THE PROGRESS OF THE TELEGRAPH *

IV.

IT will only be necessary to describe generally the construction of the Syphon or Recording Galvanometer. It consists essentially of two parts; first, that portion of the machine which, being influenced by the received current, oscillates or moves, thus becoming the motor or mechanical power; and, second, the arrangement for permanently recording or registering this motion. The motor or mechanical power is obtained by the employment of a very light suspended coil consisting of a small number of turns of fine insulated wire, placed in a very powerful magnetic field produced by permanent magnets or electro-magnets; these act with great exciting force upon the suspended insulated wire coil, causing it to deflect or vibrate when the current passes through it.

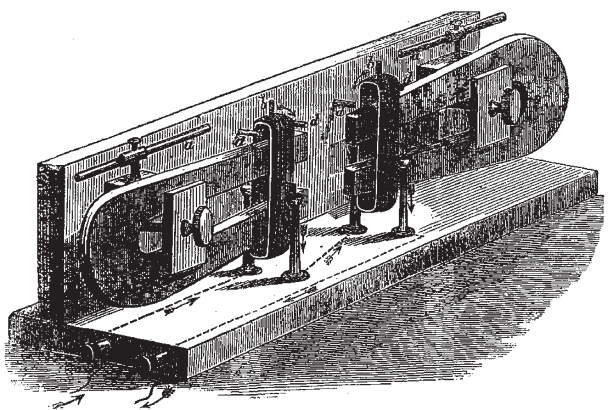

FIG. 18.—Mr. William Sykes Ward's Telegraph, September 1847.

This deflection of a vibratory coil through which a current is passed, over the poles of a magnet, was the subject matter of a patent in 1847, by Mr. William Sykes Ward, of Leeds, in which it is stated, "Signals are indicated by the deflection of electro-dynamic coils, free to vibrate over the poles of a permanent magnet;" the deflection of the coil to right or left indicating either the dot or dash of the Morse alphabet, or the beats of the old double-needle instrument.

This apparatus is represented in Fig. 18. Two permanent magnets are attached to a suitable frame, over the poles of which the oscillating coils are placed, the lateral motions of which, to the right or left, according to the direction of the current, are regulated by the stop pins *d d*.

In connection with each permanent magnet an adjustable permanent magnetic bar *a* is placed, which, acting upon a soft iron exponent *b* attached to the upper extremity of the oscillating coils, regulates the sensitiveness of their movement to the required degree, according as the magnetic bar *a* is advanced or withdrawn from proximity to the soft iron medium *b*. The completion of the circuit through the coils is indicated by the arrows and metallic contacts in the illustration.

In the Syphon Recording Apparatus, to produce the maximum amount of deflection of the coil with the minimum amount of current force, this delicate recording helix is suspended so as to vibrate over a soft iron core placed between the two poles of a powerful electro-magnet, so that the most delicate current traversing the coil receives the maximum amount of magnetic sympa hy; the space between the iron core and the poles of the magnet being as narrow as is consistent with freedom of oscillation of the coil.

In tracing the history of the various step-by-step developments of the telegraph, which will be done subsequently, we shall show that a very beautiful scientific application of electrical statics, obsolete as regards practical results, was developed by Henry Highton in 1846, where the voltaic current was passed through a narrow strip of gold leaf enclosed in a glass tube and placed in a vertical direction before the poles of a powerful magnet. In this arrangement similar results were obtained to that of the oscillating coil over the poles of the magnet, the gold leaf filament being deflected in a curve to the right or the left, according as the current is passed in the one or other direction from the voltaic battery through the gold leaf strip.

