The Development of the Printing Telegraph*

A Description of the Several Systems Which Influenced the Design of the Present Types Used for Message Service

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AS the development of printing telegraph is rather a large subject, this article is confined to those systems having to do with the development of printers in use in the United States today. Electric telegraphs were first used about the year 1800, which was soon after Volta discovered that electricity could be generated by chemical means. In the original system, marks were made on chemically impregnated paper by means of the decomposing action of the received currents. About 1824 the electro-magnet was discovered and in 1837 Morse, making use of this discovery, invented the electro-magnetic telegraph. There were many attempts made to develop type printing telegraphs after Morse, but the first successful one was the Hughes, invented by an American in 1855. This system found no permanent place in the United States, but was taken to Europe, where it found wide application. It is strange, in view of the fact that an American invented the telegraph, the first type being the recording type, that up to a few years ago printing telegraphs were little used in this country, although widely used abroad. This was probably due to the fact that the Americans have a knack of learning sounder Morse and the Europeans have not. Having an adequate supply of good sounder operators the telegraph companies were loathe to adopt a more complicated system, for it is self-evident that sounder Morse is the simplest form of telegraphy.

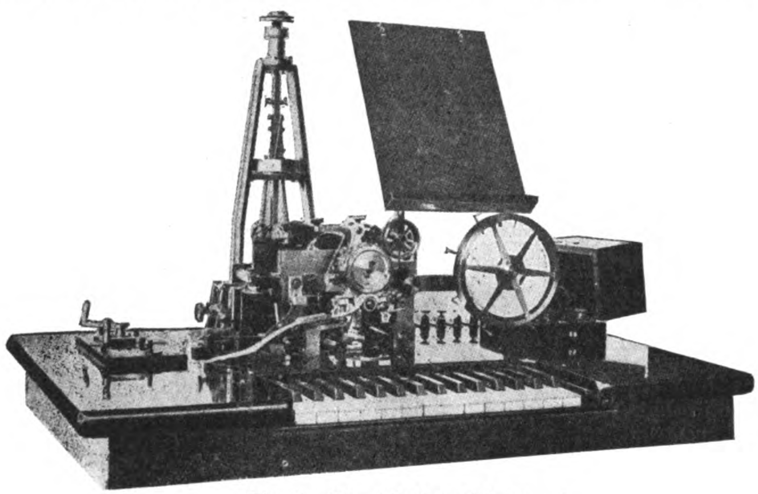

Fig. 1. The Hughes Printer

Requirements of Printing Telegraph

There are two general requirements which the printing telegraphs must meet in order to secure adoption.

1. Saving in the number of wires between stations.
2. Saving in labor of the transmission of messages.

Over long lines the first requirement is of the greatest importance because of the heavy investment and maintenance charges of the line. It is conceivable that a long line may be so valuable that it will pay to increase the cost of labor of operators 100 per cent to secure 50 per cent greater utilization of the line.

Signaling Codes

The foundation of any printing telegraph system is its signaling code. The code is first determined, then the apparatus is built to fit the code. The best code is the one using the least number of signaling elements per letter combination. A code in which all combinations are of equal length also has a great advantage, considering the design of the apparatus to handle it.

For printing telegraphs it is necessary to have at least 28 signal combinations. This takes care of the 26 letters of the alphabet and a shift to change to figures and upper case characters and an unshift to change back. Twenty-eight combinations are sufficient if the printing is on tape, but for page printing it is necessary to have two additional combinations, one to feed up the paper and another to return the carriage to start a new line.

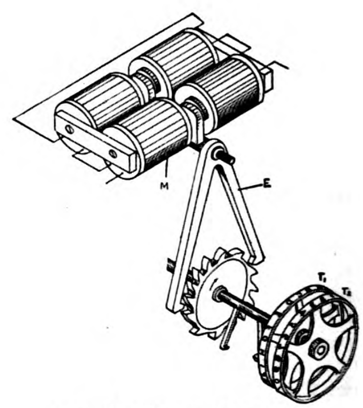

Fig. 2. Ticker Mechanism

The standard designations of the five unit code combinations is shown in the Fig. 5. The black circles represent a flow of current which will affect the selecting mechanism, or, in telegraph parlance, "marking" intervals, while the white circles or "spacing" intervals serve merely to properly locate or space the marking intervals.

Assuming two line conditions, positive or negative current flowing; or current and no current, we find that the least number of elements which give enough combinations is five. In other words, two conditions of the line varied through five portions of an interval of time will give 30 combinations. Counting the two arrangements when all five intervals are alike, we get a total of 32.

It is true that by using different variations of line current, strong, weak, zero or negative, positive and zero; it would be possible to get a sufficient number of combinations with less than five elements. However, experi-

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ence has taught us that such signals are impractical on very long lines at high speeds.

The most elementary code that could be devised is perhaps one in which one letter is designated by one element, the next by two, and so on, such as used on some types of stock tickers known as the step by step code.

The Morse code is made up of dots, dashes and spaces, the dashes being three times as long as the dots and the spaces equal the length of the dots. With the five-unit code there is no necessity for a space between successive intervals whether they are alike or different. Each letter combination is therefore only five units long.

