High-Speed Printing Telegraph System*

One of the Many Attempts to Solve a Difficult Problem

By Carl Kinsley

THE rate of increase in the amount of business transacted by telegraph has been most marked during the past few years. The extension of the network of telephone wires and their universal use in local business has seemingly stimulated the desire for a formal method of inter-communication which is more rapid than the mails.

The operating companies have responded as fully as they could, with the means available, to the public demand for a more rapid, accurate and inexpensive service. They have carefully tested many systems of telegraphic transmission that have been presented to them. None of the systems, however, have fulfilled all of the

special test in America in 1900, and later taken to England, where it was developed to a much more perfect state in the laboratories of the British P. O. Department. It has recently been given a month's trial in this country. Used duplex with four machines working on the two-wire circuit, and with eight automatic translators, a speed of 400 words per minute can be reached.

The Baudot printing telegraph¹ has been extensively used in France and India, while recently its use has been spreading to Great Britain, where certain improvements have been added. On the basis of duplex working, and using two wires, 160 words per minute can be transmitted.

is received ready for distribution. On the same basis of computation used in the above systems the speed of operation of the author's printing telegraph is 650 words per minute over a 375-mile (603.5 kilometers) line.

The method employed is direct throughout, and the transmitting and recording parts are capable of such adjustment that the speed of operation is limited only by the speed of the line. The mode of operation is as follows:

By means of a punch, which is connected to a commercial typewriter, a $\frac{1}{4}$ inch (1.27-centimeter) strip of paper is punched with a series of groupings of holes distinctively spaced in five rows, each group representing a letter. The punched strip of paper is then sent through the transmitter so that the holes pass under five wire brushes. Batteries of either polarity are thereby connected between the earth and either one of a pair of conductors. Batteries of different potential can also be

Fig. 1.—Wiring connections, and specimen of transmitting tape.

requirements for accuracy in the transmission of the messages, rapidity of operation from the receipt of the message to its final delivery, and low cost.

It is impossible to adequately mention in the brief space available the telegraph systems which have already been tried, some of which have by no means been discarded. Among them the following may be of particular interest.

The Rowland multiplex printing telegraph system² has enjoyed a limited use in Italy, and was experimentally operated on commercial business for a considerable time in this country. On the basis of eight machines, operating simultaneously over two wires, a speed of 400 words per minute could be obtained.

The Murray printing telegraph³ was given a commercial

* From a paper read at the Annual Convention of the American Institute of Electrical Engineers.

¹ G. Robichon, "Le Telegraphie Rowland," *Journal Telegraphique*, January 25th, 1901, and February 25th, 1901. Potts, "The Rowland Telegraph System," *A. I. E. E. Proc.*, April, 1907.

² Vansise; "A New Page Printing Telegraph," *A. I. E. E. Proc.*, January 25th, 1901. Murray, "Practical Aspects of Printing Telegraphy," *Inst. Elec. Eng. Jour.*, vol. 47, page 450, 1911. See also *Electrician*, May 5th and 12th, 1911.

Fig. 3.—The automatic transmitter.

The Siemens-Halske rapid printing telegraph system⁴ has been remodeled from the system developed and extensively tested about 1903, which used a photographic process of recording. In its present form it has been successfully used on certain German lines, and is being tried over three or four different circuits at the present time. It seems to be specially suited for underground cable work as the speed of each instrument is low and the required perfect control of both synchronism and phase of the transmitter and receiver is then not affected by atmospheric conditions. The necessity for an entire absence of disturbance can be comprehended when it is noted that many letters require the operation of seven relays to switch circuits in the through line in preparation for each record. On the basis of duplex working and the use of two wires a speed of 400 words per minute is obtainable. This is only half as fast as the early form which required the developing, fixing, washing, and drying of the record of the receiving message, and thus produced a condition at the receiving end which was considered uncommercial.

