant in this limited expression for sustaining patents for an art, and even for the renewed discovery of an art that had been lost. (See the Hot Blast Case, *Webster, P. C.* 683, 717, and Mr. Webster's note at p. 718, and the case of Wright's Patent, *ibid.* 736, and the cases grouped in Hindmarch, pp. 77–102.)

Indeed, the author whose treatise we have cited last, asserts with much emphasis, that it is the art, and nothing else, which is the characteristic subject of every privilege granted by a patent under the statute—*p.* 92. And it may be noted, as not without interest, that in just accordance with the spirit of the English law cases, the English patents of Cooke and Wheatstone, Davy, and Bain, claim property in the arts for which their mechanical devices are respectively adapted; not, indeed, in so many words, but in language as unequivocal as that employed by Mr. Morse.

Nor can we see that there is any reason of policy, which should deny protection to an art, while extending it to the machinery or processes which the art teaches, employs, and makes useful. Why should the type, or the ink-ball, or the press itself, be dignified beyond the art to which they minister in such humble subordination, and without which they are rubbish? Will you patent the new product, and the new elemental means, and the new process by which they act, and then debate whether you may patent the art? You have patented it already.

We are aware, of course, that it has been held in some cases under the English patent law, that the art to be patented must have some reference to a manufacture. (See Hindmarch, *ut supra.*) But while such a deduction might be legitimate from the words of the statute of James, it would be obviously otherwise under the more liberal phraseology of our act of Congress. And even in England, it must be apparent to every one who has watched the progress of their patent system, that this limitation is practically disregarded already, and that it is to be repudiated as soon as it shall interfere with the protection of an important invention.

Yet, in truth, there are few discoveries of practical moment to the daily concerns of men, even in the lapse of many years, that are not more or less directly connected with some department of manufacturing industry or skill. The convex lens—the steamboat—the iron road, on which cars are propelled by the friction of driving wheels—some of these may be so indirectly connected with manufactures, or rather they are associated so intimately with the leading pursuits and interests and enjoyments of all of us, as to make it difficult to refer them to the category of a particular manufacture. Would it not be strange if, on this account, they were excluded from the benefits of the patent system? If we go back to the early story of our race, and mark the stages of its long and difficult advance—from language, the first exponent of thought, to letters, its first record—and from letters to printing, which first diffused letters widely though slowly among men—and from printing to the telegraph, the electric register of thought, spreading its fibres of sympathy over the intelligent world, and making it throb simultaneously everywhere, as with the pulsations of one heart; who will say that each transition between these great epochs, that signalize the moral and intellectual progress of mankind, should not be marked by a memorial as stately as the first clipping of a cut nail, or the compounding of a new variety of liquid blacking? or that the men to whom we owe them should not be dealt with as liberally, or at least as justly, by the State?

2. The second general subject of Mr. Morse's patent of 1840 includes many particulars; all of them interesting and valuable in connection with the claim we have just been considering. Taken together, they give a practical form to his leading invention, and guard it from the imputation of being a mere abstract notion, a principle resting in idea. Taken singly, some of them appear to us to be new; as his alphabet (*claim* 5), his combined series (*claim* 4), by which the electric current from one battery, before entirely expending itself in its lengthened circuit, is made to set another battery in action, from which another circuit traverses to a battery still beyond—and so onwards; his adaptation of clock-work to the recording cylinders (*claim* 2); others, again, are only new as they are elements of a novel combination. There is no proof before us that any of the devices which Mr. Morse has claimed in his patent, whether as independent inventions or parts of a combination, are not really his so far as he has claimed them. It is unnecessary to claim them in detail, for they are all substantially protected, as appliances of the art, which is the great subject of his patent.

II. The second patent of Mr. Morse is for what has been termed his Local Circut. To understand the questions which arise upon this, it is necessary to refer back to the apparatus which he had patented before, and to explain in general terms its principle and modes of operation. I shall attempt to do this in popular language, and without stopping to consider very carefully the varying niceties of scientific nomenclature.

It is well known that a current of galvanic electricity, while passing along a wire that has been wound spirally round a bar of soft iron, communicates to the iron a certain degree of magnetic virtue, and that the iron loses this magnetic character again as soon as the electricity ceases to pass along the wire that surrounds it. It is also well known that the electric fluid may be passed along a wire of great length, and yet retain even at the farthest extremity of the wire a sufficient degree of energy to impart this occasional magnetism to the iron, and to make it capable for the time of attracting any small body of iron that may be near it. If such a small body of iron be made to form the extremity of a nicely balanced lever, it is plain that while the one extremity of the lever is attracted towards the temporary magnet, the other extremity will be moved in the opposite direction; and if to this other extremity we affix a pencil or stylus, this will press upon whatever surface may be interposed in the way of its motion, and may either mark the surface, or, if it be of a yielding nature, indent it. It is plain, also, that when the bar of soft iron ceases to be magnetic, in consequence of the electric fluid ceasing to pass round it, the lever will take its original position, and the stylus ceases to press upon the resisting surface.

If, now, we suppose that surface to be moved uniformly below the stylus, it is obvious that the surface will be marked with a straight line, and that this marked line will be interrupted during any intermission of the electric current, so as to form a broken series of straight lines; or, if the electric current passes and intermits in rapid alternation, a series of dots or points. These broken traces of the stylus, the lines and dots, constitute the *alphabet* of Mr. Morse; a certain succession of either, or a certain combination of the two, being arbitrarily chosen to indicate a particular letter.

The galvanic battery generates the electric fluid continuously, whenever the two extremes or poles of the battery are connected by a suitable conducting medium—such as a metallic wire, water, or the earth itself —along which *conductor*, as it is called, the electric fluid may pass between one pole of the battery and the other, thus performing what is termed an *electric current*.

Let us now extend a continuous wire from one of the poles of the galvanic battery to a distant point, taking care that it shall not be intermediately in contact with the earth or with any other good conductor of electricity, and let us at the distant point pass the wire in a spiral coil round a bar of soft iron, and thence lead it back again to the other pole of the battery, or avail ourselves of the earth itself as a part of the circuit. It is obvious, from what we have said before, that the electric fluid, passing from the battery along the wire, around the occasional magnet, and back to the battery, and then, at appropriate intervals of time, interrupted at its circuit, will cause the stylus to make its trace of lines or dots, or, in other words, its alphabetical record, at the distant station.

It only remains, then, to devise a mode of interrupting and renewing at pleasure the flow of the electricity—*breaking and closing the circuit*, in the language of the experts. This is done by dividing the wire near the battery, and then arranging a simple finger key, which, when struck or pressed upon by the finger, brings a short metallic conductor into intimate contact with the two ends of the divided wire, and thus restores the continuity of the circuit while the pressure continues on the key. This may serve as a rude explanation of Mr. Morse's Electro-Magnetic Telegraph in its simplest form.

It was found, however, at an early period, that though the electric current was still appreciable after it had passed over a great length of wire, yet in traversing the very long circuits that were required to include distant telegraph stations, it ceased to impart a sufficient degree of energy to the temporary magnet to work the stylus effectively. To meet this difficulty, Mr. Morse resorted to the simple device of employing a series of batteries distributed over his line of telegraphic communication, with as many shorter circuits, each operating by means of a magnet at its extremity, to control the movements of a small lever, that opened or closed the circuit of the battery beyond. The last battery gave efficiency to the recording apparatus at the distant station. This formed the *combined series* of Mr. Morse's first patent.

It is easy to see, that the intermediate magnets of the combined series, besides opening and closing the circuits, might be also made to act as recording magnets, by merely adapting to them the stylus with its appendages; and there would thus be as many stations of telegraphic communication as there were batteries and minor circuits. But there still remained this objection to the combined series, that it could only be worked in one direction, and it was necessary, therefore, to have two complete lines of wires, with their batteries and magnets, in order to establish a reciprocating communication.

To dispense with this duplication of machinery and expense was the object of Mr. Morse, in the invention which is the subject of his second patent. It had been found that the magnetism excited by the electric coil was capable, at the end of an almost indefinitely extended circuit, of giving motion to a delicately adjusted lever, but that this was the apparent limit of its dynamic power. A single wire might be employed, then, without intervening magnets, by connecting it at the extremities with electro-magnets of great sensibility of mechanism, and employing the force of those magnets merely to open short local circuits, from which local circuits the degree of magnetic energy adequate to the purpose of the recording apparatus could be derived.

It is found, however, that the magnetism induced in soft iron by the electric current, though truly occasional, does not absolutely cease at the instant of breaking the circuit, but seems to linger in the iron for an appreciable interval of time afterwards, with an intensity which, though slight, bears an apparent relation to the intensity of the current that induced it. This would interfere greatly with the very rapid operation of the telegraph, if the lever were left to withdraw itself from the magnet, to which it serves as armature, by the force of gravity alone. A small compensation spring is therefore connected with the machine, of sufficient strength to overcome the attraction of this lingering or continuous magnetic force, but not sufficient to resist the attraction of the magnet when the circuit is closed.

But the electric current, after passing over a long wire, does not exert a uniform dynamic energy. However carefully insulated at first, the wire becomes, after a time, more or less exposed to atmospheric action, and the fluid is more or less dissipated in consequence. The posts, on which it is supported, become conductors during storms of rain, and carry off the fluid to the earth. Under other circumstances, the electro-magnetic phenomena are exaggerated at the receiving station by atmospheric electricity from the regions through which the conducting wire has passed. The batteries, too, do not always generate the fluid with the same rapidity. In a word, the current at the extremity of the circuit is irregular.

Now, it is apparent, that under these varying states of the magnetic energy, the adjustment of the compensating spring at the receiving station must not be uniform. If its tension were just that which would neutralize or barely overcome the continuous magnetism induced by an electric current of small intensity, it would not draw back the armature when the inducing current had been in greater force; and, on the other hand, a stronger spring, adapted to the case of a powerful current, would oppose a controlling resistance to the magnetism induced by a feeble one. The *Adjustable Receiving Magnet*, described in Mr. Morse's second patent, meets perfectly the conditions of this difficulty, and enables the operator, by the mere touch of a finger on an adjusting screw, to regulate the tension of the spring, and adapt his apparatus to the circumstances of the moment.

The main line thus arranged, with its delicate receiving magnet and its short recording circuit at each extremity, made no provision for intermediate or collateral stations. But, as it had been found desirable in practice to distribute the batteries, in which the electric fluid was generated, over different parts of the line, so as to reinforce the energies of the current in its progress, it was almost an obvious suggestion to connect at these several points a receiving magnet of adjustable character, either with the main line or with the battery forming part of it, and to attach to this receiving magnet a local registering circuit, or a branch circuit leading to one or more collateral stations.

Such I understand to be Mr. Morse's *Local or Independent Circuit.* His patent of 1846, as reissued in 1848, claims it in these words:—

"The employment in a certain telegraphic circuit of a device, or contrivance called the receiving magnet, in combination with a short local independent circuit or circuits, each having a register and registering magnet or other magnetic contrivances for registering, and sustaining such a relation to the registering magnet or other contrivances for registering, and to the length of circuit of telegraph line, as will enable me to obtain, with the aid of a main galvanic battery and circuit, and the intervention of a local battery and circuit, such motion or power for registering as could not be obtained otherwise without the use of a much larger galvanic battery, if at all."

That the local or independent circuit, as we have described it, and as it is more accurately and perhaps more intelligibly set out by Mr. Morse in his specification, was original with him, cannot be seriously questioned. The devices referred to in the patents of Cooke and Wheatstone, and Davy are at least imperfect modifications of the combined series of Mr. Morse's first patent; one of them not improbably borrowed from it. The adjustable receiving magnet, the indispensable and characteristic element of the local circuit patent, no one has claimed but himself.

It is only to make the first approach to a controversy on this point, to prove to us that Professor Henry had as early as 1828 made the *intensity magnet*, with which the scientific world is now familiar—or that he afterwards, and before Mr. Morse's first application for a patent, had illustrated before his classes at Princeton, the manner in which one circuit could operate to hold another closed, or to break it at pleasure—or that he had foreseen the applicability of his discoveries to the purposes of a telegraph. The question is not one of scientific precedence; and if it were, this is not the forum that could add to or detract from the eminent fame of Mr. Henry. It is purely a question of invention applied in a practical form to a specific use; and so regarded it admits but of a single answer.

In passing from the questions of originality and identity of invention, that have been raised in the cause, without a more detailed review of all the testimony, there is occasion perhaps for an explanatory remark. It is this: the decree of a judge finds its appropriate and only justification in the facts proved before him, not in theories, however ingenious, nor the less speculative inferences of other minds; and where the essential facts of a case are as clearly established as they are here, it would be unprofitable as well as painful, perhaps, to discuss the particulars of variance between the witnesses. There is no place in which the evidence of scientific men, upon topics within their own departments of knowledge, is more to be desired than in this court, when sitting for the trial of patent causes; and the opinions, also, of such men, when duly supported by reasonings founded on ascertained fact, must of course be valued highly. But it is a mistake to suppose that, even on a question of science, opinion can be dignified here or elsewhere with the mantle of authority. Still less can we allow it to avail us here, when it assumes contested facts, or volunteers to aid us in determining the import of written instruments.

These remarks are not dictated by a spirit of unkind or uncourteous commentary on the depositions before us. We know that when opinion is active, it is not always easy to limit its range. There is besides very much of accurate scientific history, and of just and well guarded deduction from it, in these volumes of exhibits. But it must be confessed, also, that there is to be found here and there not a little of imperfectly considered dogma, as well as something of doubtfully regulated memory—and it has seemed to us, in this case as well as in some others, that the toil and expense and excitement of litigation might have been moderated, perhaps, if the appropriate tone and province of testimony had been more exactly understood by some of the witnesses.

The objections which have been taken to the terms of the reissue of Mr. Morse's patent of 1846, may be answered by a simple reference to that part of our opinion in which we have considered the arguments of the same character that were urged against the patent of 1840.

It is beyond controversy, that the Local Circuit Patent has been infringed upon at some of the stations of the respondents' line; and it is the opinion of the court, that it is also violated whenever the Branch Circuit of Mr. Rogers is employed. We have not been able to see the asserted difference in principle between the two devices. Both are equally well described as Branch or as Local Circuits. They have the same purpose; they effect it by the same instrumentality, even in appearance, to a great degree; and they seem to vary only in this, that the one derives its electric fluid from a battery placed within the line of the main circuit, the other from a battery placed without it. The change may be for the better, or it may not; if it be, it is patentable as an improvement; but it cannot be used without Mr. Morse's license, until after his patent has expired.

III. The third patent is for the Chemical Telegraph. We do not propose to enter on the discussion of this. The subject of it is clearly within the original patent of Mr. Morse, if we have correctly apprehended the legal interpretation and effect of that instrument. We will only say, that we do not hold it to have been invalidated by the decision of the learned Chief Justice of the District of Columbia on the question of interference. The forms of the two machines before him were not the same; and the leading principle of both having been already appropriated and secured by the Magnetic Telegraph patent of 1840, nothing remained but form to be the subject of interference.

The counsel for the complainants will be pleased to prepare, for the consideration of the court, the draft of a decree in accordance with the prayer of their bill.

Having been kindly furnished with the decision of Judge Woodbury, in the celebrated House case, with corrections by his son, I have published it with the decision of Judge Kane, in the celebrated Morse and Bain case, making no remarks, but allowing my readers to come to their own conclusions in regard to the exclusive claims of Mr. Morse to electro-magnetism in telegraphing.