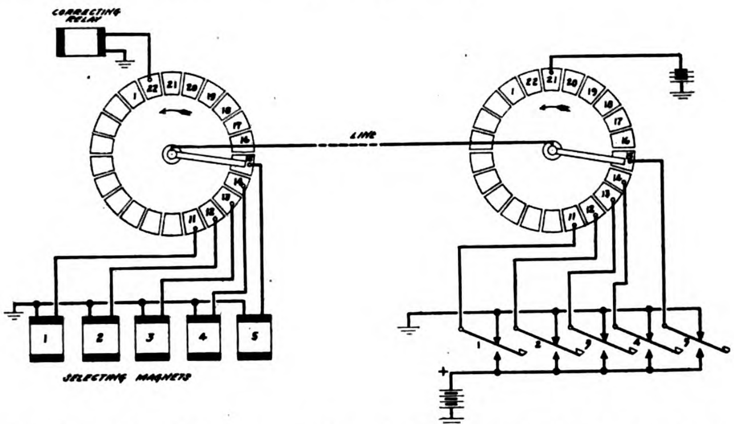


Fig. 3. Baudot Multiplex with Two Extra Segments for Synchronizing

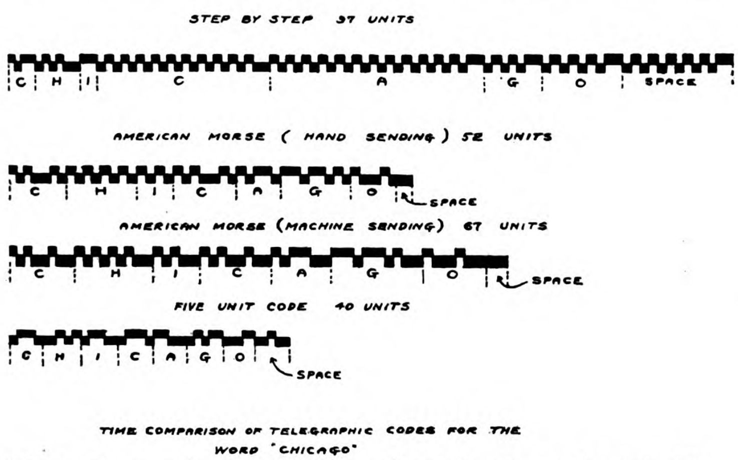


Fig. 4. Comparative Length of Line Signal Required to Send the Word, Chicago, by Various Codes

The signaling speed of any line is determined by its length and other characteristics and can be expressed in cycles per second. Twenty cycles would mean forty dot length reversals per second. It is ovbious that if the line frequency is limited that more words per minute can be transmitted using the five unit code than by using any other code, or if the limit of speed is not approached there will be more margin under adverse conditions with the five unit code than with any other. This explains why all printing telegraph systems in this country have adopted this code as standard.

In this article reference will be made to two broad classes of printing telegraph systems:

1. Single channel systems, which provide a single transmission over a wire in one direction, or, if duplexed, one transmission from either end simultaneously.

2. Multiplex systems, which provide from two to four channels in each direction, when duplexed.

The Baudot System

The five-unit code was invented in 1875 by Baudot, a Frenchman. He used the Hughes printer in his first machines but later developed a printer unit of his own, utilizing considerable of the Hughes design. Baudot developed a remarkably successful multiplex system, which has been the basis of all present day systems.

	INTERVALS 1	2	3	4	5
A-	●	●	○	○	○
B?	●	○	○	●	●
C:	○	●	●	●	○
D$	●	○	○	●	○
E3	●	○	○	○	○
F!	●	○	●	●	○
G&	○	●	○	●	●
H£	○	○	●	○	●
I8	○	●	●	○	○
J'	●	●	○	●	○
K(	●	●	●	●	○
L)	○	●	○	○	●
M.	○	○	●	●	●
N,	○	○	●	●	○
O9	○	○	○	●	●
P0	○	●	●	○	●
Q1	●	●	●	○	●
R4	○	●	○	●	○
S'	●	○	●	○	○
T5	○	○	○	○	●
U7	●	●	●	○	○
V;	○	●	●	●	●
W2	●	●	○	○	●
X/	●	○	●	●	●
Y6	●	○	●	○	●
Z"	●	○	○	○	●
..	○	●	○	○	○
SPACE	○	○	●	○	○
,,	○	○	○	●	○
FIGURES	●	●	○	●	●
LETTERS	●	●	●	●	●
BLANK	○	○	○	○	○

Fig. 5. Standard Designation of the Five-Unit Code Combination

The rotary distributors for the transmission and reception of the signals consisted of a segmented ring having 20 insulated segments. These segments were divided into 4 groups of 5 each; each group was connected to a set of 5 keys. The line wire was connected to the brush rotating at a uniform speed, which swept over the 20 segments, connecting them successively to the line wire. At the receiving station was a similar device, but with the segments connected to 4 sets of receiving magnets. If the brushes at the two ends of the line were rotating in unison, each group of receiving magnets will receive the signals set up by the corresponding group of transmitting keys. The proper set of keys to be used was determined by a tapper operated by a local circuit on the distributor.

The distributors were operated by a weight-driven clock train, the small variations in speed being taken care of by a very delicate governor. In spite of this device the distributor would get out of unison

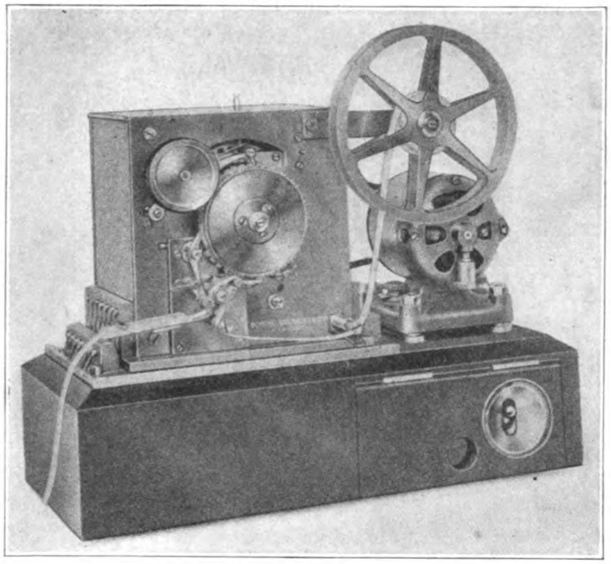


Fig. 6. The Baudot Printer

To prevent this, instead of having his brush rigidly fixed to the driving shaft, he connected it to the shaft by means of gears and through the use of a star-wheel and a detent held the brush stationary with reference to the shaft. He designated the station at one end of the line, the correcting station and the opposite one the corrected station, and he drove the distributor at the corrected station slightly faster than the one at the correcting station.

