From the North British Review.

THE ELECTRIC TELEGRAPH.*

The seven wonders of the world have passed into oblivion among the miracles of science which the present day has been permitted to witness. The inventions of former times, beautiful and useful as they have been, sink into insignificance beside those magnificent combinations of science and of art which every day excite our attention, and add to our happiness. The telescope and the microscope, the chronometer and the compass, and various other instruments which society has long possessed,—however much they have contributed to the advancement of science, and to individual and general interests, can scarcely be ranked among those grand inventions which ameliorate the social condition of all the races of mankind, which change the very habits of social life, and add to the physical and intellectual enjoyments of every inhabitant of the globe. The steam-engine, with its application to navigation, locomotion, and every species of labor once cruelly exacted from man and the lower animals,—the electric light, rivalling the sun in brilliancy,—the photographic art, by which invisible rays paint a portrait or a landscape, with unerring accuracy,—the lighting of our houses and streets by a gaseous element transmissible like water through pipes,—the electric telegraph, which despatches its messages of lightning over the wire-girdled globe, are the great inventions which have sprung up during the life of men still alive, and which display those transcendent powers which have been given to man for the benefit of his race.

But while man has nobly executed the task which the Almighty has committed to his genius, we must not forget that it is to the elements themselves which he has subjugated to his will, and to the materials provided for him by his Creator's hand, that society is indebted for the gift they enjoy. The heat, the light, the electric fluid—the great cosmical principles which enliven and enchain the universe, have been the prime ministers of the philosopher, while the coal, the metals, and the water raised to his level from the depths of the earth, have been his humbler agents.

We should require to write the history of science, were we to record the steps of discovery by which the physical laws have been established upon which these inventions depend, and to associate with each step the immortal name by which it was achieved. It is in records little known, and as little appreciated, that such names appear. It is to those who have applied the discoveries to practical use, that the prize of popular and successful invention is adjudged, and it is round their brow that the laurel of contemporary fame is entwined. The names of Oersted, Arago, and Schweigger, without whose discoveries the present electric telegraph would never have existed, are rarely pronounced even in union with those of the mechanical inventors who have been enriched by their labors.

In enumerating the wonders of the past and the passing age, we have omitted the greatest of them all. There is no principle stronger in our nature than that which prompts us to the reciprocity of kindness. Gratitude is one of the cheapest of virtues. To feel and to express it, is, in our individual capacities, to discharge the duty which we owe to a benefactor. It is different, however, with nations. The gifts which the philosopher confers upon his race can be rewarded only by the community to which he belongs. There is no cosmical legislature to take cognizance of the world's benefactors, and the principle of philanthropy combines itself with the patriotic impulse in stimulating Governments to the remuneration of national service. Is it not then the greatest wonder in the world, the most astounding truth with which we have to deal, and with which feel-

* 1. *The Museum of Science and Art.* Edited by DIONYSIUS LARDNER, D.C.L. On the Electric Telegraph. Vol. III. and IV.
2. *Mémoire de la Telegraphie Electrique.* Par M. WERNER SIEMENS, (de Berlin,) Ancien Officer D'Artillerie. Paris, 1850. Pp. 48.
3. *Reports by the Juries of the Great Exhibition.* Report of Jury X. London, 1850.

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ing has to struggle, that not one of the great men to whom the world owes the gigantic inventions we have enumerated, have ever received any of those marks of honor, which the selfish statesman takes to himself, and gives to his accomplices;—which characterize the diplomatic juggler, and which shine on the breast of the human hyæna who has risked a useless life in the battle-field of unjust and aggressive war?

In an article like the present, and within so limited a space, it will be difficult to convey, without diagrams, a distinct idea of the various inventions which are combined in the construction and use of the Electric Telegraph, but with a little attention on the part of the reader, this difficulty may to a certain extent be surmounted, and we hope to be able to give an intelligible idea of the general apparatus and arrangements by which this noble art has been brought to such high and unexpected perfection.

The word Telegraph, which means to write at a distance, has been long in use, as the name of a very imperfect system of communicating intelligence by signals, which was used by the ancients, and is at present employed, under very rude forms, even among savage nations. In modern times the art has been brought to great perfection, and was in general use in this country and on the continent during the last European war; but it has been entirely abandoned since the invention of the Electric Telegraph. Between Plymouth and the Admiralty in London, for example, various signal stations were established, and the messages sent from Plymouth passed from station to station till they reached the Admiralty. During the night the signals were of course luminous; but neither these nor day signals were visible in fogs, so that for whole days no telegraphic message could be conveyed. At the time of the peninsular war a very remarkable effect was produced, in consequence of a fog coming on during the transmission of a message from the seat of war to the admiral commanding at Plymouth. The words which reached the Admiralty were, "Wellington defeated." The ominous sentence arrived in the morning, and occasioned great anxiety till a clear afternoon brought up the other two cheering words, "The Enemy, &c., &c."

The first important step to the invention of the Electric Telegraph was made upwards of an hundred years ago by M. Le Monnier in France, and Sir William Watson in England. Le Monnier caused the electric shock to pass through an iron wire nearly 6,000 feet in length, and found that it moved through that space in less than a quarter of a second. He then electrified a wire 1,319 feet long, and he found that the electricity ceased at one end the moment the electricity was taken off at the other. Sir William Watson's experiments were made on a greater scale, and led to still more important results. On the 14th August 1747, he stretched a wire 6,732 feet long over Shooter's Hill, and supported it upon rods of baked wood. This wire communicated with the iron rod which was to make the discharge. Another wire communicating with a charged Leyden jar was 3,868 feet long. The distance between the observers was about two miles, and as two miles of *dry ground* formed part of the circuit, its length was upwards of four miles. When the shock was made to pass through this space, no time appeared to elapse during its passage, and the observers considered it as instantaneous. In another experiment, when the wire was 12,276 feet long, the very same result was obtained.

Although it was thus placed beyond a doubt that electricity passed *instantaneously*, or in a time too short to admit of being measured, no application of this valuable fact seems to have been made by the philosophers who were assembled at Shooter's Hill. It was reserved for a Scotchman, a gentleman residing at Renfrew, to suggest the idea of transmitting messages by electricity along wires passing from one place to another. This remarkable proposal was published in the Scots Magazine for February 1753, in an article bearing the initials C. M., the only name which we shall probably ever obtain for the first inventor of the Electric Telegraph.* This letter, entitled "An expeditious Method of Conveying Intelligence," is so interesting, that we shall lay the whole of it before our readers.

Renfrew, Feb. 1, 1753.

"SIR,—It is well known to all who are conversant in electrical experiments, that the electrical power may be propagated along a small wire from one place to another without being sensibly abated by the length of its progress. Let, then, a set of wires equal in number to the letters of the alphabet be extended horizontally between two given places parallel to one another, and each of them

* When the writer of this article first perused this remarkable document, he sent it to the *Commonwealth*, an ably-conducted Glasgow paper, in the hope that a real name might still be found to replace the initials C. M.

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about an inch distant from that next to it. At every twenty yards' end let them be fixed on glass with jewellers' cement to some firm body, both to prevent them from touching the earth, or any other non-electric, and from breaking by their own gravity. Let the electric gun barrel be placed at right angles with the extremities of the wire, and about an inch below them. Also, let the wires be fixed in a solid piece of glass six inches from the end, and let all that part of them which reaches from the glass to the machine have sufficient spring and stiffness to recover its situation after being brought in contact with the barrel. Close by the supporting glass let a ball be suspended from every wire, and about a sixth or an eighth of an inch below the balls, place the letters of the alphabet marked on bits of paper, or any other substance that may be light enough to rise to the electrified ball, and at the same time let it be so contrived that each of them may reassume its proper place when dropt. All things constructed as above, and the minute previously fixed, I begin the conversation with my distant friend in this manner. Having set the electrical machine agoing as in ordinary experiments, suppose I am to pronounce the word *Sir*, with a piece of glass or any other *electric per se*, I strike the wire *S* so as to bring it in contact with the barrel, then *i*, then *r*, all in the same way, and my correspondent almost in the same instant observes those several characters rise in order to the electrified balls at his end of the wires. Thus I spell away as long as I think fit, and my correspondent, for the sake of memory, writes the characters as they rise, and may join and read them afterwards as often as he inclines. Upon a signal given or from choice I stop the machine, and taking up the pen in my turn, I write down at the other end whatever my friend strikes out.

"If any body should think this way tiresome, let him, instead of the balls, suspend a range of bells from the roof equal in number to the letters of the alphabet, gradually decreasing in size from the Bell A to Z, and from the horizontal wires let there be another set reaching to the several bells, one, *viz.*, from the horizontal wire A to the Bell A, another from the horizontal wire B to the bell B, &c. Then let him who begins the discourse bring the wire in contact with the barrel as before; and the electrical spark working on bells of different sizes, will inform the correspondent by the sound what wires have been touched. And thus by some practice they may come to understand the language of the chimes in whole words, without being put to the trouble of noting down every letter.

