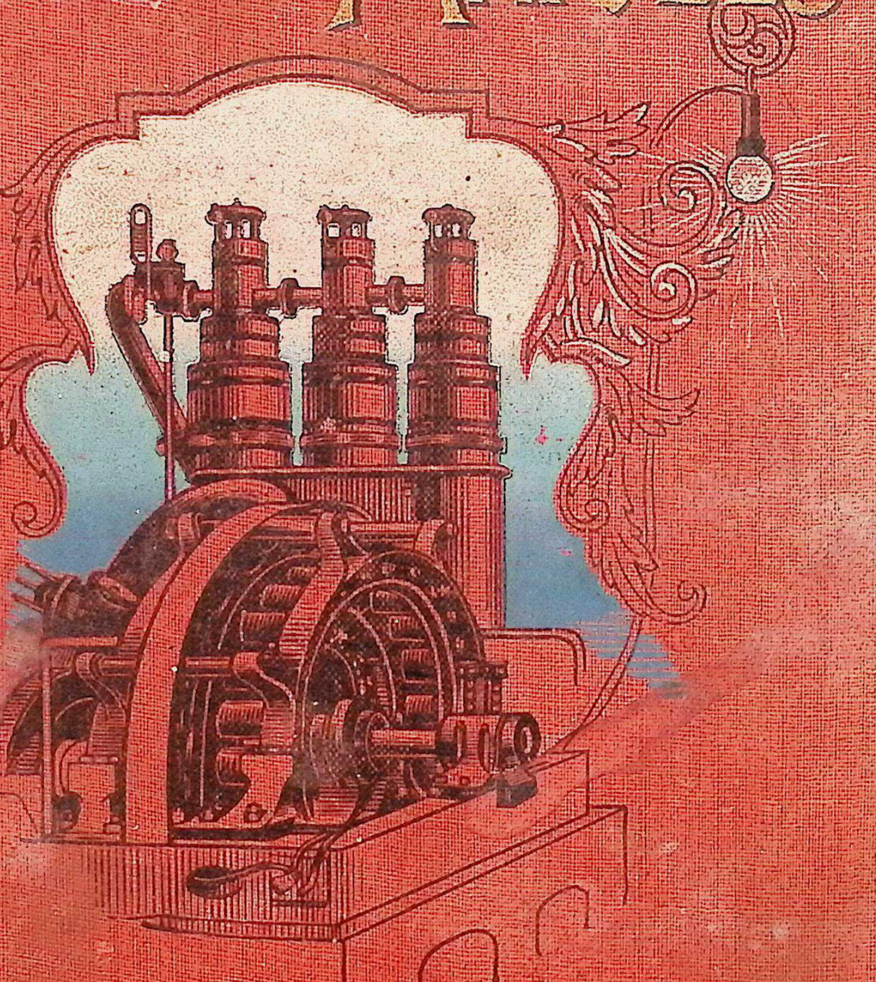
ELECTRICIANS AND THEIR MARVELS



WALTER JERROLD

date approx. 1895
see pp. 86/87.

From photo by] THOMAS ALVA EDISON. [*Falk, New York.*

ELECTRICIANS AND THEIR MARVELS

BY

WALTER JERROLD

AUTHOR OF "MICHAEL FARADAY, MAN OF SCIENCE;" "W. E. GLADSTONE, ENGLAND'S GREAT COMMONER;" "OLIVER WENDELL HOLMES," ETC., ETC.

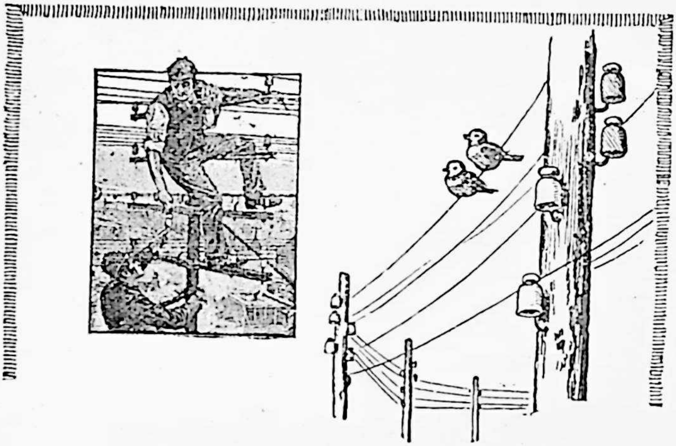
"Electricity leaves her thunder in the sky, and like Mercury dismissed from Olympus acts as letter carrier and message boy."

SECOND EDITION

LONDON

S. W. PARTRIDGE & CO.

8 & 9 PATERNOSTER ROW



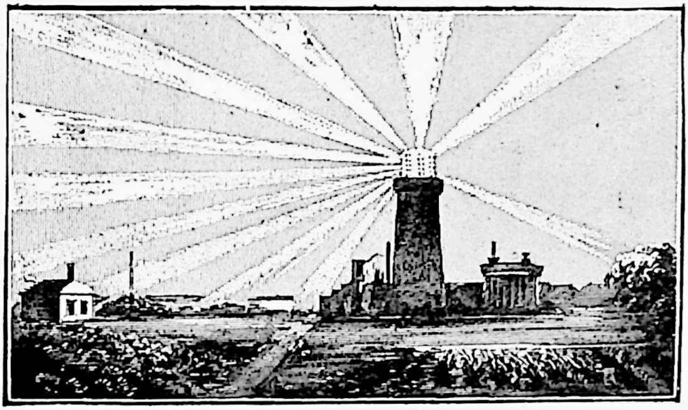
CONTENTS.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.



PREFACE.

OF electricians and their marvels at this latter end of the nineteenth century, we certainly have no lack. Some of the most distinguished of electrical inventors are yet, happily, living. Thomas Alva Edison, Elisha Gray, Graham Bell, Silvanus P. Thompson, to name but a few, and those at random, are still among us; while the electricians of the past, from Gilbert of Colchester to John Tyndall—investigators as well as inventors—form a long line of distinguished men, all of them more or less intimately connected with the subject-matter of this little book. Franklin, Davy and Faraday, Wheatstone, Cooke and Morse, Galvani, Volta and Miniotto, Schilling, Siemens and Leclanché,—these are but a few of the names that at once occur to the mind when we come to think of the men who have investigated all the wonders of electrical phenomena, and made many of them serve our everyday uses. In glancing at the list, however short, of the illustrious names connected with the science of electricity, it immediately becomes patent to us how much truth there is in the remark which has been made that "the inventor has no nationality." The real value of the work done by a large number of electricians, among those named above as well as among those omitted, can only be properly known to and appreciated by specialists.

The international unity in the sphere of invention and science is well shown in the terms which are used all over the world to express the standard of electrical measurement, and which were adopted at an international conference of electricians held in Paris in 1881. Ohm, farad, ampere, and coulomb are all of them words coined from the names of celebrated electricians.

Within the limits of this small volume it is, of course, only possible to treat specially of a few of the men more markedly identified with particular inventions, and only to deal with some of the more striking and widely significant of the "marvels" which these men have made, or are making, part of our daily lives. To describe the invention and growth of any one of these marvels at all fully would take more space than is here devoted to the whole, and it has, therefore, appeared best to describe the inception, perfecting and popularisation of the various inventions dealt with, rather than attempt any explanation of *how* they work. To do that belongs more particularly to the province of the technical hand-book. Here we are concerned more with the inventor and the development of his invention in public use, than with the scientific theory which may underlie its discovery and working.

We shall see in the course of the following pages that many of the most striking "marvels" which electrical science has given to us were more or less definitely foreshadowed in a curious way by earlier writers—certainly it has been the case with the telegraph, the telephone, the electric light, electric cars and boats, and many more. Sometimes, it is true, these things were referred to, but in a very vague fashion, or as belonging to some Utopia, New Atlantis, or other ideal state: in such a way some of these things were very plainly spoken of by Roger Bacon and Francis Bacon. In the *New Atlantis* of the latter author many of the electricians' "marvels" of to-day are very curiously foretold. Sometimes the "marvels" were more definitely referred to, as though with some inkling of the scientific facts, by such writers as Strada, Galileo, and others; and sometimes they are spoken of poetically, as in Shakespeare's line so wonderfully applicable to the electric telegraph—

> "I'll put you a girdle round about the earth
> In forty minutes."

With the investigators of electrical phenomena, as apart from the inventors who have practically applied the result of those investigations, we are here but little concerned. The life-story of one of the very greatest of those scientists has already been told by the present writer in a small volume similar to the present one.[1] Here, as typical of the electrical student, we have a short notice of the life of the late Professor Tyndall. Other scientists, such as Sir Charles Wheatstone, with whom we are concerned, have also been celebrated in connection with the practical application of electricity to the concerns of daily life.

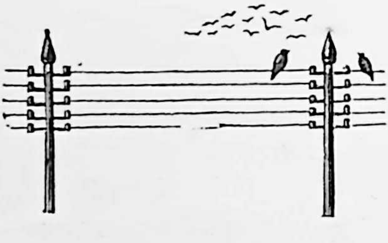
[1] *Michael Faraday, Man of Science.*

It may be interesting to note here that within a few years there will be celebrated the tercentenary of the publication of the first book on the subject of electricity. *De Magnete*, by William Gilbert of Colchester, "the founder of electrical science," as he has been called, was published in 1600. Since Gilbert pursued his primitive experiments electrical science has extended its dominion on every hand. Yet those early systematic researches are not by any means to be despised because we have travelled far since they were made. A few years ago "The Gilbert Club" was formed in London—with many of the most distinguished of contemporary men of science on its roll of membership—for the purpose of arranging a fitting celebration of the important anniversary. It is proposed, among other things, to issue an English edition of Gilbert's work, as nearly as possible in the style of the original folio of three hundred years ago.

So many are the marvels with which electricians have made us familiar, that the exclamation of a poet —presumably American—does not seem so *very* extravagant when he asks—

> "Oh, Science ! give us one more link—
> Teach us to hear our neighbours think."

WALTER JERROLD.



ELECTRICIANS AND THEIR MARVELS.

—o—

CHAPTER I.

INTRODUCTORY—EARLY ELECTRICAL KNOWLEDGE —TYNDALL.

> "There are more things in Heaven and earth, Horatio,
> Than are dreamt of in your philosophy."
>
> —SHAKESPEARE.

FOR over two thousand years the world has been aware of a certain mysterious force, existing or capable of being generated, in widely different objects. But, although its earliest record shows that what is to-day known as electricity was known so very long ago, yet the wonderful development of its application as a servant of mankind commenced well within the recollection of "the oldest inhabitant." The knowledge that amber when rubbed became electrical, that a strange power was in the torpedo fish and other animals, was possessed by Thales of Miletus, 600 B.C. Theophrastus mentions it three hundred years later, and Pliny refers to it during the first century of our era. Indeed, there is even an early record of the practical application of electricity, where we learn that a certain freedman of Tiberius, named Anthero, was cured of the gout by a shock from a torpedo fish.

Probably some acute observer also became aware of the fact that the human body itself was capable of manifesting electricity, although this must have appeared so remarkable that, as remarkable facts will, it got considerably exaggerated. An ancient writer, Eustathius, records that Wolimer, King of the Goths (415 A.D.), was reputed to be able to emit sparks from his own body, and then goes on to state that a certain philosopher while dressing and undressing emitted occasionally crackling sparks, while at other times flames blazed from him without in any way burning his clothes.

In the sixteenth century, Dr Gilbert of Colchester pursued a number of investigations, and performed many experiments, which entitle him to the name of the "father of modern electricity." More than half a century after Gilbert's death, Robert Boyle wrote his *Experiments on the Origin of Electricity*, and at about the same time a German student, Otto von Guericke, was pursuing a similar line of investigation. During the eighteenth century several attempts were made to prove the practical value of electricity, but only with slight success. These attempts, chiefly of a telegraphic kind, will be referred to in a subsequent chapter. In this little book, however, as has been already suggested, we are mainly concerned with electricians and their marvels as at work all around us at present,—with those wonders which are in daily operation, bringing us messages in a few moments from all quarters of the globe, or permitting us to speak directly to the ear of a friend two or three hundred miles away. Davy, Faraday, Tyndall, Joule, Thomson, and a number of other scientists have, by years of patient investigation, acquired the knowledge which famous inventors have applied. Here we are concerned more with the practical inventors than with the theoretical, though no less worthy, no less remarkable, scientists. We shall have to speak of Sir Charles Wheatstone, of Sir William Cooke, of Edison, Morse, and Bell, of the methods by which they have succeeded in giving to the world the telegraph, the telephone, the electric light, and a number of other marvellous things entirely undreamt of in the philosophy of our grandparents.

No sooner has the world become accustomed to one remarkable novelty, than another is announced. It has not long been found that we can send messages by the electric current deflecting a needle at a distance, than it is discovered that the electric current will convey the message in our own voices; no sooner is the possibility of electric lighting an accomplished fact, than it is shown that the same mysterious agent may be employed to convey trains. It seems, indeed, to be very true that, as some one has put it, "the further the radius of investigation is extended, the greater appears the circumference of the unknown beyond."

It is often asked, What is this electricity of which we have all learned to speak so glibly? To answer that question definitely in the present state of our knowledge is impossible. We are getting to know year by year more of what this mysterious agent is doing and can be made to do, but we are apparently far from really knowing what electricity itself is. For convenience, and as an approximate correctness, it is often called "the electric fluid," and this reminds us of a picture which appeared in *Punch* some years ago, when the possibilities of electric lighting were beginning to be realised. Charles Keene, who was the artist, showed the driver of an omnibus asking a box-seat passenger, "What is this 'lectric fluid, sir?

Is it anything like beer, for instance?" Hearing it associated with the name of Edison, he apparently imagined it to be a new kind of American drink.

Each year's investigation serves but to bring the various sciences more and more together as a closely connected whole—light and heat, electricity and magnetism, even matter and motion, are all merged into one all-embracing theory of molecular physics, such as that put forward by Sir William Thomson in his "vortex theory," according to which the whole of every part of space is filled with a fluid called ether. Recent investigations by Mr Tesla, a young Montenegrin, naturalised in America, serve to show the vast importance of this vortex theory; and before referring to the endless vistas opened up by those investigations, it may be as well to more clearly realise what is signified by Thomson's vortex theory. For this purpose we will avail ourselves of an admirable summing-up of it given in one of the reviews some time ago by Mr J. E. H. Gordon.

"The historic experiments of Faraday," says Mr Gordon, "interpreted by the mathematical researches of Clerk Maxwell, have demonstrated almost beyond doubt that the same ether whose waves carry light and heat from the sun and stars to the earth, also carries the waves of electric and magnetic induction which, as the daily experiments at Kew Observatory show, follow each outburst of solar activity. Sir William Thomson holds that all that which we know as matter consists of vortices or whirlpools of this ether, which, from their rapid rotating motion, resist displacement, and therefore show the common properties of hardness and strength in the same way as a spinning top or gyroscope tends to keep its axis in a fixed direction. But whether the molecules or particles of what we know as matter are independent matter, or whether they are ether whirlpools, we know that they keep up an incessant hammering one on another, and thus on everything in space."

The reason why these great forces around us do not crush us, are indeed unfelt by us, is because they are exerted equally in all directions. Mr Tesla holds out hopes, however, that we may yet learn how to direct these forces,—a possibility which, if realised, would revolutionise our lives as much as the use of steam and electricity has already done during the past century. As Mr Tesla put it during his remarkable lectures at the Royal Institution, "we shall then hook our machinery on to the machinery of Nature,"—thus very literally fulfilling the forecast of Roger Bacon—"Let the pure and simple elements do thy labour; bind the eternal elements and yoke them to the same plough."

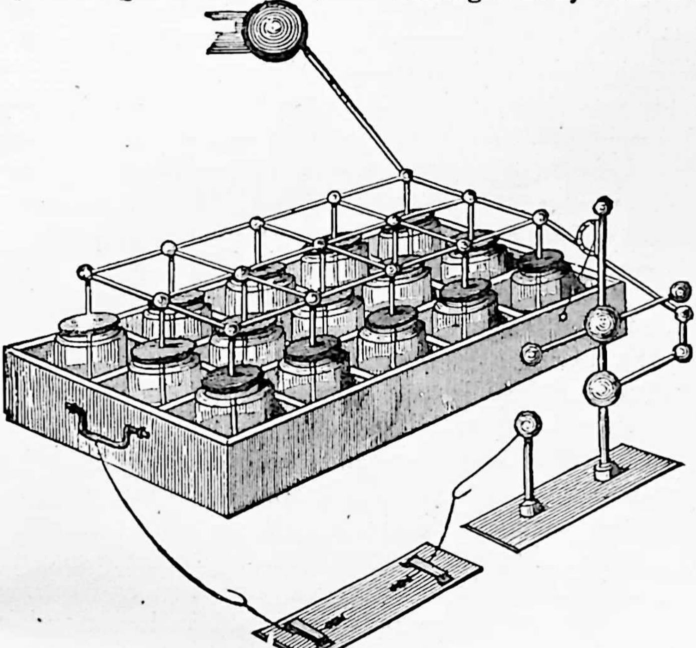
Among the most remarkable facts demonstrated by this brilliant young investigator, one of the most startling was that although an ordinary electric current of 2,000 volts is sufficient at once to kill a man, a current of 50,000 volts does no harm whatever—it is not even felt. In illustrating his lecture Mr Tesla stood, says an eye-witness, "in the midst of an electric storm, receiving unharmed in his hands flashes of veritable lightning, and waving above his head a tube through which the very life-blood of creation pulsed, in waves of purple fire."

It is worthy of recalling, too, that on the same table as that on which Mr Tesla's experiments were shown in February 1892, "there swung in the year 1834 a delicately balanced galvanometer needle under the influence of the first induction current produced by the genius of Faraday. The force availing to move it was very small, ... yet that force has now developed one of the greatest industries of the world. It lights millions of lamps in London and elsewhere; in America it drives cars on thousands of miles of railways, and will soon distribute the power of Niagara Falls to the inhabitants of neighbouring states."

Mr Tesla's experiments certainly open up wonderful possibilities to the imaginative mind. But the world is now becoming so accustomed to the "wonders of science" that the wildest imaginings of M. Jules Verne appear often to be coming well within the sphere of practical working. We have, indeed, feasted so long on the marvellous that it is now almost impossible that we should be startled by any suggested discovery or project. Here, however, we are concerned more with the realised marvels of the electricians than the possibilities opened up to us by recent research.

People have given up the incredulity which but little more than half a century ago could make a member of the English Government declare "that telegraphs of any kind were wholly unnecessary, and that no other than the one then in use (the semaphore) would be adopted." The incredulity which inspired that reply was then, we may feel sure, pretty general; now, however, it has given place, as by a natural rebound, to a credulity which will accept anything that is offered in the name of electrical or any other science.

One or two very important discoveries—important in the use made of them by later investigators—were made during the eighteenth century. One of these, fraught with wonderful and far-reaching consequences, was the discovery of the Leyden jar by Muschenbroek in 1745. This experimentalist had been much struck by the escape of electricity into the air,—an escape which he imagined to be due to the vapours and effluvia suspended in the air drawing off the electric fluid. He sought, therefore, some method of imprisoning the electricity—of storing it away from the

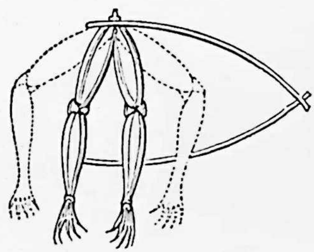


Leyden-Jar Battery.

air. He selected a glass bottle full of water as the most likely thing to retain the subtle and mysterious agent. Once, when he was charging the water by a wire leading to a very powerful electrical machine, and was holding the bottle with his right hand, Muschenbroek went to remove the wire with his left hand, when he received a shock, the unexpectedness of which probably made him imagine it much more severe than in reality it was. Describing his experience to Résmur, he said that he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow and the terror. "For the whole kingdom of France," he is reported to have added, "I would not take a second shock."

The Leyden jar, which is one of the most convenient of accumulators, is simply a glass jar—something like a jam-jar—coated with tin-foil to a certain height both inside and out. The top of the jar is stopped with cork or wood to prevent dirt or moisture reaching the uncovered glass within. Through this stopper there is a wire, in metallic connection with the tin-foil inside, the wire ending outside in a metal knob, from which the electricity is drawn off. A number of these jars are connected with one another to form a battery.

There are two other men who flourished during the latter half of the eighteenth century whose discoveries gave a wonderful impetus to the investigation of electrical phenomena, and therefore to its practical application to the uses of everyday life, and whose names are now commonly employed in innumerable words in general use. These men were both Italians, Luigi Galvani and Alessandro Voltà. Galvani had studied medicine and become Professor of Anatomy at Bologna, when, it is reported, an accident made him discover animal electricity, or galvanism as it has been called, from his name. Galvani's wife was in a very weak state of health, and had been ordered a soup made from frogs. By a chance some of these animals, ready prepared for cooking, were lying on the laboratory table near an electrical machine. During the experiments which were being carried on, one of the assistants accidentally brought the point of a scalpel near the crural nerves of a frog lying near the conductor. Immediately it was noticed that the limbs were agitated with strong convulsions. Galvani at once entered upon a series of experiments to investigate the curious law of nature which had thus been stumbled upon; and made public our earliest knowledge on this "new principle in nature," just over a hundred years ago, in a treatise presented to the Institute of Sciences in Bologna. Volta further investigated the subject opened up by Galvani but his name now chiefly lives for us as that of the discoverer of how to generate a current of electricity by means of the voltaic pile,—a column formed by a number of pairs of plates or disks of two dissimilar metals, as zinc or copper, alternating in regular order of succession with some porous matter which is kept moist. Volta demonstrated many experimental results which could be obtained with this pile, and showed that all the effects produced were the same as those obtained from electrical machines, and thus that "galvanism" and "electricity" were one and the same thing. He lived for many years after making his important discovery—dying, upwards of eighty years of age, in 1827—yet he did nothing else of first importance in electrical science, although he lived to see wonderful progress made, by means of his discovery,


Galvani's Experiments.

by Sir Humphrey Davy, Faraday, and other investigators.

Before we come to glance at the lives and works of such practical electricians as have given us the telegraph, the telephone, and a number of other marvels, it is fitting that we should say something of the illustrious scientist who died some months ago, the great explainer of electrical and other phenomena, who succeeded Michael Faraday as Professor at the Royal Institution, and who, in his capacity as investigator and experimentalist, helped to make possible the results given us by inventors. JOHN TYNDALL—for it is of him we would speak—has been described as "a masterly expounder of the results of science, an unrivalled experimentalist, and an unsurpassed controversialist." Certainly, in his capacity as popular lecturer upon science, he seemed to have succeeded to the mantle of his great friend and master, Faraday, for with him also the more ignorant or youthful his audience might be, the more particular he was to present his facts in a clear, comprehensible, and perfectly truthful manner.

John Tyndall, "the Apostle of Physical Science," was born in 1820 at Leighlin Bridge, forty-six miles south-west of Dublin. His father, heir to a small estate, was disinherited owing to a family quarrel, and the future scientist was born, therefore, in most humble circumstances. The elder Tyndall had early joined the Irish Constabulary, and was regarded by all who knew him as a man of exceptional ability and integrity. He was a zealous Orangeman, and was said to preserve, as one of his most precious relics, a bit of one of the flags that fluttered at the momentous Battle of the Boyne. Remembering his origin and bringing-up, one writer has said of Tyndall, "in such a man Protestantism was no mere hereditary faith. It was evolved from his own inner consciousness, and was part of his intellectual being." The scientist himself was wont to say of his origin that he could trace it back to that illustrious Englishman who first translated the Bible. To use Tyndall's own words, "I am distantly connected with one William Tyndall, who was rash enough to boast, and to make good his boast, that he would place an open Bible within reach of every ploughboy in England. His first reward was exile, and then a subterranean cell in the castle of Vilvorden. It was a cold cell, and he humbly, but vainly, prayed for his coat to cover him and his books to occupy him. In due time he was taken from the cell and set upright against a post. Round neck and post was placed a chain, which being cunningly twisted, the life was squeezed out of him. A bonfire was made of his body afterwards."

Luckily for young Tyndall, his father from the very first fostered his taste for reading and talking of what he read. He early evinced a taste for natural science, and showed his powers of reasoning in the manner in which he distinguished himself at mathematics. His father still more increased these tastes by the glowing account which he gave him of Sir Isaac Newton and his wonderful studies. Tyndall was at first desirous of becoming a civil-engineer, but when he was nineteen an opportunity occurred for him to obtain employment on a division of the Ordnance Survey established in his native town. He became a "civil assistant" to the Survey, his mathematical knowledge, and readiness in adapting it, making him peculiarly well fitted for such work.

He remained on the Ordnance Survey for a period of five years. In 1841, when stationed at Cork, he was engaged at mapping, along with a much older man, who took an interest in him and his work, and inquired how he occupied his leisure time, and who finished the conversation by saying, "You have five hours a day at your disposal, and this time ought to be devoted to study. Had I, when I was your age, had a friend to advise me, as I now advise you, instead of being in my present subordinate position, I should be the equal of the Director of the Survey." On the following morning young Tyndall was at his books by five o'clock, and the studious habits then commenced he continued to pursue for many years afterwards.

In 1844 Tyndall left the Ordnance Survey, and referring back to that period he has said that his salary was then a little under one pound a week; "I have often wondered since," he added, "at the amount of genuine happiness which a young fellow of regular habits, not caring for either pipe or mug, may extract even from pay like that." For a short while after leaving the Survey he contemplated emigrating to America, when he was offered a position by a firm in Manchester. He accepted it, and for the three following years was engaged in engineering operations in connection with the laying of railways. During this period all his leisure was devoted to the study of science. In the year that he left the Manchester firm of engineers, 1847, Tyndall accepted an appointment as teacher in Queenswood College, Hampshire,—an institution newly started, partly as a school for junior boys and partly as a preliminary technical school for the education of agriculturists and engineers. At Queenswood the new teacher fell in with a kindred spirit in Dr Frankland, who was acting as resident chemist to the college. At Queenswood, too, he first had opportunities of carrying out such original experiments as were later destined to place him in the very front rank of explorers and translators of the wonderful secrets of science.

Tyndall and Frankland together left Queenswood in 1848, that they might further pursue their studies in Germany. They went to the University of Marburg, in Hesse Cassel, where they continued to work under the eminent chemist, Robert Wilhelm Bunsen. Later, Tyndall prosecuted his researches in the laboratory of Magnus at Berlin, where he was especially engaged in investigating the phenomena of magnetism and diamagnetism. In his delightful little volume on "Faraday as a Discoverer" Professor Tyndall has spoken of his own aims and objects in going abroad:—"Drawn by the fame of Bunsen as a teacher, in the year 1848 I became a student in the University of Marburg, in Hesse Cassel. Bunsen behaved to me as a brother as well as a teacher, and it was also my happiness to make the acquaintance and gain the friendship of Professor Knoblauch, so highly distinguished by his researches on Radiant Heat. Plücker's and Faraday's investigations filled all minds at the time, and towards the end of 1849 Professor Knoblauch and myself commenced a joint investigation of the entire question. Long discipline was necessary to give us due mastery over it . . . . At length, however, it was our fortune to meet with various crystals whose deportment could not be brought under the laws of magne-crystallic action enunciated by Plücker . . . In December 1851, after I had quitted Germany, Dr Bence Jones went to the Prussian capital to see the celebrated experiments of Du Bois Reymond; and influenced, I suppose, by what he heard, he afterwards invited me to give a Friday evening discourse at the Royal Institution. I consented, not without fear and trembling; for the Royal Institution was to me a kind of dragon's den, where tact and strength would be necessary to save me from destruction. On February 11, 1853, the discourse was given, and it ended happily. I allude to these things that I may mention that, though my aim and object in that lecture was to subvert the notions both of Faraday and Plücker, and to establish, in opposition to their views, what I regarded as the truth, it was very far from producing in Faraday either enmity or anger. At the conclusion of the lecture he quitted his accustomed seat, crossed the theatre to the corner into which I had shrunk, shook me by the hand, and brought me back to the table."

Tyndall first made the acquaintance of Michael Faraday in 1850, and the acquaintance soon ripened into a firm and lifelong friendship on the part of Faraday, and of admiring discipleship on the part of the younger man. In 1853, the same year in which he had given his first "Friday evening lecture," Tyndall was elected Professor of Physics in the Royal Institution, and succeeded Faraday as superintendent.

In 1849 Tyndall made his first trip to Switzerland, a country that thenceforward exercised over him a peculiar fascination, such as it does over a great number of visitors. Six years later he revisited it with his friend Professor Huxley, that they might investigate the action and rate of progression of those great glaciers which to the ordinary tourist are nothing but wonders to be looked upon and left, but which tell many facts to the patient investigator as to their formation and influence. For many years Tyndall regularly summered in Switzerland, where indeed he had built for him a châlet near the beautiful village of Zermatt.

Always hard at work as a painstaking and thorough investigator, Tyndall became one of the very first of the scientists of the day. His lectures and books on electricity, on sound, light, and heat, have all tended to give him his place in the front rank. In 1872, when he visited the United States, so great was his popularity that for thirty-five lectures he received as much as twenty-three thousand dollars. He did not, however, choose to profit by the journey, and so, after deducting all expenses of the tour, he had the residue invested, that its proceeds might go to the founding of scientific scholarships in Harvard and Columbia Colleges and in the University of Pennsylvania. The scholarships are specifically "in aid of students who devote themselves to original research."

In 1876 Tyndall married the eldest daughter of Lord Claud Hamilton, and about ten years later retired to Hind Head, Haslemere, in Surrey, where he had built himself a house. There he spent the last six or seven years of an honourable and useful career in well earned retirement, only leaving it during the summer months, when he went to his little Swiss châlet. When he died, early in 1894, English electrical science lost one of her most notable sons, one of her most brilliant expounders.

CHAPTER II.

THE ELECTRIC TELEGRAPH—HUMOURS OF THE WIRE.

"I'll put a girdle round about the earth
In forty minutes."

—SHAKESPEARE.

WHEN Puck first spoke those words to an Elizabethan audience, three hundred years ago, not one of the people who listened to them could have imagined that they were anything but the expression of a poet's exuberant fancy, put into the mouth of a flighty and irresponsible being. They were, however, curiously prophetic. Shakespeare himself wrote "better than he knew" when he penned the lines; for in about two and a half centuries the girdle was put round about the earth in considerably less time than the wildest imaginings of tricksy Puck allowed him to suggest.

Although to-day, when we speak of "the telegraph," we always mean the electric telegraph, it must be borne in mind that while the latter is but the child of the nineteenth century, the former is of much more ancient origin. The word is made up of two Greek words signifying "I write afar off," and different methods of writing afar off were in vogue in very early times. In the tragedy of *Agamemnon*, written by the great Greek poet Æschylus, we find that the news of the taking of Troy was conveyed by land signals from Mount Ida to the island of Lemnos, thence to Mount Athos, and by various other land stations over the gulfs and promontories of Greece to a hill above Argos, and so on into the very palace of Clytemnestra. But, to come to more modern times, we find that in the middle of the fifteenth century the Scottish Parliament directed that for the guidance of those who looked after the beacon fires, "one bale or fagot shall be the warning of the approach of the English in any manner; two bales, that they are coming indeed; and four bales blazing beside each other, that the enemy are in great force." And then, again, what English boy but remembers how the news of the arrival of the Spanish Armada was telegraphed throughout the length and breadth of England? Who does not recall Macaulay's stirring lines in which he describes the "writing afar off" which commenced immediately after the historical game of bowls had been disturbed at Plymouth?—

For swift to east and swift to west the ghastly war-flame spread,
High on St. Michael's Mount it shone; it shone on Beachy Head.
Far on the deep the Spaniard saw, along each southern shire,
Cape beyond cape, in endless range those twinkling points of fire.
The sentinel on Whitehall gate looked forth into the night,
And saw o'erhanging Richmond Hill the streak of blood-red light.
And eastward straight from wild Blackheath the warlike errand went,
And roused in many an ancient hall the gallant squires of Kent.
Southward from Surrey's pleasant hills flew those bright couriers forth;
High on bleak Hampstead's swarthy moor they started for the north;
And on, and on, without a pause, untired they bounded still,
All night from tower to tower they sprang, they sprang from hill to hill.

This certainly was telegraphing, though of course the messages that could be sent thus could be but very little varied, as we saw in the order of the Scottish Parliament above. Another method of telegraphing which was long employed, and which a member of the British Government thought but half a century ago was too good to be superseded by the electric telegraph, was that of the semaphore, or boards moved about in pre-arranged manner to signify different letters of the alphabet. For instance, such telegraphing stations were placed on elevations all the way from Whitehall to Plymouth.