In addition to the transmitting impulses the correcting station sent out a correcting impulse each revolution. If the brush of the corrected station had advanced far enough to allow this correcting impulse to fall on the segment to which the correcting magnet was connected, a pin would be interposed in the path of the star-wheel and the brush would be retarded slightly. Of course, this process would be repeated each time the brush had crept ahead a certain definite amount.

Referring to Fig. 3. The correcting impulse is sent when the brush passes over segment 21. If the receiver brush is then on segment 21 there will be no effect, but when the receiver brush advances far enough so that it is partly on segment 22 when the correcting impulse is received, the correcting magnet will be actuated.

Fig. 7 shows the correcting mechanism. The brush axle carries a plate rigidly fastened to it. A short shaft carrying two gears C passes through this plate. The left hand gear C meshes with gear F attached to drive gear E, which is loose on the brush axle. The right hand gear C meshes with pinion D, attached to star-wheel G. This star-wheel is prevented from turning by detent roller P, shown below. This arrangement causes the brush axle to be driven just as if the drive gear was fastened to it.

However, when correcting magnet J is energized it attracts armature L and pushes pin M into the path of G. As G revolves the pin will engage one of its points and turn it one tooth. This will shift the brush backward on tooth with reference to the drive gear.

Baudot at first employed the Hughes printer in connection with his Multiplex system, but later developed a very simple and sturdy printing unit, which printed in Roman characters on a tape, which was then gummed to the message form.

Fig. 6 shows the Baudot printer. The letters of the alphabet are engraved on the rim of a steel wheel. As in the Hughes printer, the tape passes around a printing roll on an arm beneath the type-wheel.

While the bulk of the French telegraph has been handled for many years by the Baudot system, it never came into use in this country for the following reasons: (1) The speed adjustment of the Baudot governor is very delicate, requiring long experience and a great deal of patience to secure good results. (2) The Baudot printer prints on tape, which is then gummed to the message blank. The American idea was to have a printer print directly on the blank. (3) The operation of the Baudot keyboard requires considerable training. The operator must know the code combination for the letter and press the keys in the proper combinations to form it. In addition he must manipulate the keys at just the proper time to take advantage of every revolution of the distributor. His skill too nearly approaches that of a Morse operator.

The Wheatstone System

The Wheatstone is an automatic Morse system invented in England in 1858. Although not strictly a printing system, it came into wide use in this country and had considerable influence on other developments. Instead of sending the Morse by hand, perforated tape is prepared and run through the transmitter at a high rate of speed.

The first perforator used for the preparation of this tape had only three keys, one for the dash, one for the dot, and one for the space. The operator, who must know the code combinations, struck these keys with small mallets and thus perforated the Morse characters in the tape.

At the receiving end a relay carrying an inking wheel prints the dots and dashes on another tape. These tapes are transcribed onto message forms by typewriter or long hand.

A specimen of five unit perforated tape is shown to illustrate the saving in tape with the five unit signals perforated across the tape. See Fig. 12.

In the mechanism of the Wheatstone transmitter, Fig. 10, a rocking bar RB is rocked by means of an eccentric geared to the drive shaft. Through the pins P and P′ arms A and A′ are alternately moved up and down. The pins S and M are alternately moved up against the tape and when there is a hole the pin passes through and by means of the corresponding push rod R or R′ the lever L is moved against one of the contacts D or D′ and the current polarity on the line is reversed.

Later, perforators having typewriter keyboards came into use. This system was capable of very high speeds. In England it has been operated at speed of 200 to 400 words per minute, but no such speeds were secured in this country, partly because the lines were longer and operated duplex, while abroad they were frequently operated simplex.

The Wheatstone had certain objectionable features. Perhaps the two most objectionable were that while the tape was transmitted at a high rate there was a considerable lapse of time from the start of the preparation of the message to its actual transmission, and at the receiving end there was a delay from the time a message was received until it was transcribed. If there was an error in the message it was not discovered until it had been transcribed and it was then subject to a delay until a mes-