"The same thing may be otherwise effected. Let the balls be suspended over the characters as before, but instead of bringing the ends of the horizontal wires in contact with the barrel, let a second set reach from the electrified cask (barrel) so as to be in contact with the horizontal ones; and let it be so contrived at the same time, that any of them may be removed from its corresponding horizontal by the slightest touch, and may bring itself again into contact when left at liberty. This may be done by the help of a small spring and slider, or twenty other methods, which the least ingenuity will discover. In this way the characters will always adhere to the balls, excepting when any one of the secondaries is removed from contact with its horizontal, and then the letter at the other end of the horizontal will immediately drop from its ball. But I mention this only by way of variety.

Some may perhaps think, that although the electric fire has not been observed to diminish sensibly in its progress through any length of wire that has been tried hitherto, yet as that has never exceeded thirty or forty yards,* it may be readily supposed that in a far greater length it would be remarkably diminished, and probably would be entirely drained off in a few miles by the surrounding air. To prevent the objection, and save longer argument, lay over the wires from one end to the other with a thin coat of jeweller's cement. This may be done for a trifle of additional expense; and as it is an *electric per se*, will effectually secure any part of the fire from mixing with the atmosphere.—I am, &c., C. M."

Here we have an electric telegraph upwards of a hundred years old, which at the present day would *convey intelligence expeditiously*, and we are constrained to admit that C. M. was the true inventor of the electric telegraph, and that every step made since that time, however sagacious and valuable, can be viewed in no other light than an improvement. It is singular that the ingenious author should not have adopted some of the obvious modes for diminishing the number of wires; but as he seems to have had no expectation of his invention being adopted, he probably contented himself with a general view of the principle.

*** The Author was obviously ignorant of Sir. W. Watson's experiments.**

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Twenty-one years after this invention was published, in the year 1774, M. Lesage of Geneva is said to have established a telegraph there, which, in so far as it has been described, is precisely the same as that of our countryman C. M. It had twenty-four wires imbedded in an insulating material, with a pith ball electrometer attached to each wire, the motion of which indicated the letters of the alphabet.

When our countryman Arthur Young was in France in 1787, he either saw or heard of an electric telegraph which he thus describes: "M. Lamond has made a remarkable discovery in electricity. You write two or three words upon paper. He takes them with him into a room, and turns an electrical machine, above which is an electrometer with a little ball made of the pith of a feather. A copper wire is joined to a similar electrical machine in a distant apartment, and his wife, on observing the movement of the corresponding ball, writes the words which it indicates, from which it appears that he has constructed an alphabet of motion. As the length of the copper wire makes no difference on the effect, a correspondence might be maintained at a great distance; for example, at a besieged town, or for purposes much more worthy of attention, and a thousand times more innocent." It is obvious from this description that the different letters of the alphabet must have been indicated by different numbers of displacements of the pith ball, making one wire the tedious narrator of the message.

In 1787, M. Betancourt, a French engineer, established telegraphic wires between Aranjuez and Madrid, and transmitted messages by successive electric discharges from a Leyden jar. Cavallo, in 1795, proposed to transmit signals along wires by the inflammation of several combustible or detonating substances, such as gunpowder, phosphorus, and phosphorated hydrogen, or by means of simple electrical sparks given out by the wire.

An important step was made in telegraphic apparatus by Mr. Francis Ronalds. Previous to 1823, he constructed a telegraph on his lawn at Hammersmith, by insulating *eight miles of wire* with silk strings. He made the same experiments with 525 feet of *bronzed wire.* The wire was laid in a trough of wood two inches square, well lined both within and without with pitch, and inside the trough were placed thick glass tubes through which the wire ran. The joints of the glass tubes were surrounded with short and wider tubes of glass, the ends of which were sealed up with soft wax. The wooden trough was then placed in a trench four feet deep. An ingenious apparatus, with a dial containing letters and figures, was fixed upon the seconds arbor of a clock, which beat dead seconds, and another in front of it with an aperture and an electrometer, so that the collapsing and diverging of the pith ball corresponded with the letter or number on the dial, as seen through the aperture of the plate in front of it.

In all these contrivances, ordinary or *statical* electricity, such as is produced by friction in electrical machines, was employed; and if no other form of the electric force had been discovered, it is obvious, from the preceding inventions, that we should have had at this day a real working electric telegraph, not so simple, nor with so many resources, but still an instrument which would have amply fulfilled the grand object of communicating intelligence with the speed of lightning. A new source of electric power, what has been called *dynamic* electricity, however, was discovered by Volta in 1800, and became the agent in various new forms of the electric telegraph. If we take a disc of *copper* like a penny piece, and another of *zinc* of the same size, and placing one above the tongue, and the other below it, make them touch at or below the tip of the tongue, we shall feel a sharp taste which disappears as soon as the discs are freed from contact. If we now join these two discs with a piece of wire soldered to each, and place them in a glass or stone ware vessel of salt water, or water made acid with nitric, muriatic, or sulphuric acid, the water will be decomposed, and a current of electricity will flow from the *zinc* disc, which is the *positive* end, to the *copper* disc, which is the *negative* end of this little galvanic battery, as it may be called. When a number of these vessels, with their united discs of copper and zinc, are placed in a row, so that the zinc of one vessel is connected by a wire with the copper of another, we have a large and powerful battery, capable of giving severe shocks, and causing combustion, light, and chemical decomposition. In order that this battery may produce any of these effects, one wire passes from the last *copper* disc at one end, and termintes in a point A, while another wire passes from the last zinc disc at the other end, and terminates in a point B, A and B representing the ends of the wires. When the extremities A and B are in contact, or if the wire has no break at these points, the current of electricity would have

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passed from B to A, but when the current is interrupted, and bodies are placed between A and B, the current forces its way through them, turning and decomposing them, and producing sparks and shocks when the current passes through the human body, or any part of it. The electric force may be obtained by placing the zinc and copper discs in a pile above one another, and separating them by discs of cloth wetted with acidulated water. In this form it is called the Pile of Volta.

The first application of this new power to telegraphic purposes was made by M. Sœmmering of Munich in 1811, and by means of a very ingenious contrivance. Upon the bottom of a glass vessel he fixed thirty-five points of gold, indicating thirty-five letters, and ten numerals from 0 to 9. From each of these thirty-five points there passed a copper conductor terminating in a small brass cylinder, in the middle of which was a groove for receiving a small screw nut for fixing the wires which united the corresponding point with the positive or negative pole of the battery or pile which he used. When the glass vessel was filled with water, and the electricity communicated to the letter at one end of a wire, the gold point coresponding to this letter gave out a bubble of gas, which was largest when it was oxygen and smallest when it was hydrogen, so that he could transmit two letters at once. Sœmmering covered each of his thirty-five wires with silk, and surrounded the whole with varnish. Our limits will not permit us to describe this beautiful invention more particularly, but it is obviously one capable of doing real telegraphic work, and wanted only what he added afterwards, a contrivance or alarm, for calling the attention of the operator at the distant station. Like C. M. the Bavarian mechanician never seems to have thought of reducing the number of his wires by different combinations of his gas bubbles, as afterwards suggested by Schweigger, who proposed the detonating pistol of Volta as an alarm.

The grand discovery of electro-magnetism by Professor Oersted of Copenhagen, in 1819, led to great improvements in the construction and use of the electric telegraph. By placing a compass-needle parallel to the conducting wire of a Voltaic battery, that is, parallel to the current, he found that it placed itself across the current, or at right angles to the wire. When the current passed above the needle, its north pole deviated to the west, and the current came from south to north, and the same pole deviated to the east when the current came from north to south. When the current passed below the needle the opposite effects were produced, the south pole being deviated to the east when the current passed from south to north, and to the west when it came from north to south. M. Ampere illustrated this in a very happy manner. He supposed a miniature figure of a man to be placed in a lying position along the conducting wire, with the feet towards the zinc pole, and the head towards the copper pole, so that the current passing from the zinc to the copper pole entered at the feet and came out at the head, the figure having its face turned to the middle of the needle, the effect of the current will be always to turn its south pole to the left hand of the figure. The electro-magnetic force thus exhibited, even when extremely feeble, may be augmented to almost any extent by the beautiful contrivance of Schweigger, called a multiplier. If one wire produced a perceptible action upon the needle, he concluded that the effect would increase with the amount of wire, and having coiled a wire upon itself fifty or an hundred times, he found the result such as he expected, provided none of the electricity escaped from one wire to those adjacent to it. To prevent this or to insulate the wires, he covered each of them with a silken thread coiled so closely as to cover their surface completely. These multipliers have been made so powerful that they required a wire three miles and a half long.

