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, is turned under a spring the end of which is in contact through a platinum point with the paper. The spring is attached to the centre of a diaphragm in such a way that, when the drum is turned, the friction between the point of the spring and the paper deflects the diaphragm. The current from the line is made to pass through the spring and paper to the cylinder. Now it had been previously shown by Edison that, when a current is made to pass through an arrange­ment like that just described, the friction between the paper and the spring is greatly diminished. Hence, when the undulating telephonic currents are made to pass through the apparatus, the constant variation of the friction of the spring causes the deflexions of the diaphragm to vary in unison with the variation of the electric currents, and sounds are given out corresponding in pitch, and also to some extent in quality, with the sounds produced at the transmitting station. A cylinder of chalk was used in some of Edison’s later experiments with this receiver. The transmitter is illustrated (see fig. 10) and described (p. 132) below.

Experiments very similar to these of Edison were made by Elisha Gray of Boston, Mass., and described by him in papers communicated to the American Electrical Society in 1875 and 1878. In these experiments the electric current passed through the fingers of the operator’s hand, which thus took the place of the spring in Edison’s ap­paratus. The diaphragm was itself used as the rubbing surface, and it was either mounted and rotated or the fingers were moved over it. When the current passed, the friction was felt to increase, and the effect of sending a rapidly undulating current through the arrangement was to produce a sound. The application of this apparatus to the transmission of music is described by Gray.@@1  In another form of telephone, brought prominently forward by Professor Dolbear,@@2 the effects are produced by electrostatic instead of electromagnetic forces, as in the Bell telephone. Sir W. Thomson observed in 1863 @@3 that when a condenser is charged or discharged a sharp click is heard, and a similar observation was made by Cromwell F. Varley, who proposed to make use of it in a telegraphic receiving instrument.@@4 In Dolbear’s instrument one plate of a condenser is a flexible diaphragm, connected with the telephone line in such a way that the varying electric potential produced by the action of the transmitting tele­phone causes an increased or diminished charge in the condenser. This alteration of charge causes a correspond­ing change in the mutual attraction of the plates of the condenser ; hence the flexible plate is made to copy the vibrations of the diaphragm of the transmitter. It is obvious that this apparatus may be used either as a transmitter or as a receiver, but that the effects must under ordinary circumstances be in either case extremely feeble.

In the Reis instruments the transmitter and receiver are separate parts, which are not interchangeable. The Bell telephone can be used either as a transmitter or as a

receiver. The Edison receiver and the Dolbear condenser were only intended to be used as receiving instruments.

It was very early recognized—and, indeed, is mentioned in the first patents of Bell, and in a caveat filed by Elisha Gray in the United States patent office only some two hours after Bell’s application for a patent—that sounds and spoken words might be transmitted to a distance by causing the vibrations of a diaphragm to vary the re­sistance in the circuit. Both Bell and Gray proposed to do this by introducing a column of liquid into the circuit, the length or the resistance of which could be varied by causing the vibrations of the diaphragm to vary the depth of immersion of a light rod fixed to it and dipping into the liquid (see figs. 8, 9 below). This idea has been per­haps the most fruitful of any modification of telephonic apparatus introduced.

On 4th April 1877 Mr Emile Berliner filed a caveat in the United States patent office, in which he stated that, on the principle of the variation with pressure of the resist­ance at the contact of two conductors, he had made an instrument which could be used as a telephone transmitter, and that, in consequence of the mutual forces between the two parts of the current on the two sides of the point of contact, the instrument was capable of acting as a receiver. The caveat was illustrated by a sketch showing a diaphragm with a metal patch in the centre, against which a metal knob was lightly pressed by an adjusting screw. This seems to have been the first transmitter in which it was proposed to use the resistance at the contact of two conductors.

Almost simultaneously with Berliner, Edison conceived the idea of using a variable resistance transmitter.@@5 He proposed to introduce into the circuit a cell containing carbon powder, the pressure on which could be varied by the vibrations of a diaphragm. He sometimes held the carbon powder against the diaphragm in a small shallow cell (from a quarter to half an inch in diameter and about an eighth of an inch deep), and sometimes he used what he describes as a *fluff,* that is, a little brush of silk fibre with plumbago rubbed into it. In another form the plum­bago powder was worked into a button cemented together with syrup and other substances. In the specification of the patent applied for on 21st July 1877 he showed a sketch of an instrument which consisted of a diaphragm, with a small platinum patch in the centre for an electrode, against which a hard point, made of plumbago powder cemented together with india-rubber and vulcanized, was pressed by a long spring, the pressure of the carbon against the platinum disk being adjusted by a straining screw near the base of the spring. Subsequently he filed an application for a patent in which various forms of springs and weights assisted in maintaining the contacts and otherwise improved the instrument.

In the early part of 1878 Professor Hughes, while en­gaged in experiments upon a Bell telephone in an electric circuit, discovered that a peculiar noise was produced when­ever two hard electrodes, such as two wires, were drawn across each other, or were made to touch each other with a variable degree of firmness. Acting upon this discovery, he constructed an instrument which he called a microphone,@@6 and which consisted essentially (see fig. 11) of two hard carbon electrodes placed in contact, with a current passing through the point of contact and a telephone included in the same circuit. One of the electrodes was attached to a sounding board capable of being vibrated by sound- waves, and the other was held either by springs or weights

of these modifications, see Du Moncel, “ Le Téléphone,” in *Bibliothèque des Merveilles,* Paris, 1882.

@@@1 See George B. Prescott, *The Speaking Telephone,* London, 1879, pp. 151-205.

@@@2 *Scientific American,* 18th June 1881.

@@@3 *Electrostatics and Magnetism,* p. 236.

@@@4 See *Tel. Journ.,* 1st August 1877, p. 178 ; also Adams, *Journ. Soc. Tel. Eng.,* 1877, p. 476.

@@@5 See *Journal of the Telegraph,* New York, April 1877 ; *Philadelphia Times,* 9th July 1877 ; and *Scientific American,* August 1877.

@@@6 This term was used by Wheatstone in 1827 for an acoustic ap­paratus intended to convert very feeble into audible sounds ; see his *Scientific Papers,* p. 32.