AUGUST, 1912

THE MURRAY PRINTING TELEGRAPH JOURNAL

ENGLISH EDITION

The Morkrum Printing Telegraph.

We invite special attention to Mr. Murray's account of our printing telegraph system on page 8 of this issue of the Murray Printing Telegraph Journal. The Morkrum is the first really successful typewriter working at a distance over a single telegraph wire by means of a free typewriter keyboard that any person can use.

Enquiries from countries outside of North America should be addressed to Messrs. Brown & Murray, Ltd., Mildmay Park Works, London, N., England. Enquiries originating in North America should be sent to the Morkrum Printing Telegraph Co., 717 Railway Exchange, Chicago, U.S.A.

THE MORKRUM COMPANY.

NOTICE.

Two copies of the Journal will be sent free of cost to each Telegraph Administration, and one to each Company desiring to receive it.

Additional copies will be supplied post free at 3d. each or 2/- per dozen (or the equivalent in money of other countries).

English, German, French and Spanish editions of the Journal are published. In ordering, it is necessary to mention the edition preferred.

All communications should be addressed to

Mr. DONALD MURRAY,

MILDMAY PARK WORKS, LONDON, N., ENGLAND.

The

Murray Printing Telegraph Journal.

VOL. I. No. 2. 30th AUGUST, 1912.

NUMBER TWO.

An apology is due to the readers of the Murray Printing Telegraph Journal, for the rather leisurely way in which it has been published. Two years have passed since the first number was issued. I had intended to bring it out two or three times a year, but pressure of other work has rendered it impossible to prepare the second number until now. It is hoped that it will be found practicable to publish future numbers at least once a year.

The present issue of the Journal is devoted to an account of things seen during my recent visit to America, which proved to be full of interest from a printing telegraph point of view.

TRIP TO AMERICA.

Progress of Printing Telegraphy in the United States.

In a confidential letter, No. 65, dated 12th April, 1912, copies of which were sent to all the leading telegraph Administrations, I gave some information about the sale of the Murray multiplex United States patents to the Western Union Telegraph Company. The following report is an amplification of the letter, and also describes various matters of general interest to telegraph Administrations that came under notice during my trip to America, from November, 1911, to March, 1912.

A description of the Murray multiplex system was given in the paper on "Practical Aspects of Printing Telegraphy," read before the London Institution of Electrical Engineers on the 4th May, 1911. Many improvements in detail are being made, but the essentials remain the same. It is therefore only necessary to say here that the Murray multiplex is designed on the same general principles as the Baudot. It uses the Baudot alphabet and the Baudot distributors, but instead of the motor and weight method of driving the distributors used in the Baudot system, the phonic wheel motor is employed. The method of governing is similar to that used in the Murray automatic system. The transmission is by means of a keyboard perforator, perforated paper tape, and an automatic tape transmitter for each channel of the multiplex.

Perforated tape transmission and retransmission are of great practical value, and an unfavourable opinion should not be formed of this method of transmission because the British Post Office has tried the Baudot keyboard perforator and tape transmitter and has found them unsatisfactory and has ceased to use them. That was due to the instruments and to the speed at which the Baudot is worked, and not to any defect in the principle of indirect transmission by perforated paper.

In the Murray multiplex the messages are typed in Latin letters by means of printing machines, which print the messages automatically in page form, and feed in the message forms to the right printing point for the beginning of each message. There is also a tape perforating mechanism for reproducing the perforated transmitting tape at the receiving station. In this way any desired message can be re-transmitted automatically. Briefly, the advantages of the Murray multiplex over the Baudot are :—

1.—A really good typewriter keyboard perforator and automatic tape transmission, requiring much less skill and increasing the output compared with the direct transmission method of the Baudot.

2.—Direct and completely automatic printing of messages in page form ready for checking and delivery, instead of printing on a tape as in the Baudot.

3.—Speed 33 to 100 per cent. greater per channel, the Murray multiplex working at 40 to 60 words per minute, compared with 30 words per minute on the Baudot. This is an important point when automatic tape transmission is employed.

4.—Messages may be automatically re-transmitted from the perforated receiving tape. No perforated receiving tape is produced except in the case of messages requiring re-transmission. The printing of the message and perforating of the tape proceed simultaneously. There is no provision of this kind in the Baudot, and it is an arrangement that promises to be of great practical importance, as it will save time and labour and will reduce the percentage of errors due to the human factor at present employed in re-transmission.

I took an exhibition set of the Murray multiplex system to New York, and the Western Union Company officials tested it carefully for three months, the result being that the Western Union has bought the United States rights.

The trial of the system by the Western Union proved that the type-wheel typewriter that I had employed as part of the Murray multiplex printer was not strong enough for the work it had to do. The Western Union engineers accordingly fitted a typebar typewriter on the printer in place of the typewheel typewriter. This will remove practically the only serious weakness that has been discovered in the Murray multiplex system.

The advantages of paper tape with the letters perforated across instead of along the tape were carefully considered, and it was decided to use the cross-perforated tape. This will greatly reduce the cost of the paper tape, and will enable cheap keyboard perforators and transmitters to be constructed.

The Western Union has arranged with its allied company, the Western Electric, to manufacture the Murray multiplex apparatus for use in the United States. A good deal of development work will be needed before the commercial manufacturing stage is reached, but everything is being pushed on as rapidly as possible, and it is probable that in about a year the Murray multiplex will have reached final commercial shape in all essential respects, and will be ready for manufacture in quantity. In order to expedite the development, I am working on it in London as well as the Western Union and the Western Electric engineers in New York.

The Western Union has from the beginning shown great interest in printing telegraphy, and is reputed to have spent over a million dollars on various printing telegraphs, including the development and equipment of

circuits with the Buckingham and Barclay systems. Not only has the Western Union done much pioneering and useful work on the subject of printing telegraphy, but the indications are that all the main factors of success, including long accumulation of experience and skill, are now in the possession of the Company. The money is there, and the enterprise, and the engineering ability, and, most important of all, there is a great incentive in the shape of large economies in the handling of telegrams and improved service that will result from the employment of various printing telegraphs designed to meet modern requirements.

TELEGRAPH SYSTEMS INSPECTED.

America is the land of printing telegraph inventors. The important inventions, however, are few, and, with one or two exceptions, attention was paid only to those of practical value or of technical interest. Stock tickers have reached standard shape and no progress in them is apparent. The following notes will therefore be confined chiefly to printing and other telegraph systems for handling ordinary telegraph messages between centres of population.

The Buckingham-Barclay System.

The most important printing telegraph at present in use in America is the Buckingham-Barclay system employed by the Western Union on about 60 circuits all over the United States. It was originated by Buckingham, and considerably improved by Barclay and other engineers of the Western Union. It is an automatic system using typewriter key-board perforators and Wheatstone automatic transmitters, and it has the advantage of printing direct in page form at the receiving station. Its chief drawback is the employment of the Buckingham alphabet, which averages 10½ units compared with six in the Baudot alphabet, as used in the Baudot and the Murray multiplex, and five in the Baudot alphabet as used in the Murray automatic, and eight in the Morse. A unit is a half cycle. Not only is the Buckingham alphabet double the length of the Baudot alphabet, thereby reducing the speed or the length of the line by half, but the letters are also of unequal length. This adds very materially to the complexity of the mechanism compared with the mechanism required with the Baudot alphabet. I was informed that the Barclay circuits in the United States carry about ten million messages a year. This is probably about one eighth of the total annual telegraph traffic of the Western Union, apart from leased wires and railroad traffic.

The system is worked duplex, and it gives good service on the whole; but its output is not great, and the fact that it is in successful use is due chiefly to the skill and perseverance of the Western Union engineers and to careful attention to innumerable practical details. Its main advantage is that it enables cheap and comparatively unskilled labour, chiefly female, to be employed, as it is equipped with a typewriter keyboard perforator for preparing the transmitting tape. This is an important consideration in America where skilled labour is so highly paid. The Barclay system was undoubtedly one of the main weapons that enabled the Western Union to break the last American telegraph strike. If the Barclay system is to continue in use it seems inevitable that it will have to be modified so as to employ the Baudot alphabet. This would greatly increase the usefulness of the system, and would enable it to work interchangeably with the Murray multiplex, the Murray automatic, the Morkrum, and any other system using the Baudot alphabet.

The extent to which automatic telegraphy is employed in America is shown by the fact that the Western Union Company uses 75 million yards of Wheatstone paper tape per annum for the Barclay and the Wheatstone systems (chiefly for the Barclay). This is equivalent to about 84 tons of paper tape per annum. As this tape costs about £60 a ton in the United States, it represents an outlay of about £5,000 a year. The use of cross-perforated tape would reduce this expenditure down to about £2,000 a year for the same amount of work.

An interesting feature of the Barclay system is the use of separate cut message forms in the printing mechanism. The messages are printed in page form, and the line and column feeds are automatic, but the page feeding is done by hand, the attendants showing great dexterity in slipping in a fresh message form and pulling out the printed message. This arrangement eliminates the page-feed mechanism and rolls of message forms, but it probably requires more labour than the purely automatic page feed provided in the Murray multiplex. This method of manual page-feeding is also employed in the Morkrum printing telegraph. I am informed that girl operators on the Barclay system can feed in the message forms and check the messages at the rate of 100 per hour.

The Morkrum System.

Next to the Barclay, the most important system in practical use in the United States is the Morkrum. There are a very large number of telegraph circuits which have not sufficient traffic to require more than one transmission each way. For such circuits automatic or multiplex printing telegraph systems with a high message-carrying capacity are needlessly expensive. At present such circuits are worked simplex or duplex with the Morse key and sounder, or with the Hughes. It is for such circuits that the Morkrum printing telegraph seems to me to be specially well adapted. It is more rapid than the Hughes or Morse key, and requires much less skill to operate. Of course a considerable portion of this class of traffic will ultimately be handled by the telephone, but for dealing with a large part of it the Morkrum or some similar printing telegraph has decided advantages.

The Morkrum printing telegraph may be described as a direct transmitting free typewriter keyboard system giving one transmission in each direction by means of the duplex balance. It is not a multiplex system, and its value appears to be on circuits carrying from 400 to 800 and possibly 1,000 messages per day. It was invented by Mr. Charles L. Krum, a Chicago cold-storage engineer, assisted by his son, Mr. Howard L. Krum, and it is being financed by Mr. Joy Morton, a Chicago millionaire. The development of the system has taken from 12 to 14 years, and it is now in very good shape. From what I saw of the Morkrum at work in the head office of the Postal Telegraph Company in New York, I thought so well of it that I went to Chicago at the beginning of March last and spent a week studying the Morkrum system. I found it to be well made and designed. It has a free typewriter keyboard and uses pure alternating current. The Baudot alphabet is employed with an extra positive starting impulse. Only the good central portion of each signal is utilised, as in the Baudot and the Murray multiplex. The system is page-printing, and there is a

"home recorder," on which the sending operator can see what he is doing. The system is built up in instantly interchangeable units, so that interruptions of work are quickly cleared by inserting duplicate units. There is no synchronism or isochronism except during the short interval required for the transmission of one letter. I was informed in Chicago that the Morkrum system working duplex easily exchanges on the average 800 American messages on one wire in a day of nine hours. This information was confirmed by the results obtained by the telegraph companies in New York. These results are with one girl operator sending and one girl receiving at each end of the line. During one week at the Postal Telegraph Company's office the average throughout the week was 988 messages per day of nine hours. The Postal Telegraph Company has eight Morkrum circuits in use on lines averaging about 300 miles in length, the longest being on a New York-Chicago wire, 1,000 miles, with one repeater half way. The Western Union Company has six duplex circuits fitted with the Morkrum between New York and Philadelphia, 90 miles. Several circuits belonging to various railroads in the United States are equipped with the Morkrum, and two installations are in use by the Canadian Pacific Railroad Company on two wires between Montreal and Toronto.

The following are the latest records achieved by the Morkrum system: 1207 messages (655 one way and 552 the other) were exchanged in one day of nine hours on the Chicago—St. Louis circuit (300 miles). A girl operator in Boston on the New York-Boston Morkrum circuit (250 miles) sent 745 messages in nine hours, and in one hour she sent 104 messages. These results speak for themselves.

In view of the excellent results obtained in America, I entered into business relations with the Morkrum Company, and arranged to represent them in Europe and other countries outside of North America. I shall therefore be happy to reply to enquiries and to suppy any further information that may be desired in regard to the Morkrum printing telegraph system.

The Wright System.

The attention of printing telegraphic inventors in America has been devoted largely to the idea of two typewriters, one at each end of a telegraph line, each able to operate the other over a single wire. To secure a practically free typewriter keyboard so that the keys may be struck rapidly and without any cadence, the carrying capacity of the line is sacrificed by raising the speed of transmission to 70 or 80 words per minute, though the actual output on such systems working duplex is on the average only about 30 words a minute each way. The saving lies in the cheap and comparatively unskilled labour that may be employed. Some of the girl operators on the Morkrum in the Postal Company's offices cannot even use the Morse key. They are simply girl typists. The Morkrum is a good example of this class of printing telegraph. Another is the Wright system. Mr. J. E. Wright is an American inventor who has had long and successful experience with stocktickers. Several years ago he started developing a system on somewhat similar lines to the Morkrum; but, unlike the Morkrum, he used an eight unit alphabet instead of the five unit Baudot, and he depended on positive, negative and zero current, instead of pure alternating current. He used a double tongued polarised relay, one tongue responding to positive and the other to negative signals. The Wright printer is at present operated by cams and is motor-driven. The speed of the Wright system is not so favourable as the Morkrum. The Morkrum gets 72 words a minute with signals transmitted at the rate of 25 cycles per second on the line. The Wright system has at present a rate of 24 cycles per second on the line for a speed of 46 words per minute, and a maximum speed of 32 cycles per second for a speed of 61 words per minute. The Wright system uses 53 characters and several operative signals, but there is no figure shift. This is a decided advantage, but it means extra complexity of mechanism. The Wright system was tried by the Postal Company in New York for several years, but was abandoned towards the end of 1911, the Morkrum being found preferable. It is only fair to the Wright system, however, to say that it has given good service under favourable conditions, and 20,000 words of press messages have been transmitted on it in 6½ hours. This is at the rate of 51 words per minute, which is a very good record.

I visited Mr. Wright's factory, and Mr. Wright showed me his apparatus and the improvements he is making. He informed me that the Postal Company had agreed to give the Wright system another trial if it was altered so as to use the Baudot alphabet without any zero interval. Mr. Wright is accordingly making extensive alterations in his system, and it is instructive to note that the employment of the Baudot alphabet necessitates the use of devices very similar to those employed in the Morkrum. Mr. Wright, however, instead of using the five unit Baudot alphabet, is using the six unit alphabet giving 64 permutations, and a positive starting impulse is used as in the Morkrum. This gives seven units per letter compared with six units per letter in the Morkrum. Against this disadvantage of longer signals per letter there is the advantage of no figure shift with the Wright system. The new Wright direct transmitting keyboard is good and strong, and with very light touch of the keys. Various improvements are also being made in the printer and other portions of the system. When the improvements are completed it will certainly be a very much better system than it was when tried by the Postal Company. Even then, however, it will not be superior, and I doubt if it will be equal to the Morkrum. It is a hard task to overtake a successful rival who has passed you in the race and has got a long way ahead of you. The Morkrum is the successful rival. Mr. Wright's courage in continuing the race when so heavily handicapped inspires one with the friendly hope that he will obtain his share of success. Like the Morkrum, the Wright system has been honestly financed and decently exploited. That, I am sorry to say, cannot be said of some other telegraph inventions, which have been used by unscrupulous persons to extract money from the public, the American company laws enabling people to organise a company with say ten million dollars of nominal capital, and then gradually retail the shares to the public in small lots day by day, sometimes for years, by means of advertisements and circulars. In London the company promoters rob the public wholesale at one swoop. In America the process is carried out retail over months and years. Telegraph inventions, including wireless, seem to be specially suitable for this form of enterprise, which has been carried on in many cases without the inventor realising the truth. Of course there is nothing wrong in selling shares in this way. It is the grossly misleading statements so often made in the circulars sent out by stock selling companies that constitute a fraud on the public, and that have brought this form of financial enterprise into disrepute.

The Cardwell System.

The Morkrum and the Wright are the only systems of their particular class in the United States that have real merit, and at the same time have reached the stage of practical usefulness. Another system designed to meet the same requirements is the Cardwell printing telegraph, owned by the "American Telegraph Typewriter Company." This system is on exhibition in finely furnished offices in William Street, near Lower Broadway, New York, but its performance is poor. The speed is low, the printing is not good, and the signals consist of positive and negative, and strong and weak currents and zero intervals, unless two wires are used. It was invented by G. A. Cardwell, a dentist, and it has been more or less in existence for about 12 years. The nominal capital of the company owning the system is ten million dollars, and the company collects money by selling its shares to anyone who can be induced to buy them. The pamphlet issued by the company claims that it could lease 10,000 machines in 30 days. It says that:—"In 1912 we will undoubtedly have in service 5,000 machines, bringing in $750,000 rental per annum, payable $62,500 per month in advance." The pamphlet asserts that the 5,000 machines will pay for the construction of 5,000 more machines, and give a net profit of $312,500. The second year 10,000 machines will pay for the construction of 10,000 more, and pay the company a net profit of $625,000. The third year 20,000 machines will build 20,000 more, and pay the company $1,250,000 net profit. "These figures are right; carry them forward two or three years further and see for yourselves the vast business ahead of this enterprise in that short time."

In spite of these magnificent figures the system in its present form is of no serious value, and it is not being used either by the Western Union or the Postal Company.

G. A. Cardwell's son, A. D. Cardwell, having become dissatisfied with his father's system, or with the company promoting it, set up as a printing telegraph inventor on his own account, and is developing a printing telegraph system for which he makes large claims. This system is not yet of importance, but it may grow. The alphabet employed at present has the usual defect of zero intervals, and a balanced relay is used with the tongue in the middle. This arrangement has been tried over and over again without success by most printing telegraph inventors. In fact it is interesting to observe how narrow and well defined are the possibilities in connection with printing telegraphy. Given a certain alphabet and a certain printing telegraph will grow out of it, which will have the same general characteristics as all other printing telegraphs using that alphabet. An interesting point about the A. D. Cardwell system is the employment of telephone relays. These are very cheap and appear to work well. The Morkrum and the Wright systems show the same tendency towards telephone construction. Mr. A. D. Cardwell's system is not being run by a stock-selling company.

The Crehore System.

A much more interesting printing telegraph is the Crehore. This, of course, is being properly conducted, and there is no stock-selling company connected with it. It is owned by the Typewriter Telegraph Company, of 30 Church Street, New York. When I called at the offices of the company Dr. Crehore was away, but his brother told me nothing had been done with the system for two years, and he rather bitterly blamed the big telegraph companies for their inaction with regard to it. Also he said that Dr. Crehore is now more interested in his theory of gravitation than in printing telegraphs. Some beautiful samples of the printing done by the Crehore system were shown to me. The apparatus was not on exhibition, but Dr. Crehore's brother explained that it sends four messages in each direction simultaneously (octuplex) at 50 words a minute per channel (200 words per minute in each direction, or 400 words a minute in all), two telegraph wires being used, one for the messages and the other to maintain synchronism. If only one wire is employed, then the system is worked sextuplex, two of the eight channels being used for synchronism. The eight unit alphabet is employed and cross perforated tape is used for transmission, and also for re-transmission. The employment of the eight unit alphabet and the use of two wires or the sacrifice of two channels to secure synchronism are objections to the system, but there are real merits, especially the use of perforated tape for transmission and re-transmission, and it is a pity that the system has not been tested out in practical work.

The Crehore Company is at present arranging for the use of a modified form of the system for telegraphic work in large manufacturing plants. This modification was shown to me at the company's office. It works nicely and is similar in general idea to the Morkrum and the Wright systems, although differing widely in details. It is believed by the Crehore Company that there is a very large field in the United States for a satisfactory printing telegraph of a simple character for large factories and manufacturing plants. In such cases a multiple wire cable can be employed as the distances are not very great. This gets rid of synchronism and greatly simplifies and cheapens the mechanism. I was assured on several occasions by different inventors in the United States that there really is a large field in America for a printing telegraph suitable for big factories to transmit written orders, but it is difficult to believe that such an arrangement can compete with the telephone. On battleships, however, there seems to be scope for such a system. That at any rate is the opinion of a well-known British admiral, who consulted me on the subject.

The Delany Telepost.

In February last I called at the offices of the Delany Telepost Company in New York, and saw Mr. Delany and his chief engineer, Mr. Larish. The company is being run by the Sterling Debenture Corporation, a concern with a large staff of about 30 clerks and typewriter girls, which specialises in selling shares in companies by sending out circulars to possible purchasers all over the United States and other countries. I heard regret expressed in New York that the Delany Telepost system should have got into the hands of such people. Their conduct is no doubt within the limits of the law; but they are certainly trying to sell the shares of the Delany Telepost Company by holding out hopes of enormous profits—14 million dollars per annum—that are not likely to be realised. It is a pity, because the Delany Telepost system has merits. It is the old Bain damp chemical tape system with various detail improvements. Transmission is effected by drawing perforated tape between spring contacts and a metal roller, and the reception is similar, except that damp chemical tape takes the place of the perforated tape. This is the old Bain system. Mr. Delany and his assistants have provided keyboard perforators for perforating the transmitting tape, and they have improved the transmitting mechanism so that it is now possible to transmit good signals from ordinary Wheatstone perforated tape. This has been achieved by providing two small round ridges or projecting bands on the metal roller corresponding to the two lines of message perforations on the Wheatstone tape. These two raised bands on the small metal roller tend to project through the holes in the tape as the tape passes round the roller. This enables the metal contact springs to make good contact with the roller. I was informed that since this arrangement had been adopted the transmission had been very reliable. The Telepost engineers claim to be able to transmit by this arrangement 2,000 words per minute perfectly from ordinary Wheatstone perforated tape. It was shown to me working nicely at 600 words per minute, and the received signals were perfectly good and clear, and equal to any Wheatstone receiver signals. The keyboard perforator that I saw did not produce Wheatstone tape, but Mr. Delany told me they had recently completed a greatly improved keyboard perforator that would produce perfect Wheatstone transmitting tape as rapidly as an operator could touch the keys. He explained that it is not larger than a typewriter and works by means of a solenoid electro-magnet. There is no motor. It was away at the factory at the time of my visit. A good Wheatstone keyboard perforator and reliable transmission at a very high speed from ordinary Wheatstone perforated tape is a distinct improvement on the old Bain system. A self-starting and self-stopping arrangement has also been applied to the receiver. This is operated by two polarised relays at the receiving station. When a prolonged positive impulse is sent from the transmitting station, one of the relays responds and trips a switch in the receiver, which starts the chemical receiving tape running and also cuts out the relay from the line. At the end of the message a prolonged negative impulse operates the other polarised relay which then reverses the switch and cuts in the starting relay. The stopping relay is wound with low resistance and is heavily shunted so as not to interfere to any material extent with the high-speed signals. An arrangement of this kind is a necessity when using chemical tape at 600 to 1,000 words a minute.

The Telepost Company, having failed to interest the Western Union or the Postal Company, started to work on the lines of the independent telephone companies in the Western States, the Telephone circuits being super-imposed simplex on the Telephone loops. There is said to be no complaint about interference with the telephone service except when weather or line conditions are very bad. The Telepost Company is, or was at the beginning of this year, working from St. Louis as a centre, branching out with a circuit to Chicago (380 miles) with an intermediate station at Springfield; another circuit to Kansas City (350 miles) with an intermediate station at Sedalia; and a third circuit to Indianapolis (285 miles) with an extension to Louisville; also Boston to Portland, Maine. Working on a telephone simplex circuit of 700 miles from Kansas City to Louisville with 110 volts they got 700 words a minute (no repeater). Of course these would be heavy copper telephone long distance wires, so that the resistance would be low. In any case, however, the speed is beyond the capabilities of the Wheatstone system. The chief trouble is that when the lines get bad so that there is interference, the telephone companies have no spare circuit to give the Telepost Company. The result is that the Telepost service is severely handicapped. The Telepost Company is also heavily handicapped by want of funds to extend the service. While I was in Chicago I noticed that the Telepost office was closed and dismantled. Possibly they had taken another office, but no one seemed to know.

The following information was given to me by a friend in New York, a telegraph engineer, formerly in the employ of the Telepost Company. He said the Telepost works very well, in fact so well that they can get 300 to 400 words a minute over their lines when it is impossible to work with the morse key. They have only one circuit between each station and no alternative route, and, when the one circuit fails, their service is crippled. He added that they did magnificent business while the lines were in good order, and then when the circuits broke down their customers dropped away from them and went to the Western Union and Postal Companies. When the circuits were right again the Telepost would again build up a good business, only to lose it once more on the occurrence of further interruptions. The Telepost Company sends telegrams at the rate of 25 words for 25 cents (one shilling) and five cents for each additional ten words. "Teleposts" are sent at the rate of 50 words for 25 cents and 5 cents for each 10 words extra. These are posted at the receiving station for delivery by the Post Office. "Telecards" are used at the rate of 10 words for 10 cents (fivepence). These are posted at delivery office. The rates are uniform irrespective of distance. They sell telegraph message forms good for 25 words for 25 cents each, with a 10% reduction if 100 message forms are bought. Also they sell special 5 cent stamps to put on the forms for each 10 extra words. They likewise give the time when the messages are handed in by the public. This is not done by the big American telegraph companies, who also charge 25 cents for 10 words as the minimum, and vary their charge according to distance. My informant said the Telepost Company did a lot of business with the telecards. He added that the selling of the cards and message forms and stamps did away with much book-keeping that the big companies were at present burdened with. He said it was surprising how much more customers telegraphed when they could send 25 words for 25 cents. The low rate seemed to encourage them to telegraph more than in proportion to the reduced rate. One of their big customers was the Republic Iron and Steel Company, which bought large quantities of the Telepost Company's telegraph forms for use between Chicago and St. Louis. He maintained that it was the competition of the Telepost Company that led the Western Union Company to go in for night letters and other developments.

The Electric Press Bulletin Company.

One of the most curious printing telegraphs in America is that owned by the Electric Press Bulletin Company of Philadelphia. It is a giant stock-ticker with a typewheel of aluminium 2 feet in diameter with rubber letters cemented on the periphery, and printing in column form on a web of paper about 3 feet wide. The letters are about two inches high. It is in all respects a column-printing news ticker and its object is to display the latest news at the earliest possible moment in the windows of newspaper offices. Three of the machines are in use at the *New York Times* office in Times Square. I had a talk with the operator in charge of the apparatus. He showed me the machine at work. Owing to its great size it is slow. It is operated from a typewriter keyboard, but the speed is limited to about 10 words a minute. It is a two wire system and the news may be printed several miles away. It was remarkable to notice how quickly a big crowd gathered in the street as soon as the machine started to work. The operator cut a few lines of news from an

evening paper, and in a short time it was up in large type in the window and being gazed at by a crowd in the street. The operator told me it had been in use for 18 months, but the novelty and attraction for the man in the street was as great as ever. Certainly from the newspaper and advertising point of view the machine is a success and it seems to work well mechanically. The operator told me the rental charged to the *New York Times* was $300 (£60) per annum for each machine. He said it was a good machine and they had received orders for many hundreds, but the directors of the company seemed to be chiefly occupied with selling shares to the public, and only a few machines had been built. He said the company's treasury was empty and they had not paid him his salary. It seems to be another example of a meritorious invention afflicted with the stock-selling blight. No doubt it will come into use in time for displaying news and advertisements on a scale sufficiently large for everybody to read at some distance. A man in a club or a hotel would certainly find it convenient to glance up and read the latest news on the other side of the room from his easy chair.

The Giara Teletype.

Another stock-selling concern is the "Telegraphic Mail Company," owning the Giara Teletype. It is a million dollar company, and the shares are being sold by the inventor, T. V. Giara, who sends out exceedingly sanguine circulars and pamphlets to possible buyers. I had a talk with him and saw his machine. His sanguine temperament appears to prevent him from seeing that he is deluding the public by extravagant statements. His printing telegraph works all right, and it is certainly remarkable because he proposes to use a separate wire for each character transmitted and printed. He exhibits samples of the multiple wire cables that he proposes to have erected all over the United States. These samples are not much thicker than a lead pencil. The statements made in the Giara pamphlet are surprising. For instance:—"The wires in the Teletype line can be so small that a cable may be made with half the copper there is in one single telegraph wire." The apparatus he showed me consisted of two Blick electric typewriters, connected by a 32-wire cable and a magnet for each key of the typewriter. He is now using the Hammond typewriter. The Giara system would not be worth mentioning except for the circumstance that there seems to be a field for the Giara or some similar machine for signalling or fire control on battleships. The inventor told me he is getting his apparatus made at the Hammond typewriter factory in New York, and he has an order for two of his fire control typewriters for the United States Navy at $500 (£100) each. They have 13 keys, including 10 numerals, and space and shifts. Only numerals are required in this case, and a 15-wire cable will be used. The figures are printed quite large, about $\frac{1}{4}$-inch (6 m/m) high. Giara is therefore another of many American inventors who are trying to fill the supposed demand for a printing telegraph for short distances, such as factories, large shops, and battleships. The multiple wire cable is most favoured owing to the extreme simplicity of a printing telegraph under such circumstances, and the cost of a multiple wire cable is moderate within the limits of a factory or battleship.

Another System.

The most remarkable printing telegraph that I saw in the United States was one that I am not at liberty to describe at present. The inventor and owners showed it to me in confidence, but they do not want it brought into public notice until it is completed. It impressed me favourably, but its success depends on so many uncertain factors that it is difficult to prophesy about it at present. If it succeeds I shall probably enter into business relations with the owners to assist in the commercial exploitation of the system.

Spread of the Baudot Alphabet.