Although these primitive methods of telegraphing or signalling continued to be practised up to so recently, yet it is curious to find that there were many hints and suggestions as to the coming of the electric telegraph. More than two centuries ago, for example, a certain philosopher named Glanville, in a work addressed to members of the Royal Society, treating of things which were then but rumours, but which might become practical realities, said, "to confer at a distance of the Indies by sympathetic conveyances may be as usual to future times as to us is literary correspondence." In that sentence we certainly get a curious faint foreshadowing of the electric telegraph. Rather before Mr. Glanville made his communication to the members of the Royal Society, Strada, in Rome, had spoken of the possibility of one friend communicating with another at a distance by means of a loadstone so influencing a needle on a dial containing the letters of the alphabet as to make it point to the letters intended to form the communication. And yet again, in 1632, the celebrated astronomer, Galileo, referred to a secret art by which, through the sympathy of magnetic needles, it would be possible to converse at a great distance. A little later a German philosopher, referring to the magnetic telegraph, called it a "pretty invention," but doubted if a magnet of sufficient power could be had to make it really serviceable.

Addison, in one of those charming *Spectator* essays which are to-day, it is to be feared, more talked about than read, writes in a playful manner of the sympathetic needles of which Strada had spoken. He describes how two lovers by this subtle telegraphy could communicate with one another though divided by a continent, and he then continues, "if ever this invention should be revived or put in practice, I would propose that upon the lover's dial-plate there should be written, not only the four and twenty letters, but several entire words which have always a place in passionate epistles. This would very much abridge the lover's pains in this way of writing a letter, as it would enable him to express the most useful and significant words with a single touch of the needle." The genial essayist could conceive apparently of no other possible future for the telegraph than as a method of conveying lovers' secret vows. Less than two centuries have elapsed since he wrote, yet the present position of the electric telegraph would, we may imagine, considerably astonish the Right Honourable Joseph Addison. Several steps forward were made along the path towards the consummated electric telegraph during the eighteenth century, although over a third of the nineteenth was destined to pass away before its real practicability was to be finally established.

A pensioner of the Charterhouse, Stephen Gray by name, made one important step forward—only a few years after Addison's death. Connecting a glass tube to a wire about seven hundred feet long and rubbing the tube, he found the wire become so electrified as to attract light bodies at the other end. To the same man also belongs the small but significant discovery that a metal loop must not be used to support the wire, as by its means the electricity escaped. Twenty years later another experimentalist, Sir William Watson, succeeded in passing an electric current through about 9,000 feet of earth and water across the Thames, and also through 10,000 feet of wire suspended upon poles at Shooters Hill. At about the same time that Sir William Watson was experimenting near London, the great American, Benjamin Franklin, was pursuing his memorable investigations at the other side of the Atlantic Ocean, and Du Lac was performing similar electrical experiments on the Lake of Geneva.

It was in 1753 that the first account of any really practical kind of electric telegraphy was published in any detail, and, strangely enough, by an anonymous writer. In that year there appeared in the *Scots Magazine* a remarkable article on "an expeditious method of conveying intelligence" from one place to another by means of electrical power. This article, which was merely signed with the initials "C. M.," is supposed to have been the work of a Renfrew surgeon, born at Greenock, by name Charles Morrison. "C. M.'s" letter is undoubtedly one of the most interesting pieces of writing to be met with in connection with the early history of the electric telegraph, and as such may very fittingly find a place here, where we are taking a cursory survey of that history.

"It is well known," begins this celebrated anonymity, "to all who are conversant in electrical experiments, that the electric 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 numbers to the letters of the alphabet, be extended horizontally between two given places parallel to one another, and each of them about an inch distant from that next to it. At every twenty yards' end let them be fixed in glass or jeweller's 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 wires, and about one inch below them. Also let the wires be fixed in a solid piece of glass at six inches from the end, and let that part of them which reaches from the glass to the machine have sufficient spring and stiffness to recover its situation after having been 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 continued that each of them may reassume its proper place when dropped. 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 these 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 my pen in my turn, I write down whatever my friend at the other end strikes out. If anybody 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*, etc. Then let him who begins the discourse bring the wires in contact with the barrel as before; and the electric spark, breaking on bells of different size, will inform his 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 may be otherwise effected. Let the balls be suspended over the characters as before; but instead of bringing the horizontal wires in contact with the barrel, let a second set reach from the electrified cable, 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 set at liberty. This may be done by the help of a small spring and slider, or twenty other methods, which the least ingenuity will soon 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, and that has never exceeded some thirty or forty yards, it may be reasonably 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."

A few years later, and Monsieur Lomond had put in actual practice the "expeditious method" of which "C. M." wrote, though the Frenchman had apparently arrived at the result from his own investigation. Arthur Young, in his travels in France during 1787, 1788, 1789, describes a visit to M. Lomond, whom he speaks of as "a very ingenious and inventive mechanic." "In electricity he has made a remarkable discovery: you write two or three words on a paper; he takes it with him into a room, and turns a machine, inclosed in a cylindrical case, at the top of which is an electrometer, a small fine pith ball; a wire connects with a similar cylinder and electrometer in a distant apartment; and his wife, by remarking the corresponding motions of the ball, writes down the words they indicate; from which it appears that he has formed an alphabet of motions. As the length of the wire makes no difference in the effect, a correspondence might be carried on at any distance; within and without a besieged town for instance; or, for a purpose much more worthy, and a thousand times more harmless, between two lovers prohibited or prevented from any better connection. Whatever the use may be, the invention is beautiful." Shrewd and observant as was this delightful traveller, he could not realise the general public significance of the invention which he saw at work in M. Lomond's house.

Step by step, we thus see, inventors were advancing towards the wonderful mastery of electricity manifested by the general establishment of the electric telegraph. In 1794, but seven years after Arthur Young had visited M. Lomond, another Frenchman, M. Betancourt, succeeded in working a "pith ball telegraph" for thirty miles, from Madrid to Aranjuez.

When we reach the nineteenth century, but few further stages bring us to the work of Sir Charles Wheatstone and those who are associated with him in the introduction of the telegraph as an instrument of universal usefulness. In 1816 a Mr Ronalds worked a telegraph which he had erected at Hammersmith, through eight miles of *single wire.* A few years later he described a complete system of telegraphy, and went so far as to venture to hope that he would live to see the day when the King (George IV.) at Brighton should be able to communicate by telegraph with his ministers in London. His wish was far more than gratified, for he lived to the great age of ninety-one, and, shortly before his death, was knighted in recognition of his work on the electric telegraph.

The first line of telegraph regularly used was one fixed up at Göttingen University by two of the Professors, Gauss and Weber, who, though a mile apart, succeeded in regularly communicating intelligible signals to one another, by the sending of magneto-electric currents. The needle which they employed was so weighty that they realised that much improvement of the apparatus was necessary before it could be made generally practicable. Being themselves too much engaged, they invited Professor Steinheil of Munich to construct an improved electric telegraph. The Göttingen line was destroyed by lightning.

The year 1837, which saw the accession to the throne of Queen Victoria, is always looked upon as the year of the birth of the electric telegraph. It was then that Messrs Cooke and Wheatstone first demonstrated the practical utility of the new method of communication which they had gone so far to perfect. Of these men and their lives we shall have something to say in the next chapter; here we are more particularly concerned in the result of their labours, as manifested in the line of telegraph wire, a mile and a half in length, which they were permitted to place along the North-Western Railway, from Euston to Camden Town Station. The railway company had accorded permission to the inventors to erect their line; and when it was finished, and on the 25th of July the first message was to be sent over it, there must have been some very anxious moments to the projectors, to whom it meant so much. Yet, much as they knew it meant to them, it really meant vastly more to the world at large; for from that small beginning has grown the gigantic network of telegraph wires and cables that now stretches over all habitable parts of the globe.

Charles Wheatstone alone occupied the operator's office at Euston, while Cooke, at the other end of the wire, was accompanied by Messrs Charles Fox and Stephenson. The experiment was distinctly successful, and raised considerable interest among scientific men. General interest was, however, not yet evoked in the electric telegraph, for "the public treated it with indifference; the directors of the railway soon gave it notice to quit, and one of them even denounced it as 'a new fangled thing.'" In the June of this year Messrs Cooke and Wheatstone had taken out the first of their joint patents, the two inventors having been brought together by an introduction from Professor Faraday, who had himself done so much by electrical experimental research to make such wonders as the electric telegraph practicable. Under their joint agreement, Wheatstone and Cooke continued to bring forward a number of improvements towards the perfection of the telegraph.

It was in 1838 that Steinheil made the very important discovery that a single wire, if connection with the earth be made at both ends, would serve as well as two, the earth in reality acting as a return wire and conveying the current back to its original source. This was certainly a great step forward from the many wires employed by "C. M." The most important step of all was, however, due to

Faraday, whose discovery of volta-electric induction and magneto-electricity made easier the paths of inventors,—made, indeed, practically possible the realising of the telegraphic dreams of men who for long years had been striving to attain the same end with frictional electricity.

Although, perhaps, a little disheartened by finding the result of their labours curtly dismissed as "a new-fangled thing"—even by a railway director—Wheatstone and his colleague were by no means discouraged from further attempts to render popular what they had already proved to be not only possible but really practicable. The Great Western Railway Company granted them permission to place a line alongside the railway from Paddington to West Drayton, a distance of thirteen miles. This was completed in July 1839, and from the very first it worked satisfactorily, though it was found advisable to re-fix the line along poles instead of placing it in an underground tube, as was at first done. In the latter position it was thought that the wires were too much influenced by wet. For two months the reliability of the line was tested by communicating to Paddington the time at which each train passed through West Drayton.

In 1840 Wheatstone had ready two further improvements, in the shape of his system of dial telegraph and also a printing telegraph. In the same year, too, he claimed that, as the result of experiments, as many as thirty signals could be conveniently made in a minute. The telegraph was rapidly becoming an acknowledged power in the land, and at this time, it is much to be regretted, Cooke and Wheatstone, who together had done so much patient work, began to disagree as to the proportionate share of honour due to them. With these jealousies we have here nothing to do beyond merely recording that they existed. In 1843 an agreement was drawn up by which the various patents were assigned to Cooke, with the reservation of a certain mileage charge to Wheatstone.

That the electric telegraph in England was by this time beginning to attract popular attention, if not as a serious addition to the resources of civilisation, at least as a remarkable novelty, is evidenced by the advertisements which appeared in contemporary papers. For example, one announcement, drawing attention to the new telegraph as one of the greatest wonders of the time, stated that, "under the special patronage of Her Majesty and H.R.H. Prince Albert, the public are respectfully informed that this interesting and extraordinary apparatus, by which upwards of fifty signals can be transmitted 280,000 miles in one minute, may be seen in operation daily (Sundays excepted) from 9 A.M. till 8 P.M. at the telegraph office, Paddington, and telegraph cottage, Slough. Admission, 1*s*."

An early series of messages which passed over the telegraph wires of the Great Western Railway excited considerable interest at the time, and perhaps more than a qualm in the mind of many a thief, who must have felt moved to exclaim, with the Moor of Venice,—

"Othello's occupation's gone."

First, the following notice was issued: Eton Montem, August 28th, 1844.—The Commissioners of Police have issued orders that several officers of the detective force shall be stationed at Paddington to watch the movements of suspicious persons going by the down train, and give notice by the electric telegraph to the Slough station of the number of such suspected persons and dress, their names if known, also the carriages in which they are.

These were the telegrams which were sent between Paddington and Slough during that morning only just half a century ago :—

Paddington, 10.20 *a.m.*—Mail train just started. It contains three thieves, named Sparrow, Burrell, and Spurgeon, in the first compartment of the fourth first-class carriage.

Slough, 10.48 *a.m.*—Mail train arrived. The officers have cautioned the three thieves.

Paddington, 10.50 *a.m.*—Special train just left. It contained two thieves: one named Oliver Martin, who is dressed in black, crape on his hat; the other named Fiddler Dick, in black trousers and light blouse. Both in the third compartment of the first second-class carriage.

Slough, 11.16 *a.m.*—Special train arrived. Officers have taken the two thieves into custody, a lady having lost her bag, containing a purse with two sovereigns and some silver in it; one of the sovereigns was sworn to by the lady as having been her property. It was found in Fiddler Dick's watch-fob.

Slough, 11.51 *a.m.* — Several of the suspected persons who came by the various down trains are lurking about Slough, uttering bitter invectives against the telegraph. Not one of those cautioned has ventured to proceed to the Montem.

Well might the thieves mutter "bitter invectives" against this latest born of Science, which had come to interfere with their little plans to a very considerable extent. Well might they grieve to find that the new telegraph—

> "Horsed upon
> The sightless couriers of the air,
> Should blow the horrid deed in every eye."

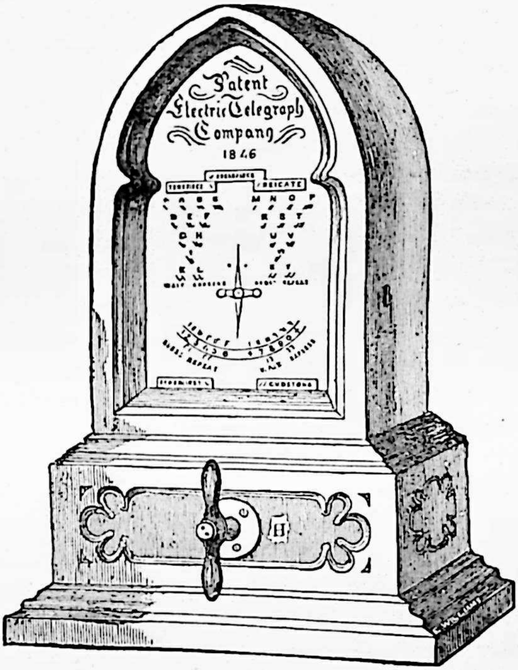
A later report of what took place at Slough said that when the train arrived, a policeman opening the door of the carriage named in the telegram asked if any passenger had missed anything. Search was at once made by the surprised passengers, and one lady among them exclaimed that her purse was gone.

"Then you are wanted, Fiddler Dick," said the constable to the thunderstruck thief, to whom the discovery must have appeared supernatural. Fiddler Dick at once surrendered himself, and delivered up the stolen money.

Incidents such as these must have soon served to show the practical value of the telegraph other than as a medium for the sending of lovers' letters, which, as we have seen, Addison and Arthur Young seemed to consider its most probable sphere of usefulness.

In 1845 Messrs Wheatstone and Cooke sold their patents in the telegraph to the Electric Telegraph Company for £140,000, which was a sufficient proof, if proof were wanted, of the great commercial value of the new institution.

The first long line which was completed in England was between London and Portsmouth, and an amusing incident marked its inauguration. A party had gathered in the London office anxious to witness instant communication with the distant seaport. The signal was given, and every eye was instantly fixed upon the needle. It did not move—there was no reply; again, with the same result. Yet a third time the signal was flashed over the line to Portsmouth, and this time it called forth a response, for the operator, translating the signals, read off to those present, "Fast asleep by the fire." Over the same wire a game of chess was played in May 1845



Cooke and Wheatstone's Single Needle Telegraph.

between Staunton at Vauxhall and Captain Kennedy at Gosport; it lasted from half-past eleven in the morning until seven in the evening.

How much of a luxury the telegraph was for some time after its introduction is made manifest to us by glancing at the scale of charges made by one of the companies, for it must be remembered that it was long before the telegraph system of the country became national property. In 1846 the South-Eastern Railway Company charged three half-pence per mile for a message of twenty words, the minimum charge, however, being five shillings. The cost of sending a short message to Ramsgate from London was twelve shillings and sixpence.

One example of telegraphic speed in 1845 created considerable astonishment and amusement. To use the words of a periodical published at the time, "By the use of the telegraph has been accomplished the apparent paradox of sending a message in the year 1845 and receiving it in 1844: thus, directly after the clock had struck twelve on the night of December 31st, the superintendent at Paddington signalled to his brother at Slough that he wished him a happy new year. An answer was immediately returned suggesting that the wish was premature, as the new year had not yet arrived at Slough!"

Despite the half-hearted support of some persons and the scoffing of others, the enthusiasm of the projectors of the electric telegraph was far more than justified, for, as we have already seen, in little less than eight years after their first attempt to demonstrate the practical value of the invention, the inventors sold it for a very large sum of money. It was spreading its influence year by year, so that a prophetic remark made by Lord Palmerston in 1848 was quite justified, although looked upon at the time as a mere piece of pleasantry. He said that the day would come when a minister, if asked in Parliament whether war had broken out in India, would reply "Wait a minute; I'll just telegraph to the

Governor-General, and let you know." Seeing that it then took from two to three months to get a reply from Calcutta, we can understand why the remark was looked upon as a pleasantry which was never likely to come true. Come true it did, however, and that in a very short time.

Nowadays, when our early morning newspaper contains telegraphic information of events which have happened in all parts of the world only a few hours before, we are apt to forget the wonderful enterprise to which we owe that news. In 1849, M. Reuter opened a small office for sending news at Aix-la-Chapelle. The news was sent by telegraph wherever it had become possible, but there was then no electric telegraph to Brussels, so that messages had to be conveyed there by means of pigeons. Two years later Reuter transferred his headquarters to London, and devoted his attention to inducing the English press to depend upon him for a regular supply of the foreign news, which they then obtained at a great cost. His business grew, however, but slowly at first, until in 1858, to show what could be done, he distributed particulars of all the news he received to all the various newspapers free of cost. From this time the value of the system was made manifest, and all the leading papers subscribed. To-day it seems difficult to realise what our morning paper would be like without the telegrams from Reuter's agents in all parts of the world. The great success of this agency has, of course, led to the formation of others, but Reuter's remains by far the most important. One of the first manifestations of the great value of the agency was when in February 1859 the French Emperor made his famous speech threatening

Austria through her ambassador. The speech was delivered at one o'clock in the afternoon, was directly transmitted to London through Reuter's agency, and published in the third edition of the *Times* by two o'clock.

In 1850 the charge for a telegram of twenty words was ten shillings for any distance; yet only five years later than that, a writer dared to speak of the time "when the sixpenny or penny telegraph comes into play." We have now long enjoyed the sixpenny telegram: can it be that the rest of that forecast is to come true, and that one day we shall be able to send a telegram for the price that we now send a letter?

In June 1858 Faraday delivered an interesting lecture at the Royal Institution on "Wheatstone's Electric Telegraph in relation to Science (being an argument in favour of the full recognition of science as a branch of education"). In this the lecturer did ample justice to the wonderful work of the younger electrician. In the quarter of a century that has since elapsed wonderful strides have been made, not only in science generally, but in the improvement of the electric telegraph. We have advanced from duplex to quadruplex telegraphy; that is to say, from the sending of *two* messages simultaneously over one wire, to the sending of *four*: from a speed of a comparatively few words a minute up to thousands. So far back as 1869 Edison thought he might get up to a speed of telegraphing one thousand words a minute, whereas he actually got up to three thousand. When Mr Gladstone explained in the House of Commons his plan for giving self-government to Ireland, the Wheatstone automatic transmitter transmitted from London *one and a half million* words during the one night. A rapid speaker could utter the same number of words in one week if he never stopped.

Before dismissing the subject of the electric telegraph, and before recounting one or two of the "humours of the wire," there are some practical particulars which may not be out of place. And first, with regard to overhead and underground wires. We saw in the account of one of the earliest lines that it was laid in leaden pipes underground, but was not very successful until it was rearranged on poles. It is still found that for working purposes the overhead wires are the better, and they also cost less. They are, however, liable to such damage in severe storms as to cripple the whole system. Climatic conditions, on the other hand, hardly affect underground wires as laid at present. In cities and towns, too, many accidents have been found to result from the snapping of overhead wires, and similar mishaps. Despite these drawbacks, in many places overhead wires are still retained. In London they are giving way to underground wires to such an extent that, of about three thousand wires led into the Central Telegraph Office, they are almost without exception underground.

In 1887 a grand banquet was held in London to celebrate the Jubilee of the electric telegraph, at which, although none of the men who made telegraphy possible were there, all the leading English electricians and telegraphists were present. A number of speeches were made, in which it was pointed out how great was the advance which half a century had seen. In 1837 Cooke and Wheatstone's first five-needle instrument required five wires and was capable of transmitting five words per minute. In 1887, over the same number of wires, 2500 words could be sent in the same time! Commenting on this jubilee celebration a scientific paper of the time said, "The success of the telegraph in this country is due essentially to the superposition of scientific method on to the rude rules of practice. The rule of thumb principles of the early engineers were in operation in telegraphy; for the exact laws of Ohm, Ampere, and Coulomb, the experimental skill of Faraday, Joule, and Grove, the mathematical genius of Helmholtz, Thomson, and Maxwell, have kept our electricians in the straight path, and prevented them from wandering in the wilds of guesswork, and in the labyrinth of tentative troubles. It is impossible to say how much this influence has been reflective. The science of electricity has been indebted as much to practice, as practice has been indebted to science."

The State took over the control of the telegraph in Great Britain in 1870, and it is interesting to find by a recent Treasury return what is the financial result of the public working of the system. In 1893 the total receipts of the Post Office Telegraph Service amounted to £2,526,312, while the total expenditure was £2,692,994. The total balance of expenditure over receipts since the transfer of the telegraph service to the State up to the end of 1893 is £509,706.

Innumerable "good stories" are told not only of the misunderstanding which many persons had in the early days of the electric telegraph as to what it was, and how it worked, but also of the results of carelessness in the sending of telegrams on the part sometimes of the writer and sometimes of the operator. A few of these stories may fittingly close our chapter on that which Sir David Brewster has called "the most precious gift which science has given to civilisation."

The vague—or at least incorrect—notions which existed as to the telegraph are well exemplified in the Lincolnshire labourer who walked three miles that he might *see the man run along the wires* with the letter bags! Little, if any, less vague were the ideas of the old countrywoman who, when a telegram was brought to her from her son asking for money, looked at it, and then answered knowingly that she wasn't going to be swindled in that way, for *that*—pointing a scornful finger at the telegram —wasn't her son's writing.

An American went into one of the first telegraph offices in the States and gave in a telegram to be sent off to a friend. He was noticed to hang about the office for some time, and was at length asked by the operator what he was waiting for. He replied promptly that he was waiting to see his message sent; and when told that it had already been gone some time, he retorted, indignantly, "Not a bit of it. Didn't I see you stick it on that file."

One would have thought that by the time of the Franco-Prussian war more or less clear notions of the telegraph would have penetrated into pretty well every village and hamlet in Europe, but that it had not entirely done so was shown at Carlsruhe towards the end of the war. An aged peasant woman came into the telegraph office there carrying a dish full of sauerkraut which she wished sent to her son at Rostadt. When laughed at, and told that it could not be sent, she expostulated, and said that they were deceiving her, "else how could so many men have been sent to France by telegraph?"

A similar case to that of the American just mentioned was when a man entered a country telegraph office to send a telegram. The operator was about to commence, when the signal to "wait a minute" came from the other end. When the man was told this, he said he didn't believe it, for he had not heard them speak.

We come now from mistaken notions as to what the electric telegraph is, and how it performs its work, to ludicrous errors in messages themselves. Sometimes these are the result of careless writing on the part of the sender of the message, sometimes of a misplaced dot or dash on the part of the operator. These mistakes speak for themselves; so that we will just select a few from many that have been noted, putting in brackets after the mis-read word the one which had been really intended:—

"Meet me at the Peabody Statue, Royal Exchange, *Piccadilly* (precisely) at two."

"Mary *is ill* (will) be at home in the evening."

"Just received a *balloon* (salmon) from London."

"Your aunt *came direct* (Kate) died at twenty minutes past eleven. Will write particulars."

"Warmest *congratulations* (sympathy) to Ellen and yourself in your sad loss."

"Send us *twenty* (two) waiters."

"Ask Lady Grantly if *you* (Cox) can read aloud."

"Your sister has consented to an engagement with father's *apostle* (approval)."

"All going well a little *fire* (girl) at seven o'clock this morning."

"Don't *call* (fail) this evening Lord Dash is coming."

"Cannot go to theatre to-night Baby no *more* (worse)."

"*Yes* (biscuits)."

"Your *banker* (bacon) has been forwarded."

"Personal character *undesirable* (indispensable)."

"Sorry I cannot come *to-morrow* (Tom) will meet Mr B. as arranged."

"Send *on* (no) more corkscrews until I advise you."

"Please *destroy* (despatch) pamphlets forthwith."

"Your mother is *dead* (better)."

"Peters *here* (father) dead."

On one occasion it is related that quite a series of errors occurred as follows :—In an invitation to dinner *Sunday* was altered in the telegram to an invitation for *Monday*. The recipient on telegraphing to know if *Sunday* or *Monday* was really meant, had his telegram altered to *Saturday* or *Monday*, while the final answer of *Sunday* was telegraphed as *Tuesday*!

The following, in conclusion, will show how very simple an error in transmitting the Morse alphabet will cause a considerable difference in meaning :—

	b	a	d	
Bad =	— · · ·	· —	— · ·	

	d	e	a	d
Dead =	— · ·	·	· —	— · ·

CHAPTER III.

WHEATSTONE—COOKE—MORSE.

"Th' invention all admir'd, and each, how he
To be th' inventor missed; so easy it seem'd,
Once found, which yet unfound most would have thought
Impossible." —MILTON.

THE names of Sir Charles Wheatstone and Sir William F. Cooke in England, and Samuel Morse in America, are those most closely connected with the history of the electric telegraph. It is to them that the world owes the vast system which makes it possible for one person to communicate in a few moments with another in any part of the civilised world. By their ingenuity and perseverance time and space have, in a measure, been annihilated. For although, as we saw in the preceding chapter, the possibility of electric telegraphy had been demonstrated before, it was these three men who reduced the possibility to an everyday actuality. It may be interesting, then, to show in a short chapter who these three men were, and how it was that they came to devote their energies to the perfecting of the telegraph.

CHARLES WHEATSTONE was born at Gloucester in February 1802. His father was a music-seller in that town, and later a flute-player in the metropolis. The boy was educated at a private school in Gloucester, where he gave evidence of an early aptitude for the study of mathematics and physics, thus showing the natural bent of his mind. A natural bent cannot, however, be followed from the first except by very unusually circumstanced individuals, and young Wheatstone, on his father's removal to London, had to cast about for some method of earning his living

Sir Charles Wheatstone.

and the field in which it offered itself was that of the making of musical instruments. This work, though the lad probably did not at first see it in that light, was really helping him forward on the path which he would have chosen. Of a practical and ingenious character, he soon found himself not merely going on making the musical instruments, which it was his business to do, but also thinking for himself and studying the theory of sound. In the prosecution of his regular work he managed to carry out various experiments, and displayed his practical ingenuity in the application of the scientific principles he discovered to the construction of philosophical toys, and the improvement of musical instruments. An early invention of Wheatstone's, which he called "the enchanted lyre," may perhaps be more properly referred to in a later chapter, when we come to deal with the telephone. Thenceforward all the time that he could possibly devote to it was given up to scientific investigation, although he still found time to apply himself closely to the improvement and invention of musical instruments; among other things he invented the concertina.

In 1833, with the reading of a paper "On Acoustic Figures," he may be said to have really finally started on his scientific career. The following year he made an important discovery in demonstrating that the velocity of electricity is greater than that of light. The paper announcing this was read before the Royal Society, and attracted considerable attention among other scientists. During the same year he was elected Professor of Experimental Physics in King's College, London, and two years later was made a member of the Royal Society. King's College, as we shall see, was intimately connected with Wheatstone's work on the electric telegraph. Indeed, during the lectures given in this the first year of his Professorship, he proved, by sending a current of electricity through four miles of copper wire, that communication by the electric telegraph was practicable. In this connection it may be interesting to recall a piece of reminiscence which George Cruikshank wrote when Wheatstone's share in the discovery of the electric telegraph was called in question. "The discovery of the telegraph," wrote the artist, "arose from the circumstance that when first appointed lecturer at King's College, he had seven miles of wire in the lower part of the building which abuts upon the river Thames for the purpose of measuring the speed of lightning or the electric current. Upon one occasion, when explaining his experiments to me, he said, 'I intend one day to lay part of this wire across the bed of the Thames, and to carry it up to the Shot Tower on the other side, and so make signals.' This was, I believe, the first idea or suggestion of a submarine telegraph."

Although it is very certain that Wheatstone was not the original discoverer of the practicability of sending signals by means of electricity—in other words, of telegraphing by this means—as we have already seen in the preceding chapter, yet to him primarily belongs the credit of having made it workable. It is, of course, absolutely impossible to estimate the relative value of Wheatstone's and Cooke's efforts, owing to the unfortunate disputes which arose between them after some years of their partnership. It may, however, be here recalled that Wheatstone was in the habit of talking so freely about his own inventions with any one who showed any real interest, that on one occasion he had to pay ten guineas for a piece of apparatus to an "inventor" who had derived the idea from Wheatstone himself. With this dispute it is not in our province to deal, and their direct work on the telegraph we have already discussed; here we are concerned with the men themselves.

Wheatstone, in demonstrating the velocity of the electric current by means of ingenious experiments, showed it to be as much as 288,000 miles a second, or nearly double the velocity of light. The apparatus by means of which he made this manifest, he used later to show the duration of an electric spark. This duration he proved to be about $\frac{1}{25,000}$ of a second, or so brief that, to use an illustration, a cannon-ball illuminated by a flash of lightning would appear to be stationary, or the wings of an insect moving ten thousand times in a second would seem to be at rest.

The name of this great scientist, too, is well known in connection with the early history of Spectrum Analysis. In 1835 he read a paper at the meeting of the British Association, held that year in Dublin, on "The Prismatic Analysis of Electric Light." He found, among other things, that a single electrical discharge passed through a gold wire at once dissipated the metal into vapour. It was during the course of this same paper, too, that he suggested a most important line of investigation, which has since been taken up by many men with remarkable results, in the spectra of metals. "Within this fact," says one writer, "a new mode of distinguishing bodies from each other lay folded like the tree within the seed, awaiting evolution."

In 1838, in reading a paper before the Royal Society, Wheatstone described the then unknown stereoscope, the title to inventor of which he shares with Sir David Brewster. In 1839 Wheatstone and Faraday were jointly consulted by a committee of the Admiralty as to the value of lightning-conductors upon ships. The following year, besides telegraphic inventions, Wheatstone discovered his "electric clock," showing how the principle of his telegraph could be applied so as to enable the time of a single clock to be shown at the same time in all the rooms of a house, or in all the houses of a town, connected together by wires. "You propose, in fact," said a friend to Wheatstone after he had explained this synchronising scheme, "to lay on time through the streets of London as we now lay water." This synchronising of time, though on a different principle, is now a common thing: railway clocks and others in public places being corrected by hourly electric currents from Greenwich Observatory. The following year he invented his chronoscope, an instrument for measuring very small intervals of time. These things show us in how remarkable a degree Wheatstone "combined the faculty of invention with that of utilisation." Indeed, in a measure, he may be said to stand alone as an example of these combined faculties. We have many brilliant original investigators of natural laws—Faraday, Tyndall, Thomson, and many more—and we have remarkable inventors or adaptors of these laws to practical purposes in men like Edison, Morse, Cooke, and others; but, in a unique degree, Charles Wheatstone is a combination of the two.

Very many honours were accorded to Wheatstone, both at home and abroad, in recognition not only of his valuable services in the introduction of the electric telegraph, but on account of a long and useful career devoted to the cause of science.

A banquet was given to him at the Royal Polytechnic on December 21, 1867, when the Duke of Wellington and many other celebrities were among those present. The wires of the Atlantic cable were brought into the banqueting-room, and the following message was sent to the President of the United States:—"The Duke of Wellington, the directors, and scientific guests now at the Royal Polytechnic, London, send their most respectful greeting to the President of the United States, their apology being, that to the discoveries of science the intercourse between two great nations is indebted."

This message was nine minutes thirty seconds in transit from London to Washington, by Heart's Content and New York. The following reply, occupying twenty-nine minutes in transmission, was received :—

"I reciprocate the friendly salutation of the banqueting party at the Royal Polytechnic, and cordially agree with them in the sentiment that free and quick communication between governments and nations is an important agent in preserving peace and good understanding throughout the world, and advancing all the interests of civilisation.—ANDREW JOHNSON."

In the following year Wheatstone received the honour of knighthood. In 1869 he was given the degree of LL.D. of Edinburgh University. In 1873 he was made a foreign member of the French Academy, and he died in Paris, two years later, on October 19, 1875.