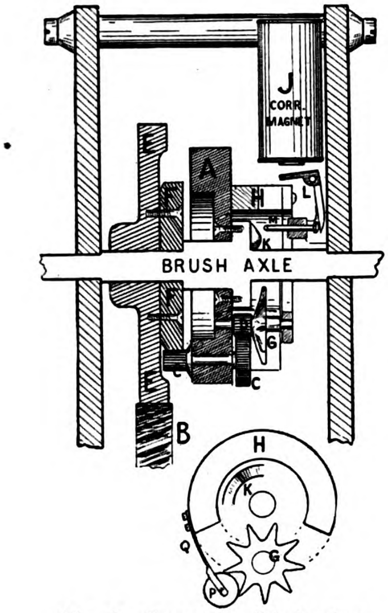


Fig. 7. Correcting Mechanism

Fig. 8. Baudot Keyboard

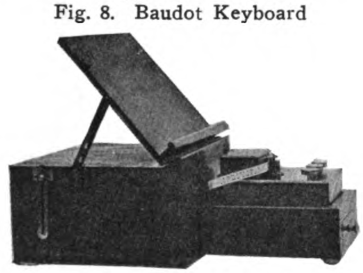


Fig. 9. Mallet Perforator

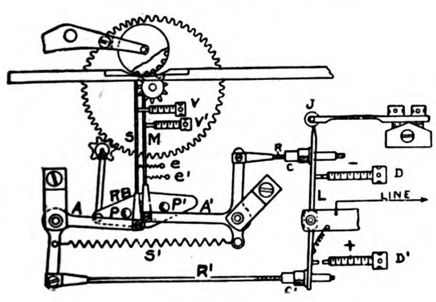
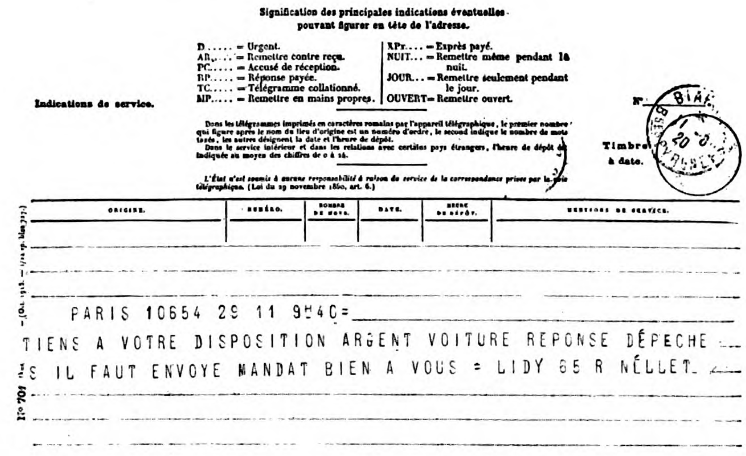


Fig. 10. Wheatstone Mechanism


Signification des principales indications éventuelles pouvant figurer en tête de l'adresse.

Indications de service.

D..... = Urgent.
AR..... = Remettre contre reçu.
PC..... = Accusé de réception.
RP..... = Réponse payée.
TC..... = Télégramme collationné.
MP..... = Remettre en mains propres.
XPr.... = Exprès payé.
NUIT... = Remettre même pendant la nuit.
JOUR... = Remettre seulement pendant le jour.
OUVERT = Remettre ouvert.

Dans les télégrammes imprimés en caractères romains par l'appareil télégraphique, le premier nombre qui figure après le nom du lieu d'origine est un numéro d'ordre, le second indique le nombre de mots taxés, les autres désignent la date et l'heure de dépôt.
Dans le service intérieur et dans les relations avec certains pays étrangers, l'heure de dépôt est indiquée au moyen des chiffres de o à 24.

L'État n'est soumis à aucune responsabilité à raison du service de la correspondance privée par la voie télégraphique. (Loi du 29 novembre 1850, art. 6.)

N° BIARRITZ 20 BASSES-PYRÉNÉES

Timbre à date.

ORIGINE.	NUMÉRO.	NOMBRE DE MOTS.	DATE.	HEURE DE DÉPÔT.	MENTIONS DE SERVICE.

PARIS 10654 29 11 9H40=
TIENS A VOTRE DISPOSITION ARGENT VOITURE REPONSE DÉPECHE
S IL FAUT ENVOYE MANDAT BIEN A VOUS = LIDY 65 R NÉLLET

N° 701

Fig. 11. A French Baudot Message

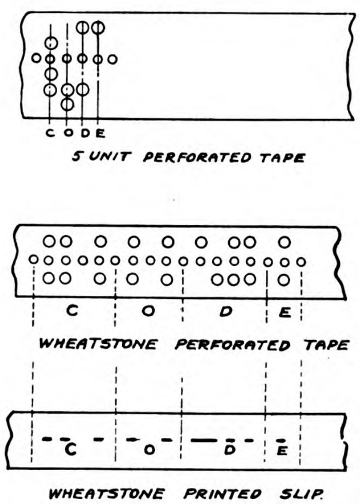


Fig. 12. Specimen of Wheatstone Perforated Tape and Corresponding Receiving Tape

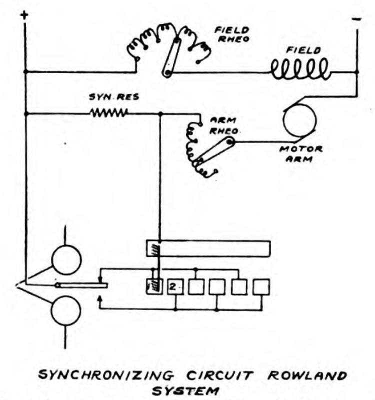


Fig. 13. Synchronizing Circuit, Rowland System

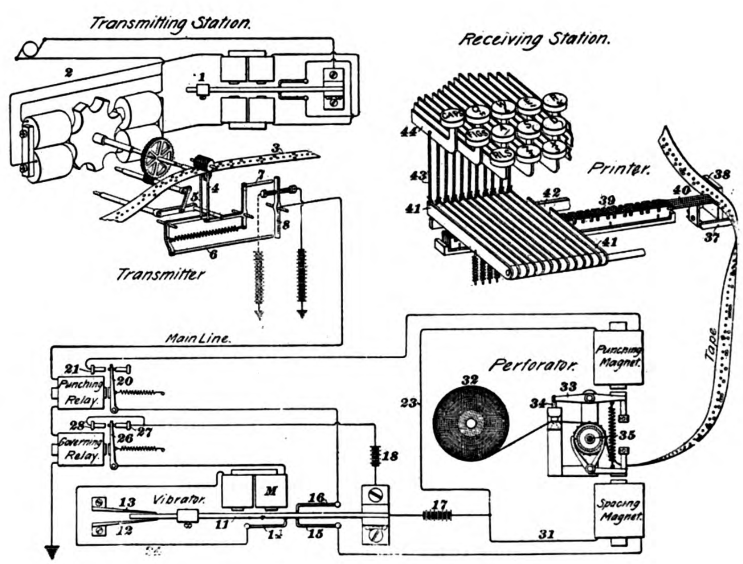


Fig. 14. Murray Automatic Apparatus

sage could be sent to the transmitting station and a reply received. These service messages were given preference, but even so the message held for correction was apt to get pretty old.

