other, being very similar in appearance. The bromide paper is automatically passed through a developing bath, a fixing bath, and drying rollers. This operation occupies about twelve seconds, giving a message written in column form ready for delivery. It is not a system likely to have general application.

*Type Printing Telegraphs.—*The first considerable improvement in type printing telegraphs was made by D. E. Hughes in 1855.

In the Hughes instrument two trains of clockwork mechanism, one at each end of the line, are kept moving at the same speed. Each instrument is provided with a keyboard, resembling that of a small piano, the key levers of which communicate with a circular row of vertical pins. A horizontal arm fixed to a vertical shaft in gear with the mechanism sweeps over these pins at the rate of about two revolutions per second. When a key is depressed, slightly raising one of the pins, the horizontal arm will pass over it and in doing so will momentarily join the battery to the line. 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 an electromagnet, which releases the printing mechanism. The electromagnet consists of two coils, each wound on a soft iron core fixed to the poles of a strong permanent horse-shoe magnet. The armature of the electromagnet is normally attracted by the effect of the permanent magnet, but it is furnished with two antagonistic springs tending to throw it upwards. These springs are so adjusted that they are not quite able to release the armature. When a current comes in from line it passes through the electromagnet in such a direction as to weaken the effect of the permanent magnet ; hence the springs are able to release the armature, which rises smartly and in its turn releases the printing mechanism. Either a weight or a motor is used for making the movements of the mechanism required to effect the printing of the signals. The type-wheel is carried round continuously by the mechanism to which it is attached by a friction disk and ratchet drive. An axle carrying four cams is normally at rest, but it is thrown into gear with the mechanism when the armature rises, makes one complete revolution, and comes to rest ready for the next signal. In its revolution one of its cams engages with the correcting wheel attached to the type-wheel in order to ensure that the latter is in the correct position for printing a complete letter; the second cam lifts the paper against the type-wheel and prints the letter; the third moves forward the paper tape one space to be ready for the printing of the next letter ; and the last cam replaces the armature on the cores of the electromagnet. This complete operation occu­pies about one-twelfth of a second. It is of course necessary that two instruments working together should have the same speed. This is obtained by causing one of them to send a series of signals from one particular key, while the operator at the other station adjusts his speed until he receives the same signal after short- circuiting his electromagnet for ten revolutions. Both type-wheels are then set to zero by the lever provided for that purpose, and released by the current from the letter-blank key; then all subse­quent signals will be recorded similarly at the sending and re­ceiving ends. If by any chance wrong signals are printed or the instruments get out of phase, the sender is stopped by the receiver sending a few signals, after which both type-wheels are again set to zero and correspondence continued. This system of telegraphic printing has a great advantage over the step-by-step system in avoiding the necessity for the rapidly acting electric escapement, which, however skilfully planned and executed, is always liable to failure when worked too rapidly. In Hughes’s instrument almost perfect accuracy and certainty have been attained; and in actual practice it has proved to be decidedly superior to all previous type-printing telegraphs, not only in speed and accuracy, but in less liability to mechanical derangement from wear and tear and from accident. It involves many novel features: the receiving electromagnet is of peculiar construction and remarkable efficiency and the transmitting apparatus has a contrivance to prevent unin­tentional repetitions of a letter through the operator holding his finger too long on a key. This instrument was for some years extensively used in the United States, until superseded by G. Μ. Phelps’s modification of it, known as the “ American combination printing telegraph," because it embodied part of Hughes’s and part of House’s instruments. With this modified form somewhat greater speed was obtained, but it was found difficult to drive, requiring the use of steam or some such motive-power. In a subse­quent modification introduced in 1875 an electromotor was applied to drive the printing mechanism. This allowed a shorter train and stronger wheelwork to be used, securing more certain action, and involving less risk of derangement. Hughes’s form was taken up by the French government in i860, and is very largely in use not only in France but in all European countries, including Great Britain.