It is interesting to note the progress being made by the Baudot alphabet. Inventors paid little attention to it until I pointed out its importance in the paper on "Setting Type by Telegraph," read before the British Institution of Electrical Engineers in 1905. Now its fundamental importance for machine telegraphy is admitted by all. The Morkrum printing telegraph used the Baudot alphabet from the beginning with great advantage. The Wright printing telegraph did not use the Baudot alphabet, and as the result of direct competition with the Morkrum system the Wright system has been forced to employ the Baudot alphabet. The Western Union has bought the United States rights to the Murray multiplex system, using the Baudot alphabet, and in view of the improvement that would be effected, it seems reasonable to suppose that the Barclay system in use by the Western Union will be modified so as to employ the Baudot alphabet.

Keyboard Perforators.

The Barclay keyboard perforator is largely used by the Western Union for perforating the tape for use with the Barclay printing telegraph system. It has a differential feed and it can produce Wheatstone tape. It is rather a clumsy machine, however, and it did not appear to me to be as good as the Gell perforator, now so largely used by the British Post office. The Delany Telepost Company is getting out a keyboard perforator for producing Wheatstone tape, but it was not ready at the time of my visit. A noteworthy Wheatstone tape keyboard perforator is the Kleinschmidt, made by Messrs. Brooks & Kleinschmidt, an electrical manufacturing firm in New York. It is very simple and all the parts are easily accessible. A single magnet punches on the front stroke and feeds the tape forward on the back stroke. The inventor informed me that it uses about half an ampere at 110 volts; the maximum power required being about 70 watts. It has only recently been completed, and one is being tried by the Postal Telegraph Company and another by the Western Union. It is about the same size as an ordinary typewriter.

The Typewriter Position.

A great sensation was made in typewriter circles in America by the order given by the Western Union to the Underwood Typewriter Company for 10,000 Underwood typewriters, and it loosened the tongues of representatives of the rival typewriter companies. The general typewriter gossip in New York was that the Western Union was getting the Underwood typewriters for $32 each (£6 12s.). I do not know whether this was true or not, as the Western Union was silent about it. The retail price of the Underwood in New York is $100. The actual cost of making a modern typewriter does not exceed about £5, but the cost of selling is heavy. The Western Union invited the leading typewriter manufacturers to send in a number of their machines for six months'

trial. This was done, and the Underwood was selected, so it is said, because it was a good machine and was offered at the lowest price. The L. C. Smith typewriter is alleged to have been the most favoured from the mechanical point of view. It certainly is a fine machine.

The representative of a large typewriter company in New York explained the typewriter position in America to me as follows. There are a number of typewriters such as the Blickensderfer and other double-shift-key machines, which have a large field amongst small users, and for writing foreign languages; but none of the double-shift key machines, that is to say the machines with one shift key for capital letters and another for figures, can stand against the competition of big, strong, typebar machines with only one shift, when used in big business, that is to say, in big commercial and manufacturing offices where as many as 300 or 400 typewriters are in constant heavy work all day and every day. It is not until a new typewriter has conquered a place for itself in the big business field that it can be described as a real success. For hard work in big offices, a successful typewriter must be a typebar machine, a visible writer, and must have not more than one shift key, like the Remington. On the other hand, no shift at all on a visible typebar typewriter leads to undesirable crowding of the typebars. The single-shift as used in the Remington seems to be a happy compromise. For years the Remington typewriter company had a practical monopoly. As time went on other machines got a foothold, and they were joined with the Remington in the Union Typewriter Company (the typewriter trust). A number of visible, but otherwise not very good typewriters, were making their way and educating the public into the advantages of visible writing. Underwood, who manufactured the ink ribbons for the typewriter trust, realised the advantages of visible writing and brought out the Underwood typewriter. This had the three requisites for big business, namely, typebars, visible writing, and the Remington single-shift keyboard, and in the absence of any real competition the Underwood company grew into an immense concern, manufacturing on a great scale. The typewriter trust, controlling the Remington, Smith-Premier, Monarch, and other invisible writing typewriters, declined to bring out a visible typewriter. When I was in New York 12 years ago I had occasion to see Mr. Clarence Seamans, the president of the typewriter trust, and I asked him then why he did not bring out a visible typewriter. He said they did not dare to do so. They had a splendid business and it would wreck it to bring out a visible Remington. They had sold 360 more Remingtons that week than they had sold during the corresponding week of the previous year. That business was too good to be risked. However, one of the members of the typewriter trust, Mr. L. C. Smith, became alarmed at the progress being made by the Underwood machine, and after vainly urging his colleagues to bring out a visible typewriter, he sold out his holdings in the Union Typewriter Company and started the L. C. Smith Typewriter Company. The L. C. Smith machine was so well designed and so well made that it soon established itself as one of the best on the market, and well adapted for the big business field. The typewriter trust was at length forced to move, and brought out a whole group of visible writers—the visible Remington, the visible Smith-Premier, and the Monarch visible. The Remington, Smith-Premier and the Monarch are now being sold in New York from the same office, and the typewriter expert already referred to, told me also that the Smith-Premier visible is not a real success and will be allowed to die out. The Remington visible is a good machine and its sale is being pushed; but neither the Smith-Premier nor the Monarch are being pushed. The result will be that in the course of time these machines will die out, and the struggle for the big business field will then be narrowed down to the Underwood, the Remington, and the L. C. Smith visibles. It is a noteworthy fact that these three machines are all curiously alike in general design, and they seem to represent the final form of the typewriter machine, gradually evolved after prolonged trial of every possible design. The opinion seems to be that the L. C. Smith is the best machine; but, as in the case of bicycles and motor cars, it is largely a matter of personal preference. When bought in large quantities the price of the good typewriters like the L. C. Smith is said not to exceed $60 (£12) each, the retail price being $100 (£20). Certainly for telegraph work there does not seem to be any typewriter worth considering outside of the three visibles, the Remington, the Underwood and the L. C. Smith, with the possible exception of one or two very good German machines and the remarkable American "Noiseless" typewriter. It really is practically noiseless, and this feature is no doubt desirable in a telegraph office, but the advantage has been obtained by adopting a design that is not very good. The price is also high, £25 retail, compared with £20 for other typewriters. Bought in large quantities no doubt it would be cheaper. The "Noiseless" company has a large factory in Connecticut, and they inform me that they have more orders than they can fill at present, and that it will be another year before they will be able to start selling in England and Europe.

So far as the Murray Multiplex is concerned, the typebar typewriters best suited for it seem to be the L. C. Smith and a very neat little German machine known as the "Bijou." Experiments are being made with both of these typewriters to determine which is the more suitable.

MISCELLANEOUS NOTES.

Electric Contact Materials.

One of the most interesting minor points noted during the trip was the extent to which silver is being used for contacts. The cost of platinum is so high that the employment of a cheap substitute is no longer a matter of indifference. Silver contacts are being used by both of the big telegraph companies in America and also by all the printing telegraph inventors, and the results appear to be satisfactory, in spite of the high voltages and heavy currents employed in telegraph practice in the United States. The French telegraph administration has used silver contacts for years. Silver has the advantage that the dirt on the contacts is a fairly good conductor; but silver is soft and much more easily fusible than platinum, and it is not unlikely that a more satisfactory contact metal or alloy would be discovered if some attention was devoted to the matter in telegraph laboratories. For instance, ductile tungsten appears to have special advantages for the purpose.

Electro-magnets for Relays.

Electromagnets are being quite largely substituted for permanent magnets in telegraph relays in America. The P.O. standard design of relay is being generally used with an electromagnet substituted for the permanent magnet. The Western Union officials state that they are using more of the electromagnetic relays than permanent magnet relays, as the electromagnetic relays give less trouble. They find that, at any rate under American conditions, the permanent magnets are not permanent, especially with high-speed working, as the reversals tend to demagnetise the permanent magnets. Messrs. Bunnell & Co., large American manufacturers of telegraph instruments, are supplying P.O. standard relays fitted with electromagnets in place of permanent magnets, the electromagnets being neatly packed away in the form of a long thin coil behind the armature pivots. Electromagnetic relays are used in the Morkrum system, and Mr. Wright, of the Wright printing telegraph system, also uses them. He says he gets better results with the electromagnetic relays. In this connection also it may be mentioned that the Eastern Telegraph Company has been experimenting with electromagnets in the Brown drum relay in place of the large permanent magnets hitherto used.

Style of Type for Printing Telegraphs and Typewriters.

In telegraph work in the United States plain block letter capitals are preferred thus—A B C D. They are employed on the Morkrum, the Wright, and other printers, and the Western Union is specifying this kind of type for the 10,000 Underwood typewriters that it has ordered. It is a good clear style of type, but the German system of using small letters (lower case) instead of capitals is undoubtedly the best from the point of view of legibility. I was informed in Berlin that the matter was carefully investigated by the German telegraph administration, the outcome being that small letters were found to be the best. The consequence is that now in all telegrams in Germany, even in the case of handwritten telegrams, only small letters and no capitals are employed.

The Edison Accumulator.

The commercial use of the Edison nickel accumulator is making rapid progress in the United States, and it is so durable and robust that it should be of interest to telegraph administrations. I went out to Orange, New Jersey, and was shown over the extensive and wonderfully equipped factory that has been built to manufacture the Edison accumulator. I also had the privilege of a chat with Mr. Edison. He and his associates have great confidence in the future of the Edison accumulator, and very large sums of money have been spent in equipping the factory with wonderfully intricate and ingenious machines and processes for the construction of the accumulator. In fact the whole secret of success in the case of this battery may be said to lie in the machinery and methods employed in its construction.

It is a circumstance not without significance that Edison, the foremost inventor of our time, is drawing his main revenue from popular amusements, that is to say from his phonograph and cinematograph film factories. Amusing people is more profitable than inventing printing telegraphs.

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MEMBER OF THE ENGINEERING STAFF, POSTAL TELEGRAPH-CABLE COMPANY, NEW YORK

McGRAW-HILL BOOK COMPANY
239 WEST 39TH STREET, NEW YORK
6 BOUVERIE STREET, LONDON, E. C.
1913

CHAPTER XX

HIGH-SPEED AUTOMATIC TELEGRAPHY

THE WHEATSTONE AUTOMATIC

Of the many systems of automatic telegraphy invented and tried out in actual service since the Morse telegraph was introduced about 75 years ago, the system which has been most extensively employed and which has been found to answer the requirements of service most satisfactorily is that known as the Wheatstone Automatic.

In the Wheatstone system of automatic telegraphy, the dot and dash combinations which form the letters of the alphabet are perforated in the Morse code on specially prepared strips of paper about 1/2 in. in width. When the letters and words forming the message or messages have been perforated in the paper strip the latter is then passed through a Wheatstone transmitter which is connected into the main-line circuit, and driven by an electric motor.

The Wheatstone transmitter is practically a high-speed pole-changer operated automatically instead of by means of a Morse key in the hands of a telegrapher, as is the case with manually operated single and multiplex telegraphs.

The preparation of the transmitting tape is accomplished by means of three-key mallet perforators, or by keyboard perforators, which may be operated by any telegrapher after a little practice.

If the Wheatstone transmitter is run at slow speed the transmitted Morse signals can be read by sound in the receiving relay (or from a sounder connected thereto) in the same way as hand sending may be read, as the Morse is plain and accurate. When the motor which drives the transmitter is speeded up, the rate at which signals can be sent over the line may reach 300 or 400 words per minute, depending upon the speed of the repeaters in circuit—if any are employed,—upon the *KR* limitations of the line wire, and upon the speed at which the polar relay at the receiving end of the line will work satisfactorily.

It is the usual practice to operate the system duplex, which means that most of the apparatus of the ordinary polar duplex is retained. At the receiving end the armature of the polarized relay has attached to it an extension arm bearing an inking wheel, which, when the tongue of the relay is in the spacing position (against its back-stop), is held close to, but not touching, a moving band of paper tape, and which, when the tongue

of the relay is moved into the marking position, makes contact with the moving paper slip, causing an ink mark to be made thereon of a length depending upon the time the relay tongue is held in the marking position. As the speed at which the tape travels under the inking wheel may be regulated to suit the speed of the received signals, each word received by the relay will appear in the familiar dot and dash characters marked upon the paper strip.

The receiver complete, including the polarized relay, the inking gear, and tape-moving mechanism is known as the Wheatstone recorder.

The received tape is passed to copyists who understand the Morse code, and who translate the characters, writing the message on a received telegram blank by means of a pen or typewriter.

Messages received by the automatic system at any office for relaying to points beyond, may be translated and copied as above described, or the received tape may be passed directly to a Morse operator who transmits the message appearing thereon to destination by hand. If the message is to be forwarded from the relay office over another automatic circuit, the received tape must be translated and the message typewritten, and then repunched on transmitting tape as at the originating office, so that it may be passed through the automatic transmitter connected into the second circuit and sent over the line at high speed.

THE MALLET PERFORATOR

The perforator which is shown in plan and front elevation at *a* and *b*, Fig. 365, is purely mechanical in its action. Groups of perforations corresponding to the letters of the alphabet are made by it in a slip of oiled paper which is afterward propelled automatically through the transmitter.

The keys or plungers, *a*, *a*–1, and *a*–2, actuate five steel punches used in making the desired perforations in the moving band of tape; *a*, corresponding with a "dot," *a*–1, with a space, and *a*–2, with a "dash." The center row of perforations acts as a guide to keep the tape in its proper place in the transmitter and as a rack by which it can be propelled. The perforations above and below the center determine the number and order of the main-line currents sent out from the transmitter.

Figure 365*c* shows the mechanism of the perforator placed underneath the metal cover, and Fig. 365*d* shows the levers *b*, *b*–1, and *b*–2, which are pivoted in the block *B*, under the base, and connected respectively to the keys *a*, *a*–1, and *a*–2. The opposite ends of the levers project upward through the base and terminate at the back of the mechanism near the ends of the five steel punches. Above and below the punches are two small rods provided with steel spiral springs for withdrawing the punches after the depression of the keys. Spiral springs are also used to restore the keys and levers to their normal positions after each operation.

The action of the mechanism in perforating the paper strip is rather difficult to learn from an unavoidably complicated diagram, and it may suffice to observe, for example, that in perforating the word "hat" in the tape the operator depresses the key *a* four times in forming the letter "h" then the

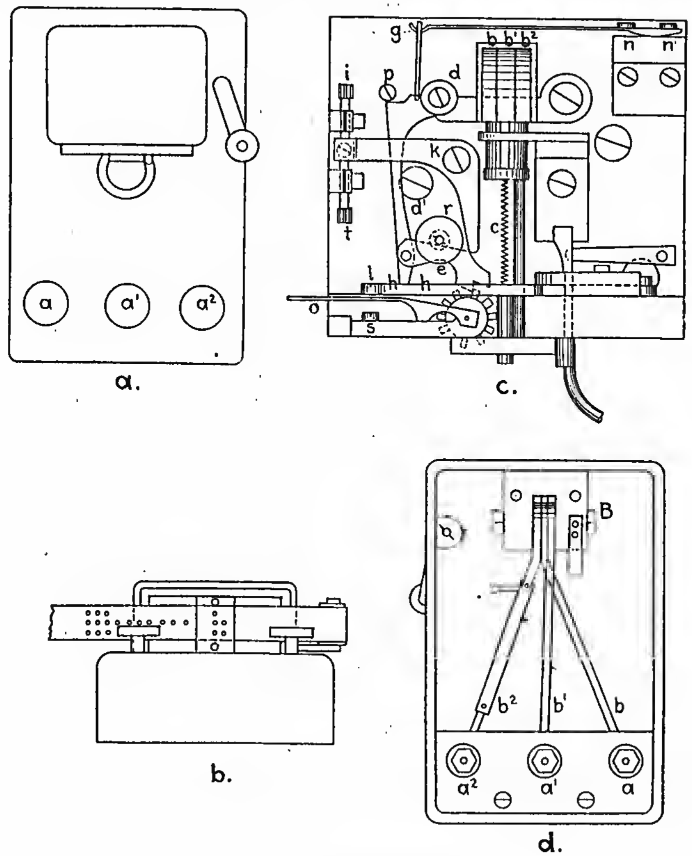

FIG. 365.—Mallet perforator.

key *a* once and the key *a*–2 once in forming the letter "a" and then the key *a*–2 once forming the letter "t." Between each two letters the space key *a*–1 is depressed once and between words twice, in order that the letters and words of the message will be properly spaced and not run together on the receiving tape at the distant station.

ADJUSTMENT OF THE PERFORATOR

The lever *h*, Fig. 365*c*, is connected by means of a small rod passing through the base to the lever *b*–2, and is only actuated when a dash is

punched. Its function is to regulate the movement of the pawl, *e*. When either a dot or a space is punched, the movement of lever *d*–1 is limited by the tail-piece of *h*, and the pawl moves over one tooth only of the star-wheel, pushing the tape one space forward; but when *a*–2 is depressed the lever *h* is raised so that the movement of *d*–1 is not limited by *h*, but by the pin *l*, and the pawl accordingly moves over two teeth of the star-wheel, so that when the key rises the tape advances two spaces.

The instrument is adjusted by means of two screws *i*, *t*, which act upon the bent lever *k*. It must be so adjusted that 120 center guide holes and 120 spaces are produced in exactly 12 in. of paper tape. The adjustment of the screws *i*, *t*, moves the lever *k*, either inward or outward. If the end nearest the punches be moved toward them, then the perforations will be spread over a greater length of tape; but if it be moved away from the punches, the perforations will be closer together and will occupy less space. If a length of slip be taken, containing 121 spacing perforations (which number may be obtained without counting by punching the word "message" four times, including five spaces between words, and seven spaces at the end of the last word), then the distance between the centers of the first and last holes must be 12 in. In other words, the distance between the centers of any two adjacent guide holes must be exactly one-tenth of an inch. Although a perforation more or less will not make any material difference to the working, it is well to adhere to exact spacing when possible; especially is this important when working at high speeds.

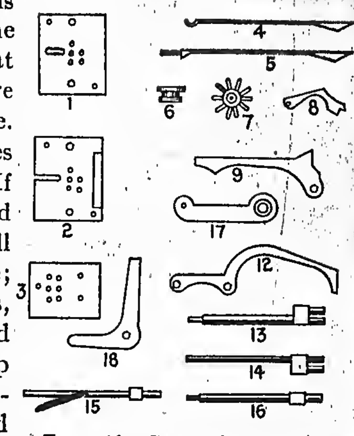

FIG. 366.—Parts of the mallet perforator. 1, Front puncher plate; 2, back puncher plate; 3, back guide to punchers; 4, back spring acting on star wheel click lever; 5, vertical spring on which guide roller is pivoted; 6, guide roller; 7, star wheel; 8, star wheel click; 9, star wheel click lever; 12, lever regulating play of star wheel click lever; 13, center punch (for dot, dash and space); 14, top punch (for dot and dash); 15, bottom punch (2, 1 for dot 1 for dash); 16, center punch (for dash); 17, socket lever; 18, adjusting lever.

The flat spring *g* can be adjusted by means of the screws *n*, *n*–1 and must exert sufficient force to propel the paper freely after each depression of the keys. The vertical spring which carries the small grooved roller, *r*, is adjustable in a similar manner by means of two screws under the base. It should exert just sufficient force to cause the pawl, *e*, to drop between the teeth of the star-wheel. When the keys *a*, or *a*–1, are depressed, the pawl should move freely over one tooth, and when the key *a*–2 is depressed, it should be drawn back over two teeth of the star-wheel. If undue force be required to produce this action between the pawl and the star-wheel, it will probably be found that the rubber washer under the head of the faulty key is a trifle too thick.

The star-wheel frame is provided with a tail-piece which projects outward through the vertical plate, *o*, on the left-hand side. When paper tape is inserted this tail is pulled toward the operator in order to move the star-wheel out of the way, and as soon as the tail is released, the star-wheel resumes its normal position.

Where two screws are provided for adjusting the lever, care should be taken always to release one before tightening the other, or the heads are liable to be broken off, the thread stripped, or the standards bent. Lock-nut screws, or clamping screws, also, should be loosened before moving the adjusting screws which they clamp, and carefully tightened again after the proper adjustment has been made.

A test gage 1/2 in. wide and 0.009 in. thick should pass freely between the back and front die-plates of the perforator. The standard width of perforator tape is from 0.472 in. to 0.475 in. and its thickness 0.004 in. to 0.0045 in.

Figure 366 shows the various parts of the mallet perforator, each part numbered to correspond with the accompanying list of parts.

KEY-BOARD PERFORATORS

There are several makes of key-board tape perforator on the market, which have been designed to take the place of the mallet perforator in the preparation of tape for transmission by means of automatic transmitters. Among these might be mentioned the Gell used in England and in some of the British colonies, the Kleinschmidt perforator, and the Storm perforator made in the United States. Fig. 367 is a reproduction of a photograph of one of these perforators, which is similar in appearance to all other makes.

Figure 368 shows a key-board arrangement which has been found to answer the requirements of automatic telegraph service.

The Morse characters as they appear in perforations in the tape are shown complete, the alphabet used being American Morse, with the exception of the letter "*L*," which is here shown as consisting of one dot, a space and three short dashes, instead of the regulation long dash of the Morse code.

THE AUTOMATIC TRANSMITTER

Figure 369 shows the mechanical construction and electrical connections of a transmitter arranged to operate a polar relay, the latter serving as a pole-changer in a duplex arranged for automatic transmission.

The movements to and fro of the divided lever *D–U*, are regulated and

FIG. 367.—Keyboard tape-perforator.

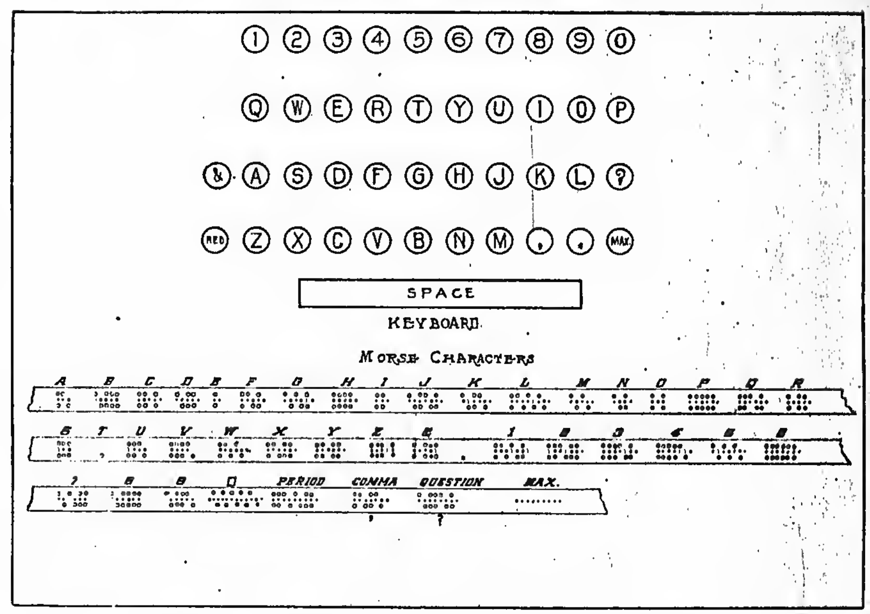

FIG. 368.—Keyboard arrangement of tape perforator, showing specimen of tape after being punched.

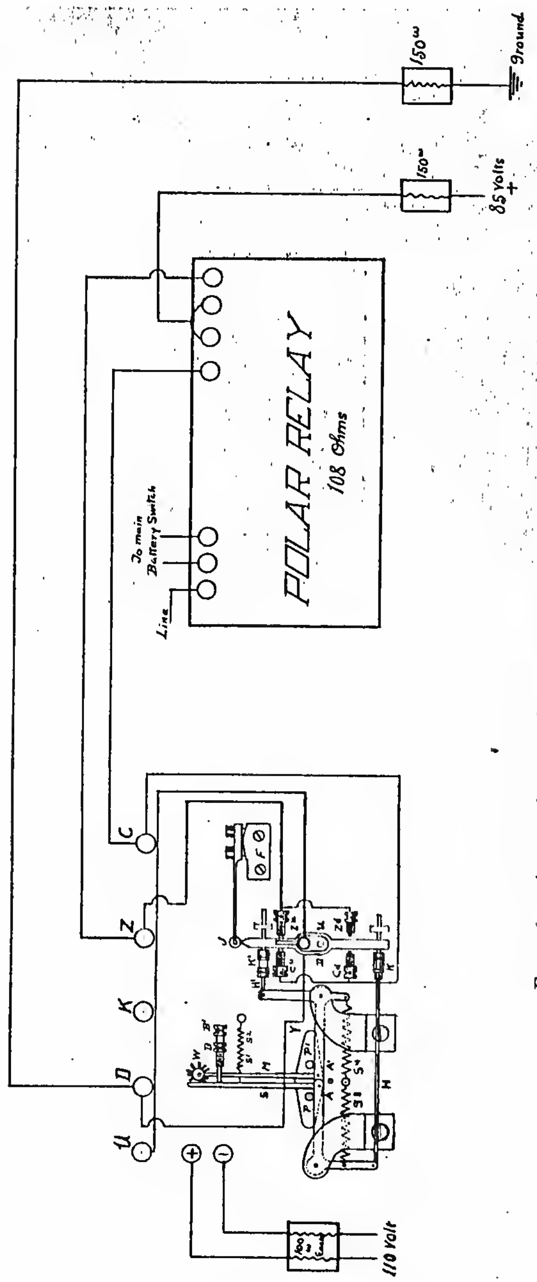

FIG. 369.—Automatic transmitter connected with polar-relay pole-changer.

controlled by the perforated holes in the paper slip, as the latter is moved along from right to left by the star-wheel W, above the arms S and M. The transmitter is constructed so that it may be connected directly to line, the contact points Cu–Cd and Zu–Zd acting as the duplex battery terminals and the divided lever as the pole-changer tongue connected to the main-line wire, but it has been found that the ranges of adjustment are not so limited where the automatic transmitter is employed to operate locally a polar relay, the tongue of which is connected to line and the local contact points of which carry the main-line potentials, plus and minus. The upper and lower halves of the divided lever D–U are mechanically connected, but separated electrically, that is, one is insulated from the other, so that either the lever D, or the lever U, in connection with the lower or upper contact points respectively Cd–Zd, or Cu–Zu, may be used to operate the line instrument. In case the operation is transferred from the upper to the lower contacts, or *vice versa*, the only alteration in connections required is that the ground contact be transferred from transmitter binding-post U to D or D to U, as the case may be.

The significance of the letters D and U may be borne in mind by noting that U refers to the upper pair of contacts, and D "down" or lower pair.

The rocking beam is equipped with two pins P, P', which project outwardly. The revolution of a driving wheel (within the case of the instrument and not shown) which is fitted with a projecting pin near its periphery, causes the rocking beam to move up and down alternately upon a central pivot. The pivoted cranks A and A' are held against the under side of pins P and P' by springs attached at right angles to the lower extremities of the cranks. Rising from the ends of the two cranks are the rods S and M. Actually, the rods are side by side, one on each side of the star-wheel W. In the sketch the position of one of them has been changed somewhat in order to show both rods. Two adjustable screws B and B' regulate the distance backward at which the rods may be set, the springs S' and S^2 holding the rods against the screws. In their upward movement the rods pass through slots cut in a brass platform. As the perforated tape is moved along the platform by the star-wheel, the rods continuously moving up and down enter the holes in either side of the tape directly as these holes appear over the rods. Above the star-wheel is mounted another wheel a trifle wider than the tape which acts to hold the tape down and permits the projections of the star-wheel to enter the center row of holes in the tape and thus propel it forward.

With the transmitter running free, that is without tape, rods S and M, in response to the movements of the rocking arm, rise and fall alternately. The lower extremity of the upright section of crank A moves to the right when the rod S moves upward; this action pushes the lever acting between the contact points to the right by means of the rod and boss K. The upward movement of the rod M in the same manner causes K to push the lever U to the right. Were the transmitter connected directly to line, this action would mean that a "make" or marking current would go to line at the instant the rod M rises, and a spacing current would be sent to line when the rod S rises. Thus, with the transmitter running without tape, a series of reversals are sent out producing "dots" in the distant polar relay.

Inserting a strip of perforated tape in the transmitter results as follows: Assuming that the marking rod M has risen and entered a hole in the tape and that the tape moves forward three or four spaces before a perforated hole appears above the rod S, then the marking current will be continued until the spacing rod S has an opportunity to rise. It is obvious that the rod S has in the meantime continuously bombarded the tape, awaiting the first opportunity to travel over its full course in response to the tension of the spring $S3$ and which it has been prevented from doing by having presented before it a portion of the tape in which no perforations have been made.

As in the regulation polar relay, the lever of the transmitter must remain on either closed or open-contact point. In the polar relay this is brought about by employing permanent magnets to hold the armature in either position. In the transmitter the same thing is accomplished by the jockey wheel J. It is evident that as the lever moves to the right or left it is held in either position by the action of the spring bearing down the jockey wheel.

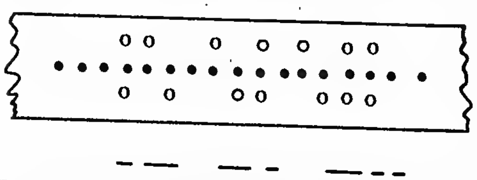

FIG. 370.—Specimen of perforated tape bearing the word "and."

Figure 370 shows a sketch of the perforated slip required to transmit the word "and." The upper holes are those engaged by the rod M and the lower ones by the rod S. When the tape is in proper position in the transmitter the lower holes are on the outward side, or toward the attendant, the tape moving from right to left.

When unpunched paper is inserted, both rods S and M are pressed downward and the pins P, P', in their motion do not actuate the crank levers A, A'; the lever DU, consequently, does not move and a permanent current is therefore sent to line.

If now, slip, perforated, say, with the letter (a) be inserted, then, when rod M rises, it will be free to pass through the first upper hole, and the lever DU will be moved and will send out a "marking" current. When the reverse movement of the rocking beam Y takes place, rod S will be free to pass through the first lower hole, and the current sent by DU will be reversed; a *dot* will therefore have been sent. On the next movement of the rocking beam, M will be free to pass through the second upper hole, and the length

of the "spacing" current is consequently precisely equal to that of the previous "marking" current (*dot*). The "marking" current being now to line, when the rocking beam leaves S free to rise, it is prevented from so doing by the paper, which is not perforated below the second upper hole. In this case, therefore, the "marking" current is kept on until the rod S is again free to rise, which it can do through the second lower hole, and the current is then reversed. It will be seen that the "marking" current is kept to line during movements equal to two dots and the space between, this being the established length of a dash. It is clear, therefore, that when correctly perforated slip is run through the transmitter any required Morse signals—dots, dashes and spaces—can be automatically sent to line.