To overcome the delay at the receiving end inventors went to work to provide apparatus which would translate the dots and dashes into printed characters.

An Englishman perfected a very ingenious machine which caused the received signals to control a pneumatic perforator which produced a perforated tape at the receiving end, identical with that used for transmission. This tape was then fed into a printer and mechanically controlled a number of slide valves, which allowed compressed air to act on pistons and operate type bars to print in Roman characters on a tape. As this printer operated at high speed and was placed adjacent to the receiving perforator, the transcribing delay of the Wheatstone was practically eliminated. This system has been very successful in England, but as it is very expensive to install and to operate it has not been adopted in this country.

The Buckingham Printer

The Buckingham printer, which was developed by the Western Union, used the Wheatstone transmission and page printing reception. The shortest possible signal was 8 units long and the longest 18; this limited the transmission speed.

The Barclay Printer

Barclay used the same code and transmission as Buckingham, but he used a Blickensdeffer electric typewriter for a printer, so arranged that the received signals should set up a path to the proper magnet and the long spacing impulse at the end of each signal would send current into the magnet printing the letter. The Western Union had 60 circuits of this type in service at one time, but because the line signals were too long the system has been abandoned.

The Murray System

About 1900 Donald Murray, an Englishman, came to this country and developed a five-unit code system which was tried out by the Postal Telegraph Company. He used a keyboard perforator and transmitter similar to the Wheatstone, but in order to secure uniform transmitting speed he drove the transmitter by means of a tuning fork and phonic wheel. At the receiving station there was a tape perforator driven by a tuning fork. Fig. 14. Arrangement of the code signals in addition to perforating the tape also corrected the speed.

The Rowland Multiplex

The Postal Telegraph Company next tried out the Rowland multiplex system. This system operated a maximum of four channels and four transmissions were secured in each direction by duplexing. The distributors, printers and keyboards at the two ends of the line were all synchronized; the distributors being driven by shunt motors. These motors were kept in step by a shunt resistance controller by a polar relay which in turn was controlled by an ingenious side circuit off the correcting commutator which received energy at certain points. Fig. 13. On account of the extra correcting half waves the line signals were 14 units long. Consequently on a four-channel system, operating at 35 words per min. per channel, the line frequency was 98 cycles. This extremely high frequency produced disturbances on adjacent wires of the pole line to such an extent that the system was abandoned. However, there is still at this time a Rowland system in use in Italy.

The Wright System

After the Rowland, the Postal tried out the Wright system. It was foredoomed to failure, however, as its line signal employed the positive, negative and zero intervals. The operation of the system was not satisfactory under adverse weather conditions.

The Western Union Multiplex

About 1913 the Western Union called in Donald Murray, who has been mentioned before, and in conjunction with Western Electric engineers a successful multiplex system was evolved. The extra correction impulses of the Baudot system were eliminated, the correction being secured from the letter signals themselves. A page printer is used. However, by using two, three and four-channel installations, 50 words per min. have been secured on some four-channel circuits. At 50 words per min. per channel an interchange of 800 words per min. is secured over the wire, which is duplexed. This same wire operated by a duplex Morse would not yield more than 80 words per min. For lighter lines the Western Union uses the Morkrum, described later, and circuits that will not justify this system are operated by the Morse code.

The Morkrum System

The Morkrum system was first placed in service in 1910 by the Postal Telegraph between Boston and New York. This system used a direct keyboard, page printing system, using the five-unit code of signaling, with positive and negative intervals. It was operated at a speed

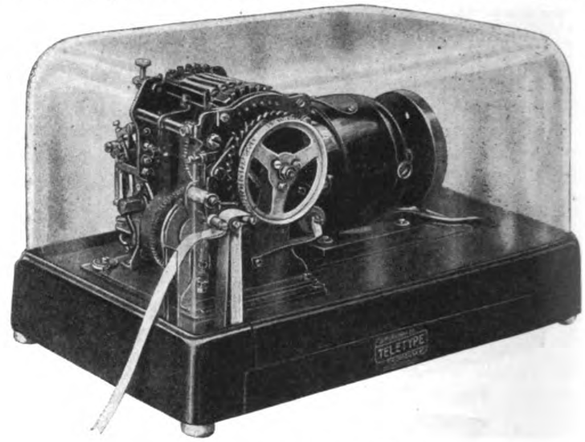


Fig. 15. Receiving Teletype

of 60 words per min., giving an interchange of 120 words per min. as it was duplexed. The keyboard was free, that is, it did not have to be operated in cadence with the transmitting mechanism. With a keyboard of this type the system had just as direct communication between the sender and receiver as has the Morse system.

With this type of keyboard and page printer set at 60 words per min. the operator would fall frequently below this amount but would never be able to exceed it. Consequently the average would be considerably less than the limit. With a tape perforator an operator can write at his maximum speed, as the perforator is capable of speeds far over 100 words per min.

The next step in the Morkrum development was to adopt the tape transmission, so arranged as to cause the transmission of a letter only a few seconds after it was perforated. With this movement the transmission proved to be 15 to 20 per cent greater than with the direct keyboard transmission. This type also allows a little time to catch an error before it goes out on the line.