UNITED STATES CIRCUIT COURT, DISTRICT OF MASSACHUSETTS.

May Term, 1850. JUSTICE WOODBURY, Presiding.

F. O. J. Smith vs. *Hugh Downing* et al.

This was a bill in chancery for an injunction against the defendants not to use longer an electro-magnetic telegraph between Boston and New York. It was alleged that the plaintiff, by assignment, was owner of the patent for Morse's Telegraph between those two cities, and that the defendants, without license, were using a similar one on that line, and thus infringing on Morse's patent, and injuring greatly the plaintiff.

The bill was filed in October, 1849, but not being ready for a hearing, asked for a temporary injunction till the spring of 1850. Such temporary injunction was then in the spring waived, and the case was set down for a final hearing June 15, 1850, on the application for a final and permanent injunction.

The record was very long, with much evidence by witnesses and depositions, and many documents.

The contents of the bill need not be farther recited here, as anything more in it which is deemed material will be noticed in the opinion of the court.

The answers by some of the defendants denied their participation in the use of any telegraph, except as shareholders in one worked by the other defendants—and the others, in a separate answer, denied the originality of Morse's invention, as well as claimed that House's, which they employed, was invented by him, was unlike Morse's in principle, and was no infringement on it in any way.

The testimony, which was very voluminous, will, when necessary, be referred to or recited in the opinion, and need not be detailed here.

The case was argued at the time assigned, by F. O. J. Smith and B. R. Curtis for the plaintiff, and by Charles Levi Woodbury, Gifford, and Choate, for the defendants.

WOODBURY, J.—This case is full of difficulty, in respect both to the facts and the law.

The operations of the conflicting machines depend much on the principles of electricity and galvanism—two sciences not very well understood, except by those who have made them a special study; and the trouble in comprehending with clearness and fulness their operations here, is increased by the intricate and novel mechanism employed.

More especially is this last the case with the machine worked by the defendants, and alleged to have been invented by Mr. House, and which is made still more complicated by the use of the new species of magnetism, called axial magnetism, and by the use of air as an additional power to move parts of the machine. As these two inventions are both conceded to be remarkable in their character—relating to an improvement in telegraphic communication by electro-magnetism at great distances with almost lightning speed, and thus forming one of the wonders of the age; and as their value is estimated to be very large, both to their owners and the public, I have hastened to examine the rights of each party as early and as fully as other pressing avocations would permit.

The prayer of the bill, by F. O. J. Smith, the assignee of Morse, is for a permanent and final injunction in equity against those who are operating under House. And this remedy should be granted, if it appears on the whole evidence that Morse was the original or first inventor of what he really claims in his patent, and that the machine by House is not different in principle, but the same in substance as Morse's.

These two questions, with some incidental considerations under each, will be found to cover the whole case.

In order to ascertain whether Morse was the original inventor of all which he claims, it will be necessary first to examine and settle how much he does claim—that is, how much is embraced in his specification.

This inquiry is made somewhat complicated by his having taken out two different patents on the subject of electro-magnetism and its use in telegraphs, and having renewed one of them twice, and the other once, and having preceded the first patent by a *caveat*, describing its character and extent.

But what he claims does not seem material in this case, except as set forth in the first patent and its various renewals.

I shall therefore confine my inquiry to that, though the others must at times be adverted to, the better to understand what was meant in that.

As represented in his letter to the Treasury Department in 1837, Morse says he had been attempting, since 1832, to make electricity visible at a distance by signs, intelligible and certain, so as to communicate information. (See it in *Vail's Hist.* 152.) And in his *caveat* of October 6, 1837, he claims to have "*invented a new method of transmitting and receiving intelligence by means of electro-magnetism.*" Or, in other words, in the same instrument, "a method of recording permanently electrical signs" at a distance. His specification filed in 1838, April 7, is much the same in substance.

Following up a like idea in 1840, in his first patent, he claims in that to have invented only a "*new and useful improvement in the mode of communicating information by signals,*" and by the power of electro-magnetism. (See first patent, June 20, 1840.)

Such is, in substance, the title of this patent in its original form and under all its renewals.

In his last specifications, in 1848, he claims to have invented merely "a new method," or "*a new and useful apparatus* for a system of transmitting" intelligence, which puts in motion machinery for producing signs, and at a distance recording said signs. (See last renewal, 13th June, 1848.)

From all these, standing by themselves, it would seem manifest, that he makes no pretension to have invented or discovered any new principles in physics, or to have discovered the old principles of electricity or galvanism. Nor does he claim to have invented or discovered any new principle in mechanics, like a new power, resembling the lever or screw. As little would any one have supposed that he meant to claim as his invention, and as new, the application at all of electro-magnetism to the purposes of telegraphing at a distance, whether by making intelligible marks or signs there, or in some other mode, if it had not been for some remarks in one of his letters in 1837, and some words in the 8th clause of his last specification, and the ground taken in the argument, recently, by his counsel.

Thus, in his letter in Sept. 1837, to Jackson, he seems to have believed he had some claim to this discovery, viz.: as he describes it, "the original suggestion of conveying intelligence by electricity," as well as to the invention which he calls "the devised mode of doing it." —(79, a, *Ev.*)

Yet nothing of this is believed to be inserted in any of his official documents till 1848.

In his last renewal in 1848, there are introduced, for the first time, some changes of language and some tendencies in a part of them, as well as in some of the arguments, to make the claim broader, and, as in the letter just quoted, to cover all application of electro-magnetism, if not of electricity, to *convey intelligence*, or to telegraph to a distance.

But as late as 1846, so far from claiming the discovery or invention of any new general principle or art, and asking a patent to protect himself in the exclusive use, as inventor of all telegraphs by electro-magnetism, he asks for protection of only his own *improvement*, his own *method*, his own *apparatus*. And he seems, in his last specification in 1848, to regard as the great excellence and novelty of his invention, that it imprints the signals at one end, which were sent at the other, and in such characters as to be intelligible, without an observer to note them, and easily translated into English by means of his stenographic alphabet, and hence he there styles it a "*recording or printing telegraph.*" When there, for the first time, he speaks also of "*the essence* of my invention being the use of the motive power of the electric or galvanic current," "*however developed,*" "for marking or printing intelligible characters," "at *any distance,*" being "a new application of that power of which I claim to be the first inventor or discoverer," he must, by all before said and done, be considered as claiming it in the form of his application, according to his *machinery*, and in the modes he had described in 1837, '38, '40, and 1846, rather than in this succeeding clause of 1848, and by it intending to cover the application itself of electro-magnetism to telegraphic purposes, in every possible form. Otherwise, his renewed patent of 1848 must be regarded as void for claiming too much, and for wishing to protect a mere principle, or effect, "*however developed,*" and without reference to any method described by him, and to cover a principle, also, before known. (*Harvey, Ev.* 223.)

But limiting the patent to what is described as his *method*, or *mode*, and considering that in his "first claim," in 1848, he disclaims such broad views as appear in the "eighth claim" of that date, and expressly says: "I wish to be understood that I do not claim the use of the galvanic current, or current of electricity, for the purpose of telegraphic communications generally, but a new *mode* of using it, to move machinery, to print signs, &c., as described," all is consistent, and confined substantially to the mode he sets out in his specifications, and in his own testimony in the record. (P. 49.)

What he thus sets out is the subject invented.

What is to be protected is not an abstract or isolated principle, but the embodiment of a principle into a machine or manufacture, as described in the specification; and it is the invention in conformity to that embodiment or representation of its working, which the act of Congress will protect. (Bolton *vs.* Bull, 2 *Hen. Bl.* 458, 403, 483, and *D. & E.* 95; *Web. Ca.* 208; *Web. on Pat.* 4, 58, 126–8; 2 *Stor. R.* 408, 412: *Curtis on Pa.* §§ 4, 96, and 145; 1 *Stor. R.* 271; *Godson on Pat.* 72; *Phil. Pa.* 90; 1 *Gallis*, .478; *Hindmarsh*, 157.) Because by those laws, the inventor is not to be protected, unless he describes plainly and fully what he has done, so that the public may copy or imitate, and use it after his term expires.

That is the consideration for the exclusive use during the period of the patent, and having this, prevents the patentee from claiming afterwards more than he had invented when his patent issued. (*Web. Case*, 719, 1 & 2, and *D. & E.* 100, 2; *Curtis*, §§ 128, 205. And what he does not, or certainly what in the misty future he cannot describe, he must be presumed not to have invented. 2 *Hen. Bl.* 483.)

As this broader claim goes far beyond what we have already seen was that made in the caveat, and in the first specification, and in the original patent, as well as in all the subsequent renewals; as it conflicts with much of the language in this very last renewal, looking only to a *new method* and a mere *improvement* on what existed before; and as he seems to disavow it in his own evidence (49 record); and as, on everything in the case, it is at least questionable whether he could have intended to patent anything, except an improvement on what before existed, I do not think it just to place a broader construction on his language than the whole subject-matter, and description, and nature of the case seem to indicate as designed.

These are all to be looked to; and no fancied construction, travelling too far, on a new and doubtful ground, is to be adopted, but rather what is natural and clear, considering what already exists on the same subject. (Haworth *vs.* Hardcastle, *Webst. Ca.* 485; Duval *vs.* Brown, 1 *Woodb'y & Minot*, 53, 58; 6 *Peters*, 218; 1 *Stor. R.* 272, 287; 2 *Stor. R.* 164; 1 *Leemen*, 482.) And I the more readily adopt this course for his own protection, as such broader view might subject his patent be considered void, both for claiming too much, and for claiming also the invention of a mere principle. It would be claiming too much, as it would cover the application in every way of electro-magnetism to telegraphs; when this, as will be seen hereafter by the history of this subject, and is sworn to by a large number of highly intelligent experts, had been known publicly and for years before Morse's first attention to the subject in 1832. (*Prof. Henry's Ev.* 76, v; *Prof. Hare*, 92, v; *C. B. Moss, Ev.* 84; *Henry, Ev.* 223; *Renwick, Ev.* 234–5; *Steele, Ev.* 245–6; *Reid, Ev.* 150; *Chilton, Ev.* 286; *Bordon, Ev.* 218; *Channing, Ev.* 40; *Jackson*, 77, r, and 81, r.)

Indeed, he himself virtually admits the truth of this in his testimony. (*Morse, Ev.* 49, r.)

Others, no less than the persons cited, as well as the history soon to be given of the progress on this subject, show that several had, before Morse, not only made this discovery, but applied both electricity and electro-magnetism to the purpose of telegraphing. But if, by his alphabet and record, he has been successful in making an improvement in the use of electricity for that purpose, and wished to secure the new method of doing it, he was at liberty, in point of law, to make out a patent for that new mode, but for nothing more. (*Henry's Ev.*)

He came into the world too late for truly claiming much as new. A large galaxy of discoverers on this subject had preceded him.

The avoidance of patents for claiming too much is of frequent occurrence, and needs no explanation as to the reasons for it when an applicant is so improvident or unjust to others as to claim for himself more than he invented, and the credit or profit of which belongs to others rather than himself. (See 1 *Stor. R.* 273; 2 *Stor. R.* 4; 1 *Sumner*, 482; 1 *Web. Cases*, 485; 6 *Peters*, 218; 1 *Wood and Min.* 53–8.)

As to the second objection, that this would be seeking to cover by a patent a new principle without reference to any mode or method of enforcing it, the patent laws are well settled never to permit it. (2 *Hen. Pst*, 4 & 6.)

The impropriety of claiming a patent for the invention or discovery of a new principle, however important it may be *per se*, rests on the idea that the exclusive use of the invention, for a term of years, is given to the patentee, to reward his genius and expense in making the invention, and pointing out in his specification how it can be used beneficially, and the machine, if it be a machine, easily made by any mechanic for general employment. The patent is, in such case, and must be, in order to possess validity, not for the principle, but for the mode, machine, or manufacture, to carry out the principle, and reduce it to practice. (*Webs. on Pat.* 45–8.) In short, the principle thus becomes the *modus operandi*, and rests in the new mode adopted to accomplish certain results. And though some expressions may have been used by one or two judges which look like a sanction to patenting a principle, yet they are used in the above sense of a principle in operation, in the manner set out in the specification, or are used too loosely from haste and inadvertence. Except for this view as to the method, what use would there be in a specification describing the machine or method? So where any judge speaks of patenting an *art*, it is not an art in the abstract, without a specification of the manner in which it is to operate, as a manufacture or otherwise. But it is the art thus explained in the specification and illustrated by a machine, or model, or drawings, when of a character to be. It is the art so represented or exemplified, like the principle thus embodied, which alone the patent laws ever are designed to protect. In the English patent acts, the word "art" is not used at all.

And in ours, as well as in our constitution, the word art means a useful art or a manufacture, which is beneficial, and which by the same law is required to be described with exactness in its mode of operation, and which of course, for the reasons already laid down, can be protected only in the mode and to the extent thus described. (1 *Stor. R.* 273, 285; 4 *Wash. C. C.* 9, 12; 1 *Howard*, 204; *Web. on P.* 8, 9; *Phil. Pat.* 74 to 76; *Hindmarsh*, 49; *Curtis*, 38, 9th section.)

No lawyer, conversant with the patent system, could for a moment suppose that because Arkwright first invented and perfected the art of spinning by machinery, he could have taken out a patent for this art generally, and covered and monopolized all kinds of future and different improvements in that art. On the contrary he could shield no mode of the art, but that which he had devised, used, and described. So it has been held that a patent for cutting ice by human power, does not cover any mode but that described. (1 *Story*, *R.* 273.)

So, though Woodworth first invented planing boards by machinery, he could not take out a patent for that art, principle or system generally, and thus either monopolize or prevent future improvements, when differing substantially from his machine. But the whole effort of Woodworth's assignees has been to describe his particular mode of planing, so as not to omit anything material, or to cover too much, and no attempt is made to protect anything connected with planing by machinery, except the mode, thus described, or what is substantially the same.

Considering the opinions I have thus formed on this, and, as will soon be explained, on other points of the case, it does not seem necessary to decide, on this occasion, whether the severe criticism, which has been made by the counsel for the respondents on several other portions of Morse's claims is well founded or not; and more especially whether his chief patent is not invalid, because covering too long a period, the time included by a previous foreign patent not having been deducted. It suffices now to add, that the general conclusion as to the extent of Mr. Morse's claim in his specification, as amended or renewed, is, that he intended, in the words of the patent, to embrace only "a new and useful improvement." Or, as repeated in the specification itself, only "a new method" of communicating and recording signs by "electro-magnetism;" and he does not seem to have meant to cover merely a new object or purpose, to which an old principle or machine was to be applied, and which is not patentable. (*Hindmarsh on Patents*, 96; *Webs. Ca.* 208; *Curtis*, § 4; 2 *Stor. R.* 408.) Nor a new abstract principle to produce new results in telegraphing by means of electro-magnetism.

The essence of his method beyond what before had existed or been practised, was to make the electro-magnetism, when excited and moving in a particular form, and marking at one end of the wires, not merely exhibit some evanescent sign at the other end, but a sign which the machine is made to trace, and thus record there permanently. This sign is excited by the closing and opening of the circuit by a stroke or by lifting the wire from the cups, or by a knob pressed down and acting by a spring, and the mark by machinery is made to assume several forms; but the one generally practised, is that of dots and straight lines. These, traced in succession on the rolling paper, and by being different in number and combination are, by the stenographic alphabet invented by Mr. Morse and embraced as a part of the system, made to represent all the letters, and, when you please, certain words in most common use.