Adjustment: One end of the flat spring which carries the jockey wheel J, is attached to a brass piece F, which is in turn screwed rigidly to the frame of the gearing. The upper side of F is V-shaped, and the tension of the spring is adjustable by means of the two screws which fasten it to its support. It should have sufficient tension to enable it to push the lever DU suddenly to the right or left when either of the collets K or K' push it beyond the center of the jockey wheel.

The collets K and K' can be adjusted by being screwed forward or backward; their correct position may be found by running the transmitter with a blank slip, when the bar should remain unaffected, whether resting in its right or left position. The collets must, however, be sufficiently close to push the bar over the center when the slip is removed, so as to allow the jockey roller to complete the movement.

In order to insure reliable action at high speed, it is essential that the spiral springs s–3 and s–4 be strong enough to easily overcome the tension of the flat spring acting through the jockey wheel upon the lever. The amount of play allowed between the contact screw C–d and the lever D when it is resting on Z–d, or *vice versa*, is about 5 mils. The contacts C–u and Z–u should be adjusted to suit, so as to preserve similar distances with respect to U.

The exact positions of the vertical rods S and M are regulated by the screws B, B'; each of the rods should be so adjusted that it commences to enter a perforation in the slip when the left-hand edge of the perforation is sufficiently clear of the left-hand edge of the rod to allow it to pass through freely. If the screws P or P' are screwed too much either way out of their correct position, the rods will catch against the edges of the perforation, and the mechanism will not act properly.

The springs S–1 and S–2 pull the rods S, M, back against the screws P, P', when they have become sufficiently withdrawn to be just clear of the slip. Although these springs are very light, they must be strong enough to cause the rods to return to their normal positions promptly.

THE MOTIVE POWER OF THE WHEATSTONE TRANSMITTER

Until recently, high-speed transmitters have been operated by weight-driven gears, and while this method permitted the employment of the high-speed system at small offices not equipped with sources of electric power when upon occasion a small office was called upon to handle for a few days a large volume of business, in large offices where automatic equipment is permanently located it is desirable to have transmitters which are driven by electric motors, first, to obviate winding up the weight, and second to obtain constant speeds.

Transmitters are equipped with small direct-current motors which are run at constant speed, approximately the maximum speed of the motor. No motor-control rheostat is used. An extension of the motor shaft is fitted with a metal disk which acts as a friction plate. On the face of this friction plate rests the edge of another small disk made up of compressed rawhide held rigidly between two brass plates by means of which the disk is securely attached to its axle. The end of the armature shaft remote from the friction plate is fitted with two tension-springs which act to hold the plate in contact with the rawhide disk. The axle of the disk has on one end a pinion gear which operates the driving axle of the transmitter by means of a clutch. The opposite end of the axle bearing the rawhide disk is hollowed out cone-shaped in order to engage the point of the adjusting screw which determines the position of the rawhide disk on the face of the friction plate. The method of regulating the speed of the transmitter is founded on the principle that the speed through space of various points from center to periphery of a revolving wheel, is greatest at the periphery and least at the center. The speed-regulating screw as it moves the axle of the friction disk along, results in the friction disk being pushed nearer to the periphery of the friction plate, thus increasing the speed of rotation of the transmitter driving axle.

As there is no spring used to withdraw the axle of the rawhide disk when it is desired to reduce the speed by causing the disk to take up a position nearer the center of the friction plate, it is evident that another property of the revolving wheel is availed of to accomplish the desired end.

It is well known that the upper half of a revolving disk or wheel has a motion in the reverse direction to that of the lower half and any device in frictional contact with the side of the wheel, unless restrained, takes on a motion of translation of that portion of the wheel with which it is in contact, thus when the adjusting screw which holds the friction disk up to its work, is withdrawn the natural tendency is for the friction disk to move inward toward the center of the friction plate and the speed is gradually reduced.

The clock-work gearing which drives the moving contacts of the transmitter proper is connected with the driving axle by means of a universal clutch. The transmitter proper is detachable from the base, the armature and battery-contact wiring being made to buffer contacts. When the transmitter gets out

of adjustment and there is a spare unit available it requires but 10 or 12 seconds to remove the defective instrument and substitute one known to be in working order. As the transmitter is set in place the buffer contacts engage their corresponding projecting terminal points and the driving clutch engages the driving axle without any action on the part of the attendant except that he place the transmitter in proper position on its brass bed-plate and tighten the thumbscrews.

Where 110-volt current is available, it is customary to use it for the operation of the transmitter motor. The regulation of the speed of the transmitter (and consequently of the speed of transmission) is accomplished by means of the friction drive. A hard rubber knob mounted on one side of the transmitter

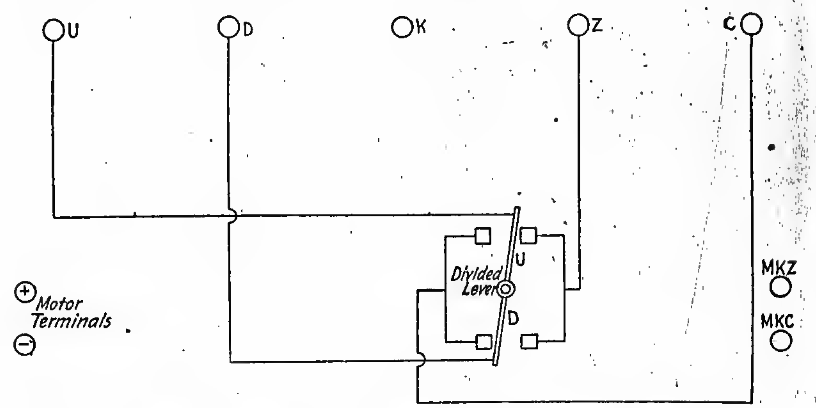

FIG. 371.—Main line and battery connections of the automatic transmitter.

case, accessible to the attendant, permits of regulating the speed at which signals are sent over the line, ranging from 10 words per minute to 300 words per minute.

As there is no rheostat control of the motor circuit, it is well to have a resistance of about 100 ohms in each side of the 110-volt circuit to prevent heating of the motor.

Revolving the shaft of the motor causes the rocking beam of the transmitter to move up and down at a speed corresponding to the speed at which the star-wheel forwards the paper strip. These two related movements are accomplished by means of suitable clock-work gearing.

Figure 371 shows an enlarged view of the transmitter main connections, where the automatic transmitter is employed to operate a pole-changer in the form of a standard polar relay. The terminals *K*, *MKC*, and *MKZ* are not used except when the duplex line potentials are connected directly to the transmitter. The terminals marked − and + show where the 110-volt motor leads are to be connected. When a polar relay is used to control the line battery, the main-line and artificial-line binding posts of the relay are connected to the terminals Z and C, and the terminal U or D is grounded. Either the upper or lower contacts may be used by changing the ground connection from U to D, or *vice versa*.

The Wheatstone system has for many years been used on certain lines of the Western Union Telegraph Company, and within the past year or two has been introduced on the lines of the Canadian Pacific Railway Telegraph system, in the operation of a Pacific cable circuit between Montreal, Que., and Bamfield, B. C., with repeaters at Fort William, Ontario, 995 miles from Montreal, and at Calgary, Alberta, 1,256 miles distant from Fort William, also at Vancouver, B. C., 646 miles from Calgary. The distance from Vancouver to Bamfield is 115 miles, including 80 miles of submarine cable. At Montreal dynamo current is used; at Fort William, Calgary and Vancouver, storage battery is used, and at Bamfield, gravity battery.

On the Pacific cable circuit, overland through Canada, the question of speed is of secondary importance, and high speeds of transmission are not aimed at. The principal object in employing the Wheatstone system is to insure accuracy. Also, a material advantage accrues from the fact that at a given speed in words per minute, Wheatstone signals on account of their evenness and regularity, "carry" much better over long circuits than do hand signals at the same speed, resulting in fewer calls for repetition of doubtful words or letters.

At a speed of, say, 40 words per minute, using Wheatstone transmission, the total amount of business handled over a circuit in a day exceeds considerably the amount of business that would be handled during the same period by means of the Morse key; where the sending operator does not exceed a speed of, say, 40 words per minute. This is due to the fact that in Wheatstone working there is generally 2 or 3 ft. of slack tape which has been perforated, between the perforating machine and the transmitter, so that the frequent stops made, from one cause or another, by the perforator operator—the sender—do not interrupt the continuity of line transmission, which goes on continuously as long as tape is fed to the transmitter.

Wheatstone working may be applied to any polar duplex, or polar side of a quadruplex, by providing a three-point switch at each sending end for the purpose of switching the automatic transmitter, or the Morse key into circuit as desired, and by providing a similar switch at each receiving end for the purpose of switching the line wire into the automatic recorder, or the regular polar relay as desired.

Where speeds above 150 words per minute are to be maintained, it is necessary to use at the terminal offices and at repeater stations the most efficient and "fastest" polar relays obtainable, otherwise the equipment and connections of the Wheatstone automatic duplex are the same as those of the high efficiency duplex (see Fig. 237).

THE POSTAL AUTOMATIC

The Postal Automatic Telegraph System is identical with the Wheatstone in so far as concerns the preparation of the transmitting tape, and the transmission of the signals; but the reception of the signals is accomplished in an entirely different manner, being received by an electromagnetic punch, or "reperforator" which, instead of marking the dots and dashes of the letters on the receiving tape with ink, as in the Wheatstone system, perforates the characters in a continuously moving strip of paper tape, the received tape resembling the transmitting tape, inasmuch as the Morse characters appear thereon in a series of perforations. The improvement in this method as compared with Wheatstone recorder reception, is that the received tape may be passed through a local "reproducer," and the messages copied by ear from an ordinary sounder.

The reproducers are motor driven and are under the control of the reproducing operator so that the speed of reproduction may be regulated to accord with the ability of the operator. At his convenience the tape may be stopped, pulled back and run through again for the purpose of confirming doubtful words. In practice, therefore, the reproducing operator copies from a "sender" over whom he has absolute control in the matter of speed and of repetition. Moreover, with this system, messages received at relay offices for points beyond, which are equipped with automatic apparatus, may be relayed automatically, simply by passing the received tape through an automatic transmitter of the reproducer type. In this case the reproducer operates the duplex pole-changer in the same way as it operates the sounder for local reproduction.

The Reperforator.—The operation of the receiving punch, or reperforator, will be understood by tracing the receiving circuits shown theoretically in Fig. 372.

It will be observed that here the main-line polar relay of a duplex instead of operating locally a reading sounder, as is customary in ordinary duplex working, operates an extra polar relay, the armature lever of which is grounded through a 6-m.f. adjustable condenser. Two double-spool electromagnets, M, M', of the reperforator have circuits leading through their windings from 200-volt dynamos of each polarity, thence, extending to the open and closed contact points respectively of an auxiliary polar relay. The "punch" magnets control the movements of two armatures which on their free ends are equipped with steel punches, P, P, about 1/16 in. in diameter, and 1 in. long, which when the magnets are energized are driven through holes (h, h, Fig. 373) in a die plate, and perforate holes in a strip of paper which is being drawn through a slot past the holes in the die plate, the slot being just large enough to permit free passage of the tape.

The tape is moved forward continuously by means of a tape-transmission and take-up gear, operated by an electric motor the speed of which is regulated by a small hand rheostat.

It is customary to adjust the receiver from hand sending at the distant station, before the automatic transmitter is connected to line. A closed key, sending a marking current from the distant station, results in the tongue of the home main-line relay moving over to its front contact, thereby presenting a ground contact to the 85-volt dynamo circuit by way of the front contact of the main-line relay, and the magnet *EM* of the auxiliary relay, which causes the latter to attract its armature to the left, permitting the 6-m.f. condenser to empty itself of the negative charge which it had accumulated while the tongue of the auxiliary relay was in contact with the negative battery terminal. The process of reversing the charge held by the condenser

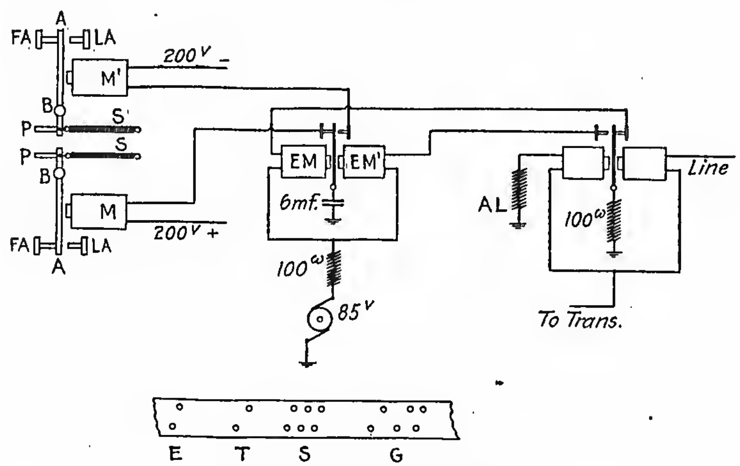

FIG. 372.—Theory of the reperforator.

from negative to positive, after the relay tongue makes contact with the positive battery terminal, causes the magnet *M* to momentarily attract its armature *A*, and as the armature lever is pivoted at *B*, the steel punch *P* is driven through the moving strip of paper, perforating a hole near the lower edge of the tape. As the distant key is opened and a spacing current sent to line, the home line-relay "opens," thereby transferring the ground contact presented to the 85-volt dynamo circuit, through the magnet *EM'* of the auxiliary relay, causing the lever of that relay to move into contact with the opposite local contact, whereupon the charge held by the condenser is changed from positive to negative, causing momentary magnetization of the punch magnet *M'*, the result of which is that the armature lever actuating the upper steel punch, drives the latter through the tape, perforating a hole near its upper edge. The horizontal distance between the two holes depends upon

the time elapsing between the instant the marking current is sent out and the time the spacing current is sent from the distant station. If the positive and negative battery contacts made by the distant pole-changer are made close together, as in forming the letter "e," the holes in the received tape appear as at "e" in the specimen slip, Fig. 372. If a greater period of time separates the positive and negative battery applications, as in forming the letter "t," the holes in the receiving tape appear as at "t," in the specimen slip.

The steel punches are adjusted to travel forward just far enough to go through the paper and make a clean round hole, and backward just far enough to clear the face of the die-plate.

In view of the fact that the tape is passing continuously through the slot in front of the steel punches, the act of punching the holes must be accomplished by extremely rapid movement of the punches so that there will be no tendency to tear the tape. The speed at which the punches move forward and backward in response to the operation of the auxiliary relay is regulated by having the capacity of the condenser accurately adjusted, and by adjusting the tension of the strong retractile springs *S*, attached to the armature levers of the reperforator, so that when the steel punches are traveling the required distance to and fro, the action will be rapid and snappy.

It is evident that the tape being perforated is stopped each time either the upper or lower punch is in the act of perforating a hole, and as each punch is operated many times per second, it is necessary so to adjust the tape-moving mechanism that these momentary stoppages are compensated for by "slip" in that part of the gear which pulls the tape through the slot. The instruments have been designed to do this satisfactorily, and it has been found that attendants can, with little practice, learn the correct adjustment. The present method of taking care of the received tape coming from the reperforator is the same as that used in caring for the original transmission tape as turned out by the Wheatstone perforator, that is, by rolling it up by hand as it comes from the receiver.

The receiver when in operation requires the constant attention of an attendant, and it is quite convenient for him to take care of the received tape in the manner above referred to. The received tape may be parceled out in units of one message, two messages, or in any number required by traffic conditions, as the receiver attendant very quickly learns to read the tape and is able to follow the wording as perforated thereon. The end of each message is signified by a paragraph sign (---‐) or by a succession of letters "a," without space between them.

The code used is the Morse alphabet, except that the letter "L" is changed from "long dash" (—), to "dot, three dashes," (·---), and the figure "nought" from "long dash" to five short dashes (-----).

The received tape is passed to the reproducing operators in whatever size bundles the traffic demands, and by them is run through local repro-

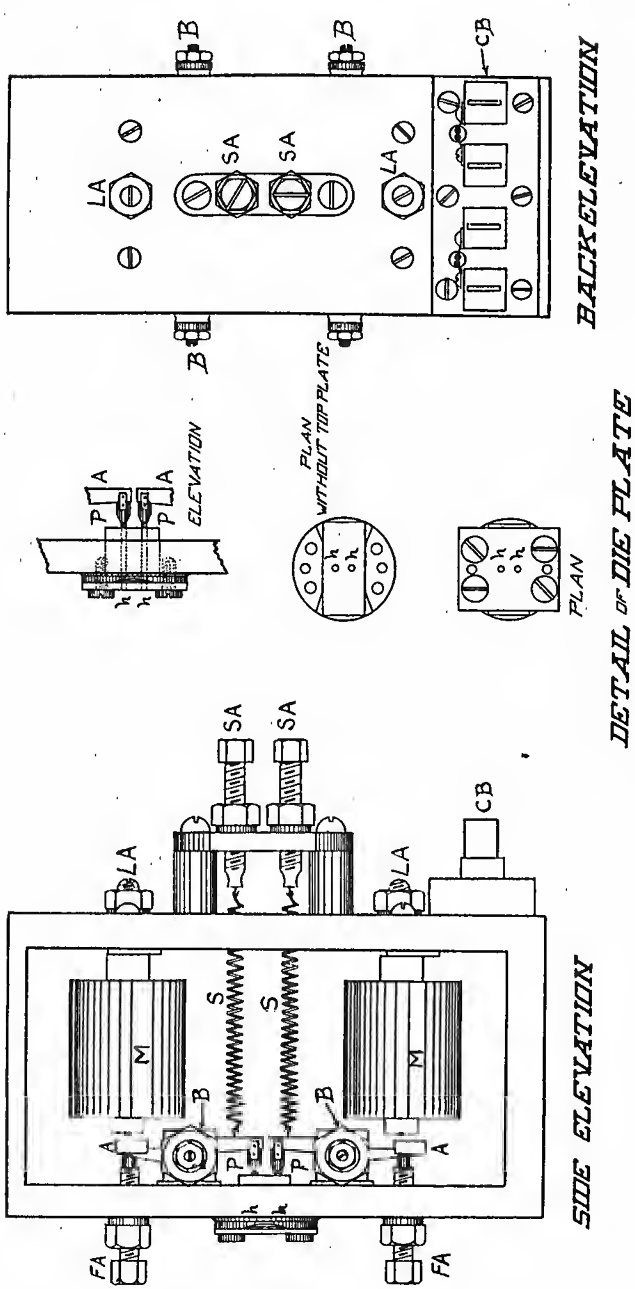

FIG. 373.—Actual construction of the reperforator.

ducing machines at a speed to suit the convenience of the operator as before stated.

The operation of the reproducers is quite simple, and may be learned by any Morse operator in a short time and without difficulty.

Figure 373 shows the actual construction of the reperforator used in connection with the Postal automatic telegraph system, the various parts bearing the same index letters as do the same parts illustrated in the theoretical diagram, Fig. 372. The spring adjustments *SA*, are for regulating the retractile tension exerted by the springs *S*, upon the armature levers *A*. The front adjustment screws *FA* act as back-stops for the armature levers, and must be so set that the steel punches fastened to opposite ends of the levers, when pulled back by the springs, will come to rest in the punch guide holes *h*, just clear of the face of the die-plate. The lever adjustment screws *LA* extend between the two spools of each magnet, projecting far enough to prevent the armature striking the cores of the magnet, and also serve as adjustments for regulating the distance beyond the face of the die-plate the punches *P* are allowed to travel. The forward and the backward travel of the steel punches, therefore, is regulated by means of the adjusting screws *FA* and *LA*. In practice, a forward travel, from rest, of 0.006 in. is all that can be allowed where high speeds are to be maintained.

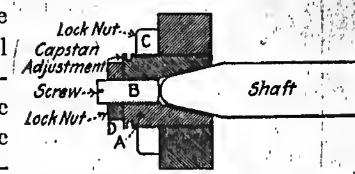

FIG. 374.—Reperforator bearing adjustment.

Figure 374 shows an enlarged view of the armature-shaft bearing of the reperforator. The successful operation of the reperforator is largely dependent upon the elimination of lost motion in the shaft bearings, and the bearing employed while somewhat elaborate is the only one among those tried out which satisfactorily answers the purpose.

The parts of the bearing are made of the hardest grade of Tobin bronze, and the adjustment is made as follows:

To adjust bearing: Disconnect retractile spring from armature lever. Tighten screw *A*, leaving just space enough between its inner surface and the surface of the shaft to hold a film of oil. Tighten screw *B* of each bearing so that when the steel punches are properly lined up in the punch guide holes the play of the shaft will be equal in the bearing *A* on each side of the shaft. Lock-nut *C* should then be tightened, securing the adjustment of *A*, care being taken not to disturb *A* after being properly set.

The reperforator as here described is the invention of Mr. F. E. d'Humy.

Figure 375 shows the transmitter circuits, arranged so that either the high-speed automatic transmitter, or a Morse key operating an ordinary pole-changer may be switched into circuit, depending upon the position of the lever of the switch on the right. The duplex "balancing" switch is shown on the left.

A reading sounder circuit for the out-going signals is provided by means

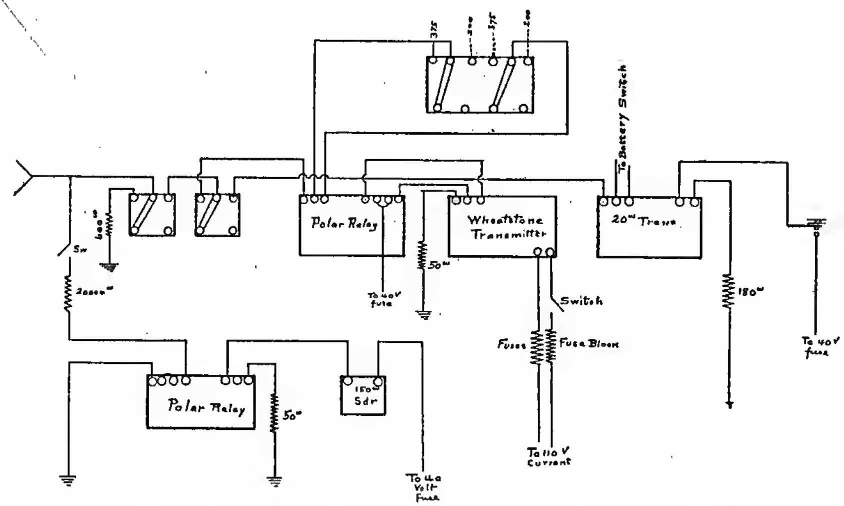

FIG. 375.—Transmitting circuits, Postal automatic.

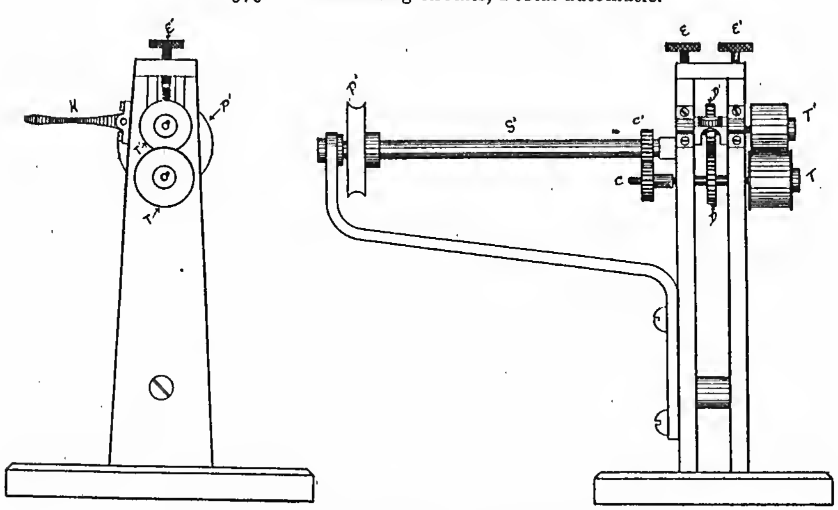

FIG. 376.—Tape take-up gear, Postal automatic.

of a 20,000-ohm leak to earth through a polar relay as shown in the lower left-hand portion of the diagram. After the speed of transmission is run up higher than 65 or 75 words per minute, the sounder, of course, fails to record the signals intelligibly.

Figure 376 shows the construction of the tape take-up gear.

The receiving tape is fed to the reperforator by a tape transmission device, the speed of which may be regulated to suit the speed of signaling. As the perforated tape leaves the reperforator it passes between the rollers T, T', of the take-up gear, which are in light contact with each other, the degree of tension being adjustable by means of the compression-spring screws E, E'. A spring belt extends from the pulley P′ to a pulley mounted on a shaft which is geared to the driving mechanism of the tape-transmission

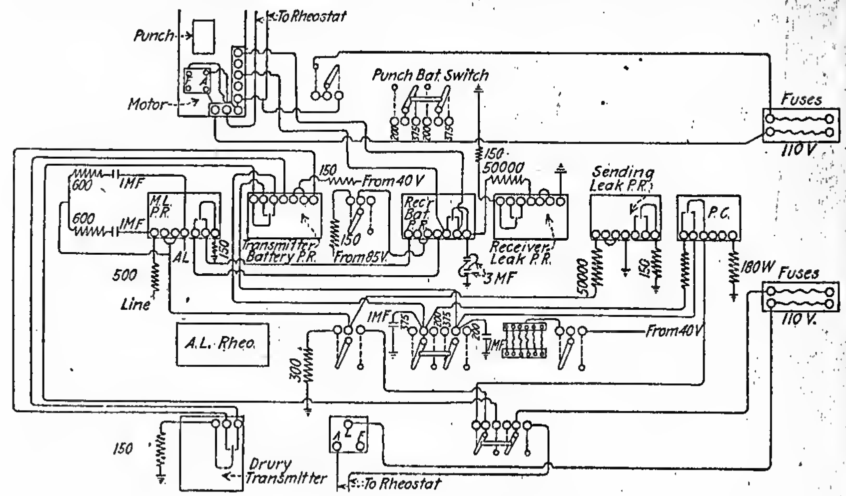

FIG. 377.—Complete wiring connections of sending and receiving circuits. Postal automatic.

gear (not shown), and the speed ratios are such that the rollers T, T', of the take-up, revolve three times as fast as the feed rollers of the transmission device, which means that the "pull" of the rollers T, T', is not positive or constant. It is necessary that there shall be considerable "slip" of the tape as it passes through the rollers of the take-up, for, if the pull were positive the tape would be torn during the brief instant that either of the steel punches of the reperforator are punching a hole in the tape. The combined "slip" of the spring belt and of the rollers T, T' compensates for the many stoppages of the tape which take place during the operations of punching.

Figure 377 shows the wiring and binding-post connections of both transmitting and receiving circuits of the Postal automatic arranged for duplex operation.

PRINTING TELEGRAPHS

Although the subject of printing telegraphs is an old one with the inventor and with the promoter, the development of satisfactory printing telegraph systems has not reached that stage where the subject is in shape for practical consideration in a work dealing with telegraph practice.

The reason for this (so far as the employment of printing telegraph systems in America is concerned) is that the systems which have been tried out, and which at the present time are in service, have been operated by the inventors themselves, or under their direction, and in some cases by specially trained staffs, recruited, largely, from mechanics who know little or nothing about Morse telegraphy.

On account of the many mechanical movements involved in the operation of telegraph printers, these machines are necessarily somewhat complicated in construction, and although in their design great ingenuity has been exercised in applying known laws and principles of mechanics, the apparatus produced, to do its best work, must be handled by competent mechanics. In most of the systems so far introduced, the purely electrical features, such as line-potential and line-current values, and main-line relay and transmitter functions, are comparatively simple, and it is with these features only that the Morse telegrapher has been concerned.

When a new system is tried out in service, apparently it has been a much easier matter to teach mechanics what they need know about the electrical features involved, than to teach the expert telegrapher what he must know about mechanics, in order to operate the printer efficiently. These considerations, in a sense, isolate the subject of printing telegraphs from the subject of Morse telegraphy.

It is not to be inferred, however, that printing telegraph systems cannot be employed to the advantage of the service, as it is quite possible that the time may arrive when a large portion of the telegraph traffic of this country will be handled by means of printing telegraph systems, and it is possible that within a few years, one, two, or more systems will have reached a stage of development and of standardization, that will make possible a technical treatment of the subject from a telegraphic standpoint that will be intelligible to Morse operatives.

NAMES OF PRINTING TELEGRAPH SYSTEMS INVENTED, TRIED OUT, AND IN SERVICE

Two different systems, known as the Rowland and the Wright, have within the past few years been tried out experimentally on the lines of the Postal Telegraph-Cable Company. Each of these systems was the product of printing telegraph inventors of great skill, and who were quite familiar with the requirements of such inventions.

The performance of the Rowland system and of the Wright system was excellent under certain conditions of traffic, but both have been taken out of actual service and returned to the laboratory for further development.

The Western Union Telegraph Company has for a number of years past been using a printing telegraph system known as the Barclay printer. Formerly the system was known as the Buckingham, in which certain changes and improvements have been made by Mr. Barclay.

The Buckingham-Barclay printer is at the present time employed commercially by the Western Union Company, but is still being studied with the object of introducing further improvements, or of making alterations, in order that the machine may more satisfactorily meet the requirements of modern telegraph traffic conditions.

In British Post-office telegraph service, the following named systems are being used to a greater or less extent: The Creed, Murray, Baudot, and the Hughes.

In the United States at the present time a printing telegraph system known as the Morkrum, is being tried out on certain lines of the Postal Telegraph-Cable Company, and of the Western Union Telegraph Company.

In Canada the Morkrum system is being tried out on a Canadian Pacific Railway-telegraph circuit between Montreal and Toronto.

