THE TELEPHONE EXCHANGE SYSTEM.

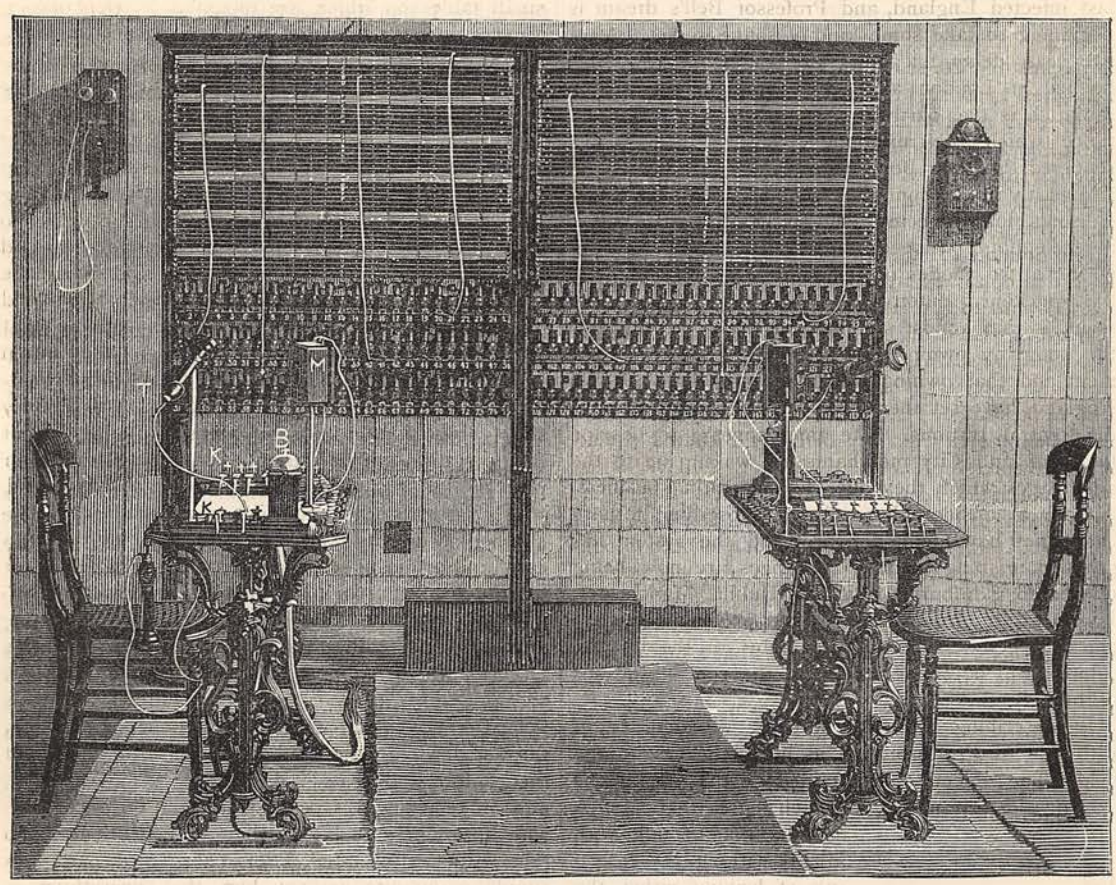

FIG. I.

WHEN Professor Graham Bell in 1877 introduced his remarkable invention, the first speaking telephone, to English audiences, he was in the habit of telling them that the day was not far distant when the instrument would be in general use amongst all classes of the people. The great cities would be ramified by a net-work of wires radiating like spiders' lines from central telephonic stations to all points of the compass within the urban and suburban limits, and stretching out even from town to town and village to village. Every home might have its private telephone, if desired, connected by a special wire to the nearest central station, so that any member of the household would be able, if he pleased, to talk to any one in all the other homes connected by telephone to the same station, by merely requesting an attendant at that station to cross-connect his private line with that of the person he wished to speak to. Nor need the intercommunication be restricted to all the clients of a particular station only, since there might easily be wires connecting all the separate stations together, and linking all the telephones in the country into one gigantic system, so that a person at Land's End could have a chat with a friend in John O'Groat's House with as much ease as if he were conversing across a dinner-table. In short, every man's house was to be in electric communication with everybody else's, and it was to be in the power of any one to talk to any one else in the country without leaving his own fire-side.