In 1820, M. Ampere was led to prefer the substitution of a compass-needle in the electric telegraph in place of the gold points and gas bubbles of Sœmmering, so that by touching a number of keys corresponding to each letter of the alphabet, the needles at the other end of the twenty-five wires were put in motion. A telegraph of this description was actually made in Edinburgh by Mr. Alexander in 1837, in which thirty wires communicated with the same number of magnetic needles, and the instrument was wrought by touching thirty keys as in the telegraph of Sœmmering. Coupling this idea with that of Schweigger to reduce the twenty-five wires to two by means of two piles, we have obviously an electric telegraph of a very high order perfectly fitted to perform telegraphic work, though still susceptible of many improvements. But even if the most perfect electric telegraph of the present day had been then invented, no person would have thought of making use of it. It is to the railway system alone that we are

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indebted in this country for all the advantages of telegraphic communication.

Our limits will not permit us, nor indeed is this the proper place, to give an account of the fine discoveries of Arago and Faraday, on the magnetic properties of electric currents. MM. Arago and Ampere magnetized needles instantaneously by placing them within a helix of insulated copper wire, so that the electric current passed in a direction perpendicular to their length. Mr. Sturgeon of Woolwich applied this principle to the construction of temporary magnets of great power by merely surrounding soft iron, either in the form of bars or of a horse shoe, with insulated coiled wire. The soft iron becomes a powerful magnet while the electric current is passing through the coil, and loses its power the moment the current is stopped. In this way Mr. Joseph Henry, now the distinguished Secretary to the Smithsonian Institution, produced magnets which were capable of lifting several tons, and the same principle has been employed by Logeman and others for communicating permanent magnetism to steel.

Mr. Faraday's beautiful discovery of electro-dynamic induction in 1832, was a most important step in the improvement of the electric telegraph. He demonstrated by two fine experiments, that an electric current is capable of developing at a distance by induction electric currents in a conducting wire. If we suddenly bring near to any part of a conductor forming a closed circuit another conductor traversed by a current, we produce instantaneously on the first conductor a current moving in a direction contrary to that of the inducing current, or that brought near the conductor, and when we reverse the inducing current we produce instantaneously in the first conductor a second current moving in the same direction as the current that is reversed. Mr. Faraday also found that a magnet is capable of inducing similar currents in a conducting wire, and that the phenomena of induction may be produced in the conducting wire itself, an effect which is termed the induction of a current upon itself. Mr. Faraday was thus led to the construction of a magneto-electric machine which was greatly improved by Pixii, Saxton, and Clarke, and extensively employed for telegraphic purposes.

Such is a brief notice of the history of the electric telegraph, and of the principal discoveries in electricity and magnetism, upon which the present telegraphic apparatus is founded. It is not our intention to give any account of the innumerable inventions, all more or less ingenious, by which telegraphic communications are generally transmitted. It is difficult for ordinary readers to understand these operations even with the aid of good diagrams,* and those who are desirous of making themselves master of the apparatus commonly employed, will do this most satisfactorily by visiting any of the stations where an electric telegraph is placed. Our object in the present article is to give some account of the general telegraphic system, and of the labors and services of those who have been the means of introducing the electric telegraph on our railways, and who have invented remarkable contrivances for communicating intelligence, such as the printing telegraph, the electro-chemical telegraph, the autographic telegraph, and any others that are distinguished from those commonly used by remarkable peculiarities.

We have already seen from the experiments of Sir W. Watson, and the fact was evident from every future experiment, that the electric power was transmitted along wires instantaneously, or in so short a time that its velocity could not be appreciated by the ordinary instruments by which time is measured. Any more accurate measure of its velocity was of no consequence for telegraphic purposes. Means, however, have been taken to obtain a rude estimate of its velocity, which of course must depend on the conducting power of the transmitting wire, though it does not upon its thickness. By a very ingenious apparatus Mr. Wheatstone found that the electric force moved along a copper wire at the rate of 288,000 miles in a second. According to the more recent experiments of MM. Fizeau and Gonelli its velocity is only 112,680, less than half of the preceding estimate. In the iron wire employed for telegraphic purposes, its velocity, according to MM. Fizeau and Gonelli, is only 62,000 miles in a second; according to Professor Mitchell of Cincinnati 28,500; and according to Professor Walker of the United States, 16,000 miles. But it is obvious, that whichsoever of these velocities is the correct one, the electric influence is transmitted in so short a time that an effect produced at one station is produced simultaneously with the effect produced at another.

In order to transmit messages along the

* The reader will find the most complete and intelligible description of telegraphic apparatus in Dr. Lardner's admirable chapter on the subject, in the third and fourth volumes of his *Museum of Science and Art.*

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telegraphic wires, a certain amount of electric power is required, and this force must be increased in proportion to the length of the wire. A large wire, however, will transmit more electricity than a small one, in proportion to the squares of their diameters, or the areas of their section. According to some accurate experiments made by M. Pouillet, a distinguished member of the Institute of France, a voltaic battery of ten pairs of plates will supply electricity sufficient for telegraphic purposes by means of a copper wire one-eighth of an inch in diameter, and 600 miles in length. A force of much less intensity, however, is amply sufficient, as it is easy to strengthen the current by batteries at intermediate stations.

Having obtained a cheap and durable line for conducting the electric influence, and a simple power for generating it of sufficient intensity, the next step is to place the lines or wires in a proper position. The general practice has been to support them by posts placed at the distance of sixty yards. On some lines the distance of the posts is much greater; and on the great telegraphic line between Turin and Genoa, the wires are carried across extensive ravines and valleys, from half a mile to three-quarters of a mile in width, without any support whatever, and at an enormous height above the ground. When the line reaches Turin it passes under ground, and when it arrives at the Maritime Alps it stretches from crest to crest, hiding itself again in the earth till it terminates at the ducal palace in Genoa.

M. Siemens, whose ingenious telegraph received a Council Medal at the Great Exhibition, and which is used on all the Prussian lines, and those in the north of Germany, recommended the subterranean system of construction, and had it carried into effect on upwards of a thousand miles of German railway. By carefully covering the copper wires, which were about the 50th of an inch in diameter, with gutta percha, to prevent the escape of the electricity, by placing them about 2½ feet deep in iron tubes, and by ingenious methods of discovering the locality of any defect either from the insulating coating or from the copper wire, he found the system answer so well, that at the end of three years the wires had not suffered the slightest change. There are obviously many advantages in the subterranean system. The wires are not influenced by rain or snow—they are secure against storms and hurricanes, and their locality in the earth, as well as upon the railway path, protects them from being injured by human hands. M. Siemens has observed two interesting facts on these lines. In the one a diminution of the effect is produced by inverse currents arising from the wires acting like a Leyden phial. The gutta percha which coats the wire is the glass of the phial, the wire is the internal coating of the phial, and the damp ground is the external coating, so that the opposite electricity of the ground acts upon, and neutralizes to a certain extent the internal electricity of the wire. It was apprehended that this disturbing cause would have interfered with the working of the subterranean wires, but the Magneto-Electric Telegraph Company, who have in work 900 miles of subterranean wire, and who often send their messages through 500 miles without any stoppage, have not experienced any inconvenience from it. The other phenomenon observed by M. Siemens is the electrical influence upon the wires by the Aurora-Borealis. During the brilliant display of this phenomenon on the 18th October, 1848, he observed currents varying in intensity and direction, in the line between Berlin and Coethen, 20 German miles in length, the direction of which was E.N.E. to W.S.W., nearly perpendicular to the magnetic meridian. During the prevalence of this meteor, the electric telegraphs in England were temporarily unfitted for use.

In the telegraphic lines established in India by Dr. O'Shaughnessy, he has adopted both the aërial and subterranean system. He found that the wires used in England were quite insufficient in India. In his experimental line of eighty miles from Calcutta, he was obliged to employ iron rods resting on bamboos. Flocks of heavy birds like the adjutant perched upon them, and groups of monkeys followed their example, while loaded elephants broke them down when they came in their way. He therefore used thick galvanized wires suspended at the height of fourteen feet upon posts upwards of 200 yards apart, and so strong was the system, that a soldier suspending himself from the middle of one of these long wires produced on it but a small curvature. In the subterranean system, where it is used in India, Dr. O'Shaughnessy lays at the depth of two feet his wires, coated with gutta percha, on wooden sleepers saturated with arsenic, in order to defend them from the white ants, which we suppose, like the rats in the north of Germany, reckon gutta percha a great luxury.

The wires employed for telegraphic pur-

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poses are commonly made of iron about the sixth part of an inch in diameter. They are coated with a plating of zinc, by what is called galvanization. As zinc is very oxydable, it is soon converted by the air and by moisture into an oxyde of zinc, which being insoluble in water, protects the wire from rust and corrosion. M. Haighton, however, has found that the gases from the smoke of large towns converts the oxide into a sulphate, which being soluble in water permits the wire to be corroded, and to such a degree that he found his wires reduced to the dimensions of a common sewing needle in less than two years. Some very peculiar conditions of the wires in America, which are not galvanized, have been discovered. On the telegraphic lines which cross the extensive prairies of the Missouri, the telegraphs refuse to act in the months of July and August during the four hottest hours of the day, from 2 to 6 o'clock!