For the information of those who may wish to study the historical development of printing telegraph systems, or who may desire to investigate the principles of operation, and the construction of printing telegraph machines, a condensed bibliography of printing telegraph literature is incorporated in the appendix, see section A.

[illegible]

[illegible]

GRBenyan

THE [illegible]

Special Instructions

for improving [illegible].

[illegible]

[illegible]

CHIC[illegible]

[illegible]

[illegible] of the unevenness of the alignment [illegible] due to the play between the shift lever and shaft. This lost motion is [illegible] made up by a strong spring which holds the typewheel fork down against the casting.

To make this change remove the present spring which holds the typewheel down and [illegible] the new strong one. Remove the [illegible] shaft spring on Right hand bearing ([illegible] not used any more). Remove the [illegible] for shift lever which is on the [illegible] hand bearing. (This is not used any more.) [illegible] these changes have been made the [illegible] hold the typewheel fork firmly [illegible] and take up all the lost [illegible] the shift connections.

[illegible] the letters print heavy on top [illegible] not due to [illegible] by [illegible] copy.

If the letters print heavy on top the typewheel should be raised and vice versa. This may be done by adding or removing washers [illegible] the typewheel fork and casting.

Uneven alignment may also be caused by the typewheel shaft being bent. This can be [illegible] by striking letters which are on [illegible] sides of the typewheel and noting [illegible] combinations are out of alignment. [illegible] the following combinations in order, [illegible] BASE [illegible] JEJE [illegible] QOQO VIVU [illegible]

[illegible] which combination is [illegible] alignment remove the type[illegible] [illegible] low letter of the com[illegible] [illegible] the shaft slightly towards [illegible] be taken not to mar the shaft.

[illegible]

The [illegible] to be printed should strike [illegible] the center. This [illegible] by bending the inker lever [illegible] where it is attached to the

[illegible]

The [illegible] on the inker lever [illegible] should be strong enough to insure [illegible] of the letters M [illegible] Figure 5.

SIDE PRINTING.

Side printing is generally caused by typewheel being slightly off center with relation to the star wheel and can be remedied by bending the locating arm in the [illegible] direction. It shows up most on letters [illegible] and I. If the side print is to the left of the letter bend the locating arm to right and vice versa.

If the side printing shows equal on both sides of the letter it is generally [illegible] the typewheel being worn flat, but may be caused by the Main Break not opening sufficiently. It should open 1/16" when typewheel is against platen.

UNEVEN SPACING.

Uneven spacing is sometimes caused by the chain not running evenly. This is due to the form of chain which has been used in the past in which the links are brazed in pairs. In case this bothers put in one of the new single link chains, which will eliminate this fault.

Uneven spacing may also be caused by excessive overtravel of the spacer pawl on its up stroke. This travel should be just sufficient to let the holding pawl drop in.

It is sometimes necessary to increase the tension of the carriage return spring to hold the carriage steady.

Bulletin No. 9
June 1914

G. A. Benjamin

Theory of Tape System

The Morkrum Telegraph Printers

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MORKRUM COMPANY

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The Morkrum Telegraph Printers
Tape Transmission

The intent of this bulletin is to present the theory of the transmission and reception of signals in the operation of the Morkrum Telegraph printers, and to show the sequence of operations. A careful study of the following diagrams and the accompanying explanations will greatly facilitate the work of handling the printers.

In the Morkrum tape system, a message which is to be transmitted is first prepared on a perforated tape by means of a keyboard perforator. The message is then automatically transmitted over the line by means of this tape, and is received directly on a page printer.

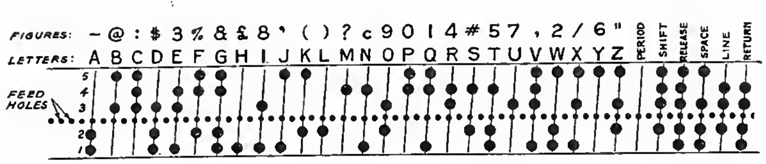

Figure 1—Morkrum Code

The tape perforator has a keyboard similar to that of a standard typewriter. There are six rows of holes on the tape. The continuous row is used to feed the tape in the transmitter. The letters and signals are formed by different combinations of holes in the five remaining rows, which are placed two in front of and three behind the feed row. The arrangement of the holes in these five rows controls the polarity of the five selective impulses which are sent over the line for every signal.

SPECIFICATION 263 B—PART I
JAN. 15, 1915

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THE WESTERN UNION TELEGRAPH COMPANY

THE MULTIPLEX PRINTING TELEGRAPH SYSTEM

	1	2	3	4	5
A	1	2			
B	1			4	5
C		2	3	4	
D	1			4	
E	1				
F	1		3	4	
G		2		4	5
H			3		5
I		2	3		
J	1	2		4	
K	1	2	3	4	
L		2			5
M			3	4	5
N			3	4	
O				4	5
P		2	3		5
Q	1	2	3		5
R		2		4	
S	1		3		
T					5
U	1	2	3		
V		2	3	4	5
W	1	2			5
X	1		3	4	5
Y	1		3		5
Z	1				5
LINE		2			
SPC			3		
C.R.				4	
FIGS	1	2		4	5
LTRS	1	2	3	4	5

MARKING IMPULSES.

FIG. 1.

	1	2	3	4	5
A	−	−	+	+	+
B	−	+	+	−	−
C	+	−	−	−	+
D	−	+	+	−	+
E	−	+	+	+	+
F	−	+	−	−	+
G	+	−	+	−	−
H	+	+	−	+	−
I	+	−	−	+	+
J	−	−	+	−	+
K	−	−	−	−	+
L	+	−	+	+	−
M	+	+	−	−	−
N	+	+	−	−	+
O	+	+	+	−	−
P	+	−	−	+	−
Q	−	−	−	+	−
R	+	−	+	−	+
S	−	+	−	+	+
T	+	+	+	+	−
U	−	−	−	+	+
V	+	−	−	−	−
W	−	−	+	+	−
X	−	+	−	−	−
Y	−	+	−	+	−
Z	−	+	+	+	−
LINE	+	−	+	+	+
SPC	+	+	−	+	+
C.R.	+	+	+	−	+
FIGS	−	−	+	−	−
LTRS	−	−	−	−	−

SEQUENCE OF IMPULSES FOR EACH CHARACTER FOR FIRST AND THIRD TRANSMITTER. THE MINUS SIGN INDICATING MARKING OR OPERATING IMPULSES.

FIG. 1a

	1	2	3	4	5
A	+	+	−	−	−
B	+	−	−	+	+
C	−	+	+	+	−
D	+	−	−	+	−
E	+	−	−	−	−
F	+	−	+	+	−
G	−	+	−	+	+
H	−	−	+	−	+
I	−	+	+	−	−
J	+	+	−	+	−
K	+	+	+	+	−
L	−	+	−	−	+
M	−	−	+	+	+
N	−	−	+	+	−
O	−	−	−	+	+
P	−	+	+	−	+
Q	+	+	+	−	+
R	−	+	−	+	−
S	+	−	+	−	−
T	−	−	−	−	+
U	+	+	+	−	−
V	−	+	+	+	+
W	+	+	−	−	+
X	+	−	+	+	+
Y	+	−	+	−	+
Z	+	−	−	−	+
LINE	−	+	−	−	−
SPC	−	−	+	−	−
C.R.	−	−	−	+	−
FIGS	+	+	−	+	+
LTRS	+	+	+	+	+

SEQUENCE OF IMPULSES FOR EACH CHARACTER FOR SECOND AND FOURTH TRANSMITTER. THE PLUS SIGN INDICATING MARKING OR OPERATING IMPULSES.

FIG. 1b.

11. One way of operating these five relays would be to have five wires between the sending and receiving stations, connect one relay in each wire, and operate each combination of relays simultaneously. Obviously this would be impracticable.

12. Distribution of the Elements of the Code.—A more advantageous method consists in utilizing a single line wire and instead of sending the elemental signals forming a character combination, simultaneously over five wires, to send them on the single wire at five different moments. In this manner, we can dispose of the 31 combinations made up of the five elemental units taken one by one, two by two, etc.; but the different elemental unit signals which constitute a particular character will be distinguished, one from another, by the moments at which they manifest themselves. When we wish to form the first combination, for example, we send a selective current at the first and second moment; if the twelfth combination is desired we form it by sending a selective current at the second and fifth moment and so on.

13. This code and method of transmission is that used with the Multiplex System.

14. We will now investigate the principle on which a system of transmission employing such a code can be constituted.

15. At the sending station 1 on an insulating base (Figure 2) are fitted two concentric metallic rings A and B on which bear evenly two trailers or brushes F, F^1, electrically connected together and kept moving at uniform speed, let us assume, by a clock or other movement, which can be regulated as desired.

16. The ring B is whole, and is electrically connected to the line wire.

17. The other ring is divided into five segments, or metallic contacts a^1, a^2, a^3, a^4, a^5, insulated from one another and connected respectively to each of the five metallic levers L^1, L^2, L^3, L^4, L^5, which on being depressed, are connected by means of the studs B^1, B^2, B^3, B^4, B^5, with one pole of a battery or generator, whose other pole is grounded.

18. The combination of the two rings A and B and the two connected brushes constitutes a distributor.

19. At the receiving station 2, a similar distributor is provided having the complete ring B^1 connected to the line wire and the five contacts C^1, C^2, C^3, C^4, C^5, of the ring A^1, respectively joined to one side of the coils of 5 electro-magnetic receivers R^1, R^2, R^3, R^4, R^5, the other side of each being grounded.

20. The brushes of distributor No. 2 are rotated at the same uniform speed as those of No. 1. Moreover, at each revolution they occupy the same corresponding positions as the former, that is printer could complete its selection during the time b and use the period c, d, a, for translating and recording its selection; a third printer could complete its selection during the time c and use the period d, a, b, for translating and recording its selection and in a similar way a fourth printer could complete its selection during the time d and use the period a, b, c for translating its selection. We could thus readily control four printers during the time required for the full cycle of operation for each, by only using the line time for the transmission and reception of the selecting impulses for each printer in regular sequence and allow the translating and recording of each printer to take place, without regard to the line, in the remaining three units of time.

49. While for the sake of clearness we have assumed that the whole of the time represented by b, c, and d is required for the translation and recording of the selection in the printer, it is in fact, only a fraction of this time that is required.

50. It is by taking advantage of this time in just such a manner that the multiplex principle is obtained and is made use of in the system under consideration.

51. Instead of the five keys or levers L^1, L^2, L^3, L^4 and L^5, Figure 10, being arranged for manual transmission of signals we can arrange them so that they will form part of an automatic device, which will then accomplish automatically, the result, obtained by the manipulation of the five keys.

52. As this automatic transmitting device is controlled by means of a paper tape, containing a series of perforations corresponding to the code combination of the various characters to be transmitted, it may be well at this point to briefly describe the apparatus upon which this tape is prepared before we explain the operation of the automatic transmitter.

KEYBOARD PERFORATOR

53. **General Description.**—The keyboard perforator consists of a keyboard with a system of transverse levers, bars, etc., and an electro-magnet, all of which are mounted on a metal base and so arranged that the depression of any key causes perforations to be made in a paper tape. These perforations represent the signals intended for transmission by the automatic transmitter previously mentioned. The magnet is operated at the end of each stroke of any key and causes a striking arm to be thrown against the punch pins. These pins are six in number, five of them are used to make up the different combinations of the alphabet and the sixth to punch the feed hole.

54. The perforations for each character are made across the tape, that is, at right angles to the direction of feed, which makes possible a uniform feed, in this case, one-tenth of an inch. Figure 12 shows a facsimile of the tape with the character indications above each group of perforations.

55. The lower edges of the key-levers have projections arranged in combination so that the depression of any key will depress one or more transverse bars lying directly under the key-levers

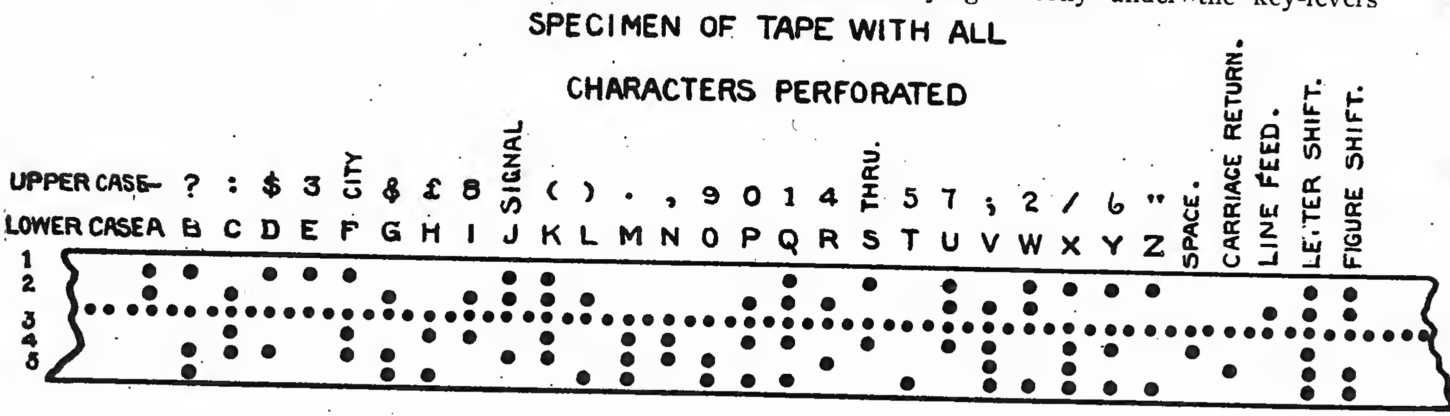

FIG 12.

and at right angles to them. The depression of one of these transverse bars causes a selecting arm to be inserted between its corresponding punch pin and the striking arm. These selecting arms are each normally held clear of the striking arm by a spring. If now, with one of these selecting arms in the path of the striking arm, the latter is raised, the punch pin directly over the selecting arm will be forced up through the die-plate and perforate a hole in the paper tape. The pin which punches the feed hole is forced upward every time the striking arm is raised, regardless of whether any of the selecting arms are in the path of the striking arm or not.

56. The striking arm is connected to a magnet armature through a universal coupling and is thrown against the selecting arms every time the magnet is energized. A spring retracts the magnet arma-

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THE PRINCIPLES OF MODERN PRINTING TELEGRAPHY.

By H. H. HARRISON, Associate Member.

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PART I.

Fundamental principles. Elementary forms of type-printing telegraph. Step-by-step printing telegraph. Isochronous free-running type-wheel printing telegraph. Inversion devices. The 5-unit code. The locked keyboard. Mechanical storage transmitter. Tape-perforator mechanisms. Automatic stop and start.

The printing telegraph is one of the oldest methods of communication employed since telegraphy became a public utility. Over a period of about 80 years innumerable systems have been invented, but up to 1900 only two can be said to have achieved permanent success: the Hughes, invented by the late David Hughes as far back as 1854, and the multiple system of Baudot, first introduced in 1874. From this latter date onward, high-capacity printing-telegraph systems have been proposed, but they have all possessed some fundamental defect. To Donald Murray must be given the credit of first clearly laying down the broad principles on which a printing telegraph should be designed. His paper, read before the Institution in February 1905,* will always be the classic on this subject and, in addition, is a model of style, unusual in a paper of a technical character.

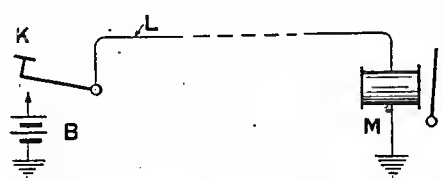


FIG. 1.—Elements of a telegraph installation. Transmission in one direction only.

One of the facts which forcibly strike the student of present-day printing telegraphy is the convergence of nearly all inventors towards the adoption of the 5-unit alphabet. As a result, there is close similarity between the devices employed in competing systems. This is not surprising, for, as has been pointed out by Murray, given an alphabet then the design of instruments produced to use it must proceed on certain lines.

Reduced to its simplest terms, a telegraph installation will be found to comprise a circuit-making device or transmitter K (Fig. 1), a battery B, and an electromagnetic receiver M, all connected in series through the line L. The transmitter takes the form of a lever, adapted, when depressed, to connect an earthed battery to the line. This is the familiar Morse key which has been in use for over 60 years. Usually transmission is desired in either direction at will, and the lever is so arranged that in the normal position (Fig. 2) the line at both ends is connected to earth through the coils of the receiving electromagnet. So arranged, it is the typical installation of the simplex Morse sounder circuit employed all over the world. It is not, however, suitable for any but short lines, or those which are free from inductive and other disturbances. The spaces between signal elements are intervals of no current or zero units, and during these times the receiving instruments are liable to be interfered with by any disturbing currents to which the circuit may be exposed. This tendency may be largely overcome by employing polarized

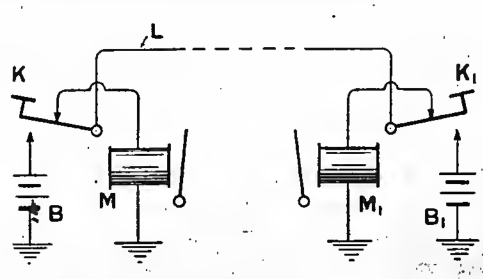


FIG. 2.—Elementary telegraph installation, with automatic and instant reversal of direction of transmission.

* D. MURRAY: "Setting Type by Telegraph," *Journal I.E.E.*, vol. 34, p. 555, 1905.

Colonel Squier. the outside surface of his wires as he now does to the composition of the wires themselves. These surfaces may serve him to appropriate and control certain closely bounded regions of the free ether of space to create for him new channels of communication by guided electric waves. Our knowledge of skin effect should be extended by researches into the region bordering upon pure radiation, where we are dealing with a super-skin effect or film effect, and it seems not unlikely that we may be able ultimately to dip the wire or paint it with a metallic paint rich in unstable atoms or free electrons, which will tend to reduce the attenuation of the guided waves. Here the efforts of the master physicists should furnish a sure guide in the near future. These guided high-frequency channels are in some respects superior to any wire circuit. For telephony we may have in them a perfectly silent line, and one with no distortion whatever. The attenuation is greater, but it is not attenuation which limits wire telephony at present, but a mixture of line noises with distortion. With these new channels the telephone repeater comes into its own, since there is nothing to repeat but pure articulation and quality. The telephone receiver itself may be of the radio type, 10 or 15 times more sensitive than those possible to use in wire telephony. In printing telegraphy these channels should also be useful as they can operate relays. They are free from many fluctuations of pure radio circuits, such as day and night differences, etc., and in a twisted-pair become very reliable indeed. The new ionized-gas form of generator now furnishes a convenient high-frequency source in single or multiple units. The power required is negligible when compared with the case of free waves in three dimensions. The object of these remarks, therefore, is to offer a plea for a more general survey of telegraphy by engineers and physicists at this stage of rapid progress. At present we find the separation and segregation of the field of telegraphy into certain more or less watertight compartments under the head of wireless telegraphy, land-line telegraphy, ocean-cable telegraphy, etc., each of these possessing a separate technique. For instance, the radio engineer prefers to think in wave-lengths, and he calls a variable inductance a "variometer" and a certain tuning coil a "jigger," etc., whereas, of course, there is nothing new in principle in these pieces of apparatus. The wire engineer prefers to think in terms of "frequency," and plots his graphs with *n* as a principal variable. The cable engineer thinks in terms of "curves of arrival." Has not the time arrived for the standing telegraph committees, wireless committees, cable committees, etc., of our scientific societies to combine in a membership that can look at this whole subject as one subject, which in fact it appears to be?

Mr. Judd. Mr. W. JUDD: The author mentions the question of printing telegraphs on long ocean cables. The whole of the Eastern Company's cables that land in England are fitted with printing telegraphs and work into London direct; all the traffic is received and printed off ready for delivery. We have one circuit working direct between Alexandria and London; we have two working between Gibraltar and London; we have one working between Lisbon and London; and we have two working between St. Vincent, Cape Verde Islands, and London. All those six cables bring the traffic direct into the City where it is printed off ready for delivery. We are using both the Morse code and the ordinary cable code, and we are trying to find out which is the better. Up to the present time we have not been able to decide. The speed and the amount of traffic which can be carried are just about the same by either method. We are using in London the Creed system with one or two of the cables, and we are using perforators of our own on the others, largely due to my friend Mr. Fraser, who designed them. With regard to the question of alphabets, we had brought to us in 1901 by Mr. Donald Murray a 3-unit alphabet which is very ingenious; it works out at about 3·3 units per letter, taking the word spaces into consideration. The advantage in the matter of speed, therefore, in changing from our present system, which is the universal conventional alphabet, to the new one, would be very small; it would not justify any change. Supposing, however, the gain anticipated were considerable, both the 5-unit and the 3-unit alphabets are unreadable at the distant end of a long cable, and the question of being able to read the signal that is coming in to operate the printing mechanism is of absolute importance to us; we cannot do without it. On land lines one can be fairly certain that whatever is put in at the sending end of the line will be received in identical form at the other end of the line, but on a long ocean cable there are deformations, distortions, disturbances, etc., and with all the delicate cable relays and apparatus of that kind we must have people on the watch looking at the record as it comes in and diagnosing any deviations from the normal, so that they may be rectified before they cause a breakdown. The question of the "readability" of these signals is a *sine qua non* with us. It is a thing that does not occur in land-line telegraphy. We shall continue to extend the use of the receiving perforators, as we call them, and of the printers all over the service if we can only get time. We are extending it now, and shou d have got a great deal further if it had not been for the war, which has delayed the delivery of apparatus.

Mr. Murray. Mr. DONALD MURRAY: This paper is of special interest to me because I have requently urged upon the author the importance of publishing more freely the results of his research work in connection with the development of printing telegraphy. The paper seems to me to outline the possibilities in connection with printing telegraphy; that is to say, it shows in a general way the limitations within which printing-telegraph inventors must work and the means at their disposal. There are books showing all the known mechanical movements, and this paper gives in a generalized form practically all the known movements of printing telegraphy. It is a compendium of the stock-in-trade of the printing-telegraph inventor, and with the author's paper before him any competent engineer can now design a printing telegraph. The inventive stage is nearly over. The mystery is gone and printing telegraphy has become one of the exact arts. There is only one portion of the subject left for some future paper, and that is the means and methods and mechanisms that will be employed for linking up the individual circuits of the great printing-telegraph networks that are spreading all over civilized countries. The author has made some brief reference to this subject at the end of his paper; but there is a great deal more to be said and done and invented

Mr. Murray.

before a comprehensive paper on printing-telegraph networks can be written. Some idea of what such networks will be like may be obtained by inspection of Figs. 8 and 9 in Mr. Beard's recent paper* on "The Design of High-pressure Distribution Systems." It is curious to note how many of the devices described by the author date back further than is generally supposed. Taking one or two such items, I was assured by an inventor of a keyboard perforator that the selecting device shown at E in Fig. 21 was "new in the art." The author, however, finds that it was used before in type-composing machines. Printing-telegraph translators are quite remarkable in this respect of dating back, and the lion's share of credit in this department seems to be due to Baudot. Many inventors have availed themselves of the permutation bars shown in Fig. 25. They have been and remain a favourite device with me, but I did not know that Baudot had employed them. Also I did not know that Baudot had tried the the signals themselves. Quite independently of me the Siemens automatic system adopted the same plan at a later date, and Picard developed the idea in a very ingenious way, adding the improved arrangement shown in Fig. 83. Picard's plan is strangely like the device subsequently invented by Rainey, shown in Fig. 85, and Picard's device was probably the inspiration also for Fig. 84. Picard's rectification arrangement shown in Fig. 86 bears curious analogies to the subsequently developed plan shown in Fig. 87. These Picard inventions are the more interesting because in British patent 9666/1914 by Dixon of the Western Electric Company, the first claim is for a system of synchronism in which the polarity of the current in the line is changed at the distributor during the rotation of the latter, irrespective of whether signals are being sent or not. That is exactly what the Picard system has been doing for years. It is true that the claim refers to the "speed" of the distributor being corrected. If the claim

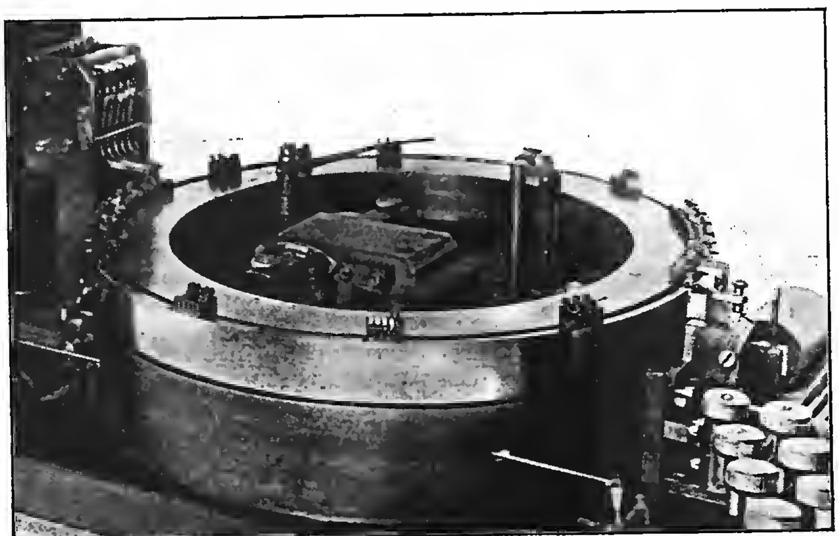


FIG. A.—Ring transmitter.

permutation-disc plan shown in Fig. 26; and the similar device illustrated in Fig. 28 is identical in all essential respects with the arrangement employed by the Western Electric Company. The early electrical translator of Baudot (Fig. 24) is also of special interest in view of its recent use in the Siemens automatic system. The illustration of the Kirk Himrod overlap device in Fig. 64, likewise since adopted in the Siemens automatic system, reminds me that I saw the Himrod printing telegraph in New York about 15 years ago. It was beautifully made, and it had a transmitter that stored up three or four letters, thus giving a certain degree of freedom of the keyboard, but it used positive, negative, and zero units for signalling, and that was fatal. Printing-telegraph inventors know better now. Another example of how great minds think alike is to be found in the device for correction of synchronism from the signals themselves. I suggested in 1903 the use of the idle signal for a multiplex system synchronizing from is interpreted in this narrow sense as being confined to distributors with speed correction, it may pass, because Picard uses the superior method of clock-hand correction, and this does not entail speed correction; but a broad interpretation of the claim is certainly not justified by the state of the art as explained in the author's paper. The Picard arrangement is free to all to use, and cannot be monopolized by any subseqnent inventor. Another subject of special interest to me is the question of metal-pin storage transmitters, which the author has illustrated in a generalized form in Fig. 17. I did a good deal of experimenting along this particular line for the British Post Office, and members may be interested in the photograph reproduced in Fig. A, which shows what I described as the "ring transmitter" made for the British Post Office abont nine years ago. The author's description will enable it to be understood. There is a rotating ring driven by a small motor in the centre. On the periphery of the rotating ring are small sliding letter blocks, in which

* See pp. 134 and 136.

Mr. Murray.

I used small levers or "leaves" capable of being set in one of two positions. Setting of the leaves in the letter blocks takes place by means of the keyboard on the right, and the transmitting mechanism is on the left. One great drawback to these metal-pin transmitters is that although they are cadence-free they are not speed-free. The keys can be struck freely but not rapidly, nothing like so rapidly as in keyboard tape-perforators. My experience is that they are not suitable for busy multiplex circuits, and my impression is that there is a good field for them on minor circuits where the pressure of traffic is not so great as to demand rapid operation on the keyboard. Such machines have the curious capacity of acting as what I may describe as "channel repeaters." They can retransmit from any one channel of a multiplex circuit into any other channel of another multiplex circuit. This facility may prove valuable in future years. They can also be arranged to retransmit Morse cable signals at ocean-cable stations in such a way that perfect signals are retransmitted from imperfect signals. One of the disheartening features about printing telegraphy is the extreme slowness in getting such apparatus established in commercial use. Perhaps the most remarkable instance of this inertia is the neglect for long years to employ the phonic wheel motor and vibrator to drive the Baudot distributor and printers. All the arguments are in favour of this arrangement, but it has lain neglected for more than 20 years. At last, however, thanks to my employment and persistent recommendation of them, the phonic wheel and vibrator are coming into their own for multiplex work. Another curious illustration of the difficulties with which printing-telegraph inventors have to contend is supplied by the history of automatically alternating transmission of messages. I suggested this arrangement in a confidential paper in 1903, and Mr. John Gell also hit upon the same idea independently of me, patented it, and applied it to Wheatstone working. Mr. Gell has been working for several years to get it into use, but up to the present it has not secured a permanent footing. I have arranged terms with Mr. Gell under his patents for using it with the Murray multiplex, and I have repeatedly urged its value during the past two years, but so far with little effect. It enables each of two typists to transmit, say, 60 messages an hour to one printer, printing, say, 120 messages an hour, thereby raising the operator average from 60 to 80 messages an hour. It is unquestionably valuable, and will no doubt be used after Mr. Gell and I have passed on to the inventor's heaven where all inventions are adopted at once and huge royalties are paid to the inventors.

Mr. Raymond-Barker.

