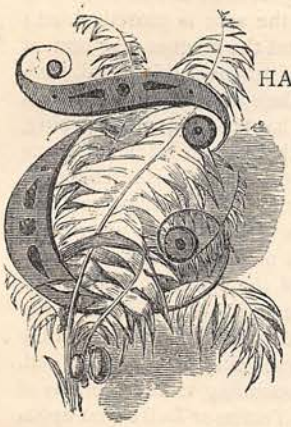
the royal family, two to the nobility, and one denoted the ordinary gentry. I have recently seen some towels copied from mediæval models, executed for the Imperial Crown Princess of Prussia. They each consisted of a simple length of fine diaper or huckaback, hemmed at each end. A row of a cross-stitch pattern, very similar to the one given at page 90 of this Magazine, was worked in blue ingrain cotton at one end, while at the other, in the right-hand corner, were the initials, the number, and the date in cross-stitch marking, with the same-coloured cotton. The effect was very pretty and quite novel. Now that marking with cotton has been so long out of fashion, I think a few instructions on the art may be requisite to help my readers to do it themselves. Children are best taught to mark on canvas, and should have a sampler, which may be from six to eight inches square. Two threads are generally taken each way, one thread being left between each letter of a large-sized alphabet; and one thread only, with one thread between each letter, for a small one. The canvas used should be fine, not "Penelope canvas" on any account, the division into squares of threads rendering that kind unsuitable. In marking on linen, two or four, or if very fine indeed, eight threads should be left between the letters. The old method of arranging the marks was to place the number of the article at the top, and the initials on the centre line, the date following last, thus:

8.
E. A. B.
1878.

The first initial stood for the gentleman's Christian name, the second for the lady's, the last for the surname of both. Modern taste prescribes the initials of the master of the house only, or the initial letter of the surname alone. DORA DE BLAQUIERE.

THE TELEPHONE.



THAT one person should be able to talk in his natural voice to another person tens or hundreds of miles away was a consummation which, we believe, did not even enter into the remarkable foresight of Old Mother Shipton. But it is well known that this apparently impossible feat is now an everyday event. The first rumour of the existence of an articulating telephone, or, as we may call it, a speaking telegraph, reached us from the Centennial Exhibition at Philadelphia, in 1875. There had been previously a variety of telephones for transmitting simple musical notes or melodies, and even simple harmonies, over a telegraph wire by means of electricity, but no telephone capable of conveying speech. The mere idea of a speaking telephone had, however, been thought of many years before by an ingenious Frenchman, just as the idea of an electric telegraph was conceived by an ingenious Scotchman years before it was practically accomplished.

But the Frenchman's idea had been regarded as a dream and forgotten, until the actual speaking telephone of Professor Graham Bell recalled it to the mind of the student. Sir William Thomson, who first introduced this instrument to the notice of English people, justly characterised it as the crowning marvel of the electric telegraph, and one of the most interesting inventions ever made in the history of science. Simple as it is, it sums up in itself the powers of all previous telephones, however complicated, since it can transmit noises, or single and blended musical notes; and, in addition, it crowns the whole by transmitting the infinitely varied modulation and quality of human speech.

The first attempt to transmit musical tones by means of electricity was made by Professor Page of Massachusetts, in 1837. He found that when a discontinuous current of electricity was circulated in a wire round an iron needle, the needle emitted a faint "tick" at every interruption of the current. When the current was rapidly interrupted these ticks merged into a continuous hum, to which he gave the name of "galvanic music." Herr Reis in 1860 transmitted tones by causing the tone vibrations to interrupt a current, and reproducing them by means of Page's discovery. Since that time Varley, Gray, and Lacour have transmitted a number of tones at once, by employing vibrating tuning-forks to interrupt the current and to reproduce the tones. They have even made the tones record themselves in ink, so as to telegraph a number of messages at once.

Professor Alexander Graham Bell, the inventor of the speaking telephone, was born at Edinburgh in 1847. He comes of a family of teachers, his grandfather having taught elocution in London, his uncle in Dublin, and his father, Mr. Andrew Mellville Bell, the inventor of visible speech, in Edinburgh. Five years ago Professor Alexander Graham Bell accompanied his father to Montreal in Canada, and was there engaged in applying his father's system of visible speech to the teaching of deaf mutes to speak as we do. Deaf mutes are mute because they are deaf, not from any defect of the vocal organs; and Mr. Bell's system instructs them through the eye how to actuate the vocal organs in uttering language, and to read what another person is saying by the motions of his lips. The system was so successful in America, that the elder Bell was invited to introduce it into a large day-school for mutes at Boston; and he procured the transfer of the post to his son, who soon became famous in the United States

for his success in this important and interesting work; and we believe that mainly through his efforts there are now some 3,000 deaf mutes in America who can speak almost, if not quite, as well as those who hear.