The great result of the improvement is by this machinery and the alphabet of signs for letters, to trace at one end the dots and lines, which represent what it is wished to communicate, and thus to have the same traced at the other end on paper, by like dots and lines.

The great beauty of the system is the identity of the tracing at both ends by the new machine (whether through the type rule at the beginning, or the breaking and closing the circuits through the type rule or thumb spring), and also the rapidity as well as the exactness with which this tracing or recording is accomplished.

Indeed, so impressed was the inventor with this striking peculiarity in his system, that in his last specification he proposes to characterize it as "the first *recording and printing* telegraph by electro-magnetism."

Describing his invention as including these improvements, and limiting it to them, he escapes the imputation or fatal error of claiming too much, or claiming to have discovered only a new or a mere art.

The next question in connection with the first head of inquiry is, if this improvement or method was original with Mr. Morse?

He states that the first idea he formed in relation to the subject of communicating information by electricity to a distance, was on board the Sully, on his return from Europe in the autumn of 1832. But from various obstacles and imperfections in existing batteries, and a want of pecuniary means, and the novelty and complicated nature of the proposed improvement, he was not able nearly to complete it till October, 1837, when he filed a caveat on the subject, and in April, 1838, put his specifications and drawings on the records of the patent office, and in June, 1840, took out his first patent.

When his attention was first turned to the subject in 1832, not having before been particularly engaged in scientific pursuits, though possessed of good general information and much ingenuity (*Day's Ev.* 92, a; *Prof. Silliman*, *Ev.* 94, a), he did not appear to know with exactness what discoveries had before been made in the matter, and how far others, by vast ingenuity and science in the same path, had already carried into effect what then struck him as practicable and likely to prove highly useful.

Whether he or Dr. Jackson first spoke on that occasion of what might probably be done to convert the power of electricity to use in recording ideas as well as in communicating them to a distance, is disputed. (*Jackson*, *Ev.* 162–4.) It does not seem necessary to settle this point on this occasion; and it is a controversy very unpleasant to discuss, if avoidable, between two gentlemen of such high reputation and public usefulness.

It would seem probable, that after the matter was broached by some one, Dr. Jackson, from the nature of his scientific studies, fresh from lectures in Paris, with an electro-magnet in his baggage on board, and some recent books, treating of some of the operations which had been performed with this power (*Jackson*, *Ev.* 187, r, 162, r, 18, r,) could impart more information in respect to it, and to any probable improvement in the use of it. While, on the other hand, it is certain from what has taken place since, that Mr. Morse possessed the perseverance, industry, and skill, to go on with inquiries concerning the subject when once started, till he perfected an instrument or machine to accomplish what was then agitated, and that he is, therefore, under the patent system, alone entitled to be protected as the inventor of what is claimed and described in his specification, so far as it had not been completed before by others. (1 *Mason*, 66, 305; 3 *Story*, *R.* 133; 2 *Woodbury & M.* in Allan *vs.* Blunt.)

Undoubtedly much which, in his first reflections on the matter, seemed to him novel, had been matter of deep inquiry and frequent experiments in the universities as well as private laboratories of Europe and even of America.

It appears, on examination, that as early as 1746, Winckler, at Leipsic, had used common electricity for telegraphic communications by the discharge of Leyden jars, in connection with a long wire. (3 *Annals of Electricity*, p. 445.)

In 1748, the same was done by Watson with two wires on an extended circuit of four miles. (*Ditto*, 445, and *Barrett's Ev.* 208, a.)

And in 1784 or 1787, Lomond, by frictional electricity and a wire extending thence into another room, transmitted telegraphic signals. (*Vail's History*, 121.)

In 1794, Reusser, by an electric spark and wires, illuminated letters of tinfoil at a distance on a glass plate. And in 1798, Betancourt, in Spain, sent this spark by Leyden jars and a wire, twenty-six miles; and in the same year, Salva, at Madrid, worked for many miles what was called "an Electric Spark Telegraph." (3 *An. of Elec.* 446; *Vail's Hist.* 121.)

If nothing more had occurred than these cases, it would be a little surprising, that any one acquainted with the subject should, in 1832, near thirty-four years after, anxiously inquire, as if a novelty and wonder, whether electricity could not be used for telegraphic communications?

But galvanism having been discovered in 1790, it is not strange, after the experiments with it for seventeen to nineteen years, that Soemmering should at Munich, in 1807, be able to erect a galvanic telegraph, and make the voltaic pile decompose water, and show as signals air bubbles over the proper letters, and conduct a wire to a trough in which were thirty-five gold pins, with letters or numbers on each, and so arranged as to complete a communication of information. (3 *An. of Elec.* 448; *Vail's Hist.* 122; *Hibbard, Ev.* 31, a; *Gould*, 68, a.)

Common electricity had been found too intense and erratic, and difficult to be confined, whereas that generated by galvanism had proved more quiet and manageable, and not costly.

Inquiries, therefore, did not stop here, but after that were much multiplied and advanced, long before the year 1832.

In 1813, Œrsted, the Danish philosopher, commenced his experiments on the subject, and by 1819 or 1820, discovered that a magnetic needle at a distance might be deflected by a galvanic current, and thus mark information, and he is generally considered the discoverer of the magnetic properties of electro-currents. (*Ditto, Hibbard, Ev.* 29, a; *Daniell's Chem.* 561–2; 3 *Hewett on Inductive Science*, 309.) In the interim of 1816, Dr. John Redman Coxe, of Philadelphia, described the use of galvanism as a telegraph by decomposing water. (*Vail's Hist.* 129, and *An. of Ph.* 162.) How its decomposition and the air bubbles enable the machine to act is fully explained by *Channing, Ev.* 46, a.

In the same year, Ronalds constructed a telegraph at Hammersmith, which operated for eight miles, and used the disk of clocks for his signals at both ends, keeping exact time, and one, when touched, indicating the same at the other end. But it worked very slow, the interval between each was so great. (3 *An. of El.* 449.)

In 1820, Arago, Ampère, and Sir Humphry Davy, all experimented and discovered as much as Œrsted had; and Ampère expressly stated, that the deflective needle would, in his opinion, be used for telegraphing by the magnetic fluid. (*Vail's Hist.* 133–4; *Prof. Henry's Evid.* 85, a, record; *Doct. Channing's Ev.* 47, a, record; *Hillard, Ev.* 31, a.)

The use of magnetism in connection with electricity to make communications by telegraphs, thus became known and practised to some extent twelve years before Mr. Morse proposed to commence any improvements on the subject.

This last period was a new era in the science and in the mode of operating by deflecting the needle or lever by magnetism. The preceding era, from 1790 to 1820, had been distinguished by decomposing water, ringing a bell, exploding a pistol, and other great changes and improvements, introduced by galvanism in a manner superior to common frictional electricity. All before that had been the circuit by wires and the use, so far as practicable, of the spark and other signals, connected with it, through ordinary electric power. (*Channing, Ev.* 41, a.)

It is not a little remarkable, looking to both Morse and House as inventors, that Ampère's plan was to have as many wires as letters, and press down a key on each as wanted. (*Do.* 36, *Lon. Jour.* 131.) And that, the same year, Cavallo proposed the communication to be made by a spark as a signal. (3 *An. of Elec.* 446.)

The public mind, among the scientific and machinists, had got so excited on the topic four years previous to 1832, the period of the voyage in the Sully, that numerous attempts were made in 1828 to carry out into more practical use, and to perfect what had been before indicated so often and so distinctly, as to the use of electricity and electro-magnetism for the purpose of telegraphing. Jacob Green wrote on it. Travoilot proposed to act by a wire from Paris to Brussels, and Sturgeon actually constructed, at Woolwich, an apparatus with a horse-shoe magnet, and the end of a wire coiled round it, communicating with the opposite poles of a galvanic machine, and thus supporting a weight or bar of 9 pounds. (19 *Silliman's Journal*, 330; *Prof. Henry*, 84, r.)

It is believed that Prof. Henry had discovered and described as early as this, and shown at Albany, in 1829, how to increase the power at little expense (*Do.* 400; *Prof. Henry's Ev.* 86, v); and Feckner suggested that galvanism could thus be applied to telegraph from Leipsic to Dresden. (*Vail's Hist.* 135.)

But the most surprising discovery on this subject about this period was by Harrison Gray Dyer, another enterprising American. In 1827 or '28, he is proved, by Cornwell (64, a, r), to have constructed a telegraph at Long Island, at the race-course, by wires on poles, and using glass insulators. Doct. Bell (16, a, r) fortifies this statement, having seen some of his wires, and understood its operation to be by a spark sent from one end to the other, which made a mark on paper, prepared by some chemical salts. (See also *Channing, Ev.* 54, a; *Chilton, Ev.* 286, as to some such operations in 1828.)

Dyer's own deposition, taken since this cause was argued, and to be substituted for a letter from him to Dr. Bell, which was then objected to by the plaintiff and ruled out, now verifies the truth of the letter, and goes into several details as to the condition of his invention, when abandoned in 1830, from fears of prosecution by some of his agents.

He used common electricity, and not electro-magnetism, and but one wire, which operated by a spark, which, after going through paper, chemically prepared so as to leave a red mark on it, passed into the ground, without a return circuit. The difference of time between the sparks was by an arbitrary alphabet, to signify different letters, and the paper was to be moved by the hand while the telegraph operated, though machinery was contemplated to be introduced for that purpose. This device of an alphabet by spaces of time between sparks, evinced remarkable ingenuity, and differs in some degree from either Morse's or House's, though much nearer in principle to the former.

It seems that, in 1830, Booth, in Dublin, explained fully how electro-magnetism could be used to telegraph at a distance, and cause marks to be made by the fall of the armature from the horseshoe magnet when the circuit was broken. (*Byren's Ev.* 199, r.)

But Barlow had failed of success in England from want of more power, and following out the new idea to increase the power of the magnet by closer coils of wire and otherwise, and when the want of greater power to operate farther and quicker, and at less expense, seemed the chief desideratum, Moll, in 1830, succeeded in making a magnet which would sustain 75 lbs., and soon after 150 lbs., and Prof. Henry, in 1831, completed one that could sustain a ton. (*Hibbard, Ev.* 30, a, 20; *Prof. Sill.* 201.) During this last year, also, Faraday had matured fully the horseshoe magnet, and caused, under Saxton, at a distance, a strong circular motion, and brought magnetic electricity almost to maturity.

While all these clearly preceded what took place in the Sully, and remove very much all novelty in some of the ideas then suggested, yet it is certain that there yet remained to be constructed, on these or other principles, some practical machine for practical, popular, and commercial use, which would communicate to a distance by electro-magnetism, and record quickly and cheaply what was thus communicated.

From that time forward, Morse is entitled to the high credit of making attempts to do this, however imperfectly informed he may then have been of what had already been accomplished towards it; and he has the still higher credit, among the experimenters from that time to 1837, of having then succeeded in perfecting, what he describes at that time in his caveat and specification. Laboring on the same subject, and before 1838, Sturgeon, in 1832, had formed a rotary "electro-magnetic machine," which gave motion to working models of machinery so as to pump water, saw wood, and draw weights. He had batteries of zinc and electric currents from them, and magnets with attraction and repulsion. (3 *An. of Elect.* 433; 1 do. 75.) And Baron de Schilling, the same year or the next, constructed an electric telegraph at St. Petersburg, which had 36 magnetic needles, and sounded alarms, and made signals by the deflection of the needle, which indicated letters by numbers. (*Vail's Hist.* 155; *Hibbard's Ec.* 31; *Channing, Ec.* 41.) In 1833, Dr. Sculther, at Zurich, caused a pendulum motion between two horseshoe magnets (3 *An. of Elec.* 433), and Ritchie, with various others, showed how increased power could be cheaply created and used at a distance. (*Barrett's Evi.* 214.) And Prof. Henry made experiments for this object with success, and explained that the fall of the weight or armature would ring bells, &c. (19 *Sill. Jour.* 329; 3 *An. of Elec.* 430.) *Gauss & Weber* constructed the first magnetic telegraph at Gottingen the same year, carrying the wires above ground and over houses, and making signs for letters. (*Vail's Hist.* 158; 3 *An. of Elec.* 449; *Hibbard's Ev.* 31, a.) Some of their wires are still standing. (*Gould's Ev.* 67–9.) And in 1834, Jacobi made one similar in some respects. (1 *An. of Elec.* 410; 3 *An. of Elec.* 434.) And Mr. Gurly, at Dublin, made another, and in 1836, Taquin and Eutychaussen carried another over the streets of Vienna. (*Vail's Hist.* 159.) All which remained to complete what was desirable in a tracing or writing telegraph at a distance, was to make dots or marks, intelligible or significant of letters and words, so as to be read or translated with ease, and to perform the operation with useful speed.

To make dots and color them by the paper being chemical had already been discovered, but not an alphabet in connection, unless by Dyer in 1828 (3 *An. of Elec.* 450); nor a movement of the paper on a roller, so as to make the dots and marks successive, unless by him with the hand. The struggle was such in 1837, to finish what was wanted, that Morse became alarmed lest others might first complete and obtain patents for the invention, and hence proceeded more actively with his; and in 1837 filed his caveat, in the month of October. (*Gale's Ev.* 123.) In the same year, whether earlier or later is not known, Alexander formed an electric telegraph by which, through signals somewhat like House's, he communicated and spelled out at a distance the word *Victoria.* (*Vail's Hist.* 184.) See evidence that this was done earlier, using a key-board, and letters on each key like House's. (*Evidence*, 83, a.) Davenport, too, in Vermont, announced another, and obtained a patent in 1838 (3 *An. of Elec.* 535); and M. Cooke, Wheatstone, and Steinheil, some using the needle, deflected; some making dots and lines; and some using the ground and water for a part of the circuit. (See same articles in Vail and the Annals before cited.) Cooke and Wheatstone took out a patent for theirs in June, 1837, making the deflection of the needle point to letters on a board. (*Hibbard*, *Ev.* 31.)

Steinheil, that year, had at the Royal Observatory, an electro-magnetic telegraph, half a mile long, on poles. (*Vail*, 179.) This made dots and short marks on paper, and preceded Morse's caveat, according to *Dr. Channing's Evidence*, 48, a, rec., and *Hibbard*, *Ev.* 27, a, 31–2 (being before July 19, 1837), *Gould*, *Ev.* from 7, a, to 8, a.

It used the ground as a part of the circuit which had been before discovered, but which Morse does not appear to describe or claim, till his first renewal in 1848. (*Dr. Channing*, *Ev.* 54, a.)

Nor did Morse use poles, or posts at first, in 1844, when constructing a telegraph between Baltimore and Washington. (*Avery's Ev.* 125, rec.) Though they were used by Steinheil before 1839, and by Dyer, even in 1828 (*Cornell*, *Ev.* 64, a; *Channing*, *Ev.* 49, a); and were suggested to Morse, early as 1830, by Prof. Henry, 89, r; yet Morse thinks he himself invented them. (59, r.) After all this, there still was wanting a more perfect succession of marks to be made or recorded, which were letters themselves, or signs of letters, intelligible by an alphabet and power obtained and applied so as to do it quick enough for purposes of business. (*Chilton*, *Ev.* 286; *Gale's Ev.* 124; *Renwick's Ev.* 234–5.) This deficiency was at length supplied.