Mr. E. Raymond-Barker: In submitting this paper the author has given submarine-cable authorities and their engineers a lead which I venture to hope they will see their way to follow, once the present war tension is at an end. The present-day electrical departments of the leading cable companies teem with interesting data and new departures and could provide first-rate material for an occasional telegraph paper. With regard to Fig. 13, may I suggest that the author would make his comparison all the more complete were he to add a graph of what is generally known as the "cable code." He will find that, taking the word "London" as he has done, the cable code, with equal-time-value dots and dashes, will give him 49 units as compared with 69 on Morse.* Apart from the future of 5-unit code telegraphy on high K R cables—a matter regarding which I seek information—apart, also, from the special information we have heard this evening from Mr. Judd, it is probable that, on the majority of high K R lines, cable code will hold its own against any form of Morse, excepting, perhaps, Morse worked on Picard's perfectly self-neutralizing system of inverse-current momentary impulses. It is clear, too, that Picard transmission may be applied to cable-code purposes. The late Mr. John Gott's 2-power inverse-current system of transmission, also Colonel Squier's sine-wave alternating-current system, using three amplitudes, are both based on the cable code. As regards type-printing telegraphs on high K R cables, as far back as 1898 Picard, whose Baudot work on the French Government Mediterranean cables has been mentioned by the author, made the following claims for his momentary-impulse inverse-current transmission, which I will read from his specification:† "Even the Baudot instrument, at a reduced speed compatible with the length of the cable, could be used between, say, Paris and New York, with relays at the land ends. . . . In these conditions the efficiency of the Baudot . . . will certainly not be less

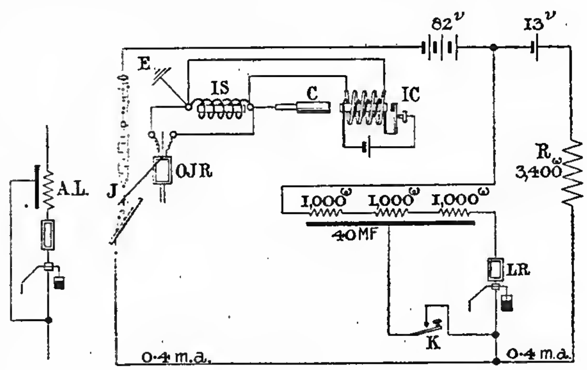


Fig. B.

than that of the siphon-recorder." On page 362 the author very pertinently refers to a certain working speed as being too high if the maintenance cost is to be kept down to a certain figure. This is a point only too frequently ignored by the non-technical, would-be reformer. The author emphasizes another just contention when, on page 363, he recommends moderate-speed direct printing on several Baudot sets over one cable, as shown in Fig. 105. This method of working he compares favourably with that involving the use of some high-speed system with all traffic confined to one set of instruments. In a word, the author shows that, for practical traffic facilities, several low-speed sets on a given telegraph line are more useful than one high-speed set. I am very glad that Heurtley's magnifier and Orling's jet relay and magnifier have been mentioned in the paper, as most remarkable results have been obtained in this direction. On page 363

* In this same example the use of the cable code with Colonel Squier's unbroken alternations would give a graph total of 24 units. This low figure is due to the space economy inherent to Colonel Squier's transmission in which there is no space waste between contact units, but only to the extent of one space unit between letters, and two units between words.

† British Patent, No. 2382/1898.

Mr. Preece. could be served by a Wheatstone set which included keyboard perforators and typewriters for transcribing. The staffs in these two cases per shift would be:—For the Baudot, two operators and two receiving clerks at each station, *i.e.* eight men; for the Wheatstone, three operators at each station, one for the perforator which is known to be able to perforate at the rate of over 70 words per minute, and say two typists, each of whom could certainly transcribe at the rate of 25 words per minute, probably a good deal more. Thus there would be a saving in staff of at least two per circuit in favour of the Wheatstone, which apparatus also requires less maintenance and is simpler and less expensive. One attendant per set would be required in each case. It would thus seem that, for circuits connecting two centres, the multiplex cannot compete with the Wheatstone, if the later is coupled with mechanical labour-saving apparatus. Where, however, circuits branch off the main line to other places, and carry a moderate amount of traffic, the multiplex may possibly have the advantage. Major Booth stated that London and Birmingham are connected by two duplex sextuple Baudot circuits. These circuits would therefore carry a maximum of 360 words in each direction, *i.e.* 720 words per minute in all. The staff required would probably be two attendants, 12 operators, and 12 gummers in each station, or a total of 52 persons. Now if the Creed-Wheatstone were employed, and duplexed, at least 800 words per minute could be transmitted over the two circuits, using four receivers, as a maximum, and the staff, for 720 words maximum, would consist of not more than four attendants, 8 keyboard operators, and say 8 gummers per station, or a total of 40 persons as against 52, that is to say a saving of 12 persons per shift in favour of the Wheatstone. Another point which has considerable influence on colonial engineers in favouring the Wheatstone apparatus is due to the fact that the distances in the Dominions between main centres are usually great, and a breakdown of the line may necessitate a long delay. Now if multiplex is used, the messages are received and stored up until the line is again through. Then the transmission must progress at the normal speed, and the time lost cannot be regained. If, however, the Wheatstone is used, these messages during the wait are all perforated on tape. Then, immediately the line is repaired, the whole batch of messages can be transmitted at the highest possible speed to their destination. Also, as all the perforating has been done, the whole staff can be employed in transcribing the messages as they arrive, and often an appreciable portion of the time lost by the breakdown is actually saved in the delivery of the messages.

Mr. Gell. Mr. J. GELL (*communicated*): In the discussion, reference has been made to an automatic switch that I have invented. By means of this apparatus a number of operators may be engaged perforating slip for high-speed transmission, and each in turn is given possession of the line whilst one message is sent forward. The switching system is so controlled that extra long messages, or unequal abilities amongst the operators, do not detrimentally affect the traffic. The control is so flexible that the number of operators engaged is in keeping with the volume of traffic for the time being. The system enables the usual operator in charge of the transmitter to be dispensed with; the line time is saved by the elimination of the blank slip at the commencement and ending of batches; each message is sent independently and is not held up whilst the others are being perforated. The time of the perforating operators is saved, because there is no necessity to start and terminate each batch of messages, or to snake up the tape, etc., and send it to the transmitter clerk. In connection with this switch I think it only right to mention the assistance that was rendered to me by the British telegraph authorities. Engineers were sent from London to Glasgow and Liverpool to supervise the installation and testing of the switches. They took as much interest in the success of the switch as though it were their own, and the consideration they manifested towards me is typical of the courtesies I have received from the different sections of the department. Through the knowledge I obtained at this test I was enabled to perfect the switch and make it absolutely reliable. It is considered that this switch will be of value in connection with modern printing-telegraph systems. With reference to printing-telegraph systems generally, I am of the opinion that one uniform type of apparatus will not be adopted, even in any one country. The conditions of traffic vary so greatly on different circuits that whilst it will pay to put a relatively expensive high-speed system between two large cities, on the other hand the traffic on another circuit will only justify a small outlay. The main object to be aimed at is to reduce as far as possible the number of different kinds of instruments, and endeavour to utilize those which for high-speed and low-speed circuits can be handled by similarly trained operators, so as to ensure as far as possible full flexibility in regulating the staff to the traffic.

Mr. Creed. Mr. F. G. CREED (*communicated*): I shall confine my remarks to the author's conclusions in the last two pages of the paper. He says the last few years have seen the triumphant advance of the 5-unit equal-letter alphabet. In this I think he is mistaken. As Sir William Slingo has already pointed out, the advance made in connection with the 5-unit alphabet has been rather in the nature of refinement in methods and apparatus than in the general introduction of apparatus based on that alphabet. In fact, when one considers how well established the 5-unit apparatus was five years ago, it is rather remarkable that the use of such apparatus has not been much more widely extended in the succeeding period, during which it has been very persistently pressed upon the attention of the telegraph world. The increased use of the 5-unit apparatus in Great Britain, for instance, during the last five years has been trifling, and cannot compare with that made in the last two years by printing telegraphs based on the Morse code. Very much more traffic is handled to-day in the United Kingdom by Morse code printers than by all the 5-unit telegraphs together. The author fears that the use of the Morse code for high-capacity printing telegraphs involves delicately constructed machines at both ends of the line and all the complexity imposed by the necessity for differential feed devices. This, he thinks, involves high first cost, and, though no information is available, the maintenance must be heavy also. On this point I am able to give some first-hand information. The extra first cost due to the differential feed in the Morse code printer, with which I am familiar, does not exceed 5 per cent per printer, and when made in bulk would not perhaps exceed 2½ per cent. The cost of maintenance, includ-

Mr. Creed. ing the attendance of a mechanic, does not amount to 5 per cent per annum. The author says that the maximum speed would not be more than about 150 words per minute. As to maximum possible speed, I may mention that a line-speed of 165 to 170 words per minute has been maintained as the normal working speed of the Morse-code printing system used by the *Glasgow Herald* between its Fleet-street offices and Glasgow (400 miles) since the installation of the apparatus two years ago. Although handling up to 80,000 words per night, they have never, as far as I am aware, suffered any interruption or breakdown of the system, and this fact will perhaps be the best assurance that the author's fears about the delicacy and complexity of the apparatus are unfounded. The author believes that high-capacity systems with a low speed per printer unit can be of more robust construction than high-speed printers. Although more of them will be required to do the given work, they can be manufactured more cheaply, owing to their simpler and stronger construction. I am not by any means convinced, however, that four low-speed printers can be manufactured or maintained as cheaply as one fast one. Moreover, the 5-unit system requires not only the printers but the expensive and delicate distributor and control mechanism. In this connection also we must not fail to take into account the difficulty and expense of handling the 5-unit alphabet at repeating stations, a difficulty that is not experienced with Morse printers. Sir William Slingo very justly pointed out that the method of comparing the various codes suggested in Fig. 13 is quite erroneous. An alphabet is faster or slower, not because its unit is smaller or greater with relation to its average letter than the unit of another alphabet, but because it can be telegraphed more quickly or more slowly by means of the instruments in connection with which it is used. Mr. Judd, in discussing the author's suggestions with regard to the application of the 5-unit alphabet to ocean cables, mentioned that in the experience of the Eastern Telegraph Company the land-line Morse and the cable-Morse alphabets can be telegraphed over ocean cables at practically the same speeds, although theoretically the cable alphabet is about one-third shorter than the land-line Morse. In stating this fact, Mr. Judd very neatly exposed the underlying fallacy of the favourite argument employed by the advocates of the 5-unit alphabet. The fact is that at the root of all the controversy between the advocates of the 5-unit alphabet and the Morse lies the failure to recognize certain essential factors which do not appear upon the surface. There are several very good and sound reasons why the 5-unit alphabet does not and never can equal the Morse for printing telegraphs. With some of these reasons I made myself acquainted years ago when I decided to give my allegiance to the Morse. I hope to explain them fully in a paper at some future time. Meanwhile I will content myself with pointing out that, in spite of all the arguments which go to prove that the contrary should happen, the Morse code printer in this country has obtained better results than the 5-unit code in every case where it has been permitted to compete with it on equal terms. By way of indicating some of the difficulties which have still to be overcome with the 5-unit system, may I suggest a few questions arising out of the actual working of the various systems in the United Kingdom?

(1) Why is the Baudot sextuple duplex confined to the short and easy underground loop between London and Birmingham?

(2) Why is the Western Union multiplex, with its apparently enormous capacity for work, installed between Manchester and London instead of upon the much heavier London–Glasgow circuits?

(3) Why are all the 5-unit printing telegraphs confined exclusively to underground loops instead of overhead wires, although the Morse printer is used on overhead or underground wires, long or short, with perfect indifference?

(4) Why are all 5-unit machines shut down at night, and why is the Morse code printer the only one that is opened at night to cope with any unusual pressure of traffic or to distribute news?

(5) Why are Morse wires, apparatus, and staff usually kept in reserve in connection with circuits worked by the 5-unit systems?

(6) Why does it take so long, sometimes several hours, to change 5-unit systems, especially when duplexed, from one line to another in case of interruption?

(7) Why are no news circuits in this country worked by 5-unit apparatus?

(8) Why have the majority of the provincial newspapers using private wires adopted the Morse code printer for their work instead of one of the 5-unit systems, which are claimed to be less costly and which have been much longer in the field?

(9) Why does the Western Union Telegraph Company employ a Morse code printer on its most difficult and valuable land circuit (between its New York office and the cable ends in Nova Scotia)? This Company claims to have developed the best of all the 5-unit systems and to have had it in daily use for about two years.

These are questions that call for an answer, and they will find their answer in the hidden and neglected factors to which I have alluded.

The President. The PRESIDENT: Before asking the meeting to give a vote of thanks to the author, I should like to say a few words. This paper, containing two illustrations per page, is one of the most exhaustive that we have ever published. In a time of war, when we have to be economical, we must of course only publish papers of the highest merit, and we decided, at considerable expense, to print this paper. I do not think we have ever received one better put together or more beautifully illustrated.

Mr. Harrison. Mr. H. H. HARRISON (*in reply*): The preparation of the paper has been very largely a labour of love, and carried with it, therefore, its own reward. The appreciation it has met with to-night is, however, none the less welcome.

Sir William Slingo asks why I did not refer to the photographic printer. Type printers employing photographic means for recording have been proposed from time to time, and Ader replaced the siphon recorder on the Mediterranean cables by a photographic recorder of the Einthoven string-galvanometer type, but as far as I am aware all such apparatus has long since disappeared. The developing, fixing, and drying plants incidental to photographic printers take up space, and the extra processes involved must, I think, be regarded as objectionable. The idea of photographically recording signals is very attrac-

Bulletin No. 16
October 1916

G R Benjamin

Theory of Tape System

The Morkrum Telegraph Printers

IMPORTANT NOTICE

MORKRUM COMPANY

Factory Office
24 West Austin Avenue
CHICAGO

The Morkrum Telegraph Printers
Tape Transmission

The intent of this bulletin is to present the theory of the transmission and reception of signals in the operation of the Morkrum Telegraph Printers, and to show the sequence of operations. A careful study of the following diagrams and the accompanying explanations will greatly facilitate the work of handling the printers.

In the Morkrum tape system, a message which is to be transmitted is first prepared on a perforated tape by means of a keyboard perforator. The message is then automatically transmitted over the line by means of this tape, and is received directly on a page printer.

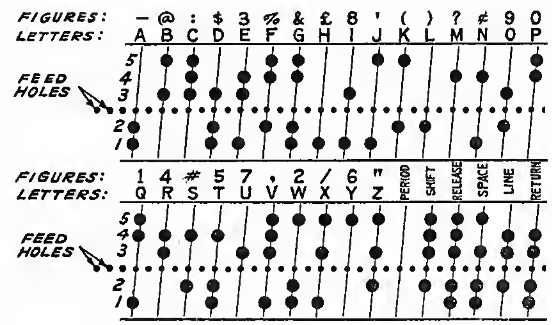


Figure 1—Morkrum Code

The tape perforator has a keyboard similar to that of a standard typewriter. There are six rows of holes in the tape. The continuous row is used to feed the tape in the transmitter. The letters and signals are formed by different combinations of holes in the five remaining rows, which are placed two in front of and three behind the feed row. The arrangement of the holes in these five rows controls the polarity of the five selective impulses which are sent over the line for every signal.

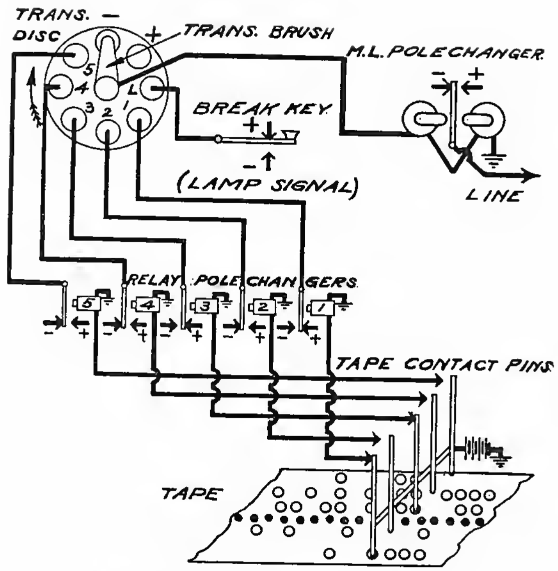


Figure 2—Local Transmitting Circuits

There are five contact pins which rest on the tape, one for each row of holes. These contact pins operate relay pole changers, the tongues of which are connected to five of the buttons on the transmitter disc. The position of each relay pole changer will determine which pole of the local battery will be connected to the corresponding button on the transmitter disc. Therefore, as the transmitter brush revolves, it will send through the coils of the main line pole changer a series of impulses, the polarity of which is determined by the setting of the relay pole changers. The setting of the relay pole changers will, of course, depend upon the arrangement of the holes in the tape.

In addition to the five buttons on the transmitter disc, which are used for sending out the selective signals, there are two buttons which send out the synchronizing pulses, one connected permanently to the negative and the other to the positive pole of the local battery. There is also one button connected to the tongue of the break key which operates the lamp signal at the distant end. The polarity of the impulses sent out from the buttons will determine to which side the armature of the main line pole changer will be moved and which pole of the main line battery will be sent to the line.

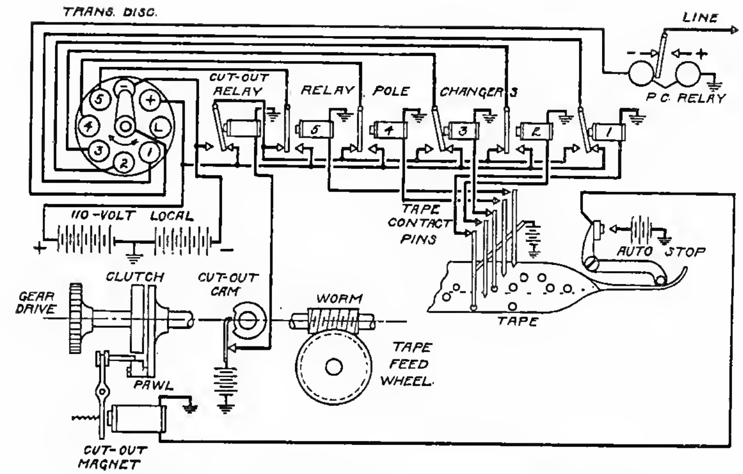


Figure 3—Direct Distributor Transmitting Circuits

The direct type of distributor is equipped with an automatic stopping device which allows the tape to be fed directly from the perforator into the distributor. The tape passes around a lever which is so arranged that when the tape draws tight, it will open a contact. The opening of this contact disengages the clutch which drives the tape feed wheel and so prevents the tape from being torn when the operator does not keep up with the distributor. When the clutch is disengaged and the drive shaft comes to rest, the cut-out cam which is on the drive shaft closes a contact which operates a cut-out relay. This relay switches the negative contacts of the five relay pole changers to positive so that during the interval that the distributor is stopped, all positive pulses are sent out. The transmitter brush, of course, continues to rotate and to send out the synchronizing pulses but, as stated before, the five impulses are all transmitted positive during the interval while the automatic stop is operated.

Printers for use with the direct distributor are arranged so that the all-positive signal will not affect them, the shift release signal being arranged to operate in conjunction with the space signal.

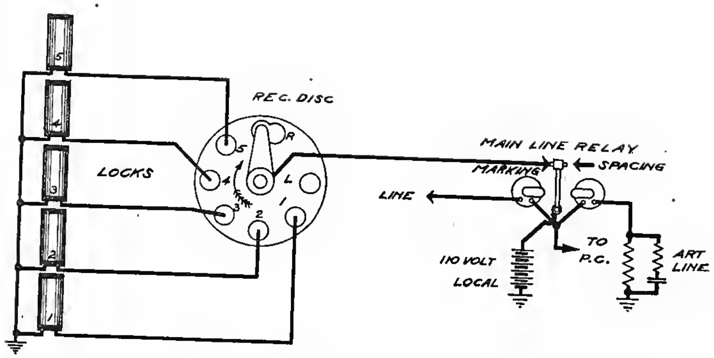


Figure 4—Selecting Circuits

At the receiving station there are five lock relays which are connected to the buttons of the receiver disc. By operating different combinations of these locks the printer is made to perform its various functions.

The tongue of the main line relay is connected to the local battery and its marking contact is connected to the receiver brush. Therefore, when negative or marking impulses are received by the main line relay the locks will be operated; but if positive or spacing impulses are received, the local battery will be disconnected from the receiver brush and the locks will not be operated.

When there is no tape in the transmitter all the five pin contacts are closed, hence all the relay pole changers will send out positive pulses to the coils of the main line pole changer, which will send out to the line positive or spacing current. This will move the main line relay armature at the distant end of its spacing contact. Since the receiver brush is connected to the marking contact of the main line relay, none of the locks will be operated. If a piece of tape, in which there are no holes except feed holes punched, is put into the transmitter, all of the pin contacts will be opened and the relay pole changers will send out negative or marking pulses and the armature of the main line relay at the distant end will be against its marking contact, and the battery will be connected to the receiver brush. Therefore, all the locks will be operated.

It will be seen from this that whenever the tape is left intact, negative impulses are transmitted to the line and the locks at the receiving station will be operated. Wherever the tape is perforated, positive impulses will be transmitted to the line and the corresponding locks will not be operated. In this manner the perforations of the tape determine the combinations of the locks to be operated, which in turn control the printer actions.

The signal lamp relay is operated in the same manner as the five lock relays. At the transmitting end the tongue of the break key is connected to a button on the transmitter disc and normally sends out positive pulses. If the key is depressed, negative pulses are sent out and the lamp relay will be operated and light the lamp.

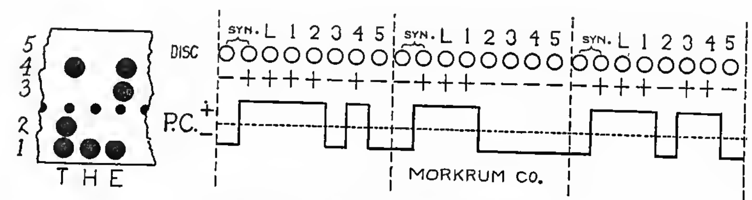


Figure 5—Tape and Line Signal

Figure 5 shows the line signals for the word "THE." The transmitter brush makes one revolution for every letter sent out and the tape feed wheel is geared so it will advance the tape one feed hole for every revolution. The diagram shows the holes punched in the tape for the word "THE," the polarity of the segments of the disc, and also the signals sent out by the main line pole changer. It will be noticed that where impulses of the same polarity follow one another the main line pole changer joins them into a continuous current in that direction.

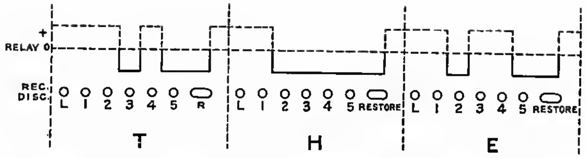


Figure 6—Main Line Relay and Receiver Disc

Figure 6 shows the operation of the main line relay in receiving the word "THE." As the receiver brush is connected to the marking contact of the main line relay, only negative pulses will close the circuit from the local battery to the receiver brush. The negative portions of the received signal are therefore shown in solid lines and the positive portions in dotted lines. In the letter "T" the third and fifth impulses are negative. Therefore, the main line relay armature will be against its marking contact when the brush passes the third and fifth buttons of the receiver disc and will operate the third and fifth locks. The main line relay armature is always against the marking contact when the receiver brush passes the restoring button, owing to the corresponding button on the transmitter disc being permanently connected to negative.

It is apparent that the brushes of the transmitter and of the receiver must be over corresponding buttons at the same instant. To accomplish this, means are provided for keeping them in unison.

In order to maintain proper relation between the transmitting brush at the home end and the receiving brush at the distant end, the receiver shaft is geared to run slightly faster than the transmitter shaft and the correcting mechanism retards the receiver brush every time it gets slightly ahead of the transmitter brush at the other end.

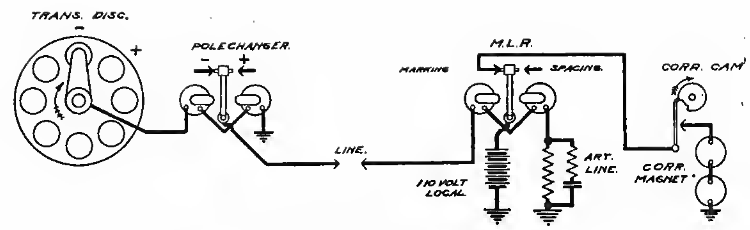
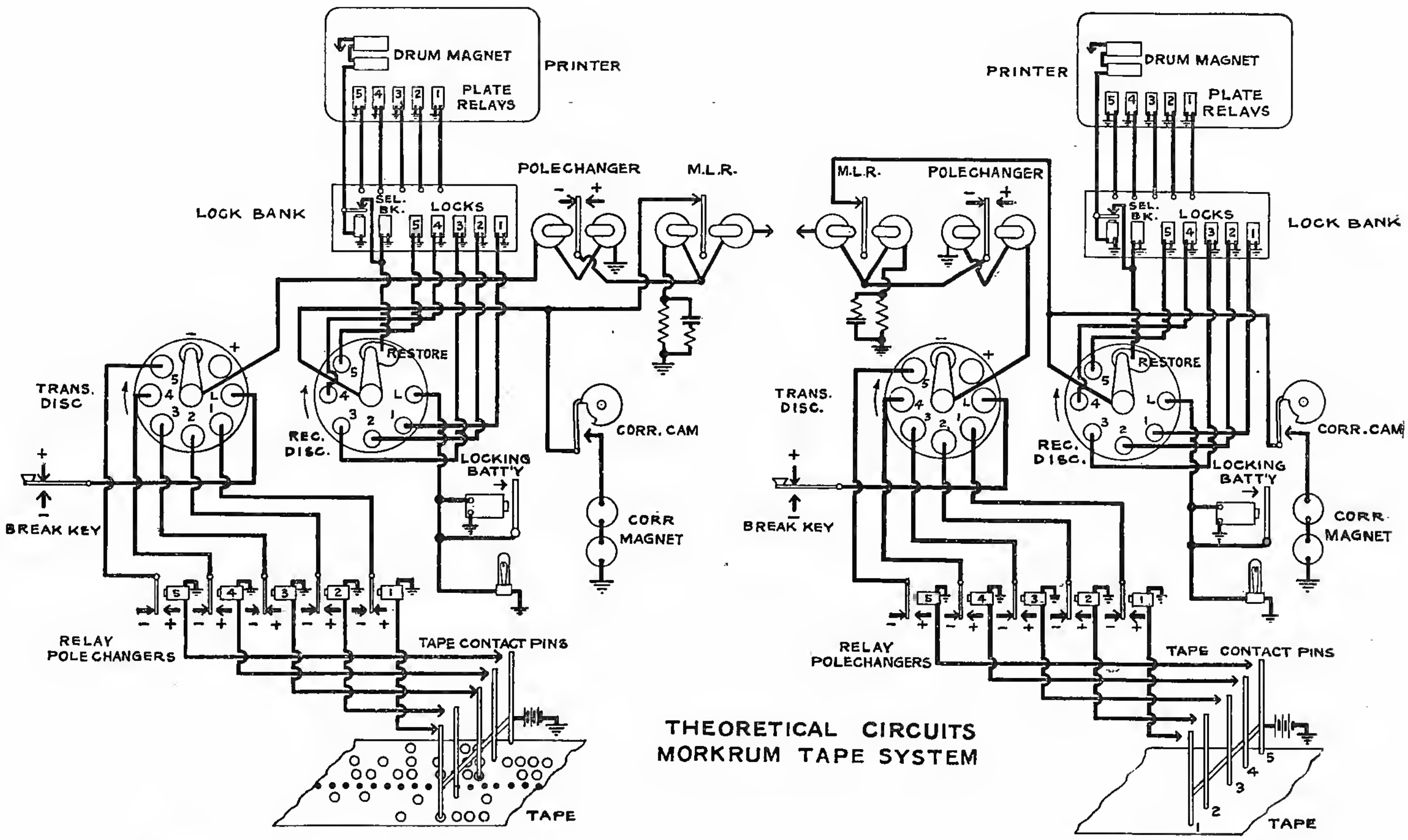


Figure 7—Synchronizing Circuits

The transmitter disc sends out every revolution a negative pulse followed by a positive pulse. These pulses actuate the main-line relay at the far end. The marking contact of the main-line relay, besides connecting to the brush of the receiver disc, also connects to a contact operated by a cam on the receiver shaft and through this contact to the coils of the correcting magnet. If the receiver brush and the transmitter brush are running exactly in step, the relation of the cam contact to the receiver brush is such that when the marking pulse is received by the main-line relay the cam contact will just be on the point of closing and connecting in the correcting magnet, but it will not close quite soon enough. The receiver brush is geared to run a little faster than the transmitter brush at the other end. Therefore, a time will come when the receiver brush is enough ahead of the transmitter brush at the other end for the cam contact to close at the same time that the marking pulse is being received by the main-line relay. When this happens the correcting magnet will operate and will interpose a pin in the path of the revolving star wheel on the main shaft, which will, through a system of gears, shift the position of the receiver brush slightly back. In this way the position of the receiver brush is corrected every time it gets ahead of the transmitter brush at the other end. This correction is, of course, very slight.