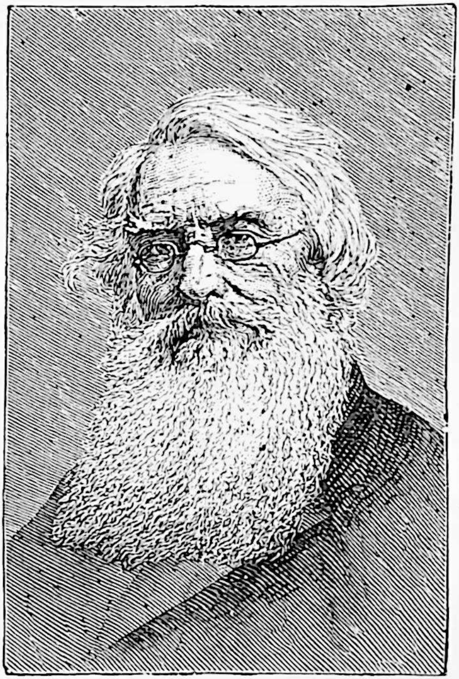
WILLIAM FOTHERGILL COOKE, whose name was so intimately associated with that of Wheatstone in the establishment of the electric telegraph, was a younger man than his colleague, having been born at Ealing in Middlesex in the year 1806. His father was a doctor in what was then the village of Ealing, but is now a suburb of London. Doctor Cooke, after his son's birth, was appointed Professor of Anatomy at Durham University, and it was at Durham that young William Cooke received his first education. Later he went to Edinburgh University, and at the age of twenty entered the Indian Army. He remained in India for five years, after which he returned home, desirous of following in his father's footsteps and adopting the medical profession. With this end in view he studied first at Paris, and then under Professor Müncke at Munich. So far, nothing had occurred likely in any way to associate this young man with the great invention which a few years later was to revolutionise the world. It was while with Müncke in 1836 that his attention was first called to the possibilities of electric telegraphy. The Professor had studied the subject, and to illustrate some lectures he was giving, constructed a telegraph on the principle introduced by a German physician, Baron Schilling, of the action of the galvanic current on a magnet. Cooke entered with much spirit into the novel experiments. He appears to have instinctively become aware of the great future there was for this new means of communication; his imagination was fired with the idea that he might make this new principle workable for general use. The study of medicine was given up, and all his energies were centred upon this one thing—to make generally practicable some method of instantaneous electrical communication at a distance.

Early in the year 1837 Cooke returned to England, armed with letters of introduction to Professor Faraday and Roget. They in turn introduced him to Wheatstone, being aware of the work which he had already done and the investigation he was still pursuing. When thus introduced to the scientist, with whom thenceforward his name was generally to be coupled, Cooke had already constructed a system of telegraphing with three needles on Schilling's principle, and had prepared designs for a mechanical alarm. He had also advanced so far as to commence negotiations with the Liverpool and Manchester

Railway Company for the use of his telegraph. After several interviews between Cooke and Wheatstone, they agreed to work in partnership: the former was possessed of good practical knowledge, energy, and business capabilities, while the latter, with neither taste nor leisure for business, possessed the requisite scientific knowledge and inventiveness. Within a month of the formation of the partnership the first patent was taken out, and the work of demonstrating the practicability and general usefulness was rapidly proceeded with; the joint inventors gradually approximating towards perfection, until at length they patented the single-needle instrument, and success was assured. For some years the partnership continued, until, spoiled by success, the two principals quarrelled, each claiming the chief credit for the invention, where both had done so much. "Cooke contended that he alone had succeeded in reducing the electric telegraph to practical usefulness at the time he sought Wheatstone's assistance; and, on the other hand, Wheatstone maintained that Cooke's instrument had never been, and could never be, practically applied." Wheatstone, it may be added, however, admitted that he could not have succeeded so early without Cooke's "zeal and perseverance and practical skill."

In 1867 the Albert gold medal of the Society of Arts was presented to Cooke and Wheatstone on equal terms. In 1869 Cooke was knighted (Wheatstone having received the same honour the year before), and afterwards he was granted a civil-list pension for his services in introducing the telegraph. He died on June 25, 1879.

Of all the names associated with the electric telegraph, that oftenest on the lips of men is Morse. SAMUEL FINLEY BREESE MORSE was born in Charlestown, Massachusetts, on April 27, 1791. His father was a clergyman, of Connecticut—Jedediah Morse. Young Samuel's early life, indeed upwards of



Samuel F. B. Morse.

the first thirty years of his life, gave very little indication that it would be with a scientific invention that his name would be associated in the minds of posterity. Although he took a keen interest in science lectures at school and at Yale College, where he went when he was fourteen, it was as an artist he desired to win name and fame for himself; and, indeed, his natural talents appear to have marked him out as a painter, for before he left college he could proudly write home that he was already painting portraits, and that his price per portrait was five dollars.

In 1809 he attended a course of lectures on the laws of electricity delivered by Jeremiah Day, and was much interested in the illustrative experiments; so much so that, referring to these lectures in later years, he described them as "the acorn which, falling into fruitful soil, eventually spread its boughs far and wide." He took his degree in 1810.

So decided was his leaning toward art, despite his awakened interest in electrical science, that young Morse was placed as a pupil with the celebrated painter, Washington Allston. In 1811 he accompanied Allston to England, and was introduced to his countryman the great Benjamin West, and was soon after admitted a pupil of the Royal Academy School. There, and under the tuition of Allston and West, the young artist made rapid progress,—so rapid, indeed, that in 1813 he exhibited at the Royal Academy Exhibition his colossal picture of "The Dying Hercules," which was described as one of the best dozen pictures of the year; while the plaster-cast which the artist had made to assist him in the picture gained a gold medal from the Society of Arts. All this was, of course, very gratifying, but the young artist needed money, and to provide himself with it took to portrait painting, which he continued in England with varying success for a couple of years. In 1815 he returned to America, and with his newly made fame as an artist was warmly welcomed. He soon found, however, that there was among his countrymen very little demand for large mythological and historical pictures, while there was a brisk demand for portraits,—so brisk that he could write to his old master, Allston, in 1819, "I am painting from morning till night, and have continual applications." In 1818 he married Lucretia Walker, at Concord, New Hampshire. So he continued for some years on a fairly prosperous course as a painter of portraits.

In 1826–7 Morse attended a course of lectures on electro-magnetism given at the New York Athenæum by his friend Professor Dana. On the formation of the National Academy of the Arts of Design, in which Morse assisted, he was elected to the position of its president, an office which he continued to hold for sixteen years. In 1829, that he might further study the art to which he had devoted himself, Morse again visited Europe, and spent three years in Paris and the various art centres of Italy. According to the testimony of the popular story-teller, James Fenimore Cooper, it was while Morse was staying in Paris at this time that he first had the idea of the practical application of electricity to telegraphy occur to him. To use Fenimore Cooper's own words, "Our worthy friend first communicated to us his ideas on the subject of using the electric spark by way of a telegraph. It was in Paris, and during the winter of 1831–2." In 1830, while in Paris, Samuel Morse was elected a corresponding member of the Historical Institute of France.

On the 1st of October 1832 Morse sailed from Havre for New York in the packet-ship "Sully." It was, indeed, a momentous voyage which was then started. Among Morse's fellow-passengers was Charles T. Jackson, who had been studying electricity and magnetism in the laboratories of Paris. During an early part of the voyage, we are told that a conversation arose on some recent experiments of Ampère with the electro-magnet. Someone having asked whether the velocity of the current of electricity along a wire did not depend upon the length of the wire, Jackson replied by drawing attention to the result of Benjamin Franklin's experiments—"electricity passes instantaneously over any known length of wire." Morse, on hearing this repeated, at once exclaimed, "Then, if the presence of electricity can be made visible in any part of the circuit, I see no reason why intelligence may not be transmitted instantaneously by electricity."

The idea took firm hold of him, and all his energies were devoted thenceforward to this one end; for, as he said prophetically, "If it will go ten miles without stopping, I can make it go around the globe." At once, and while still aboard the "Sully," he began to consider how communications might be made intelligible, and then, almost as though by inspiration, he hit upon the "dot and dash" alphabet, which has since been the most generally used of all systems. The following illustration of how a mere arrangement of dots and dashes is made to serve all the purposes of our alphabet may well find a place here in this brief notice of the life of Morse.

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

So rapidly did the inventive genius of Morse work when he had brought it to bear upon this matter that, besides the very ingenious alphabet which he invented while crossing from Havre to New York, he also planned and drew his electro-magnetic and chemical recorder almost as it was used. So soon as he reached New York he entered with indefatigable energy upon his task of making a thoroughly practicable electric telegraph. It is a curious coincidence that at the time when Wheatstone's experiments were leading him to such splendid results in England, Morse was quite independently reaching the same goal in America. Although he had so rapidly seized upon the idea and so quickly set himself to work upon it, it was not until 1835 that Morse produced a really effective working model of his telegraph, and in that year he hit upon a method, as Wheatstone had also done, of reinforcing a current which had become enfeebled owing to the distance it had travelled from its source. In the same year, too, he was appointed Professor of the Arts of Design in New York University. During the next two years his energies were mainly devoted to experiments in the modifying of his marking apparatus.

In 1838 Morse visited Europe, hoping to interest some of the governments in his new telegraph. In this, however, he was unsuccessful. His invention was shown before the Members of the Royal Society in London and before the Academy of Sciences in Paris. Praise and congratulation met him everywhere, but no indications of anything more substantial. All that he secured were French patents, which were not worth anything, owing to certain restrictions. While in Paris he met Daguerre, who explained to him all that he had so far done towards the perfection of the daguerreotype. Morse acquired such knowledge of the process as the inventor himself had attained, and in America "shares with Professor Draper the honour of being the first to make photographs of living persons."

Early in 1839, considerably disappointed with the result of his journey, Morse returned to America quite penniless. He arrived, to use his own words written at the time in a letter to a friend, "without a farthing in my pocket, and have to borrow even for my meal; and even worse than this, I have incurred a debt of rent by my absence." For four years he endured a considerable amount of trouble and almost abject poverty, being indeed at times reduced to such extremity as to have to go for twenty-four hours without any food. He had succeeded in perfecting his invention, but could get no public man with sufficient faith in the new thing to help it forward. For these four years his living, such as it was, was gained by teaching a few pupils, and painting occasional portraits. He had, however, largely divorced himself from art in his enthusiasm to complete and bring forward his telegraph, and it naturally irked him to waste time over the old profession which should properly have been devoted to the new. Before Congress after Congress he persisted in bringing forward the matter, until at length, in February 1842, came a first measure of reward in the shape of a grant of thirty thousand dollars. The bill had passed through Congress with a narrow majority of but eight votes. Still it had to pass the Senate, and over and over again it got postponed, until the very last day of the session, March 3rd, 1843. "My bill had indeed passed the House of Representatives, and it was on the calendar of the Senate; but the evening of the last day had commenced, with more than one hundred bills to be considered and passed before mine could be reached. Wearied out with the anxiety of suspense, I consulted one of my senatorial friends. He thought the chance of reaching it to be so small that he advised me to consider it as lost. In a state of mind which I must leave you to imagine, I returned to my lodgings to make preparations for returning home the next day. My funds were reduced to the fraction of a dollar. In the morning, as I was about to sit down to breakfast, the servant announced that a young lady desired to see me in the parlour. It was the daughter of my excellent friend and college class-mate, the Commissioner of Patents (Henry L. Ellsworth). She had called, she said, by her father's permission, and, in the exuberance of her own joy, to announce to me *the passage of my Telegraph Bill at midnight*, but a moment before the Senate's adjournment.

"This was the turning-point of the telegraph invention in America. As an appropriate acknowledgment for the young lady's sympathy and kindness—a sympathy which only a woman can feel and express—I promised that the first despatch by the first line of telegraph from Washington to Baltimore should be indited by her. To which she replied, 'Remember now, I shall hold you to your word.' In about a year from that time, the line was completed, and everything being prepared, I apprised my young friend of the fact. A note from her enclosed this despatch:

'*What hath God wrought!*'

"These were the first words that passed on the first completed line of electric wires in America. None could have been chosen more in accordance with my own feelings. It baptised the American Telegraph with the name of its Author."

As may be gathered from the words of the inventor himself just quoted, Morse recommenced his work with renewed energy. The construction of the line between Washington and Baltimore was rapidly proceeded with, and on May 24, 1844, the public opening of it took place. Having demonstrated the usefulness of his system, Morse offered to dispose of all his rights in the telegraph to the United States Government for one hundred thousand dollars, but his offer was not accepted, the government declining to go to any further expenditure than eight thousand dollars for the maintenance of the initial line. Shortly afterwards Morse's patents passed into private hands, and the system became the property of a joint-stock company, called the Magnetic Telegraph Co., and thenceforward step by step the telegraph passed all over the United States.

Everything was not, however, plain sailing for the inventor, even by this time, for his "patents were violated, his honour disputed, and even his integrity was assailed, and rival companies devoured for a time all the profits of the business." After a series of vexatious lawsuits, however, his rights were affirmed by the United States Supreme Court. In 1846 he was granted an extension of his patent, and ultimately the Morse system was adopted in France, Germany, Denmark, Sweden, Russia, and Australia, until at the present time it is in far more general use than all other systems together, so much so indeed that the Morse instrument and alphabet are now used on no less than ninety-five per cent. of the telegraph wires of the world. From the accompanying illustrations (pages 68 and 69) some idea may be gathered as to the way in which the telegraph operators send and receive messages on the Morse system.

Happily, though he had had a hard struggle, Morse lived to a ripe old age to enjoy the fruits of his inventiveness, and indomitable perseverance. In 1847 he purchased an estate on the Hudson river, near Poughkeepsie, which he called Locust Grove; the year following he married again, his first wife having died some years before. He bought a city residence in New York, where he spent his winters, and on the front of which is now to be seen a tablet recording that, "In this house S. F. B. Morse lived for many years, and died."

During his later years Morse occasionally visited Europe, to which half a century earlier he had gone with Washington Allston in such very different circumstances. During one of these visits, in 1858, the telegraph companies of Great Britain gave him a grand banquet in London. Two years later, at the instance of the French Emperor, Napoleon III., representatives of France, Sweden, Russia, Sardinia, the Netherlands, Turkey, Holland, the Papal States, and Tuscany met in Paris to decide upon an international testimonial to the great "Father of the telegraph," as some one called him. The result of this collective deliberation was the voting of a sum of 400,000 francs to Morse, equal to about sixteen thousand pounds, or eighty thousand dollars. During the same year the American colony in Paris entertained him at a great dinner.

Honours of all kinds showered upon him from all sources, from the time of the earliest recognition of the value of the telegraph. As he was returning from abroad in 1868 he received an invitation from his fellow-citizens, which ran—"Many of your fellow-countrymen and numerous personal friends desire to give a definite expression of the fact that this country is in full accord with European nations in acknowledging your title to the position of the

Sending message by the Morse Sounder.

father of the modern telegraph, and at the same time in a fitting manner to welcome you to your home." In accordance with this invitation a gigantic banquet was given on the 30th of December 1868 in New York. Less than three years later, on June 10, 1871, a bronze statue of Morse was erected in the New York Central Park. On the evening of the same day a grand reception was held in the Academy of Music at which a large number of eminent men were present. It was an occasion of unique interest.

At nine o'clock the chairman announced that the telegraphic instrument before him — the original register employed in actual service—was connected with all the wires of the United States, and that a touch of the finger on the key would soon vibrate throughout the Continent. The following message

Receiving message by the Morse Writer.

was then sent, and instantaneously transmitted to every telegraph station in the States—"Greeting and thanks to the telegraph fraternity throughout the land. Glory to God in the highest, on earth peace, goodwill to men." At the last click of the instrument Morse struck the sounder with his own name amid a scene of the most uproarious applause. When the great excitement had somewhat subsided, the chairman appropriately said, "Thus the father of the telegraph bids farewell to his children."

Six months after that very remarkable scene in the New York Academy of Music, Samuel Morse, then upwards of eighty years of age, performed his last public service in the unveiling of a statue to Benjamin Franklin in Printing House Square, New York. The peculiar appropriateness of this act was well pointed out at the time, for, as it was said, "the one conducted the lightning safely from the sky, the other conducted it beneath the ocean, from continent to continent. The one tamed the lightning, the other made it minister to human wants and human progress." Shortly after his return home from the unveiling of the Franklin Statue, Morse was seized with severe neuralgia in the head, and after much suffering he died on April 2, 1872. Thus passed away one to whom, perhaps, more than to any other, the world owes its vast telegraph system as at present used. Wheatstone and Cooke, as we have seen, also reduced the theory of the electric telegraph to practice; Edison and a number of other electrical inventors have gone on making wonderful improvements in the working of it; yet it is to Samuel Morse, undoubtedly, that our greatest debt of gratitude is due. It is worthy of note, too, that at the time when Morse, the "father of the electric telegraph," died, Edison, the "wizard of Menlo Park," had just entered upon the most successful and most richly inventive period of his remarkable career.

CHAPTER IV.

SUBMARINE TELEGRAPHY—THE ATLANTIC CABLE.

"The electric chain, whose mystic girth
Makes distance but a span;
And science covering all the earth
With benefits for man;
And countless triumphs to be born
In the new dawning of the morn."
—CHARLES MACKAY.

IT was inevitable that, so soon as the electric telegraph had been proved to be a practicable thing for communication between distant places, the attention of electrical inventors, and that of commercial men also, should be turned to the possibility of establishing the same kind of communication from one country to another. In our notice of early telegraphing experiments we saw that Sir William Watson in the eighteenth century, and Wheatstone in the nineteenth, had sent signals over wires laid through the river Thames. In October 1842 Morse made further experiments in the same direction by fixing up a cable between Castle Garden and Governor's Island, New York—a greater distance than either of the previous attempts had been. These experiments satisfied Morse as to the possibility of submarine telegraphy, and the following year he felt emboldened to say that the Atlantic Ocean would one day be crossed by a telegraphic cable capable of transmitting electrical messages. But few of those who heard him would imagine that such a wonderful event would be realised in their lifetime. And yet not very many years were to pass before the bold prophecy was to be fulfilled. So early as 1845 J. Watkins Brett and Jacob Brett conceived the possibility of laying a telegraph wire across the Atlantic, and proposed a plan for doing so to the United States Government. The proposal was not accepted, and the question was allowed to drop for a while. Before 1850 projects were afoot for connecting England and France by means of a telegraph cable; indeed, Wheatstone suggested it so early as 1840. The new method of rapid communication had not then become so general as to make such a proposal seem feasible to the general public, and the consequence was that it met with a good deal of criticism as well as some good-natured chaff, such as the following passage from a popular magazine:—"It cannot be denied that difficulties of a formidable kind threaten the invention. One is the danger of the fracture of the wire; it may be caught by the fluke of a ship's anchor, as she is endeavouring to ride out a stiff gale, and thus dragged away and broken. Then, again, it is to be remembered that the lower regions of the waters are only unvisited by fish when their depth is far greater than that of the Channel, and these monsters of the deep might happen to take a fancy to the long body of the wire, and, by a single effort of their powerful jaws, snap it in twain—perhaps in the very middle of an important official despatch!"

These imagined drawbacks have not proved as fruitful of disaster as the writer of that article appeared to think. Despite criticism and banter, however, the projectors of the scheme pursued their preparations, and in the year 1850 the first cable was successfully laid, but communication by means of it only continued between the two countries for one day, when it broke. The cable selected had not proved strong enough; it consisted of copper wire, insulated by gutta percha. The next year a new cable was laid down, being further strengthened with an outer covering of wire. This second cable was not only successfully laid, but has remained in use ever since. After the breaking of the first one, a Frenchman, M. Dupont, thought to solve the difficulty by sinking the cable forty feet, and keeping it at that depth by means of floating buoys placed thirty feet apart right across the Channel! This suggestion was certainly more ingenious than practical, and no one attempted to realise it. Thanks to Mr Brett, who had secured concessions from the French Government to permit him to lay the cable from Dover to Calais, the possibility of ocean cables was thoroughly demonstrated even by the first line which was laid, despite the fact that it was available for so short a period. One early fault discovered in practice was that there were very small air-holes in the gutta percha insulating cover. The water, by means of these holes, got to the wire, and thus afforded an outlet for the electric current. This fault was soon remedied; but a much more serious mishap occurred to this early cable when a Boulogne fisherman got part of it caught in his tackle, and cut off a bit, which he bore back triumphantly to Boulogne, and exhibited to his townsmen's wondering gaze as a specimen of very rare sea-weed, with its centre filled with gold. In the hopes of finding more of this precious "weed" the fisherman returned near the place where he had secured it, and searched for more. Whether he succeeded or not is unknown, but, at all events, he had effectually destroyed the cable.

The copper wire, insulated with a covering of gutta percha, having proved itself not sufficiently strong for deep-sea telegraphy, it occurred to Mr Küper, one of the gentlemen engaged in the undertaking, to protect the line still further by making it the core of a wire rope. This was done with the cable of 1851, and unqualified success was the result. Cables were rapidly laid down within the following few years in various parts of Europe. America had as yet, however, given no sign—other than Morse's experiments mentioned—of taking up the question. Land telegraphy was then rapidly spreading over the great Western Continent. It occurred to Gisborne, an English engineer in Newfoundland, who had been in London at the time of laying the Channel cable, and some others of that Colony, to lay a cable to New York which would considerably shorten the period taken to correspond with Europe. After commencing the work, several difficulties, monetary and others, sprang up, and Gisborne then visited New York, in 1854, to see if he could enlist support for the scheme. Accident took him to exactly the right man in Cyrus Field.

The millionaire, who had just returned from travelling in the South, listened with attention to his visitor; and, having heard all that *had* been done, and what practical men thought could be done, mused for a time over the proposition. "To lay these submarine cables so as to connect Newfoundland with Maine?—Good. To run a line of steamers from St John's to Galway?—Certainly. It would shorten the time of receiving news in New York from Europe four or five days. . . . But if a cable can be laid in the bed of these seas—if the great Atlantic itself could be spanned——?" It was like an inspiration, and from that moment Cyrus Field entered into the new project heart and soul. The very same

Cyrus West Field

day he wrote to a naval authority inquiring as to the formation of the bottom of the Atlantic Ocean, and to Professor Morse to know if—given the wire duly laid—the electric current would successfully do the journey. Both replies were satisfactory, and he at once proceeded to enlist the support of brother capitalists. He visited Newfoundland, got all the necessary grants and concessions, visited Canada, and then visited England, where he interviewed the various submarine cable makers, and set them making investigations.

By his indomitable energies, Cyrus Field had secured the enormous capital required for the great undertaking, and also important assistance from the American and British Governments. By the close of 1856 everything was in train so that the directors felt justified in ordering the cable itself. It was ordered from three firms, two of them supplying lengths of 1250 miles each, and the third 2500 miles, at a cost of about £40 per mile. Six months after the orders were given the cable was complete. It consisted of a centre strand of copper, made up of seven wires, one-sixteenth of an inch in diameter. This copper was then covered with three separate layers of refined gutta percha so as to perfectly insulate it. The greatest care was exercised in carrying the cable to this stage. It was made in two-mile lengths, and subjected to rigorous tests before being passed on to be covered with wire. The wire covering consisted of eighteen strands of iron wire, each strand consisting of seven firmly twisted wires. The cable, when completed, weighed one ton per mile length. There was used in its manufacture sufficient iron and copper wire to "put a girdle round about the earth" some thirteen times, or, in other words, no fewer than 332,500 miles!

"To the eye," said one observer, "the rope seems fitted to connect the posts of a laundress's drying ground rather than the Eastern and Western Continents of the wide world."

This great cable—especially interesting as being the first designed for crossing the Atlantic—was coiled in the holds of two vessels, the U.S.N. frigate "Niagara" and H.M.S. "Agamemnon." The shore end was fastened at Valentia on the Irish coast on the 5th August 1857, and two days later the two vessels started on their journey, "paying out" the cable at a rate of about four or five miles an hour. On August 11th, 280 miles from land, the signals which had been kept up with the shore ceased, and it was discovered that the cable had broken. With the length of cable left at their disposal the officers and engineers did not feel justified in re-starting, and so the attempt for that year was abandoned.

In 1858 a further attempt was made, nine hundred miles more cable having been prepared meanwhile, the American and British again lending the services of the two vessels which had made the earlier attempt. Cyrus Field, whose energies were such that he *would not* know defeat, so soon as the earlier cable snapped, had thrown himself heartily into plans for the second one.

All being ready, the vessels left Plymouth early in June, and proceeded to sea. Instead of laying the shore end first, it was decided that the two ships should proceed to mid-ocean, there splice the two ends of the cable and steam away, one to the east and the other to the west, paying out the cable. On the 26th of June, after experiencing terribly stormy weather, the two vessels met and spliced the cable, which almost immediately broke. Again it was spliced, and the ships went on their respective journeys, when suddenly the continuity of the current ceased, and the electricians declared that the cable had snapped at the bottom. After having paid out about eighty miles the vessels had again to meet and splice the cable a third time on June 28. Once more the cable broke when upwards of 140 miles had been paid out from the "Agamemnon," and on this occasion no cause could be suggested for the mishap. Yet once again, on July 28, the vessels met in mid-ocean, and for a fourth time effected a splicing of the cable.

Patience and perseverance were to be at length rewarded. On August 5 the "Agamemnon" anchored off Valentia, and on the same day the "Niagara" reached Trinity Bay, Newfoundland, and the Atlantic cable, as a means of communication between England and America, was an accomplished fact. The fixing of the shore ends was rapidly proceeded with, and on the 18th the directors in England "wired" their American colleagues—"Europe and America are united by telegraphic communication. 'Glory to God in the highest, on earth peace, goodwill towards men.'" This message was immediately followed by one from Her Majesty the Queen to the President of the United States, which, as an historical document, is worth preserving. It ran as follows:—

"To the President of the United States. The Queen desires to congratulate the President upon the successful completion of this great international work in which the Queen has taken the deepest interest.

"The Queen is convinced that the President will join her in fervently hoping that the electric cable, which now connects Great Britain with the United States, will prove an additional link between the nations whose friendship is founded upon their common interest and reciprocal esteem.

"The Queen has much pleasure in communicating with the President, and renewing to him her wishes for the prosperity of the United States." This message occupied a little over an hour in its transmission. The President immediately replied to it as follows :—

"To Her Majesty Victoria, Queen of Great Britain. The President cordially reciprocates the congratulations of Her Majesty the Queen on the success of the great international enterprise accomplished by the science, skill, and indomitable energy of the two countries. It is a triumph more glorious, because far more useful to mankind than was ever won by conqueror on the field of battle. May the Atlantic telegraph, under the blessing of Heaven, prove to be a bond of perpetual peace and friendship between the kindred nations, and an instrument destined by Divine Providence to diffuse religion, civilisation, liberty, and law throughout the world. In this view will not all nations of Christendom spontaneously unite in the declaration that it shall be for ever neutral, and that its communications shall be held sacred in passing to their places of destination even in the midst of hostilities?

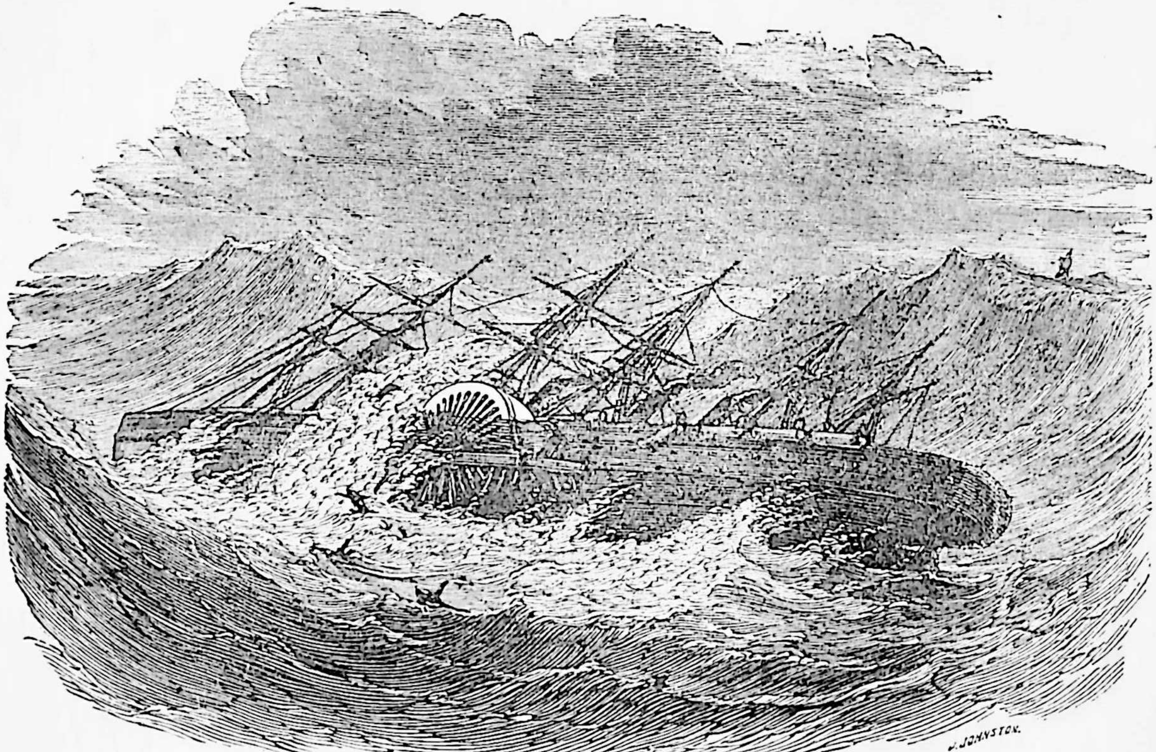
(Signed) "JAMES BUCHANAN."

Great was the delight, both in England and America, over the gigantic triumph which had been achieved. In America, indeed, the enthusiasm was boundless. Wonderful as was the success which had rewarded the indefatigable efforts of the scientists, capitalists, and others concerned in the enterprise, a very severe disappointment was in store for them all, and not for them alone, but for civilised peoples all over the world. Towards the close of August there were rumours that the electric current was becoming feebler and feebler. Numberless investigations were made and experiments tried by electrical experts, but all to no purpose. On September 4th, just one month after the two cable ships had anchored in their respective harbours, *communication entirely ceased.*

Several causes for the failure were suggested, but the conclusion finally arrived at was that there must have been some fault of construction. Cyrus Field and his colleagues, however, were determined not to be defeated. The possibility and the value of the cable had alike been demonstrated, and plans were immediately made with the object of making a further attempt. In 1860 a new company was formed to carry out the work.

In 1862 Mr Samuel Gurney, M.P., gave a telegraphic *soirée*, at his residence near Hyde Park, when it was shown that a message could be sent through five thousand miles of wire. The Submarine Telegraph Company's wires were led direct into Mr Gurney's residence. The Earl of Shaftesbury, who was present, sent a message to St Petersburg inquiring after the health of the Emperor of Russia, and in *four minutes* received a reply that he was well, the message having been conveyed about two thousand miles in that time. It was then suggested to complete the circuit of Europe with the wire. The signal was given, and it was connected through Berlin, St Petersburg, Moscow, Kiel to Southern Hungary, through Trieste and Vienna to Verona, whence came the reply that the lines between there and Turin were broken down. This message had traversed through sea and over land five thousand miles of wire! a sufficient indication that distance was no hindrance to the current.

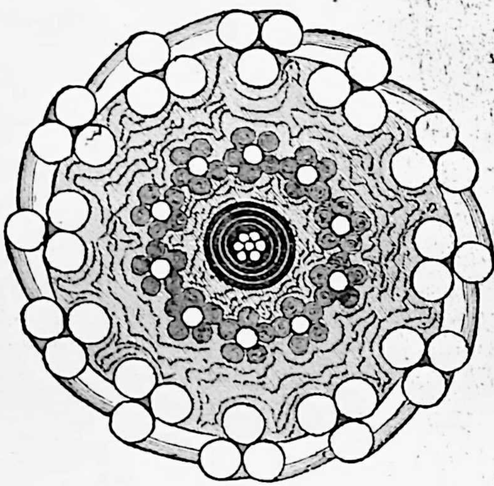
It was 1865 before the renewed efforts towards establishing a permanent means of electric communication between Europe and America were so far advanced as to have everything ready once more for actually laying the cable. The many notable men on



The "Great Eastern," with Cable on board, in a Storm.

either side of the Atlantic, who were giving the undertaking their zealous support, had resolved to triumph ultimately, and, profiting by their previous efforts and temporary success, despatched the "Great Eastern" to carry out the work during the summer of 1865.

The "Great Eastern," as is well known, was—within the last few years she has been broken up—the largest vessel afloat. She was duly prepared for her



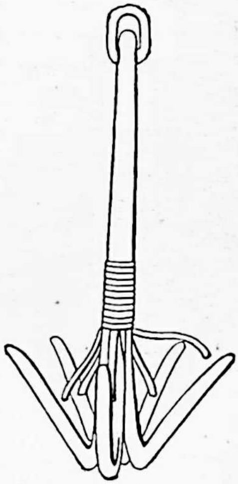
Atlantic Cable, 1865, shore end.

load, and at length, on the 15th of July, with 2300 miles of cable coiled in three gigantic tanks in her hold, she left the Thames on her eventful voyage. Captain Anderson was in command of the vessel, and Professor William Thomson and Mr Cromwell F. Varley were to superintend the paying out of the cable. Other gentlemen aboard included Mr Cyrus Field, still sternly bent on realising his scheme; Dr W. H. Russell, the "Pen of the War"; Henry O'Neil, A.R.A., and a number of other notabilities. Mr O'Neil, in describing the voyage, said that, on first going about on board, it was like being in a village, the vessel was so large. To feed the five hundred people aboard there were a dozen oxen, one hundred and twenty sheep, and numerous pigs, besides ducks, geese and fowls galore. Among the passengers, too, must not be omitted "a jackdaw who often, during the voyage, would perch for hours on the top of the dynamometer watching the paying out of the cable, apparently with self-satisfied complacency."