Among about sixty-two competitors to the discovery of the electric telegraph by 1838 (as computed in *Channing's Ev.* 41, a), Morse alone, in 1837, seems to have reached the most perfect result desirable for public and practical use. (*R.* 6, *Morse's Ev.* 128–9, r.) This may not have been accomplished so wholly by the invention of much that was entirely new as by "improvements," to use the language of his patent, on what had already been done on the same subject, *improvements*, ingenious, useful, and valuable. By the needle, or lever instead, not only deflected by the magnet, but provided with a pen to write, or, in other words, a pin at the end to make a dot or stroke, when thus deflected as the circuit was held longer closed or broken, with machinery to keep the paper moving in the mean time, and so as to inscribe the dots and lines separately, and more especially with an alphabet, invented and matured, assigning letters and figures to these dots and lines according to their number and combination, he accomplished the great desideratum. (1 *Renwick*, *Ev.* 235.) Thus the fortunate idea was at last formed and announced, which enabled the dead machine to move and speak intelligibly, at any distance, with lightning speed.

It will be seen that, amidst all these efforts at telegraphic communication by electricity and electro-magnetism, more or less successful from 1745 to 1838, none had attained fully to what Morse accomplished.

Some had succeeded in sending information by signals, even beyond the decomposition of water and the declivity of the needle. They had made persons at a distance recognize the sign used, and thus obtain intelligence. They had also made marks at a distance. But in no way does it appear that they had sent information at a distance, and at the same moment, by the same machine, traced down and recorded it permanently and intelligibly, and quickly. This triumph was reserved to Morse's inflexible perseverance in experiments and close observation; and chiefly after arming the end of the needle or lever with a pin, by use of a roller with appropriate machinery to move his paper, so as to trace successive dots and marks, and by a stenographic alphabet to explain the marks made on the paper, and by more power through his combined circuits, to effect all at a greater distance, and with greater dispatch. (*Gale's Ev.* 123, r.) Afterwards, by the improvements in batteries by Daniell and Grove, in 1843, he was enabled, without these local circuits, to increase the power of the electro-magnet so as to accomplish this at any distance, and with a speed and economy which rendered the invention applicable to general use. (*Jackson's Ev.* 166.) Before 1843, Hare's battery was used, and was too feeble (*Jackson's Ev.* 164, v, *Channing's Ev.* 45, v), and before that Cruikshank's. The want of this increased power had rendered former attempts at times abortive for practical purposes; and its being recently supplied by the science of Faraday and Henry, tended more speedily by Daniell and Grove's battery, founded on them, to remove the greatest obstacle to success. (*Davis's Manual*, p. 125; *Silliman's Ev.* 95, v; *Jackson*, 166.)

Others had before, and about the same time, as has been noticed already, made marks on paper at a distance by the deflection of the needle, and by sparks, and attached special meanings to them, and the spaces between them. But the evidence is strong that Morse's, if not the very first, in these respects, was the most perfect and available for practical use, and the improvements by others in batteries came very opportunely to aid in its power for distant operations, beyond what even the local circuits had done. (*Prof. Silliman's Ev.* 96, a.) His special advance beyond others, except some new combination, looks as if chiefly mechanical, but still it sufficed to promote the desired object.

By them and his new combinations, he was going a step farther than any of his predecessors, for practical use, had accomplished; and this entitles him to protection and the fame he has achieved. This he and his assignees can therefore protect, but not particulars known long before him, or which he neither claimed, nor described, nor invented. As before explained, he must not be considered to have claimed the invention of the general principle or art of telegraphing by electro-magnetism, nor could he, as already shown, have protected it if he had. But all he clearly claimed was "a method" of doing it, "an improvement" in doing it, and these he has a right to protect, and these only. They were the pin, to mark or trace in the end of his lever or needle, a happy thought, but the movement of the paper on a roller was almost as necessary to receive marks in succession, and his alphabet to be thus applied and used was the crowning art of his invention. (*Renwick*, *Ev.* 244, p.)

Much more might be offered as to the details of Morse's machinery, and as to those inventions existing before and since, and how far the latter have been imitative or independent. But it is not necessary to explain or discuss them, for the purpose of settling the present case.

It is certain, that in 1837, he had so far completed his invention as to announce it in his *caveat*, and have it described also by a brother, in a public paper called the *Observer;* and in *Silliman's Journal.* And that, though a specification followed in '38, and a patent in '40, without putting it in operation for practical purposes, yet, by the aid of Congress in 1844, it was successfully used from Baltimore to Washington. It thus became perfected and turned to practical account; and is to be protected to its legitimate extent, against every real violation.

However ingenious, then, have been some of the attacks on the originality of Morse's invention, and however cogent may be some of the objections to its validity on other grounds urged in argument by the defendants, I do not find it necessary, as before remarked, to give an opinion on them in this case. Because, considering Morse's patent as good, if limited to the extent claimed in his specifications, as we have construed it on this occasion, and as we feel bound to construe it on the law of the case and the evidence before us, and considering it as original to the extent we have already explained, the situation of the House machine, as used by the defendants, is such as to render no farther examination useful concerning the first two points.

The character of House's machine, and more especially as compared with Morse's, does not seem, to a very wide extent, to have been fully examined and understood.

Having ascertained with some care what must be considered the real claim of Morse in his patent, and how much of it is new, we are prepared better to decide the chief and final inquiry, what there is in the machine used by the defendants, and alleged in their answer to have been invented by House, which violates what is novel in Morse's.

Firstly: What is meant in law by a violation or infringement of a patent?

It would amount to an infringement of such an invention as Morse's or the patent for it, to adopt his mode of acting, operating, &c., or merely to change it by substituting some mechanical equivalent in a part of it, or altering only the form and proportion so as not materially to affect results, or making any change merely evasive, colorable, and not "substantial" or "considerable" in its character. (Jupe *vs.* Pratt, *Webster's Cases*, 146–9; *Neilson's Case*, 342; 1 *Mason*, 470; 1 *Gallis*, 478.) But one machine or manufacture is not a violation of another, within the purview of the patent system, unless it is substantially the same. It need not be identical, but it must be similar in the principle or mode of operation.

When its results differ favorably and considerably, it is considered that there must be an improvement involved in it over and beyond the other; or this could not happen. So when its mode of operation is unlike the other in material respects, the author of it is not culpable, and is of course not guilty of any mechanical piracy.

The same latitude for farther inventions and improvements is open to others as were open to Mr. Morse himself. He was allowed to make any improvement on his predecessors; and others are equally allowed to make any improvement on him. To be sure, if his improvement was engrafted on a machine or manufacture before made and patented, he could use or patent only his improvement, and not what had been previously patented, without obtaining first a license or purchase from the patentee. So of others in relation to him. But if his machine did not merely amount to an improvement on others, but to more, and did constitute a new and useful combination, he had a right to use it without license from others. (36 *Lond. Journ. of Arts*, 130, Eden. *et al. vs.* De Costa *et al.*) So as to others, in respect to their improvements after his.

But is the new combination when the patent is for that, not violated when only parts of it are used by others and not all of them, which are material? (Prouty's Case, 16 *Peters.*)

Scrutinizing these two machines together, the defendants insist that House's operates on a principle radically different from Morse's; that its results are greatly superior; and that it resembles Morse's in nothing which did not exist before Morse's invention, and which was not produced before by others rather than by him.

In answer to this, it is true, that the general object of the two is the same, and so is it with all rival inventions. But this, of course, does not necessarily make all new inventions or patents for a like object an encroachment on all previous ones. Such a doctrine would discourage progress, rather than encourage useful arts, as the Constitution wishes to be done, by granting patents.

It would, after one invention as to the same subject, or same principle or art, halt and bar all farther advances on the same subject.

It would petrify everything as it stood, to the great loss of mankind, and in derogation of both private and public rights to advance human improvements and human power. It would, also, render the first improver a monopolist, and exclude the exercise or reward of farther genius, science, and labor, in the same line, however useful, and however much needed beyond what has already been accomplished.

But limit the doctrine, as we have done already, to the particular improvement made, and the patentee of it is allowed to protect that improvement, as he ought to be, it being his own invention, his own property, and the fruit of his own exertion, though, of course, it does not protect, and should not, a monopoly of what else may have been invented by others before, or may be invented by them afterwards on the same subject. The chief care must be, while allowing others their rights, to shield his, and not let others claim or use his method or improvement colorably or fraudulently, but only use what is substantially different. Elec. Tel. Co. *vs.* Little *et al.*, 34 *Lond. Journ. of Arts*, 130.)

Analyzing and comparing these inventions together in particulars, it will be difficult to designate anything in House's which in point of law or fact amounts to a violation of the other under the principles of well settled law, applicable to the subject which we have laid down.

It is certain, on examination of the two machines, that they appear to the eye entirely unlike, except in some particulars as to wires, magnets, and batteries, which were in existence and use before Morse's invention, or have been since improved by others.

It is certain, too, that Morse's is less complicated, and easier intelligible, while House's is very difficult to be comprehended in its operations in detail, and works with the addition of two more powers, one air, and the other called *axial magnetism.*

Indeed the difference is, in these respects, so strongly marked to the eye and to the mind, that while Morse's can readily be understood by most mechanics and men of science, it requires days, if not weeks with some, thoroughly to comprehend all the parts and movements of House's.

And House's without any patent, has been sufficiently protected thus far from piracy by the apparent inability of others to imitate it with success.

It is manifest still farther, that while Morse's operates rapidly and records in a species of hieroglyphic or stenography, which has to be translated into English, House's moves much faster, and at the astonishing rate of 60 or 70 strokes or breaks in a second, and at once records the information by its own machinery in Roman letters. It literally gives "letters to lightning" as well as "lightning to letters." In short the system of Morse in one respect, viz.: in its tracing or writing, is essentially different as to its mode of recording from that of House's, and depends on machinery and devices original in Morse. Whereas, House does not copy this, either in form or substance, but records in a different manner, and by new machinery, and by aid of one new power in axial magnetism, and of another old but different power in air, applied in a new way. And it does this in letters, not signs, and with wonderful speed and accuracy. This was a thing attempted before Morse or House, and to a certain extent realized, though not then by the same powers, nor then perfected so as to be useful. (See Alexander's, and others before described.) To be more minute, as before indicated, the chief principle or characteristic of Morse is that by its type rule, or knob spring at the starting-place, it is able to make dots and lines, by breaking the circuit, for a shorter or longer time, and then being felt along the wires to the other end, trace there on paper, passing over or under the needle or pin, at the end of the lever like dots or lines, which remain on it permanently written, to be afterwards by the stenographic alphabet translated into Roman letters and words.

This does not appear ever to have been accomplished before, so as to be turned to practical account, though developed in part and approximated as before described. (See Steinheil and others.) But House's makes no such tracing at either end of the circuit. It acts at both ends by means of signals, and traces nothing, and at the closing end by the power of air, operating on the type-wheel, it literally prints the letter signalized on the rim of the wheel.

Such signals were known and some used long before Morse's patent, and they are here perfected and printed by House in a manner exceedingly ingenious, rapid, and interesting.

Without going into fuller details in explanation of the principle in House's machine, operating so unlike Morse's (for which see *Bordon's Ev.* 5 a, at length), it may suffice to add, that the machine of the former, at the starting-point, does not trace any marks or dots and lines, but has signal letters stamped on twenty-four keys, like those of a piano. The operator touches one of these so as to hold the circuit closed till by means of the machinery the same signal letter is presented at the other end on the rim of the type-wheel, where twenty-four letters are separately attached. There the signal letter is not then traced on the paper, like Morse's, by the movement and tracing which have taken place at the other end, but this real letter on the type-wheel is itself printed on the paper, and others in rapid succession follow till the word and sentences appear, as the paper rolls onward, printed in perfect form.

It will, therefore, be manifest that one machine—Morse's—traces at the distant end what is traced at the other; while House's does not trace at either end, but makes a signal of a letter at the distant end which has been made at the other, and thus by new machinery, and a new power of air and axial magnetism, is enabled to print the signal letter at the last end; and this with a rapidity marvellous, and at the same time novel and practicable for commercial use. In short, one is a tracing or writing telegraph, the other a signal and printing telegraph. This distinction between writing and printing may not be very material for some purposes when a name or assent is wanting on paper, as under the Statute of Frauds, or in voting. (4 *Pick.* 313, and Hale *vs.* Hale, 4 *Wood and Min.*)

Yet the art of writing is a very different one from the art of printing; the latter being a modern invention, and the former a very ancient one, and every one knows that the process to perform each rests on principles wholly different. (*Crossman's Ev.* 111, r; *Boynton, Ev.* 120.) Again, it must be conceded that House uses a moving power, such as the other does, for some purposes, when employing electro-magnetism between two stations. But this had long been employed by others for a like purpose before Morse or House used it; and hence the conduct of the latter in this respect is no infringement on anything original and duly patented by the former.

There are other material differences. The rest of the machinery in one, that is in Morse's, is simple, and in some respects new; while the rest in the other, that is in House's, is complicated, is aided by new forces and causes new results, though founded on a theory of signalizing older than either of these inventions.

In the next place, an objection urged against House's is, that if not like Morse's in most material respects, it is in all of them a mere equivalent. By equivalents in machinery is usually meant the substitution of merely one mechanical power for another, or one obvious and customary mode for another of effecting a like result.

That these two machines are not equivalents seems manifest from a fact, admitted in the argument, and testified to by Foss (142, rec.), a witness for the plaintiff, that though by some changes House's could do all which Morse's does, yet Morse's could not be made to do all which House's does. (*Channing's Ev.* 60, a.)

Looking, also, into details, it is manifest, that differences exist between Morse's and House's, which consist of nothing resembling equivalents such as the different results produced by each on the recording paper, and this by a different mode of operation, and by the assistance of two different powers. Another difference which prevents the two from being equivalents, is not only the want in Morse's of much that is in House's, but *vice versa.* Besides what the latter omits, before enumerated, he throws away entirely the "U" magnet, as well as other parts of Morse's as a combination. (*Renwick, Ev.* 240; *Chilton, Ev.* 286.)

Among other material things, not used by House, which are used by Morse, and show the machines neither identical nor equivalent, are a *local circuit*, one of the two galvanic batteries and one of the circuits of conductors, the mode of closing and opening the circuit, the *pen and lever*, &c. &c. (*Byrne*, 200–1; *Renwick, Ev.* 236. *Reynolds's Ev.* 268 to 271.)

Again, most if not all which House uses, that is in Morse's, was known before Morse's patent. (*Philip's Ev.* 298, record; see others below; *Hibbard, Ev.* 27, a; *Channing, Ev.* 38, a.)

Where House uses powers and machinery, known before Morse, he does not use the same or an equivalent, which Morse invented or can protect. He has the same right to use all known and not patented before as Morse had.

See what was thus known. (*Hibbard's Ev.* 27, a; *Henry, Ev.* 125, a. See the use of different parts, not new in Morse, *Ch. B. Morse*, 83 to 5; *Henry*, 93, 156, 223; *Hare*, 96; *Jackson*, 158; *Byrne*, 197; *Barrett*, 202; *Renwick*, 232; *Borden*, 3 to 8, a; *Channing*, 38, a.)