Having thus briefly described the *motor*, the second part or recording mechanism of the apparatus comes under notice. The function of this is to impart the motion of the receiving coil to a light capillary tube or syphon of glass, suspended and adjusted to the coil by means of the torsional elasticity of a helical wire. The long leg of this syphon acts as the marker; the short end dips into a reservoir of ink or other marking fluid which is continuously caused to be spurted or ejected from the end of the syphon, by means of electric agency, on to a moving ribbon of paper mechanically drawn over a metal plate electrified in an opposite direction to that of the syphon. Thus a powerful difference of potential or electrical equilibrium is constantly maintained between the tube and the metal plate, the tendency to produce equilibrium resulting in a succession of sparks between the syphon and the metal plate, producing a fine stream of ink or a succession of minute dots on to the surface of the moving paper ribbon. A very fine hair-pencil may be attached to the syphon as a capillary marker, and so dispense with the electrical arrangement. If the syphon remains in a neutral position, a continuous line will be drawn over the paper, but when by reason of the motion of the receiving coil the syphon is drawn either to the right or left, a corresponding deviation from the straight line will be indicated; thus a record is maintained on paper of the movements of the coil, without that movement being in the least degree impeded by friction or any other mechanical defects. To develop fully the effective results of this most delicate recording apparatus, it is evident that some means must be employed more accurate than the human hand for the transmission of the several electric groups and sequences of currents passing through the wire which severally and collectively compose the message. From facts that have been already stated regarding the rapid transmission of electric currents through extended submarine cable circuits, it will be remembered that with a view to obtain a maximum amount of speed, the electric throbs transmitted by the cable should be of equal duration and at equal intervals of time, so as to allow mechanically for the regular difference of tension in the current at the distant end, as well as for the charge and discharge of the circuit. An automatic transmitter for passing the several currents and groups of currents into the circuit is therefore employed. The details of construction of this essential piece of mechanism will be given in the following description of Sir Charles Wheatstone's automatic high-speed printing instrument. It is only natural to suppose that there are several automatic transmitters scheduled in the Patent Office: the reader does not, however, require to become a dictionary upon patent lore or mechanical variations of electrical apparatus, but simply to acquire a general knowledge of the progress of the telegraph up to the year 1875.

In years long since passed, the invention and introduction of the Jacquard Loom produced a vast revolution in the processes of weaving; by its means an automatic record of the groups and sequence of the threads necessary to produce the pattern by being raised to the surface of the cloth was maintained, and a simple mechanical arrangement performed simultaneously with the succes-

* Continued from p. 472.

sive to-and-fro motion of the shuttle, superseded the laborious and complicated hand process previously in vogue. An endless band of cards is passed successively over the register of the loom, and brought forward at each throw of the shuttle, each card being perforated with holes to represent that integral portion of the pattern, and each hole controlling the elevation of one or more threads in the warp. A series of weighted needles are, as the holes pass, momentarily allowed to drop, and in so doing by a mechanical adjustment raise the respective threads or groups of threads to the surface of the cloth, so that the shuttle passes underneath, and thus the pattern thrown on the surface is automatically repeated as the cards in succession pass over the register. It is this Jacquard loom principle that Wheatstone has employed to weave his electric currents into the line and produce the electric pattern upon his paper at the distant end. The Jacquard loom weaves rapidly, because the mechanical labour incident to the preparation of the pattern is carried out before it is placed on the loom. So with the automatic printer, or electrical Jacquard, the transmitting speed is rapid. The cards used in the electrical loom to regulate the sequence of the currents and groups of signals are prepared before being passed through the instrument, so that the time occupied in transmitting any number of currents and groups of currents to represent letters and words is reduced to a minimum. In electrical transmissions this is important, the cost of manual labour per minute or hour being inappreciable as compared to the value of a minute or hour in the occupation of an extended telegraph wire, erected at a cost of thousands of pounds. For instance, a line of poles and a single wire between London and Glasgow would require at least 12,000*l.* for its erection. To obtain the greatest amount of work out of such a wire in a given time is one of the problems of mechanical telegraphy, and commercial success depends greatly upon the speed at which currents of electricity can be sent through a wire of given length. This speed is regulated by the rapidity with which the currents can be transmitted through the wire without coalescing, that is, without interfering with each other and running together to form a continuous mark at the distant end. Reference has already been made to the conditions to be observed in the passing of currents into metallic conductors to ensure the maximum of speed, that they should be passed into the wire at equal intervals of time and of equal duration. Now, this is what the electrical Jacquard of Wheatstone so beautifully carries out, and the mode by which this electric pattern is woven will now be explained.