In order to handle efficiently the growth of the business even on the lines with the lightest loads the Morkrum Company developed a printing telegraph which will operate on the standard five-unit code; but which is so simple that it can be efficiently used at a station which handles as low as 50 messages a day.

In view of the remarkable record of service of the printing unit of the Baudot system, it was decided to adopt a similar mechanism for the printing portion of this

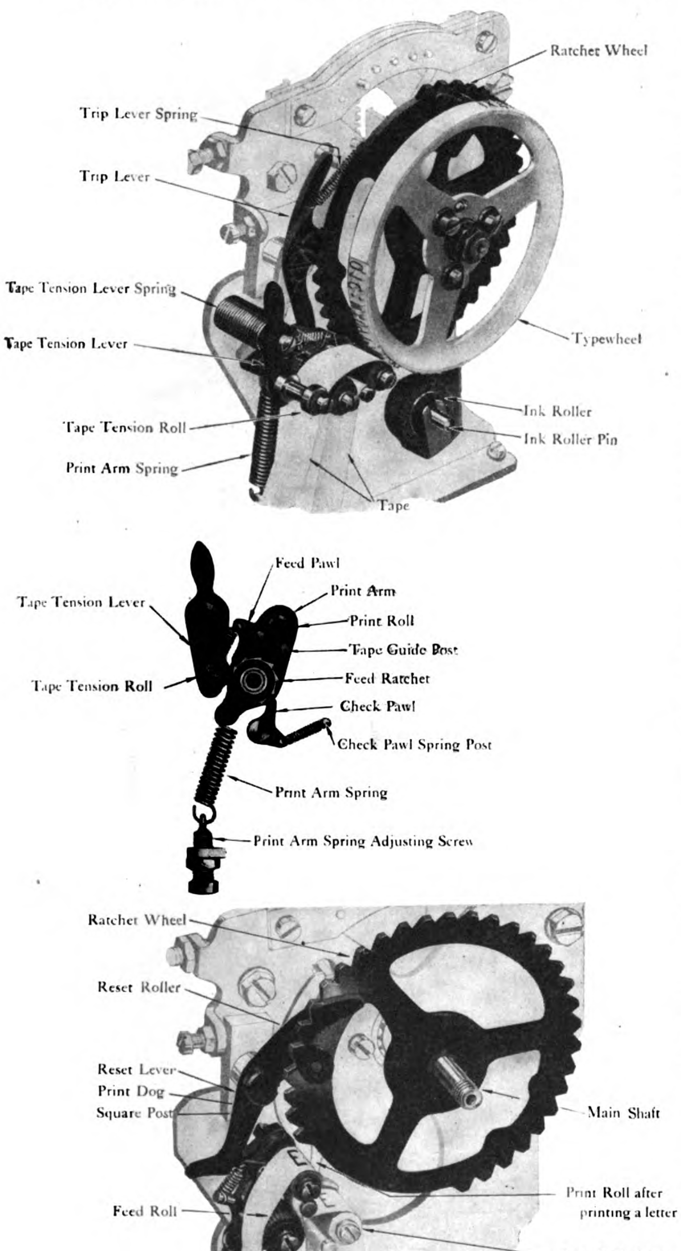


Fig. 16. Showing How a Letter Is Printed

machine. This means, of course, printing on a tape and the consequent gumming of the tape to the message blank, but investigation has proved that this operation is not nearly as complicated as it sounds and an operator can gum the tape as fast as it is received so that no consequent delay is introduced.

There is also a considerable saving in line time with a tape printer, for with page printing the code combinations for feeding up the paper and returning the carriage, comprise an appreciable percentage of the characters transmitted for the printing of a message. Such signals are, of course, unnecessary with page printing.

The tape printer is infinitely simpler than a page printer. In fact, a tape printer of the Baudot class has only about one-tenth as many parts as a page printer. This is partly because the page printer has to perform two distinctly different classes of operation. The first is to print the characters, the second is to perform the various typewriter functions of moving the carriage for spacing, feeding up the paper, returning the carriage to start a new line and shifting for upper case characters, etc. These functions complicate the mechanism considerably and as either the paper or the printing element has to be moved along to print the characters at different points on the line, the printer is apt to be rather bulky.

With a type wheel tape printer of the Baudot class it is merely necessary to release the printing arm at the time determined by the particular code combination to secure printing or spacing or shifting.

From Fig. 16 it may be noted that the tape passes around a printing roller below the type wheel. Behind the type wheel is a notch corresponding to each letter on the type wheel. It is merely necessary to release the arm carrying the print roll at the proper time and the spring will cause the pointed end or "print dog" to fly up and engage a notch in the ratchet. As this ratchet is revolving with the type wheel the print roll with the tape will roll over the face of the corresponding letter.

As the tape passes from the print roll, it passes over a feed roll against which it is pressed by a tention roll. The feed roll is attached to a ratchet at its rear end and as the print arm is thrown out of engagement with the ratchet wheel and assumes a vertical position a feed pawl engages a tooth of the ratchet and moves the feed roll and the tape.

Now as the type wheel and ratchet revolve farther, a reset roller on the back of the ratchet wheel strikes the upper end of a reset lever. The lower end of this lever strikes the print arm and moves it back to the horizontal position where it latches again with the trip lever. A certain portion of the type wheel has no letters on the rim and a corresponding portion of the ratchet wheel has the teeth cut away. It is while these are passing the print arm that it is reset.

Fig. 17 shows how the print arm is tripped at the proper place. There are five selectors or seekers which are bent up metal pieces, each having a toe which presses on the rim of a notched combiner wheel. The upper portions or heads of the seekers are in contact with each other. A spring attached to a tension lever on the left presses the heads of the seekers to the right, since the heads of the seekers are all in contact, the tension lever cannot rotate on its shaft unless all of the seekers move. Such a movement can only take place when there is a notch beneath each of the five toes at the same instant.

