against an anvil or screw *b* (fig. 16) in such a way as to give a dis­tinct and somewhat loud sound. Dots and dashes are distinguished by the interval between the sounds of the instrument in precisely the same way as they are distinguished when reading from the recorder by sound. The form of sounder commonly used in England is shown in fig. 16; it is one of the simplest possible instruments, is easily adjusted to the current by tightening or slackening the spring *s,* and is very little liable to get out of order.

Another and in some respects a simpler method of recording is to use a chemically prepared ribbon of paper. Suppose, for in­stance, the paper ribbon to be soaked in a solution of iodide of potassium and a light contact spring made to press continu­ously on its surface as it is pulled forward by the mechanism. Then, if a current is sent from the spring to the roller through the paper, a brown mark will be made by the spring due to the liberation of iodine. This was the principle of the chemical telegraph proposed by Edward Davy in 1838 and of that proposed by Bain in 1846. It gives a ready means of recording on the Morse plan at a high rate of speed, and Bain’s telegraph was successfully worked for some years in America. Several ingenious applications of his method have been proposed, as, for example, the copying telegraph of Bake­well and of Cros, by means of which a telegram may be transmitted in the sender’s own handwriting ; the pantelegraph of Caselli ; the autographic telegraphs of Meyer, Lenoir, Sawyer, and others ; and the autographic typo-telegraph of Bonelli. The principle of action of these instruments is this. Suppose two metallic cylinders, one at the sending and the other at the receiving station, to be kept revolving synchronously, and suppose the axis of each to be threaded with a fine screw so that as it revolves rapidly it has a slow side motion. Wrap round the cylinder at the sending station a ribbon of tinfoil, or paper covered with a conducting coating, on which the message is written in varnish or some other insulating substance. Suppose also a ribbon of paper which has been soaked in iodide of potassium to be wrapped round the cylinder at the receiving station. Cause a stile, as in the Bain telegraph, to press on each cylinder and set it in motion. It is evident that so long as the stile at the sending end presses on the clean foil the stile at the receiving end will continue to make a brown mark, but that when it passes over the varnish the mark will be interrupted. In this way, as the two cylinders revolve and move sideways, the series of interruptions made at the receiving end form an exact copy of the varnish marks at the sending end. These instruments are at present but little used.

It has been found possible to make the Morse ink-writer so sensi­tive that it can record signals sent over land lines of several hundred miles in length very much faster than they can be transmitted by hand, and this has led to the adoption of automatic methods of transmission. One was proposed by Bain as early as 1846, but it did not come into use. That now employed is, however, practically a development of his idea. It consists in punching, by means of “ a puncher,” a series of holes in a strip of paper in such a way that, when the strip is sent through another instrument, called the “transmitter,” the holes cause the circuit to be closed at the proper times and for the proper proportionate intervals for the message to be correctly printed by the receiving instrument or recorder. The most successful apparatus of this kind is that devised by Wheatstone ; others have been introduced by Siemens and Halske, Garnier, Humaston, Siemens, and Little.