The apparatus consists essentially of three distinct parts—one for the preparation of the electrical loom card

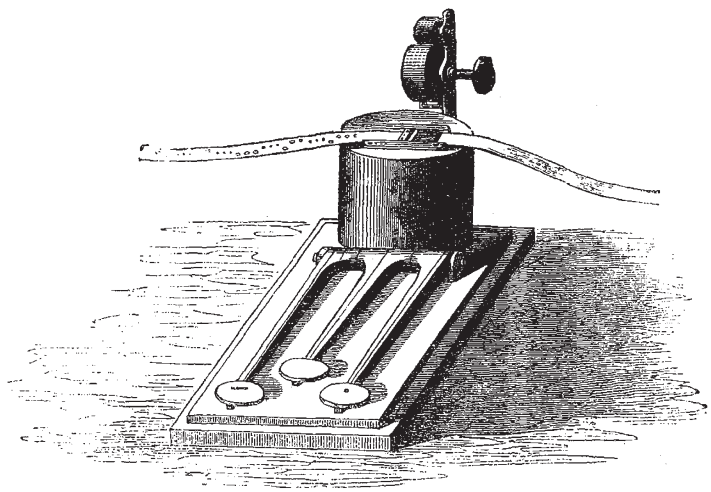

FIG. 19.—The "Perforator," for cutting out the message on the paper ribbon.

to regulate the succession and sequence of the currents in the electrical writing; another, the loom for the passing the currents so grouped into the line; and the third, the shuttle or pattern-producing arrangement by which the currents so passed into the line are recorded and transformed into symbols representing letters, words, and sentences. All automatic high-speed instruments for either submarine or land-wire circuits embody these essential conditions, the mechanical modification of parts

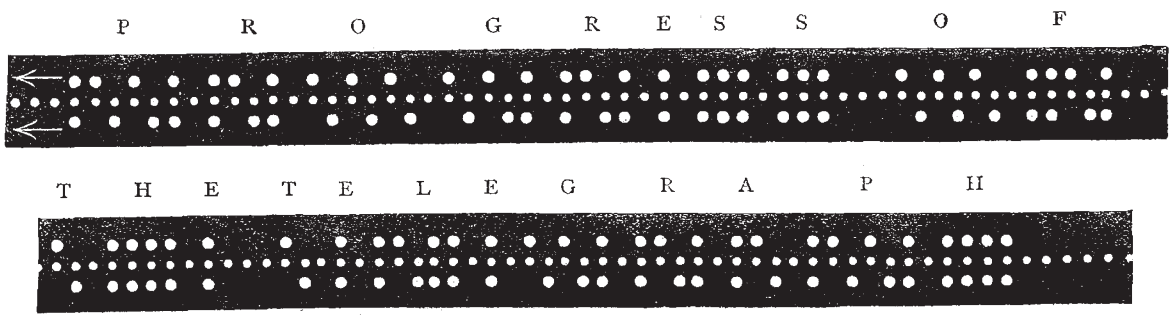

FIG. 20.—Perforated message on paper ribbon.

alone regulating the character of the apparatus for the work to be performed. The message to be sent is first punched out in holes (arranged to represent the "dot" and "dash" of the Morse alphabet) on a continuous paper ribbon by means of an instrument called the "Perforator," shown at Fig. 19, in an elementary form. Each of the three finger-keys on depression perforates a small round hole in the paper ribbon, the right being representative of the dot, the left of the dash, the centre one the mechanical spacing of the holes, and necessary for the regular motion of the ribbon through the loom or "transmitter."

This perforating machine is so constructed that upon the depression of any one of the keys a threefold action takes place: namely, the paper ribbon in the machine is locked in position to receive the perforation; secondly, the hole is cut by the pressure on the paper of a steel pin; thirdly, a mechanical movement, which at first holds the paper in the direction in which the ribbon enters, after the hole is cut automatically, carries it forward the requisite dis-

tance to receive the next hole ; and thus, by successive depression of the respective punches, the holes are cut in the paper ribbon in the necessary sequences to represent letters and groups of letters to form words. The centre punch, besides mechanically spacing the perforations to ensure their proper passing through the "transmitter," also by individual pressure spaces the distance between the letters and words of the message. The appearance of the paper ribbon thus prepared is shown full size at Fig. 20. Thus the message is written away from the wire, and the time taken up in its preparation is independent of loss of revenue on capital incident to the unnecessary occupation of the circuit by the slow and protracted results of manual labour.