Even while he was in Scotland, Mr. Graham Bell had turned his attention to telephony, and in Canada he designed a piano which should transmit its notes to a distance by means of electricity. At Boston he carried on his researches in this field, and aimed at

producing a telephone which would not only send musical notes, but speech itself. In the course of these researches he independently invented the musical telephones of Varley, Gray, and Lacour, even to the point of causing them to mark telegraph signals in ink. But he went beyond these inventors in discovering a principle which rendered an articulating telephone possible. This principle was the employment of what are called *undulatory* or wave-like currents of electricity. All merely musical telephones involve currents of electricity which are merely intermittent—that is to say, they involve only a uniform current rapidly interrupted by the vibrations of the body emitting the sound. They are therefore only capable of transmitting to a distance the *pitch* of a note, since pitch depends entirely on the frequency of the vibration of the sounding body. They are incapable of transmitting to a distance the lowness and loudness—in a word, the *intensity* of a note, since that depends not on the number of vibrations per second, but on the *amplitude* or swing of the vibrations; a greater swing in the vibrations of the sounding body corresponding to a louder sound. It is clear that to convey speech a current must be capable of transmitting not only the pitch of the voice, but the loudness, and in addition to that the changing of the voice from a low to a loud sound, and from a low to a high pitch. The current must be capable of fitting the voice like a glove, so to speak, and an undulatory or wave-like form of current can be made to do so. The succession of the waves can be made to transmit the succession of vibrations or pitch of the voice, and the size of the waves can be made to transmit its intensity. There need be no break or interruption of a wave-current; the waves have only to follow the modulations of the voice.

Having discovered the principle, it still remained to put it into practice. The practical problem was how to cause the voice, or any other source of varying sounds, such as a musical instrument, to generate these sympathetic wave-currents of electricity. It is well known that magnetism and electricity are intimately connected, and that magnetism can be converted into electricity, and electricity into magnetism. For instance, if a magnet is moved about near a wire, a current of electricity will tend to arise in the wire, and that current will vary in strength according to the motion of the magnet. When the magnet is approached to the wire the current will increase in strength, and when it is withdrawn the current will decrease in strength. In this way by the to-and-fro motion of a magnet it is possible to set up undulatory currents in a wire. These currents are due to the magnetic changes in the space around the wire, and it is not essential that the magnet itself should be moved. The magnet may be still if the wire is moved about; or, further, both the coil and the magnet may remain at rest together, if a piece of magnetisable metal, such as iron, is moved about in their neighbourhood. This piece of iron moving about has the effect of disturbing, and stirring up as it were, the magnetism in the space about the wire, and this disturbance is attended by electric currents in the wire. We can now see how it was possible for Professor Bell to create undulatory currents in a wire by means of the mechanical effects of sound. If the motions of the sounding body could be communicated to a piece of iron free to move in the neighbourhood of a magnet and a coil of wire, they would produce a series of electric currents in the coil, of a wave-like form, corresponding to the motions of the sounding body itself. Professor Bell's first apparatus constructed on this plan was intended to transmit musical tunes. It consisted of a series of magnets with coils of wire round them, and in front of the magnets were placed a set of short iron rods like the teeth of a comb. These rods were tuned to give out different notes when plucked, so that it was possible to play a tune upon them as on a harp. It will be seen that when a rod was plucked it vibrated to and from a magnet and coil, thus disturbing the magnetic space about the coil and setting up corresponding wave-currents of electricity in the coil. By connecting this coil in the circuit of a telegraph wire these currents could be carried to a distant place and made, by a precisely reverse process, to evoke a similar note from a similar iron rod there. Thus it was possible to send musical tunes "by wire."