The lower portion of Fig. 17 shows the seekers when they have each dropped in a notch at the same instant. This allows the tention lever to move and its horizontal extension strikes the upper end of the trip lever, which causes the lower end to disengage the print arm.

Fig. 18 shows a different view of the combiner wheel. It is made up of two notched discs. Note that where there is a notch in the front disc there is a corresponding smooth place on the rear disc. There is a separator plate between the two discs which prevents the seekers from passing from one disc to the other except at one point. By moving some of the seekers to the front disc and leaving the rest on the rear disc, the print arm can be tripped at thirty-one different places according to the different settings of the seekers.

Fig. 19 illustrates how the received signals control the

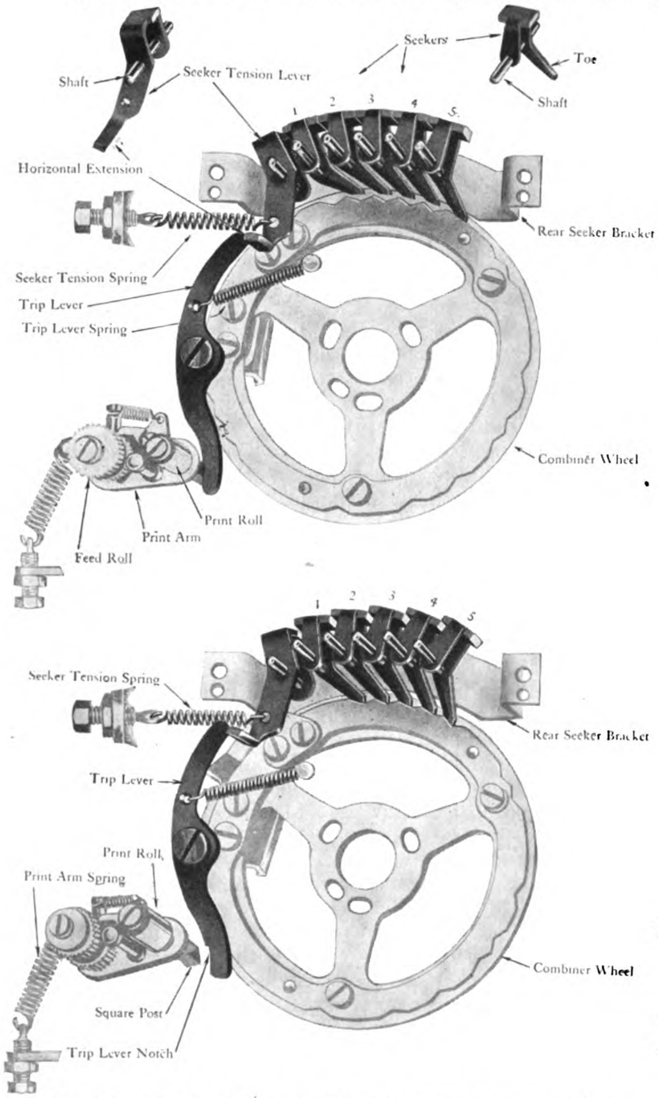


Fig. 17. Showing How the Print Arm Is Tripped at the Proper Place

setting of the seekers. The shuttle is a metal tube on the main shaft which can slide backward or forward. A spring normally presses it toward the rear. A roller on the side of the shuttle is pressed against a cam ring which

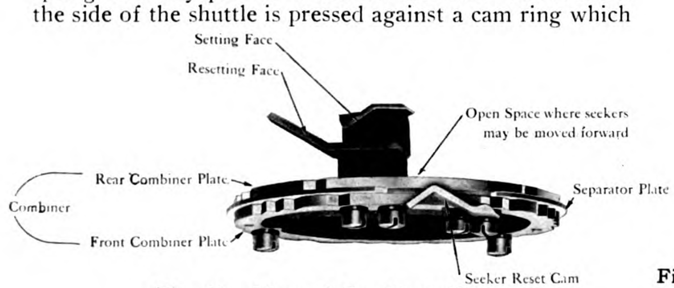


Fig. 18. View of Combiner Wheel

has five cuts or indents. At the bottom of each indent a pin projects through the cam ring and the rear end of the pin is against the lower end of a selector lever.

If the shuttle roller drops into an indent, this pin will be moved backward and press the upper end of the selector lever forward, pushing the selector plunger forward.

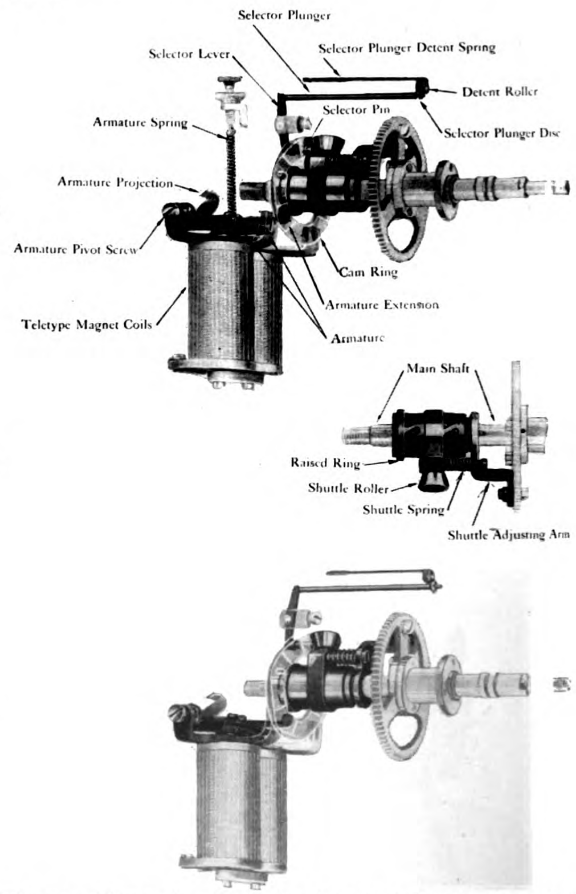


Fig. 19. Illustrating How the Received Signals Control the Setting of the Seekers