The Pollak-Virag writing telegraph system,⁵ unlike any of the preceding, does not require synchronism between transmitter and receiver. The received message, however, is photographically recorded on a sheet, which process entails expense and delay in handling the message. It was given an extensive commercial test over German lines and also was exhibited in England and in this country in 1899. On the same basis as that used in the tests of the previous systems the Pollak-Virag telegraph operated at 650 words per minute.

The system about to be described does not employ synchronism between transmitter and receiver, there are no relays used in the operation at either end of the line, only one instrument is employed, and the message

³ "D'Appareils Baudot," Poulaine and Faivre, Paris, 1906. Williams, "The Baudot Telegraph System in India," *Electrician*, March 22nd, 1907.

⁴ Franke, "Der neue Schnelltelegraph der Siemens und Halske," *Elektrotechn. Zeitschr.*, September 25th, October 2nd and 9th, 1913.

⁵ "Der Schnelltelegraph von Pollak und Virag," *Elektrotechn. Zeitschr.*, October 11th, 1900. "Recent Improvements of the Pollak-Virag Writing Telegraph," *Electrician*, July 3rd, 1903. "Telegraphie Rapide Systeme Pollak et Virag," *Bol. Electr.*, January 5th, 1907.

Fig. 2.—Machine for preparing the transmitting tape.

used, and in one case that is done, making five different transmitting impulses. Fig. 1 shows the wiring connections, a representative piece of transmitting tape, the printing elements and a section of the record.

At the receiver there are five elements which are separately controlled, except that No. 3, which needs only the normal current, also operated when the strong current needed to operate No. 5 is received.

The printing is accomplished by subdividing the alphabet into four independent elements and a fifth which, whenever used, accompanies one of the others. These elements then make an autographic record by means of a local battery on a moving sensitized paper whenever they touch the surface. It is merely necessary to have them operated in the proper sequence and with the desired interval in order to obtain any letter or figure of the alphabet.

Fig. 2 shows the punch for preparing the transmitting tape. A commercial typewriter is set on the punch base and the operation of preparing an office copy of the message also punches the transmitting tape. The depression of the digit bar sets the proper punch combination, then closes the circuit of an electromagnet, which completes the operation of punching and spacing the transmitting tape. The tape is then rolled up ready for use on the transmitter. As many punching machines can be used at the same time as may be needed to supply the transmitter with a sufficient number of rolls of prepared messages.

Fig. 4.—Artificial line for testing the system.

Fig. 5.—The receiver.

Fig. 3 illustrates the automatic transmitter. The roll of paper carrying the message is driven under the wire brushes which drop through the holes and make contact with the underlying rings, five in number. These rings are slowly rotated, driven by the paper friction, so as to insure a continually changing point of contact. No trouble at all has been experienced with faulty contacts. No speed control has yet been used on the driving motor as it has not been found necessary to have any exact speed of transmission.

Fig. 4 shows the method of construction of the artificial line used for testing this system, which needs more than a passing notice. It is made of a great many sections, all connected in series. Each section consists of two tinfoil grids, separated by wax paper with solid tinfoil sheets outside of them, also separated from the grids with waxed paper. The solid sheets are $6\frac{1}{2}$ inches by 9 inches (16.5 centimeters by 22.8 centimeters) and completely cover the grids, which are superimposed. There is thus complete distribution of the capacity and resistance of the two parts of the circuit with respect to each other as well as with respect to the ground, while each section is shielded from the neighboring sections. The total capacity from either line to ground, measured with an a-c. pure sine wave of 120 periods per second, is 4.05 microfarads. The total resistance of each line is 747 ohms, while the leakage resistance due to dielectric absorption is 2×10^4 ohms. There is no appreciable self-induction. On the basis of an open wire circuit having a conductor 0.43 centimeter in diameter, the capacity and resistance relation would make the artificial line equivalent to a circuit 375 miles (603.5 kilometers) long.* Since the open wire line has also distributed self-induction, the current at the distant end of the actual line would be greater than that at the end of the artificial line, if the impressed electromotive force were the same. The oscillograph record shown in Fig. 8 gives the current distortion, due to the long line.