Having fixed the shore end at Valentia, the "Great Eastern" started on July 23rd on it's long voyage, accompanied by H.M.S. "Sphinx" and "Terrible." From the time of starting, telegraphic signals were to pass through the cable to the shore-hut every ten or fifteen minutes, day and night, so as to make sure that all was going well, and that the cable had not got damaged at the bottom. The day of commencing was bright and auspicious, and all went well, according to the account of Mr O'Neil; but "at 4.30 on the following morning (Monday), I was aroused from sleep by the booming report of one of our guns—that being a preconcerted signal for the men of war to stop. I hurried on deck, and, to my dismay, learned that the signalling was imperfect, indicating that some accident had happened to the cable." Nearly twelve miles of the cable had to be drawn on board again, at the rate of about one mile per hour, before the "fault" was discovered. A piece of the covering wire was pressed through the gutta percha, thus destroying the perfect insulation of the copper. Foul play was suspected, though it was impossible to bring it home to anybody, because a similar case had occurred in laying a cable in the North Sea, when the culprit had confessed that he had been bribed with an offer of £1000 if he succeeded in destroying the cable. By 1 P.M. on Tuesday the splice was completed, and again the "Great Eastern" continued its western voyage. On the Saturday another and even more serious "fault" of the same kind was discovered and repaired. After that it was decided that the various gentlemen on board should take it in turn to watch the men who were engaged in the paying-out work. On July 31st, when the keen-eyed Cyrus Field was on the watch, yet another of these mysterious faults was found, and directly afterwards the cable *snapped* and went with a fearful run overboard! "I am not exaggerating," said the artist whom we have already quoted, "when I say that the crash represented a loss of nearly a million sterling, and with it fled, for the time at least, the prospects of the projectors and the hopes of all civilised nations."

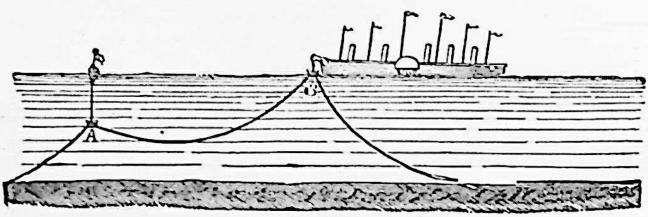
For ten days the "Great Eastern" kept about the spot trying to grapple the cable; and at length, on August 11th, actually caught hold of it—though it was in water 2000 fathoms deep—and was hauling it on board, everybody's hopes running high once more, when the hauling-line broke, and *all was over*. The "Great Eastern" immediately returned to England, Cyrus Field retiring to his cabin to draw up a prospectus for a new company, undeterred by this fresh failure.

The results of the three cable expeditions of 1857, 1858, and 1865, although they did not directly establish permanent communication between the two continents, were yet of such value as could not properly be estimated by the monetary outlay. The practicability of bridging the Atlantic Ocean with an electric current had been, at the least, successfully demonstrated, and that was no mean result. Upon the return of the "Great Eastern," after its 1865 expedition, a contemporary writer summed up the lessons taught by the three attempts, saying that it had been shown that "a submarine cable can be laid between Ireland and Newfoundland, for it was done in 1858. Messages can be sent through a cable so laid, even if it were not perfectly insulated. The difficulties in the laying of a submarine cable are much diminished by the use of one ship instead of two, and the 'Great Eastern' affords singular facilities for the operation. If a cable be broken, it can be caught by grapnels in the deepest water of the Atlantic plateau; and, therefore, the danger of losing it altogether from fracture is considerably diminished. The cable can be stopped when a fault is discovered, and ten miles of it can be hauled on board from a depth of two miles. A fault can be cut out, and the cable re-spliced on board with the greatest ease. Buoys can be moored in upwards of 2000 fathoms of water, so as to ride out a gale without shifting. Faults, whether designed or accidental, can be almost immediately detected and remedied. The insulation of the cable is much improved by immersion. The cable is capable of bearing ten times the weight to which it is subjected in the process of paying out in 2400 fathoms. The paying-out machinery answers perfectly; the picking-



Grapnel used for recovering Cable.

up machinery is exceedingly imperfect; and, finally, it is most desirable to have a cable so constructed that the outer covering shall, if possible, be proof against injury." Such results as these, although not absolute success, were such as to guarantee that success at a very early date. And, indeed, all the splendid efforts which had been made were not much longer to be without their reward. Early in 1866 the



A, Cable hauled up and buoyed.
B, Lifted by "Great Eastern."

telegraph company was reconstructed, the new cable was prepared and stowed in the tanks of the "Great Eastern," and once more, on the last day of June, that vessel started upon her important journey, this time destined to be completely successful. The shore end was fastened at Valentia, and the "Great Eastern" started away from there on July 13th. By the 27th of the same month the cable was fixed at Heart's Content, Newfoundland—an appropriately named spot—and a message was sent to Lord Stanley. The next day the Queen sent the following message to the President of the United States:—"The Queen congratulates the President on the successful completion of an undertaking which she hopes may serve as an additional bond of union between the United States and England."

The success of the Atlantic telegraph cable was this time thorough, so thorough that it has been in constant use ever since—now close upon thirty years. No sooner was this enterprise completed than the "Great Eastern" once more voyaged out into the Atlantic Ocean with proper lines and grappling tackle to fish for the 1865 cable, and, sure enough, it was recovered on September the 2nd, and its laying completed at Newfoundland six days later; there were thus, almost from the beginning of ocean telegraphy, two cables across the Atlantic.

With this the romantic story of the Atlantic cable is told. The obstacles to be overcome were considerable—the men of energy and indomitable will to overcome them were found; the wealth required was enormous—the capitalists and public men of both countries were not slow to respond. The disappointments and defeats were numerous—they were met with plans for a further attempt, and so the great thing was achieved, and the Atlantic cable, though thirty years old—and though science has done many wonders since—remains one of the most marvellous marvels of our time. Cables have since been laid in all parts of the globe. Puck's "girdles" have been "put round about the earth" in all ways. Perhaps the best indication of their increase is seen in the fact that, within fifteen years of the successful laying of the 1866 cable, there were no fewer than eight of these subtle connecting links between Europe and America stretched across the bed of the Atlantic, and that there are now upwards of 120,000 miles of ocean cable stretched in all directions over the world.

The statement that "we are running a race with time; we outstrip the sun, with the round world for a race-course," has been fully justified by the results of ocean telegraphy.

CHAPTER V.

The Telephone—Philip Reis—Graham Bell.

> "Blessings on Science! When the earth seem'd old,
> When faith grew doting, and our reason cold,
> 'Twas she discovered that the world was young,
> And taught a language to its lisping tongue."
> —Charles Mackay.

IT is certainly curious to notice how, in the case of nearly all the marvels which science has given to us during the nineteenth century, they have been more or less distinctly foreshadowed by earlier inventors or earlier writers. Even the phonograph and telephone, which set us all marvelling on its discovery some few years ago, is no exception, for Mrs Somerville—the celebrated astronomer—writing in the days when the electric telegraph was but a recent invention, said, in her *Connection of the Physical Sciences*:—"It may be presumed that ultimately the utterance or pronunciation of modern languages will be conveyed not only to the eye but also to the ear of posterity."

But with the phonograph we have no concern in a book on electricians and their marvels, although we have with that other marvel which is more or less closely associated with it in most persons' minds—the telephone. Over two hundred years ago the telephone was very clearly foreshadowed by Robert Hooke, a seventeenth century experimental philosopher. Writing in 1667 he described a method of making sounds audible at a distance by means of wire tightly drawn and bent into many angles. In the light of present-day practice Hooke's words are decidedly interesting. "'Tis not impossible," he says, "to hear a whisper at a furlong's distance, it having been already done; and, perhaps, the nature of the thing would not make it more impossible, though that furlong should be ten times multiply'd. And though some authors have affirm'd it impossible to hear through the thinnest plate of Muscovy glass, yet I know a way by which 'tis easie enough to hear one speak through a wall a yard thick. It has not yet been thoroughly examin'd how far otacousticons (instruments to assist the hearing) may be improv'd, nor what other wayes there may be of quick'ning our hearing, or conveying sound through other bodies than the air: for that is not the only medium: I can assure the reader that I have, by the help of a distended wire, propagated the sound to a very considerable distance in an instant, or with as seemingly quick a motion as that of light,—at least, incomparably quicker than that which at the same time was propagated through the air; and this not only in a straight line, or direct, but in one bended in many angles."

The telephone thus foreshadowed by that "ancient sage philosopher" is certainly more like the real thing as known to us to-day than were the "telephones" which nearly twenty years ago used to be sold in the street for one penny. These consisted of pill-boxes with a tightly stretched piece of string or thread between. These certainly conveyed the voice some little distance, but merely by mechanical means, by the vibrating of the stretched string in accordance with the words spoken into the pill-box. The real telephone works by means of the waves of sound being carried, not by the wire, but by the electricity which courses along the wire. Sound travels through the air at the rate of 1130 feet per second, but electricity takes it over the telephone wires at the terrific rate of 288,000 *miles* in a second.

One of the first attempts at practical telephony, or conveying of sound to a distance, was made by Sir Charles Wheatstone, to whom the world owes so much on account of the telegraph; for it was when he was still but a young man, engaged in the mending and manufacturing of musical instruments, that he invented "the magic lyre," an instrument which attracted a considerable degree of attention to the young experimentalist and would-be scientist. By means of this "magic lyre" Wheatstone showed that, when the sounding-boards of two musical instruments were connected by a pine-wood rod, a tune played upon one would be faithfully reproduced on the other. In those early days of scientific knowledge, three-quarters of a century ago, we may imagine how the audiences, before whom the "enchanted" instrument played, must have wondered how "the trick" was done. For ignorance invariably puts down to trickery anything which it does not thoroughly understand. In 1831 Wheatstone read a paper on his discovery, but some years before, when it was first exhibited, a writer, commenting on it as follows, seems to have prophetically foreshadowed the telephone of to-day. "Who knows but by this means the music of an opera performed at the King's Theatre may ere long be simultaneously enjoyed at Hanover Square Rooms, the City of London Tavern, and even at the Horns Tavern at Kennington, the sound travelling, like gas, through snug conductors, from the main laboratory of harmony in the Haymarket to distant parts of the metropolis; with this advantage that in its progress it is not subject to any diminution? What a prospect for the art, to have music 'laid on' at probably one-tenth the expense of what we can get it ourselves! And, if music be capable of being thus conducted, perhaps words of speech may be susceptible of the same means of propagation. The eloquence of counsel, the debates in Parliament, instead of being read the next day only——but we really shall lose ourselves in the pursuit of this curious subject."

Some few years later, when he was busy perfecting the electric telegraph, Sir Charles Wheatstone made investigations to try and determine the possibility of speaking machines. He declared that the advantages which would result upon the completion of such an instrument rendered the subject worthy of the attention of both philosophers and mechanicians, and he endorsed a remark which had been made by Sir David Brewster to the effect that before another century was completed a talking and singing machine would, there was but little doubt, be numbered among the marvellous conquests of science. How thoroughly well that remark was justified has long since been patent to everybody. For, within half a century of the time, such "singing and speaking machines," as the telephone and the phonograph, were both realised facts.

The pine-wood rod which Wheatstone had employed was but a primitive telephone, however, and probably capable of no further development. It was not until 1860 that the possibilities of electric telephony were known, although the inventor, both of the instrument and its name, had carried on earlier but unsuccessful experiments in 1852; while a French

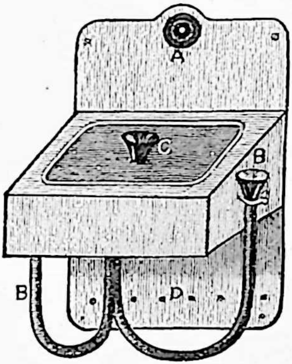
Philip Reis.

writer, two years later, had said, "It is certain that, in a more or less distant future, speech will be transmitted by electricity." This inventor was one Philip Reis, a modest and retiring but ingenious and persevering student of natural science, who acted as teacher of natural history in a grammar school at Friedrichsdorf near Homburg, from 1859 until his death about 1876. The experiments carried on by Reis in 1860 were sufficiently successful to allow of his reading a paper on telephony, "The Art of Reproducing Sounds at a Distance from their Source," before a learned audience at Frankfort in the following year. He had, however, only been able to transmit musical and other sounds by means of this telephone; he had not succeeded in making it respond, as it does now, to the slightest inflection of the human voice; that he designed it, however, with a view to its conveying human speech, is very clearly shown in the lecture referred to, where he says, "Hitherto it has not been possible to reproduce human speech with sufficient distinctness. The consonants are, for the most part, reproduced pretty distinctly, but not the vowels as yet in an equal degree." As a writer in the *Encyclopædia Britannica* puts it, "Reis seems to have understood very well the nature of the vibrations he had to reproduce, but he failed to comprehend how they could be reproduced by electricity." Yet he was so near to the discovery that later, when the results of Bell's experiments were known, it was possible, with but very slight modification, to transmit human speech by one of Reis' instruments.

How true it is that "great events from small occasions spring" is well illustrated in an account of the first telephone made by Philip Reis, which has been given by a Dr Messel, a manufacturing chemist, who witnessed his early experiments. "The original telephone, made by Reis, was," says Dr Messel, "of a most primitive nature. A bung of a beer-barrel had a conical orifice cut through it, the smaller end being closed with the skin of a German sausage, which did service as a membrane. To this was fixed, with a drop of sealing-wax, a little strip of platinum (or platinum wire) representing the hammer of the ear, and which closed or opened the circuit precisely as in the instruments of a later date. The receiving instrument was a knitting-needle surrounded with a coil of wire, and placed on a violin to serve as a sounding-board. Some idea of the roughness of the main parts of the first telephone can thus be formed. When first exhibited at Frankfort it astonished every one quite as much as the more perfect instruments of Bell now do. The instrument here described has now passed into the hands of the Telegraph Department of the German Government."

The name most intimately associated with the telephone, as it is known to us in every-day use, is that of Alexander Graham Bell, to whose inventiveness and energy we owe the instrument which has proved so great a success. "Reis," it has been said, "gave the electric wire a tongue so that it could mumble like an infant; but Bell taught it to speak."

Bell is a Scotchman, and was born at Edinburgh on March 3, 1847. His father was Alexander Melville Bell, lecturer at Edinburgh University, and later at University College, London, who was celebrated as the inventor of a method for removing impediments of speech. In 1870 Professor Bell removed to Canada, and his son accompanied him. Two years later the younger Bell took up his residence in the United States, where he successfully introduced his father's system of instruction for deaf-mutes, and became Professor of Vocal Physiology in Boston University. For some years he interested himself in the transmission of sound by electricity. The partial success which had attended the efforts of the German investigator convinced him that more real success was possible, and to this end he worked for some time devising many different kinds of apparatus for the purpose. At length, after working at it for four or five years, he had brought it to a sufficiently advanced state of perfection to show it publicly, which he did at Philadelphia in 1876.



The Gower-Bell Telephone.

A Push button for "call-bell." *B*, Hearing tubes. *C*, Mouthpiece for speaking. *D*, Connections for wires.

As Reis had done before him, Bell, in devising his telephone, copied the human ear with its vibrating drum. The first iron-plate which he used as a vibrator was a small piece of clock spring glued to a parchment diaphragm, and on saying to the spring on the telephone, at one end of the telephone, "Do you understand what I say?" the answer from his assistant at the other end came back immediately; "Yes; I understand you perfectly." The sounds, according to the inventor, were feeble, and he had to hold his ear close to the little bit of iron on the parchment, but they were distinct.

The Bell telephone was an almost instant success; its inventor had wisely done all that he could to perfect it before making it public. A full description of how it works belongs more to a technical treatise than to this hurried survey of the marvels which electricians have given us. It may, however, be mentioned that in this Bell telephone—which, with its improvements, is known as the Gower-Bell instrument, and is the one in most general use—a strong ordinary bar-magnet has wound round one of its ends a coil of fine silk-covered wire in "metallic connection" with two terminals, one of which is connected, by means of telegraph wire, with the terminal of a similar instrument at a distance; the other terminal being connected by a short wire with the earth. Just in front of the extremity of the magnet—as near as possible without being actually in contact—there is a thin plate of iron, and in front of this the mouthpiece of a speaking-tube. The sound of the voice falling on the metal plate causes it to vibrate. These vibrations excite undulating electric currents which exactly correspond with the vibrations of the plate. These electric currents, being instantaneously transmitted along the wire to the telephone at the other end, cause exactly corresponding vibrations on its metal plate, which in turn sends similar air vibrations to the ear.

After having successfully exhibited his new and wonderful invention at Philadelphia, Bell showed it at Boston in the same year, when a speaker from the neighbouring town of Cambridge was distinctly heard. During the following year Bell delivered a lecture at Salem, a town some miles away from

Boston; yet every word of it was distinctly audible in that town.

In the year 1876 the British Association met in Glasgow. The members of one of the sections were somewhat startled at being told by Sir William Thomson that he had heard in Philadelphia Shakespeare quoted through an electric wire by the aid of the invention of Mr Graham Bell. This invention he went on further to describe as "the greatest by far of all the marvels of the electric telegraph." Any doubts which some of Sir William Thomson's hearers may have had as to the real practicability of Bell's invention were soon to be laid to rest, for, during the following year, 1877, the inventor visited England, where the fame of the latest electrical marvel had raised considerable curiosity and wonder, and, perhaps, no small degree of incredulity in the minds of many persons. However some persons may have imagined the telephone as merely a "tall tale," they were soon put right with regard to it, for its inventor exhibited it in London before the Society of Telegraph Engineers and other learned bodies, its success always being entirely unqualified. Everybody talked of the new wonder; all were anxious to see for themselves—or hear for themselves—how the thing really worked. During his visit Professor Bell was requested to exhibit his telephone before the Queen at Osborne, when a number of highly successful examples of its power were given. Among other interesting experiments shown was that of singing a song by telephone, which was distinctly heard, though a chain of five persons formed part of the circuit through which the current was made to travel. A number of exhibitions of the new marvel were made, and its great possibilities as a commercial and social success were very soon manifested. Both in America and England, as well as in other countries, companies were speedily formed and rapidly grew, until, at the present time, every important place of business is in telephonic communication with all others in the same city by means of telephone exchanges.

Early and distinctly successful telephonic experiments were tried over the telegraph wires between St Margaret's Bay, near Dover, and the French coast. "Although the wires were being used," wrote one who took part in the experiments, "on the ordinary business of the station, and the clickings of the Morse instruments being worked at Dover and Calais were going on all the time, yet the voices could be plainly heard and their tones distinguished. The songs sung in a little wild hut on the French coast were reproduced note for note and word for word, *piano* and *forte*, like the distant murmur of a shell—a small far-off voice—on this side the water. 'Star of the Evening' and 'Auld Lang Syne' came rolling across the rough and stormy Channel, down which ships were staggering with shortened sails, and through the tumbling surf, without the loss of a tone or a note. Whistling was tried with equal success, and the tunes were equally distinguishable with the songs. It was suggested that the popping of a cork might be made out, and our French friends were asked to listen attentively to what would happen. Unfortunately no bottles were at hand, but a gentleman of the party, equal to the occasion, put his finger into his cheek and admirably imitated the drawing of a cork. 'You have just drawn a cork,' came the voice from the other side, with just a shade of melancholy in its tone. A hearty laugh was raised by this mistake."

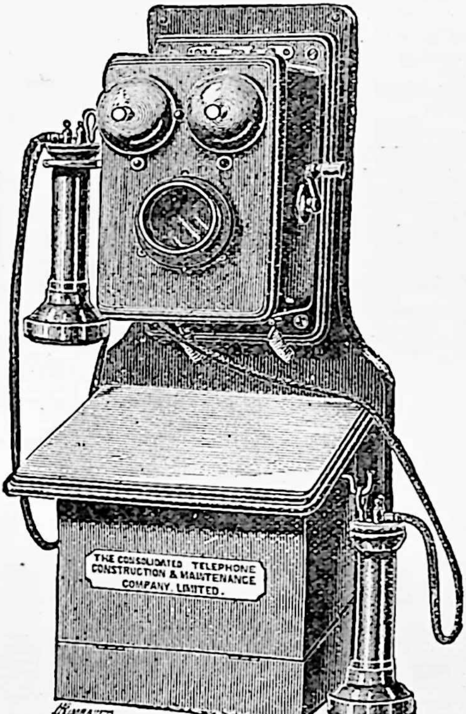
All these experiments and numerous others soon demonstrated the thoroughly workable nature of the new "marvel," and it was almost at once brought into practical operation in different countries, and has gone on rapidly spreading year after year. We have not yet, however, quite realised the following bold forecast, written when the invention was still in its infancy: "It is hardly going too far to anticipate the time when, from St James's Hall as a centre, Mr Gladstone will be able to speak to the ears of the whole nation, collected at a hundred different towns, on Bulgarian atrocities, or some other topic of burning interest. Nor need we despair of seeing Herr Wagner, from his throne at Bayreuth, dispensing the 'Music of the Future' in one monster concert to St Petersburg, Vienna, London, New York,—in short, to all the musical world at once."

In following the history of electricians and their marvels it is pleasant to find that, unlike Morse and Wheatstone with their telegraph, Graham Bell's invention met with almost instant success. It was received at first more as a wonderful toy, perhaps, than as a great commercial undertaking. Indeed, we find, as we found with the electric telegraph, that one of the first uses for which it was thought fitted was a medium for "lovers' whispered vows," for an early writer on the subject says, "one of the first steps which a young couple, upon their engagement, would naturally take, would be to have speaking wires laid down to their respective rooms, and then at any time, far from the curious eye of the world, they would be able to indulge in sweet converse."

Edison applied himself to experimenting with the telephone with important results, his first attempt being made with a Reis transmitter and a resonant receiver of his own invention. "My experiments in this direction," the great inventor wrote in 1878, "which continued until the production of my present carbon telephone, cover many thousand pages of manuscript." The telephone, as perfected by Bell and Edison, has become a daily companion well within a couple of decades. The instrument in most general use now may be said roughly to embody Bell's invention in the receiver and Edison's in the transmitter.

The use of the new means of communication spread very rapidly in all civilised countries; in America, as might be expected, the progress of the telephone was particularly rapid. By 1880, when the marvel was still of the newest, eighty-five towns in America had become connected by telephone, and numbered the grand total of 70,000 subscribers. In the New York central office there were *then* as many as 6,000 communications made daily.

During the Electrical Exhibition, which was held in Paris in 1881, an amusing peculiarity of the telephone was shown by Professor Hughes. He had found that the instrument has a fundamental note of its own, which it is more ready to vibrate in response to than any other. Professor Hughes was examining, as juror, and with many of his colleagues, a telephonic apparatus made by Dr Werner Siemens. No one could make it answer to his voice, when Professor Hughes, an accomplished musician, stepped forward and secretly ascertained the fundamental note of the telephone by tapping its plate. With a smile, he then turned to his fellow-jurors, saying that there was a peculiarity about the instrument; it was an Anglophile, and would only respond to the honoured name of Faraday. His colleagues all, of

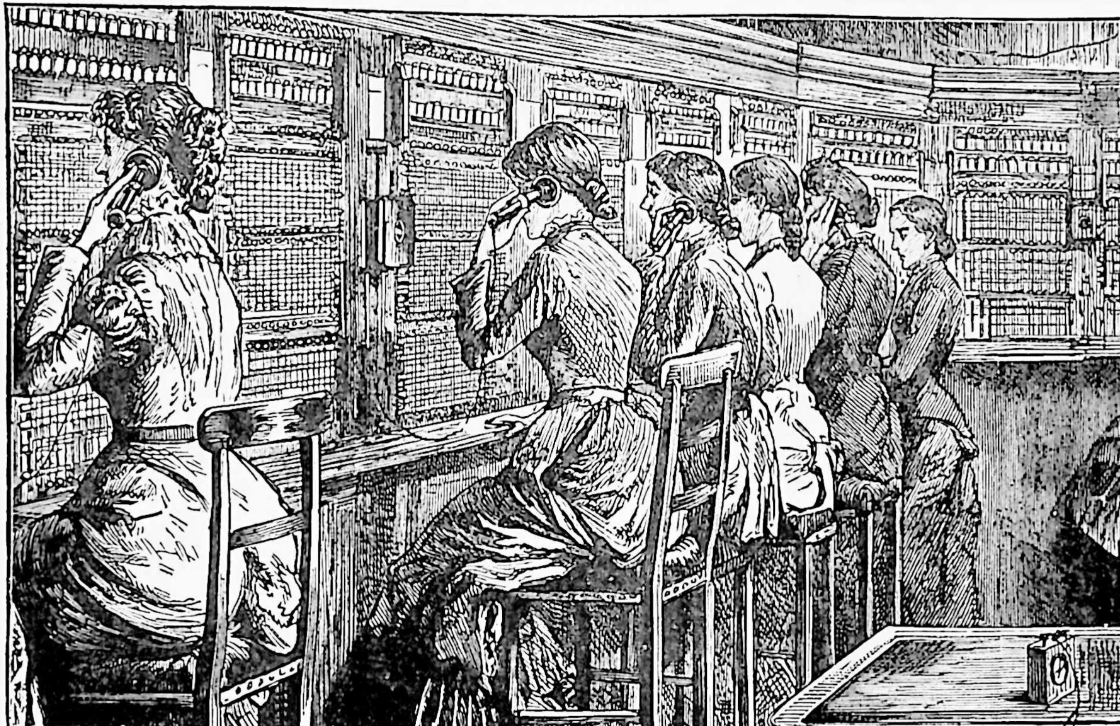


The Exchange Telephone.

course, declined to believe this, but looked with wonder when, after crying Siemens, Ohm, Volta, Ampere, Franklin, the telephone remained obstinately uncertain until Professor Hughes pronounced the magic word Faraday, to which it at once responded. The word Faraday had simply been spoken by him in the same tone of voice as the fundamental note of the telephone plate.

The year following that exhibition an interesting telephonic experiment was tried, according to the newspapers of the day, during the bombardment of Alexandria. A telephone was attached at Malta to the Alexandria cable, and connection was made with the other end of the cable on board the "Chiltern" off Alexandria. It was found that, owing to the distance, or the vibration caused by the firing, it was impracticable to send any spoken message, but the gun-firing at Alexandria was distinctly heard through the telegraph wires at Malta—a distance of more than a thousand miles.

Rapid as has been the growth of the telephone all over the world, its progress in Great Britain has been less rapid than in most other countries. By the year 1888 there were in London just over five thousand instruments connected with the various exchanges, representing nearly as many subscribers. In addition, there were also between one and two thousand private wires in the metropolis. The numbers are, however, steadily increasing, and communication can now be made to Manchester, Liverpool, and many more Midland and Northern cities. Paris and London were successfully connected by telephone in 1891; but America has a very much longer line in use between Chicago and New York, which shows that speaking over a distance of a thousand miles is quite practicable. The day may yet come when a telephone cable shall connect the Old World and the New, so that a whisper in London shall be heard in New York. On the Continent the rapid growth of the telephone is shown by the fact that in 1893



In a Telephone Exchange.

there were 70,000 miles of telephone wires laid in Germany, used by 50,000 subscribers; in Belgium, 12,000 miles of wire and half that number of subscribers; while Switzerland can number 10,000 subscribers and just as many miles of telephone wires.

One remarkable use to which the telephone has been put by Professor Hughes is in an invention for discovering the presence of metals. By uniting it to the coils of his induction balance the Professor has made the telephone sensitive in a remarkable degree to the presence of metals; so much so that it is possible to tell a good coin from a bad one, or a worn coin from a new one, by the sounds given out by the telephone. A further development of the balance was suggested for use in prospecting veins of metal; and the same—or a very similar—arrangement was used by Graham Bell in an attempt to locate the assassin's bullet in the body of President Garfield. The marvellous delicacy of the apparatus was once demonstrated in a decidedly curious and interesting fashion. Mr Elisha Gray, who had himself done much in telephonic investigation, expressed himself as doubtful of the performances of the balance, and suggested a severe test. He told Professor Hughes that for thirty years a very small spark of iron had lodged in one of his fingers, and could still be felt there like a pin-head. Could the balance discover which finger it was in? One after another the fingers of the injured hand were put in the balance; and when the "game" one was inserted, the telephone announced the fact in unmistakable tones. A similar contrivance has been arranged for discovering chains, anchors, etc., which have been lost at the bottom of the sea,—the balance, immediately it comes in contact with the missing metal, "telephoning" the message very audibly to the operator on deck.

Professor W. F. Barrett, at a time when the electric telephone was yet a novelty at which all people were marvelling, described a simple telephone which might easily be contrived by any one at a small expense:— It is simply an ordinary tooth-powder box, the lid of which is reversed, and fastened by screws to the bottom of the box; straight through the centre of both, a hole about the size of a sixpence is bored; and between them a disc of iron is firmly secured— the bottom of a thin tin canister answers very well. To permit of its vibration the wood must be slightly cut away. A penny reel of silk thread has its silk removed and the inner part of its bobbin reduced so as to bring the wire, which must be wound round it, very near the magnet; or a zinc or cardboard bobbin may be made. About thirty or forty yards of No. 36 silk-covered copper wire is coiled on the reel, which can then be glued to the lid. Another and perhaps better arrangement is to make the hole in the lid large enough to receive the rim of the bobbin, which is thus brought very close to the iron disc, a point of some importance. A few pence will purchase a bar magnet, that must be made to slide stiffly in the hole in the bobbin. The ends of the fine wire are joined to binding screws, which can be procured at an optician's for a trifling sum, and to these again are fastened the wires leading to and from the distant and similar instrument. or a gas-pipe may be used instead of the return wire A careful adjustment of the distance of the magnet from the iron disc is necessary. This is best done by bringing the magnet into contact first, and then withdrawing it to as small a distance as possible.

CHAPTER VI.

THOMAS ALVA EDISON.

"A man of herculean suggestiveness; not only the greatest inventor of the age, but a discoverer as well; for when he cannot find material with the properties he requires he reaches far out into the regions of the unknown and brings back captive the requisites for his inventions."

MOST people, if asked to-day to name the greatest electrician, would promptly reply "Edison, the inventor of the telephone, the megaphone, the rotophone, the aerophone, and numberless other wonderful things." A large number of persons would probably include the phonograph in their list, unconscious of the fact that that, seemingly the most wonderful of all Edison's inventions, is in reality perhaps the simplest, and a purely mechanical instrument. As an inventor, Thomas Alva Edison has constantly been before the public for the last twenty years with some new wonders, and these of a most varied kind,—so varied, indeed, that had we considered his life in our chapter on the electric telegraph, we should have been instantly reminded of his work in perfecting the telephone, his micro-tasimeter, his electric shears, and other important discoveries and inventions "too numerous to mention." So prominently does Edison stand to-day as the great human manipulator of the mysterious force of electricity, that it seems most fitting to associate an entire chapter with his name. We will therefore glance over the incidents of his eventful life, and take a peep at some of the marvels which he has perfected or is perfecting in his world-famous laboratory at Menlo Park, near New York.

The father of Thomas Alva Edison, of Dutch descent, had been tailor, nurseryman, dealer in grain, in lumber, and in farm lands, and later a produce merchant. He was always fairly successful and kept up a happy home, in which the future great inventor was brought up. In his mother, Edison was truly blessed. She was a woman of Scottish and English parentage, of good education and considerable force of character, who had spent part of her earlier life as governess in a Canadian high school. Edison was born on February 11, 1847, at the town of Milan, in Erie county, Ohio. His early education he received almost entirely from his mother, for his term of schooling was of the shortest. He very soon, however, gave evidence of an avid and catholic taste for reading. At the age of ten, for example, he was to be found deep in Hume's *History of England*, Gibbon's *Decline and Fall of the Roman Empire*, the *Penny Encyclopædia*, and such books on chemistry as he could obtain. We learn that Samuel Edison was so interested in his son's education as to pay him a fixed sum for each book that he read, so as to encourage him in his work. According to a writer who had opportunities of inquiring among members of Edison's family and others who knew of his early life, "there existed an unusual and superlative affection between the mother and her son. She seemed to love his very presence, and for this reason young Thomas was taught at home, where he might constantly add to the parental pleasures. It can be easily seen how Thomas Edison, under such benign and potent influences, became a well instructed and, we may add, a well educated boy; for he was taught the presence, power, and possibilities of human resources, and what he himself might ultimately accomplish if 'faithful to the end'; that the wide world was one great, broad field of activities, and that Nature was brimmed with law, order, the beautiful and good. His mother taught him not only his alphabet, spelling, reading, writing, and arithmetic, but also the great object of all learning. She was careful to implant the love of learning, and fire the young mind with a burning desire to know more of the 'great beyond.' In this she succeeded in a degree commensurate with her efforts, for at the age of ten young Alva's mind was an electric thunder-storm, rushing through the fields of truth."