Professor Bell had now accepted the Professorship of Vocal Physiology in the Boston University, and was engaged in training teachers to instruct deaf mutes in articulation; but whilst his days were given to this work his nights were devoted to invention and research. At this stage of his telephonic efforts, he desisted from them for a time in order to carry out another idea which had occurred to him in connection with his

daily duties. He wished to find out a mode of graphically recording the sounds of speech, so that it would be possible by its means to teach deaf mutes how to articulate at a glance. He employed the phonautograph for this purpose, and succeeded in causing the membrane of this instrument, when vibrated by the voice, to delineate its vibratory motion on a plate of smoked glass by a long wooden stylus. The undulatory line scrawled on the smoked glass was a linear representation of the vibratory motion of the membrane. Professor Bell was struck with the similarity of the phonautograph to the human ear, and he conceived the idea of constructing a phonautograph modelled on the ear; but at the suggestion of his friend Dr. Clarence Blake, the distinguished Boston aurist, he was led to employ the ear itself. With a human ear, having the stapes bone removed, the membrane moistened with glycerine and water, and a stylus of hay attached to the incus or anvil, he obtained a series of beautiful wave-lines corresponding to vocal sounds uttered beside the ear.

While engaged in these experiments the subject of telephony was in abeyance, but not forgotten in Professor Bell's mind, and it is interesting to note that this side investigation inspired the idea which crowned his telephonic work with success. He remarked with surprise the wonderful disproportion between the mass of the membrane of the ear and that of the bones vibrated by it, and at once it occurred to him that "if a membrane as thin as tissue paper can control the vibrations of bones which, when compared to it, are of immense weight and size, why may not a larger and thicker membrane vibrate a piece of iron in front of an electromagnet?" If it should prove to do this, the harp arrangement of steel rods could manifestly be done away with, and a simple piece of iron attached to a vibrating membrane put in their place. He prepared a membrane of goldbeater's skin, and attached an iron spring to it so that its vibrations would be communicated to the spring, which was placed very close to a coil and magnet. The spring here took the place of a rod in the harp arrangement. On trying this contrivance by speaking against the membrane, Mr. Watson, his assistant, at the remote end of the wire employed, thought he heard a sound; but Professor Bell failed to hear it himself. He next reduced the size of the spring and glued it on to the membrane, which he brought very close to the coil of wire surrounding the magnet. The first trial of this modified form was made between a room of Professor Bell's house at Boston and the cellar. Professor Bell in the room held one instrument in his hands, while Mr. Watson in the cellar held another, the two instruments being connected by a wire so as to form a complete telegraph circuit. Professor Bell spoke into his instrument, "Do you understand what I say?" and we can imagine the inventor's delight at hearing the piece of steel spring on his instrument reply, "Yes, perfectly."

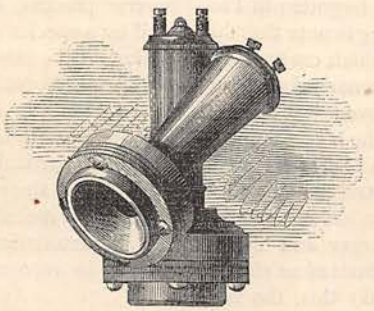
The articulation, however, of the telephone in this primary form was not very satisfactory, and it was subsequently modified into the form which it now has, and which is so extremely simple that any one knowing the elements of electricity is able to understand its action. As now made, the telephone is composed of three parts—a thin disk of soft iron, a small coil or bobbin of silk-covered copper wire, and a small bar magnet about four inches long. The bobbin of wire is placed on one pole of the magnet, so that the wire is as it were *steeped* in the magnetic space round the pole. The iron disk or diaphragm is placed with its face very close to the pole and the bobbin, so that when it vibrates in front of the pole, a series of wave-currents will be set up in the coil of wire on the bobbin. The whole is encased in mahogany, and a mouthpiece is provided for speaking against the diaphragm. The coil of wire on the bobbin is of course connected by its two ends into the circuit of a telegraph line, and the instrument is ready for use, no battery or other apparatus being required. On speaking into the mouthpiece the membrane vibrates with the sound, and generates corresponding wave-currents in the coil, which travel to the remote end of the telegraph line and pass through the coil of an exactly similar telephone there, setting its diaphragm into vibration by a reverse process, and causing it to give out to the ear, as if by a species of ventriloquism, the original sounds spoken at the other end.

The telephonic voice is small and elfin—an epitome of a voice—and as yet only to be heard when the ear is quite close to the mouthpiece. It is, however, very distinct, its articulation being superior to that of many individuals, since it does not even drop its "h's." A remarkable peculiarity is its faithful reproduction of the characteristic quality of various voices, so that it is easy to recognise a familiar voice, even the first

time one hears it through the wire, and though the wire be a hundred miles in length. Yet the speaker's natural voice is changed in a slight degree; it sounds as if he spoke from a great distance.