Fig. 5 shows the receiver of the author's printing telegraph system and Fig. 6 is another view of it with the head lifted from the tape to display the printing elements. It uses two local circuits; one energizes the magnetic circuit which normally holds the printing members off of the recording surface and polarizes them. The other is in series with a resistance and has its positive terminal connected to the receiver elements which are here also the printing members, while the negative terminal is connected to the slightly moistened tape. A ferrocyanide of potassium solution and iron tips to the receiver elements have been found to be cheap and satisfactory. The line circuits are connected to the receiving spools and temporarily change the magnetic flux as the signaling currents are received. It is found to be desirable to use various magnetic fluxes in the different circuits, but in every case the magnetic density is not large when the parts of the magnetic circuit are proportioned as in this receiver.

The five elements are mounted on a circular frame so that the printing faces nestle closely together and form the pattern already shown in Fig. 1. This pattern is only one of several which have been tested. The form of the alphabet produced by it seems to be entirely satisfactory. A sixth element could be added if greater perfection were desired, while an alphabet of four elements which was thoroughly tried out was found to be legible to most people, but vastly inferior in appearance and doubtful of acceptance by the public. A sample of the transmitting tape and of the message as received is shown in Fig. 7, although the dark blue record on a slightly tinted background is a difficult object to reproduce photographically, and it is impossible to do justice to the original. The reproduction serves, however, to show the forms of all the letters and figures as received

over the whole of the artificial line, whose constants have been given, at a rate of 650 words per minute.

The receiver is astonishingly consistent in its operation and it would probably be of interest to consider its functioning more in detail. The adjustment of the position of the core of a receiving magnet is accurately made by means of a reducing gear, all lost motion being avoided by the use of a stiff spring. After adjustment the receiver can be operated for a long time without any further attention. In one case, over four months elapsed without touching an adjustment screw, during which time it gave perfect service; then a break in the circuit made a repair and readjustment necessary. When a signaling current is received it will further magnetize the receiving magnet of one section of the receiver and reduce the magnetization of the one connected in series with it. The magnetization due to the local current lifts the receiver element from the paper and holds it against the core of the receiver magnet. When the signaling current slightly reduces the pull on the receiver element it is released and the spring causes it to strike the paper, leaving its record, and then to rebound, when it is again caught by the local magnetic circuit and held, ready for another release by the signaling current. The local current therefore does the work of distorting the spring and the signaling current merely supplies enough energy to release and to allow the stored up energy in the spring to become effective. The receiving

Fig. 7.—Specimen of transmitting tape, and form of letters as received.

Fig. 8.—Current at end of a 375-mile artificial line, obtained by photographing oscillograph curves.

element has a flat spring rigidly attached to the core of the magnet which is energized by the local current. The natural period of the printing element can be made whatever is desired by varying the thickness or width of the spring and the size or location of the attached armature. The natural period of the receiving element should lie between rather sharply defined limits. Its period should be sufficiently long so that the signaling current has passed and the magnetizing current is again the controlling quality before it returns to its resting position; and the period should be short enough so that the receiving element is back at rest before another signaling current intended to operate it is received.