Many inferior contrivances, which require diagrams to make intelligible, and which will be found clearly described in Dr. Lardner's volumes, have been adopted to insulate the wires in passing the posts. The wires at the posts generally pass through tubes of earthenware or of glass, or they rest upon cylinders or rollers of the same substance. In order to prevent the bending of the wires, and their mutual interference in high winds, an apparatus is placed at distances of half a mile for tightening them, and the posts where this is done, and which are larger than the usual ones, are called winding-posts.*

We have already stated that the electricity of the aurora, comparatively feeble as it is, deranges the operation of the telegraph; but the influence of atmospheric electricity in thunder-storms is of course much more injurious, and is often dangerous at telegraphic stations. The natural remedy for this is to place conductors on the top of each post, which is very easily done; but at telegraphic stations very beautiful and efficacious contrivances for their protection have been invented by Mr. Walker of the South-Eastern Company and M. Breguet of Paris. A remarkably fine copper wire is placed between the main wire and the station, so that any current of electricity imparted to the main wire must pass through the fine one before it reaches the station: but the effect of powerful electricity upon a fine wire is to fuse or deflagrate it, owing to the difficulty that it has in passing along so narrow a channel; so that all communication between the wire of the station is cut off by the destruction of the fine wire. Cases have occurred in which these wires have been made red hot, and even melted.

When the system of wires is thus erected either above or below the ground, it becomes interesting to see at what rate signals or words can be transmitted to great distances. About three years ago some interesting experiments on this point were made in Paris by M. Leverrier and Dr. Lardner before committees of the Institute and the National Assembly. In one experiment, a message of 40 words was sent 168 miles, and an answer of 35 words returned, in the space of 4 minutes and 30 seconds. In another experiment, a message of 282 words was transmitted along a continuous wire 1,082 miles long. "A pen," says Dr. Lardner, "attached to the other end, immediately began to write the message on a sheet of paper moved under it by a simple mechanism, and the entire message was written in full in presence of the Committee, each word being spelled completely and without abridgment, in *fifty-two seconds*, being at the average rate of *five words and four-tenths per second!*" This was done by Mr. Bain's electro-chemical telegraph, which the writer of this article saw in operation at the time when this experiment was made in Paris, and which, from its peculiarly ingenious construction, we shall endeavor to describe.

The sheet of paper which is to receive the written message is wetted with an acidulated solution of the ferroprussiate of potash, and placed upon a plate of metal. If we now take a metallic point or style, and place it in contact with the paper, and conceive a current of electricity to pass through the style, it would enter the copper plate through the paper and make a blue spot, so that we could easily write upon the paper, as if blue ink streamed from the point of the style. Let us now suppose that the upper end of the style is connected by a wire with the positive pole of a voltaic battery, and the metallic plate with the negative pole, a current will flow through the point of the style whenever it is brought in contact with the paper, and will decompose the prussiate of potash, one of the elements of which will mark it with a dark blue spot. If the paper is moved or drawn aside, the style will trace a blue line upon it. If the current is stopped at different intervals, the blue line will be stopped also, and we shall have short or long spaces between the blue lines, in proportion to the length of time during which the current has been stopped.

* If we place our ear close to one of these posts during a breeze, sounds like those of falling water are distinctly heard.

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Mr. Bain has contrived various ways of moving the paper beneath the style, but the one which he prefers is to lay a large circular disc of it upon a metallic plate of the same size, which is made to revolve by clock-work round its own centre and in its own plane, while the style has a slow motion from the centre to the edge of the disc. The consequence of these two movements is, that the style will describe a spiral commencing at the centre of the disc of paper, and terminating at its edge; and when the current passes through the circuit uninterruptedly, this spiral will be a continuous blue line, but if the current is interrupted, it will consist of short blue lines and white spaces of different lengths.

The next step is to construct an alphabet for this telegraph, which is done as follows:— The letter *a* is represented with one short line thus –, *b* – —— – with one long and two short lines, *c* —— – – with the same lines differently placed, *d* with four lines – – – ——, *e* with two short ones – –, *f* —— —— with two long ones, and so on, the greatest number for any letter being four lines, with short and long ones differently placed.

The message being supposed to be written out, a narrow ribbon of paper, about half an inch wide, after being unrolled from a cylinder, is made to pass between rollers under a punch, which by an ingenious mechanism punches out a hole beneath it, and through the paper when it is passing. Two or three of these holes form the short line *a* –, and several form the long lines, such as *f* —— ——. The operator is thus able to make short or long lines at pleasure, and can therefore perforate in the paper-ribbon or message-strip the message which is to be sent. In this work a number of agents may be simultaneously employed in perforating messages for the telegraph, to which they are applied in the following manner:—

The perforated message-strip is now coiled upon a roller, and placed on an axle attached to the telegraphic machinery. The extremity where the message commences is then placed on a metallic roller in connection with the positive pole of the voltaic battery, and is pressed upon the roller by a small metallic spring terminating in points like the teeth of a comb This spring communicates with the conducting wire, and when it falls into the perforation of the paper, the electric current passes to the point of the recording style, which then makes a blue line corresponding to the one in the perforated stripe, but when the spring rests upon the white paper between the perforations, the electric current does not pass, and the style makes no blue mark, but leaves a corresponding blank. In this way the message of perforation is transferred in blue lines to the chemical paper a thousand miles off, and arranged in a spiral from the centre to the circumference of the paper disc. A boy previously taught reads this record to a clerk as quickly as if it were in ordinary type.

The reader can not fail to be struck with the singular beauty and ingenuity of this contrivance, imperfect as our description of it must be. When we saw in Paris the whole operation of perforating the message, and recording it in blue lines at the other end of the wire, it seemed more like magic than any result of mechanism which we have ever seen. The dry steel point, when tracing its spiral path, actually seems to be depositing blue ink upon the paper. But it is not merely ingenuity that is the characteristic of Mr. Bain's Telegraph. In is unlimited in its quickness, and unerring in its accuracy; and it has another advantage of requiring a battery of much less power than other forms of the telegraph. An example of the value of its accuracy was recently shown in a case where the importance of a single figure was experienced. In an agitated state of the funds, a stock-broker in London received from a distance an order to purchase at a certain time of the day, £80,000 of consols. The broker doubted the accuracy of the number from the magnitude of the sum, and as the message had been sent by the *recording* instrument, it was found that the real message was to purchase only £8000 of consols, the transcriber having by mistake inserted a cipher too many.

But this telegraph has another advantage which no other possesses. It is a cipher telegraph, by which individuals may communicate with their friends, or companies with their correspondents, or governments with their distant functionaries. The short and long lines of the telegraphic alphabet may be varied in innumerable ways, which it would be impossible to decipher, and a punching machine, which would cost little, might be either in the possession of individuals, or at their command in the town or village where they reside. Any arrangement of this kind, however, is not likely to be adopted, except in a small number of cases, until the expense of telegraphic despatches is reduced to a very moderate sum. But if such a change should take place analogous to the penny-post, as Dr. Lardner has stated, Mr. Bain's telegraph

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would be the only expedient of all those hitherto contrived by which such augmented demands could be satisfied, the instruments in common use, of whatever form, being utterly inadequate to the purpose. How this would be effected by Mr. Bain's telegraph, Dr. Lardner has satisfactorily shown. "Nothing more," he says, "would be necessary than to engage a great number of persons, for the purpose of committing the despatches to the perforated ribbons. If a great number of despatches, short or long, be brought at once into the telegraphic office for transmission, let them be immediately distributed among a proportionate number of the persons engaged in the preparation of the ribbons. A long despatch might be divided into several portions, and distributed among several, just as a manuscript report, intended for publication in a journal, is distributed among several compositors. When the despatches thus distributed should be committed to the ribbons, new ribbons might be connected together, so as to form longer continuous ribbons, which being put into the telegraphic instruments, would be sent to their destination at the rate of 20,000 words an hour on each wire!"

In certain cases, such as the transmission of reports of debates, or speeches of public interest, or Government despatches, the same documents are required to be sent to different places. We have then only to take the perforated ribbons to the different wires belonging to different places; or, as Dr. Lardner suggests, two or more ribbons might be perforated simultaneously, and the message which it contains sent at the same instant to different telegraphic stations, and transmitted in various directions. "In this view of the question," says Dr. Lardner, "the system of Bain is to the common telegraph what the steam-engine is to the horse, — the power to the hand-loom,—the lace frame to the cushion,—the self-acting mule to the distaff,—or the stocking-frame to the knitting needle."

With such peculiar advantages, which we trust will soon be realized, all letters which require despatch will be sent by telegraph, and the post-office will be employed only for sending heavy orders or letters, when there is no occasion for extraordinary celerity of transmission. When the sixpenny or the penny telegraph comes into play, Mr. Bain will stand forth as the greatest of our telegraphic inventors, and Scotland will be able to boast that the telegraph was invented and perfected within her domains. Mr. Bain has hitherto, like all other great inventors, been unfortunate in not deriving from them those material benefits which their invention so amply confers upon others; but we trust that the time is not distant, when his merits will be appreciated and rewarded.