THEORETICAL CIRCUITS
MORKRUM TAPE SYSTEM

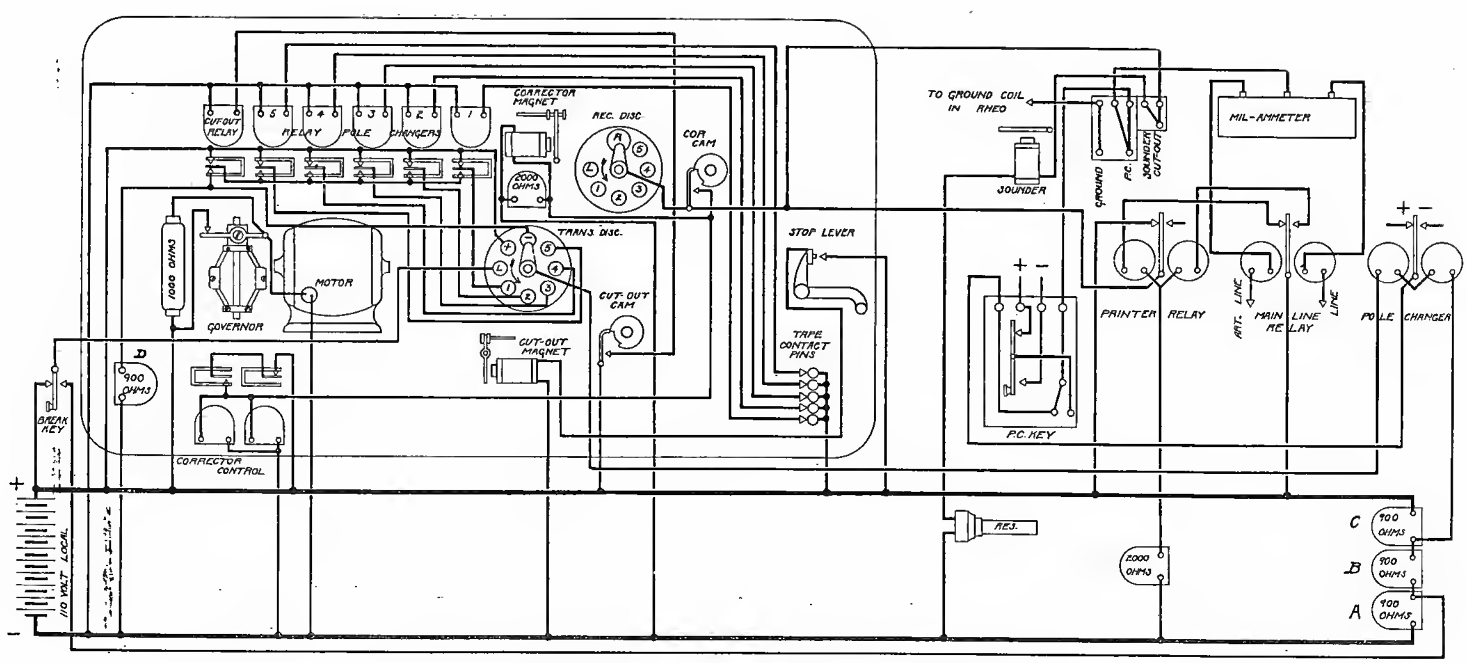


Figure 8—Complete Transmitting and Synchronizing Circuits

Referring to Figure 7; the five contact pins are connected to the local battery and the contact points are connected to the coils of the relay pole changers.

When speaking of front and back contacts of relays it is understood that the front contact is the one against which the tongue is held when the relay is operated. The back contact is the one against which the tongue lies when the relay is unoperated.

The back contacts of the relay pole changers are connected to the negative pole of the local battery through the coil "D," the purpose of which is to prevent a short circuit in the local battery through the points of the relay pole changers. The front contacts are connected to the positive pole of the local battery.

When the transmitter brush is on the top button, there is a circuit from the negative pole of the local battery through coil "D," through the coils of the main line pole changer, thence through coil "C" to the positive pole of the local battery. This current will move the armature of the main line pole changer to the left and will send out negative current to the line.

When the brush is upon the next button in the direction of rotation, the circuit is from the positive pole of the local battery through the coils of the main line pole changer, thence through coils "B" and "A" to the negative pole of the battery. Since the current is flowing through the coils of the main line pole changer in the opposite direction, the armature will move to the opposite side and will send out positive current to the line.

The circuit from the tongue of the pole changer passes through the three-point switch of the pole changer key, through the ground switch to the mil-ammeter. From this point the current divides, passing through the differential windings of the mil-ammeter and main line relay to the main and artificial lines.

The three-point switch on the pole changer key is used to disconnect the printer pole changer and connect the Morse key to the line.

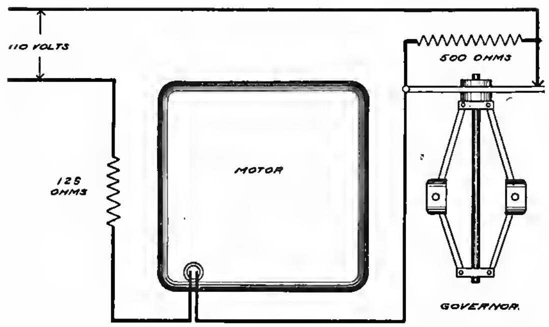


Figure 9—Motor Governor Circuits

The motor which drives the shafts must maintain a constant speed, so it is equipped with a fly-wheel and governor. There is a 125-ohm resistance unit in series with the motor to reduce the current. The governor is of the fly-ball type. When revolving, the pull of the governor weights tends to open the governor contacts. The speed at which the contacts are opened is determined by the position of the adjusting screws. The circuit from the local battery to the motor passes through the contact points of the governor and there is a 500-ohm resistance unit bridged across these contacts. When the governor contacts are opened the 500-ohm resistance is put in series with the motor, which immediately slows down. The slowing down of the motor allows the contacts to again come together, cutting out the 500 ohms. The motor speed will then increase, and cause the contacts to open again. Thus it will be seen that the speed will be kept constant by the opening and closing of the governor contacts. If the speed tends to increase, the contacts will be held open longer. If it tends to decrease, the contacts will be held closed longer. This allows a wide variation of voltage, and also changes of load, without a change in the speed.

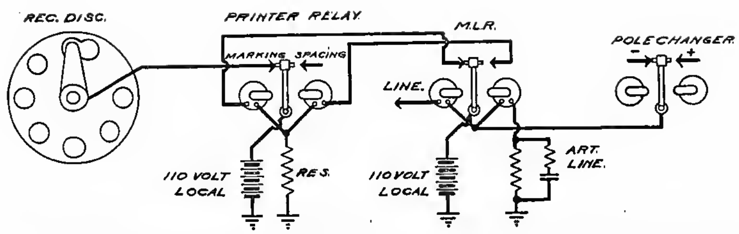


Figure 10—Operating Circuits of Main Line Relay and Printer Relay

The main line relay armature is controlled by the transmission from the distant end. Instead of receiving the signals direct from the main line relay, the main line relay is made to operate a printer relay whose armature opens and closes a circuit from the battery to the receiver brush. When the main line relay receives a negative or marking signal from the distant end, the printer relay closes the battery circuit to the receiver brush. When the main line relay receives a positive or spacing signal, the printer relay will open this circuit.

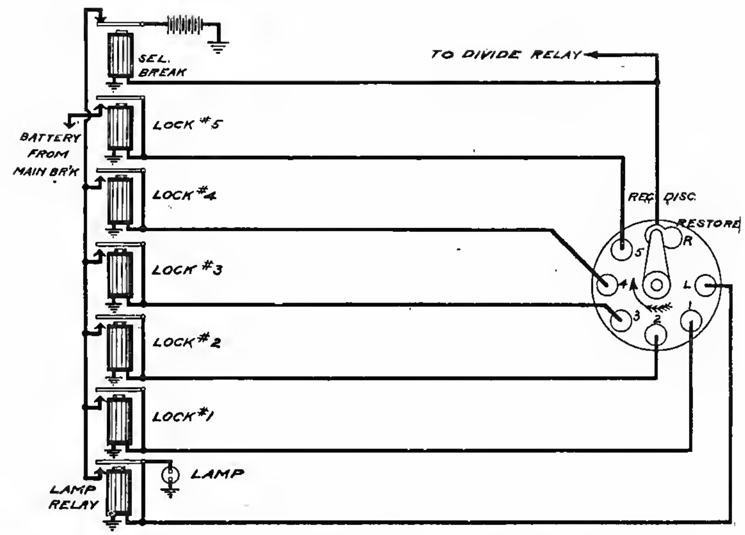


Figure 11—Receiver Disc and Locking Circuits of Lock Relays

There are seven buttons on the receiver disc. The large button is the restoring button. The next button in direction of rotation is connected to the relay which controls the signal lamp, the next five buttons in order are connected to lock relays 1, 2, 3, 4 and 5 in the lock bank.

The different letters and signals on the printer are made by operating different combinations of the five locks. It will be seen from the diagram that the tongue of each lock relay is connected to its own coil and the front contact is connected to the battery through the contacts of the selector break relay. When a lock relay operates, the battery from the contact flows through its own coil and locks the relay in operated position until the selector break opens, cutting off the battery. Lock five is locked with battery through the main break in the printer so in case it is operated it is held locked until the main break opens. The lamp signal relay is operated in the same manner as the lock relays. If the distant end is sending out marking current when the receiver brush is on the lamp button the lamp relay is operated and will lock battery from the selector break to the signal lamp which will remain lighted until the selector break opens.

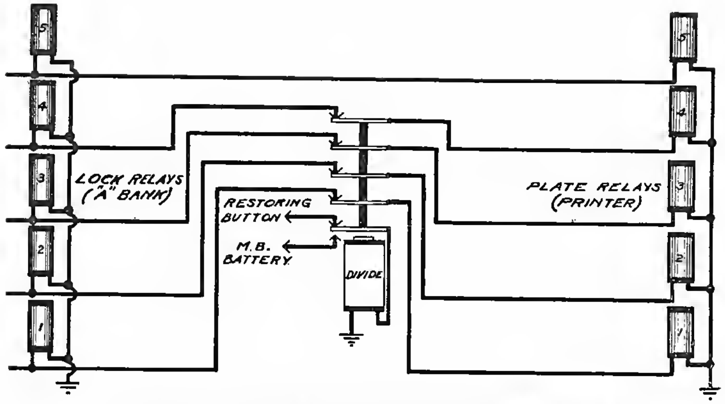


Figure 12—Circuits from Locks to Plate Relays

The lock relays in the bank are connected to the corresponding plate relays in the printer through the contacts of the divide with the exception of the fifth which goes direct to P-5 in the printer. When the divide relay is operated and all its contacts opened the printer is cut off entirely from the first four lock relays. This is done in order to allow the bank to pick up the next combination over the line and store it until the printer has completed the operations of rotating and striking or any of its other various functions.

Since the lock relays control the printer actions, we will consider first how the different combinations are set up in the bank.

Tracing the operations which take place while a combination is being selected. Starting with the brush on the first button, if the transmitter at the far end is sending out negative current the printer relay will close the circuit from battery to the receiver brush, then through the first button on the disc, and from there to the magnet of the first lock relay. This magnet will pull over the armature of the relay and lock itself in operated position as described above. If the transmitter at the distant end is sending out positive current the printer relay will open the battery circuit to the receiver brush and the first lock will be left unoperated.

The receiver brush will now pass to the second button. If the transmitter at the distant end is now sending out negative current the circuit from the battery to the receiver brush and the second lock relay magnet will be closed and the relay

will be operated and will lock itself in. If the transmitter at the distant end is sending out positive current the printer relay will open the circuit from the battery to the receiver brush and the second lock will be left unoperated. In this way, tracing the circuits when the brush is on each button, it will be seen that if the transmitter at the distant end is sending out negative current the printer relay will close the circuit from the battery to the receiver brush and the battery will flow through the button to the lock relay magnet and operate the relay. If the transmitter at the distant end is sending out positive current the printer relay will open the circuit from the battery to the receiver brush and no battery will flow into the lock relay magnet and the relay will remain unoperated.

When the fifth interval is negative the fifth relay will be operated and will lock itself in the same manner as the other locks except that its locking current is supplied through the main break in the printer instead of the selector break.

After leaving the fifth button the brush passes over the restoring button. The circuit from the battery to the receiver brush is always closed by the printer relay at this time due to the fact that the button after the fifth in the transmitter disc is permanently connected to negative.

One branch of the circuit for the restoring button passes through the magnet of the selector break relay. When this magnet is operated it opens the selector break and cuts off the locking battery from the first four lock relays, restoring them all to normal unoperated position. The fifth lock being locked by main break battery does not restore until the operation of the main break in the printer.

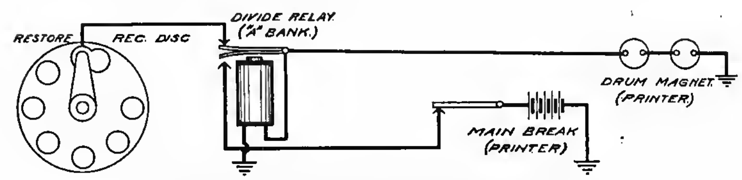


Figure 13—Divide Relay Operating Circuits

Another branch of the circuit from the restoring button connects the battery to the divide relay magnet and drum magnet in the printer through the right hand back contact and double tongue of the divide relay.

Having traced out the method of selecting a combination in the lock bank we are now ready to consider the operation of the printer, which is purely local.

The circuits of the printer will be more easily understood if we first consider the mechanical actions of the printer in printing a letter.

The typewheel must first be rotated to the proper letter and then thrown forward against the paper to print.

There are two rotator magnets which turn the gear shaft by means of a segment and pinion. The gear shaft is connected to the typewheel by a pair of bevel gears and a universal joint. The typewheel is stopped opposite the different letters by means of the selector drum mechanism as follows: On the gear shaft, in front of the selector drum, there is an index lever. The drum contains a number of stop pins and there are four interference plates between it and the index lever. These interference plates are controlled by the plate relay solenoids, which are in turn controlled by the first four locks in the lock bank. In any setting they will allow two of the pins to pass through them when the drum is operated owing to the holes in all the plates being lined up opposite these particular pins. The gear shaft will rotate either to the right or left according to which rotator magnet is operated, and will rotate until the index lever strikes a stop pin. This will bring the letter on the typewheel corresponding to the pin, directly in front. The striker magnet is then operated and throws the typewheel against the paper and prints the letter.

Considering now the electrical circuits by means of which this succession of operations is accomplished.

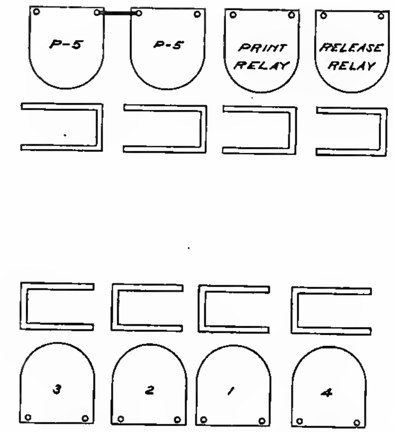


PLATE RELAYS.

Figure 14—Arrangement of Distributing Relays in Printer (Looking at the Printer from the Back)

At the left end there is a bracket on which are mounted eight relays. The lower four of these, in addition to controlling the distributing circuit, operate the solenoids which control the plates on the selector drum.

The two relays on the left of the upper row are the relays that are operated by the fifth lock. The magnets of these two relays are in series so they act as a single relay. They are designated as P-5.

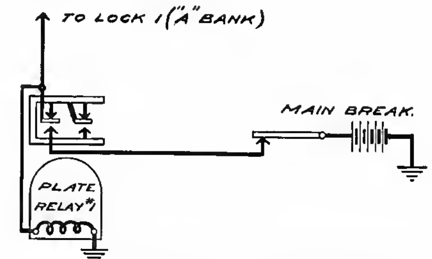


Figure 15—Plate Relay Locking Circuit

The plate relays lock themselves operated in the same manner as the lock relays. Their left hand front contacts are connected to battery through the main break and the left hand tongues are connected to their own coils so that when a relay is operated battery from the contact flows into the coil and it is held operated until the battery is cut off by opening the main break.

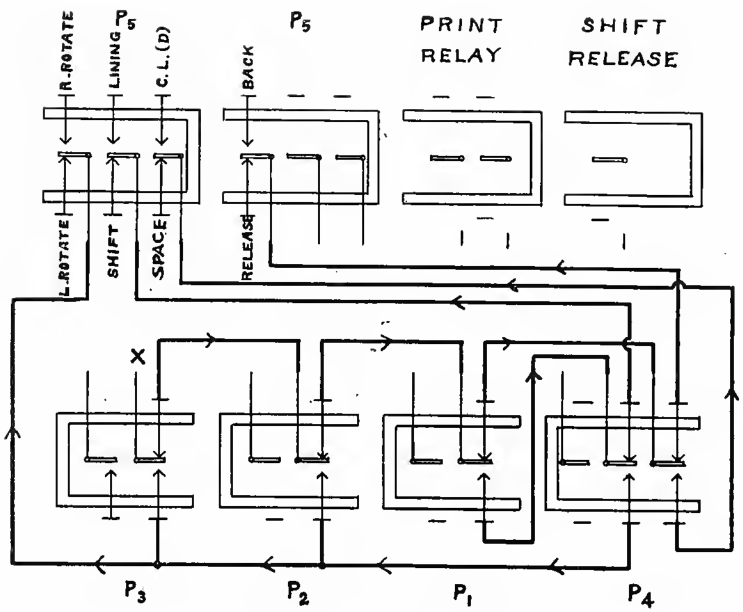


Figure 16—Distributing Circuit

The remaining tongues and contacts of P 1, 2, 3 and 4 and the four left hand tongues and contacts of P-5 make up the distributing circuit which determines what path the current in the printer shall take and what magnets shall be operated. In the case of letters being printed the path of the current leads through one of the rotator magnets which revolve the typewheel. In case the lining or other signal is received the path leads through the lining magnet or other manet to perform the proper operation.

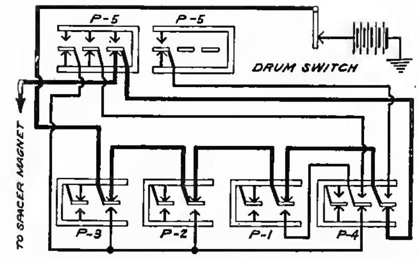


Figure 17—Distributing Circuit Set for Spacer Signal

For spacer signal the fourth plate relay is operated, so it is shown with its tongues against its front contacts and the path of the current from the drum switch through the distributing circuit to the spacer magnet is indicated by heavy lines.

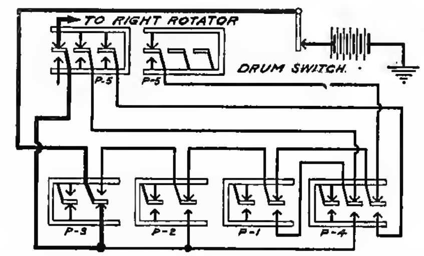


Figure 18—Distributing Circuit Set for Letter "T"

P-3 and P-5 are operated, so they are shown with their tongues against their front contacts, and the path of the current from the drum switch through the distributing circuit, to the right rotator is shown by heavy lines.

Following the circuits in detail. We have, starting from the magnet of the first lock relay, a circuit which leads over to the magnet of the first plate relay in the printer through one of the contacts on the divide relay. When the first plate relay operates it locks itself in operated position as described above.

The reason for having the plate relay lock itself independent of the lock relay is on account of the fact that the lock relay is restored to its normal position as soon as the receiver brush passes over the restoring button, while the plate relay must stay operated until the printer has finished printing the letter. This is also the reason for having the circuit from the lock relay to the plate relay pass through the divide so the printer can be separated from the locks while it is completing the printing operation and the bank can go on with the selection of the next letter. As explained before, at the same time the plate relays are setting their contacts, they are also operating the solenoids that set the interference plates in the proper position to select the proper stop pin for the letter to be printed. In a similar manner the connection is made from the second lock through one of the divide contacts to the second plate relay which also locks itself with battery from the main break. The circuits for the first four lock relays are similar. The circuit from the fifth lock does not pass through the divide contacts but goes direct to the P-5 relay in the printer. It is not necessary to separate the printer from the fifth lock because the printing of a letter will be completed before the receiver brush reaches the fifth button again.

When the receiver brush reaches the restoring button on the receiver disc it will close a circuit from the battery to the coil of the selector break relay which will open the battery circuit of the lock relays and they will all restore ready for the next combination. It will at the same time close a circuit from the battery to the magnet of the divide and the drum magnet in the printer through the back contact and the double tongue of the divide relay. The divide relay will be operated and lock itself in with battery from the main break through its own front contact. Since the divide locks itself in with main break battery it will remain operated until the printer has completed its operation and the main break is opened.

When the drum operates, all the stop pins are pushed against the plates and the two stop pins opposite the holes lined up in the four plates pass through while the rest are blocked. The operation of the drum also allows a small switch, known as the drum switch, to close. The drum switch connects the battery to the start of the distributing circuit, which is the right hand tongue of the third plate relay. This connection is through the double tongue and locking contact of the divide relay and main break contacts.

The distributing circuit runs through the contacts of the four plate relays and P-5, and determines which magnets in the printer are to be operated. The different outlets for the distributing circuit are on the front and back contacts of P-5 relay and connect to the various printer magnets such as the rotators, shift magnet, lining magnet, etc.

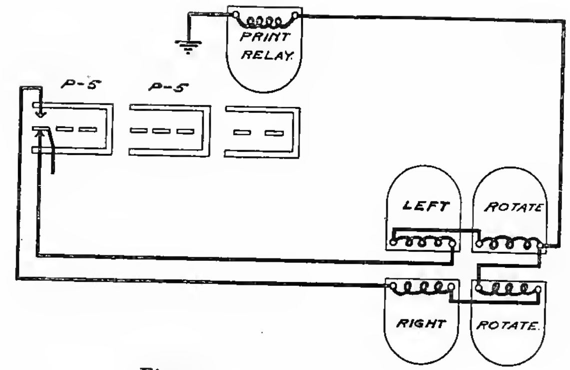


Figure 19—Rotator Circuits

For all letter combinations the distributing circuit will lead to the left hand tongue of P-5. The left hand front and back contacts of P-5 are connected respectively to the right and left rotator magnets. It will be seen from this how P-5 controls the direction of rotation of the typewheel. If the fifth interval of a letter is negative P-5 is operated and the path from the distributing circuit is through the upper contact to the right rotator magnet. If the fifth interval is positive P-5 will not be operated and consequently the tongues will lie against the back contacts and the path of the current will be to the left rotator.

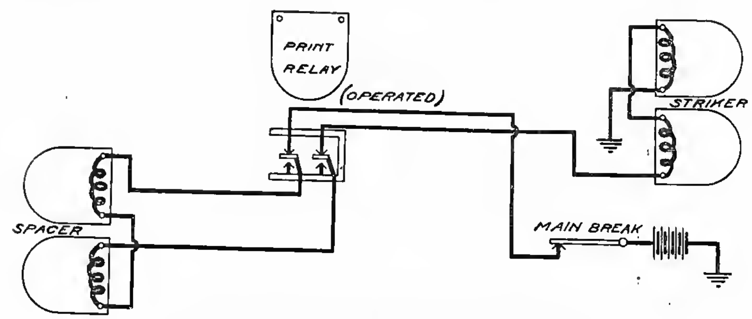


Figure 20—Spacer and Striker Circuits

When the print relay operates it connects the battery through the spacer and striker magnets in series and prints the letter. The circuit is as follows: From the battery through the main break contacts, through the left hand front contact and tongue of the print relay, through the spacer magnet, back through the right hand tongue and front contact of the print relay to the striker magnet. When the striker magnet operates, in addition to printing the letter it also, by means of a lever on the striker shaft, opens the main break, thus disconnecting the battery from the plate relays and other printer magnets that have been operated, restoring them to their normal position ready for the next letter.

The operation of the main break also allows the divide relay to restore.

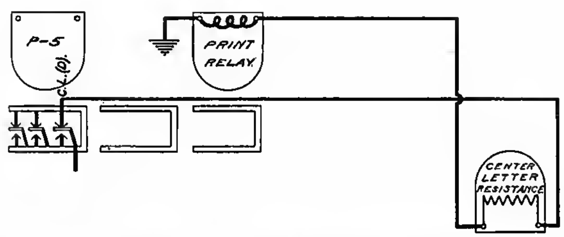


Figure 21—Print Relay Operating Circuit for Center Letter (D)

There is one letter, "D," which requires no rotation as it is located directly on the front of the typewheel. When the combination for this letter is received the path of the current through the distributing circuit leads to the contact point on P-5 marked center letter and then through the center letter resistance coil to the print relay magnet. The resistance coil compensates for the resistance of the rotator magnet which is not used. The print relay operates and connects battery to the spacer and striker as for all other letters.

While the printer has been performing the operations of printing the letter the bank has been picking up and storing part of the next combination over the line and part of the lock relays in the bank may have been operated. In this case as soon as the divide relay armature drops back to unoperated position and all the circuits from the locks to the plate relays are again closed, those locks in the bank which are operated will immediately operate the corresponding plate relays in the printer.

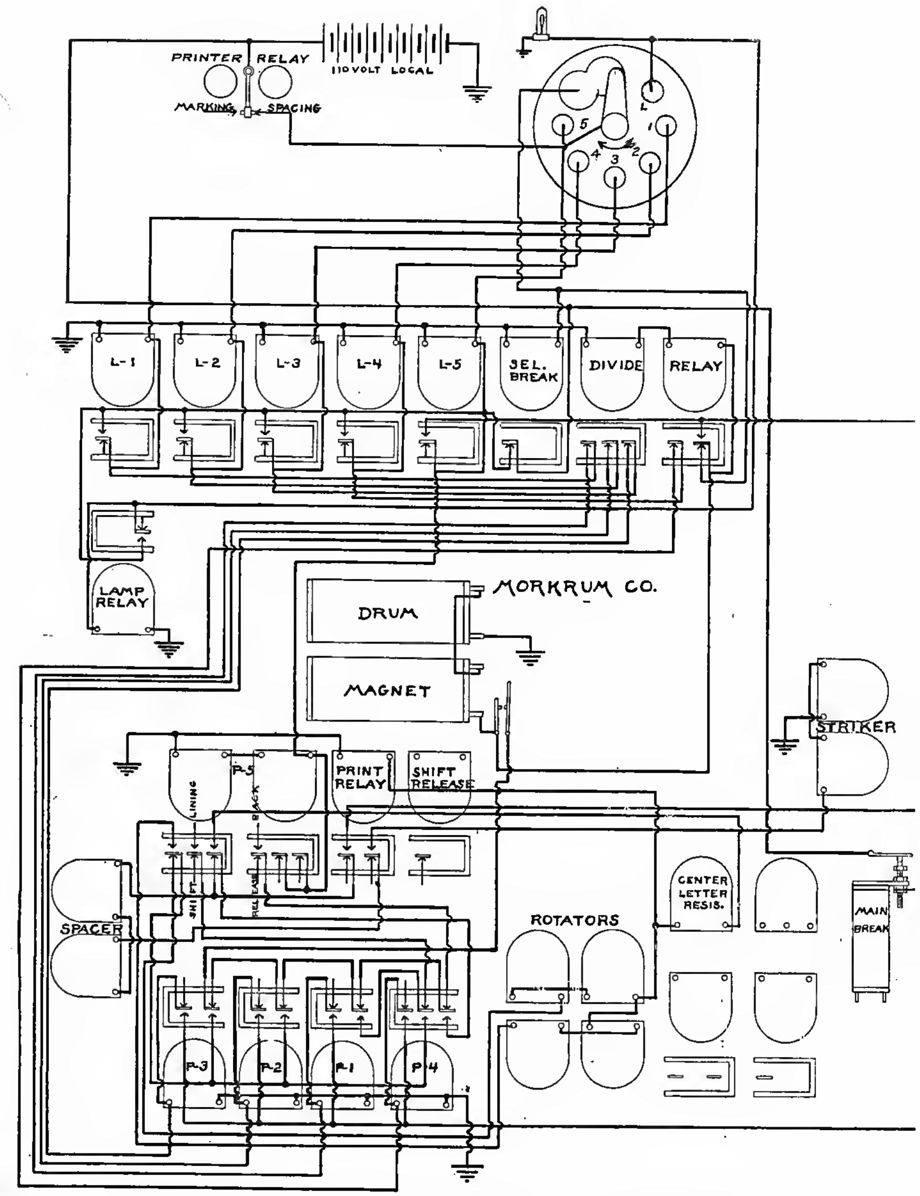


Figure 22—Complete Selector Circuits and Printer Circuits for Letters

It is easier to understand these circuits when remembering that there is a succession of operations. Each circuit is in itself a simple series circuit which closes a contact to start the next operation.

Reviewing the operation of the printer with this in mind, the succession is as follows: The locks in the bank, which are operated, set the corresponding plate relays in the printer. When the receiver brush reaches the restoring button the divide and the drum magnet in the printer are operated. The drum magnet sets the stop pins in the selector and allows the drum switch to close.

When the drum switch closes it connects battery through the distributing circuit to one of the rotator magnets and the print relay. The rotator magnet turns the typewheel to the proper letter, the print relay connects the battery to the spacer magnet and striker magnet, which prints the letter and at the same time opens the main break and restores all the printer relays and solenoids and the divide relay to normal position.

The print relay furnishes a slight interval of time between the rotation and striking in order that the typewheel may fully rotate before it strikes.

To make these operations more clear, we will trace the complete selection of the letter "K" the combination for which is — + — — +. Starting as before with the brush on the first button. Since the first interval is negative the distant transmitter will now be sending out negative current so the printer relay will close the circuit from battery to the receiver brush and from there through the button to the magnet of the first plate relay. The relay will be operated and will lock itself in as described before.

The receiver brush will now pass to the second button. The transmitter at the distant end will now be sending out positive current so the printer relay will open the circuit from battery to the receiver brush and the second lock relay will not be operated. Passing now to the third button. The third interval is negative so the printer relay will close the circuit from battery to the receiver brush and the third lock relay magnet. The relay will be operated and lock itself in. The fourth interval of the letter is also negative so the fourth lock will be operated and lock itself in. The fifth interval is positive so the printer relay will open the battery circuit to

the receiver brush and the fifth lock will remain unoperated. Since the third and fourth locks have been operated, the corresponding plate relays in the printer will also be operated, and will have locked themselves in with battery from the main break.

The brush will now pass to the restoring button and will connect the battery to the magnet of the selector break, which will open and cut off the battery from the first, third and fourth locks, which were operated, so they will restore to normal position. The battery from the restoring button will also operate the divide relay and the drum magnet in the printer.

The drum will operate and the two stop pins, one of which corresponds to the letter "K," will come through the plates. The drum switch will then close and connect the battery to the start of the distributing circuit. Since the first, third and fourth plate relays are operated the path through the distributing circuit will lead to the left hand tongue of P-5 and since P-5 is not operated the path will be through the back contact to the left rotator magnet and then through the print relay magnet. The typewheel will be turned until the index arm strikes the stop pin, which will bring the letter "K" directly in front. The print relay operates and connects the battery to the spacer magnet and the striker magnet which will print the letter and open the main break, clearing the printer.

In the case of combinations other than letters the main break is opened electrically. Directly below the main break is a solenoid the plunger of which strikes the main break armature, opening the contact points.