Among them, we have already seen where the wires and the circuit, the galvanic battery, the use of the posts and the ground for a part of the circuit, the brakes in it by various devices, as by lifting the wire out, or a blow, the making of signals and marks, the paper and the clock-work, and the needle deflected if not the lever. (See history before given. *Hibbard*, *Ev.* 27, a; *Channing*, *Ev.; Henry's Ev.* 213; *Barrett*, 214, 202.) There had been, too, in use in other business, numerous arrangements and machines for self-recording, such as *gasometers* for measuring the gas used, registers of tides and the quantity of rain falling, or work of certain kinds performed, direction of winds, distances travelled by men or carriages, &c., &c. (*Bordon*, *Ev.* 7, a.) Some of these resembled much Morse's system of marks on paper. (*Channing's Ev.* 40, a.) And to imitate those by like means would be permissible, though not by new means or machinery obtained from Morse.

It would likewise be difficult to consider House's as identical or equivalent with Morse's, when he uses neither of the new and distinguishing parts in Morse's, viz: the pin in the level or needle to trace or record characters, nor the stenographic alphabet to make them intelligible. (*Hibbard*, *Ev.* 28, a.)

House also uses some things, which seem new and peculiar to his machine and prevent it from being a mere equivalent. (*Barrett*, *Ev.* 204–5; *Renwick*, 244; *Hibbard*, *Ev.* 26.)

The supposed new discovery and use by House of axial magnetism, operating perpendicularly within a cylinder, covered by coils of wire, and helping to produce the astonishing number of 54 to 84 vibrations in a second, is claimed to be important and to aid materially in the operations of his machine. (*Reynolds*, *Ev.* 274.) How that may be must be decided by experts, where necessary, as also the importance of the air and air apparatus which he employs. It is true that air is old as creation, and its use, as a moving power, almost coeval with navigation, but the employment of this all-pervading and nearly spiritual element in telegraphic machinery to move by its vacuums with superhuman strength and speed, and contribute to print rather than speak ideas, may be new and original.

But it does not seem useful on this occasion to go into details concerning either of them, considering how the machines stand on other grounds and their external appearance in connection with it.

Indeed, we are compelled by the history of this subject, and the most decisive weight of evidence on the stand, to believe what is certainly not in accordance with our own previous general impressions, that much we supposed new in connection with both of these machines is not new, nor to be protected against use by others. For instance:—

The use of electro-magnetism generally for communicating intelligence at a distance and there recording it, is, as heretofore shown, not new to either Morse or House. The idea had, as already explained, been long perceived prior to the experiments of either. But the want of a sufficient power to operate at a great distance, till after the discovery of galvanism, and the electro-magnet, prevented its complete success for practical objects, leaving it rather, as then called, a "philosophical toy" in most places. After this discovery and improvement, the want of mechanism to repeat the breaks rapidly enough for general use and mark down the results, presented difficulties. To be sure, the marking down a dot at the distant end, made at the starting-place was known by the deflection of a needle and other devices, such as the spark, though not with the pin and the kind of machinery throughout, used by Morse, or with the stenographic alphabet invented by Morse. So the signal of a letter at one end plainly understood at the other, was known before House's invention, but never made to work with the speed of his, and to print that letter as well as know it, at the distant place where it was signalized.

The lever, of which so much is said, seems only the old needle depressed at one end by the magnet, and of course elevated at the other till the circuit is broken; and by putting a pin or a pen in the last end, a dot or stroke is made on the paper rolling above or below, and the stenographic signs are then recorded. One other view to illustrate whether House has or has not encroached on what Morse invented, and we shall be done with this mode of investigating this branch of the subject. From the examination made, it appears that the novelties in Morse's pateuts are, first local circuits, and for these his last patent seems chiefly to have been taken out; secondly, recording or writing at a distance by electro-magnetism; and, thirdly, doing it by a regular stenographic alphabet on rolling paper. Now, as to the local circuits, they are not used at all by House.

As to the tracing or writing at a distance in any way and by the aid of electro-magnetism alone, it is not the mode in which House's machine operates. But, on the contrary, it records by a distinct art, viz: the art of printing, and by means of two additional powers in axial magnetism and in air, and by new and different machinery. To be sure, he uses also the power of electro-magnetism, but Morse did not invent that power or its employment in telegraphing.

Lastly, as to a stenographic alphabet, as invented and used by Morse, it is manifest that it is not employed by House at either end of his line, but the ancient Roman letters unchanged and unmodified in any respect whatever.

It seems thus demonstrable, that all which Morse appears entitled to protect as new is untouched by House.

If we proceed next to the opinion of experts, whether House infringes on Morse, or, in other words, whether the principle of the two machines be unlike or not, there seems to be a remarkable preponderance in favor of House's machine. Mr. Morse is a gentleman, not educated specially to any branch of science, but having the general information of a man liberally taught, and a highly ingenious mind. (*Prof. Silliman's Ev.* 94, a.) He was a painter by profession, according to his evidence, (48, r,) and beside him, regarding House as infringing, is only Mr. Foss, an assistant in working one of his machines, but a baker and grocer till 1845. (*Foss's Ev.* 134.) These are all against House's machine: and neither of them seems to be experts, such as usually are relied on to give scientific opinions rather than mere facts. On the other hand, and that the principles of the two machines are clearly unlike, are numerous experts, including some of the most experienced and talented men in this line of science in the country, and some of them also, very practical men. They all, twelve or fourteen in number, unite in the conclusion, that the principle of the two is wholly different. (See *Borden*, *Ev.* 8, a; record 2, a; *Harvey*, *Ev.* 322; *Philip's Ev.* 307, 97; *Eddy*, *Ev.* 59; *Chilton*, 286, 292; *Channing*, 44, a; *Hibbard*, 27, a; 32, a; *Byrne*, 199, 201; *Avery*, 19; *Barrett*, 204; *Gould*, 68, a; *Reynolds*, 271; *Renwick*, 240; *Jackson*, 165.)

Some consider the two as unlike as "a goose-quill is to a printing-press." (*Borden's Ev.* 7, a.) And several of them express a decided opinion that House's is superior, some think as a work of science, some as a piece of mechanism, and some as to its practical utility. (*Chilton's Ev.* 286; *Byrne*, 198–9; *Harvy's Ev.* 224, 230; *Barrett's Ev.* 205, 219; *Philip's Ev.* 303, 311, 298; *Lindsay*, 311; 3 *Andrews*, 109; *Crossman*, 106; *Jackson*, 165.) Though more complicated, its results are in Roman letters and require no translation, its speed in action is greater, and it is not so liable to mistakes in transmitting, or construing and copying. Many of the patents or inventions which have been upheld, are such slight changes from former modes or machines as to be tested in their material diversity, chiefly by their better results, such as the flame of gas rather than of oil, the hot blast rather than the cold, charcoal used in making sugar, hot water in place of cold in making cloth, &c. &c. (*Web. Ca.* 409; 5 *Mason* 1; 1 *Wood and Min.* Devol *vs.* Brown; 3 *Wash.* 197; 1 *Peters*, *C. C.* 394.)

The meaning attached to the word "principle," may lead to a part of the difference expressed by Messrs. Morse and Foss. (*Webs. Pat.* 43, note, and 342, v. g.) But the larger number concurring in a different view, and the definition, which the law, as heretofore explained, requires us to place on the favored principle, in the patent system, leave no doubt, that setting aside the use of wires, batteries, and electro-magnets, which neither Morse nor House invented, their machines or improvements rest on principles in some respects totally and clearly unlike.

Again, regarding Morse's as a new combination of old parts, or improvements with one new part, invented by him, which is perhaps nearest the truth, it is then manifest that if House's does not adapt the new part, or all the different elements of the new combination, it is not an infringement. (*Curtis on Pa.* 93; Barrett *vs.* Hall, 1 *Mason*, 447.)

In order to violate a new combination, all the material parts of it must be used, or that is not used which the patentee claimed as necessary to constitute his new improvement. As before shown, on the evidence, it cannot be pretended that House uses at all, many things material in Morse's, such as the "U magnet," "the clock-work," the lever, the pin, or pen, or type rule, or local circuits. The last machine, then, in such a case, being in parts, in principle, and combination so unlike the first, except the general use of electro-magnetism, invented by neither, cannot be regarded as an infringement on the first, but its author has the same right to invent and employ it as the author of the first had to invent that. The public, too, as well as men of genius have the same right to make and employ still farther improvements in telegraphing by electro-magnetism, and in recording the results, as Morse had in 1832, or 1838, or 1840.

All, however, must take care not to use anything which Morse himself invented, but only like him use the fruits of their own perseverance and ingenuity.

While they do not go beyond this, as the defendants under House do not appear to have done in this case, the plaintiff, as assignee of Morse, is not entitled in equity to the extraordinary remedy of an injunction to stop forever, the operations under House's machine.

On the evidence presented to me on both sides, and after a careful examination of that and the legal principles which should govern my decision, I have been forced into the conclusion, contrary to my previous impressions, that the defendants have not been proved guilty of any such wrong.

If I have fallen into an error in this conclusion, I deeply regret it, but it is some satisfaction to reflect that it can easily be corrected; for any views expressed by me in this case in Equity can not only be revised by another tribunal, the Supreme Court, and if erroneous, corrected; but another remedy exists at law, if the plaintiff supposes he will be able to prove there with clearness, that the House patent is a violation of the principles involved in Morse's.

A decision by the District Judge of Kentucky has been cited for the plaintiff on some of the points of this case. But as the defendants were not parties to it, and as it related to another telegraph than House's, it cannot bind the defendants, and cannot, on any legal question, be an authority to govern this Court, though its reasoning has received, and is entitled to respectful consideration, where it refers to any legal principle.

Injunction refused.

By the following decision of the Judicial Committee of the Privy Council, it will be seen that Messrs. Cooke and Wheatstone were refused an extension of their patent, on the ground of their having been "sufficiently remunerated, and that the Electric Telegraph had not been so poor an investment as we have been led to believe by the English Press," as the shareholders have received a bonus of £15 per share, besides the usual dividend of 4 per cent. on £300,000.

The Electric Telegraph Company sought to obtain the prolongation of letters patent which had been granted to William Fothergill Cooke and Charles Wheatstone on the 12th of June, 1837. The books of the petitioners were made up, it appeared, and balanced to the 31st December, 1850, and the subjoined statement will show the receipts and disbursements of the petitioners since the introduction of the electric telegraph:—

Receipts from the railway companies for their use of the company's patents,	£122,285 13 2	
Receipts from maintenance and sundries,	7,301 13 1	
		£129,587 6 3
In addition to the foregoing, the company have received gross profits on the erection of telegraphs for railway companies amounting to	40,747 4 2	
Less charges, including part of the law and parliamentary expenses,	34,319 6 7	
		6,427 17 7
Making the total receipts		£136,015 3 10
Total amount paid for patents		£167,688 9 0

Showing that, after crediting the patent account with the above-mentioned amount of £40,747 4*s.* 2*d.* received for erections, the total payments have exceeded the total receipts by		31,673 5 2
The company have in their books charged the capital account of their commercial telegraph with £33,603 10*s.* 8*d.* as the estimated value of the patent employed therein. If this nominal charge be added to the amount of actual receipts, as above stated, the patent account will then show an apparent surplus for all patents of		1,930 5 6
The commercial telegraphs have yielded during the three years which have elapsed since the commencement of their working a total gross return of	£103,444 7 11	
At charges amounting to	83,265 6 11	
Showing a surplus of		20,179 1 0

Which surplus of 20,179*l.* 1*s.* is the total net return upon a capital of 104,229*l.* 17*s.* 8*d.*—the actual cost, but much more than the present value of the patent—the amount actually expended in the erection of the commercial telegraphs; or upon a capital of 137,833*l.* 8*s.* 4*d.* if the patent account is to have the benefit of the above nominal charge of 33,603*l.* 10*s.* 8*d.*

The evidence which was adduced in support of the petitioners' case was chiefly directed to show the reasonable charges made by the company, and the accuracy of the accounts.

Their lordships decided that, as the patentees themselves had been sufficiently rewarded, the company—who derived their right from them—had no *locus standi*, and therefore refused the application.

The following is an extract from *Newton's Patent Journal*, giving the result of an interesting trial in connection with the Telegraph above described. I understand from good authority that the Electric Telegraph Company have compromised and paid Brett and Little for their improvements, and intend employing them in addition to their telegraph.

Opinion of Justice Cresswell, *in the Case of The Electric Telegraph Company* vs. *Brett and Little.*

Judgment delivered by Mr. Justice Cresswell as follows: This was an action brought by the plaintiffs against the defendants for the infringement of a patent. The patent was granted in 1837 to Messrs. Cooke and Wheatstone, for "improvements in giving signals and sounding alarms in distant places, by means of electric currents transmitted through metallic circuits," and was afterwards assigned to the plaintiffs. The action was tried at the sittings after Hilary term, 1850, before Lord Chief-Justice Wilde, and a verdict was then found for the plaintiffs; and in answer to certain questions put to the jury by the learned judge, certain special matters were found, on which the defendants had leave to move to enter the verdict for the defendants. A rule *nisi* was accordingly obtained, to which cause was shown; and in the argument the chief question raised was, what was the proper verdict to be entered in respect of the special matters found by the jury in answer to the questions of the Lord Chief-Justice. To the third question, which was material, the jury found that the magnetic ring and indicator of the defendants was a different instrument from the needle claimed in the specification of the plaintiffs' patent; and they also found, in answer to the fourth question, that "the sending of signals to the intermediate stations was new to the plaintiffs," by which expression was to be understood that it was a new invention of the patentees. The jury also found, in answer to the fifth question, "that the angular motions of the needles in vertical planes or horizontal axles, conjointly with the stops, was new to the plaintiffs," meaning that it was a new invention of the patentees. In answer to the sixth question, they found, "that as a whole the defendants' system of communicating with one wire and two needles was not the same as the plaintiffs'." It was insisted by the plaintiffs on showing cause, that on these findings they were entitled to retain the verdict in respect to the answers on the fourth and fifth questions. It appeared that the defendants, by means of duplicate coils and apparatus at the intermediate stations, had sent signals to all the intermediate stations, as well as between the terminal stations, and that they used an instrument moving in a vertical plane, called "a magnetic ring and indicator," producing nearly the same result as the needle described in the plaintiffs' specification. The jury, however, having found that the magnetic ring and indicator was a different instrument from the needle used by the plaintiffs, the defendants insisted that their use of it was no infringement of the plaintiffs' patent. The objection, however, mainly relied upon, was, that the plaintiffs' specification protected only the patentees' improvements as applied to metallic circuits, and that if the electric current was transmitted by improved machinery, not by a circuit wholly metallic, the improvements might be used without an infringement of the patent. The defendants using the earth to complete the circuit of the electric current, did not use a metallic circuit, and, therefore, they denied that the use of the plaintiffs' other improvements was an infringement of the patent. This was a grave objection, but the court was of opinion, after full consideration, that it ought not to prevail. At the time of the grant of the patent the transmission of electric currents through metallic circuits was known, and also that the power of the current might be increased by coils in the wire. The discovery that the earth would complete the circuit of the current between the two ends of the wire struck into the ground, was made after the grant of the patent. The patentees did not, therefore, claim the invention of metallic circuits, but only improvements in the method of using electric currents—the currents being transmitted by a means open to the public. The circuit used by the defendants, so far as it operated in giving signals, and in all the parts to which the plaintiffs' improvements applied, was metallic: and it was not a necessary condition that the residue of the circuit should be metallic. The specification which claimed and described the invention was to be more strictly construed than the title of the patent, and the court thought that the specification sufficiently comprehended all the circuits that were metallic, as far as it was material to the improvements claimed that they should be so.