In Wheatstone’s automatic apparatus three levers are placed side by side, each acting on a set of small punches and on mechanism for feeding the paper forward a step after each operation of the levers. The punches are arranged as shown in fig. 17, and the levers are adjusted so that the left-hand one moves *a, b*, *c* and punches a row of holes across the paper (group 1 in the figure), the middle one moves *b* only and punches a centre hole (2 in the figure), while the right-hand one moves *a, b, d, e* and punches four holes (3 and 4 in the figure). The whole of this operation represents a dot and a dash or the letter “a.” The side rows of holes only are used for transmitting the message, the centre row being required for feeding forward the paper in the transmitter. The perforation of the paper when done by hand is usually performed by means of small mallets, but at the central telegraph office in London the keys are only used for opening air-valves, the actual punching being done by pneumatic pressure. In this way several thicknesses of paper can be perforated at the same time, which is a great convenience for press work, since copies of the same message have often to be transmitted to several newspapers at the same time. The mode of using the paper ribbon for the transmission of the message is illustrated in fig. 18. An ebonite beam E is rocked up and down rapidly by a train of mechanism and moves the cranks A and B by means of two metal pins *p, p.* A and B are in metallic contact with each other through the springs *s*, *s*, and they carry two light vertical rods M, M1, the one as much in front of the other as there is space between two successive holes in the perforated ribbon. To the other ends of A, B rods H, H1 are loosely hinged, their ends passing loosely through holes in the ends of the bar P, which is fixed to the divided disk D. By means of two collars K, K1 and the wheel W, the disk D is made to oscillate in unison with the beam E. The cranks C and C1 are connected with the poles of the sending battery B. The operation is as follows. The paper ribbon R is moved forward by its centre row of holes at the proper speed above the upper ends of the rods M, M1 ; should there be no hole in the ribbon it pushes the crank A or B out of contact with the pins *p, p* and prevents a current passing to the line. Should, however, a row of holes, like group 1 above, be perforated, the rod M1 will first be allowed to pass through the paper and copper will be put to the line ; at the next half stroke of the beam, M will pass through, and as the disk D reverses the battery zinc will be put to the line. Thus for a dot first a positive and then a negative current are sent to the line, the effect of the positive current continuing during the time required for the paper to travel the space between two holes. Again, suppose groups 3 and 4 to be punched. The first part will be, as before, copper to the line ; at the next half stroke of the beam M will not pass through, as there is no hole in the paper ; but at the third half stroke it passes through and zinc is put to the line. Thus for a dash the interval between the positive and the negative current is equal to the time the paper takes to travel over twice the space between two successive holes. Hence for sending both a dot and a dash reverse currents of short duration are sent through the line, but the interval between the reversal is three times as great for the dash as for the dot. In the receiving instru­ment the electromagnet is so constructed that the armature, if pulled into any position by either current, remains in that position, whether the current continues to flow or not, until a reverse current is made to act on the magnet. For the dot the armature is de­flected by the first current, the ink-wheel being brought into con­tact with the paper and after a short interval pulled back by the reverse current. In the case of the dash the ink-wheel is brought into contact with the paper by the first current as before and is pulled back by the reverse current after three times the interval. The armature acts on an inking disk on the principle described above, save only that the disk is supplied with ink from a groove in a second wheel, on which it rolls : the grooved wheel is kept turning with one edge in contact with ink in an ink-well. By this method of transmission the battery is always to the line for the same interval of time, and alternately with opposite poles, so that the effect of electrostatic induction is reduced to a minimum. Through the instrumentality of this method as many as 400 words per minute have lately been transmitted by Mr Preece between London and Newcastle, a distance of 278 miles.

The first considerable improvement on the House type-printer, referred to above, was made by D. E. Hughes of Kentucky in 1855. In the Hughes instrument (see fig. 19) two trains of clockwork mechanism, one at each end of the line, are kept moving synchron­ously by powerful spring governors. Each instrument is provided with a key-board, resembling that of a small piano, the key levers of which communicate with a circular row, R, of vertical pins. A horizontal arm A fixed to a vertical shaft in gear with the mechan­ism sweeps over these pins at the rate of from one to two turns per second. When a key is depressed, slightly raising one of the pins, the battery is put to the line for a short time at that part of the revolution by means of a sledge S carried by the horizontal arm. The current thus sent to the line may be made either to act directly on the printing instrument or to close a local circuit by means of a relay. For simplicity we will suppose direct action. The current then passes through the coils of a powerful electromagnet M, which relieves the printing mechanism. The electromagnet consists of two coils each containing a soft iron core of the same length as the coil. These cores rest on the ends of the two arms of a powerful horse-shoe permanent magnet, and thus become strongly polarized by induction. A soft iron armature is placed across the free ends of the soft iron cores and is pulled by a strong spring, the tension