A good story is told of Edison's childhood. It is given on the authority of his only sister. When he was about six years old he found out that a goose belonging to the family was sitting. Later he saw the surprising result in a number of goslings. One day he was missing. He was sought everywhere, but no one could find him, until at length his father discovered him curled up in a nest he had made in the barn, and filled with goose eggs and hen eggs. He was actually sitting on the eggs and trying to hatch them!

In 1854 his parents removed from Milan in Ohio to Port Huron in Michigan, and five years later young Edison began the battle of life low down in the ranks. He made his start as an active citizen of the United States in the capacity of train-boy on the

Grand Trunk Railway of Canada and Central Michigan. He seems early to have shown himself capable of making friends, and when the line between Port Huron and Detroit was completed, he was able to secure the exclusive right upon it as newsagent, and after a time in this capacity came to employ several assistants. Now the duties or privileges of the seller of newspapers on an American railroad car include the selling of fruits and sweets (they call them "candies") and books, and Edison has been asked, when talking of his early days,—

"Were you one of the kind of train-boys who sell figs in boxes with bottoms half-an-inch thick?"

"If I recollect right," he replied, with a merry twinkle, "the bottoms of my boxes were a good inch."

The headquarters in which the lad kept his stock-in-trade of newspapers and fruit was the disused smoking section of an old baggage car, and into this place he introduced two novelties. The first took the form of a number of bottles, retort stands, etc., that, with the aid of *Fresenius's Qualitative Analysis*, he might indulge in certain chemical experiments, which one cannot but think must have been rudely interfered with by the motion of the cars. The second novelty introduced into this strange sanctum was nothing other than a small printing press; for young Edison, by hanging about a large printing office in Detroit, had become seized with the idea of turning his newly acquired knowledge to account. Having at a favourable opportunity secured some three hundred pounds of type, he began printing a weekly paper, which he named *The Grand Trunk Herald*. The size of the paper was twelve by sixteen inches, and it was printed by the very primitive method of hand pressure, and on one side of the paper only; its columns being devoted to railway gossip, changes, accidents, and general information. The chief contributors to this unique periodical were

Edison printing *The Grand Trunk Herald.*

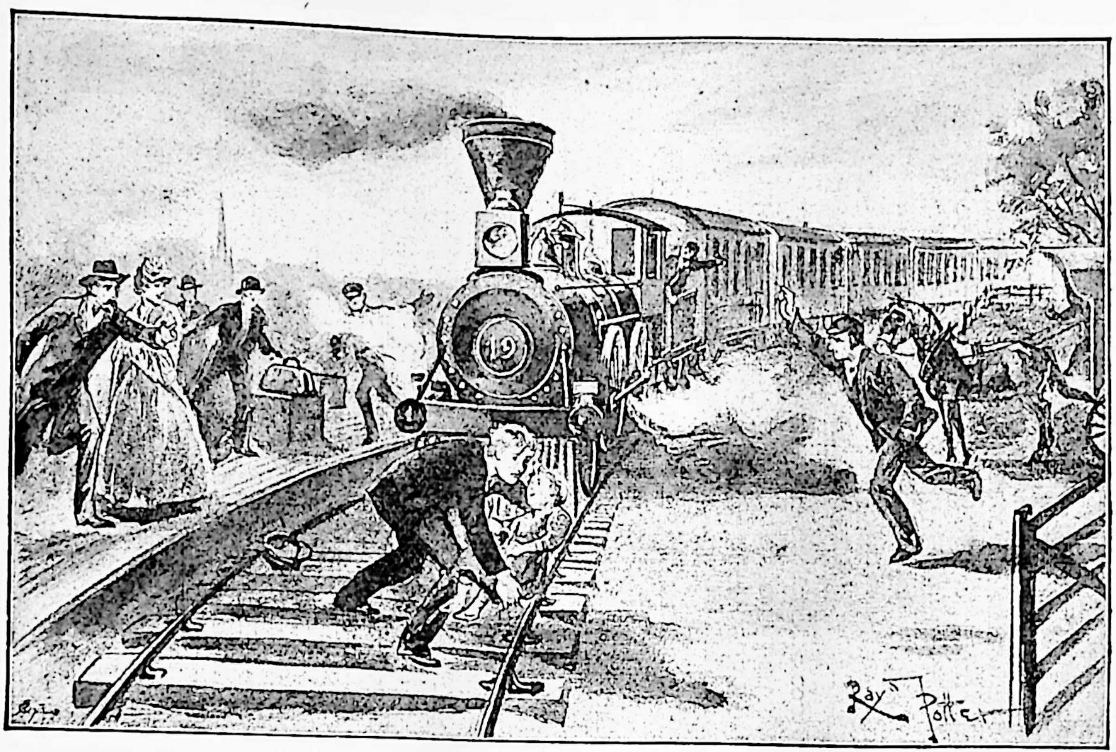
baggagemen and brakemen on the line. Insignificant as the journal was as a newspaper, yet a contributor to *The Times* drew attention to it as the only periodical printed in a railway train. The lad's first interest in the telegraph was awakened in connection with this paper; for when a certain battle had taken place in 1862, at Pittsburg Landing, he had exciting news for his patrons, and therefore telegraphed the head-lines of it on to those stations at which his train would stop, and where we may be sure the paper rapidly sold on its arrival. *The Grand Trunk Herald* continued in existence for six months, and attained a circulation of several hundred copies a week. The price was three cents a copy. On one occasion the modest but significant little *Herald* came under the eye of the great engineer, Robert Stephenson, who at once ordered an extra edition for his own use. This fact is well worth recollecting, for Edison was destined with his invention to work as great a revolution in modern life as the Stephensons had done with the locomotive.

The young train-boy scientist and editor did not, however, have things all his own way in his improvised laboratory and printing office, for when a phosphorus bottle, which had got thrown over, set fire to the old car, the conductor of the train rushed in, flung all the laboratory appliances out of the place, gave his young colleague a thrashing, and ejected him from the car. His next laboratory young Edison fixed up in the basement of his father's house at Port Huron, where, to prevent anyone tampering with his chemicals, he labelled every bottle "poison." There, too, he put up his printing press, and made a fresh essay in the triple capacity of editor, printer, and publisher. The new journal was called *Paul Pry*, and had a considerable success at first, but in an unlucky moment the youthful editor set up an article from a contributor, which gave great offence to a subscriber, who, meeting Edison near the river, deliberately picked him up and pitched him in. *Paul Pry* was discontinued.

Visits to Detroit had not only fired Edison with the idea of printing, but visits to its public library had shown him an easy method of acquiring knowledge. He resolved that he would systematically read everything in the library, and actually progressed along fifteen feet of shelving, in the course of which he read through, among other learned books, Newton's *Principia*, Ure's *Scientific Dictionaries*, and Burton's *Anatomy of Melancholy*. He, however, at length became aware that more effectual methods of study have to be adopted by such short-lived mortals as we are.

Always eager to be doing something, or learning something fresh, while he was thus engaged on the railroad, young Edison was seized with a desire to learn telegraphy,—he wished to know how the manipulating of the mysterious wires was managed. His opportunity came in a manner the most unexpected. He was hanging about the station at Mount Clemence one day, when he observed that a young child had wandered on to the rails. An express train was rapidly nearing the station ; there was not a second to be lost, when Edison leaped in front of the oncoming train, seized the child, and cleared the track just as the train rushed past. The child whom he had thus rescued from certain death happened to be that of the station-master, who became Edison's fast friend, and gave him his first lessons as telegraph operator.

From the basement office in his father's house in Port Huron, Edison extemporised a short telegraph line to the residence of a young friend and helper,



Edison rescuing the station-master's child.

James Ward. In its construction they proved the truth of the familiar proverb that "necessity is the mother of invention." The materials they employed were common stove-pipe wire, insulated with bottles placed on nails driven into trees, and crossed under an exposed road by means of a piece of an abandoned cable found near the river. The magnets were made of old wire wound about with rags for insulation, while a piece of spring brass formed the all-important key. The youthful electricians, having fixed up their line, "were somewhat mixed as to the relative value of dynamic and static electricity for telegraphic purposes, and the first attempt to generate a current was by means of a couple of huge cats rubbed vigorously at each end of the line at an appointed time." The chief result of this novel experiment was the extraordinary manner in which the cats, under the pressure of the moment, "lit out" at lightning speed, and were never heard of afterwards. Undeterred by failure—or by temporary hindrance, for it is doubtful whether Edison admits the word "failure" into his vocabulary—the young experimentalists purchased some old telegraph instruments and battery materials, and successfully fixed up telegraphic communication between their respective homes.

The bent of Edison's mind had manifested itself in a decided manner, and his knowledge as operator increased apace under the grateful tuition of Station-master Mackenzie. In five months after beginning these lessons he had qualified to act as operator, and was engaged in the telegraph office in Port Huron at a salary of twenty-five dollars a month, with the promise of extra pay for extra work. Night and day he stuck at his work that he might make himself thoroughly efficient as operator. But, finding after six months that the promised extra pay was withheld, he promptly resigned his post, left Port Huron, and went to Stratford in Canada, where he immediately got an engagement as night operator, despite the fact that he was only about sixteen years of age. While at Stratford he manifested his talents in a manner that was certainly more ingenious than honest. Every half hour he was instructed to report "six" to the circuit manager, but managed to arrange a mechanical contrivance to do the reporting for him. Meanwhile he slept. He was not at Stratford long when a slight error of his might have resulted in the wrecking of a train. The superintendent so alarmed him with reprimands, threats of imprisonment, and other dreadful penalties, that, without even waiting to gather his things together, young Edison left Canada, and returned to his Port Huron home.

On one occasion at Port Huron Edison gave a clear example of the fertility of his invention and the readiness with which he could adapt his knowledge. An ice-jam had broken the telegraphic cable between Port Huron and Sarnia on the Canadian side, and the river being a mile and a half wide, communication was of course stopped, but young Edison jumped on to a locomotive and seized the valve controlling the whistle. It had suddenly occurred to him that the scream of the whistle might be broken into long and short notes, and so represent the dots and dashes used in telegraphing.

"The whistle sounded over the waters: Toot, toot, toot, toot—toot, tooot—toooooot—toooooot—toot-toot—toot-toot.

"'Hullo! Sarnia! Do you get me?'

"'Do you hear what I say?'

"No answer.

"'Do you hear what I say, Sarnia?'

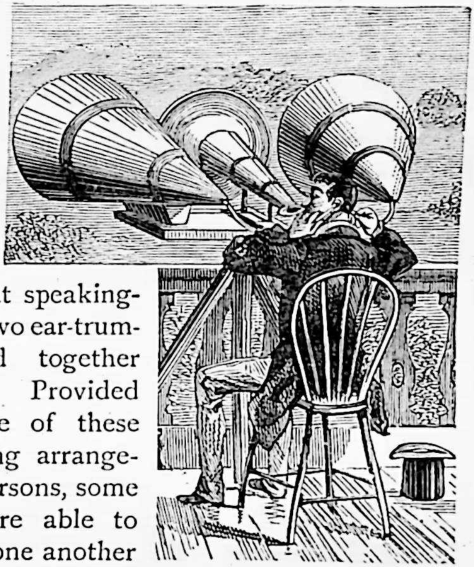
"A fourth, fifth, and sixth time the message went across without response, but finally the idea was caught by an operator on the other side; answering toots came cheerfully back, and the connection was again established. This novel incident was a feather in young Edison's cap, and his praises were sounded abroad."

His next station as operator was at Adrian in Michigan; from there he went to Cincinnati, where in three months he so distinguished himself as to have his salary raised from 65 to 105 dollars per month, and to be given control of the most important wire in the office. The special instance in which he had distinguished himself was when all the other operators had gone off "on a gigantic spree" to celebrate the organising of a branch of the Telegraphers' Union, and he remained and single-handed worked through the night clearing up the business. In 1864 he went to Memphis, thence to Nashville and Louisville, where he stayed for about two years, and afterwards to New Orleans and back to Port Huron, in each place making himself remarkable by his perpetual appetite for work and his incessant trying of experiments; it was, indeed, for the frequency of his experiments that he was generally dismissed. He had got firm hold of the idea of duplex telegraphy —of the possibility of sending two messages over a wire simultaneously—and was working towards this, despite all the chaff and insult of which he was made the object. For years he was called "loony" or crazy, merely, it would appear, because of his close study, his indomitable energy, and his objection to joining more frivolous-minded colleagues in their pleasures. Again he was given an important post in the Louisville office, but was compelled to leave owing to damage resulting from his experiments; once more he visited Cincinnati, but did not remain there long, for his fame as a rapid operator was becoming known to telegraph men, and a telegraphic message from Boston offered him a position to work the heaviest wire between that city and New York.

In Boston, where he commenced work in 1868, he rapidly made friends, and also extended the sphere of his experiments. He started a shop in which he spent all his spare time perfecting two or three telegraphic inventions, including a machine for printing the messages as received. Two years later, in 1870, Edison arrived in New York absolutely penniless. For three weeks he unsuccessfully sought for work in the various telegraphic offices. His position was becoming desperate, when, by great good fortune, he happened to go into the office of the Laws Gold Reporting Telegraph Co. Their instrument was out of order, how, or why, no one, not even the inventor of it, was able to explain. Edison promptly offered to put it to rights, and not too confidently, as we may imagine, he, a total stranger, was allowed to try his hand. In a very short time the instrument was working again as well as ever. His success gave them instant evidence of his ability, and Edison was immediately offered a post, and may be said from that moment to have gone forward upon his remarkably successful career.

He shortly afterwards entered into an agreement with the Gold and Stock Company of New York, which left him free to pursue his experiments to the full extent which he desired. He started a large electrical manufacturing establishment, where he employed a great number of men in making the things he had already patented, while he worked with feverish energy at a number of new ideas that filled his teeming brain. His opportunity had arrived, and he was not the man to let it go by neglected. At one time in his Newark establishment he had as many as forty-five separate inventions and improvements of inventions in hand at once. It was about this time that he was spoken of by the Patent Commissioner as "the young man who kept the path to the Patent Office hot with his footsteps." At the age of twenty-three he had attained success, yet had never attended a college or even a course of scientific lectures.

In 1876, then well started forward on the really successful stage of his remarkable career, Edison found his Newark establishment too small, and therefore removed to Menlo Park, about a dozen miles out of New York, where he erected and equipped a magnificent two-storied laboratory, 100 feet long by 28 feet wide. For nearly twenty years public attention has been drawn to that laboratory from which "the Modern Doctor Faustus," as he has been well named, has sent forth so many things whose wonderful nature has startled the world. One of the many visitors to Menlo Park had the curiosity to note down a list of some of the wonders of Edison's workshop, the existence of which we owe to his inventive mind. In glancing over this we shall find how wide is the range of the inventor's interests, and also make the acquaintance of some of the electrical and other "marvels" of this first of electricians, although it must be understood that the list is far from being exhaustive of all the marvels which we owe to Edison's inventive genius and untiring energy. The things mentioned are all of such a "marvellous" nature as to strike the popular imagination, but the list might be swelled by a number of other inventions and improvements more significant to the technician than to the general reader.



Using the megaphone on the balcony of Professor Edison's House.

First on the list comes the "megaphone," a great speaking-trumpet, and two ear-trumpets mounted together on a tripod. Provided each with one of these strange looking arrangements, two persons, some miles apart, are able to converse with one another in ordinary tones. The practical value of the megaphone is, however, somewhat minimised by the fact that all intervening sounds between the two speakers are gathered into the capacious ear-trumpets, so that the listener might get his friend's voice blent together with the lowing of cattle and the singing of birds. The instrument is best fitted for night use, because of the comparative stillness which then reigns over all.

Then comes the "aerophone," a great voice of two hundred and fifty times the capacity of the human lungs, which is designed to be used between lighthouses or lightships and vessels at sea. In the aerophone the inventor seems to have gone far towards realising the result of Homer's

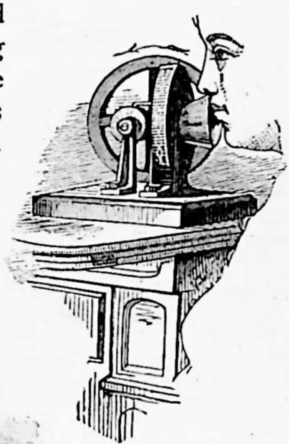
> "Thousand tongues,
> A brazen throat and adamantine lungs."

The "electric pen," the drawings and writings made by which could be used as stencils, may also be added to this list.

Another electric invention of some real, though perhaps not popular, importance is the "electromotograph"; and yet another is the "harmonic engine," a tuning-fork electro-magnet, two feet six inches in length, which is capable of pumping up three or four barrels of water at a cost of almost nothing.

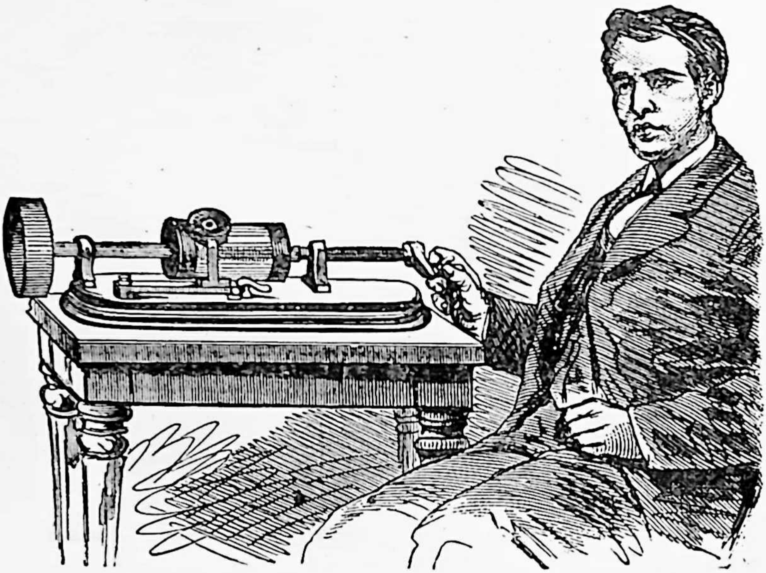
"Telegraphic printing," a method by which the sender sends his own handwriting; "electric shears," for cutting heavy materials; "electric engine," for embroidering, for revolving lights and goods in shop windows, and many other minor uses; a "flying bird," to go 1000 feet; a "phonomotor," in which a wheel that resists the hardest blowing is revolved easily by the sound of the human voice; a "microtasimeter," for measuring the heat of the stars; a "rotophone," in which a metal plate not only vibrates when spoken upon, but in doing so sets in motion a small toothed wheel by escapement so that speech can actually be made in a small way to do real work; a "phonograph";—these are but some of the marvels called into being by the hard work and teeming inventiveness of the Wizard of Menlo Park.

A later visitor has thus described his first introduction to the last of the marvels mentioned in the foregoing list. "At an adjoining table a workman was busily engaged in putting together the framework representation of an ancient negress, with a wide grinning face, and whom one could almost imagine to be shaking her sides with laughter. She was seated in an armchair. As the mechanic silently turned a crank with a heavy balance wheel the automaton turned its grinning head from side to side, fanned itself with a palm-leaf which it held in its right hand, and tapped its right foot in time with 'Mary had a little lamb,' which it seemed to utter with its lips. This was followed by a number of plantation and other melodies dear to the Southern darkey's heart. The old lady's clothes certainly did not fit her, but they came as near it as they usually do to fitting an overdressed plantation woman, and the song was almost perfect as one heard its melody exactly following the time kept by the tapping of the foot. It was the new phonograph toy, for the phonograph can be made to give a perfect voice to all the familiar automatic toys."



Young lady using the phonomotor.

Most of Edison's inventions have been carefully thought out and experimented upon for months or even years before they have become sufficiently perfected to make them public. Yet the inception of the phonograph appears to be an exception to this rule, for we learn that it was while he was working on the telegraph and telephone that he suddenly stumbled upon this, one of the most marvellous of all his inventions. He was experimenting in the winter of 1877 on an automatic transmitter when he determined to try tinfoil, instead of paper, to receive



Edison's first Phonograph.

the indentations of the Morse recorder. "These indentations, passing under another needle, were to repeat the message automatically to another wire. A few days after, while handling a telephone, the fancy seized him to fix a needle-point to a diaphragm, and see whether the vibration of the diaphragm, when spoken against, would prick his finger. It did. Then he wondered what sort of indentation this would make in a slip of paper. He tried it, and, sure enough, there was the semblance of an indented track! What would be the effect of drawing this slip under the point again, following the working of the automatic transmitter? He tried that, and the result was one which made him almost wild. A sound like the stifled cry of words seeking birth came from the diaphragm. No sleep or food until he had made a grooved cylinder, put a piece of tinfoil instead of paper on it, attached the diaphragm, and shouted into it, when, upon turning the crank, the words came back with a marvellous elocution, and the phonograph was a success."

Although it was Edison's electrical experiments that led him to discover the phonograph, that instrument itself is a purely mechanical contrivance with which we are not here further concerned. We have spoken of Edison's hard work, and it must be borne in mind that he has all his life been a most real hard worker. Many are the tales of his remarkable endurance told by his assistants. He often, when deeply engaged over some new invention, would work throughout the entire night. On one occasion he had undertaken a contract to finish a certain machine by a given date. The machine was finished some days before the time, but would not work. Edison resolved that a new one that *would* work must be made in the short time that remained. He took five men with him to the loft of his factory, and vowed that he would not leave it until he had succeeded. It took sixty hours' consecutive work, but was accomplished, and then the inventor took a short nap of *thirty hours.* For nearly ten years, according to one of his laboratory assistants, Edison averaged eighteen hours' work a day. "I have worked with him," the same informant adds, "for three consecutive months, all day and all night, except catching a little sleep between six and nine in the morning."

One of Edison's objects in removing so far out of New York as Menlo Park was that he might be less troubled with inquisitive visitors, but the difference in distance did not change matters much, and many scientific amateurs, and a large number of others anxious to see the "wizard" at work, still make the Edison laboratory the goal of many a pilgrimage; and, though always protesting against being thus lionised, he always receives his visitors with unfailing good humour. "Still, I shall blow up somebody yet," he is wont to remark laughingly. "I am considering the idea of fixing a wire connecting with a battery that knocks over everybody that touches the gate."

But, genial as he is to all who visit him at his workshop, it must be confessed that among the visitors are all sorts and conditions of persons who have not the slightest claim on his attention other than their own desire to satisfy curiosity. Among such persons the inventor sometimes meets with most decided bores. With one of these he had, he says, an amusing experience. The man wished to know all about the telephone. Edison is, of course, an enthusiast, and imagining he had come upon a kindred spirit, immediately began describing the telephone. "He explained it forwards and backwards, within and without; explained all around it, in fact, and received the usual answers."

"Yes," said the visitor, "I comprehend perfectly; simple enough." And so on until there was nothing left to show.

"Then," says Edison, "you can imagine how I felt when he said, 'Yes, Mr Edison, I understand it all, except how the sound gets out again.' I thought he had understood it, and he hadn't. I gave him up."

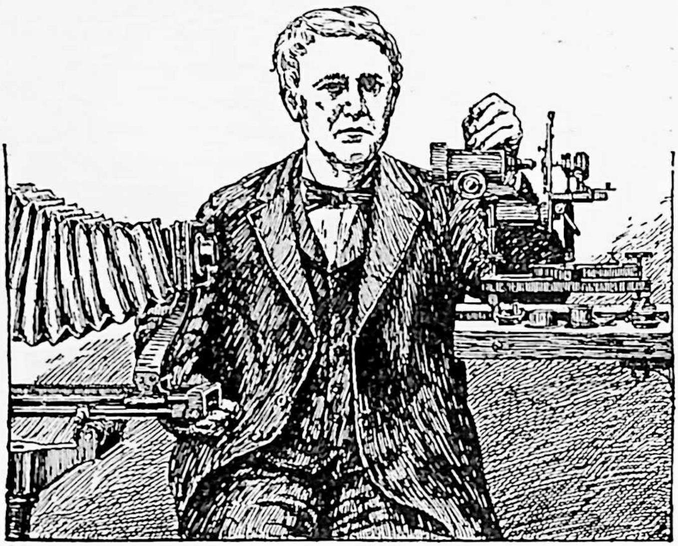
In his wonderful laboratory Edison has gathered together specimens of all known materials, that he may have everything at hand to further an experiment without delay. In the course of some experiments he may discover the action of a new chemical combination; it may have no significance bearing upon the matter in hand, but is nevertheless fully entered in one of the volumes of "laboratory notes," and put away in case it may some day be wanted. And in all these discoveries and experiments the great electrician has none of the secretiveness which is so often a part of the inventor's nature. His work is done in a manner that all can see, he seeming to have no fear of a workman or a visitor running off with one of his ideas and working it up elsewhere. This was once well illustrated when a visitor was looking over one of the numerous volumes of "laboratory notes." His companion interfered, saying that the volume was probably private.

"Oh, no," answered one of the men sitting near, "there is nothing private here. Everyone is at liberty to see all that he can, and the boss (Edison) will tell him all the rest. He has taken out more patents than any other man in America, but he never made an attempt in his life to keep anything secret."

It may be well before parting with Edison to recall that he is a pleasant-looking man of average size, about five feet ten inches in height, with his dark hair rapidly silvering, and with wonderfully piercing grey eyes. He married Miss Mary Stillwell at Newark in 1873; and nicknamed two of his young children

Dot and Dash after the signs employed in telegraphing on the Morse system.

An amusing story is told of Edison's marriage. A friend was passing his workshop in Newark very late one evening, and, seeing a light in Edison's room, went in to him and found him dozing over a problem which he had some difficulty in solving.



Edison and the Kineto-Phonograph.

"Hullo! Tom," cried the visitor cheerily, "what are you doing here this late? Aren't you going home?"

"What time is it?" inquired Edison sleepily, rubbing his eyes and stretching himself.

"Midnight, easy enough. Come along."

"Is that so?" replied Edison in a dreamy manner.

"By George! I *must* go home, then. I was *married* to-day."

Wonderful as are the many inventions which Edison has made, he has almost outdone himself in the one which he has just completed, called the Kineto-phonograph. This apparatus not only records and reproduces sound, but it records and gives back the impressions to the eye as well as to the ear. This is done by means of a series of photographs taken with such rapidity that 165,600 pictures are yielded in an hour. The camera for taking these pictures is electrically connected with a phonograph, and thus the records they take keep pace with one another. The scene which they have recorded is then thrown upon a screen, and as the apparatus is worked all the action is to be seen, and the voices of the speakers heard, as though the actual individuals were present. Speaking of this latest invention, Edison himself says that he believes that in coming years, by his own work and that of others, a grand opera will be able to be given at a theatre without any material change from the original, and with artists and musicians long dead.

And so we must take leave of the greatest inventive genius of all times. Edison is not yet fifty years of age, and comes of a very long-lived race, so that we may hope he has many more marvels yet to make known to the world. His grandfather lived to the age of 103, and his great-grandfather to that of 102.

CHAPTER VII.

ELECTRIC LIGHTING—EARLY ATTEMPTS.

"We have also furnaces that keep great diversity of heats. But, above all, we have heats in imitation of the sun's and heavenly bodies' heats, that pass divers inequalities, and, as it were orbs, progresses, and returns, whereby we may produce admirable effects. . . . We represent also all multiplications of light, which we carry to great distance, and make so sharp as to discern small points and lines; we find also divers means, yet unknown to you, of procuring of light originally from divers bodies." —FRANCIS BACON.

"IT will not do for us," says Oliver Wendell Holmes, "to boast about our young days, and what they had to show. It is a great deal better to boast of what they could *not* show—and, strange as it may seem, there is a certain satisfaction in it. In these days of electric lighting, when you have only to touch a button and your parlour or bedroom is instantly flooded with light, it is a pleasure to revert to the era of the tinder-box, the flint and steel, and the brimstone match. It gives me almost a proud satisfaction to tell how we used, when those implements were not at hand or not employed, to light our whale-oil lamp by blowing a live coal held against the wick, often swelling our cheek and reddening our faces until we were on the verge of apoplexy."

To old men, such as the genial "Autocrat" who wrote the above passage, the progress which has taken place in scientific knowledge during their lifetime must seem very remarkable when they mentally compare, as Dr Holmes was here doing, certain surroundings of their young days with that which at present obtains. Gas as a household illuminant was but newly discovered when Holmes was born; in 1807, just two years before that event, the first business house in the city of London was lighted by gas, and many were the prophecies uttered as to the early and utter collapse which was destined to attend upon the new light. Gas, however, despite all forecasts, rapidly proved its value, and in the course of the century, when every one had got thoroughly accustomed to it, there came rumours that the electric light, which had been discovered many years before, was going to be proved applicable to ordinary lighting purposes. Again many persons spoke of it as a fad and a dream, as their fathers had done of the gas, but to-day the electric light, if it has not yet become the most common illuminant, is lighting streets, houses, trains, 'buses, and public buildings pretty well all over the world.

Faraday's discovery that an induced current is produced by passing a magnet through a helix of wire forming part of a closed circuit, has worked wonders within the last half century in making possible the use of electricity as a motive power, and also in simplifying the production of electricity. To Faraday's early master and benefactor, Sir Humphrey Davy, the world is indebted for the first electric light. Yet it was the discovery of the younger man which, later, made it possible for the electric light to be generally used as an illuminant. What Davy did was to discover the arc-light which springs into existence between the points of two carbon pencils supplied with a current of electricity. When, in 1810, Davy first demonstrated this at the Royal Institution, probably there was nobody present who had any idea that before the century had passed away the new mysterious light upon the platform would have come to seriously rival the then wonderful and recently introduced gas. Davy himself probably never imagined what his discovery would lead to, for the cost of producing the light by means of chemical electricity, even during one short experiment, was very considerable. The same experiment was reproduced in Paris nearly a quarter of a century later by Professor Dumas, who was so enthusiastic over the intensely brilliant light produced that he ventured to predict its final success as an illuminant; and this despite the great cost of the light, which was then, we learn, about five and twenty shillings per minute!

The first occasion on which the new light was brought into actual use was only two years after Dumas' bold prediction. At the Paris Opera the electric light made its *début*, where it was used in one piece for a short time to represent the rising sun. This was a somewhat significant first appearance. Since then the light has risen far above the horizon, though it has not yet attained its zenith.

Paris was to witness, also, the second attempt at making the electric light practically useful. M. Achereau had been experimenting with the new light for some time, when at length in 1843 he was to make a public display of it in the Place de la Concorde. The eventful evening arrived, and the Place was filled with a crowd of four or five thousand persons, all eager and expectant. Everybody's gaze was fixed upon the apparently insignificant apparatus affixed on the base of one of the statues. The hour fixed upon for the display was nine o'clock in the evening. "All that was visible was a glass globe of about twelve inches diameter, with a movable reflector attached to it, and a couple of wires descending from it to some galvanic apparatus at the foot of the erection. Until a little before nine all was in darkness so far as the simple mechanism was concerned, but the Place was illuminated with its usual complement of a hundred large-sized gas-burners. The proper signal being given, the galvanic circuit was completed by the junction of the wires, and almost instantly the light of day seemed to burst upon the entire area. Although all the gas-lights were burning, they were almost invisible in the glare of the new source of light. A large number of them were put out, but the light did not seem to be in the least diminished. At the distance of a hundred yards it was possible to read moderate-sized print with great facility. The astonishment and applause of the populace were equally great, and the exhibition excited much interest in all scientific circles."

Faraday's great discovery had been made some years earlier than this, but had not yet been made so generally available as it was to be about twenty years later. It is curious that in 1845, two years after the display of the arc-light in the Place de la Concorde, we get the first hint of the incandescent light which in Edison's hands was to prove an even greater triumph, because more generally usable than the arc of Sir Humphrey Davy. In the year mentioned an ingenious American inventor named Starr, with the assistance of the wise philanthropist, George Peabody, visited England and took out patents for the use of platinum as a means for lighting purposes. In the same year another experimentalist recorded that he was enabled to read by the light afforded by an incandescent platinum spiral; while in 1847 Dr. Draper of New York made a number of experiments to test the qualities of highly heated platinum, and wrote that "an ingenious artist might arrange a self-acting apparatus to keep the platinum at a uniform temperature." It does not seem to have occurred to Dr. Draper that a current of electricity would have the desired effect, and some years were to pass before the "ingenious artist," in the person of T. A. Edison, was to arrive at that point by independent investigation. A little later than the date of Dr. Draper's experiments, a French inventor experimented with incandescent carbon.

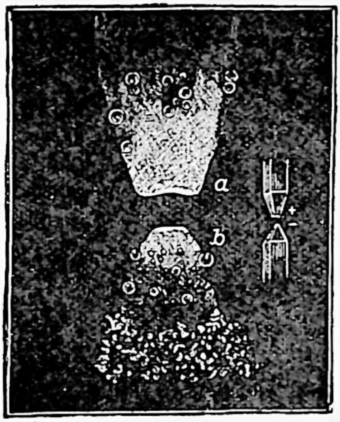
In 1850 an inventor of the name of Staite produced and exhibited in England an electric light, which was so successful that a company was formed to introduce it into general use. So favourable were the opinions entertained of it, that gas stock suffered a panic for a short time. Nothing came of this first effort to popularise the electric light. A few years later it was very effectively employed in France during the construction of the docks at Cherbourg. By its means nearly two thousand workmen were able to work at night-time. "Electric lighting had now," says one of its historians, "passed through three stages. It had been a brilliant laboratory experiment; it had been the subject of practical investigation; and it had been advanced to the precarious dignity of occasional use."