And with regard to the use of the term "metallic currents," in the title of the patent, the court thought the title gave sufficient notice to any person acquainted with the discovery, or who had invented similar improvements to the patentees', to put him on his guard as to the nature of the plaintiffs' patent, and lead him to inquire how far any contemplated improvements would infringe it. The court thought it but reasonable to hold that a claim for a patent for improvements in the mode of doing something by a known process, was sufficient to entitle the claimant to a patent for his improvements, when applied either to the process as known at the time of the claim, or to the same process altered and improved by subsequent discoveries. The next objection was, that the plaintiffs' patent was for a system of giving signals by means of several wires and converging needles pointed to certain letters; whereas, the defendants used one wire, and made signals by counting the deflections of the needle, which was found by the jury to be a different system. The court thought this objection founded on a wrong discussion of the specification, which showed the patent to be not for a system of giving signals, but for certain distinct and specified improvements comprehending those now in question. The court, therefore, thought the objections ought not to prevail to the grounds on which the plaintiffs claimed the verdict in respect to vertical needles and of the use of duplicates at intermediate stations. It might be doubtful whether the plaintiffs could claim the verdict with regard to the use of vertical needles by the defendants, considering the finding of the jury; but the court thought that the use of duplicate apparatus at the intermediate stations, which the jury found to be a new invention, and which undoubtedly the defendants had used, entitled the plaintiffs in this respect to keep their verdict. If, however, the defendants' discovery enable intermediate stations to send as well as receive signals, that was a very important improvement, for which the inventor might probably be entitled to a patent, though he might not be entitled to use it except by the license of the patentee of the less perfect invention on which the latter invention was grounded. For these reasons the court thought the plaintiffs entitled to retain their verdict, and the rule must be discharged. Rule discharged.

Samuel F. B. Morse and Alfred Vail *vs.* F. O. J. Smith.

The defendant became an owner of one-fourth part of the Morse Patent in 1838. The agreement between him and the owners of the residue was special, and contained various covenants on the part of each party. In 1845, the plaintiffs severally appointed Amos Kendall their attorney, to manage their interests in the telegraph and all matters connected therewith.

Difficulties having occurred between the parties in the management of their joint interests, several agreements were entered into between them on the 22d of June, 1847, commonly called the division contracts, by one of which the defendant was to have full and exclusive power to bargain, sell, and convey any and all routes for the construction and use of Morse's Patents, and of all improvements thereon, **not then** sold, or placed under contract, in all the territory of the U. States, **bounded** on the south by the route extending from Pittsburgh to St. Louis, *via* Wheeling, Columbus, Cincinnati, and Louisville; then to St. Louis, by any route the defendant should select, and on the west and north by the western and northern boundaries of Illinois, Wisconsin, Michigan, and Ohio, and on the east by the eastern boundary of Ohio, to the intersection of the telegraph route from Wheeling to Columbus, opposite Wheeling; also, all within the boundaries of New York and New England. The like power and authority was given to Mr. Kendall, to bargain, sell, and convey any and all other routes, within all the remaining territory of the several States of the Union, then existing.

The contract prescribed the manner of disposing of such lines, of realizing payments therefor, and of accounting to each other for their portion of the proceeds.

Difficulties arose between the parties in relation to the accounts of each against the other under these contracts. The plaintiffs complained of the manner in which defendant had exercised the powers conferred by these contracts; of the terms on which he had authorized new routes to be constructed; of his allowing the patent to be used without first obtaining payment therefor; of his failure to perform covenants on his part contained in these contracts, and of various other matters enumerated in their complaint. The complaint prayed for a judgment, that the joint interests of the parties be severed and divided, by a just and equitable partition and division of territory; for an accounting, in reference to their joint dealings and transactions; that defendant be charged with three-fourths of certain amounts alleged to have been received by him for various enumerated telegraph lines constructed within the territory allotted to him; and for an injunction restraining him from collecting or receiving the amount due for the price of the patented invention on the New York and Erie line; or from taking any steps to subvert or invalidate the patent; or from making any farther sale of plaintiff's interest in the patented invention, in any part of the territory assigned to him under the division contracts, or from exercising any farther power under such contracts.

A temporary injunction, according to the prayer of the complaint, was issued when the suit was commenced, and this was a motion to continue it until the hearing. The very clear and able opinion of Judge Bosworth will be found in these columns.

In this statement we have not pretended to give any accurate idea of the various and particular frauds, or the abuse of power, alleged, or breaches of contracts charged; but a consideration of the matters assigned by the court, in their reasons for denying an injunction, will enable the reader to better understand what points are decided, and their bearing on the controversy. The motion was heard on the complaint, and on answering and rebutting affidavits. These and other papers used on the argument, covered nearly two thousand printed pages, and related to all the transactions between the parties in relation to the telegraph, from the time the defendant became a part owner, and to almost every line of telegraph in the United States, constructed under their authority, or that of either of them.

Superior Court. Argued May Term, 1852, *before Sanford, Duer, and Bosworth, JJ. Samuel F. B. Morse and Alfred Vail* vs. *Francis O. J. Smith. Decided Nov.* 20, 1852. *Justice Sanford died in July,* 1852.

By the Court, Bosworth, J.—The court is asked to enjoin the defendant from doing any farther acts or exercising any farther power under either of the contracts of the date of June 22, 1847, and also from collecting or receiving the amount due for the price of the patent on the line of telegraph from New York to Fredonia, commonly known as the New York and Erie Line.

Unless the court, in the proper exercise of its discretion, is called upon to restrain the defendant in these respects, the motion for an injunction should be denied, and the temporary injunction heretofore granted should be wholly dissolved.

For, if enough is not shown to justify an interference of the court to prevent the defendant from acting farther under the contracts of June 22, 1847, it would be improper to enjoin him from taking any steps to invalidate or subvert the patent, as such an act of the court would, by implication, impute to the defendant the existence of a purpose to act most disreputably towards his co-proprietors. This the court could not properly do, if it did not feel at liberty, on the case made by the papers used on this motion, to restrain him from acting farther under the authority conferred by the division contracts.

One of these contracts gives to the defendant "full and exclusive power to bargain, sell, or convey any and all routes for the construction and use" of the patent, not then sold or placed under contract within a specified part of the United States, and to Amos Kendall, the agent of Morse and Vail, the like power within all the remaining territory of the several States of the Union existing. That contract, by its terms, was to continue in force six years from its date; it will expire by its limitation on the 22d of June, 1853.

It cannot be pretended that any misrepresentations are proved to have been made, or any fraud to have been practiced, by Smith, to induce the plaintiffs or their agent to enter into any of the contracts of the date of June 22, 1847, signed by either of them, which would justify the court in rescinding them on the ground that the plaintiffs, or their agent, were induced to enter into either of them by the misrepresentations or fraud of Smith.

There is no just ground for holding that the defendant is not able to respond to the plaintiffs for the amount of any claim which they may be able to establish against him under either of those contracts, or under that by which he became a part owner of the patent.

If the defendant ought to be enjoined, in whole or in part, as prayed by the complaint, it is not in consequence of any fraud contemporaneous with the contracts of June 22, 1847, which would of itself be sufficient to avoid them, but it must be for the reason that his subsequent conduct is a clear perversion and abuse of the powers which they confer upon him, or that his management of the joint interests in his own territory has been such as tends, and if continued will tend, to render ineffectual any judgment in favor of the plaintiffs for such relief as they would be entitled to upon the case made by the papers before us.

The two important matters which form the basis of the most grave complaints made against the defendant are the construction of the New York and Erie Telegraph Line, and his neglect to settle the O'Reilly controversy, and the motives and purposes imputed to him for his acts in the one case, and his omission to act in the other. Many other various acts and contracts of the defendant which are a subject of complaint, and charged to have been done with a fraudulent intent, are alleged to have been parts and parcel of a scheme of fraud, whose existence wholly depends upon the question whether the New York and Erie Line was as between those parties, wrongfully constructed, and, on the part of the defendant, with the grossly fraudulent purposes imputed to him.

The New York and Erie Line is charged to be a fraud on the plaintiffs, on the ground, as is alleged, that at the time of making the division contracts, the parties only contemplated in authorizing new lines, the construction of such as would be side lines, or lines tributary to those previously contracted, or contemplated as main arteries of communication, and that the defendant had authorized this to be constructed as a new main line, and with a view of drawing off from existing main-lines (in which the plaintiffs were large stockholders), their legitimate business, and taking it over lines of which the defendant was substantially the sole proprietor; and that, by the terms of the contract for the building of this line, the defendant, on its completion, would become the owner of a large portion of its stock, while the plaintiffs would have no interest in it, and would only be benefited at the rate of $\$37\frac{1}{2}$ per mile, the price to be paid for interest in the patent.

The right of the defendant to authorize the construction of precisely such a line as this, or of so much of it as falls within the territory allotted to him, has never been denied, but has been at all times conceded, provided it was built as a side line, and under a contract, with proper provisions and stipulations, to secure its continued use as a side line.

It cannot be charged that there had been anything secret or stealthy, on the part of the defendant, in making the contract for the continuation of this line, or that he has attempted to conceal its terms, or his purpose, from the outset, to make it a main artery of communication. The purpose to make it a great artery of western lines with the Atlantic cities, was publicly advertised as early as the 15th of August, 1847, and a copy of the published notice was communicated at the time, by the defendant, to Mr. Kendall.

Mr. Kendall, under the date of August 22, in his reply to the defendant's letter inclosing this notice, stated his opinion that the measures and policy proposed by defendant, might bring the O'Reilly concern to a pause, but remarked that it was his "duty to look at the possible consequences of some of them: If, in a fight with O'Reilly, the business appropriate to the direct line from *Philadelphia to St. Louis*, shall be diverted to other lines, depreciating the stock of the former, and you should *then propose to pay* my principals in that stock, it would be in violation of the equity of your contract with them. *In this view*, it is my duty to object to all such arrangements; besides, I doubt the policy of the announcement that the line along the Erie Railroad is to be a main line. Its tendency is to induce a coalition between Faxton and the O'Reilly concern; and I am not sure that it would be quite just to the *New York and Buffalo Company*, and would not involve you in difficulties with them."

This shows a purpose, openly avowed at the time by Smith, to make this a main line, and that this purpose was specially communicated to the agents of the plaintiffs. It also shows the precise ground of objection then taken on behalf of the plaintiffs. No objection was made that the parties to the division contracts contemplated the sale of side lines only, or that there was any legal or equitable impediment to its construction as a main line, but it was alleged that if it had the effect to draw off from the line, from Philadelphia to St. Louis, its legitimate business, and thus depreciate the value of the stock of the last-named line, it would be inequitable to afterwards insist that the plaintiffs should receive such stock in payment, according to the terms of one of the division contracts.

To understand the point of this objection, as well as the merits of other matters controverted in this motion, it is proper to remark that in June, 1838, all the owners of the patent entered into a contract with O'Reilly, by which he undertook to construct a telegraph line, to be worked by the Morse patent, from Philadelphia, through Harrisburg to Pittsburg, thence through Wheeling and Cincinnati to St. Louis, and also to the principal towns on the Lakes. The proprietors of the patent were to be paid, for the right to use it on this line, one-fourth part of so much stock as should be issued to represent the capital required to construct a line of two wires, and one-half of the stock issued on the capital employed to construct such additional wire. Prior to the execution of the division contracts, the owners of the patent had become dissatisfied with O'Reilly, and claimed and acted on the assumption that he had forfeited his contract, and all rights under it. By one of the division contracts, the other owners of the patent sold to Smith all their rights in any contract before made by them for the use of the patent on the line (among others) specified in the O'Reilly contract; and Smith, on his part, undertook to hold them harmless from any and all claims of or liability to O'Reilly under his contracts with the owners of the patent, and to cause all of O'Reilly's claims to be settled, at his own expense, "amicably or judicially, as soon as may be." Smith, as a means of paying in part for interests sold to him, assigned to the plaintiffs a certain amount of stock and right of certificates to represent the same that should be thereafter issued, namely, $\frac{3}{16}$ths of such issues on the two first wires between Philadelphia and Pittsburg, and $\frac{3}{16}$ths of all that should be issued to represent the interests of the grantors of the patent on such additional wire between said points, and $\frac{3}{4}$ths of $\frac{3}{8}$ths of all that should be so issued on the two first wires between Pitts-

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burg and St. Louis, and a like proportion of the stock that might be issued to represent the interest of the grantors of the patent in each additional wire between the points last named.

Mr. Kendall's letter of August 23, 1847, objected to the inequitable act of offering this stock to his principals as a compliance with this contract, and before making the offer, the Erie line should have the effect to diminish its value by drawing from the line between Philadelphia and St. Louis its legitimate business, and directing it to other lines. This was the objection made to the sale and the use of the patent on the Erie as a main line.

It is also proper to observe that Mr. Smith, having failed to induce O'Reilly and his associates to compromise these difficulties or to consent to arbitrate them, and discontinue operations until the end of an arbitration, formed the design, in addition to instituting legal proceedings against O'Reilly, and those who might attempt to use Morse's patent on the lines constructed by him or under contracts made with him, of executing a system of bold competition, by constructing competing lines throughout the territory embraced in O'Reilly's contract, and elsewhere, and of arresting his operations by the diminished cost of the new lines, and by using the means within his power to control the business that might otherwise be done on the O'Reilly lines.

It is very natural that in such a state of things, and knowing this to be a leading purpose of the defendant's system of competition, Mr. Kendall should not have canvassed the purpose, when just announced, to make the New York and Erie line a main line, as closely, or to have considered the bearings of it as minutely, or to have objected as particularly as he would have done, if there had been no controversies with O'Reilly.

But it would seem to be equally obvious that it must have been understood, when first announced, that a new main line was to be constructed from New York to Fredonia; that those who subscribed on the faith of a contract, that a right to use the patent and all future improvements of it should be conveyed to a company to represent the rights and interests of the subscribers, would expect that it would be continued as a main line so long as the company might see fit to keep it in operation.

Without intending to intimate any opinion as to rights of the plaintiffs, or the liability of the defendant, under the agreement to settle the O'Reilly claims, upon the evidence presented on this motion, we have come to the following conclusions:—

First. The papers before us do not show any intentional omission of the defendant to do any acts which it can be fairly presumed he considered, or was advised by his counsel, would expedite a judicial settlement of the controversy.

Second. They do not show that the proceedings instituted were commenced and protracted as a cover to a fraudulent scheme to organize new companies, and construct new lines, with a design to enhance the value of stock in lines owned by himself, by drawing off business lines in which the plaintiffs were large stockholders, and his own interest was relatively nominal.

Third. They do not establish the fact that, in refusing the various compromises offered by the O'Reilly interests, he was actuated by any purpose of defrauding the plaintiffs, or that he acted otherwise than in accordance with his convictions of what was just and proper in the premises, in view of all the consequences that would have followed an acceptance of either of the proposed adjustments.