So much for the inventor's dream. Two years passed by, during which little or nothing was done towards its realisation. Although the admirable invention of Professor Bell was received in this country with loud acclaim, and gave rise to a mushroom crop of popular discourses and scientific experiments, it fell quite flat upon the community in a practical sense. The original enthusiasm soon passed away, and a pernicious faith gradually got abroad that the instrument was merely an interesting toy, very amusing to a drawing-room company, or highly ornamental to the physical cabinet of a philosophical *dilettante*, but utterly unfitted for serious every-day use. That this belief was in the main erroneous is amply demonstrated

by the contemporary success of the telephone in America, where it was taken up with spirit.

The triumph of the telephone in that country has at last infected England, and Professor Bell's dream is beginning to take some kind of shape in fact. After two years' delay, telephonic exchanges are now established in London and other large towns. This initiation is due partly to the assistance which the microphone has rendered Professor Bell's instrument, and partly to the completion of Mr. Edison's long-expected loud-speaking telephone. Indeed, the rivalry of these two modes of telephoning has quickened enterprise, and the result is that almost simultaneously the company owning Bell's instrument and that owning Edison's, in England, have set themselves to the task of furnishing central stations. The time appears to be ripe for them, and City merchants are waking up to the advantages which they offer for expediting business. Already a considerable number of subscribers to both companies have come forward, and the system has got a flourishing start. Exchanges are now being opened in Edinburgh, Glasgow, Dublin, Manchester, Liverpool, and many other large provincial towns; and a scheme is matured whereby all the London suburbs will be connected up to the central stations of the City.

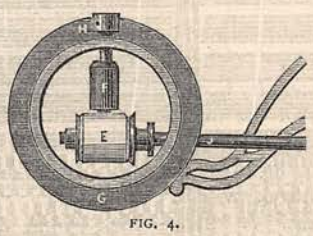

FIG. 4.

In describing the rival systems, we shall begin with that of Professor Bell, as being the first in the field. The object to be attained by the use of the exchange is of course, in each case, that Mr. A may be able to talk with Mr. B without the necessity of leaving either the room or office where he is seated to go and meet the other. This is done by providing A with a special telephone-wire from the central station to his office, and B with a special wire from the same station to *his* office. When A desires to converse with B, he telephones to the central station and requests the attendant there to put him in communication with B. This the attendant does by telephoning on his own part to B, informing him that A desires to speak with him; and on receiving the assent of B, he connects A's wire directly to B's, and thus allows them to address each other personally. When the conversation is ended he receives a signal from one or the other party to that effect, and thereupon disconnects their wires from each other again. The peculiar apparatus by which this is carried out inside the central station on the Bell method is represented in our first illustration. The attendant is seated at one of the small tables on which are mounted a telephone, T, a microphone, M, an alarm-bell, B, for calling attention, and two sets of keys, K K, for connecting and disconnecting the special wires. The curious barred frame standing behind the table is a contrivance termed a "switch-board," for the purpose of cross-connecting the different wires or circuits centring in the station. Each subscriber to the system is, of course, provided with a microphone and telephone connected in his office to his end of the wire. Let us suppose that subscriber A signals to the station for the purpose of getting the attendant to put him into communication with B. By simply touching a knob he sends a signal current to the station, which causes a red disk in the lower part of the "switch" to fall with a slight noise, which attracts the attention of the clerk. The number of the disk tells the latter that it is A who calls, and by means of a movable wire contact pendent from one of the bars (as shown), his assistant immediately puts his table telephone and microphone into connection with A, who tells him that he wishes to speak with B. The attendant thereupon shifts his speaking apparatus into connection with B, and calls the latter up. B answers the call by a signal which throws down another red disk, and the attendant then informs B that A desires to speak with him, and on receiving B's permission he at once puts A's wire in circuit with B's, so that these gentlemen can talk without the intervention of a third party. A simple manœuvre assures him that everything is working properly, and that A and B are in communication. The whole of this process occupies but a minute or two, so rapidly can the changes be effected by the arrangement illustrated; and it is found in practice that each attendant can in this way manipulate twenty different lines, with the help of an assistant to make and unmake connections on the switch-board. There are seventy-five lines joined up to each board, so that one of these suffices for four tables with their attendants. Our engraving (Fig. 1) exhibits two boards side by side, with their accompanying speaking tables. The microphone, which acts as transmitter of the speech,

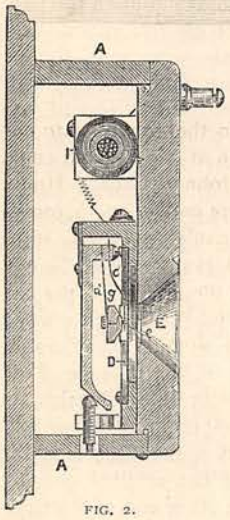

FIG. 2.

