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 were devised by Siemens and Halske, Garnier, Humaston, Siemens, and Little.

In the Wheatstone 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. 28, 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, and at other large offices, 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. 29. An ebonite beam B is rocked up and down rapidly by a train of mechanism, and moves the cranks

A and A' by means of two metal pins P, P'. A and A' carry two light vertical rods S, M, 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, A', rods H, H' are loosely hinged, their ends passing loosely through holes in the end of the bar L. By means of two collars K, K', the lever L is made to oscillate in unison with the beam B. The operation is as follows : the paper ribbon or perforated slip is moved forward by its centre row of holes at the Croper speed above the upper ends of the rods S, M ; should there be no holes in the ribbon then the cranks A, A' will remain stationary, although the beam B continues to rock, since the rods S, M are pressing against the ribbon and cannot rise. Should, however, a row of holes, like group 1, fig. 28, be in the ribbon, the rod M will first be allowed to pass through the paper, and the corresponding movement of crank A' will, through the agency of collet K, throw over lever L, and the battery zinc will be put to the line; at the next half stroke of the beam, S will pass through, and crank A by its movement will, through the agency of collet K', throw over lever L in the reverse direction, so that the battery copper will be put to the line. Thus for a dot, first a negative and then a positive current is sent to the line, the effect of the 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, zinc 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 copper 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 constructed in precisely a similar way to the relay (fig. 20), so 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.

Although it is quite possible to obtain good signals at a rate corresponding to 600 letters per minute, in practice it is found that such a high speed is not advisable, as it is difficult or im­possible for even the most skilled operators properly to handle and transcribe from the “ slip” on which the signals are recorded.

In Squier and Crehore’s "Synchronograph ” system “ sine waves ” of current, instead of sharp "makes and breaks,” or sharp reversals, are employed for transmitting signals, the waves being produced by an alternating-current dynamo, and regu- ated by means of a perforated paper ribbon, as in the Wheatstone automatic system. The arrangement has been found under certain conditions to give better results than those obtained with sharp reversals.

In the undulator apparatus, which is similar in general principle to the “ siphon recorder ” used in submarine telegraphy, a spring or falling weight moves a paper strip beneath one end of a fine silver tube, the other end of which dips into a vessel containing ink. The siphon is supported on a vertical axle carrying two armatures which are acted upon by two electromagnets. It is in fact the electromagnet and spindle of a telegraph relay with a siphon in place of the tongue. Screw adjust­ments are provided for closing or opening the air gap between the electromagnets and armatures, for raising or lowering the siphon, and for adjusting the point of the siphon to the centre or side of the paper strip. The received signals are recorded on the paper strip in an undulating continuous line of ink, and are distinguished by the length of deviation from zero. The amplitude of the signals can be varied in several ways, either by a shunt across the electro­magnet, or by altering the tension of the controlling springs or by altering the air gap between electromagnets and armatures. Up to 100 words per minute the signals are easily readable, but beyond that speed they are more difficult to translate, although experts can read them when received at 200 words per minute.

*Pollak-Virag System.—*In the improved Pollak-Virag system the received signals are recorded in characters similar to ordinary hand­writing. The operator actuates a typewriter form of perforator which punches varying groups of holes, representing the different characters, in a paper strip about one inch wide. This slip is then passed through a transmitter fitted with brush contacts and con­nected to the two line wires of a metallic loop. One circuit is formed by the loop itself, and a second, quite independent, by the two wires in parallel, earthed at each end. At the receiving end there are two telephone receivers, one joined in the loop circuit, the other in the earth return circuit. The diaphragms of these are mechani­cally connected to a small mirror and control its movement in accordance with the strength and direction of the received currents. One diaphragm gives the mirror a movement in a vertical direction while the other gives it a horizontal motion. The two acting to­gether can thus give the mirror any desired movement within limits. A ray of light is directed upon the mirror, and the motion of the latter, due to the varying strengths and direction of the received currents, is made to write the transmitted signals upon a strip of bromide photographic paper about three inches wide.

The line of writing is of course continuous, there being no break, although there is a space between words. The writing, although not well formed, is sufficiently distinct for ordinary' messages; the figures 3, 5, and 8 are, however, liable to be mistaken for each