Let us assume that the transmitter connects batteries directly between a line and the ground either with or without the condensers, which are of service only when the source has large self-induction. Fig. 8 shows the current at the end of a 375-mile artificial line, due to the impressed constant electromotive force, as obtained by photographing oscillograph curves at both transmitter and receiver. The current is such as would be used in the vertical lines of a G. If we consider the negative current, which releases the element making the lower half of the vertical line for its two strokes, it can be seen that the natural period of the element should lie between definite limits. Since the element is more strongly held in place while the positive current impulse is on the line but is released when the negative current reaches a_1 and held again when the current is not more than b_1 , then the period of the printing element should be longer than time between a_1 and b_1 but shorter than the time between a_2 and b_2 . There is one exception that is of minor importance since it is desirable to avoid synchronism in general, that is, if the natural period is exactly as long as the interval from a_1 to a_2 , then the second release will come at the proper time. If the natural period has a value such that the element returns to its initial position at any time between b_2 and b_1 , except at a_2 , then the resulting stroke will be given at the wrong time. This may not be so far wrong as to lead to illegibility, but will obviously give an imperfect result. The natural period used with this instrument as now adjusted lies half way between a_1 and a_2 . This high natural period allowed the use of the " " marks, which are not considered a necessary part of the telegraph alphabet.

Hundreds of oscillograph records have been made, and it can be stated positively that with the present

Fig. 6.—Receiver, with head lifted.

circuit and apparatus design no combination of currents can occur which will cause errors in the record. It is evident that a sufficient increase of speed or an increase in the length of the line without an appropriate reduction of speed will produce an inoperative condition, but as previously stated, the speed attainable is limited by the line and not by the terminal instruments.

The elements most frequently used are the two which combined make a straight upright line. This is produced, as already shown in Fig. 7, by connecting the battery to the line for $1/720$ of a second and then reversing it for the same interval.

At the receiver, the current flow, so far as it materially affects the printing elements, is a sine wave of frequency 360 periods per second, as is apparent from an inspection of the oscillograph curves of Fig. 8.

The whole receiving and printing part of the mechanism can be easily held in the hand or carried in one's pocket. Aside from the paper drive and the power circuits there are only five moving parts and they consist of stiff flat springs rigidly attached to the frame. The movement of each is less than $1/25$ of an inch (one millimeter) and there is no possibility of their getting out of order or needing adjustment. If the paper drive is started by a line impulse from the transmitter, a message could be received without the necessity of an attendant ever being present. The receiver, due to its extreme simplicity and entire absence of delicate parts, would have its first cost considerably less than that of a single sensitive relay. The cost of maintenance and operation will obviously be reduced to a minimum, since on account of its simplicity and speed the number of attendants and their individual skill will be far less than at present needed. Of the entire system, the most complex part as well as the most expensive is the commercial typewriter. It is not altered in any way, and if large users of the telegraph should themselves prepare the transmitting rolls the typewriters would be available at other times for general office purposes.

The widespread interest in and need for a cheaper telegraph service should undoubtedly lead to the adoption of some machine method of telegraphy which would make possible a large reduction in telegraph tolls.

[Detecting Air Contamination from Gas Heating]

A METHOD has recently been announced by which contamination of the air by products of combustion from gas heating apparatus that is quite simple of application. A piece of thick glass is chilled ice cold and held edge toward the fire and close to the cowl of the grate or stove. This test is made after the fire has been burning some time, and if there is any escape of the products of combustion into the room they will be condensed on the plate. Of course, this applies entirely to the better class of gas heaters which have a chimney connection. Of course, the cheap unconnected heaters so commonly used in cities discharge the entire products of combustion directly into the room and are most unhealthy.

Insulating Armature Coils

THE corona discharge from armature coils of generators that develop high voltage is very liable to injure the insulation and cause a breakdown, and various methods have been tried to improve the insulation. While mica answers fairly well it is not entirely satisfactory; but a new system in which a metal ribbon is used has been devised that is said to give excellent results. This method consists in covering the coils with layers of thin metal ribbon, each turn overlapping the preceding one, but insulated from it to prevent eddy currents. Experiments show that the insulation of an unprotected coil is gradually eaten away by corona, causing the formation of nitrous oxide and nitric acid fumes. This does not occur with a coil protected as described.

* The above equivalence is obtained by interpolation in the table on page 256 of "The Propagation of Electric Currents," J. A. Fleming.