Fourth. There is nothing in the evidence relating to the various propositions for an arbitration of the matters in controversy between the plaintiffs and defendant, which satisfactorily establishes the absence of a purpose on the part of the defendant to enter upon a reference of all such matters as he expressed a willingness to refer. He was not bound to submit it to referees to make a new contract as to a division or reparation of interests. That, he uniformly and from the first refused to do. Any and everything else he expressed a willingness to refer. There is no pretence for saying that the sincerity of his professions is falsified by his conduct, unless it can be successfully insisted that the obstacles which he alleged existed in March, 1850, to their entering without delay upon a reference, were unreal, and were falsely put forward as an excuse for not then doing an act which he untruly avowed a willingness to perform. There is nothing in the papers before us to justify such a conclusion.

In August, 1851, the defendant again suggested a reference. Mr. Kendall replied that he would meet the defendant, and have a reference of matters, provided that the referees were given the power to adjust all differences, and "dissolve all business connections having reference to the telegraph," and were to be governed by the rules of law and equity as established by the court, and as they might understand them.

Smith replied, consenting to a reference of everything, and that the arbiters might prescribe their own rules of evidence and principles of decision.

To this Mr. Kendall avowed that he was not without doubt whether, at that late day, his principals ought to consent to any terms of arbitration which would allow a compromise of their legal or equitable rights. He then requested defendant to draw up such a submission as he proposed, and said that on receiving it he would invite his principals to meet him "for the purpose of coming to a decision."

There ended all attempts between the parties to arbitrate. It cannot be said that the defendant declined to arbitrate, nor is there any evidence that he did not intend to do so, as he there promised to do. After he had agreed to refer everything on the broad terms proposed, he is answered in effect that the plaintiffs must decide for themselves, whether they will consent, and that their agent doubts whether at that late day they ought to consent to such arbitration.

The affidavits and other papers do not establish the fact that Smith did not expect, at the time of contracting with Spread and Cornell, that they would pay in cash for the patent according to their contract, or that he collusively allowed the patent to be used on the line without the contract price for it being paid.

What the precise liabilities of Smith to the plaintiffs may be in relation to that line, in consequence of all that has transpired, we do not intend to express any opinion; that can be more advisedly formed at the hearing on a full consideration of all the facts relating to that transaction.

Whether in the event of a sale of the patent at $50 per mile in cash, or at any other price deemed reasonable in the fair exercise of the judgment of either party, it is not as just and proper for either within his own territory to stipulate in addition, and for his own benefit, for a part of the stock as profits of construction, as well as for a part of the money subscribed, over and above what is required to complete the lines and put them in operation, it is not necessary to decide in order to dispose of this motion; the negative of the proposition is not so clearly right, as to call upon us to grant any part of the prayer for an injunction *pendente lite*, on that ground.

It is not material to the proper decision of this motion, to decide which party is right in his construction of the contract between them of March, 1838, or whether either or both of them has violated or failed to perform any of the covenants on his part, contained in it.

The right to an injunction, if it exists, grows out of acts and omissions to act, the doing or omission of which violate the rights of the plaintiffs as regulated by the division contracts, and which, if continued, would tend to render ineffectual the judgment for any substantial relief, which, it is apparent, or highly probable, they may recover on the hearing of the cause on its merits.

All that we now intend to decide is that there is no such clear proof of any of the acts or omissions alleged with the motives imputed, as justifies the court, at this stage of the cause, in granting any part of the prayer for an injunction. The motion for an injunction must be denied, and the temporary injunction heretofore granted dissolved. The costs of either party upon this motion to abide the event of the action.

On the Obligation of Telegraph Companies to give Testimony respecting Telegraphic Communications.

HENISLER *vs.* FREEDMAN.

This case came before the court under the following circumstances: A domestic attachment had been issued at the suit of John R. Henisler *vs.* Freedman & Company; a motion was made to dissolve the attachment, and the parties applied for a rule to take depositions before an alderman. During the examination of the witnesses, one David Brooks, a manager in the office of the Ohio and Atlantic Telegraph Company, in the city of Philadelphia, was produced as a witness for the plaintiff, before the alderman. It was alleged that Max Freedman & Co. were absconding debtors, which they denied, but alleged they had only left the city for business purposes. In the course of the taking of testimony, some evidence was introduced to show a fraudulent absconding, by a witness named Ansfelt, who referred to certain telegraphic dispatches that had been received at Pittsburg, signed by Freedman & Company, but whether they were sent by these defendants or not, depended upon the nature and character of the dispatches sent from this city to Pittsburg, to one of the partners there. It was alleged, by the counsel for the plaintiff, that if the telegraphic dispatches were produced, these would clearly establish the points of their case. Brooks, the witness, was subpœnaed before the alderman with a *duces tecum*, to produce the dispatches sent by the defendants to Pittsburg, in relation to the matter. When sworn, he stated that he was a manager in said telegraph office, and that the office had a connection with Pittsburg; that he had dispatches with him sent by M. Freedman & Co., of this city, to Freedman & Co., at Pittsburg, in the month of April, 1851. He was then asked, by the counsel for the plaintiff, to produce them; but the witness, in answer, said he declined doing so, except at the request of the party who sent them, or the party that they were sent to, as it was contrary to law, as he conceived; but admitted that he had been regularly subpœnaed to bring the dispatches with him, and had them there. Under these circumstances the examination of the witness was suspended, and the alderman reported the facts to the court. And the question was submitted, as a question of law, whether the witness was bound to produce the dispatches for the examination of the counsel for the plaintiff before the alderman, to establish what he alleged to be a material point in the cause, and one necessary to establish his case against the defendant. It was not controverted but that the evidence designed to be adduced by the counsel for the plaintiff was material to the issue before the court, but it was alleged that the witness had no right to disclose any telegraphic communication, under the 7th section of the act of the 14th of April, 1851. Therefore the court were asked by the counsel on both sides to express their opinion on the point of law thus presented, and give a construction to the act of assembly.

The case was argued by Messrs. Webster and H. M. Phillips for the plaintiff, and E. D. Ingraham for the defendants.

It was contended by the plaintiff's counsel that the prohibition under the act had relation solely to voluntary communications, and was never intended to prohibit the introduction of testimony material in a court of justice. That the rules of evidence were not designed to be violated by this act, but were left as before. It only prohibited the agents employed in a telegraph office from a wanton abuse of the confidence reposed.

The counsel for the defendant contended that the act was broad enough in its language to embrace all cases; and a communication to a telegraphic operator could no more be divulged than the contents of a letter, sealed, and in the charge of a postmaster for transmission through the post-office.

Opinion of the Court.—The opinion of the court was delivered by Judge King, president.

At the last session of the Legislature an act was passed, declaring "that it should not be lawful for any person concerned with any line of telegraph within this Commonwealth, whether as superintendent, operator, or in any other capacity whatever, to use or make known, or cause to be used or made known, the contents of any dispatch, of whatever nature, which might be sent or received over any line of telegraph within the Commonwealth, without the consent or direction of either the party sending or receiving the same; and that all dispatches which might be filed at any office in this Commonwealth, for transmission to any point, should be transmitted without being made public, or their purport in any manner divulged at any intermediate point whatever; and in all respects the same inviolable secrecy should be maintained by the officers and agents employed upon the several telegraph lines in relation to all dispatches which might be sent or received as may be enjoined by the laws of the United States in relation to the ordinary mail service of the United States." An exception is made in reference to dispatches of a public nature, intended for publication. It was farther provided that if any person, in any capacity connected with any such telegraph line, "should *use* or cause to be used, or make known or cause to be made known the contents of any dispatch sent from or received at any office in the Commonwealth, or in any other way *unlawfully expose* another's business or acts, or in any way impair the value of any correspondence so sent or received, such person, being duly convicted thereof," should be punishable with fine and imprisonment.

David Brooks, a manager in the office of the Ohio and Atlantic Telegraph Company, being under examination as a witness before an alderman of this city, engaged in taking depositions under a rule of this court, to quash a domestic attachment issued against an alleged absconding debtor, being asked whether a telegraphic dispatch had been sent by M. Freedman & Co. to Freedman & Co., of Pittsburg, and answering in the affirmative, he was required to produce it. This he declined doing, admitting that he had the dispatch in his possession, claiming to be exempt from any obligation to do so under the provisions of the act of Assembly above recited. The alderman suspended his proceedings, in order that the objection of the witness should be submitted to the decision of this court. The question for solution is, whether the production of a telegraphic dispatch by any person connected with any line of telegraph within this Commonwealth, when required to do so, being under examination as a witness in a judicial proceeding, is the "unlawful exposure of another's business or acts," subjecting the telegraph officer to the penalties prescribed by the act. If so, of course the witness cannot be compelled to answer, for no court of justice can or would compel a man to commit a crime against the public law.

It must be apparent that, if we adopt this construction of the law, the telegraph may be used with the most absolute security for purposes destructive to the well-being of society—a state of things rendering its absolute usefulness at least questionable. The correspondence of the traitor, the murderer, the robber, and the swindler, by means of which their crimes and frauds could be the more readily accomplished, and their detection and punishment avoided, would become things so sacred that they never could be accessible to the public justice, however deep might be the public interest involved in their production. For the result of the principle contended for is, that the seal of secrecy is placed on all telegraphic communications, as well in courts of justice as elsewhere, and that they are to be classed with privileged communications, such as those between husband and wife, counsel and client. The wife or husband are not permitted to testify against each other, nor is the counsel permitted to reveal the secrets of his client, because otherwise these most important social relations could not effectively exist. The claim that society has on the testimony of all its members, in courts appointed to administer public justice, is made to give way in such cases to the maintenance of other great relations, in which the public are even more interested. If the Legislature had intended to place telegraph communications on a similar basis, it would have been easy to have said that no person connected with any line of telegraph should be permitted to produce a telegraph dispatch, or to prove its contents in a court of justice, without the assent of the parties to it. Had such a direct proposition been placed before the Legislature, I cannot think that it would have prevailed; and I am unwilling to give this law such a construction as to produce precisely the same results as would have followed such a direct enactment.

The real intent and object of this law was to prevent the betrayal of private affairs communicated through the telegraph by those connected with it for the promotion of private gain, or the gratification of idle gossip. This new and wonderful mode of communication, and the impossibility of maintaining otherwise the confidence necessary to the existence of private correspondence, required such a law as that before us. But in using the phrase, "*unlawfully* expose another's business or acts," the Legislature certainly show that they did not consider all exposures of another's business or acts "communicated through telegraph by a party connected with it," to be "unlawful," otherwise they would not have rendered punishable only "unlawful exposures."

If we are asked what are lawful exposures of business or acts, communicated through telegraph, the answer would seem to be, exposures made in courts in the course of the administration of public justice; or exposures made to the public authorities for the sole and *bona fide* motive of preventing crime, or leading to its detection or punishment. The analogies of the law show this distinction between the lawful and unlawful exposure of secret communications. Thus, a grand-juror is sworn to secrecy; yet when the testimony of a grand-juror is absolutely required in a court of justice, he is produced to testify. All the members of a court-martial are sworn to the maintenance of secrecy as respects certain parts of their proceedings, yet they are required to testify in courts of justice in respect to such proceedings.

The law is jealous of extending the circle of persons excused or interdicted from giving testimony. Parents are required to testify against children, children against parents, brothers against brothers, friends against friends. Communications by letter, made under the deepest obligations of friendship, affection, or honor, still must be produced, if deemed necessary to the ascertainment of truth, and the administration of justice by the public tribunals. To this great end of social organization all secondary causes are required to give way.

If there exists any great and overruling public necessity, which requires that telegraphic communications should be exempted from this almost universal principle, it is for the Legislature and not the judiciary to say so.

On the whole, I am of opinion that the witness must produce the dispatch in his possession.

THE LAW OF TELEGRAPH IN PENNSYLVANIA.

An Act relating to the Commencement of Actions, &c., relative to Penalties on Telegraphic Operators, &c.

SECT. 7. That from and after the passage of this act, it shall not be lawful for any person connected with any line of telegraph within this Commonwealth, whether as superintendent, operator, or in any other capacity whatever, to use, or cause to be used, or make known, or cause to be made known, the contents of any dispatch of whatsoever nature, which may be sent or received over any line of telegraph in this Commonwealth, without the consent or direction of either the party sending or receiving the same—and all dispatches which may be filed at any office in this Commonwealth, for transmission to any point, shall be so transmitted without being made public, or their purport in any manner divulged at any intermediate point, on any pretence whatever, and in all respects, the same inviolable secrecy, safe keeping, and conveyance shall be maintained by the officers and agents employed upon the several telegraph lines of this Commonwealth, in relation to all dispatches which may be sent or received, as is now enjoined by the laws of the United States in reference to the ordinary mail service: *Provided*, That nothing in this act contained, shall be so construed, as to prevent the publication at any point of any dispatch of a public nature, which may be sent by any person or persons with a view to general publicity.

SECT. 8. That in case any person, superintendent, operator, or who may be in any other capacity connected with any telegraph line in this Commonwealth, shall use, or cause to be used, or make known, or cause to be made known, the contents of any dispatch sent from or received at any office in this Commonwealth, or in anywise unlawfully expose another's business or secrets, or in anywise impair the value of any correspondence sent or received, such person, being duly convicted thereof, shall, for every such offence, be subject to a fine of not less than one hundred dollars, or imprisonment not exceeding six months, or both, according to the circumstances and aggravation of the offence.

Approved April 14, 1851.

MAGNETIC TELEGRAPH LAW IN NEW YORK.

The Legislature of New York passed, about a month ago, an amendment to an act passed in 1848, for the incorporation and regulation of telegraph companies. The first section authorizes any persons to associate for the purpose of owning or constructing, using and maintaining a line or lines of electric telegraph, whether wholly within or partly beyond the limits of the State, and to become a body corporate. The second section authorizes such association to erect and construct, from time to time, the necessary fixtures for such lines of telegraph, upon, over or under any of the public roads, streets, and highways, and through, across, or under any of the waters within the limits of this State, subject to the restrictions in the former act, and also to erect and construct such fixtures, upon, through, or over any other land, subject to the right of the owner or owners thereof to full compensation for the same. The other sections are as follows:—

SECT. 3. Every such company owning or using a line of electric telegraph, partly within and partly beyond the limits of this State, shall render to the proper officer a true report of the cost to such company of their works within this State; and the stock of such company in amount equal to such cost, or the dividends thereof, shall be subject to taxation in the same manner, and at the same rate, as the stocks or dividends of other companies incorporated by the laws of this State, are subject.

SECT. 4. The liability of any share or stockholder in any company organized under this act, as provided for in the act, of which this is an amendment, shall only apply to the amount due by any such share or stockholder in such company, and unpaid, on or for any such share or stock.

A Bill for the better Regulation of Telegraph Companies in the State of Indiana, and legalizing their former Acts.

SECT. 1. *Be it enacted by the General Assembly of the State of Indiana,* That all telegraph companies organized under the laws of this State shall have power to lease or attach to them other telegraph lines by lease or purchase.

SECT. 2. Any of said companies, through its Board of Directors, with the consent of a majority of the stockholders, shall have power to reduce its capital stock to any amount not below the actual cost of construction.

SECT. 3. The officers and directors of said telegraph companies shall hereafter be elected from among the stockholders residing in this State, or at some point in any of the adjoining States where any of said companies shall have a telegraph station.

SECT. 4. All irregularities or defects in the organization of said telegraph companies are hereby legalized: *Provided,* That this section shall not be construed in such a manner as to prejudice the rights of citizens of this State, nor in such a manner as to allow such companies to institute any suit or suits against the inhabitants of this State, which they are not now allowed to institute by the laws of this State.