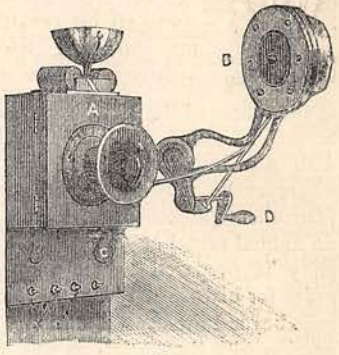

FIG. 3.

is placed in front of the speaker's mouth at the comfortable distance of a foot or two, and the telephone is supported so as to come conveniently near to the right ear. The attendant, without shifting his position in his chair, can thus converse and hear with ease; while at the same time his hands are free to manipulate the finger-keys on his right and left, for the purpose of connecting his apparatus to the various lines in turn.

This particular form of telephone was described in detail by the writer in CASSELL'S FAMILY MAGAZINE for February, 1878, so that it is unnecessary here to explain its construction. An account of the microphone was also given in the Magazine for October of the same year; but as the form employed by the Telephone Company is somewhat novel, a short description of it will not be needless. A microphone is ordinarily made by taking two pieces of carbon and placing them in contact, then passing an electric current across the joint. This point of touch is sensitive to sound-waves, and has the mysterious power of varying the strength of current flowing across it in accordance with these waves. The form of microphone in question—which was devised by Mr. Blake, an American—will be best understood by reference to Fig. 2, which represents a vertical section through it. It consists of a piece of carbon, *g*, and a piece of platinum, *e*, pressed together by springs, *d* and *c*, and both impinging on a metal diaphragm, D, the whole being enclosed in a wooden case, A. When one speaks into the mouthpiece, E, in front of the diaphragm, the sound-waves breaking on it set it in vibration, and these vibrations are communicated to the metal-carbon microphone contact, whereby they are able to vary the current in a manner corresponding to themselves. The electric stream, thus impressed with a vibratory quality, is passed through the primary coil of an induction apparatus, I, and the secondary current from the latter travels along the line wire, and on passing through the receiving telephone is able, by means of the electro-magnetic attraction it occasions, to set the diaphragm of the latter into a vibration which is heard as an imitation of the original sound.

The Bell telephone central exchange is established at the offices of the Telephone Company, 36, Coleman Street, London, E.C. Each subscriber is furnished with a wire running from his residence, office, or wherever he may require it, with all the necessary instruments attached, to this central station; and for an annual rental of £20, payable in advance, the company is prepared to fix up and maintain in good order for his use a line anywhere within a radius of a mile beyond the central station. Longer lines in connection with the station, as well as detached telephone lines, are also of course erected by the telephone companies to suit the requirements of their clients.

The Edison "loud-speaking" telephone is the outcome of two remarkable properties observed by Mr. Edison several years ago. The transmitter is based on one of these, and the receiver on the other. That upon which the transmitter is based is the property which powdered carbon possesses of diminishing in its resistance to the passage of an electric current under applied pressure, and it is taken advantage of in the Edison transmitter by causing the sound-waves of the voice to beat against a metal diaphragm bearing on a button of kneaded carbon, through which an electric current is flowing from a battery into the line. The sound-waves are thereby made to vary the resistance of the carbon in proportion to their force, and the strength of the current is in consequence proportionately varied. The result is a vibratory current in the line, capable of reproducing the vocal sounds at the distant station by means of a suitable receiving instrument. The resemblance of this transmitter to the microphone is obvious at first sight; but a skilled electrician can tell the difference. The discovery made by Professor Hughes in the microphone was the fact that a naked "contact" between two conductors pressed with a certain force together was sensitive to sound-waves, and not, as M. Clérac and Mr. Edison had found out before him, that a single piece of carbon varied in its electric resistance under pressure. The carbon transmitter of Mr. Edison has been described before in the pages of this Magazine, as also has his electro-chemical receiver; but as the latter has quite recently been brought to greater perfection than before, we shall fully illustrate it here. The principle of the receiver by which Mr. Edison translates the undulatory current of electricity set up in the line by his carbon transmitter, is the property that an electric current possesses of reducing the mechanical friction between certain substances in contact if it be made to flow across the point of contact. For example, if the paper on which I am now writing with a steel pen were moistened with a solution of certain salts of potash, and a wave of electricity were passed from my pen to the paper, the pen would slip upon the paper as I write. If a succession of electric waves—or, in other words, a varying current—were sent, the pen would glide over the paper more glibly at every wave, and the consequence would be that I should have some difficulty in writing, for I should have to struggle against a periodic movement set up in the pen independently of my hand. Now, Mr. Edison applies this peculiar property to the reproduction of speech and other sounds, by causing the undulatory sonorous current of the line to pass across the contact between a metal stylus or point and a surface of prepared chalk, which is kept rubbing past it in such a way as to lessen the friction between them and cause the stylus to slip or "skid" on the chalk at the passage of each wave. The stylus is thereby set into vibration, and being connected to a light diaphragm of talc or mica, which it also sets into vibration, the result is audible sounds in accurate imitation of the original ones that actuated the transmitter at the other end of the line.