Mr. Bain's Electro-chemical Telegraph is in use upon 1,200 miles in the United States, and such is its value, as we are informed by Mr. Whitworth, in his Report on the Industrial Exhibition of New York, that in damp and rainy weather, when Morse's telegraph works imperfectly, they find it convenient to remove the wires from it, and connect them with Bain's in which "they find it practicable to operate when communication by Morse's system is interrupted."

A very ingenious and striking modification of the Electro-chemical Telegraph has been invented by Mr. Bakewell, and was rewarded with a Council Medal at the great Exhibition. It has been called the Autographic Telegraph from its conveying the message actually written in the handwriting of the person that sends it. The message is written upon a sheet of tinfoil, with a thick ink like varnish, which, when dry, is a non-conductor of electricity. This sheet is rolled round a metallic cylinder, so that the lines of the writing are parallel to its axis. A blunt steel point or style is made to move over the message in lines, parallel to the axis of the cylinder which revolves round its axis, as if the steel point were obliterating the message by a number of parallel lines. The style, like that in Bain's telegraph, is connected with the telegraphic wire, at the other end of which is a similar steel point, which draws similar lines upon a sheet of paper wetted with a solution of prussiate of potash, and rolled upon a metallic cylinder. When the style, which passes over the written message, rests upon the tinfoil, the electric current passes along the wire, and the writing style at its farther extremity makes a blue line, but whenever it passes over the non-conducting varnish, the current is stopped. and the recording style leaves a *white space* of the same breadth as the breadth of the varnished lines. In this way, when the style has passed over the whole of the message in parallel lines, the recording style will have left the message written in white letters of exactly the same form, and relieved by the blue ground produced by the blue lines drawn on the chemically prepared paper. This operation is analogous to that of the workman who is cutting letters upon boxwood for a wood-cut. In cutting out the letter O, for example, he cuts away all the wood excepting what forms the circle. In

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like manner the recording style covers over with blue lines all the surface of the paper excepting what forms the letters, thus  which may represent the letter O, as if written with white paint on a shaded ground. These electro-chemical telegraphs may, upon the principles we have described, transmit to a distance copies of profiles, or portraits, or outline drawings of any kind.

The art of photography has for a long time been employed in France for the detection and identification of thieves and other criminals. When the culprit is brought into the police office, his picture is instantaneously taken, and though he has learned to put his features on these occasions into contortions, yet the artist never fails to catch them in their natural state. Mr. Gardiner, the governor of Bristol goal, has recently introduced the same practice. His apparatus cost only £10, and the expense of working it is not above £5 per annum. The following case, which he has published, shows the great value of his plan, which he is anxious to have introduced throughout the kingdom. "J. H. came into the Bristol goal upon commitment for trial, a perfect stranger to me and my officers. He was well attired, but very illiterate. The state of his hands convinced me that he had not done any hard work, while the superiority of his appearance over his attainments led me to suspect that he was a practiced thief. I forwarded his likeness to several places, and soon received information that he had been convicted in London and Dublin. The London officer who recognized him by his portrait was subpœnaed as a witness, picked him out from among thirty or forty other prisoners, and gave evidence on his trial in October 1854, which led the Recorder to sentence him to six years' penal servitude." This admirable process may now be extended by means of the copying telegraph. We can not convey a photograph along a wire with its lights and shades, but an outline either of the whole person, or of the head, or profile, may be easily transmitted, and there can be no doubt that an outline of the culprit, even if the face is not seen at all, may often be sufficient for his identification.

The next telegraph that attracts our particular notice is the printing telegraph of Mr. J. Brett, who received a Council Medal at the Great Exhibition for this and other inventions connected with telegraphic communications which he exhibited. By this telegraph communications are sent in any language, and printed upon paper with considerable rapidity and precision. The paper and ink are self-supplied from a store which lasts for a considerable time. Plumbago or vermilion are considered preferable to printing ink, as they do not require to be so frequently replenished. Mr. Brett arranges his letters on the type wheel in the order of the frequency of their occurrence, which is as follows — *e, t, a, i, o, n, s, h, r, w, d, l, c, f, m, u, b, g, p, j, y, k, v, x, q, z.* He assures us, that messages may be printed more rapidly than a well-practiced person could write them; and that after a little experience, "a clerk might manipulate upon the finger key-board upwards of 150 letters in a minute."

The American printing telegraph of Mr. House is a very complex but ingenious and useful instrument. It has at the transmitting station a key-board with each letter of the alphabet upon a key. When the operator presses down the key with the letter A, for example, the same letter A, which is a type upon a dial or wheel at the recording station, is brought by the electric current into a certain position, and having in its passage to this position received ink from the inking apparatus, a band or ribbon of paper is pressed against it and receives an impression of the letter. The next letter of the message is brought into its position in the same way, and as the ribbon of paper is drawn forward, its impression is made next to the letter A which preceded it. The advance of the ribbon, the inking of the type, and the pressure of the paper against it, are produced by an apparatus moved by the operator, at the recording station, by the action of a treadle. Grove's battery is used as the electric power, and about thirty cylindrical pairs are required to produce the effect for a distance of 100 miles. This apparatus was first employed in 1849 upon the line between Philadelphia and New York. It is now in use on upwards of 1,858 miles of the American lines, and messages printed at the rate of from thirty to thirty-five words, or from 165 to 200 letters per minute, have been printed in common Roman character at a distance of 500 miles. The celerity of transmission must no doubt depend on the skill of the operator, for we are informed by Mr. Turnbull, that on one occasion 365 letters per minute, or upwards of six per second, were transmitted from New York to Utica, a distance of 240 miles. The average number, however, as we have stated already, is from thirty to thirty-five words per minute, or 500 letters, when, as a newspaper, abbreviations are allowed. In the

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autumn of 1850, a newspaper despatch of 7,000 words was transmitted from Syracuse to Buffalo in two hours and ten minutes, which is at the rate of fifty-four words in a minute.

The telegraphs most commonly used in this country are what have been called the Needle and the Dial Telegraphs. The first transmits messages by signals or the different positions of a magnetic needle, and the second by pointing in succession to the different letters of the messages upon a dial-plate containing the letters of the alphabet and numerals. Although the telegraphs of both these constructions perform their work well, yet it seems to be the general opinion that the dial telegraphs are more easily wrought and less subject to error. In the needle telegraphs each signal is independent of those which precede it, so that in making up the despatch the operator does not discover the error, whereas in the dial telegraph he notices any incoherence in the despatch while he is reading it, as it were, upon the instrument.

The single needle telegraph consists of a galvanometer or coil of wires for strengthening electric current, and a commutator apparatus, by turning the handle of which in different directions, the current may be either stopped or inverted in its direction. A magnetic needle is placed within the galvanometer, but on the same axis is placed another needle which may be either magnetic or not, but which, while following all the motions of the magnetic needle, indicates upon a dial plate the letters or signals which are to be transmitted, or which are received. The alphabet is placed into two halves, the first half from A to L on the left hand of the needle standing vertically, and the other half from L to Y on the right hand of it. Beneath each letter is placed the number of motions of the needle by which the letter is expressed, the needle moving to the left for the first half, and to the right for the second half of the alphabet. In like manner a row of numerals is placed beneath the lower end of the needle, those from 1 to 6 on the left hand, and from 6 to 9 and 0 on the right hand, and the number of motions of the lower half of the needle which correspond to them is placed above them. The letter M, for example, is indicated by one click and motion of the upper half of the needle to the right, and the letter A by two clicks and motions of the needle to the left.

The double needle telegraph is merely a combination of two single ones, which can be wrought by the right and left hand of the operator, each telegraph working upon a separate wire. The object of the double instrument is to make the signals more rapidly, in consequence of a much greater number of signals being obtained by combining the deflections to the right and left of both needles.