SECT. 5. It is declared that an emergency exists requiring the enactment hereby made, and that this act shall be in force from and after its passage.

Passed January 27, 1853.

GENERAL TELEGRAPH LAW OF ILLINOIS; AND THE SPECIAL LAW CONCERNING THE "ILLINOIS AND MISSISSIPPI TELEGRAPH COMPANY."

An Act for the Establishment of Telegraphs.

SECT. 1. *Be it enacted by the people of the State of Illinois, represented in the General Assembly,* That any number of persons may associate for the purpose of constructing a line of telegraph through this State, or from and to any point within this State, upon such terms and conditions, and subject to the liabilities prescribed in this act.

SECT. 2. Such persons, under their hands and seals, shall make a certificate, which shall specify, 1st, the name assumed to distinguish such association, and to be used in its dealings, and by which it may sue and be sued; 2d, the general route of the line of telegraph, designating the points to be connected; 3d, the capital stock of such association, and the number of shares into which the stock shall be divided; 4th, the names and places of residence of the shareholders, and the number of shares held by each of them respectively; 5th, the period at which such association shall commence and terminate; which certificate shall be proved or acknowledged, and recorded in the office of the clerk of the county where any office of such association shall be established, and a copy thereof filed in the office of the Secretary of State. Such acknowledgment may be taken by any officer authorized to take the acknowledgment of deeds of real estate, in the place where such acknowledgment is taken.

SECT. 3. Upon complying with the provisions of the last preceding section, such association, and their successors and assigns, shall be and hereby is declared to be a body politic and corporate, by the name so as aforesaid to be designated in said certificate; and a copy thereof, duly certified by the clerk of the county where the same is filed and recorded, or by the Secretary of State, may be used as evidence in all courts and places for and against any such association.

SECT. 4. Such association shall have the power to purchase, receive, and hold such real estate as may be necessary and convenient in accomplishing the objects for which such association may be formed, and may appoint such directors, officers, and agents, and employ such servants, and make such prudential rules, regulations, and by-laws, as may be necessary in the transaction of the business, not inconsistent with the laws of this State or of the United States.

SECT. 5. Such association is authorized to construct lines of telegraph, and maintain such as are already constructed, along and upon any of the public roads and highways, and across any of the waters, and across and over the lands, whether public or private, within the limits of this State, by the erection of the necessary fixtures, including posts, piers or abutments, for sustaining the cords or wires of such lines; provided the same shall not be so constructed as to incommode the public use of said roads or highways, or injuriously interrupt the navigation of said waters; nor shall this act be so construed as to authorize the construction of any bridge across any of the waters of this State.

SECT. 6. If any person over whose lands said lines shall pass, upon which said posts, piers or abutments shall be placed, shall consider himself aggrieved or damaged thereby, it shall be the duty of the circuit judge within whose district such lands are, on the application of such persons, and on notice to said association (to be served on the President or any director), to appoint three discreet and disinterested persons as appraisers, who shall severally take an oath, before any person authorized to administer oaths, faithfully and impartially to perform the duties required of them by this act; and it shall be the duty of said appraisers, or a majority of them, to make a just and equitable appraisal of all the loss or damage sustained by said applicant by reason of said lines, posts, piers or abutments; duplicates of which said appraisement shall be reduced to writing, and signed by said appraisers or a majority of them; one copy shall be delivered to the applicant, and the other to the President or any director or officer of said association or corporation, on demand; and in case any damage shall be adjudged to said applicant, the association or corporation shall pay the amount thereof, with costs of said appraisal, said costs to be liquidated and ascertained in said award; and said appraisers shall receive for their services two dollars for each day they are actually employed in making said appraisement.

SECT. 7. Any person who shall unlawfully and intentionally injure, molest, or destroy any of said lines, posts, piers or abutments, or the materials or property belonging thereto, shall, on conviction thereof, be deemed guilty of a misdemeanor, and be punished by a fine not exceeding five hundred dollars, or imprisonment in the penitentiary not exceeding one year, or both, at the discretion of the court having cognizance thereof. Prosecutions under this act shall be by indictment, in any court having criminal jurisdiction.

SECT. 8. It shall be lawful for any association of persons organized under this act, by their articles of association, to provide for an increase of their capital, and of the number of the association, and for the extension of new lines of telegraph, from time to time, as they may think proper.

SECT. 9. If any association or associations, organized under this act, shall refuse to receive dispatches from and for other telegraph lines or associations, and shall refuse to transmit the same in good faith, and with impartiality, such association or associations, so offending, shall forfeit all rights and privileges acquired under this act, and the same shall cease and be dissolved.

SECT. 10. The legislature may at any time, alter or repeal this act.

SECT. 11. It shall be the duty of all persons employed in transmitting messages by telegraph, to transmit them in the order in which they are received; and any person who shall fail so to transmit messages, or who shall suppress a message, or who shall make known the contents of a message to any person other than the one to whom it is addressed, or to his attorney, shall be deemed guilty of a misdemeanor, and be punished by a fine not exceeding one thousand dollars.

SECT. 12. Process or notice served upon any clerk or agent of any of said companies formed under this act, at any of the offices of such company, shall be deemed sufficiently served for all purposes whatsoever.

SECT. 13. This act is hereby declared to be a public act, and to take effect on its passage.

Approved February 9, 1849.

An Act to Amend the Charter of the Illinois and Mississippi Telegraph Company.

SECT. 1. *Be it enacted, &c.*, That the Board of Directors of the Illinois and Mississippi Telegraph Company are hereby vested with power to levy, from time to time, assessments upon the capital stock of said company, of such amount as may be sufficient, in the opinion of said Board of Directors, to pay the debts and liabilities of said company, and to repair and reconstruct the lines of telegraph belonging to said company, and to keep and maintain the same in good working order.

SECT. 2. The said assessments shall be levied by orders of the Board of Directors, which shall specify the amount of the assessments levied upon each share of the capital stock, and all the assessments shall be equal and uniform, so that each share of said stock shall be assessed to the same amount.

SECT. 3. After any order shall have been passed by the said Board of Directors, levying any such assessment, notice thereof shall be given to the stockholders of said company, by publication for twenty days in some newspaper printed in each county in this State, within which the said company shall have a telegraph station, if there be any newspaper printed in said county; and it shall be the duty of the publishers of such papers to file certificates of said publication with the secretary of said company, which certificates shall be evidence of such publications in all places, should such publications ever be called in question. And a certificate from the secretary of said company that any publications have been made, as by this act required, shall be *prima facie* evidence thereof in all courts and places whatever.

SECT. 4. If payment of any assessment upon any share or shares of said stock shall not be made to the treasurer of said company within the time limited by the order of the said Board of Directors levying such assessment, which shall not be less than thirty days from the time of the passage of such order, it shall be competent for the said Board of Directors, and they are hereby vested with full power to declare any and all stock of said company, upon which any assessment shall not have been paid, to be forfeited to said company. And the said stock shall be, and the same is, hereby declared to be forfeited and cancelled.

SECT. 5. In case the said Board of Directors shall not think it advisable to proceed by their own order to declare such stock forfeited, upon which any such assessment shall not have been paid, it shall be competent for said company to apply to the Court of Chancery in any county in this State, within which the said company shall have a telegraph station, by petition, setting forth the order of the Board of Directors levying such assessment, the fact of publication of notice of said assessment, as required by this act, and the non-payment of said assessment, describing the stock by its numbers, and praying the said court to decree that the said non-paying stock be forfeited to said company, and that the same be cancelled; or the prayer of the said petition may be that the said court may order the said non-paying stock to be sold by the treasurer of said company to the highest bidder; and the said company is hereby authorized to bid at such sale upon the share or shares offered, the amount of the said assessment, and no more; and in case the same shall be sold to said company, the same shall be cancelled. But in case any person shall pay more for said stock than the amount of the assessment, it shall be the duty of the secretary of said company to issue a certificate of said stock to the purchaser; and the original certificate or certificates of the stock thus sold shall be, and the same is hereby declared to be cancelled and void. And the amount paid for said stock, over the amount of the assessment, shall be paid over to the owners of said stock.

SECT. 6. The said Court of Chancery is hereby vested with jurisdiction to grant the relief which may be prayed for in said petition, according to the provisions of the preceding section. And the said Court of Chancery is hereby declared to be always open for the purpose of executing said jurisdiction, and to make any order or decree in relation thereto.

SECT. 7. Notice of the pendency of said petition shall be published for at least two weeks, in some newspaper published in the county where such petition shall be filed, and a copy of such notice shall be filed with the secretary of said company, certified by the publishers.

SECT. 8. The official certificate of the secretary and treasurer of said company shall be *prima facie* evidence of the non-payment of any such assessment.

SECT. 9. The said Board of Directors may transact business without assembling together in open meeting, by means either of telegraph or written communications. And the votes of Directors may in this way be given and ascertained. And any order, by-law, or resolution in favor of which a majority of the Directors shall vote, by forwarding their votes to the president or secretary of said company, either by telegraph or written communication, shall be entered of record by the secretary of said company, and shall be valid and binding to all intents and purposes.

SECT. 10. The said Board of Directors is hereby authorized and empowered to adopt and pass all orders, resolutions, and by-laws which the interest, well-being, good order, and management of the affairs of the said company may require, not inconsistent with the laws and Constitution, either of this State or of the United States; and with a view as far as possible to the stability, continuance, and regular working of said telegraph, or as much thereof as it is practicable for said company to maintain and support, in the opinion of the said Board of Directors, and may vest in their subordinate officers all necessary powers therefor.

SECT. 11. The said Board of Directors is hereby authorized and empowered to divide their lines of telegraph into such divisions as may be deemed convenient and proper; and may provide for the government and management, in whole or in part, of such divisions, and may separate the financial interests and liabilities of each division from the others. And any debt or liability contracted or incurred by the officers or governmental authority of one division, for or on account of that division, shall only create a special liability against said company, so as only to subject the property assets, resources, and funds of such division to the payment thereof.

SECT. 12. All process to or against said company shall be served by reading to, or leaving a copy thereof with the president or secretary of said company.

SECT. 13. It shall be unlawful for any person to fasten any boat or vessel to the posts or poles of said lines of telegraph, or to check the progress of any boat or vessel by means thereof. And any person who shall do so, or cause the same to be done to the injury of the said lines of telegraph, shall be liable to the same punishment, and may be prosecuted in the same way as is provided in section 7 of an act, entitled "An act for the establishment of Telegraphs," approved February 9, 1849; and shall moreover be liable to pay to said company three times the damage which such injury may cause, which may be recovered before a justice of the peace, or circuit court of the proper county.

SECT. 14. A certified copy by the secretary of said company, of any order, by-law, or resolution, passed or adopted by the Board of Directors of said company, shall be evidence of the due passage or adoption thereof in all courts and places whatever.

SECT. 15. This act to take effect, and be in force, from and after its passage.

Approved June 16, 1852.

ACT OF 1848. STATE OF LOUISIANA.

SECT. 1. Any person or persons may be and are hereby authorized, to construct lines of electric telegraphs, from point to point, upon and along any of the public roads, levees, and highways, and across any of the waters within the limits of this State, by the erection of the necessary fixtures, including posts, piers, and abutments for sustaining the cords or wires of such lines: *Provided*, The same shall not, in any instance, be so constructed as to incommode the public use of said roads or highways, or endanger or injuriously interrupt the navigation of said waters; nor shall this act be so construed as to authorize the erection of any bridge across any of the waters of this State. *And provided farther*, That such person or persons shall pay all damages which may be sustained by the owner or owners of all lands over which said lines shall pass.

SECT. 2. Any person who shall unlawfully and intentionally injure, molest, or destroy any of said lines, posts, abutments, or the materials or property belonging thereto, or who shall molest or interfere with, or in any way interrupt the use or operation of any line or lines, or parts thereof, shall, on conviction thereof, be deemed guilty of a crime, and be punished by a fine not exceeding five hundred dollars, or imprisonment in the penitentiary not exceeding one year, or both, at the discretion of the court having cognizance thereof.

SECT. 3. Any operator, clerk, director, messenger, or other person in the employ of any telegraph company having an office or station in this State, who shall refuse or omit to send or deliver any dispatch or message, on which the charges or fees shall have been paid or offered to be paid, or for the payment of which a contract shall have been made, or cause, or direct to give precedence to a message or dispatch subsequently brought to the office or station; or who shall in any way give precedence in time of sending or delivering any dispatch or message belonging to a director, officer, or stockholder of such company, or any other person, over any dispatch or message, shall be subject to a penalty of not less than fifty nor more than one thousand dollars, one-half to the informer and the other to the Charity Hospital, and shall be answerable in damages to the party injured; and for any subsequent offence, the person so offending shall be also subject to imprisonment in the parish prison, for a period of not more than three months.

SECT. 4. No operator or agent of the telegraph shall be permitted to transmit messages which can in any manner tend to defeat the ends of justice, by preventing the apprehension of fugitives from justice, or to communicate such information as may enable the escape of persons charged with offences, under a penalty of an imprisonment of not less than twelve months nor more than two years in the State penitentiary, and a fine of not less than two hundred and fifty dollars; nor more than five hundred dollars; one-half for the benefit of the informer, and the balance for the benefit of the free public schools, recoverable before any court of competent jurisdiction.

Liability of Telegraph Companies.

A silk firm in New York received in November, 1850, a telegraphic dispatch from Adrian, Mich., over the Lake Erie line, for "one hundred $8 blue and orange shawls," instead of "one *handsome* shawl," as the dispatch originally read. They accordingly sued the Telegraph Company in the Court of Common Pleas at Cleveland, to recover charges for freight, &c., and have recovered a verdict of $118.

Magnetic Telegraph Companies in South Carolina.

A bill has been introduced into the South Carolina Legislature, making every telegraph company liable to four times the amount paid for transmission, as well as special damages, for any delay or neglect in the transmission or delivery of any message or communication, or from neglect and delay in the depositing of any message or communication within the nearest post-office, when so directed by the party sending.

Cutting Telegraph Wires.

Mr. Alexander has been kind enough to furnish us with the following dispatch, which he received at Charleston on the morning of the 15th inst., on his way north, from Mr. Turner, his contractor, who has charge of the repairs of his line from Columbia, S. C., to Raleigh, N. C. It shows that the Courts of South Carolina make summary work of those who interfere with the wires.—*Philadelphia Ledger.*

CHERAW, S. C., Sept. 14, 1852.

ELAM ALEXANDER, ESQ., President of Washington and New Orleans Telegraph Company, Charleston. Dear Sir: At a Court held in Marlboro' District, this day, Moses Knight was found guilty of cutting the telegraph wires, and sentenced to receive *thirty-nine lashes on the bare back, publicly, to leave the District in ten days, and each and every time he is caught in the District, to receive thirty-nine more lashes without farther trial.* There is yet another one to be tried. I think we will *hang him.*

H. C. TURNER.

Suit against the New Orleans Telegraph Company.

Mr. Randall, of Athens County, Ohio, has recovered a verdict in the Superior Court, at Cincinnati, of $1,500 damages, against the New Orleans Telegraph Company, for personal injuries, caused by his being thrown out of his carriage, the horses having taken fright at the telegraph wires, which had fallen across the road.

INDEX.

ERRATA.

Page 173, fourth paragraph—"It is well *known* that moist air," &c.

Omit "W" in third paragraph, page 177.