In 1859 an arc-light was fixed in the South Foreland Lighthouse, and was duly and favourably reported upon by Professor Faraday. Three years later this light was transferred to Dungeness, and the South Foreland reverted to its oil-light. In some respects the electric light is far superior to other illuminants for lighthouse purposes, but there was long a justifiable feeling of uncertainty as to its thorough reliability. So slight a hitch would immediately extinguish the light, that it was not safe to depend entirely upon it, and other means of lighting had to be kept at hand. Knowledge of the various problems attending the production and maintenance of the electric light has, however, increased considerably since then. After 1860 the invention of improved generators gave an impetus to the introduction of the electric light. Still only the arc system was known; and owing to the wearing away of the carbon pencils, this wanted very frequent attention. Several inventors set to work to make a self-acting arrangement, which should very slowly move the carbon points towards each other, as the intense current wore them away. This process of wearing away will be best understood by a description of how the arc-light works. The light is formed by the electricity leaping from one point to the other, and carrying with it the most infinitesimal portions of carbon brought to a white heat by means of the rapid vibratory motion of the current: the upper carbon it is which gives off these particles and showers them on to the lower one. After a while the end of the upper one becomes quite hollow, its centre being the most strongly affected and most luminous part. It is for this reason partly that arc-lights, both on street lamps or in buildings, are hung so high. During the Franco-Prussian war, when the German army was laying siege to Paris, the electric light was made use of by both sides. It was still, however, an uncommon thing, as means for its utilisation in an inexpensive manner had yet to be perfected.

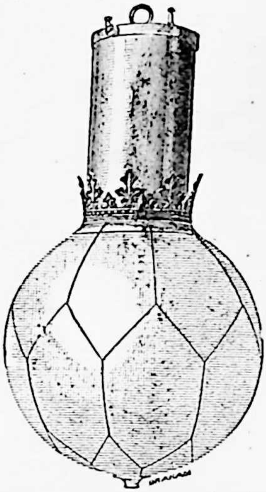
Towards the end of the seventies a number of rich American citizens interested themselves in the electric light so far as to subscribe among themselves a large sum of money—one hundred thousand dollars. This sum they at once handed over to Edison to use towards perfecting the new light. Confident that the problem was not without a solution, "The Wizard of Menlo Park" set to work with characteristic energy. At first he devoted himself to the arc-light, and the invention of a self-acting mechanism which should maintain carbons at an equal distance. To use the words of one of his assistants, "Mr Edison came to the investigation unhampered by the blunders of his predecessors. He had never seen an electric light. He took hold of the subject in his usual clear-headed, practical way."

Soon the inventor recognised the limiting powers of the arc-light, and discarded his investigations into it in favour of an incandescent light,—a light, that is to say, which, instead of consisting of a current of electricity leaping between two conductors, should consist of the current itself made visible by being carried over some substance which it heated up to a white heat. Innumerable experiments and all manner of substances were tried and discarded before the inventor finally solved the problem in a thoroughly successful manner by the production of the delicate "Edison incandescent lamp."

Another inventor, Swan, also invented a very similar light just about the same time. So similar were the two inventions that they were combined, and the small lamp, as we know it now, is generally called the Edison-Swan light. The lamp consists of a bulb of glass—pear-shaped—out of which the air has been pumped. The ends of the two wires are led into it, and connected by tiny platinum clamps to a very fine piece of carbon like a thread. The current, as it passes over the carbon, brings it to a white heat without wearing it away to any appreciable extent. The glow of the carbon thread is produced by the resistance offered to the passage of the current. The reason why the glass bulb must have the air pumped out of it—be made, indeed, as near a vacuum as can be—is because in ordinary air the carbon filament would be destroyed at once.



This block shows the "crater" of the arc, with the upper (positive) and lower (negative) carbons.

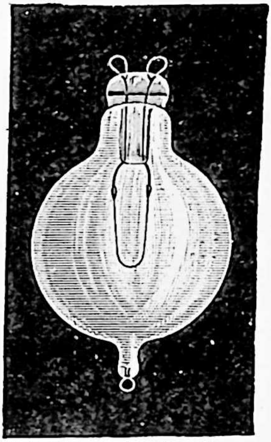


"The Harp" Arc Lamp.

Mr F. R. Upton, Edison's mathematician, in describing the light just after it was perfected, wrote, "the contrivances of the new lamp are so absurdly simple as to seem almost an anti-climax to the laborious process of investigation by which they were reached. A small glass globe from which the air has been exhausted, two platinum wires, a bit of charred paper—and we have the lamp."

When, however, the Edison-Swan lamp was a *fait* *accompli*, and it became quite feasible to fix the electric light in private residences, by means of small lights supplied from a central generating station, a further difficulty presented itself. The electric current had to pass through all the houses or other buildings connected together, so that if any mishap befell the installation in one house, the whole circuit would suffer. This was a difficult problem, but Edison set himself down to its solution, and with undoubted success. The plan which he devised for house-to-house electric lighting was that, instead of the current having to be driven through all the lamps, each house should be supplied by a branch wire from the main, another wire for each house taking the current back to the return main.

Year by year the soft, clear, and clean light of the incandescent lamp is becoming more generally used. At first the royalties due on new patents made the lamps far more costly than they should have been, but the price has now gone down to something like a quarter of what it at first was. All over the world the light is taking its place; and although it is yet far from having superseded gas as an illuminant, the day when it will have done so cannot now be far distant. Its numerous advantages are patent to everybody, while the objections of unsteadiness and glaring whiteness raised against the arc-light cannot be made against it. For illuminating large buildings and public thoroughfares the arc-light still holds its own, although it may here be mentioned that the system of lighting the British Museum reading-room by arc-lights, after nearly fourteen years' experience, has given way to the newer and better system. It was in 1879 that the reading-room was first lighted by electricity; four (later five) arc-lights were hung at about forty-five feet from the ground, and diffused a strong white but not very steady light all over the room. In 1893 these lamps were superseded by a large number of incandescent lights fixed above the readers' desks, one to each two seats. The improvement is certainly very noticeable, the new and soft light being much more agreeable than that of the arc lamps, the unsteadiness of which, it must be confessed, caused considerable irritation to the eyes.



The Edison Reading-Lamp, Incandescent.

Not only has the incandescent electric lamp proved itself admirably suitable for private houses, it has also shown itself to be unexcelled as an illuminant for railway carriages. From the passengers' point of view there can be no question as to whether oil, gas, or electric light is best. At present we are able on different lines to *enjoy* all these kinds of light, although it is to be hoped that the oil at least will soon be a thing of the past. It is nearly ten years since the London, Brighton, and South Coast Railway Company first tried the electric light in their trains, and they have now finally decided that the electrically-lighted trains are more serviceable than those lighted either by gas or oil. The electrically-lighted trains generate and store their own electricity during their running. They do not require to be hauled to the charging station as is the case with those illuminated by gas, and are therefore always ready for immediate use, and are estimated to render about fifteen per cent. more service than the others. The first cost of gas for a train of ten coaches, including the buildings and producer plant, is stated to be £700; that of oil £120; while electrically-lit trains cost £400. The yearly cost of maintenance is, with gas £120 per train; with oil from £70 to £130; while with the electric light it is only £50 per train. If these figures are to be relied upon, we ought not to have very long to wait before the electric light is adopted upon all our railway lines.

Pedestal Electric Lamp, Incandescent.

All kinds of ingenious uses have been made of the incandescent light, many of which are more marvellous than the many marvellous things spoken of by Bacon in the passages in *The New Atlantis*, from which is culled the quotation at the head of this chapter. One invention made two or three years ago by Mr Shelford Bidwell is sufficiently marvellous to merit particular mention. It is nothing less than a self-lighting and self-extinguishing electric lamp. It consists of an ingenious arrangement of ordinary Leclanché cells and a selenium cell, and is so sensitive to variations of light that directly daylight is sufficiently diminished, either naturally or by closing the shutters of the room in which the apparatus is placed, the lamp becomes lighted. Directly the shutters are opened or daylight appears the sensitive little lamp is extinguished. Although, as the inventor himself said, this is more a scientific toy than a thing of practical value, it may yet become a means to an important end.

CHAPTER VIII.

ELECTRIC TRACTION, BOATS AND SIGNALLING.

"Behold a single steersman sitting at the helm, guiding the vessel which divides the waves with greater rapidity than if she had been filled with a crew of mariners toiling at the oars. And the loaded chariot, no longer encumbered by the panting steeds, darts on its course with relentless force and rapidity. Let the pure and simple elements do thy labour; bind the eternal elements, and yoke them to the same plough." —ROGER BACON.

FRIAR BACON, the inventor of gunpowder, certainly wrote in the passage quoted above a very wonderful prophecy of the days of steam and electricity; of the days when a number of men should have arisen and united in "binding the eternal elements" so as to make them serve the purposes of mankind. We have seen in preceding chapters how this wonderful agent Electricity lights up our houses, our streets, and our railways; how it conveys for us on the instant a message to a distant friend, or enables us to converse with him privately at a distance of a hundred miles. We now come to see how this same mysterious force has been harnessed to the "loaded chariot," and will now not only carry our message or our voice to a distant place, but will also convey ourselves.

In 1831 the first electric motor was made by Salvator del Negro, and so early as 1838 the first electric boat was invented in Russia, by a man named Jacobi. This boat was launched, and worked on the Neva sufficiently to show the possibilities that were opening up in the electrical world owing to Faraday's important discovery of a few years earlier, referred to in the previous chapter. Although Jacobi had proved the possibility of propelling a small boat by electricity, the invention was carried no further for a considerable time. Scientists and business men were then too much concerned in the successful establishment of the electric telegraph to have time for such a small matter as M. Jacobi's electric boat. Yet though many years were to elapse before the early experiments of Salvator del Negro and Jacobi were to be carried out with any degree of permanent success, their efforts are not by any means insignificant. They were steps of progress, maybe, towards the crossing of the Atlantic by electric "liners." When steam was first employed on vessels, it was said that it might do very well for short journeys, but that it was ridiculous to think of employing it for any great distance. Indeed, a very high scientific authority is reported publicly to have said that he would *eat* the boilers and engines of the first steamer which crossed the Atlantic. It would be a rash undertaking of any follower of that gentleman to offer to make away in the same manner with the dynamos of the first ship which crosses the ocean by means of electricity.

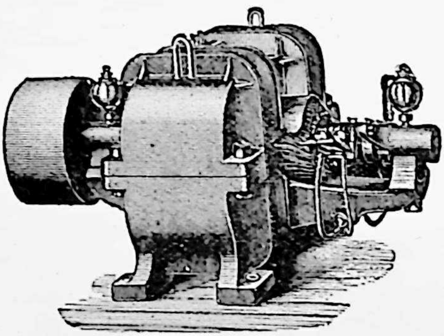
To Dr. Werner Siemens belongs the honour of having first insisted upon the value of the electric current as a motive agent. In 1867 Siemens suggested the possibility of employing electricity on elevated railroads at Paris, but it was not until some years later that he was enabled to superintend a practical illustration of what was possible. It is indeed less than twenty years since the first serious and sustained efforts were made to use electricity as a motive force, although it was some few years

Dr Werner Siemens.

earlier that the discovery of the dynamo-electric principle had made such use of it feasible. One of the earliest attempts was made by Sir William Armstrong at his country-seat, Craigside, near Newcastle-on-Tyne, where he erected a turbine,* and drove by

* A kind of horizontal water-wheel, made to revolve by the escape of

it a Siemens dynamo-electric machine. The current from this machine was then conducted to the residence, about half a mile away, where it was made to serve various useful purposes during the day; while at night it was used in the form of light, serving for between thirty and forty lamps. This case is interesting, as being one of the earliest examples of the transmission of power by electricity for practical and permanent purposes. The lamps which Sir William Armstrong employed at the time when he set up this plant were the "Swan" lights; and writing to a friend about them shortly afterwards, he said that the light given was perfect, so much resembling daylight that at the time of writing he had even been obliged to get up and draw the curtains, because there was a thrush outside trying to commit suicide by breaking through the window.



Dynamo-Electrical Machine.

Perhaps, before going any further to tell of the electric rail- and tram-ways which have been established in various parts of the world, it may be well shortly to say what the dynamo, which makes all this possible, is really like. It is difficult, of course, to avoid using technical words, and yet electrical

water through orifices, under the influence of pressure derived from a fall.

science, more perhaps than any other, has numbers of words the meaning of which the electrical student only knows. So far as possible throughout these pages, the aim has been to say what was done, and how the inventor made the doing of it possible, rather than to describe the make or action of the machinery or other agent which did it. The actual make, and method of working, of almost any one of the electrical marvels spoken of in this book would need as much space as is here given to the whole, and, besides, would then appeal more to the technical student than to the general reader. Roughly speaking, the dynamo-electric principle discovered was that one magnet revolving near another fixed magnet induced electric currents first in one direction as the revolving magnet approached the fixed one, and then in the opposite one as it receded from it. The revolving magnet thus produced an alternating current, first going in one direction and then in the opposite. This fatal objection to the conveying of power to a distance was done away with by a mechanical contrivance which switches the two currents off on to one wire in the same direction.

The working of a dynamo can best be described by an electrician, but the description is necessary, for it was not until the discovery of the dynamo-electric principle that the application of electricity to railways and other such practical uses was possible. "The machines which have caused this revolution in the application of electricity consist essentially of two parts—the fixed electro-magnets, by which a powerful magnetic field is created, and the revolving armature, which is connected with the commutator. When the machine is in action the rapid motion of the copper wire through the magnetic field induces an electric current, which leaves the helix by the brushes pressing against the commutator on opposite sides. From the brushes the current passes to the electro-magnets, and afterwards to the outer circuit, where it has to perform the useful work. In traversing the coils of the electro-magnets, it increases the intensity of the magnetic field, which in its turn induces a more powerful current, and this mutual strengthening of current and magnetic field goes on until a balance establishes itself."

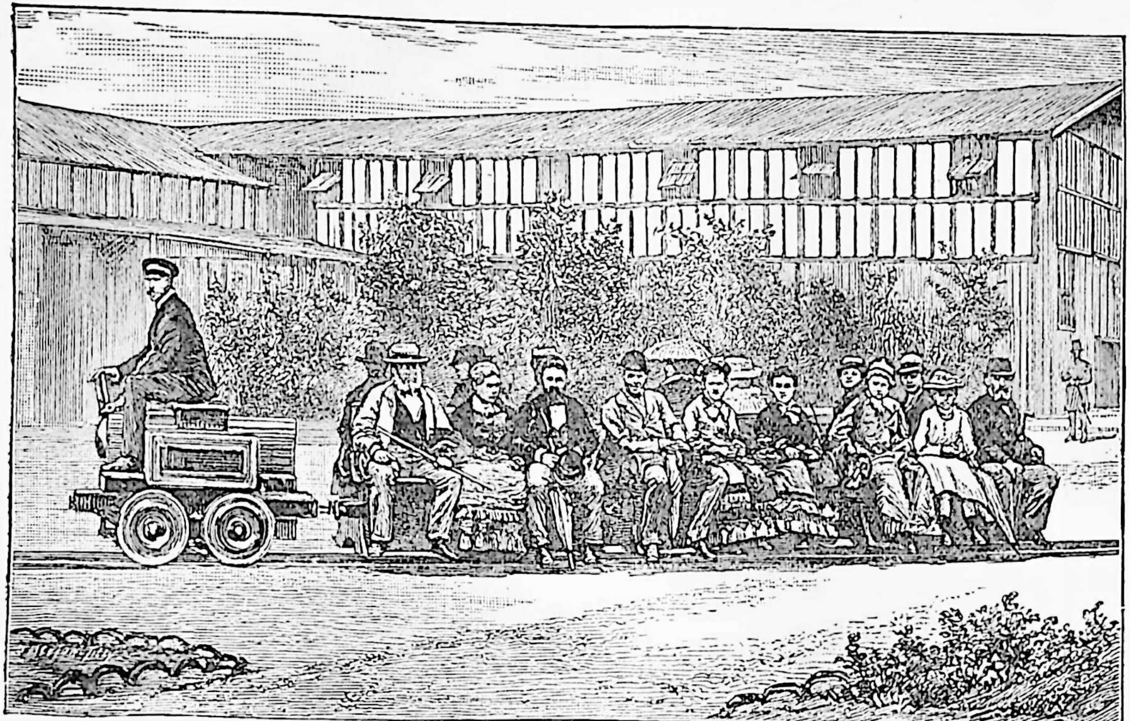
This discovery of the dynamo-electric principle, that power might be converted into electricity by an apparatus at one end of a wire driven through the wire, and in an exactly similar apparatus at the other end of the wire be re-converted into power, was one fraught, we may be sure, with very wide significance, a significance which is as yet made but little plain to us. It has rendered electric rail- and tram-ways possible; it has literally, to use Bacon's words, enabled us to bind the eternal elements and make them do our work. Indeed, Friar Bacon's words were realised with unusual exactness; for one of the early attempts at using electrical power was made in France in 1879, when a M. Felix successfully worked a double-furrow plough by its agency.

In one or two places in England, and in many towns in America and in Canada, electric tramways are now firmly established. To those who have used them much, the wonder is that they have not come more rapidly into general use, for the riding is smooth and rapid; the cars are easily started and stopped, while the cost is said to be one penny a mile cheaper than for horse traction. A good example of long-distance electric tramway is that between the "Twin-cities of the West," St Paul and Minneapolis. The cars run for ten miles, taking three-quarters of an hour over the journey, and the fare is fivepence (10 cents). The chief objection to these tramways is owing to the necessity of having in the streets so many poles and overhead wires to convey the current to the cars; this is done by means of a conducting rod, one end of which runs along the overhead wire, and the other of which is connected with the motor of the car. At night, as these cars run along the streets, frequent flashes of electricity are seen between this connecting rod and the wires, and between the wheels and the rails on which the car is run. The electric tramway of the future, that which will undoubtedly be in general use before very many years have passed, will, it is to be hoped, derive its current from an underground conductor. To speak, however, of electric tramways here as now in fairly general use in the United States, is a little out of place in the more or less chronological plan we have adopted.

In the same year, 1879, in which M. Felix successfully employed an electric plough in France, Messrs Siemens and Halske exhibited at Berlin the first serious attempt at forming an electrical railway. So successful was it, though the distance covered was but short, that they next suggested plans for building an elevated electrical railway in the German capital. This, however, they were not permitted to do; for the Emperor would not permit the Linden to be marred by being crossed at one point, and the citizens generally objected to having people look in at their second storey windows. Failing in this project, Messrs Siemens and Halske obtained a charter permitting them to lay a surface electric railway from the Berlin Military Academy to Lichtenfeld, a distance of one mile and a half. The current in this early attempt, it may be mentioned, was conveyed by means of one rail passed through the motor to the other rail, where it went back to its source and so completed the circuit. The railway was laid and opened in May 1881, and proved so successful that within the next few years it was extended to a distance of eight miles. After this line had been opened the municipal authorities of Berlin were long doubtful as to how they should classify the new railway so as to control the speed at which it might be permitted to run. After much serious deliberation it was decided that it should rank as a *one horse tram car*. In consequence of this decision the average speed of the electric railway might not exceed about nine, and its maximum twelve, miles an hour.

The same year that their Berlin electric railway was brought into actual use, Messrs Siemens exhibited their electric tramway at the Paris Exhibition, where it proved a great source of attraction to the curious. During the time that the exhibition was open, the tramway carried many thousands of passengers, and thoroughly demonstrated the value of electricity as a motive agent. The inventors of this tramway also exhibited it in several other continental towns, and afterwards it was to be seen in daily use by thousands of visitors to the grounds of the Crystal Palace.

All these Siemens' tram- and rail-ways were worked, as has been indicated, by a current of electricity conveyed to the motor and there reconverted into energy; but in 1882 a small railway—one of the earliest—was worked in France by means of electricity supplied



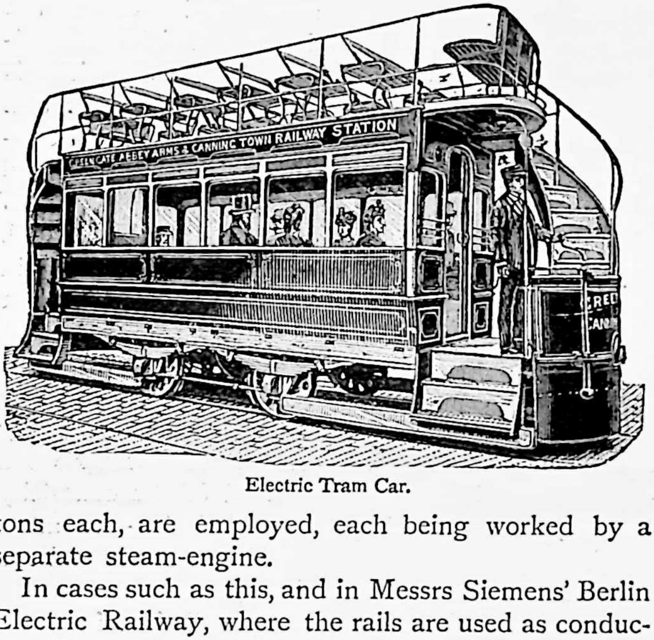
General View of Berlin Electric Railway Train.

from accumulators carried on the train. The railway was used in large bleaching fields, both for carrying the linen out into the fields and by means of a mechanical arrangement on the train of properly folding it after the bleaching had been effected. From this system the Siemens electric railway was a considerable step forward, and a still more important step forward remained to be made by the assistance of Edison.

The first electric railway within the United Kingdom was laid down by Messrs Siemens in 1883. The line runs from Portrush in the north of Ireland to near the Giant's Causeway, a distance of about six miles. The power to work the railway is generated by a waterfall on the river Bush, and is conveyed to the track by means of an underground cable. This railway has ever since been in use, and has proved highly satisfactory.

The first electric railway really worthy of the name which was established in England was the South London Electric Railway, which, starting from near London Bridge, runs under the bed of the Thames through Southwark, Kennington, and Stockwell. The success of this undertaking has been such as to cause several projects to be set forward for other metropolitan underground railways, besides extending the existing one on to Clapham Common and other of the South-western suburbs. Persons who are in the habit of having to use the ordinary underground railway, with its horribly vitiated atmosphere, would welcome electricity in the place of steam on that line, if the change could be effected.

Certain novelties in the construction of the South London Electric Railway merit mention. And, firstly, it must be borne in mind that *two* tunnels are used, one for the up and one for the down trains; these tunnels, which consist really of large iron tubes, are placed one below the other to save space. They are about sixty feet below the surface, each tube being but ten feet in diameter. The rails on which the trains run are employed as conductors. They are formed of the finest steel fixed upon glass insulators. To generate the electricity required, three large dynamos, weighing seventeen



Electric Tram Car.

tons each, are employed, each being worked by a separate steam-engine.

In cases such as this, and in Messrs Siemens' Berlin Electric Railway, where the rails are used as conductors, the current is carried along one rail to the engine, where it is picked up by an ingenious piece of mechanism, converted into mechanical energy in the motor, and thence escapes to the other rail, along which it instantly flies back to its source, and so completes the circuit. In some cases, instead of having one engine to draw a train of carriages, an electro motor is placed beneath the floor of each carriage, and thus a better and more equable speed is gained. Four things in electrical railways are absolutely essential; the differences of various systems being mainly in the manner in which the current is led to the motor. These four essentials are—a generator, or source of power, such as a steam-engine or water wheel; a dynamo-electric machine, in which the energy of the coal or water is converted into electricity; a pair of conductors, by which the electricity is conveyed to and fro between the electric motor and the dynamo; and an electro-motor, in which the electricity is reconverted into mechanical power and applied to turn the wheels of the train. One chief difficulty has always been over the third essential, that of the conductors. Overhead wires, as used in American and Canadian cities, are, to say the least of it, unsightly, while there is danger in having exposed rails where the current is anything but very weak. At Brighton, for example, as many readers will be aware, an electric railway runs along the sand, but there the current is sufficiently weak —possibly owing to a good deal of the electricity escaping, owing to imperfect insulation—to allow of visitors standing, one on either rail, to take a slight shock.

Edison and Field's system was a distinct improvement on both the overhead wires and the rail conductors. Their conductor was underground along the middle of the railway track, and a rod conveyed the current from it to the motor. Roughly speaking, this might be called a reversal of the overhead system. Professors Ayrton and Perry's improved system of electric railway appears to be the best; certainly the account Professor Ayrton gave of it some years ago makes it seem like the realisation of an ideal. It is to be presumed that some drawback has so far tended to retard its general adoption. According to the account referred to, the dangers of collision are so far minimised as to be absolutely done away with. The train takes its current by the very slight depression of the rail caused by its weight. The rail is divided into sections, and it is necessary that a vacant section should always occur between any two trains. The full significance of this invention may best be given in Professor Ayrton's own words, used in a lecture on the subject, given over ten years ago at the Royal Institution. "Not only does the train take off current from the section 1 when it is just leaving it, and entering section 2, but no following train entering section 1 can receive current or motive power until the preceding train has entered section 3. . . . The second train is not only deprived of all motive power, but is powerfully braked, since, when electricity is cut off from a section, the insulated and non-insulated rail of that section are automatically connected together, so that when the train runs on to a blocked section the electro-motor becomes a generator short circuited on itself, producing therefore a powerful current which rapidly pulls up the engine. Whenever, then, a train, it may be even a runaway engine, enters on a blocked section, not only is all motive power withdrawn from it, but it is automatically powerfully braked, quite independently of the action of the engine-driver, guard, or signalman. No fog, nor colour-blindness, nor different codes of signals on different lines, nor mistakes arising from the exhausted nervous condition of overworked signalmen, can with this system produce a collision. The English system of blocking is merely giving an order to stop a train; but whether this is understood or intelligently carried out is only settled by the happening or non-happening of a subsequent collision. Our Absolute Automatic Block acts as if the steam were automatically shut off and the brake put on whenever the train is running into danger; nay, it does more than this—it acts as if the fires were put out and all the coal taken away, since it is quite out of the power of the engine-driver to restart his train until the one in front is at a safe distance ahead."

In electric navigation, as we saw earlier in this chapter, attempts were made, so far back as 1838, by Jacobi at St. Petersburg, and a few years later a French inventor tried a smaller boat on the Seine. Two or three subsequent attempts were made, but no very definite forward steps were taken before 1882, when the little electric launch "Electricity" was successfully navigated on the Thames. Within the past few years considerable improvements have been made, and now electric launches are common objects "up the river." The change is unquestionably for the better, and it will be better still when the new boats have entirely superseded the less cleanly steam launches.

A few words may well be said here with regard to the use of electricity in signalling. It is employed largely on railways, as we shall see shortly in noticing Preece's "block system." But first it may be interesting to draw attention to a recent discovery which promises important results in the future. This is nothing less than *signalling without* wires. At the great Chicago Exhibition of 1893 Mr W. H. Preece, the eminent English electrician, read a very important paper on "The Transmission of Electric Signals through Space," in which he described experiments made across the Bristol Channel between Lavernock Point and Flatholm, an island about three miles away, and also between the Point and Steepholm, two and a half miles further away. Across the three miles there was no difficulty in communicating intelligibly, but with the longer distance conversation was impossible with the apparatus and arrangements at command. Communication has thus been proved practicable under certain conditions. Further developments of this wonderful discovery will be looked for with more than common interest.

Electric signalling on our railways is of very considerable importance; by its use on what is known as the "block system," the chance of accident is reduced to a minimum. Mr W. H. Preece, in giving a lecture before a juvenile audience at the Society of Arts, described the system in an admirably clear manner. The example he gave was chosen on the London and South-Western Railway, for there his own system was employed. "A little semaphore is in front of the instrument (electric bell and signalling apparatus), which, when down, indicates that all is clear, and, when up, that there is danger, and the train must stop. Let one instrument represent Waterloo, and another Vauxhall, and between them we have a 'section' of the railway upon which only one train is allowed at a time. To ascertain if all is clear at Vauxhall, a warning signal of two strokes of the bell, given twice, is sent, indicating 'a train is coming'; this is acknowledged by one stroke in reply, and the semaphore arm being down, and thus showing the line to be clear, the train continues, a signal of two strokes being sent on to notify the Vauxhall signalman. The semaphore at Waterloo, behind the train, is then raised by the Vauxhall man, and the signal acknowledged by one stroke of the bell. As soon as the train is in Vauxhall the semaphore is lowered, but until it is, the Waterloo man may not allow another train on to the section. Three strokes of the bell form the signal which accompanies the lowering of the semaphore and announce that the line is clear, and that the double apparatus is working properly."

It has been seen, in treating of electrical railways, how mechanical force, owing to Faraday's great discovery, may be converted into electricity, conveyed to a distance, and then, being reconverted into mechanical force, be made to do all kinds of work. So long as fifteen years ago, when Professor Ayrton was lecturing at Sheffield on "Electricity as a Motive Power," he ground knives and did other work on the platform by electrical power conveyed from a quarter of a mile away through wires carried over the houses.

Waterfalls are found particularly useful as providing the initial force to be converted into electricity. Many towns on the Continent and in America are lighted by electricity gained from a neighbouring waterfall. Sir William Thomson first proposed to utilise some of the power of the stupendous Niagara Falls for the purpose of lighting the towns and driving the mills for a hundred miles around. The suggestion has been so far carried out that part of the force of the fall is now used to generate electricity for commercial uses.

CHAPTER IX.

ELECTRICITY IN THE HOME.

> "What cannot art and industry perform
> When science plans the progress of their toil."
>
> —JAMES BEATTIE.

"CHEMISTRY," said a writer in *The Edinburgh Review* nearly half a century ago, "has long since come down from her atomic altitudes and elective affinities; and now scours and dyes, brews, bakes, cooks, and compounds drugs and manures with contented composure."

Science, in other words, instead of remaining close shut within the four walls of the study or the laboratory, has taken to going all over the house, and even to penetrating down to the kitchen and exercising her influence there. Electricity lights the home for us, it rings our bells, warms our rooms, cooks our dinners, and does so many things for us within the sphere of home that there does not appear to be any extravagance in the following forecast.

"We shall, I believe," said Professor John Perry at the Society of Arts more than thirteen years ago, "at no distant date have great central stations, possibly situated at the bottom of coal pits, where enormous steam-engines will drive enormous electric machines. We shall have wires laid along every street, tapped into every house as gas-pipes are at present; we shall have the quantity of electricity used in each house registered as gas is at present; and it will be passed through little electric machines to drive machinery, to produce ventilation, to replace stoves and fires, to work apple-parers, and mangles, and barbers' brushes, among other things, as well as to give everybody an electric light." Indeed, so far from being extravagant, the few years that have elapsed since those words were spoken have, to a very great extent, already justified them. Electricity can now be "laid along every street and tapped into every house," thanks to the inventive genius of Thomas Alva Edison; and, thanks to the same great electrician, it is possible also to measure the quantity of electricity used in each house connected with the main. And when we have once got the electric installation in our houses, when we are once connected with the central generators, we are at liberty to use the current not only for lighting purposes, but also for performing many household works.

One of the very simplest and most familiar examples of "electricity in the home" is to be found in the electric bell, which has now largely superseded the old-fashioned bell and bell-pull. For the invention of the electric bell—one of the very earliest examples of the electrical transmission of energy—we are indebted to Sir Charles Wheatstone. George Cruikshank, in testifying to Wheatstone's early telegraphic experiments, said, "We are also indebted to him for the electric bell, for, long before the telegraph came before the public, in explaining the machine to me, he said that, as it was possible that one party might be asleep at one end of the wire, he had so arranged the working that the first touch should ring the bell at the other end, even if thousands of miles apart. This, it will be admitted, is an important part of the discovery." The electric bell, which, on the slightest pressure upon the little bell-push, rings loudly, is now fitted in nearly every house, certainly in all newly built houses.

Except as a ringer of bells and an illuminant, electricity cannot, so far, be said to have made any very great way in the home, although its influence there is becoming daily more marked. In America the "domestic telegraph" has made considerable headway; and in England a similar instrument in connection with the corps of "Boy Messengers" is coming into fairly general use in large establishments. By the means of a small apparatus it is possible at once to call a messenger, a cab, or a policeman, or to give an alarm of fire. The usefulness of this is so manifest that it seems remarkable that it does not become more general.

So soon as electricity is laid on to a house it is quite easy to employ the subtle force for many of the purposes enumerated by Professor Perry. All that is required is a small Edison or other motor, which may be connected with the lighting wires and made to do such work as the turning of a sewing-machine, at no greater cost than one lamp would have been lighted for the same length of time as the machine was kept at work. In country-houses the uses which may be made of it include the working of chaff and turnip-cutters and similar machines.