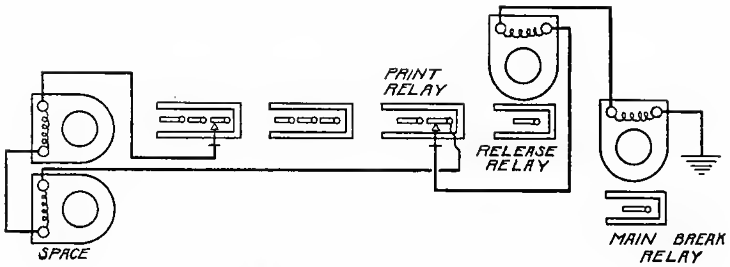


Figure 23—Space Circuit

When the drum switch closes and connects battery to the distributing circuit, the path of the current through the distributing circuit will lead to the contact on P-5, marked "SPACE," and through the Space magnet, the Release Relay magnet and the Main Break Relay magnet in series.

With this arrangement, when the Space signal is received, the Release Relay is also operated and restores the typewheel to "Letters" position.

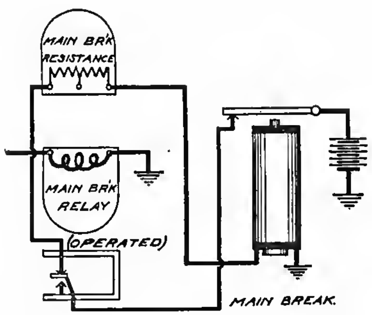


Figure 24—Main Break Relay Circuits

The main break relay will close a contact from battery through the main break resistance coil and the main break solenoid in series. The solenoid will open the main break contacts and restore the printer magnets to normal position ready for the next signal.

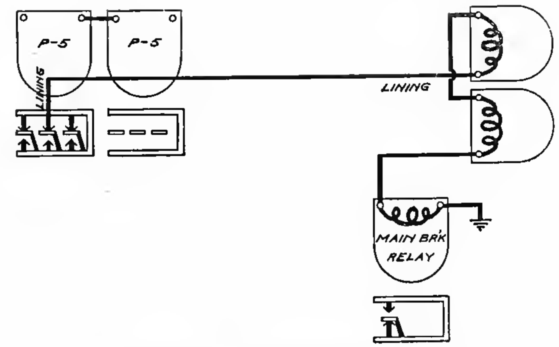


Figure 25—Lining Magnet Circuit

The operation of the lining signal is exactly similar to that of the spacer. When the drum switch closes, the battery will be connected through the distributing circuit to the contact of P-5 marked "LINING," and through the lining magnet and main break relay magnet in series. The main break relay closes a contact which connects battery through the main break resistance coil and solenoid in series. The solenoid opens the main break and restores the printer magnets to normal. The object of having the main break relay operate first and close the contact which operates the main break is to give the spacer and lining magnets more time in which to operate before the main break disconnects the battery from them.

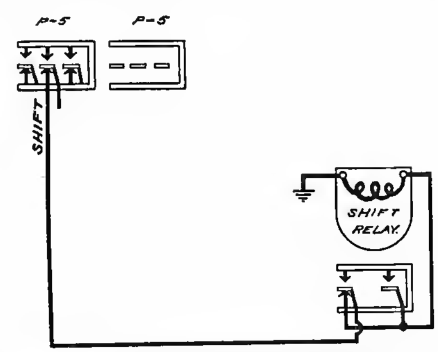


Figure 26—Shift Relay Operating Circuit

When the shift signal is received the drum switch connects battery through the distributing circuit to the contact on P-5 marked "SHIFT," thence to the shift magnet, through the left-hand tongue and back contact of the shift relay.

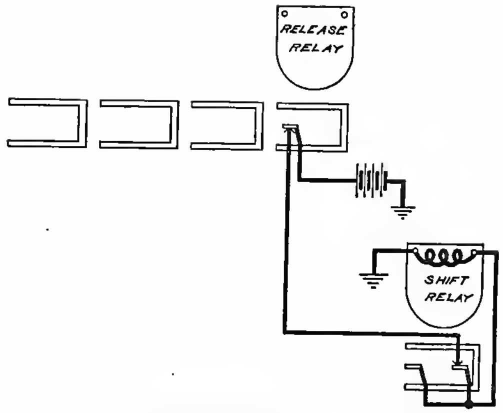


Figure 27—Shift Relay Locking Circuit

The shift relay operates and the right-hand tongue touches its front contact which connects battery to the shift magnet through the points of the release relay. This locks the relay in operated position.

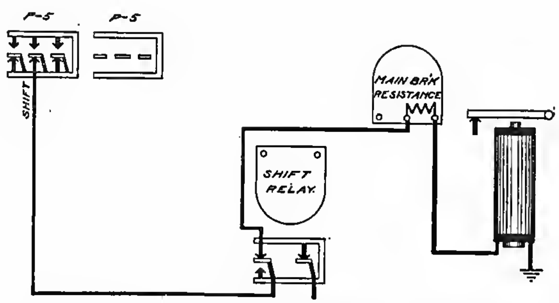


Figure 28—Shift Relay Operates Main Break

The left-hand tongue now touches its front contact and the battery from the distributing circuit is diverted through the main break resistance coil and solenoid which will open the main break contacts and restore the printer magnets to normal position, with exception of the shift magnet.

The opening of the main break does not restore the shift relay since the locking circuit of the shift relay comes direct from the battery through the contacts of the release relay. It should be noted that the shift relay contacts are so adjusted that the right-hand tongue makes contact and locks the magnet in before the left-hand tongue breaks the connection from the distributing circuit, otherwise it would not lock in properly.

The typewheel will now be held in shifted position and will print figures until it is released. When it is desired to print letters again the space signal is sent.

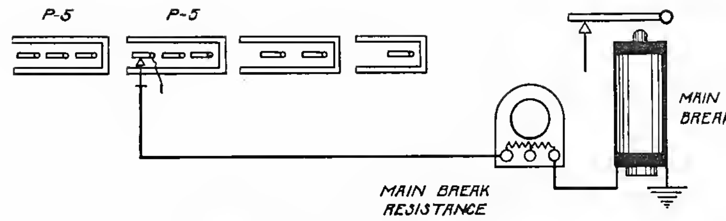


Figure 29—Idle or Rubout Signal

When the distributor is running idle, or when the "RUB-OUT" key is used, an all-positive signal is received by the printer. This signal passes from the distributing circuit, through the Main Break resistance and the Main Break, and simply clears the printer without operating any of the functions.

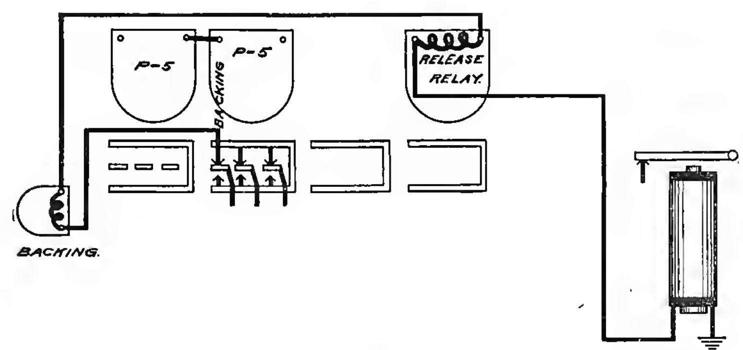


Figure 30—Backing Magnet Operating Circuit

When the backing signal is received, the current passes from the contact on P-5 marked "BACKING" through the backing and release relay coils and main break solenoid in series. This brings the carriage back to the beginning of the line and lets the typewheel drop down to letters, if it be shifted, and opens the main break which clears the printer.

THE WESTERN UNION TELEGRAPH CO.
PLANT DEPARTMENT

Specifications
732-A
August 1, 1918.

SPECIFICATIONS FOR
THE CARDWELL PRINTING TELEGRAPH SYSTEM
OPERATION AND MAINTENANCE.

SPECIFICATIONS AND DRAWINGS REFERRED TO:-

Specifications:- (None Included)

Drawings:-

CODE CHART
CARDWELL PRINTING TELEGRAPH SYSTEM

	0	1	2	3	4	5		0	1	2	3	4	5
A	–	–	–	+	+	+	Q	–	–	–	–	+	–
B	–	–	+	+	–	–	R	–	+	–	+	–	+
C	–	+	–	–	–	+	S	–	–	+	–	+	+
D	–	–	+	+	–	+	T	–	+	+	+	+	–
E	–	–	+	+	+	+	U	–	–	–	–	+	+
F	–	–	+	–	–	+	V	–	+	–	–	–	–
G	–	+	–	+	–	–	W	–	–	–	+	+	–
H	–	+	+	–	+	–	X	–	–	+	–	–	–
I	–	+	–	–	+	+	Y	–	–	+	–	+	–
J	–	–	–	+	–	+	Z	–	–	+	+	+	–
K	–	–	–	–	–	+	CAR.RET.	–	+	+	+	–	+
L	–	+	–	+	+	–	LINE FEED.	–	+	–	+	+	+
M	–	+	+	–	–	–	LETTERS.	–	–	–	–	–	–
N	–	+	+	–	–	+	FIGURES.	–	–	–	+	–	–
O	–	+	+	+	–	–	SPACE.	–	+	+	–	+	+
P	–	+	–	–	+	–							

Fig 1.

Specimen of tape with all characters perforated.

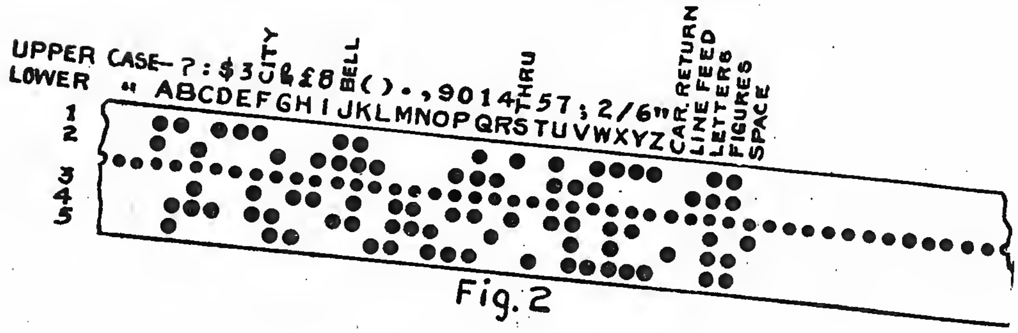
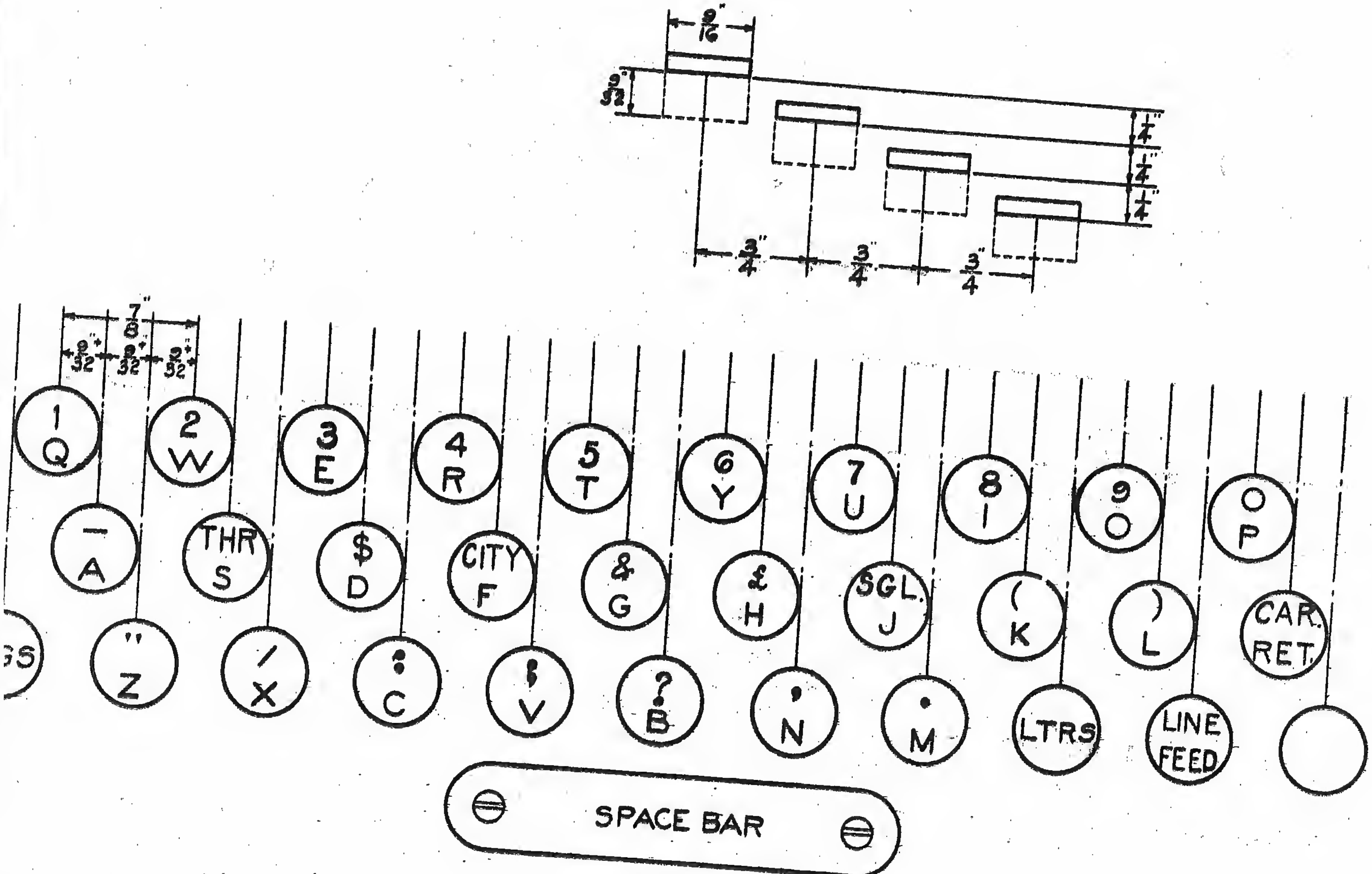


Fig. 2



9/16"
9/32"
1/4"
1/4"
1/4"
3/4"
3/4"
3/4"
7/8"
9/32"
9/32"
9/32"
1 Q
2 W
3 E
4 R
5 T
6 Y
7 U
8 I
9 O
0 P
A
THR S
$ D
CITY F
& G
£ H
SGL. J
(K
) L
CAR. RET.
GS
" Z
/ X
: C
; V
? B
, N
. M
LTRS
LINE FEED
SPACE BAR

FIG. 5

R. N. WILLIAMS.

TABULATING MACHINE AND CARDS THEREFOR.

APPLICATION FILED NOV. 13. 1915.

1,274,484.

Patented Aug. 6, 1918.

2 SHEETS—SHEET 1.

Fig. 2.

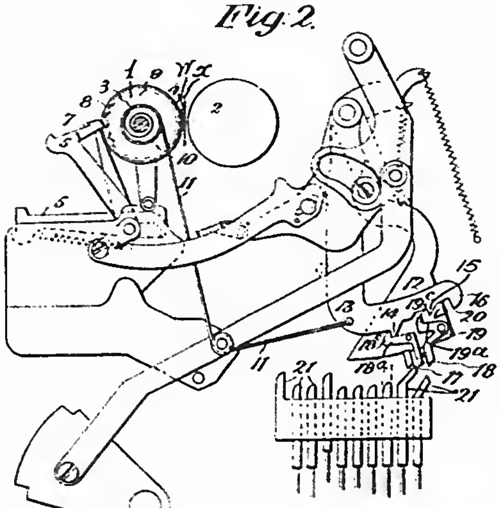
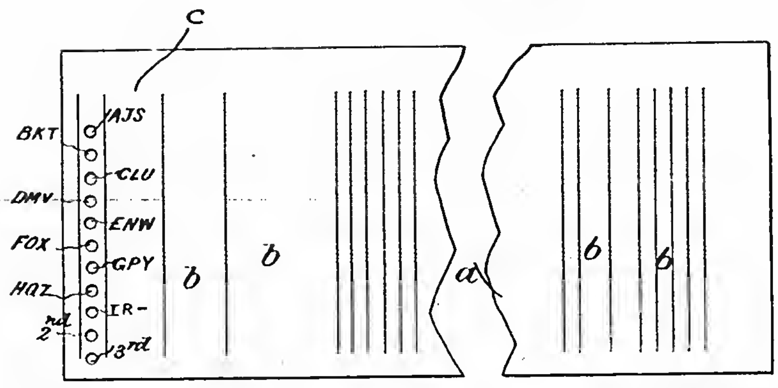


Fig. 1.



Witnesses:
Chas. E. Whiteman
H. D. Penney

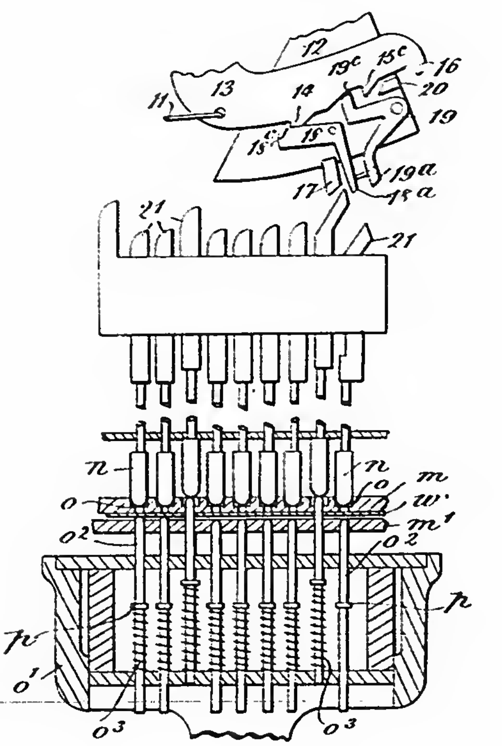
Inventor:
Robert Neil Williams,
By his Atty, F. H. Richards.

R. N. WILLIAMS.
TABULATING MACHINE AND CARDS THEREFOR.
APPLICATION FILED NOV. 13, 1915.

1,274,484.

Patented Aug. 6, 1918.
2 SHEETS—SHEET 2.

Fig. 3.



Witnesses:
Chas E Whitman.
H. D Penney

Inventor:
Robert Neil Williams,
By his Atty, F. H. Richards.

1 2 7 4 4 8 4

UNITED STATES PATENT OFFICE.

ROBERT NEIL WILLIAMS, OF LONDON, ENGLAND, ASSIGNOR TO POWERS ACCOUNTING MACHINE COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

TABULATING-MACHINE AND CARDS THEREFOR.

1,274,484. Specification of Letters Patent. Patented Aug. 6, 1918.

Application filed November 13, 1915. Serial No. 61,259.

To all whom it may concern:

Be it known that I, ROBERT NEIL WILLIAMS, a citizen of the United States of America, residing in London, England, have invented certain new and useful Improvements in Tabulating-Machines and in Cards Therefor, of which the following is a specification.

This invention relates to improvements in and relating to tabulating machines of the type in which a card is employed having perforations representing various monetary or other values or quantities, and which perforations control counting and printing mechanism whereby the said values or quantities are ascertained and translated into printed figures and impressed upon a paper or other sheet or band.

The present invention has for its object to provide means whereby certain perforations in the cards which represent the letters of the alphabet may be translated into any desired group of letters, the name of an individual for example, and translated into printed characters.

In the cards commonly employed for the machines under consideration there are provided a number of fields each representing the various data of which the particulars are to be ascertained. According to the present invention a field is provided designed to represent the letters of the alphabet, and which field is capable of accommodating a number of columns of perforations so as to provide for a number of letters comprising, for example, a name.

In order that the invention may be the better understood drawings are appended in which:—

Figure 1 is a plan of a card embodying the present invention.

Fig. 2 is a side view of mechanism designed to coöperate with said card.

Fig. 3 is a sectional view showing the cards in position in the machine and their relation to the stop pins for the sectors.

Referring to the accompanying drawings, *a* represents the ordinary card which is of standard size, and which card is divided into the desired number of fields *b* representing various data of which particulars are to be ascertained. *c* indicates a field distinct from the fields already referred to, and in which a column of perforations may be formed, each of such perforations representing a letter of the alphabet. I prefer to employ what may be termed a standard column, in which there can be eleven perforations, the presence of a perforation in any one of nine positions representing one of three letters of the alphabet. The remaining perforations above referred to indicate which particular letter of the three is intended. As an illustration, starting from the top of the column, perforations in the various positions in the column represent successively the letters:—

A	J	S
B	K	T
C	L	U
D	M	V
E	N	W
F	O	X
G	P	Y
H	Q	Z
I	R	–
2nd		
3rd		

the last of the column being utilized to represent a blank or hyphen.

In the illustration for the sake of clearness the full number of perforations are shown, each being identified by the letters it may represent. Supposing it is desired to produce the name of an individual, Smith for example, then such perforations would be formed at points in each column as would represent the particular letters S, M, I, T, H, for example a hole on the line AJS plus a hole at 3 in the first column, a hole on the line DMV plus a hole at 2 in second column, a hole at IR–, without any further perforation in 3rd column, and so on. This arrangement of letters is purely arbitrary and any other arrangement may be adopted.

By arranging the perforations in the manner described it is possible to employ the standard cards now in use upon machines also of standard construction.

While the application of the invention is not limited to any particular type of machine, it may conveniently be applied to machines such as form the subject of British Letters Patent No. 26896 of 1913, in which case there is provided a drum 1 arranged in axial alinement with the roller 2 over which the paper *x* passes upon which the items are recorded. The drum 1 is spring driven in one direction by means of a spiral spring 3 disposed therein, and it is so mounted as to be capable of a certain motion transversely of the line of its center of rotation. The periphery of the drum 1 is provided with type 4, a hammer 5 being provided which in striking the drum causes it to move forward and impress the paper *x*. The hammer may carry a pawl 7 which, engaging suitably shaped teeth 8 upon a ratchet wheel 9 upon the drum 1, will assist in positioning said drum should it have moved slightly beyond the desired limit. Coiled around a sheave 10 upon the type drum is a flexible body such for instance as a steel or other substantially inextensible wire 11, and which wire 11 at its opposite end is attached to a spring controlled swinging member 13 mounted and actuated in the same manner as the tabulating actions of the aforesaid machine, and which member 13 has three projections 14, 15, 16, upon its periphery. 12 indicates a sector by means of which, as will presently be explained, additional movement may be permitted to the swinging member 13. The sector 12 is provided with a single projection or stop 17 and in addition thereto it has secured to it two bell crank levers 18, 19, one arm 18^a 19^a of each of said levers being provided with a tooth 18^b 19^b adapted to engage projections 14 15 upon the swinging member. The levers 18 19 are disposed so that one end will engage one of the control pins 21, positioned in the manner described in the specification of the aforesaid Letters Patent No. 26896 of 1913, when such pin 21 is raised and the levers are coupled together so that while the first, 18, may be operated alone, the second, 19, cannot be operated without actuating the first. When the second lever 19 is actuated the movement of the member 13 is limited by the third stop 16 thereon which comes into contact with projection 20 on the face of the member 12.

As shown in Fig. 3 the card indicated by *w'* is fed by rollers not shown, between perforated plates *m* m^1 with which coact several series of pins such as those 21. The lower ends of the pins 21 are provided with heads *n* supported in recesses *o* in the upper perforated plate *m*. Arranged beneath the lower perforated plate m^1 is a pin box o^1 vertically reciprocated by means of a roller and cam as described in the aforementioned British Patent. The pin box o^1 carries several series of pins such as o^2 the said pins being urged upward by means of the springs o^3 by which they are encircled, the upward movement of each of said pins o^2 being limited by means of a collar *p*. The rise of the pin box allows any pins o^2 in register with holes in the card to raise the corresponding pin 21 which remains protruding from the bottom of the pin box against the action of the spring o^3. When the box descends the pins o^2 under the action of their spring are withdrawn and the card is ejected, the parts then being returned to their initial position.

The card previously provided with the desired perforations in the various fields is passed through the machine, and while the tabulating mechanism of the main machine is being set, the perforations in the name field will cause an appropriate setting of the control pins of each of the sectors 12. One sector is provided for each column upon the field together with a set of control pins 21. By this means each of the type wheels or drums will receive a corresponding setting so that when the printing of the values represented by the perforations in the main field is effected there will simultaneously be printed the name of the individual concerned. The operation of the sector 12, swinging member 13, hammer 5, is effected in the same manner and by similar means to the corresponding members of the main machine. A suitable ribbon *r* is provided for the type.

I claim:

1. In a machine for tabulating statistical and other data, mechanism controlled by a perforated card whereby certain perforations in said card may be indicated as letters of the alphabet, said mechanism comprising a type wheel having a complete alphabet thereon, a row of pins for controlling the type wheel, the pins being adapted to coöperate in combinations; and means for positioning said type wheel according to the combination of the controlling pins.

2. In a machine for tabulating statistical and other data, mechanism controlled by a perforated card whereby certain combinations of perforations in said card may be indicated as a word, said mechanism comprising a type wheel having a complete alphabet thereon, a row of pins for controlling the type wheel, the number of controlling pins being less than the number of letters in the alphabet on the type wheel, the pins being adapted to coöperate in combinations; and means for positioning said type wheel according to the combinations of controlling pins.

3. In a machine for tabulating statistical and other data, mechanism controlled by a perforated card whereby perforations arranged in a single column in said card may be indicated as letters of the alphabet, the number of perforations in a row being less than the number of letters in the alphabet, the perforations forming combinations with one another to indicate all of the letters of the alphabet.

4. In a machine for tabulating statistical and other data, the combination of a character carrying part provided with a plurality of different characters; a group of control pins adapted to control said part in

combinations; and means for positioning said character carrying part according to the combination of the control pins.

5. In a machine for tabulating statistical and other data, the combination of a character carrying part provided with a plurality of different characters; a group of control pins adapted to control said part in combinations, the number of pins in said group being less than the number of characters on said part; and means for positioning said character carrying part according to the combination of the control pins.

6. In a machine for tabulating statistical and other data, the combination of a group of pins adapted to be controlled by perforated cards; a pair of relatively movable members both movable relative to said group of pins, certain of the pins being adapted to stop one of the members; a type carrying part operatively connected to the other pin; and means controlled by said pins for causing relative movement between said members.

7. In a machine for tabulating statistical and other data, the combination of a group of pins adapted to be controlled by perforated cards; a movable member and a movable part adapted to move relatively to said pins and each other; a spring operated character carrying part operatively connected to said movable part; and means controlled by certain of said pins to permit and prevent limited relative movement between said movable part and member, said member being adapted to be controlled in its movement by other of the pins.

8. In a machine for tabulating statistical and other data in which a swinging sector is employed controlled by pins the operation of which pins is in turn controlled by means of perforated cards, a spring controlled drum, type upon said drum, a sheave upon the spindle of said drum, a flexible body wound upon said sheave and connected to the sector, whereby the type bearing drum may be positioned by means of perforations in the card.

9. In a machine for tabulating statistical and other data in which a swinging sector is employed controlled by pins the operation of which pins is in turn controlled by means of perforated cards, a spring controlled drum, type upon said drum, a sheave upon the spindle of said drum, a flexible body wound upon said sheave and connected to the sector, a second sector, levers upon said sector, stops upon the first sector engaging said levers, stops operated by pins which in turn are operated by perforations in the card and whereby the position of the sector controlling the type drum is regulated.

In witness whereof I have hereunto set my hand in the presence of the two undersigned witnesses.

ROBERT NEIL WILLIAMS.

Witnesses:
JOHN H. JACK.
GRACE H. PETERS.

C. FOSTER.

TABULATING MACHINE.

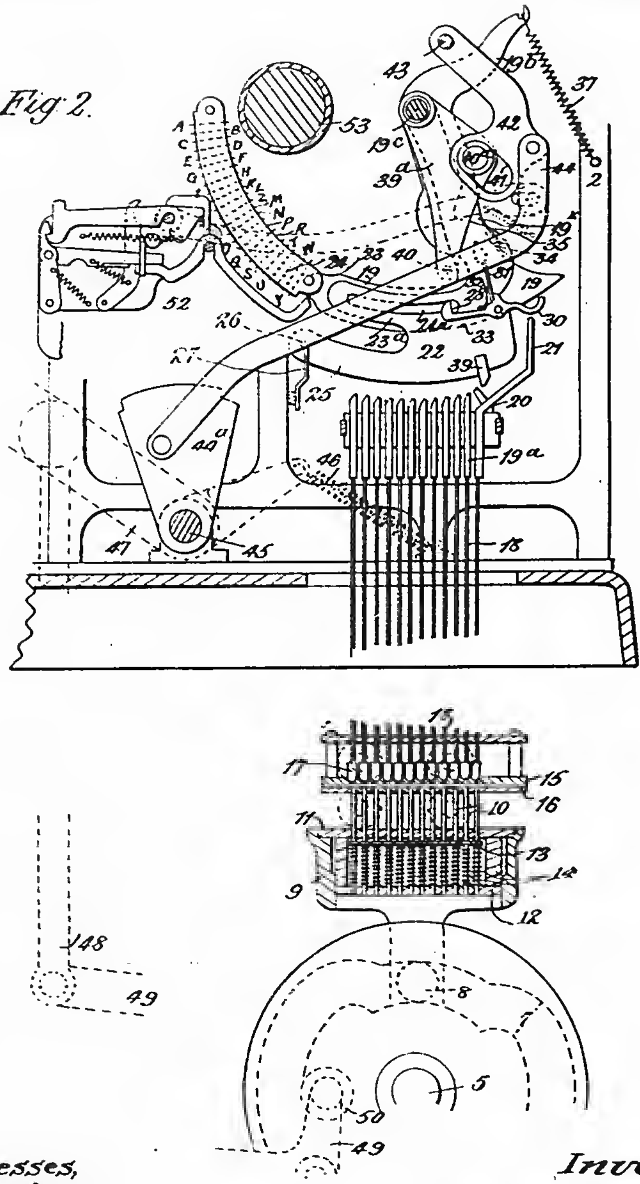
APPLICATION FILED SEPT. 18, 1917.