The dial telegraphs which are used in this country, as well as in France and Germany, all indicate letters and numbers upon a dial-plate like that of a clock, the operator at the transmitting station turning the hand or index to a particular letter, and the operator at the transmitting station observing the index on his dial-plate pointing to the same letter. These effects, though of the same kind, are produced by different pieces of mechanism, differing more or less in their simplicity and ingenuity. The German telegraphs, however, constructed by Siemens, differ in one respect from all the rest. The dial is placed horizontally, and is surrounded by a circular key-board, the letter engraven on each key corresponding in position to that upon the dial. When the current is sent through the wires, the hand or the index of the dial-plate at all the stations on the line moves with greater or less rapidity like the seconds hand of a clock, with uninterrupted but regular motion, and on all the dial-plates upon the line the hand reaches the same letter at the same instant. When the operator at the transmitting station places his finger upon the key of the letter A, the revolving index is stopped on that letter at all the stations, in consequence of the current being stopped. After the proper pause, he transmits the next letter, and so on till the despatch is completed. In this very ingenious telegraph, the index describes the semi-circumference of the dial in a second, that is, it gives fifteen signals in a second. In order to obtain this velocity, a pile of five couples of Daniell's battery is sufficient at each station for each apparatus; but the number of couples required does not increase in proportion to the length of the telegraphic circuit which separates the instruments. With subterranean wires, M. Siemens found that for a distance of 50 German miles, a pile of 25 couples of Daniell's battery was sufficient; but this power is used only on lines where there are no intermediate stations. When there are such stations, instead of employing a more powerful battery, we have only to introduce into the circuit the electricity of the intermediate piles when despatches are to be sent between the extreme stations. M. Siemens, however, has invented an additional apparatus for working

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the telegraph at great distances without greatly increasing the strength of the battery. He has constructed also a very ingenious apparatus for printing the despatch by the ordinary type upon a ribbon of paper; but though it was generally used in Prussia for a considerable time, it has been replaced by the more rapid printing process of Morse.

Having thus given a brief history of the different proposals that were made during the last hundred years to construct electric telegraphs by persons who did not realize their schemes, and perhaps were not fitted to realize them, and described, in a very general manner, the more interesting as well as the more common forms of this noble instrument, we shall now endeavor to give a popular and general account of the labors of those individuals who have the high merit of having introduced the electric telegraph into actual use, either for private or public purposes.

MM. Gauss and Weber of Göttingen, were decidedly the first persons who applied an electric telegraph to purposes of actual utility. So early as 1833, they had erected a telegraphic wire between the astronomical and magnetical Observatory of Göttingen, and the Physical Cabinet of the University, for the purpose of carrying intelligence from the one locality to the other; but the wire was destroyed on the 16th December, 1833, by a flash of lightning which struck it at the place where it passed the top of the Tower of St. John. They employed the phenomena of magnetic induction discovered by Mr. Faraday; and their signals were made by the different movements and oscillations of a magnetic needle observed through a telescope.*

The merit of inventing the modern telegraph and applying it on a grand scale for public use is, beyond all controversy, due to Professor Morse of the United States. So early as the year 1832, in the month of October, when on board the packet boat Sully, he described his invention to W. Pell, the captain of the packet boat, and to Mr. Rives, the Minister of the United States to the French Government. Both these gentlemen bear testimony to the fact in the most distinct manner;† and though an unsuccessful attempt has been made to rob the American professor of his just rights, by asserting that a Mr. Jackson had communicated the invention to him on board the same packet boat,* yet Mr. Jackson never prosecuted his views and turned them to public use; and even if, without any other evidence in his favor but his own, we were to admit that he did make a useful communication to his fellow-passenger, this would only make the invention more clearly an American one, and would still leave to Professor Morse the high merit of having realized the idea of another, and made it of general use to his own country and to Europe. While men high in office, and even men of science on both sides of the Atlantic, entertained doubts of the applicability and practical use of the telegraph, Professor Morse was actively engaged in pressing the importance of his invention on the attention of Congress, and "though only half convinced, by his earnestness and demonstrations, the federal legislature consented to make the experiment, and with that view appropriated a sum of money for the construction of a telegraph forty miles in length between Washington and Baltimore. This may be considered as the parent telegraph of the transatlantic world, from which a system has since sprung which, from its extent and achievements, is well calculated to fill both native and foreigner with astonishment."†

Morse and his coadjutors took up the subject of the electric telegraph, not as a mere adjunct of a railway for railway purposes chiefly, but as a great national instrument for the rapid conveyance of intelligence, entirely independent of the railway system, and which might have been established if railways had never existed. The American telegraphs have therefore the peculiar character of not always following the railway lines, but of pursuing a shorter path from point to point through a wild, broken, and uncultivated country through which no railway could be carried. Many places have, therefore, been brought into telegraphic communication with each other between which no railway exists, and the inhabitants of distant and inaccessible localities, who never can expect the luxury of railway transport, are provided with all the advantages of telegraphic communication.

Owing to the independence of the telegraph system of lines of railway, it has necessarily made a more rapid progress in America than in any other part of the world. A large number of independent Companies have been established, and new ones are con-

* See Göttingische gelehrte Anzeigen, August 9, 1834. No 128, pp. 1273, 1274, and 1834, No. 36.

† *Comptes Rendus, &c.*, tom. vii. p. 593.

* *Idem*, tom. viii. p. 345.

† Mackay's *Western World*, vol. ii. p. 252.

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stantly forming, each surpassing its predecessor in the extent and grandeur of its schemes. In all the American telegraphs the despatches are conveyed by a single conducting wire. They all write or print their despatches, the telegraph of House in actual letters, and those of Morse and Bain in a cipher,—Morse by indenting short and long lines upon a paper ribbon, and Bain, as we have seen, by writing them upon chemical paper. The following was the extent of their lines in 1853 and 1854.

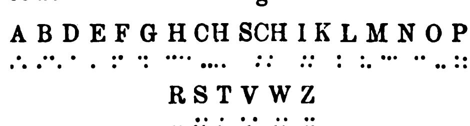
	End of 1853.	March 1854.
Morse's lines,	19,963 miles.	36,972
House's do.	2,400	3,850
Bain's do.	2,012	570
	24,375	41,392

the increase in little more than a year being 17,017 miles. The capital employed upon these lines is about a million and a half sterling.

A line of enormous magnitude, uniting the Pacific and Atlantic oceans, has been projected from Natchez in the State of Missisippi to San Francisco in California, a distance of 2,400 miles, and a Company is said to be organized to carry out this scheme with a capital of upwards of a million sterling. When this line is completed, and Newfoundland joined by a submarine or transmarine telegraph with the old world, a message may be conveyed from Europe to the Pacific in less than a day.

This great extension of telegraphic communication in America arises from the extensive use which is made of it by all classes of society as a method of transmitting and receiving intelligence. The price of a message of ten words sent ten miles is about fivepence, and for greater distances it is about 0 035 pence per mile. The messages of the government have always the precedence, those for detecting criminals come next, then death messages, then cases of sickness. Important news by the press are next sent. Commercial men use the telegraph to a great extent, some houses paying even £200 per annum. Parties converse with one another at the distance of 500 or 700 miles. Sales are effected by it—absent friends correspond with their families—medical consultations pass along the wire, and in the towns near New York, invitations to a party, inquiries about health, and even jokes, all tremble along the copper line.

As one of the earliest inventors of telegraphic apparatus, and one of the first persons who erected a real modern telegraph, we must name M. Steinhill of Munich. The Bavarian telegraph, as this may be called, is an application of the discoveries of Oersted, Faraday, and Schweigger. In a copper wire about eight English miles long, and three-fourths of a line thick, M. Steinhill produced a voltaic current by the action of a rotatory magneto electric machine, similar to that of Clarke. The conducting wire terminates at different stations in multipliers of from 400 to 600 coils of very fine and insulated wire, in the middle of each of which is a magnetic needle placed on a vertical axis terminated by two points. The deviation of this needle from its primitive position by the electric current affords the means of obtaining telegraphic signals. As visible signals, however, appeared to M. Steinhill to be imperfect, from their requiring the constant attention of the operator, he placed on the side of his two magnetic needles two bells with different sounds, and by changing the direction of the current, he could ring either of these bells at pleasure. By means of the deviation of the needle, he gave motion to two pointed tubes containing a particular kind of ink, so that at each stroke upon the bell one of the tubes pressed its point upon a ribbon of paper revolving with an uniform motion, and made a mark corresponding to the needle and bell to which it was attached. The marks of each point were, of course, formed in the same line, so that we have two lines of marks upon one ribbon of paper. By combining the sounds and marks to the extent of four, M. Steinhill has obtained a spoken and a written alphabet, comprehending all the letters which are necessary to write every word of the German language. These are exhibited in the following diagram, and if we conceive each four marks to be joined by lines, we shall see how they become more distinct as signals:



The ten numerals are distinguished in a similar manner. This telegraph was established in July, 1837, and consequently it must have been invented, and its invention known, some time before. It commenced at the observatory of M. Steinhill in the Lerchenstrass of Munich, where the conducting wire was united to a plate of copper six inches square, buried in the ground. From this the wire passed over the houses to the Academy of Sciences, where the second station was established. From this it went to the Royal Observatory at Bogenhausen, where there was a third station, and where the wire terminated in a plate of copper six inches square buried in the ground.