The present form of telephone was first publicly exhibited on the 4th of May, 1877, at a lecture given by Professor Bell in the Boston Music Hall. "Going to the small telephone-box, with its slender wire attach-

ments, Mr. Bell coolly asked, as though addressing some one in an adjoining room, 'Mr. Watson, are you ready?' Mr. Watson, five miles away in Somerville, promptly answered in the affirmative, and soon was heard a voice singing 'America.' . . . . . Going to another instrument, connected by wire with Providence, forty-three miles distant, Mr. Bell listened a moment, and said, 'Signor Brignolli, who is assisting at a concert in the Providence Music Hall, will now sing for us.' In a moment the cadence of the tenor's notes rose and fell, the sound being faint, sometimes lost, and then again audible. Later, a cornet solo played in Somerville was very distinctly heard. Still later, a three-part song floated over the wire from the Somerville terminus, and Mr. Bell amused his audience exceedingly by exclaiming, 'I will switch off the song from one part of the room to another, so that all can hear.'" Since that time, the capabilities of the telephone to transmit sound have been variously tried. Experimentally, it has been found to operate through a great length of wire; but the greatest length of actual telegraph line hitherto spoken through is 258 miles, from Boston to New York. The breathing of a man has been heard 150 miles. It picks up and transmits all extraneous noises with the same facility as speech—a gratuitous accomplishment which, in a noisy city like London, is rather against its legitimate function. It requires to be placed in a quiet chamber. Another result of its sensitiveness is that electric currents in neighbouring wires, by *induction* on the telephone wires, cause the diaphragm to vibrate and to emit peculiar noises. For instance, if the telephone is connected in circuit with one telegraph wire of a series on the same posts, and the ordinary telegraphic currents are passing in the other wires of the series, the telephone wire under the induction of these currents will cause the telephone to emit sounds like the pattering of rain on a window-pane. On one occasion an attempt was made to speak 125 miles on an ordinary telegraph wire running beside several other busy wires, and the noise heard utterly drowned all speech, and resembled nothing so much as the hammering of a boiler-maker's riveting shop. On another occasion where two telephonic wires crossed each other, the electric echoes from one wire were heard in the telephones of the other 200 miles from the point of crossing. This disadvantage can, however, be overcome, and with solitary wires it does not appear at all.



THE TELEPHONE.

The telephone is by nature unfitted to act through long submarine cables. It has been predicted by various newspaper authorities that the time is at hand when Madame Nilsson will be able to enchant opera-goers in St. Petersburg, Paris, London, and New York by telephone without leaving her boudoir, and that in a very short time we shall be able to converse in whispers through the Atlantic Cable; but these sanguine and rather reckless prophecies are by no means to be taken in earnest. The phenomenon of *induction*, which retards so seriously the ordinary signal currents in a long cable, would entirely confuse and blend the delicate undulatory currents of the telephone. It is shown by theory, and has been found by experiment, that 150 miles of the Atlantic Cable would render the telephone completely dumb. Through 100 miles of cable its articulation is muffled and husky, as if it had caught a cold in the throat.

An instrument such as the telephone is certain to become useful in a multitude of ways, the most patent being private communication between persons without having recourse to a third party. Its simplicity of use is greatly in its favour for this purpose, since any one who can speak can operate it. For business transactions, however, it is necessary to have written orders, such as are supplied by ordinary telegrams. For this reason partly, and partly from its slowness of action as compared to other fast systems of telegraph, the telephone as it is will not mainly affect existing systems of working. By the automatic, the duplex, and quadruplex systems of sending from 300 to 500 written words a minute can be transmitted over a single wire, a result beyond comparison with the rate at which we speak. For private lines between offices and works, branch and central offices, city and suburbs, and for postal telegraph lines over which there is little traffic, the telephone is likely to be largely employed. Its use is being rapidly extended in America and Europe.

The first practical application of the telephone was made by the Water Board of Cambridge, Mass., in May, 1877; and already more than 500 houses in New England hold telephonic communication, and over 3,000 telephones are at work in the United States. Mr. Brown, in the city, informs Mrs. Brown in the suburbs that he is going to bring Messrs. Jones and Robinson home to dinner at six o'clock, and directs his clerk in charge at the wharf by the river, without leaving his desk-chair. The telephone has been introduced into the mines of Pennsylvania and the Far West, and it has been recently adopted in some of our own mines, so that the pit manager on the pit-head can communicate with the foremen in the galleries below ground; and by an ingenious device the anemometer for measuring the quantity of air ventilating the passages of the mine can also be made to register itself in the manager's office. From its small size it is likely to prove useful to the diver, since it could be easily fixed into his helmet so as to enable him to speak with his assistants above water.