Whether the shuttle roller will drop into an indent is determined by the position of the magnet armature at that instant. As the magnet is energized or de-energized

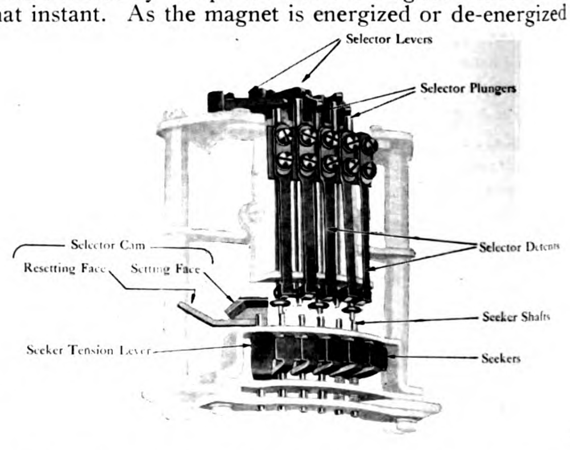


Fig. 20. The Selector Plungers Move the Seekers to the Front Combiner Disc

according to the code combinations, the armature is pulled downward by the magnet or upward by the spring. If when the shuttle roller passes off the high part of the cam the armature is up, the raised ring of the shuttle will strike the armature extension and the roller will be held out of the indent.

This condition is shown in the upper portion of Figure 19. However, if the armature is down when the roller passes off the high part of the cam ring, the roller will

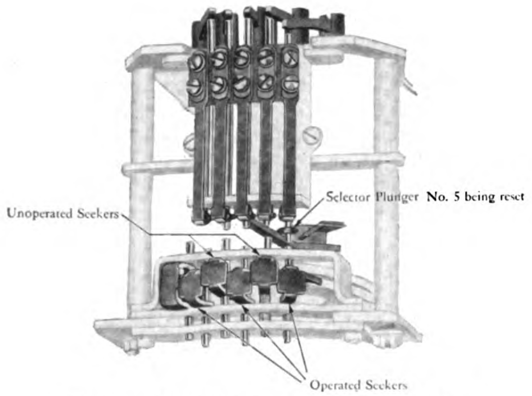


Fig. 21. Resetting Face of Selector Cam

drop in the indent and set the corresponding selector plunger.

Fig. 20 shows how the moving forward of the selector plungers will move the corresponding seekers to the front combiner disc. The first, third and fifth plungers have been moved forward. As the setting face of the selector cam moves along it will grasp the discs on the ends of the plungers and move the plungers forward against the seeker shafts, causing the corresponding seekers to move


Fig. 22. Teletype Mounted on Keyboard Transmitter

to the front disc. As the resetting face of the selector cam (Fig. 21) passes in front of the selector plungers it strikes the plunger discs and sets the plunger back in normal position.

The latest Morkrum "Teletype" printer and transmitter are shown in the illustration. These machines operate on 12 volts d.c. from a local battery or over a line. The motor is 1/40 h.p. and may be either a.c. or d.c. as required. These machines can be applied in large merchandising or industrial concerns for inter-communication. The time will no doubt come when considerable telegraph traffic of the country will be handled by tape printers.

A NEW AND NOVEL CROSSING SIGN

THE novel warning sign shown in the accompanying illustration has been erected by the San Antonio & Aransas Pass at the intersection of its line with Roosevelt avenue, in San Antonio, Texas. Surmounting a sign which bears the words, "Did the Driver of This, Stop, Look, Listen?" is a platform about eight feet above the ground, upon which is placed a wrecked automobile which figured in a fatal accident at a country road crossing on the Waco district of that road some time ago and which resulted in the death of two occupants of the car and serious injury to a third.

The New Crossing Sign Used by the San Antonio & Aransas Pass to Reduce Grade Crossing Accidents

A series of similar accidents at different points on the line suggested to J. H. Newberry, claim adjuster of the San Antonio & Aransas Pass, the necessity for devising some sort of a warning different from anything theretofore used, and of such a nature as would attract the attention of motorists and cause them to "stop, look and listen" before crossing railroad tracks. The increasing number of fatal accidents at grade crossings has created a demand for more protection; however, no automatic protection is effective unless the public realize the seriousness of disregarding such indications. The new warning sign seems to be serving the purpose for which intended, for it is causing much comment and the idea is being taken up by safety men of other roads.

ROCK ISLAND TELEGRAPH DEPARTMENT ASSOCIATION

G. D. Hood, superintendent of telegraph, and A. W. Douglas, assistant superintendent of telegraph, of the Chicago, Rock Island & Pacific, recently organized the Wire Chiefs', Operators' and Repeater Attendants into a society for the purpose of the improvement of the members in the practical and technical details of telegraph and telephone work. The society is the outgrowth of a course of instruction which has been carried on by Mr. Hood for the past year and a half with a view of bringing to the men of his department a better knowledge of the telegraph and telephone. Officers were elected, a constitution and by-laws adopted and committees appointed, and the organization is now well under way. The Committee of Direction consists of three members elected annually, one of whom shall be chairman-secretary.