M. Steinhill, to use his own words, "thinks that he has invented the first telegraph in the true sense of the word, that is to say, an apparatus which speaks a language easily comprehended, and which writes what it speaks, or rather what we wish it to speak."* We concur with the inventor that this is the character of his telegraph, and we do not hesitate to express our admiration of the sagacity and ingenuity which it displays in all its parts. The fact that the earth may be used as one half of the conductor, is a discovery of vast importance, made, independently we doubt not, by him, but we owe it to Sir William Watson, who, in 1747, completed the circuit at great distances by water, and even by two miles of dry ground.† But while we give this well-merited praise to M. Steinhill, we are not prepared to admit that his was the first real telegraph of the modern type." The claims of Professor Morse can not be overlooked, either as an inventor of telegraphic apparatus, or an active introducer of his invention as a national improvement. With all its ingenuity, the Bavarian telegraph had undoubted disadvantages, and we are told "that M. Steinhill himself has abandoned it in favor of a modification of the instrument of Morse."

The first promoters of the Electric Telegraph, sanguine as they were of its ultimate triumph over the prejudices of the railway companies, who at first rejected it, and of supine governments, who were blind to its advantages, and never contributed to its extension, they yet never anticipated that its lines would span wide arms of the sea, and, by crossing even oceans themselves, would girdle the terraqueous globe. The submarine telegraph was not a corollary of the terrestrial. It was a new idea, which it required genius to suggest, and science to realize. Dr. O'Shaughnessy, so early as 1839, succeeded in laying down an insulated conducting wire, attached to a chain-cable in the River Hoogly, which carried the electric current from one bank to another. Another step was made in 1847, by M. Siemens, who first applied gutta percha to the insulation of the wires, and laid down a telegraphic line to cross the Rhine at Cologne.

These steps, however, though very important, were not be to compared with the bold and successful attempt to carry a submarine cable from Dover to Calais. In 1850, the Submarine Telegraph Company made the necessary arrangements with the French and Belgian Governments, and Messrs. Newall and Co., the celebrated wire-rope makers of Gateshead, were intrusted with the manufacture of 24 miles of a wire-cable, to stretch over a distance of 21 miles.* For this purpose, four copper wires, the sixteenth of an inch in diameter, were covered with successive coatings of gutta percha. The wires were then twisted together, and surrounded with a mass of spun yarn soaked in grease and tar, so as to form a compact rope impervious to water. In order to give strength to this combination, and protect it from external injury, ten galvanized wires are twisted round the rope, so as to form a submarine cable. This cable was completed in three weeks, but owing to an accident in laying it down, it suffered a twist or bend, which took it out of the direct line and prevented it from reaching to Saugat, south of Calais. It was necessary, therefore, to add to it another mile of cable, which being immediately done, though the task was not an easy one, the communication between Calais and Dover was completed on the 17th October 1851, and since that time, Great Britain and the Continent of Europe have, by this iron larynx, conversed with each other on every subject which can interest humanity. The expense of the cable was £9,000, and the station at Dover and Calais, £6,000. This line of telegraph belongs to the Chartered Submarine Telegraph Company.

By the private enterprise of Messrs Newall and Company, a still longer submarine cable was stretched across the Irish Channel from Holyhead to Dublin, or rather to Howth. In the deep sea portion of it, the gutta percha rope containing one copper wire, was surrounded by ten twisted iron wires, and the shore ends of the same rope surrounded by six iron wires. Transported from the works at Gateshead on twenty wagons, it was sent by railway to Maryport, where the Britannia carried it to Holyhead. On the 4th of June 1852, it was deposited in the Irish Channel, where the depth of water is 70 fathoms,

* See *Comptes Rendus*, &c. tom. vii. p. 590–93. where he has described his invention.

† *Phil. Trans.* 1747, or Priestley's *Electricity*, pp. 102–109.

* An unsuccessful attempt had been made in 1850, when the cable broke by the action of the waves rubbing it against a ridge of rocks near Calais, at Cape Gris-nez.

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nearly double that between Dover and Calais. The length of the cable is 64 miles, and the time of laying it down was 18 hours.

The next great submarine enterprise, under the direction of the Submarine Telegraph Company, was that of uniting Dover with Ostend, a distance of 70 miles. This gigantic cable, also the work of Messrs. Newall and Company, cost £33,000, and was laid down on the 4th of May. On the 6th of May it was the bearer of a friendly message from Belgium to London.

The Magnetic Telegraph Company and the British Telegraph Company, have, according to Dr. Lardner, laid down cables of the same kind from Portpatrick to Donaghadee, a species of rivalry which Parliament ought not to have permitted. The first of these Companies have established upwards of 2,000 miles (many of them under ground) of telegraphic lines, and have 13,000 miles of wire in active operation, connecting England and Scotland with the principal towns in Ireland.

A Company, entitled the European and Electric Telegraph Company, which acts in common with the two Submarine Companies, now united, was established in order to connect the cables of those Companies with the metropolis, and with Birmingham, Liverpool and Manchester.

Our limits will not permit us to give any farther details respecting these submarine establishments. The most important facts concerning all those which are yet completed, or in progress, are contained in the following table given by Dr. Lardner:—

	No of Copper Wires.	No. of Iron Wires.	Length in Miles.	Weight per Mile in Tons.
Dover and Calais, . . .	4	10	25	8
Holyhead and Howth, .	1	12	70	1
Dover and Ostend, . .	6	12	70	7
Port Patrick and Donaghadee Magnetic Telegraph Company, ...	6	12	25	7
Ditto., do. British Telegraph Company, ...	6	12	27	7
Orfordness and the Hague,	1	10	135	2
Across the Great Belt, Denmark	3	9	16	5
Across the Mississippi, .	1	8	2	2
Across the Zuyder Zee, .	6	10	5	7¼
Newfoundland and Prince Edward's Island, . .	1	9	150	1¼
Spezzia and Corsica, . .	6	12	110	8
Corsica and Sardinia, .	6	12	8	

A submarine line of much greater length than any of the preceding, and of high temporary interest, is about to be laid down by order of Government from Varna to Cape Chersonese or Balaklava. The length will be 300 miles, and Mr. Liddell, the engineer or the new Litchfield and Hitchin Railway, who has already laid down cables in the Mediterranean and other seas, has undertaken to complete it in two months. May its first message convey to Lord Raglan and General Canrobert the gratifying intelligence that they have conquered a secure and honorable peace.

We have already mentioned the contemplated line from Natchez to San Franzisco in California, which will connect the Pacific with the Atlantic, and even with St. John's in Newfoundland, which is only five days' passage from Galway, and which would then connect the Pacific with Europe. But why may we not contemplate the union of Newfoundland with Europe by a submarine cable which has been already proposed? As a work of art it is doubtless practicable, and the European powers might contribute the means of thus uniting the two hemispheres of the globe.

A new principle of telegraphic communication, if it shall prove of practical value, may render such an enterprise within the reach even of the western states of Europe. The idea of what may provisionally be called a transmarine telegraph has been recently brought forward by Mr. Lindsay of Dundee. This plan is to send the electric current through great distances of water by means of long lines of wire stretching along the opposite shores. These lines communicate with a powerful battery, and their four terminations dip into the sea, so that the electric currents flow in two different directions across the ocean. Mr. Lindsay had made experiments on a small scale in Scotland, which so far confirmed his views; but he repeated them on a larger scale last summer at Portsmouth, where he sent messages through a mile of water, though there were many ships in the interventing space, and many of them with coppered bottoms. In this experiment the length of the lateral wires was less than half a mile. We understand that a patent has been secured by a company who intend in spring to make experiments on a great scale.

Although it would be a work of supererogation to point out to our readers the various uses of the Electric Telegraph, yet there are some of them so little known, and others of so remarkable a nature, that they deserve the widest circulation. Among these uses, those of a scientific nature may claim the first place. The beautiful arrangement which we owe to Mr. Airy, the Astronomer-Royal, of transmitting to the most distant telegraphic regions the true time of Greenwich, is one of inestimable value. The diffi-

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culty of obtaining correct time for the accurate record of astronomical and atmospherical phenomena, has been experienced by all who do not possess astronomical instruments. This may, however, be completely removed; and even with ordinary house-clocks we may record our observations with a degree of accuracy sufficiently correct for those which can be made by private individuals. Mr. Airy, however, has gone much farther than this. By having the Royal Observatory at Greenwich* connected with the submarine cables at Brussels and Paris, he has been able to determine the correct latitudes and longitudes of their observatories, and the same process will doubtless be extended to every place in the telegraphic world. Geography will thus participate in the same advantages with astronomy, and the difficult and expensive operation of national surveys will be carried on with greater facility and correctness.

In meteorology, the Electric Telegraph will be found of singular utility. The frequenters of the Crystal Palace will recollect that the weather at the leading ports and cities of England was daily exhibited to them, a kind of information of great value to ship-owners, and to the Royal and merchant navy. When the telegraph announces a storm upon our shores, the sea-faring traveller may remain at home with his friends till it has expended its fury.

But the telegraph may do more than this. When these violent convulsions of the atmosphere, in the form of tornadoes and hurricanes, advance along a line of coast, as they do in America, they move much less slowly than the electric message, and therefore preparation may be made for resisting them when we can not disarm their fury. Ships about to sail, trains about to start, travellers about to drive, to ride, or to walk, may all receive a salutary warning to remain till the destructive agent has passed. If we ever shall be able to predict the phenomena of the weather, as we do those of the heavens, the simultaneous state of the atmosphere, over extensive regions of the globe, must be previously observed and generalized.