The actual form of the Edison telephone is shown in Fig. 3, in which A is the carbon transmitter, enclosed in a protective case; and B is the electro-chemical or "electromotograph" receiver. The transmitter is provided in the middle with a mouthpiece for speaking into, an alarm-bell above to enable the distant speaker to call attention to the home instru-

ment when he desires to speak, and two finger-keys below—one (marked C) by which the home speaker can summon the distant attendant to listen, and another smaller one on the left for the purpose of putting the home battery current on to the transmitter in order to speak. The receiver B is supported by a hinged bracket, so that when not in request it can be pressed flat against the wall ; when in use, however, it is set at right angles to the transmitter, so as to be near the operator's right ear, while the speaking-tube is in front of his mouth. During the act of listening, the chalk surface is kept moving past the metal stylus by slowly turning a small handle, D. A very little practice is sufficient to enable the listener to do this automatically ; but clockwork can be applied for the purpose if required.

Fig. 4 shows the interior of the receiver in detail, the back of the vulcanite case G having been removed. E is a small cylinder of prepared chalk about the size of a bobbin of thread, and mounted on a spindle, J, which is rotated by the handle D, shown in Fig. 3. A vertical metal stylus bears against the upper face of the chalk as it is revolved, and a cylindrical spring of india-rubber, F, is fitted to the stylus for the purpose of pressing the latter gently against the chalk, the pressure being regulated by an adjusting screw, H. A talc diaphragm (not shown) is attached to the stylus in order to give out a considerable volume of sound.

The loud-speaking telephone is in this country the property of the Edison Telephone Company, 11, Queen Victoria Street, London, E.C. The company are prepared to *lease* telephones on the exchange system at £12 per subscriber per annum, or at a rate of one-half the sum charged in Paris and New York.

The principal advantages of the speaking telephone exchange system over the ordinary means of telegraphy now in vogue are, that it requires no skill on the part of any person using it, and therefore enables private parties to correspond directly without the intervention of a third party, or the loss of time in writing and deciphering telegrams. There is also less chance of error, since there is no translation of telegraphic signals into writing : nor is there so much opportunity for forging messages, because the voice of the speaker can be recognised. For local traffic the telephone is bound to supersede the slow and clumsy needle instruments now in use. It will probably become a means of expediting railway signalling, and may diminish the risk of accidents by allowing the signalman to give his attention entirely to the row of levers, instead of dividing it between these and the dial of the telegraph apparatus in use at present. As a fire-alarm it would permit the firemen to save the first and most precious moments of a fire's existence ; and in cases of shipwreck, as a means of communication between lighthouses and the shore, or between Lloyd's agents now stationed round our coasts, and head-quarters, it would doubtless prove invaluable.

J. MUNRO, C.E.

SONGS FOR THE PEOPLE.

"AID YOURSELF, AND GOD WILL AID YOU."

"AID yourself, and God will aid you,"
Is a saying that I hold
Should be written not in letters
Wrought of silver or of gold,
But upon our hearts be graven,
A command from God in heaven.
'Tis the law of Him who made you—
Aid yourself, and God will aid you.

Aid yourself—who will not labour
All his wants of life to gain,
But relies upon his neighbour,
Finds that he relies in vain.
Till you've done your utmost, never
Ask a helping hand, nor ever
Let the toilful man upbraid you—
Aid yourself, and God will aid you.

Aid yourself—you know the fable
Of the wheel sunk in the road ;
How the carter was not able
By his prayers to move the load
Till, urged by some more wise beholder,
He moved the wheel with lusty shoulder.
Do your own work—your Maker bade you—
Aid yourself, and God will aid you.

It is well to help a brother
Or a sister when in need,
But believe me, there's another
Not-to-be-forgotten creed.
Better lore did never science
Teach to man than self-reliance.
'Tis the law of Him who made you—
Aid yourself, and God will aid you.

Aid yourself—be not like ivy
Clinging still to wall or tree,
That can only rise by striving
For support unceasingly.
Rather be the oak, maintaining,
Heart and branches self-sustaining ;
For this "the Great Task-Master" made you—
Aid yourself, and God will aid you.

J. F. WALLER.