The second part, or "transmitter" of the automatic system, is the apparatus which automatically sends into the wire the sequence of currents, as prepared by the "perforator." In this process, performed much in the same manner as the perforated Jacquard card regulates the successive elevation or depression of the warp-threads in the loom, the perforated ribbon-paper strip is caused to advance step by step through the machine by the successive grip of an oscillating cradle, regulated to advance the paper a distance exactly corresponding to the spacing of the holes by the "perforator," so that by the action of a rising pin, elevated and depressed alternately at each to-and-fro motion of the rocking frame, the message ribbon is automatically and mechanically impelled forward. Two other spring *contact* pins, representing respectively the contact with the positive (copper) or negative (zinc) currents of the battery (which may be either magneto- or voltaic-currents of electricity), are actuated by the same mechanical movement, by means of eccentric cam arrangements. Thus, when the perforated paper ribbon is carried automatically forward step by step in rapid succession by the action of the central pin, if a "current-passing" perforation is in position at the moment of passing the paper ribbon with either pin, the respective pin will rise through the hole and make a metallic contact with the battery through the instrument, sending a current into the line in the one or other direction, according to the position of the perforation and the rising of the respective pin. If no perforation in the paper ribbon is in position at the time of the automatic elevation of the respective pins, they fall back by the compensating influence of adjusting springs, and a *mute* movement is made by which no current from the battery is passed into the circuit. It will thus be understood that the action of the transmitter is also threefold as regards the passing of the current and the motion of the paper.

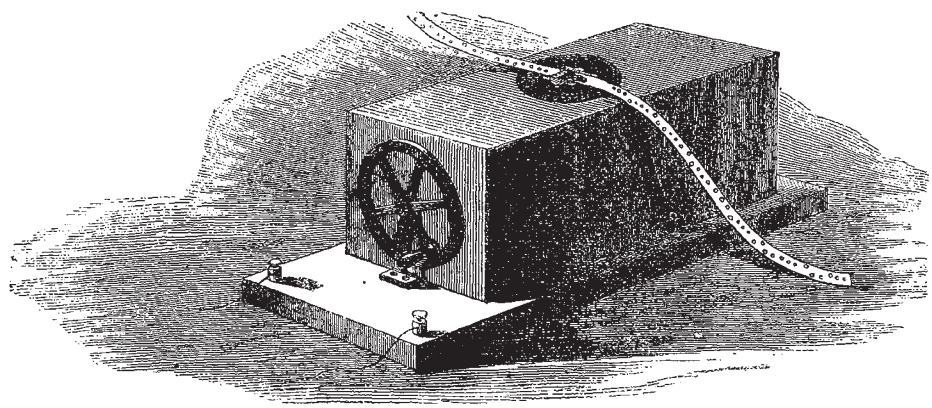

FIG. 21.—Wheatstone's Automatic Tel graph. The "Transmitter."

First, each rocking of the cradle carries the paper ribbon forward the exact distance that the depression of the key in the "perforating" machine advanced the message slip. Secondly, when the paper ribbon has been thus advanced, it is momentarily held in suspense to admit of the entrance of the respective pin, completing battery contact according to the position of the hole ; and thirdly, if no perforation representative of the passing of a current into the line is in position, a mute movement of the pin is made, and the paper is simply automatically advanced forward by a regular step by step movement. In addition to these three mechanical cam and eccentric movements in connection with the advancement of the ribbon, the elevation of the pins, and the passing of a current into the circuit from the concurrence of a perforation in the paper ribbon and the rising of a pin, a fourth important electrical contact movement takes place at each successive motion of the rocking cradle, independent of the rising of the pins, namely, that of momentarily making contact between the line wire and the earth after each successive elevation of either current-passing pin. The importance of this discharge to earth to clear the line has previously been pointed out as arising from the sensible retention in the insulated wire of a portion of the transmitted current, which, unless drawn out, would interfere with the integrity of the succeeding current, reducing the transmitting speed of the wire.

By a very beautiful arrangement of electrical contacts (perfected by Mr. A. Stroh, to whose great skill as applied to electrical problems of a mechanical nature Wheatstone is indebted for the absolute perfection of the mechanism in his automatic telegraph—the A B C telegraph—and the sympathetic electric clock movements), after each successive elevation of the pins, the circuit wire is connected momentarily to earth ; this takes place at each motion of the rocking cradle, whether a pin enters a perforation in the paper ribbon or not. Thus the line is connected for discharge at regular intervals, irrespective of its charge by the elevation of a pin, a current only passing into the line by the contact made with the battery on the elevation of either pin.

In this mechanical arrangement, therefore, the necessary contacts with the battery and the regular discharge of the line are produced without recourse to manual labour; mistakes are avoided, for machinery never forgets its registers or makes false records, both of which errors are inseparable from the employment of the human hand and brain. Man, though a thinking being, is not a machine, and it is not possible ever to turn the human frame into an automaton ; were this so, the value of invention would be at an end, and the accurate performance of machinery at a discount.

(*To be continued.*)