In conducting the business of Railways, especially in the central region of England, where they are almost jostling each other, the telegraph is indispensable, both for the efficiency of the system, and the security of the passengers. This can not be better shown than by the following table, given by Mr. Walker, which shows the number of messages sent along the South-Eastern Company's Railway in three months.

		Messages.
1.	Concerning ordinary trains,	1468
2.	do. Special trains,	429
3.	do. Carriages, trucks, goods, sheds, &c.,	795
4.	do. Company's servants,	607
5.	do. Engines,	150
6.	do. Miscellaneous matters,	162
7.	do. Messages forwarded to other stations	499
	Total	4110

or about 16,400 in a year, or about fifty per day! "If," says Mr. Walker, "the 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 receive more locomotive power, either sent to them or prepared at their arrival; if there is anything unusual in 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." All this information used to be obtained by pilot engines, but Mr. Walker informs us that the expense of maintaining and working a single pilot-engine, was greater than what is required for maintaining the entire staff of telegraph clerks, and the mechanics and laborers employed in cleaning and repairing the instruments, and keeping up the wires of the line. With regard to the safety of the passengers, we can not resist repeating, in the words of Elihu Burrit, the following story: "During a storm and violent gale, the long railway bridge across the Connecticut was lifted up by the wind and thrown into the river beneath, 200 yards in breadth, which an unusual flood of rain had swelled to a dreadful height. The line is here crossed by a bridge fifty feet above the river. The passengers in the train are congratulating themselves on their comfortable position, thinking of the blessed homes and the firesides which they soon expected to reach. On flew the train—the engine blowing off its head of steam, breasting its way nobly against the gale, which almost threatened to check its progress, the hot iron hissing furiously in the falling rain. No one knew that the bridge was gone. For two years, by day and night, the trains had passed and repassed, and obliterated the

* The beautiful application of electricity for recording observations, invented by Mr. Bond of the United States, has been carried into effect with great improvements, by Mr. Airy at Greenwich.

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thought of even the possibility of danger; but no bridge was there to receive them; and the long train, with its precious freight, rushed on towards the precipice of destruction. It was not customary to stop at this place excepting to check the speed for the landing of passengers; but the people there had learned through the instrumentality of the telegraph, the loss of the bridge, and kept a sharp look-out for the approaching train. It came—the word is given, and they are safe. Every heart leapt from its place, and the head swam giddily with fear, as the thought came of that fearful leap in the dark; and long will the passengers remember that dreadful road and the friendly yet fearful cry, 'THE BRIDGE IS GONE.'"*

Had not our space been exhausted, we should have drawn the attention of our readers to the great advantages which must accrue to individuals as well as to society at large from the introduction of telegraphic communication, and should have attempted to indicate some of those great social ameliorations which are yet to be derived from the reduction of its tariffs, and the universal application for its aid. We look forward with faith to a time not very distant, when every village in the empire shall express its wants and receive its intelligence in telegraphic despatches, and when dumb and intellectual life shall no longer sink under burdens which can be borne by so many pounds of coal and so many buckets of water.

Omitting, therefore, all that the telegraph has done for the interests of trade, commerce, humanity, and justice, and all that it might be expected to do even for other interests, we shall content ourselves with noticing the advantages which have accrued to the State from the general extension of the telegraphic system. Kings were once said to have long hands, but now they have long tongues and loud voices. Their will can, in a few minutes, reach the extremities of the empire, and all the powers of administrative government can be instantaneously summoned into action to revive patriotism or to repress crime. The approach of a hostile fleet would now be rung in the ears of the Admiralty before the hulls of the ships had surmounted the convexity of the globe; and the Horse Guards would be roused at midnight before an invading army could quit the beach on which it had disembarked.

* See the *Guide to the Electric Telegraph*, p. 39, by Charles Maybury Archer; and his *Anecdotes of the Electric Telegraph*.

The telegraph of planks and spars which formerly puzzled the provincial visitor of the Metropolis, and which had gloriously announced the achievements of the Peninsular war, was erected and maintained at the expense of the nation; but not a single wire of the million which, like a web of gossamer, cover the map of England, has been erected either with its funds or under its patronage. When the Messrs. Bretts Brothers, the original projectors of our Submarine Telegraphs, offered for £20,000 to lay down their wires across the Irish Channel, and to give the free use of them to the State, this boon to Ireland and blessing to England, was peremptorily refused by the Government.

Baffled in this purely British undertaking, these enterprising engineers addressed their next scheme of crossing the English Channel to the French and Belgian Governments. An exclusive privilege was instantly conceded, and the British Government concurred, on the condition of giving nothing, but of taking the use of the submarine cable. The idiosyncrasy of a Chancellor of the Exchequer, whose feelings and intelligence is tied up in his money-bags, may be some excuse for the meanness of the Government of which he is the organ, but no apology can be offered for the heads of successive administrations—the dispensers of cheap rewards—of laurels which they gather for their underlings, and plait for themselves. That the services of Mr. Cooke and Mr. Ricardo, to whom England unquestionably owes the introduction of the Electric Telegraph, and all its blessings, should never have been recognized by any mark of public gratitude, or Royal favor, is one of the facts in the history of England which may speedily excite a more general sympathy.

The nation now sees, and, we fear, will see more of the false consequences of this utter discouragement of theoretical and practical science. The horrors of the Crimean war—the tears of the noblest and gentlest of our families—the blood of the bravest of the brave, all cry out for wisdom in our councils, and for science in our fleets and in our camps. It is science which teaches the gigantic shell to discharge its fatal contents, —which speeds the rocket on its incendiary errand, and which guides the rifle ball to the seat of life. It is science which constructs and impels our floating bulwarks,—which places its lanterns beside the Scillas and Charybdises of the deep,—and which teaches us to predict and evade the hurricane and the storm. Law, Divinity, and Medicine,

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professions justly rewarded and honored by the State, can neither equip armies nor reduce strongholds, nor supply the soldier with the instruments and materials of his art. It is the science of matter and of motion alone, which can create and perfect all the appliances of offensive and defensive war. It is in this department of science that our Enemy, and our Ally, have so signally and so painfully surpassed us; and if England shall ever be compelled again to send her brave legions to a distant battle-field, or even to secure her Island hearths against foreign invasion, she must enlist in her service, and dignify with her honors, the theoretical and practical science of the philosopher and the engineer.*

From the Leisure Hour.

JANE DE MONTFORT.

If it be true that great events call forth correspondent abilities, it is no less a reality, that to certain characters decided adversity presents the congenial, in fact the vital atmosphere, denied by ordinary circumstances. Opposition is like a magnet to human nature —it attracts all the iron and force of our will; but it is only in occasional instances that a temperament is encountered which prefers the storms of fate to a serene sky, and can behold one hope after another shattered and abandoned, yet rise superior to the wreck, resolutely looking onward, to plot and scheme again.

Jane of Flanders (to quote the words of Froissart) possessed "the courage of a man, and the heart of a lion." One of the most beautiful women of her time, the indomitable energy and courage of her physical endowment were second only to the rare qualifications of her mind. A skilful diplomatist, no covert policy could take her by surprise: eloquent, the inherent womanly gift of enthusiasm added additional weight to her words,—results of solid and discriminating thought. "She was above her sex," says Père Morice, (a Benedictine monk and celebrated Breton chronicler,) "and yielded to no one in courage or military virtues: no adversity could crush her."

Comparatively unknown previously, but scanty information subsists respecting Jane's life up to the time of her husband's (the Count de Montfort's) imprisonment and threatened execution. This prince, who had, upon the demise of John, Duke of Bretagne, taken possession of the duchy, by prompt and skilful strategy, fell into the hands of his opponent, Charles de Blois, through treachery. He was conducted a prisoner to Paris, and shut up in the tower of the Louvre. Thus incarcerated, no obstacle remained to the claims of his rival, who had engaged the sympathies of Philip, King of France, while those of Edward of England had been given on terms of mutual accommodation, to the Count de Montfort.

But at the moment when all was given up for lost, to the surprise of her own party and the consternation of the adverse one, the countess, recently become a mother, roused herself from the grief into which the captivity of her lord had thrown her, and eagerly undertook the task of supplying to the troops the general they had lost.

Bearing her babe in her arms, she presented herself before the assembled inhabitants of Rennes, and in an address, the terms of which history has but scantily left, permitting us to judge of it only by the electric effect it produced, she set forth the claims of the illustrious child, whose father at that moment might have ceased to breathe, and enlisted the hearts of her hearers in the

* We must again recommend to the reader Dr. Lardner's admirable account of the Electric Telegraph, which occupies a large portion of the third and fourth volumes of his Museum of Science and of Art. It is at once popular and scientific, and such as might be expected from a philosopher of his high attainments and extensive information.

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