circuit at each vibration, thus transmitting as many electric pulses through the circuit as there were vibrations in the sound. These electric pulses were made to act on an electromagnet at the receiving station, which, in accordance with Page’s dis­covery, gave out a sound of a pitch corresponding to the number of times it was magnetized or demagnetized per second.

Reis’s object was to reproduce at a distance not only music but also human speech; but that he did not wholly, succeed is clear from the following extract from his lecture:—“ 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.” Con­sidering the time at which he wrote, 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. His fundamental idea—the interruption of the current—was a fatal mistake, which was not at the time properly understood. The suggestion of Bourseul and the experiments of Reis are founded on the idea that a succession of currents, corresponding in number to the successive undulations of the pressure on the membrane of the transmitting instrument, could reproduce at the receiving station sounds of the same character as those produced at the sending station. Neither of them seemed to recognize anything as import­ant except pitch and amplitude, and Reis thought the amplitude was to some extent obtained by the varying length of contact in the transmitting instrument. This might possibly be true to a small extent; but, considering the small capacity of the circuits he used and the nature of his receiving instrument, it is hardly probable that duration of contact sensibly influenced the result. The quality of the sounds was to some extent also reproduced ; but, judging from the results of later telephone investigation, it is highly probable that this was due, not to the varying duration, but to the varying firmness of the contact.

The next worker at the telephone, and the one to whom the present great commercial importance of the instrument is due, was Bell. His aim was the production, by means of the undulations of pressure on a membrane caused by sound, of an electric current the strength of which should at every instant vary directly as the pressure varied.@@1 His first idea seems to have been to employ the vibrations of the current in an electric circuit, produced by moving the armature of an electromagnet included in the circuit nearer to or farther from the poles of the magnet. He proposed to make the armature partake of the vibrations of the atmosphere either by converting it into a suitable vibrator or by controlling its vibrations by a stretched membrane of parchment

In the early trials the armature had the form of a hinged lever of iron carrying a stud at one end, which pressed against the centre of a stretched membrane. Fig. 1 shows the arrangement. M was a membrane stretched by a ring R over the end of a tube T fixed at one side of the frame F. To the oppo­site side of the frame an electromagnet I was fixed with its axis in line with the tube T, and between the end of the electromagnet and the membrane a hinged armature A was arranged in such a way that its motion could be controlled by the membrane. The instrument was joined in circuit with a battery and another similar instru­ment placed at a distance; and a continuous current was made to flow through the circuit, keeping the electromagnets energized. The ex­periments with this form were not successful, and, with the view of making the moving parts as light as possible, he substituted for the comparatively heavy lever armature a small piece of clock spring, about the size of a sixpence, glued to the centre of the diaphragm. The magnet was mounted with its end carrying the coil opposite, and very close to, the centre of the piece of clock spring. This answered sufficiently well to prove the feasibility of the plan, and subsequent experiments were directed to the discovery of the best form and arrangement of the parts. An increase in the size of the iron disk attached to the membrane augmented both the loudness and the distinctness of the sounds, and this finally led to the adopt on of a thin iron disk supported round its edge, acting as both membrane and armature (fig. 2). Again, the form of the opening or mouthpiece in front of the membrane exercised considerable

influence on the efficiency of the instrument, and it was ultimately ascertained that a small central opening, with a thin air space extending across the face of the membrane, was best. It was also found that comparatively small magnets were sufficient, and that there was no particular virtue in the closed circuit and electromagnet, but that a small permanent magnet having one pole in contact with

the end of the core of a short electromagnet, the coil of which was in circuit with the line, but which had no permanent current flowing through it, answered the purpose quite as well.@@2 The apparatus thus acted as both a transmitter and a receiver ; indeed it is essenti­ally the magneto-receiver which has come into universal use in practical telephony, though for transmission it was soon superseded by forms of microphonic transmitters. One of the latest forms of

receiver, known as the double pole, is shown in fig. 3. M and M' are two permanent magnets; P and P' are soft iron pole-pieces upon which are placed the electromagnet coils C and C , D is the diaphragm; I is a soft iron distance piece placed between the magnets at the end remote from the diaphragm; B is the brass body of the instrument, over which is placed a thin ebonite shell S. E is the ear-piece made of ebonite ; F is a cap of the same material enclosing the receiver terminals, which are mounted upon the ebonite block G, attached to the distance piece I.

A telephone transmitter and a receiver on a novel plan were patented in July 1877 by Edison, shortly after the introduction of Bell’s instruments. The receiver was based on the change of friction produced by the passage of an electric current through the point of contact of certain substances in relative motion. In one form a drum, mounted on an axis and covered by a band of paper soaked in a solution of caustic potash, was turned under a spring the end of which was in contact through a platinum point with the paper. The spring was attached to the centre of a diaphragm in such a way that, when the drum was turned, the friction between the point of the spring and the paper deflected the diaphragm. The current from the line was made to pass through the spring and paper to the cylinder. Now it had been previously shown by Edison that, when a current was made to pass through an arrangement like that just described, the friction between the paper and the spring was greatly diminished. Hence, when the undulating telephonic currents were made to pass through the apparatus, the constant variation of the friction of the spring caused the deflexions of the dia­phragm to vary in unison with the variation of the electric

@@@1 See A. G. Bell, “ Telephone Researches,” in *Journ. Soc. Tel. Eng.,* 31st October 1877.

@@@2 The extreme smallness of the magnets which might be success­fully employed was first demonstrated by Professor Peirce of Brown University, Providence, R.I.