Sir Charles Wheatstone many years ago, as we saw in an earlier chapter, proposed to "lay on time through our houses" by means of an electric current from a central clock turning the hands on a number of other clock faces. In 1893 an improvement on this system was made, in Germany. We have, of course, for some years been familiar with the synchronising of clocks in railway stations and other public places by hourly electric current from Greenwich Observatory; the new method is, however, an improvement even upon that extremely useful plan. By means of this new system one central office would control all the clocks on a given circuit. The clocks in our houses would be merely joined on to the electric lighting wires, and would then be kept wound up and at the right time by means of the current from headquarters, at a cost, it is said, of about fourpence per annum. This, surely, is a "consummation devoutly to be wished." We shall have no more clocks "ten minutes fast" or "ten minutes slow," no dreadful results of forgetting to wind the clock over night or on its eighth day: "as sure as the clock" will come to be a saying of some real significance.

Inventors are engaged in trying hard to press electricity into the service of the kitchen, not only to turn knife-cleaners and do "base mechanic" work of that kind, but to make it actually cook our dinners. Efforts in this direction have already had some success, although it has so far proved too costly and too slow a method to be practically adopted. It seems, however, quite likely that the difficulties which yet stand in the way will be cleared away by some ingenious inventor.

For heating purposes electricity has proved more amenable. In 1892 MM. Olivet of Geneva brought out a new system of electrical heating applied to conservatories, greenhouses, etc., which worked with considerable success. It is, of course, only practicable where some motor force is already available. A dynamo worked by this motor sends the current into receivers of special metallic composition, which become rapidly heated, without, however, exceeding a certain temperature. A heated air current is set up, as with steam heating, and the advantages claimed for it over that system are the total absence of any unwholesome vapour that might prove detrimental to the plants, simplicity of construction in the parts conveying the energy, perfect safety as regards heat, which can be easily regulated, cleanliness, and above all rapidity in starting and extinction, a point of some importance in a changing climate. In connection with its use in conservatories, it may be mentioned that elaborate experiments are being tried as to the influence of electric light upon plant life, and that, among other things, it has been found to considerably accelerate the growth of certain winter-crops.

The minor uses to which electricity has been put are innumerable. We have become so far familiarised with it that when a ticket inspector jumps into an omnibus, touches a little switch, and immediately has a brilliant little incandescent light burning in the buttonhole of his coat, we are no longer surprised. It is not very many years since such an action would have looked somewhat like a manifestation of evil powers. A recent invention has even employed electricity for adding a sting to a horsewhip. The invention is certainly ingenious, although it may be hoped that it will not be used in practice. The electric horsewhip is the discovery of a Frenchman. It consists of a celluloid handle, containing a small induction coil, together with a battery, the circuit being closed by means of a spring-push. Two wires carry the current to the extremity of the whip, which is furnished with two small copper plates, having points fixed to them of sufficient length to penetrate the coat of the horse, and yet not being sharp enough to inflict a wound. The invention certainly savours of cruelty, and is scarcely likely, or we should think fitted, to be really used.

We can have electricity laid on to our houses and used more effectually than the most wakeful of watch-dogs. Very simple is the arrangement, which may be so fitted to our windows and doors that if one of them be opened during the night a bell shall be set a-ringing, which shall not cease until some one is aroused and goes and breaks the circuit which has been so simply and effectively completed. A somewhat alarming disturber, this, of burglars and other evilly-disposed night-birds. Not only will electricity serve us in thus betraying the whereabouts of a housebreaker, but it will also automatically ring an alarm-bell in case of fire. This is done by means of a fine thermostat, in which the growing heat expands a metal spring until it touches another piece of metal, and so completing the circuit, rings the bell. The thermostat may even be electrically connected with a neighbouring fire-station, and so give the alarm there also. A similarly delicate instrument, too, may be used for giving warning of the approach of frost in our green-houses and conservatories.

Electricity has already become familiar to us in a number of ways: we know that there are many things it does do for us, that there are many others which it can do for us—but who shall say what it yet *may* do for us?

PRINTED BY NEILL AND COMPANY, EDINBURGH.

S. W. PARTRIDGE & CO.'S
CATALOGUE
. . OF . .
POPULAR ILLUSTRATED BOOKS.

Classified according to Price.

---

8 & 9, PATERNOSTER ROW, LONDON, E.C.

6s. each.

Large Crown 8vo. Cloth Boards, gilt top.

Adam Argham. By Mrs. S. R. Graham Clark. 430 pages.

A Wife Worth Winning. By C. E. C. Weigall. 344 pages. Twelve Illustrations.

Old Readymoney's Daughter. By L. T. Meade. 332 pages. Twelve Illustrations.

The Letter Killeth. By A. C. Inchbold. 310 pages.

Japan: From the Old to the New. By R. G. Webster, LL.B., J.P. With 16 Illustrations on art paper. Demy 8vo.

5s. each.

BY GEO. MANVILLE FENN.

Large 8vo. Fully Illustrated. Handsomely bound.

Steve Young; or, The Voyage of the "Hvalross" to the Icy Seas. Illustrations in colour.

Dead Man's Land; or, The Adventures of Certain and Uncertain Whites and Blacks at Zimbambangwe, the Ancient Home of Gold.

Trapper Dan. A Story of the Backwoods.

To Win or to Die: A Tale of the Klondyke Gold Craze.

In the Mahdi's Grasp.

BY KENT CARR,

Author of "A Rank Outsider," etc.

Playing the Game! A Public-School Story. 416 pages. Demy 8vo. Illustrated Cloth boards, gilt edges

---

Cap'n Nat's Treasure: A Tale of Old Liverpool. By Robert Leighton. Eight Illustrations. Large Crown 8vo. Cloth.

Cuthbert Hartington: A Tale of Two Sieges. By G. A. Henty. Large Crown 8vo, Six Illustrations. Cloth boards, gilt edges

The Two Babylons; or, The Papal Worship proved to be the Worship of Nimrod and his Wife. With 61 Illustrations from Nineveh, Babylon, Egypt, Pompeii, etc. By the late Alexander Hislop. Demy 8vo. Cloth extra.

New 5s. Library.

Demy 8vo. Of special bulk. Well Illustrated. Bound in handsome Cloth Boards with full gilt Edges. 5/- each.

The Three-Cornered House. By Evelyn Everett-Green.

Vashti Savage. By Sarah Tytler.

Cuthbert Hartington: A Tale of Two Sieges. By Geo. A. Henty.

The Lady of the Forest. By L. T. Meade.

True unto Death: A Story of Russian Life. By E. F. Pollard.

The Better Part. By Annie S. Swan.

3s. 6d. each.

Large Crown 8vo. Illustrated. Cloth Boards, with gilt top.

Runners of Contraband: A Story of Russian Tyranny. By Tom Bevan.

An Earl without an Earldom. By Scott Graham.

Done and Dared in Old France. By Deborah Alcock.

A Strong Man's Love. By David Lyall. Twelve Illustrations.

Just Percy. A Tale of Dickton School. By H. S. Whiting.

Old Wenyon's Will. By John Ackworth. Twelve Illustrations.

More than Money. By A. St. John Adcock. Twelve Illustrations.

The Three-Cornered House. By Evelyn Everett-Green.

Casque and Cowl: A Tale of the French Reformation. By F. M. Cotton Walker. Four Illustrations.

A Lady of High Degree. By Jennie Chappell.

Pilgrims of the Night. By Sarah Doudney. Frontispiece.

The Scuttling of the "Kingfisher." By Alfred E. Knight. Frontispiece.

The Missing Million. A Tale of Adventure in Search of a Million Pounds. By E. Harcourt Burrage.

Ruth Gwynnett, Schoolmistress. By Morice Gerard. Twelve Illustrations.

3s. 6d. each *(continued).*

The Story of the Bible. Arranged in Simple Style for Young People. *New Edition.* Demy 8vo. 620 pages Eight beautiful pictures in colours, and more than 100 other Illustrations. Cloth extra, 3s. 6d. Gilt edges, bevelled boards, 4s. 6d.

The Pilgrim's Progress. By John Bunyan. Illustrated with 55 full-page and other Engravings. Crown 4to. Cloth extra, 3s. 6d. Gilt edges, 5s. Padded Watered Silk, 6s. 6d.

2s. 6d. each.

"*Girls' Imperial Library.*"

By Popular Authors. Large Crown 8vo. 330 pages. Six Illustrations printed in photo brown. Handsomely bound in Cloth Boards.

Evan Grayle's Daughters. By Isabel Suart Robson, Author of "The Fortunes of Eight," etc.

Cliff House: A Story for Schoolgirls. By A. M. Irvine.

The Ways of a Girl: or, The Story of One Year. By M. F. Hutchinson.

Those Berkeley Girls. By Lillias Campbell Davidson.

The Heart of Una Sackville. By Mrs. George de Horne Vaizey.

Carol Carew; or, An Act of Imprudence. By Evelyn Everett-Green, Author of "The Three-Cornered House," etc.

Gladys's Repentance; or, Two Girls and a Fortune. By Edith C. Kenyon.

Ursula; or, "A Candidate for the Ministry." By Laura A. Barter-Snow.

Uncle Joshua's Heiress; or, Which shall it be? By Lillias Campbell Davidson.

Molly: The Story of a Wayward Girl. By Harriet E. Colville.

Love's Golden Thread. By Edith C. Kenyon.

Sydney Lisle; or, The Heiress of St. Quentin. By Dorothea Moore.

The Fortunes of Eight; or, The House in Harford Place. By Isabel Suart Robson.

The Little Missis. By Charlotte Skinner.

A Girl's Battle. By Lillias Campbell Davidson.

A Girl in a Thousand. By Edith C. Kenyon.

Agnes Dewsbury. By Laura A. Barter-Snow.

Monica's Choice. By Flora E. Berry.

2s. 6d. each *(continued)*.

The "True Grit" Series.

Large Crown 8vo. 320 pages. Fully Illustrated. Handsomely Bound in Cloth Boards.

A Hero King: A Story of the Days of King Alfred. By E. F. Pollard. Six Illustrations by Lancelot Speed.

Stirring Sea Fights. A Book for British Boys. By J. Cuthbert Hadden.

Sappers and Miners; or, the Flood Beneath the Sea. By Geo. Manville Fenn.

In Honour's Cause. By Geo. Manville Fenn.

The Hidden City: A Story of Central America. By Walter C. Rhoades.

The Lion of Wessex; or, How Saxon Fought Dane. By Tom Bevan.

The Scarlet Judges. A Tale of the Inquisition in the Netherlands. By Eliza F. Pollard.

By Seashore, Wood and Moorland. By Edward Step, F.L.S. Author of "Wayside Flowers," etc.

Rob Harlow's Adventures: A Story of the Grand Chaco. By Geo. Manville Fenn.

A Boy of the First Empire. By Elbridge S. Brooks. (Superior binding, gilt top, 3s. 6d.)

Smoking Flax. By Silas K. Hocking. Twelve Illustrations.

The Boy's Life of Nelson. By J. Cuthbert Hadden. Large Crown 8vo. 300 pages. Beautiful coloured frontispiece and eight illustrations on art paper.

In the Misty Seas: A Story of the Sealers of Behring Strait. By Harold Bindloss.

Two Barchester Boys: A Tale of Adventure in the Malay States. By K. M. Eady.

True Grit: A Story of Adventure in West Africa. By Harold Bindloss. Six Illustrations.

The Yellow Shield; or, A Captive in the Zulu Camp. By William Johnston. Six Illustrations.

A Desert Scout: A Tale of Arabi's Revolt. By Wm. Johnston.

Cormorant Crag: A Tale of the Smuggling Days. By G. Manville Fenn. Eight Illustrations by W. Rainey, R.I.

The Parting of the Ways. By J. L. Hornibrook.

2s. 6d. each (*continued*).

THE "TRUE GRIT" SERIES (*continued*).

The Boy from Cuba: A School Story. By Walter Rhoades.

The Fighting Lads of Devon: or, In the Days of the Armada. By William Murray Graydon.

The Crystal Hunters: A Boy's Adventure in the Higher Alps. By G. Manville Fenn.

First in the Field: A Story of New South Wales. By G. Manville Fenn. 416 pages.

The Lady of the Forest. By L. T. Meade.

The Two Henriettas. By Emma Marshall.

Popular Works by Miss Charlotte Murray.

From School to Castle. Illustrated. Large Crown 8vo. Cloth Boards.

Coral: A Sea Waif and her Friends. 268 pages. Six Illustrations. Cloth Boards.

Through Grey to Gold. Crown 8vo. 280 pages. Six Illustrations. Cloth Boards.

Love Conquereth; or, The Mysterious Trespasser. (*See under Home Library. 2s.*)

Wardlaugh; or, Workers Together. (*See under Home Library. 2s.*)

Stuart's Choice; or, Castleton's "Prep." (*See under Home Library, 2s.*)

2s. 6d. each *(continued)*.

Come, Break your Fast: Daily Meditations for a Year. By Rev. Mark Guy Pearse. Large Crown 8vo. 554 pages. With Portrait. Cloth boards.

Eric Strong: Not Forgetting his Sisters. Bright and Original Talks to Boys and Girls. By Rev. Thos. Phillips, B.A., of Bloomsbury Central Church, London. With autograph portrait. Cloth boards.

The Earnest Life. By Silas K. Hocking. Crown 8vo. 192 pages. With portrait and autograph. Handsomely bound in cloth boards.

Stories of Self-Help: Recent and Living Examples of Men Risen from the Ranks. By John Alexander. Well Illustrated.

A Young Man's Mind. By J. A. Hammerton. Crown 8vo. Cloth extra, gilt top.

The Romance of the Bible. The Marvellous History of the British and Foreign Bible Society. By Charles F. Bateman. Crown 8vo. Cloth.

Crown and Empire: A Popular Account of the Lives, Public and Domestic, of Edward VII. and Queen Alexandra. By Alfred E. Knight. Large Crown 8vo. 336 pages. Cloth boards.

Our Rulers from William the Conqueror to Edward VII. By J. Alexander. Foolscap 4to. Cloth gilt. Sixty beautiful Illustrations. Attractively bound.

The Great Siberian Railway: What I saw on my Journey. By Dr. F. E. Clark. Crown 8vo. 213 pages. Sixty-five first-class Illustrations on art paper, and a Map. Handsomely bound.

Chaplains at the Front. By One of Them. Incidents in the Life of a Chaplain during the Boer War, 1899-1900. By Owen Spencer Watkins, Crown 8vo. 334 pages. Handsomely bound.

James Flanagan: The Story of a Remarkable Career. By Dennis Crane. Fully Illustrated. Cloth boards. 2s. 6d. net.

Ferrar Fenton's Translations of the Holy Scriptures in Modern English. 2s. 6d. each *net.*

Vol. I.—The Five Books of Moses.

Vol. II.—The History of Israel.

Vol. III.—The Books of the Prophets.

Vol. IV.—The Psalms, Solomon, and Sacred Writers.

Vol. V.—The New Testament.

The Complete Bible in Modern English. Incorporating the above five volumes. Cloth extra, gilt top. 10s. net.

2s. 6d. each *(continued)*.

My Bible Picture Book. Contains 16 full-page coloured and many other Illustrations. With descriptive stories from the Old and New Testaments. Size 11 by 8 inches. In bright cloth binding.

Following Jesus: A Bible Picture Book for the Young. Size, 13½ by 10 inches. Contains 12 beautifully coloured Old and New Testament Scenes, with appropriate letterpress by D.J.D.

Brought to Jesus: A Bible Picture Book for Little Readers. Contains 12 New Testament Scenes, printed in colours. Size 13½ by 10 inches. Handsome coloured boards.

Bible Pictures and Stories: Old and New Testament. In one Volume. Bound in cloth boards, with 89 full-page Illustrations.

Potters: their Arts and Crafts. Historical, Biographical and Descriptive. By John C. Sparks and Walter Gandy. Crown 8vo. Copiously Illustrated. Cloth extra.

The Story of Jesus. For Little Children. By Mrs. G. E. Morton. Large 8vo. 340 pages. Eight pictures in best style of colour-work, and many other Illustrations. Handsomely bound in cloth boards.

Victoria Her Life and Reign. By Alfred E. Knight. Crown 8vo. 384 pages. Cloth extra, 2s. 6d.; cloth, gilt edges, 3s. 6d.

2s. each.

The Home Library.

Crown 8vo. 320 pages. Handsome Cloth Covers. Fully Illustrated.

A Gentleman of England: A Story of the Days of Sir Philip Sidney.

Dorothy; or, The Coombehurst Nightingale. By E. M. Alford.

Three Chums; or, The Little Blue Heart. By E. M. Stooke.

'Neath April Skies; or, Hope amid the Shadows. By Jennie Chappell.

Under the Roman Eagles. By Amyot Sagon.

Helena's Dower; or, A Troublesome Ward. By Eglanton Thorne.

The Red Mountain of Alaska. By Willis Boyd Allen.

True unto Death: a Story of Russian Life. By E. F. Pollard.

By Bitter Experience: A Story of the Evils of Gambling. By Scott Graham.

Love Conquereth; or, The Mysterious Trespasser. By Charlotte Murray.

2s. each *(continued).*

THE HOME LIBRARY *(continued).*

White Ivory and Black, and other Stories of Adventure by Sea and Land. By Tom Bevan, E. Harcourt Burrage, and John Higginson.

The Adventures of Don Lavington; or, In the Days of the Press Gang. By G. Manville Fenn.

Roger the Ranger: A Story of Border Life among the Indians. By E. F. Pollard.

Brave Brothers; or, Young Sons of Providence. By E. M. Stooke.

The Moat House; or Celia's Deceptions. By Eleanora H. Stooke.

The White Dove of Amritzir: A Romance of Anglo-Indian Life. By E. F. Pollard.

In Battle and Breeze: Sea Stories by G. A. Henty, G. Manville Fenn, and J. Higginson.

Crag Island; or, The Mystery of Val Stanlock. By W. Murray Graydon.

Edwin, the Boy Outlaw; or, The Dawn of Freedom in England. A Story of the Days of Robin Hood. By J. Frederick Hodgetts.

Neta Lyall. By Flora E. Berry, Author of "In Small Corners," etc. Six Illustrations.

Robert Aske: A Story of the Reformation. By E. F. Pollard Eight Illustrations.

The Lion City of Africa. By Willis Boyd Allen. Sixteen Illustrations.

The Better Part. By Annie S. Swan.

John: A Tale of the Messiah. By K. Pearson Woods.

Leaders into Unknown Lands. By A. Montefiore-Brice, F.G.S.

Lights and Shadows of Forster Square. By Rev. E. H. Sugden, M.A.

The Martyr of Kolin; A Story of the Bohemian Persecution. By H. O. Ward.

Morning Dew-Drops: A Temperance Text Book. By Clara Lucas Balfour.

Mark Desborough's Vow. By Annie S. Swan.

My Dogs in the Northland. By Egerton R. Young. 288 pages. Many Illustrations. Crown 8vo. Cloth.

Norman's Nugget. By J. Macdonald Oxley, B.A.

2s. each (*continued*).

THE HOME LIBRARY (*continued*).

A Puritan Wooing: A Tale of the Great Awakening in New England. By Frank Samuel Child.
The Strait Gate. By Annie S. Swan.
Stuart's Choice; or Castleton's "Prep." By Charlotte Murray.
Under the Sirdar's Flag. By William Johnston.
Wardlaugh; or, Workers Together. By Charlotte Murray.
Alfred the Great: The Father of the English. By Jesse Page.

Library of Standard Works by Famous Authors.

Crown 8vo. Bound in handsome Cloth Boards. Well Illustrated.

Hereward the Wake. By Charles Kingsley.
The Heroes. By Charles Kingsley.
The Channings. By Mrs. Henry Wood.
Ministering Children. By M. L. Charlesworth.
The Water Babies. A Fairy Tale for a Land Baby. By Charles Kingsley.
Hans Andersen's Fairy Tales. With Twelve Illustrations by Helen Stratton.
The Old Lieutenant and His Son. By Norman McLeod.
Coral Island. By R. M. Ballantyne.
Nettie's Mission. Stories Illustrative of the Lord's Prayer. By Alice Gray.
Home Influence: A Tale for Mothers. By Grace Aguilar.
The Gorilla Hunters. By R. M. Ballantyne.
What Katy Did. By Susan Coolidge.
Peter the Whaler. By W. H. G. Kingston.
Melbourne House. By Susan Warner.
The Lamplighter. By Miss Cummins.
Grimm's Fairy Tales. Carefully chosen from the Tales collected by the Brothers Grimm.
The Swiss Family Robinson: Adventures on a Desert Island.
Tom Brown's School-Days. By an Old Boy. 344 pages. Twelve Illustrations.
Little Women and Good Wives. By Louisa M. Alcott. 450 pages. Six Illustrations.
The Wide, Wide World. By Susan Warner.

2s. each *(continued).*

LIBRARY OF STANDARD WORKS BY FAMOUS AUTHORS *(contd.)*

Danesbury House. By Mrs. Henry Wood.
Stepping Heavenward. By E. Prentiss.
John Halifax, Gentleman. By Mrs. Craik.
Life and Adventures of Robinson Crusoe. By Daniel Defoe.
Naomi; or, The Last Days of Jerusalem. By Mrs. Webb.
The Pilgrim's Progress. By John Bunyan.
Uncle Tom's Cabin. By Harriet Beecher Stowe.
Westward Ho! By Charles Kingsley.

"Great Deeds" Series.

Large Crown 8vo. 320 pages. Full of Illustrations. Handsomely bound in Cloth Boards. 2s. each.

Heroes of our Empire: Gordon, Clive, Warren Hastings, Havelock, and Lawrence.

Heroes who have Won their Crown: David Livingstone and John Williams.

Great Works by Great Men. By F. M. Holmes.

Brave Deeds for British Boys. By C. D. Michael.

Two Great Explorers: The Lives of Fridtjof Nansen, and Sir Henry M. Stanley.

Heroes of Land and Sea: Firemen and their Exploits, and the Lifeboat.

Bunyan's Folk of To-day; or, The Modern Pilgrim's Progress. By Rev. J. Reid Howatt. Twenty Illustrations. Crown 8vo. cloth extra.

Sunday Afternoons with My Scholars. By J. Attenborough. With portrait. Crown 8vo. 290 pages Cloth gilt.

Bible Light for Little Pilgrims. A Coloured Scripture Picture Roll. Contains 12 beautifully coloured Old and New Testament Scenes, with appropriate texts. Varnished cover printed in 10 colours. Mounted on Roller for hanging.

Platform, Pulpit and Desk: or, Tools for Workers. Being 148 Outline addresses on all Phases of the Temperance Movement for all Ages and Classes. By W. N. Edwards, F.C S. With an Introduction by Canon Barker. Crown 8vo. 300 pages.

Bible Picture Roll. Contains a large Engraving of a Scripture Subject, with letterpress for each day in the month. Mounted on Roller for hanging.

Love, Courtship, and Marriage. By Rev. F. B. Meyer, B.A. Crown 8vo. 152 pages. Embellished cloth cover, 2s net, Full gilt edges, 2s. 6d. net.

1s. 6d. each.

Partridge's Eighteenpenny Series.

OF CHARMING STORIES FOR HOLIDAY AND FIRESIDE READING.
Crown 8vo. 160 pages. Well Illustrated and Attractively Bound.

Carola's Secret. By Ethel F. Heddle.
The Home of His Fathers. By Lillias Campbell Davidson.
A Great Patience. By L. Moberley.
A Late Repentance. By Hannah B. Mackenzie.
Shepherds and Sheep. By E. Stuart-Langford.
The Golden Doors. By M. S. Haycroft.
A Noble Champion. By David Hobbs.

The Up-to-Date Library.

Of Thick Crown 8vo. Volumes. 320 pages. Many Illustrations. Cloth Boards.

The Wreck of the Providence. By E. F. Pollard.
Dorothy's Training. By Jennie Chappell.
Manco, the Peruvian Chief. By W. H. G. Kingston.
Muriel Malone; or, From Door to Door. By Charlotte Murray.
A Polar Eden. By Charles R. Kenyon.
Her Saddest Blessing. By Jennie Chappell.
Ailsa's Reaping; or, Grape Vines and Thorns. By Jennie Chappell.
A Trio of Cousins: A Story of English Life in 1791. By Mrs. G. E. Morton.
Mick Tracy, the Irish Scripture Reader.
Grace Ashleigh. By Mary D. R. Boyd.
Without a Thought; or, Dora's Discipline. By Jennie Chappell.
Edith Oswald; or, Living for Others. By Jane M. Kippen.
A Bunch of Cherries. By J. W. Kirton.
A Village Story. By Mrs. G. E. Morton.
The Eagle Cliff. By R. M. Ballantyne.
More Precious than Gold. By Jennie Chappell.
The Slave Raiders of Zanzibar. By E. Harcourt Burrage.
Ester Ried. By Pansy.
Avice: A Story of Imperial Rome. By E. F. Pollard.
The King's Daughter. By "Pansy."
The Foster Brothers; or, Foreshadowed. By Mrs. Morton.
The Household Angel. By Madeline Leslie.
The Green Mountain Boys: A Story of the American War of Independence. By E. F. Pollard.

1s. 6d. each *(continued)*.

THE UP-TO-DATE LIBRARY *(continued)*.

A Way in the Wilderness. By Maggie Swan.
Miss Elizabeth's Niece. By M. S. Haycroft.
The Man of the House. By "Pansy."
Olive Chauncey's Trust: a Story of Life's Turning Points. By Mrs. E. R. Pitman.
Whither Bound? a Story of Two Lost Boys. By Owen Landor.
Three People. By "Pansy."
Chrissy's Endeavour. By "Pansy."
The Young Moose Hunters. By C. A. Stephens.
Eaglehurst Towers. By Emma Marshall.

Uncle Mac, the Missionary. By Jean Perry. Six Illustrations by Wal. Paget on art paper. Cloth boards.
Chilgoopie the Glad: a Story of Korea and her Children. By Jean Perry. Eight Illustrations on art paper. Cloth boards.
The Man in Grey; or, More about Korea. By Jean Perry. Crown 8vo. Illustrated. Cloth boards.
More Nails for Busy Workers. By C. Edwards, Crown 8vo. 196 pages. Cloth boards.
The Spiritual Grasp of the Epistles; or, An Epistle a-Sunday. By Rev. Charles A. Fox. New Edition. Cloth boards. 1s. 6d. net.
The Angel and the Demon; and other Stories. By E. Thorneycroft Fowler. Cloth gilt. Eight Illustrations.
Insects: Foes and Friends. By W. Egmont Kirby, M.D., F.L.S. 32 pages of Coloured Illustrations. Cloth boards.
Queen Alexandra: the Nation's Pride. By Mrs. C. N. Williamson. Crown 8vo. Tastefully bound. 1s. 6d. net.
King and Emperor: the Life-History of Edward VII. By Arthur Mee. Crown 8vo. Cloth boards. 1s. 6d. net.
William McKinley: Private and President. By Thos. Cox Meech. Crown 8vo. 160 pages, with Portrait. 1s. 6d. net.
Studies of the Man Christ Jesus. His Character, His Spirit, Himself. By R. E. Speer. Cloth, gilt top. 1s. 6d. net.
Studies of the Man Paul. By Robert E. Speer. Long 8vo. 304 pages. Cloth gilt. 1s. 6d. net.
Wellington: the Record of a Great Military Career. By A. E. Knight. Crown 8vo. Cloth gilt, with Portrait. 1s. 6d. net.
Baden-Powell: The Hero of Mafeking. By W. Francis Aitken Crown 8vo. Cloth gilt, with Portrait. 1s. 6d. net.

1s. 6d. each (*continued*).

The British Boys' Library.

Fully Illustrated. Crown 8vo. 168 pages. Cloth extra.

Never Beaten! A Story of a Boy's Adventures in Canada. By E. Harcourt Burrage, Author of "Gerald Mastyn," etc.

The Adventures of Ji. By G. E. Farrow, Author of "The Wallypug of Why."

Missionary Heroes: Stories of Heroism on the Missionary Field. By C. D. Michael.

Andrew Bennett's Harvest; or, The Shadow of God's Providence. By Lydia Phillips.

Brown A1; or, a Stolen Holiday. By E. M. Stooke.

The Pigeons' Cave: A Story of Great Orme's Head in 1806. By J. S. Fletcher.

Robin the Rebel. By H. Louisa Bedford.

Runaway Rollo. By E. M. Stooke.

Success: Chats about Boys who have Won it. By C. D. Michael.

Well Done! Stories of Brave Endeavour. Edited by C. D. Michael.

Little Soldiers. By Kate L. Mackley.

Noble Deeds: Stories of Peril and Heroism. Edited by C. D. Michael.

Armour Bright. The Story of a Boy's Battles. By Lucy Taylor.

Ben: A Story of Life's Byways. By Lydia Phillips.

Major Brown; or, Whether White or Black, a Man. By Edith S. Davis.

Jack. A Story of a Scapegrace. By E. M. Bryant.

1s. 6d. each *(continued)*.

The British Girls' Library.

Fully Illustrated. Crown 8vo. 160 pages. Cloth extra.

Alice and the White Rabbit: Their Trips Round about London. By Brenda Girvin.

The Tender Light of Home. By Florence Willmot.

Friendless Felicia: or, a Little City Sparrow. By Eleanora H. Stooke.

Keziah in Search of a Friend. By Noel Hope.

Her Bright To-Morrow. By Laura A. Barter-Snow.

Rosa's Mistake; or, The Chord of Self. By Mary Bradford-Whiting.

The Mystery Baby; or, Patsy at Fellside. By Alice M. Page.

Zillah, the Little Dancing Girl. By Mrs. Hugh St. Leger.

Patsie's Bricks. By L. S. Mead.

Salome's Burden; or, The Shadow on the Homes. By Eleanora H. Stooke.

Heroines: True Tales of Brave Women. By C. D. Michael.

Granny's Girls. By M. B. Manwell.

Mousey; or, Cousin Robert's Treasure. By Eleanora H. Stooke.

Marigold's Fancies. By L. E. Tiddeman.

The Gipsy Queen. By Emma Leslie.

Kathleen; or, A Maiden's Influence. By Julia Hack.

Queen of the Isles. By Jessie M. E. Saxby.

Picture Books.

Size 9 by 7 inches. Coloured and numerous other Illustrations. Handsome Coloured Cover, Paper Boards with Cloth Back.

Happy and Gay: Pictures and Stories for Every Day. By D. J. D.

Stories of Animal Sagacity. By D. J. D.

1s. 6d. each (*continued*).

"*The World's Wonders*" *Series.*

Crown 8vo. 160 pages. Copiously Illustrated. Handsome Cloth Covers.

The Conquest of the Air: The Romance of Aerial Navigation. By John Alexander.

Surgeons and their Wonderful Discoveries. By F. M. Holmes.

The Life-Boat: Its History and Heroes. By F. M. Holmes.

Firemen and their Exploits. With an account of Fire Brigades and Appliances. By F. M. Holmes.

The Romance of the Savings Banks. By Archibald G. Bowie.

The Romance of Glass Making. A Sketch of the History of Ornamental Glass. By W. Gandy.

The Romance of the Post Office: Its Inception and Wondrous Development. By Archibald G. Bowie.

Marvels of Metals. By F. M. Holmes.

Triumphs of the Printing Press. By Walter Jerrold.

Electricians and their Marvels. By Walter Jerrold.

Naturalists and their Investigations. By George Day, F.R.M.S.

Illustrated Reward Books.

Crown 8vo. 160 pages. Cloth extra. Fully Illustrated.

Bethesda Chapel. A Story of the Good Old Times. By Rev. C. Leech, D.D.

Donald's Victory. By Lydia Phillips.

A Red Brick Cottage. By Lady Hope.

Marchester Stories. By Rev. C. Herbert.

Sister Royal. By Mrs. Haycraft.

1s. 6d. each (*continued*).

Popular Missionary Biographies.

Crown 8vo. 160 pages. Cloth extra. Fully Illustrated.

Dr. Laws of Livingstonia. By Rev. J. Johnston.
Grenfell of Labrador. By Rev. J. Johnston.
Johan G. Oncken: His Life and Work. By Rev. J. Hunt Cooke.
The Christianity of the Continent. By Jesse Page, F.R.G.S.
Missionaries I have Met, and the Work they have Done. By Jesse Page, F.R.G.S.
James Chalmers, Missionary and Explorer of Rarotonga and New Guinea. By William Robson.
Griffith John, Founder of the Hankow Mission, Central China. By William Robson.
Robert Morrison: The Pioneer of Chinese Missions. By William J. Townsend.
Amid Greenland Snows; or, The Early History of Arctic Missions. By Jesse Page, F.R.G.S.
Bishop Patteson: The Martyr of Melanesia. By same Author.
Captain Allen Gardiner: Sailor and Saint. By same Author.
The Congo for Christ: The Story of the Congo Mission. By Rev. J. B. Myers
David Brainerd, the Apostle to the North-American Indians By Jesse Page, F.R.G.S.
David Livingstone. By Arthur Montefiore-Brice.
From Kafir Kraal to Pulpit: The Story of Tiyo Soga, First Ordained Preacher of the Kafir Race. By Rev. H. T. Cousins.
Japan: and its People. By Jesse Page, F.R.G.S.
John Williams: The Martyr Missionary of Polynesia. By Rev. James Ellis.
James Calvert; or, From Dark to Dawn in Fiji. By R. Vernon.
Lady Missionaries in Foreign Lands. By Mrs. E. R. Pitman.
Missionary Heroines in Eastern Lands. By Mrs. E. R. Pitman.
Robert Moffat: The Missionary Hero of Kuruman. By David J. Deane.
Samuel Crowther: The Slave Boy who became Bishop of the Niger. By Jesse Page, F.R.G.S.
Thomas J. Comber: Missionary Pioneer to the Congo. By Rev. J. B. Myers.
William Carey: The Shoemaker who became the Father and Founder of Modern Missions. By Rev. J. B. Myers.
Henry Martyn. By Jesse Page, F.R.G.S.