In Germany, where there is no patent for the telephone, it is being very quickly adopted. Messrs. Siemens and Halske, the well-known electrical contractors of Berlin, employ 100 men doing nothing

else but making them. The study of Prince Bismarck in his favourite castle at Varzin, Pomerania, is connected to the Chancellor's office at Berlin, 230 miles distant, and the Prince gives his orders and receives reports by telephone. The wire along which the Chancellor speaks is an ordinary air-line erected on posts, and when we consider the state secrets which may pass over it any day, and how easily they could be tapped by another telephone, one is tempted to become an eavesdropper to the great statesman's momentous utterances.

In England the telephone is not making way so fast as in Germany or America, partly owing to the heavy royalty added to the price of the instrument under the English patent. A telephone can be made for a few shillings, and with its alarm-bell and battery need not cost more than thirty shillings; but the proprietors of the patent have fixed the purchase-price for a pair of telephones with call-bell at from £25 to £35, and the rental price at £5 and £10 per annum. Notwithstanding this somewhat exorbitant charge, hundreds of telephones are, we believe, being sold in England; and there can be no doubt that if the price were reduced, as we trust it will be, to a much lower figure, the sale would be immense. The call-bell accompanying the telephone is an ordinary electric bell, rung to call the attention of the auditor at the other end of the wire when a conversation is desired; the voice of the telephone being too feeble in itself for this purpose. The complete equipment for each end of a telephone wire consists in the call-bell with its battery, and two telephones—one for holding to the ear to listen at, and one for speaking into. One telephone, however, is sufficient for both operations when shifted from the mouth to the ear. The telephones and bell are fitted up on a neat little writing-desk, where the oral communication can be written down as it arrives.

The speaking telephone is so entirely novel that it is impossible to say what further forms it may yet take, or what further inventions may spring from it. Manifestly the next advance beyond a speaking telephone is a *telephonograph*, or instrument whereby vocal and other sounds can be graphically recorded at a distance; and quite recently the invention of such an instrument has been reported to us from America. Mr. Edison, a distinguished American electrician, and the inventor among other things of a telephone which speaks almost as well as Professor Bell's, but is more complicated, has contrived a means of making the air vibrations of speech and music record themselves on paper in such a way, that from the paper record it is possible to reproduce the original sounds. In this way a man can speak to-day and be heard to-morrow, or 100 years hence. As described by his assistant, Mr. Edison's apparatus consists of a mouth-piece, a vibrating diaphragm to which is attached a chisel-like stylus, and a strip of paper with a raised Λ-shaped boss running along its middle. This strip of paper is caused to pass quickly under the stylus, and when one speaks into the mouth-piece the diaphragm vibrates under the voice, and the stylus indents the boss on the running paper. The indentations of the boss are the permanent record of the speech, and by a similar apparatus they can be made at any future time to reproduce, by a reverse process, the vibrations and the sounds which caused them. It follows, also, that if the diaphragm of the reproducing instrument be that of a speaking telephone, the speech may be transmitted to a distance. The invention is in its infancy yet, but we are told that Mr. Edison has already obtained all but the finer inflections of speech, and that within a year a speech made in the Senate Chamber at Washington may be recorded in New York, and by means of speaking telephones re-delivered in every editorial sanctum of that city. This reads a little like Madame Nilsson's boudoir concerts, and Atlantic Cable whispering, but it would be unwise to repudiate any invention which is correct in principle, as Mr. Edison's is. Should his future success justify his present expectations, the telephonograph will work quite a revolution in our present ways of corresponding. Letter-writing may become a thing of the past, since it will be possible to dictate a letter to the phonograph and send it by post, to be read aloud by the twin phonograph of the person who receives it, in the sender's natural voice; or, if a telephonograph is used, it may be sent direct by wire, and not by post at all. Its advantage over a telephone will lie in the permanent record it produces. Three-volume novels may be sold in the form of phonograph slip, and "The Course of True Love" may be related in the natural accents of the authoress. By a little ingenuity the characters in the novel or the play may be endowed with characteristic voices, so that the soft tenor of the hero may be heard making love to the sweet contralto of the heroine, while the deep bass of the villain mutters vengeance from his lurking-place. Every one will be able to have his own parlour opera. The orations of past orators will be familiar in our ears, and instead of treasuring autographs we will treasure the actual sayings of our best-loved friends, and our most worshipful heroes. Another fruitful field of thought and sentiment will have been taken from the poet, since it will be possible to hear the utterances of lips that have fallen to dust and "the sound of a voice that is still."

J. MUNRO, C.F.