The system brought out in 1874 by Émile Baudot and since considerably developed is a multiplex system giving from two to six channels on one wire, each channel giving a working speed of thirty words per minute. The channels can be worked in either direction according to the traffic require­ments. The line is joined at each end to distributors which are arranged to maintain uniform speed and to control their respective receivers. Each channel consists of a keyboard and receiver both electrically connected to certain parts of the distributor. The keyboard has five keys similar to those of a piano, and the letters and figures are obtained by the different combinations which can be formed by the raised and depressed keys. In the raised position a negative battery is connected to the distributor and in the de­pressed position a positive battery. At regular intervals a rotating arm on the distributor connects the five keys of each keyboard to line, thus passing the signals to the distant station, where they pass through the distributor and certain relays which repeat the currents corresponding to the depressed keys and actuate electro­magnets in the receivers. Each receiver is provided with five electromagnets corresponding to the five keys of the keyboard, and the armatures of the electromagnets can thus repeat the various combinations for all the signals allocated to the different combina­tions of the keys. When a combination of signals has been received and the armatures have taken up their respective positions corre­sponding to the transmitting keyboard, certain mechanism in the receiver translates the position of the five armatures into a mechani­cal movement which lifts the paper tape against a type-wheel and prints the corresponding letter. The movement for any particular combination of armatures can only take place once per revolution of the type-wheel and at one particular place. The signals must therefore be sent at regular intervals, and to ensure this being done correctly a telephone or time-tapper is provided at each key­board to warn the operator of the correct moment to depress his keys. The Baudot apparatus can have certain channels extended so as to form a means of continuous communication between one station and two or three others by means of one line. It can also be duplexed or repeated similar to any other telegraph system.

In the Murray system the messages are first prepared in the form of a strip of perforated paper about half an inch wide. Per­forating machines equipped with typewriter keyboards arc used for the preparation of the messages, two or three keyboard perforators being employed at each end of the telegraph lines on which the Murray system is used. The messages in the form of perforated tape are then passed through an automatic transmitter, something like a Wheatstone transmitter, at a speed of about 100 words a minute. At the receiving station electrical mechanisms record the signals once more as perforations in a paper strip forming an exact replica of the transmitting tape. This received perforated tape is then used to control what is known as the printer or automatic typewriter, a machine that translates the tape perforations into letters and prints the messages in Roman type in page form. This printer is purely mechanical, and its speed is very high. An experimental printer constructed about the middle of 1908 by the British Post Office, operated successfully at the rate of 210 words (1260 letters) per minute. The usual working speed is from 100 to 120 words per minute. The Murray auto­matic system was designed specially for dealing with heavy traffic on long lines. As it uses the Baudot telegraph alphabet it has an advantage in theory over the Wheatstone using the Morse alphabet in regard to the speed that can be obtained on a long telegraph line in the ratio of eight to five, and this theoretical advantage is more or less realized in practice. The Murray automatic system is not regarded as suitable for short telegraph lines or moderate traffic, printing telegraphs on the multiplex principle being con­sidered preferable in such circumstances. One of the longest circuits upon which it has been successfully worked is that between St Petersburg and Omsk, a distance of approximately 2400 miles of iron wire, with three repeating stations. As in some other systems retransmission is effected from the received perforated tape.

The Creed system is a development of the Morse-Wheatstone system, and provides a keyboard perforator which punches Morse letters or figures on a paper strip by depressing type­writer keys. The slips are passed through an ordinary Wheatstone transmitter and actuate Wheatstone receiving apparatus which in turn controls a "Creed receiving perforator." This machine reproduces a copy of the original transmitting slip, which can be passed on to any other Wheatstone circuit or can be run through a “ Creed printer,” which is a pneumatic machine actuating a typewriter by means of valves. Messages are thus typed upon a slip which is gummed to the telegraph form. The speed of the receiving perforator ranges from 20 to 150 words per minute.

In the Rowland multiple method of telegraphic working, the transmitter consists of a mechanical keyboard provided with a series of levers, which effect certain combinations of positive and negative currents for each letter. These currents are furnished by an alternator which, transmits sine currents over the line and operates a motor at the distant end of the line, both machines running in synchronism. At the re­ceiving end of the circuit a shaft is coupled to the motor; this is provided with gearing which rotates four combining commutators and four type-wheels, which print the letters on the band of paper. There are four transmitters and four receivers, which are operated independently by means of an adaptation of the multiplex system of working, and each circuit is provided with a number of segments set apart for its own use. Each transmitter is therefore able to