1s. 6d. each *(continued)*.

Popular Biographies.

Crown 8vo. Cloth Boards. Fully Illustrated.

John Wesley. By Rev. Arthur Walters.

Women of Worth. Sketches of the Lives of the Queen of Roumania ("Carmen Sylva"), Frances Power Cobbe, Mrs. J. R. Bishop, and Mrs. Bramwell Booth. By Jennie Chappell.

George Müller: The Modern Apostle of Faith. By Fred G. Warne.

Life-Story of Ira D. Sankey, The Singing Evangelist. By David Williamson.

Great Evangelists, and the Way God has Used Them. By Jesse Page.

Women who have Worked and Won. The Life Story of Mrs. Spurgeon, Mrs. Booth-Tucker, F. R. Havergal, and Ramabai. By Jennie Chappell.

John Bright: Apostle of Free Trade. By Jesse Page, F.R.G.S.

The Two Stephensons. By John Alexander.

J. Passmore Edwards: Philanthropist. By E. Harcourt Burrage.

Dwight L. Moody: The Life-work of a Modern Evangelist. By Rev. J. H. Batt.

Noble Work by Noble Women: Sketches of the Lives of the Baroness Burdett-Coutts, Lady Henry Somerset, Miss Sarah Robinson, Mrs. Fawcett, and Mrs. Gladstone. By Jennie Chappell.

Four Noble Women and their Work: Sketches of the Life and Work of Frances Willard, Agnes Weston, Sister Dora, and Catherine Booth. By Jennie Chappell.

The Canal Boy who became President. By Frederick T. Gammon.

Florence Nightingale: The Wounded Soldier's Friend. By Eliza F. Pollard.

Four Heroes of India: Clive, Warren Hastings, Havelock, Lawrence. By F. M. Holmes.

General Gordon: The Christian Soldier and Hero. By G. Barnett Smith.

W. E. Gladstone: England's Great Commoner. By Walter Jerrold. With Portrait and 38 other Illustrations.

Heroes and Heroines of the Scottish Covenanters. By J. Meldrum Dryerre, LL.B., F.R.G.S.

John Knox and the Scottish Reformation. By G. Barnett Smith,

1s. 6d. each *(continued)*.

POPULAR BIOGRAPHIES *(continued)*.

Philip Melancthon : The Wittemberg Professor and Theologian of the Reformation. By David J. Deane.

The Slave and his Champions : Sketches of Granville Sharp, Thomas Clarkson, William Wilberforce, and Sir T. F. Buxton. By C. D. Michael.

C. H. Spurgeon : His Life and Ministry. By Jesse Page, F.R.G.S.

Two Noble Lives : John Wicliffe, the Morning Star of the Reformation ; and Martin Luther, the Reformer. By David J. Deane. 208 pages.

William Tyndale : The Translator of the English Bible. By G. Barnett Smith.

The Marquess of Salisbury : His Inherited Characteristics Political Principles, and Personality. By W. F. Aitken.

Joseph Parker, D.D. : His Life and Ministry. By Albert Dawson.

Hugh Price Hughes. By Rev. J. Gregory Mantle.

R. J. Campbell, M.A. ; Minister of the City Temple, London. By Charles T. Bateman.

Dr. Barnardo : "The Foster-Father of Nobody's Children." By Rev. J. H. Batt.

W. Robertson Nicoll, LL.D. ; Editor and Preacher. By Jane Stoddart.

F. B. Meyer : His Life and Work. By Jennie Street.

John Clifford, M.A., B.Sc., LL.D., D.D. By Chas. T. Bateman.

Thirty Years in the East End. A Marvellous Story of Mission Work. By W. Francis Aitken.

Alexander Maclaren, D.D. : The Man and His Message. By Rev. John C. Carlile.

Lord Milner. By W. B. Luke.

Lord Rosebery, Imperialist. By J. A. Hammerton.

Joseph Chamberlain : A Romance of Modern Politics. By Arthur Mee.

General Booth : The Man and His Work. By Jesse Page F.R.G.S.

Torrey and Alexander : The Story of their Lives. By J Kennedy Maclean. Crown 8vo. Illustrated. Imitation cloth, 1s. net. Cloth boards. 1s. 6d. net.

Sir John Kirk : The Children's Friend. By John Stuart. Crown 8vo. Cloth boards, 1s. 6d. net.

1s. 6d. each *(continued)*.

"*Onward*" *Temperance Library.*

Crown 8vo. Illustrated. Cloth extra.

Dick's Chum. By Miss M. A. Paull.
"This book is well written and illustrated. It is just the book for boys."

The Bird Angel. By Miss M. A. Paull.
"One of Miss Paull's most delightful stories."

Lyndon the Outcast. By Mrs. Clara Lucas Balfour.

Ronald Clayton's Mistake. By Miss M. A. Paull.
"It is a capital book to place in the hands of working lads."

Nearly Lost, but Dearly Won. By Rev. T. P. Wilson, M.A., Author of "Frank Oldfield," etc.

1s. each.

Devotional Classics.

A New Series of Devotional Books by Standard Authors. Well printed on good paper. Size $6\frac{1}{4}$ by $4\frac{1}{4}$ inches. Beautifully bound in Cloth Boards. 1s. each, NET; *Leather, 2s. each,* NET. *(Not illustrated.)*

The Imitation of Christ. By Thomas á Kempis.

The Holy War. By John Bunyan.

Letters on the Simple Life. By the Queen of Roumania, Marie Corelli, Madame Sarah Grand, "John Oliver Hobbes," Sir A. Conan Doyle, The Bishop of London, Canon Hensley Henson, Sir J. Crichton Browne, Rev. S. Baring-Gould, Dr. Robertson Nicoll, etc. Crown 8vo. 160 pages. With Autographs of contributors in fac-simile. Imitation Linen, 6d. net. Cloth boards, 1s. net. (Not illustrated.)

1s. each *(continued)*.

One Shilling Reward Books.

Fully Illustrated. Crown 8vo. Cloth extra.

Billy's Hero; or, The Valley of Gold. A Story of Canadian Adventure. By Marjorie L. C. Pickthall.
The Straight Road. By Marjorie L. C. Pickthall.
One Primrose Day. By Mrs. Hugh St. Leger.
The Reign of Lady Betty. By Kent Carr.
The Whitedown Chums. By Jas. H. Brown.
Sweet Nancy. By L. T. Meade.
Secrets of the Sea. By Cicely Fulcher.
Norman's Oak. By Jennie Chappell.
A Fight for Life, and other Stories. By John R. Newman.
The Fairyland of Nature. By J. Wood Smith.
True Stories of Brave Deeds; or, What Boys and Girls can Do. By Mabel Bowler.
The Mystery of Marnie. By Jennie Chappell.
Gipsy Kit; or, The Man with the Tattooed Face. By Robert Leighton.
Dick's Desertion; A Boy's Adventures in Canadian Forests. By Marjorie L. C. Pickthall.
The Wild Swans; or, The Adventure of Rowland Cleeve. By Mary C. Rowsell.
George & Co.; or, The Choristers of St. Anselm's. By Spencer T. Gibb.
Caravan Cruises: Five Children in a Caravan—not to mention Old Dobbin. By Phil Ludlow.
Little Chris the Castaway. By F. Spenser.
The Children of the Priory. By J. L. Hornibrook.
Tom and the Enemy. By Clive R. Fenn.
Ruth's Roses; or, What Some Girls Did. By Laura A. Barter-Snow.
In Paths of Peril: A Boy's Adventures in Nova Scotia. By J. Macdonald Oxley.
Pets and their Wild Cousins: New and True Stories of Animals. By Rev. J. Isabell, F.E.S.
Other Pets and their Wild Cousins. By Rev. J. Isabell, F.E.S.
Sunshine and Snow. By Harold Bindloss.
Donalblane of Darien. By J. Macdonald Oxley.
Crown Jewels. By Heather Grey.
All Play and No Work. By Harold Avery.

1s. each (*continued*).

ONE SHILLING REWARD BOOKS (*continued*).

Always Happy; or, The Story of Helen Keller. By Jennie Chappell.

Birdie and her Dog, and other Stories of Canine Sagacity. By Miss Phillips (Mrs. H. B. Looker).

Bessie Drew; or, The Odd Little Girl. By Amy Manifold.

Cola Monti; or, The Story of a Genius. By Mrs. Craik, Author of "John Halifax, Gentleman."

The Children of Cherryholme. By M. S. Haycraft.

Harold; or, Two Died for Me. By Laura A. Barter-Snow.

Indian Life in the Great North-West. By Egerton R. Young, Missionary to the North American Indian Tribes.

Jack the Conqueror; or, Difficulties Overcome. By the Author of "Dick and his Donkey."

Little Bunch's Charge; or, True to Trust. By Nellie Cornwall.

Lost in the Backwoods. By Edith C. Kenyon.

The Little Woodman and his Dog Cæsar. By Mrs. Sherwood.

Roy's Sister; or, His Way and Hers. By M. B. Manwell.

Partridge's Shilling Library.

Crown 8vo. 136 pages. Illustrations printed on Art Paper. A splendid Series of Stories for Adults.

"Noodle": From Barrack Room to Mission Field. By S. E. Burrow.

The Lamp in the Window. By Florence E. Bone.

Out of the Fog. By Rev. J. Isabell, F.E.S.

Fern Dacre; A Minster Yard Story. By Ethel Ruth Boddy.

Through Sorrow and Joy: A Protestant Story. By M. A. R.

A Brother's Need. By L. S. Mead.

1s. each net.

(*Not Illustrated*).

Partridge's Popular Reciter. Old Favourites and New. 208 pages. Crown 8vo. Imitation Cloth, 1s. net; Cloth Boards, 1s. 6d. net.

Partridge's Humorous Reciter (uniform with Partridge's Popular Reciter). Imitation Cloth, 1s. net; Cloth boards, 1s. 6d. net.

1s. each *(continued)*.

Cheap Reprints of Popular Books for the Young.

Crown 8vo. 160 pages. Illustrated. Cloth Boards, 1s. each.

The Thane of the Dean. A Story of the Time of the Conqueror. By Tom Bevan.
Nature's Mighty Wonders. By Rev. Richard Newton.
Hubert Ellerdale: A Tale of the Days of Wicliffe. By W. Oak Rhind.
Our Phyllis. By M. S. Haycraft.
The Maid of the Storm: A Story of a Cornish Village. By Nellie Cornwall.
Philip's Inheritance; or, Into a Far Country. By F. Spenser.
The Lady of the Chine. By M. S. Haycraft.
In the Bonds of Silence. By J. L. Hornibrook.
A String of Pearls. By E. F. Pollard.
Elsie Macgregor; or, Margaret's Little Lass. By Ramsay Guthrie.
Hoyle's Popular Ballads and Recitations. By William Hoyle.
Heroes All! A Book of Brave Deeds. By C. D. Michael.
The Old Red Schoolhouse. By Frances H. Wood.
Christabel's Influence. By J. Goldsmith Cooper.
Deeds of Daring; or, Stories of Heroism in Everyday Life. By C. D. Michael.
Everybody's Friend; or, Hilda Danver's Influence. By Evelyn Everett-Green.
The Bell Buoy: or, The Story of a Mysterious Key. By F. M. Holmes.
Vic: A Book of Animal Stories. By A. C. Fryer, Ph.D., F.S.A.
In Friendship's Name. By Lydia Phillips.
Nella; or, Not My Own. By Jessie Goldsmith Cooper.
Blossom and Blight. By M. A. Paull.
Aileen. By Laura A. Barter-Snow.
Satisfied. By Catherine Trowbridge.
Ted's Trust; or, Aunt Elmerley's Umbrella. By Jennie Chappell.
A Candle Lighted by the Lord. By Mrs. E. Ross.
Alice Western's Blessing. By Ruth Lamb.
Tamsin Rosewarne and Her Burdens. By Nellie Cornwall.
Raymond and Bertha: A Story of True Nobility. By Lydia Phillips.
Gerald's Dilemma. By Emma Leslie.
Fine Gold; or, Ravenswood Courtenay. By Emma Marshall.

1s. each (*continued*).

CHEAP REPRINTS OF POPULAR BOOKS FOR THE YOUNG (*continued*).

Marigold. By Mrs. L. T. Meade.
Jack's Heroism. By Edith C. Kenyon.
Her Two Sons: A Story for Young Men and Maidens. By Mrs. Charles Garnett.
Rag and Tag. By Mrs. E. J. Whittaker.
The Little Princess of Tower Hill. By L. T. Meade.
Clovie and Madge. By Mrs. G. S. Reaney.
Ellerslie House: A Book for Boys. By Emma Leslie.
Like a Little Candle; or, Bertrand's Influence. By Mrs. Haycraft.
Louie's Married Life. By Sarah Doudney.
The Dairyman's Daughter. By Legh Richmond.
Bible Jewels. By Rev. Dr. Newton.
Bible Wonders. By the same Author.
The Pilgrim's Progress. By John Bunyan. 416 pages. Eight coloured and 46 other Illustrations.
Our Duty to Animals. By Mrs. C. Bray.

Books for Christian Workers.

Large Crown 16mo. 128 pages. Chastely bound in Cloth Boards, 1s. each.

The Home Messages of Jesus. By Charlotte Skinner.
Deeper Yet: Meditations for the Quiet Hour. By Clarence E. Eberman.
The Master's Messages to Women. By Charlotte Skinner.
Royal and Loyal: Thoughts on the Two-fold Aspects of the Christian Life. By Rev. W. H. Griffith-Thomas.
Thoroughness: Talks to Young Men. By Thain Davidson, D.D.
Some Secrets of Christian Living. By Rev. F. B. Meyer.
The Overcoming Life. By Rev. E. W. Moore.
Marks of the Master. By Charlotte Skinner.
Some Deeper Things. By Rev. F. B. Meyer.
Steps to the Blessed Life. By Rev. F. B. Meyer.
Daybreak in the Soul. By Rev. E. W. Moore.
The Temptation of Christ. By C. Arnold Healing, M.A.
Keynotes to the Happy Life. By Charlotte Skinner.
For Love's Sake. By Charlotte Skinner.

1s. each (*continued*).

Everyone's Library.

A re-issue of Standard Works in a cheap form, containing from 320 to 500 pages, printed in the best style; with Illustrations on art paper, and tastefully bound in Cloth Boards. 1s. each.

Hereward the Wake. By Charles Kingsley.
The Heroes. By Charles Kingsley.
Ministering Children. By M. L. Charlesworth.
Peter the Whaler. By W. H. G. Kingston.
The Channings. By Mrs. Henry Wood.
Melbourne House. By Susan Warner.
Alice in Wonderland.
The Lamplighter. By Miss Cummins.
What Katy Did. By Susan Coolidge.
Stepping Heavenward. By E. Prentiss.
Westward Ho! By Charles Kingsley.
The Water Babies. By the Same Author.
The Swiss Family Robinson.
Grimm's Fairy Tales. By the Brothers Grimm.
The Coral Island. By R. M. Ballantyne.
Hans Andersen's Fairy Tales.
John Halifax, Gentleman. By Mrs. Craik.
Little Women and Good Wives. By Louisa M. Alcott.
Tom Brown's Schooldays. By an Old Boy.
The Wide, Wide World. By Susan Warner.
Life and Adventures of Robinson Crusoe. By Daniel Defoe.
Uncle Tom's Cabin. By H. B. Stowe.
The Old Lieutenant and His Son. By Norman McLeod.

Uncrowned Queens. By Charlotte Skinner.

Golden Words for Every Day. By M. Jennie Street.

Novelties, and How to Make Them: Hints and Helps in providing occupation for Children's Classes. Compiled by Mildred Duff. Full of illustrations. Cloth boards.

In Defence of the Faith: The Old Better than the New. By Rev. F. B. Meyer. Cloth boards. 1s. *net*.

Ingatherings: A Dainty Book of Beautiful Thoughts. Compiled by E. Agar. Cloth boards, 1s. *net*. (Paper covers, 6d. *net*).

The New Cookery of Unproprietary Foods. By Eustace Miles, M.A. 192 pages. 1s. *net*.

The Child's Book of Health. By W. N. Edwards, F.C.S. 1s. *net*

1s. each (*continued*).

New Series of One Shilling Picture Books.

Size 10½ by 8 inches. 96 pages. Coloured Frontispiece and numerous other illustrations. Handsomely bound in Paper Boards, covers printed in 10 colours and varnished.

My Dollies' A.B.C. By Uncle Jack.
Merry Madcaps! By Aunt Ruth.
By the Silver Sea. By R. V.
Funny Folk in Animal Land. By Uncle Frank.
A Trip to Storyland. By R. V.
Holiday Hours in Animal Land. By Uncle Harry.
Animal Antics! By the Author of "In Animal Land with Louis Wain."
Happy Days. By R. V.
Tell Me a Tale! A Picture Story Book for Little Children. By J. D.
Little Snow-shoes' Picture Book. By R. V.
In Animal Land with Louis Wain.
Merry and Free. Pictures and Stories for our Little Ones. By R. V.
Pussies and Puppies. By Louis Wain.

Scripture Picture Books.

Old Testament Heroes. By Mildred Duff.
Feed My Lambs. Fifty-two Bible Stories and Pictures. By the Author of "The Friends of Jesus."
Bible Pictures and Stories: Old Testament. By D. J. D.
Bible Pictures and Stories: New Testament. By James Weston and D. J. D.
The Life of Jesus. By Mildred Duff. 112 pages.
Gentle Jesus.
Jesus the Good Shepherd.
My Bible Picture Book.
The Children's Saviour.
} Four Bible Picture Books beautifully printed in colours with descriptive letterpress.

Commendations from all parts of the world have reached Messrs. S. W. Partridge & Co. upon the excellence of their Picture Books. The reading matter is high-toned, helpful, and amusing, exactly adapted to the requirements of young folks; while the Illustrations are by first-class artists, and the paper is thick and durable. Bound in attractive coloured covers, they form a unique series.

9d. each.

Ninepenny Series of Illustrated Books.

96 pages. Small Crown 8vo. Illustrated. Handsome Cloth Covers.

Mina's Sacrifice; or, The Old Tambourine. By Helen Sawer.
Our Den. By E. M. Waterworth.
Only a Little Fault! By Emma Leslie.
Polly's Hymn; or, Travelling Days. By J. S. Woodhouse.
Frank Burleigh: or, Chosen to be a Soldier. By Lydia Phillips.
The Mischievous Puppy, and other Stories. By Lydia de Spon.
Lost Muriel; or, A Little Girl's Influence. By C. J. A. Oppermann.
Kibbie & Co. By Jennie Chappell.
Marjory; or, What Would Jesus Do? By Laura A. Barter-Snow.
Brave Bertie. By Edith C. Kenyon.
The Little Slave Girl. By Eileen Douglas.
Marjorie's Enemy: A Story of the Civil War of 1644. By Mrs. Adams.
Lady Betty's Twins. By E. M. Waterworth.
A Venturesome Voyage. By F. Scarlett Potter.
Out of the Straight; or, The Boy who Failed and the Boy who Succeeded. By Noel Hope.
Bob and Bob's Baby. By Mary E. Lester.
Robin's Golden Deed. By Ruby Lynn.
The Little Captain: A Temperance Tale. By Lynde Palmer.
The Runaway Twins: or, The Terrible Guardian. By Irene Clifton.
Grandmother's Child. By Annie S. Swan.
Dorothy's Trust. By Adela Frances Mount.
Grannie's Treasures: and how they helped her. By L. E. Tiddeman.
His Majesty's Beggars. By Mary E. Ropes.
Love's Golden Key. By Mary E. Lester.
Faithful Friends. By C. A. Mercer.
Only Roy. By E. M. Waterworth and Jennie Chappell.
Aunt Armstrong's Money. By Jennie Chappell.
The Babes in the Basket; or, Daph and Her Charge.
Birdie's Benefits; or, A Little Child Shall Lead Them. By Edith Ruth Boddy.

9d. each *(continued)*.

NINEPENNY SERIES OF ILLUSTRATED BOOKS *(continued)*.

Carol's Gift; or, "What Time I am Afraid I will Trust in Thee." By Jennie Chappell.
Cripple George; or, God has a Plan for Every Man. A Temperance Story. By John W. Kneeshaw.
Cared For; or, The Orphan Wanderers. By Mrs. C. E. Bowen.
A Flight with the Swallows. By Emma Marshall.
The Five Cousins. By Emma Leslie.
For Lucy's Sake. By Annie S. Swan.
Giants and How to Fight Them. By Dr. Newton.
Giddie Garland; or, The Three Mirrors. By Jennie Chappell.
How a Farthing Made a Fortune; or, Honesty is the Best Policy. By Mrs. C. E. Bowen.
How Paul's Penny became a Pound. By Mrs. Bowen.
How Peter's Pound became a Penny. By the same Author.
John Blessington's Enemy: A Story of Life in South Africa. By E. Harcourt Burrage.
John Oriel's Start in Life. By Mary Howitt.
The Man of the Family. By Jennie Chappell.
Mattie's Home; or, The Little Match-girl and Her Friends.
Nan; or, the Power of Love. By Eliza F. Pollard.
Phil's Frolic. By F. Scarlett Potter.
Paul: A Little Mediator. By Maude M. Butler.
Rob and I; or, By Courage and Faith. By C. A. Mercer.
A Sailor's Lass. By Emma Leslie.
Won from the Sea. By E. C. Phillips (Mrs. H. B. Looker).

6d. each.

The Marigold Series.

An unequalled series of Standard Stories, printed on good laid paper. Imperial 8vo. 128 pages. Illustrated covers with vignetted design printed in eight colours. Price 6d. each, net.

PRIDE AND PREJUDICE. By Jane Austen.

FROM JEST TO EARNEST. By E. P. Roe.

THE WIDE, WIDE WORLD. By Susan Warner.

6d. each (*continued*).

New Series of Sixpenny Picture Books.

Crown 4to. With Coloured Frontispiece and many other Illustrations. Handsomely bound in Paper Boards, with cover printed in ten colours.

Full of Fun! Pictures and Stories for Everyone. By Uncle Maurice.

Hide and Seek. Stories for every Day in the Week. By the same Author.

Playtime! A Picture Book for Boys and Girls.

Off to Toyland! By Uncle Jack.

Going A-Sailing! By J. D.

Follow the Flag! By J. D.

Dollie Dimple. By J. D.

Little Snowdrop's Bible Picture Book.

Sweet Stories Retold. A Bible Picture Book.

Happy Times! A Picture Book of Prose and Rhymes.

Stories of Old.
Bible Stories for the Little Ones.
Coming to Jesus.
Sunday Stories.
} Four Bible Picture Books with coloured illustrations.

Mother's Sunday A.B.C. A Little Book of Bible Pictures, which can be coloured by hand.

The "Red Dave" Series.

New and Enlarged Edition. Handsomely bound in Cloth Boards. Well Illustrated.

BRAVE TOVIAK. By Argyll Saxby.

THE ADVENTURES OF PHYLLIS. By Mabel Bowler.

A PLUCKY CHAP. By Louie Slade.

ALMOST LOST. By Amethyst.

JEPTHAH'S LASS. By Dorothea Moore.

KITTY KING. By Mrs. H. C. Knight.

THE DUCK FAMILY ROBINSON. By A. M. T.

"ROAST POTATOES!" A Temperance Story. By Rev. S. N. Sedgwick, M.A.

HIS CAPTAIN. By Constancia Sergeant.

"IN A MINUTE!" By Keith Marlow.

UNCLE JO'S OLD COAT. By Eleanora H. Stooke.

THE COST OF A PROMISE. By M. I. Hurrell.

FARTHING DIPS; or, What can I do? By J. S. Woodhouse.

ROY CARPENTER'S LESSON. By Keith Marlow.

GERALD'S GUARDIAN. By Charles Herbert.

WHERE A QUEEN ONCE DWELT. By Jetta Vogel.

WILFUL JACK. By M. I. Hurrell.

WILLIE THE WAIF. By Minie Herbert.

A LITTLE TOWN MOUSE.

THE LITTLE GOVERNESS.

PUPPY-DOG TALES.

MOTHER'S BOY.

6d. each (*continued*).

THE "RED DAVE" SERIES (*continued*).

- That Boy Bob.
- Buy Your own Cherries.
- Left in Charge, and other Stories.
- A Threefold Promise.
- The Four Young Musicians.
- Two Little Girls and What They did.
- A Sunday Trip and What Came of it. By E. J. Romanes.
- Little Tim and His Picture. By Beatrice Way.
- Midge. By L. E. Tiddeman.
- The Conjurer's Wand. By Henrietta S. Streatfeild.
- Benjamin's New Boy.
- Enemies: a Tale for Little Lads and Lasses.
- Cherry Tree Place.
- Joe and Sally: or, A Good Deed and its Fruits.
- The Island Home.
- Chrissy's Treasure.
- Lost in the Snow.
- Red Dave: or What Wilt Thou have Me to Do?
- Dick and His Donkey.
- Jessie Dyson.
- Come Home, Mother.

4d. each.

Cheap "Pansy" Series.

Imperial 8vo. 64 pages. Many Illustrations. Cover printed in five colours.

- The Strait Gate. By Annie S. Swan.
- Mark Desborough's Vow. By Annie S. Swan.
- Her Saddest Blessing.
- Miss Priscilla Hunter, and other Stories.
- Wild Bryonie.
- Avice, A Story of Imperial Rome.
- Links in Rebecca's Life.
- From Different Standpoints.
- Those Boys.
- Christie's Christmas.
- Four Girls at Chautauqua.
- Julia Ried.
- Echoing and Re-echoing.
- Cunning Workmen.
- Tip Lewis and His Lamp.
- The King's Daughter.
- Household Puzzles.
- The Randolphs.
- Wise to Win; or The Master Hand.
- A New Graft on the Family Tree.
- The Man of the House.

4d. each *(continued)*.

The Young Folks' Library

Of Cloth-bound Books. With Coloured Frontispiece. 64 pages. Well Illustrated. Handsome Cloth Covers.

LITTLE JACK THRUSH.
A LITTLE BOYS' TOYS.
THE PEARLY GATES.
THE LITTLE WOODMAN.
RONALD'S REASON.
A BRIGHT IDEA.
SYBIL AND HER LIVE SNOWBALL.
THE CHURCH MOUSE.
DANDY JIM.
A TROUBLESOME TRIO.
PERRY'S PILGRIMAGE.
NITA; or, Among the Brigands.

3d. each.

New Pretty "Gift-Book" Series.

With Beautiful Coloured Frontispiece, and many other Illustrations. Paper Boards, Cover printed in eight Colours and Varnished, 3d. each. Size 6 by 5 inches.

JACK AND JILL'S PICTURE BOOK.
LADY-BIRD'S PICTURES AND Stories.
PLAYTIME JOYS FOR GIRLS AND Boys.
DOLLY'S PICTURE BOOK.
BY THE SEA.
TOBY AND KIT'S ANIMAL BOOK.
"PETS" AND "PICKLES."
OUR LITTLE PETS' ALPHABET.
BIBLE STORIES--OLD TESTAMENT.
BIBLE STORIES--NEW TESTAMENT.

Paternoster Series of Popular Stories.

An entirely New Series of Books, Medium 8vo. in size, 32 pages, fully illustrated. Cover daintily printed in two Colours. 1d. each. Titles as follows:

ALICE IN WONDERLAND.
THE DAIRYMAN'S DAUGHTER.
ROBIN'S GOLDEN DEED. By Ruby Lynn.
THE BASKET OF FLOWERS.
BUY YOUR OWN CHERRIES. By John Kirton.
JENNETT CRAGG: A Story of the Time of the Plague. By M. Wright.
"OUR FATHER." By Alice Grey.
RAB AND HIS FRIENDS. By Dr. John Brown.
THE SCARRED HAND. By Ellen Thorneycroft Fowler.
THE GIPSY QUEEN. By Emma Leslie.
A CANDLE LIGHTED BY THE LORD. By Mrs. Ross.
GRANDMOTHER'S CHILD. By Annie S. Swan.
THE BABES IN THE BASKET; or, Daph and her Charge.
JENNY'S GERANIUM; or, The Prize Flower of a London Court.
THE LITTLE PRINCESS OF TOWER HILL. By L. T. Meade.
THE GOLD THREAD. By Norman Macleod, D.D.
THROUGH SORROW AND JOY. By M. A. R.
THE LITTLE WOODMAN AND HIS Dog Cæsar. By Mrs. Sherwood.
CRIPPLE GEORGE. By J. W. Kneeshaw.
ROB AND I. By C. A. Mercer.
DICK AND HIS DONKEY. By Mrs. Bowen.
THE LIGHT OF THE GOSPEL.

Partridge's Pictorial Magazines.

"A word of emphatic praise should be given to the old-established and excellent magazines of Messrs. Partridge and Co. They ought to hold their own against the great competition, for they are eminently sound, healthy, and interesting."—British Weekly.

"It would be difficult to surpass these magazines. All have marched with the times." —Daily Telegraph.

"There are no more attractive Annual Volumes than those issued by S. W. Partridge and Co."—The Christian.

The British Workman. Contains popular Articles and Stories on Temperance, Thrift, etc., and short biographies of eminent Self-made Men; also interesting information of special value to the sons of toil. 1d. Monthly.

The Yearly Volume, 144 pages full of illustrations, coloured paper boards, 1s. 6d.; cloth, 2s. 6d.

The Family Friend. A beautifully Illustrated Magazine for the Home Circle, with Serial and Short Stories by popular Authors, Helpful Articles, Hints on Dressmaking, etc. 1d. Monthly.

The Yearly Volume, in coloured paper boards and cloth back, 1s. 6d. cloth, 2s.; gilt edges, 2s. 6d.

The Friendly Visitor. An Illustrated Magazine for the people, full of entertaining reading with sound religious teaching in the form of story, article, and poem. Printed in good type and fully illustrated. Just the paper for the aged. 1d. Monthly.

The Yearly Volume coloured paper boards and cloth back, 1s. 6d.; cloth, 2s.; gilt edges, 2s. 6d.

The Children's Friend. Charming Stories, interesting Articles, Indoor Recreations, beautiful Pictures, Puzzles, Prize Competitions, etc. 1d. Monthly.

The Yearly Volume, coloured paper boards, with cloth back and excellent coloured frontispiece, 1s. 6d.; cloth, 2s.; gilt edges, 2s. 6d.

The Infants' Magazine. No other periodical can be compared with the Infants' Magazine for freshness, brightness, and interest. Full of bright pictures and pleasant reading to delight the little ones. 1d. Monthly.

The Yearly Volume, coloured paper boards, with cloth back and beautifully coloured frontispiece, 1s. 6d.; cloth, 2s.; gilt edges, 2s. 6d.

The Band of Hope Review. The Leading Temperance Periodical for the Young, containing Serial and Short Stories, Concerted Recitations, Prize Competitions, etc. Should be in the hands of all Band of Hope Members. ½d. Monthly.

The Yearly Volume, coloured paper boards, 1s.; cloth boards, 1s. 6d.

The Young Men Magazine. The only magazine of its kind at a popular price. Packed with articles by leading writers on subjects of interest to young men. Edited with enterprise and spirit. 1d. monthly.

The Yearly Volume, cloth boards, 2s.

271 Anne of Green Gables
272 Anne of Avonlea
273 Cedar Creek
274 Our Share in China
275 Friends tho Divided
276 When a Man's Single
277 In a Jesuit Net
278 A Blue Stocking in India
279 Victories of the Engineer

LIST OF BOOKS

1 Red Dave
2 Wilful Jack
3 The Little Governess
4 Joe and Sally
5 Jessie Dyson
6 The Duck Family Robinson
7 A New Friend
8 A Venturesome Voyage
9 Jake's Birthday Present
10 Big Brother Dick
11 The Charcoal Burner
12 Only Roy
13 Gerald's Guardian
14 Junnie's White Heather
15 Jim
16 Lady Patience
17 Little V. C.
18 Jem's Struggle for Life
19 Twilight Stories
20 Story of an Irish Setter
21 Bird's Christmas Carols
22 Bunny's Friends
23 Eric's Good News
24 Teddy's Button
25 Willie's Battles
26 A Regular Handful
27 He, She and It
28 A Sailor Lass
29 Dick Lionheart
30 Two Little Fortune Hunters
31 Cripple George
32 Secrets of the Sea
Three Little Great Ladies
...y and the Owl
...ks at School