1,274,528.

Patented Aug. 6, 1918.

3 SHEETS—SHEET 2.

Fig. 2.



Witnesses,

Chas. E. Whitman

H. D. Penney

Inventor:

Charles Foster,

By his Att'y, F. H. Richards.

C. FOSTER.
TABULATING MACHINE.
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3 SHEETS—SHEET 3.

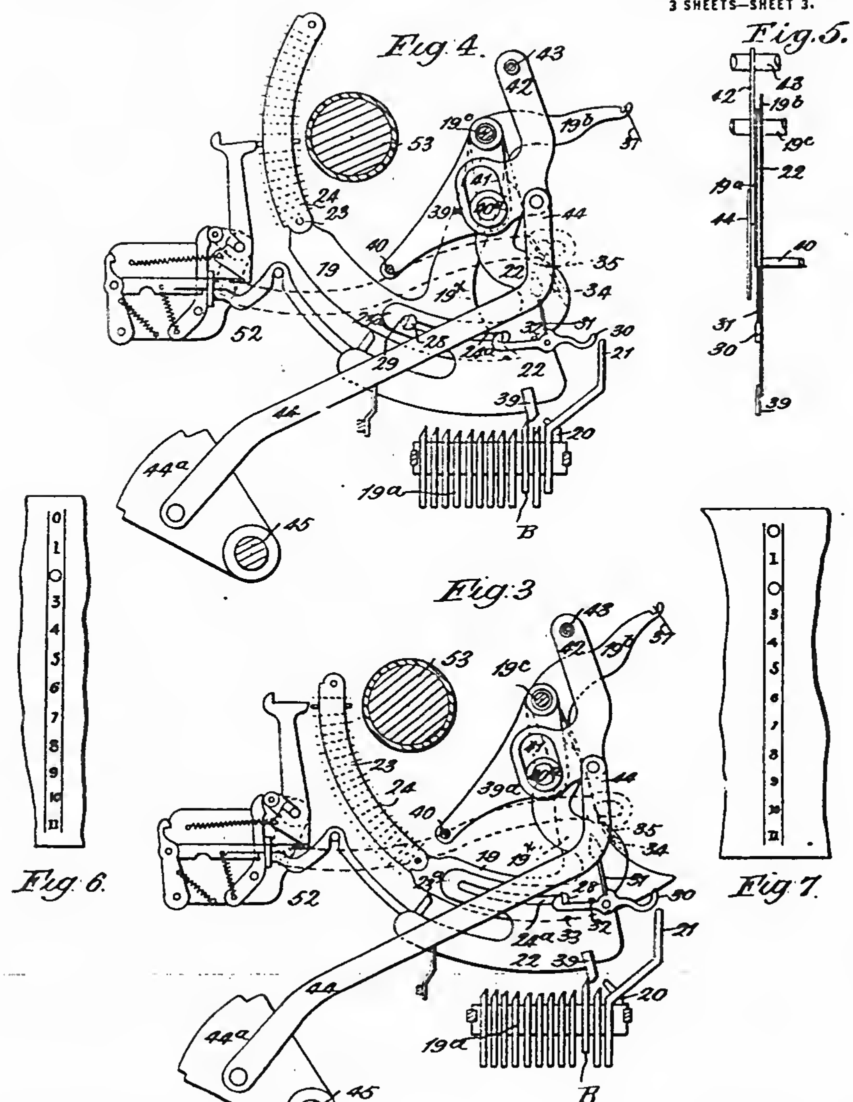

Fig. 4.
Fig. 5.
Fig. 3
Fig. 6.
Fig. 7.

Witnesses,
Chas. E. Whitman
H. D. Penney

Inventor:
Charles Foster,
By his Att'y, F. H. Richards.

UNITED STATES PATENT OFFICE.

CHARLES FOSTER, OF CROYDON, ENGLAND, ASSIGNOR TO POWERS ACCOUNTING MACHINE COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TABULATING-MACHINE.

1,274,528. Specification of Letters Patent. **Patented Aug. 6, 1918.**

Application filed September 18, 1917. Serial No. 191,930.

To all whom it may concern:

Be it known that I, CHARLES FOSTER, a subject of the King of Great Britain, residing in Croydon, Surrey, England, have invented certain new and useful Improvements in and Relating to Tabulating-Machines, of which the following is a specification.

This invention relates to improvements in and relating to tabulating machines.

It has already been proposed in the specification of British Letters Patent No. 2384 of 1915 to translate perforations in a card into alphabetical characters whereby groups of letters may be printed. In the case just referred to a card is employed having a field in which a limited number of perforations may be formed representing letters of the alphabet arranged in a single column and which perforations, by means of one or more additional perforations may be given a differential alphabetical meaning.

The present invention has for its object to provide improved mechanism designed to be operated by a card such as that just above referred to and in which, as distinguished from the known mechanism, in place of a spring actuated type drum controlled by a swinging sector the position of which is controlled by the aforesaid card acting upon settable stops, corresponding in number to the possible number of perforations in the alphabetical column, there is provided a swinging sector which sector itself carries the type, and is positioned by the settable stops. As in the prior case before referred to the settable stops may form part of a machine constructed in accordance with specification of British Letters Patent No. 26896 of 1913, and the sector may be operated in the manner and by the same means as the figure bearing sectors of the said machine.

In order, however, that the sector may accommodate the desired number of alphabetical characters, the number of possible perforations in the alphabetical column of the card and the number of settable stops remaining the same, in accordance with this invention, the type carrying portion is elongated to twice or approximately twice its ordinary length, and provision is made whereby either portion may be brought into the effective position.

In practice according to one form of the invention a swinging sector is employed constructed and operating substantially in the manner described in the aforesaid specification of British Letters Patent No. 26896 of 1913, said sector, however, being unprovided with teeth as it is not required to operate any counting mechanism. The sector just referred to is operatively associated with a second sector which corresponds substantially with the type sector of the aforesaid machine of the prior British Letters Patent No. 26896 of 1913 except that it is extended in length as already stated and that provision is made whereby without affecting the normal swing of the said sector either the main or extended portions may be brought into position so that the type hammer may act upon the selected type. The setting of the type sector is controlled by the first sector the movement of which in its turn is controlled by a series of settable stops acting upon a stop on said first sector. The two sectors are latched together so that they swing as one, the latch being controlled by the settable stop, which in the earlier patent represents the zero stop. The zero may in the present instance either be left blank or a letter may be placed on the sector at a point corresponding to this. The settable stops are in number equal to any possible perforation that may be formed in the column in the card and may be twelve in number. The type sector is provided with a slot in which works a pin on the swinging sector, whereby the forward movement of the said type sector is limited. The latch aforesaid may conveniently engage said pin so that when the said pin is engaged the forward part of the type sector may be brought into the operative position and when free of said latch and engaging the forward end of its slot, the rear portion of the type sector is in the operative position.

In order that the invention may be the better understood drawings are appended illustrating the application of the invention to a machine of the type forming the subject of the aforesaid British Letters Patent No. 26896 of 1913. It will be understood that one alphabetical sector and its attendant mechanism will be required for each letter that is to be printed in line on the record at one time. Thus assuming the whole alphabet to be required 26 of such sectors would be employed. In practice, however, it is usually possible, when surnames are to be printed, to limit the number, so that the dimensions of a section or gang are not unduly large. As the construction and arrangement of each individual sector is the same whatever the number may be in the gang only one of such sectors and its attendant parts is illustrated and described.

In the accompanying drawings:—

Figure 1 is a side elevation of a machine embodying the present invention.

Fig. 2 is a side elevation to a larger scale showing the parts in their normal or unset position.

Fig. 3 is a similar view showing the parts in one printing position.

Fig. 4 is a similar view with the parts in another printing position.

Fig. 5 is a rear edge view of the printing sector and its controlling member.

Fig. 6 is a view showing the perforation in the card column designed to effect the setting shown in Fig. 3.

Fig. 7 is a similar view showing the perforations in the card column designed to effect the setting shown in Fig. 4.

In the accompanying drawings 1. indicates the lower frames of the machine and 2. the upper frames. 2^a indicates the driving shaft of the machine operated from a motor, not shown, by means of a worm 3. and worm wheel 4. see Fig. 1. 5. indicates the main shaft to which motion is transmitted from the shaft of worm wheel 4. by bevel gearing indicated generally by 6.

Mounted on the main shaft 5. are cams such as 7. which cams engage rollers 8. attached to a reciprocating pin box 9. in which pin box are arranged a number of pins 10. passing through guide plates 11. 12. The pins are each provided with a collar 13. upon which acts a spring 14. the tendency of which is to raise the pins said pins however being held down by the upper guide plate 11. which plate engages the collars 13 and forces the pins down against the action of their springs. Disposed above the pin box and rigidly fixed with respect thereto are two plates 15, 16. each plate being perforated the said perforations being in axial alinement with the aforesaid pins 10. The upper ends of the perforations in plate 15. are recessed and engaging said recesses are the lower ends of heads 17 secured to the lower ends of rods 18. to which are secured the stops 19^a. for positioning the printing sectors 19. In the example illustrated 12. settable stops 19^a are provided there being, as will be presently more fully explained, 12 positions in the card column where a perforation may be formed, see Figs. 6 and 7. 20. indicates a stop whereby the sectors 19. are held in the non-printing position. 21. indicates a stop by which as will be presently more fully explained the alphabetical type bearing sector is primarily positioned to permit the printing of certain characters. As the sectors for each letter are identical only one unit of a set is shown and described.

On reference to the drawings it will be seen that each unit comprises two sectors mounted on a shaft 19'. one, that 19 already referred to and provided with an extension 23 carrying type, of which type only one, B is shown the remainder being indicated by the lines 24. and a second sector 22.

The sector 22. is provided with an extension 23^a slotted at 24^a. and also with a second extension 25. provided with a pin or projection 26. adapted when the parts are in the non-printing position to engage a stop 27 whereby the rearward movement of the sector 22. is limited. Projecting through the slot 24^a is a pin 28. having a head 29. which is so shaped as to form a detent designed to be engaged by the latch 30. which is maintained in the latching position by means of a spring 31. Stops 32, 33, are provided to limit the movement of latch 30. 34 indicates a projection upon sector 22. which by engaging the rear edge of the arm 19^x. of sector 19. serves to keep the two sectors 19. 22 in their normal relative positions. 35 indicates a spring mounted on sector 22. and which spring bears against the edge of the aforesaid arm 19^x. and the purpose of which is to cause a slight initial movement of the said sector 19. so that when free to move forward it is caused by the said spring to assume a position such that the latch cannot again engage the head 29. The sector 19 is provided with an arm 19^b. to which is secured one end of a spring 37 the opposite end of which is secured to some rigid body which may form part of or be secured to the frame 2 of the machine. The spring 37 acts to swing the sector 22 forward when released by the moving of the stop 20 out of the path of a second stop 39. upon sector 22. 40. indicates a restoring bar which bar normally occupies the position shown in Fig. 2. The bar 40. is carried by plates such as 39^a. pivotally mounted on the shaft 19^c. The bar 40. is caused to oscillate by means of the roller 40^a of which one is mounted upon the outer surface of each of plates 39^a. and which roller engages a slot 41. formed in a plate 42. mounted upon a shaft 43. The plate 39^a. is operated by means of a rod or bar 44. connected at one end to the said plate 42 and at the other end connected to a rocking plate 44^a on a shaft 45. said shaft being under the influence of a spring 46. The shaft 45. is operated by means of an arm 47. Fig. 2. which arm is connected to the upper end of a rod 48. connected to the bell crank lever 49. one arm of which is provided with a roller 50. engaging a cam 51. The impression of the type is effected by hammer mechanism indicated generally by 52, with which is associated a platen 53, provided with an ink ribbon. As the construction and arrangement of the parts just referred to are all well known further description thereof is unnecessary.

As already explained, there are twelve possible positions for a perforation in each alphabetical column on the card and the character represented by each perforation is dependent not only upon its position in the said column but in the presence or absence of a perforation at the point indicated by the zero sign. Without a perforation at this point perforations at the points marked 1 to 11, represent the letters A to L, the letter I, serving also as J. With a perforation at the zero mark the significance of perforations at any one of the points 1 to 11 is altered and perforations at any one of the said points now represent according to their positions the letters M to Y. The perforation at the zero point may also be utilized and in itself represent a letter, for example the letter Z. The type corresponding to the respective letters of the alphabet are arranged upon the extension of sector 19 in the manner shown in Fig. 2 and they are each identified by the letter they represent. It is obvious however that the arrangement of the type in the manner shown is quite optional and its arrangement may be raised in any manner desired, it being understood that the positions of the various perforations in the alphabet column of the card will be correspondingly varied. As an example of the working of the invention it is assumed that it is desired to print the letter B. The perforation representing this letter is in the position 2 of the alphabet column see Fig. 6 and consequently the card when passing through the machine will raise the stop B as shown in Fig. 3. As the perforation at the zero point is absent, the raising of the B stop will simply free the sector from the stop 20 so that when the restoring bar 40 is swung into its outer position the sectors being latched together will move as one and when arrested by the B stop the B type will be in the position ready to be impressed upon the paper upon the operation of the hammer. The operation for any letter from A to L is the same the sectors being positioned by the appropriate stop. Assuming that the letter N is to be printed. In this case a perforation is provided at the zero point see Fig. 7. Consequently as the card passes through the machine the zero stop is raised and contacting with the end of latch 30 raises the same and frees the sector which under the influence of its spring moves slightly forward and as already explained carries the pin 28 clear of the latch. Simultaneously with the raising of the zero stop the stop which before represented the letter B is raised and the sector is free to swing outward until arrested by the said B stop. As the type sector is now free of the latch it will move forward until its movement is checked by the pin 28 reaching the end of slot 24 and when in this position the N type will be in a position ready to be struck by the hammer. The position of the parts will then be as shown in Fig. 4. The operation will be the same for any of the letters N to Y the letters X and V being omitted, the position of the sector being determined by the particular stop which has been raised. The letter L will be printed only if a perforation is formed in the zero position of the card without any other perforation in any of the remaining positions in which case the type sector will swing to the full extent of its outward movement without any corresponding movement of the sector 22.

The parts in each case are restored after the printing has been effected by the restoring bar. It will thus be seen that by means of the arrangement according to this invention I am enabled to effect the printing of practically the whole of the alphabet without unduly increasing either the number of stops or employing a number of perforations beyond the limits of the column of an ordinary card. It will be understood that the cards will be provided with a number of alphabet columns equal to the number of letters it is desired to use. Thus supposing surnames are to be printed the number of columns provided would be equal to the number of the letters required for the longest name. Assuming that 9 letters is the contemplated maximum number then only 9 letter columns would be provided.

While I have described the invention as particularly designed for the translation of perforations into alphabetical characters, it may be advantageously employed for the production of any other ciphers or numerals and it may with particular advantage be employed to reduce the number of columns necessitated where very large amounts are to be indicated. For example for tens of thousands up to a known amount say 20,000.

In machines as ordinarily constructed it would be necessary to employ four columns upon the cards and four sectors to print values up to 9,000, and five columns and five sectors for an amount up to 20,000. By providing the sectors arranged in accordance with this invention with type representing compound members it is possible by employing only four sectors to accomplish results which as above explained under ordinary circumstances require five columns and five sectors. Thus for example instead of the alphabetical type, figure types would be employed representing 1 to 20 or thereover according to the number of type which would be carried by the sector. Obviously the arrangement and construction of the extensions upon the sectors may be varied as may be found in practice to be necessary or desirable.

Claims:

1. In a tabulating machine operated by a perforated card a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in a column of the card and means operated by said card to position the swinging member to bring the desired type into the printing position.

2. In a tabulating machine operated by a perforated card a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in a column of the card, a second swinging member controlling the movement of the type sector, means for connecting said sectors, and means operated by said card to release the swinging type bearing member to permit its adjustment to bring the desired type into the printing position.

3. In a tabulating machine operated by a perforated card, a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in the column in the card, a second swinging member, stops set by the card for positioning said second member a connection between the type bearing member and the second swinging member and means for disconnecting said type bearing member from the swinging member controlled by the card whereby the said type bearing member is free to move independently of its controlling member in order to bring the desired type into the printing position.

4. In a tabulating machine operated by a perforated card a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in the column of the card, a second swinging member, stops controlled by the card for positioning said second swinging member, a spring controlled latch upon the second swinging member, a stud upon the type bearing member engaging said latch and means controlled by the card for releasing said latch whereby it may be positioned independently of the second swinging member to bring the desired type into the printing position.

5. In a tabulating machine operated by a perforated card a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in the column of the card, a second swinging member, stops controlled by the card for positioning said second swinging member, a spring controlled latch upon the second swinging member, a stud upon the type bearing member engaging said latch and means controlled by the card for releasing said latch whereby it may be positioned independently of the second swinging member to bring the desired type into the printing position, and means for giving a slight initial movement to the type bearing member whereby the accidental reengagement of the latch before the operation of the type bearing sector is avoided.

6. In a tabulating machine operated by a perforated card a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in the column of the card, a second swinging member, stops controlled by the card for positioning said second swinging member, a spring controlled latch upon the second swinging member, a slot in the second swinging member a stud on the type bearing member projecting through said slot and engaging said latch whereby it may be positioned independently of the second swinging member to bring the desired type into the printing position.

7. In a tabulating machine operated by a perforated card a swinging type bearing member having a number of type thereon greater in number than the number of possible perforations in the column of the card, a second swinging member, stops controlled by the card for positioning said second swinging member, a spring controlled latch upon the second swinging member, a slot in the second swinging member a stud on the type bearing member projecting through said slot and engaging said latch whereby it may be positioned independently of the second swinging member to bring the desired type into the printing position, and means for giving a slight initial movement to the type bearing member whereby the accidental reëngagement of the latch before the operation of the type bearing sector is avoided.

In testimony whereof I affix my signature in the presence of two witnesses.

CHARLES FOSTER.

Witnesses:
H. A. Ball,
C. F. Horwood, Jr.

THE BAUDÔT PRINTING TELEGRAPH SYSTEM

BY

H. W. PENDRY

CENTRAL TELEGRAPH OFFICE, LONDON
REG. TEACHER, CITY AND GUILDS OF LONDON INST.
AUTHOR OF "ELEMENTARY TELEGRAPHY"

WITH 94 ILLUSTRATIONS

SECOND EDITION (REVISED)

(1919)

London
Sir Isaac Pitman & Sons, Ltd., 1 Amen Corner, E.C.4
(Incorporating Whittaker & Co.)
Bath, Melbourne and New York

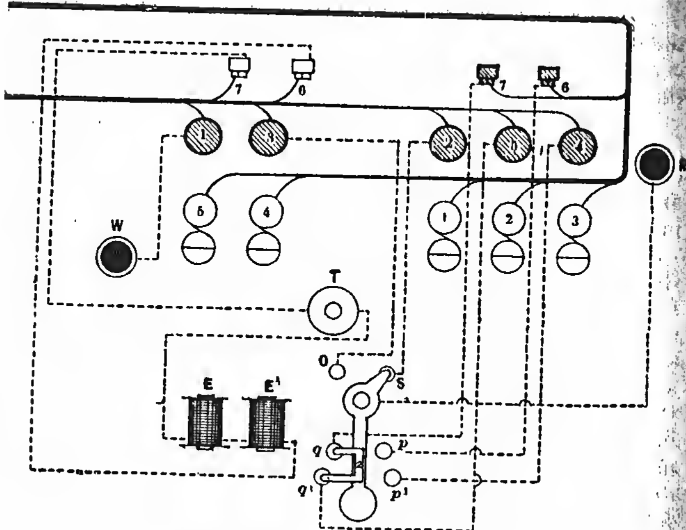

Fig. 19.
KEYBOARD—MAGNETIC—DIAGRAM OF ELECTRICAL CONNECTIONS.

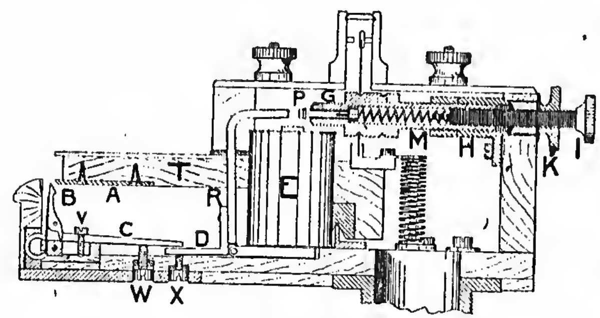

Fig. 20.
KEYBOARD WITH MECHANICAL LOCKING ARRANGEMENT.

the keys, the transmitted signals, although sufficient to correctly actuate the sender's local record, may not reach the distant station. The signals fail, and letters, say, corresponding to two instead of three marking impulses are recorded.

V	IV			I	II	III		V	IV			I	II	III
		A	I	●				●	●	P	%	●	●	●
	●	B	8			●		●	●	Q	/	●		●
	●	C	9	●		●		●	●	R	–			●
	●	D	0	●	●	●		●		S	;			●
		E	2		●			●		T	!	●		●
		É	&	●	●					U	4	●		●
	●	F	f/		●	●		●		V	'	●	●	●
	●	G	7		●			●		W	?		●	●
	●	H	h/	●	●			●		X	,		●	
		I	o/		●	●				Y	3			●
	●	J	6	●				●		Z	:	●	●	
●	●	K	(	●				●		t/	.	●		
●	●	L	=	●	●			●	●	*	*	Erasure.		
●	●	M	)		●				●	Figure Blank.				
●	●	N	№		●	●		●		Letter Blank.				
		O	5	●	●	●								

Fig. 21.
BAUDÔT SIGNALLING CODE OR ALPHABET (FRENCH).

The hands should be kept as flat as possible, with the arms resting upon the table, or, if the table is too low for any particular operator, a pad of message forms may be used. The tips of the fingers should not be employed, but as much of the surface of the fingers as possible brought to bear on the keys.

It is recommended by experienced operators that, when passing from one letter to another, only those keys should be released which are not required for the next combination. For example, with the letters D, O, the keys I, II, III, IV would be depressed for D, and O formed by the release of the 4th key.

Letters	Figures	KEYS V	KEYS IV		KEYS I	KEYS II	KEYS III	Letters	Figures	KEYS V	KEYS IV		KEYS I	KEYS II	KEYS III
A	1				●			P	+	●	●		●	●	●
B	8		●				●	Q	/	●	●		●		●
C	9		●		●		●	R	–	●	●				●
D	0		●		●	●	●	S	7/	●					●
E	2					●		T	²	●			●		●
F	5/		●			●	●	U	4				●		●
G	7		●			●		V	¹	●			●	●	●
H	¹		●		●	●		W	?	●				●	●
I	3/					●	●	X	9/	●				●	
J	6		●		●			Y	3						●
K	(	●	●		●			Z	:	●			●	●	
L	=	●	●		●	●		–	.	●			●		
M	)	●	●			●		✱	✱	●	●		(Erasure)		
N	£	●	●			●	●	Figure & space	shift		●				
O	5				●	●	●	Letter & space	shift	●					
/	1/				●	●									

FIG. 22.

BAUDÔT SIGNALLING CODE OR ALPHABET (BRITISH).

A guard against the operator allowing the keys to rise too early is provided by a mechanical locking arrangement. This is illustrated in Fig. 20. A is a steel plate underneath the key T, and when the key is depressed A is caught by the hook B. The key is held down during the remainder of that revolution of the distributor brushes until the passage of the cadence current through the electro-magnet E attracts the armature R, which causes D to raise C and throw back B, which releases A, and allows the key to resume its normal position.

The stop P, which is adjustable by the screw I and the lock nut K, takes the blow of R, and emits a sound sufficiently loud to act as the cadence warning for the operator.

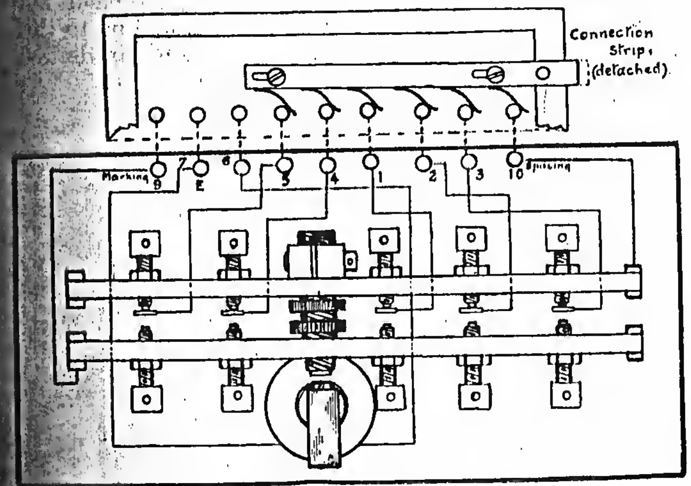

FIG. 23.

INTERNAL CONNECTIONS OF DUPLEX KEYBOARD.

In the earlier pattern a telephone is used for the cadence and an electro-magnetic locking is employed for the 4th and 5th keys (see Fig. 18).

When a keyboard is used on a simplex working set, the switch makes the changes necessary for the arm to become "receiving" instead of "sending," or *vice versa.* For duplex working the switch is unnecessary, but, if provided, must of course be maintained in the "send" position. All of the British Post Office inland circuits are fitted only for duplex working, therefore the switch has been removed with obvious advantages of economy and efficiency. This

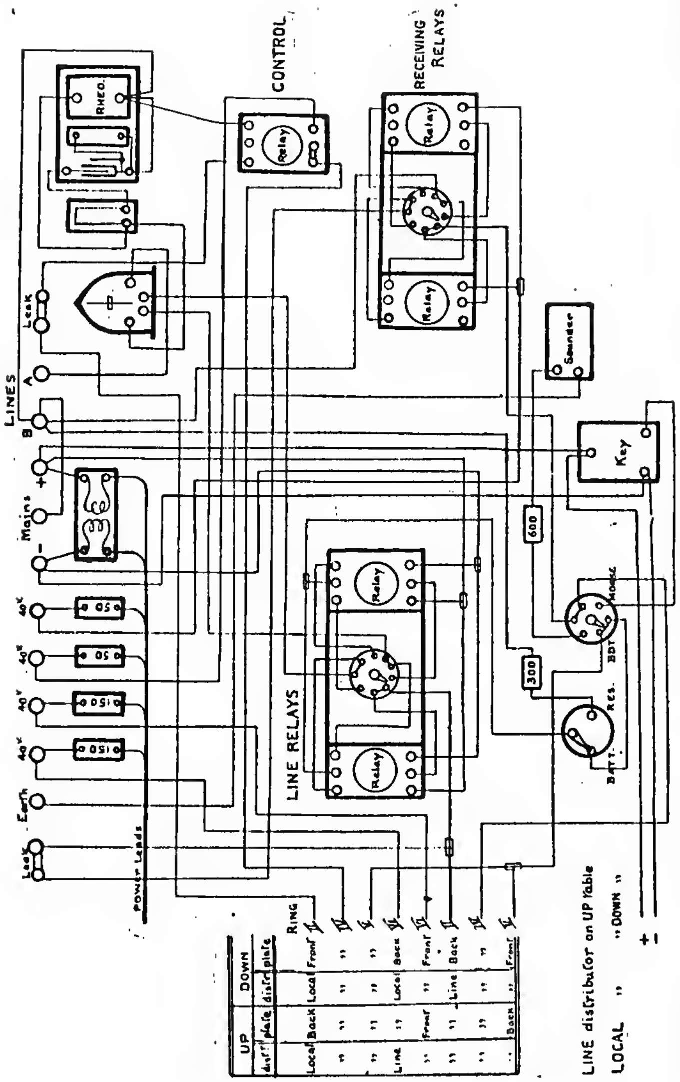

FIG. 86.

DISTRIBUTOR TABLE CONNECTIONS OF A DIVIDED DUPLEX AT INTERMEDIATE STATION.

the *thirds* which are then given by the Intermediate station.

Working currents follow the paths already traced.

In the event of an additional arm being required, say, between the Up and the Down stations, it would only be necessary for the Intermediate station to disconnect the keys and join arm C segments, ring II, to those of arms A and B, on both of the line distributor plates at the connection case, and disconnect that arm from the leak on both of the " Local " distributor's rings II.

The values of the resistances used in the Up Control leak and the Down Receiving leak should be identical. A similar equality is essential in the Down Control leak and the Up Receiving leak. This provision is necessary in order to preserve the terminal stations line balances. It may have been observed that when the Intermediate station's brush is passing over the first ten segments of ring II that the incoming line currents have two paths open to them, one through the line relay contacts and the other through the Receiving leak. As the ring II brush proceeds to arms C and D the two paths are then, one *via* the keys, the other *via* ring V local distributor and the ring II segments which are joined to the Control leak.

Turning to the full distributor-table wiring (Fig. 86), it will be seen that the usual connections of a duplex Baudôt have been closely followed. The Line and Receiving relays are paired, the one working and the other in reserve.

AUTOMATIC BAUDÔT

It was thought that some advantage might be gained by using a Baudôt keyboard perforator invented by M. Carpentier. This keyboard, which resembles that of a typewriter, is illustrated in Fig. 87. The machine perforates a slip which is passed through a transmitter. As this would easily exceed the speed of the ordinary Baudôt keyboard—namely, 30 words per minute, or half the rate of an expert typist—it was assumed that the operator would, therefore, have ample time in which to sign or check messages without the line being idle for a moment.

The appliance has, however, not been developed in this country. For it was found that the operator was unable to check the slip during its preparation, and consequently had to verify its accuracy by the transmitter's control record,

FIG. 87.
KEYBOARD FOR AUTOMATIC BAUDÔT PERFORATED SLIP.

produced as the signals passed to line. Therefore, while checking the messages already dealt with, it was impossible for the operator to prepare a fresh slip, and time was lost. The manipulation of the ordinary sender is readily acquired, and a good operator, during busy traffic periods, will maintain an output almost to the full capacity of the cadence speed.

A specimen of the perforated slip is illustrated in Fig. 88.

Each line of perforations forms a letter, but the continuous line of holes does not enter into the composition of the letters, being merely the means by which the slip is fed forward, and comparable, therefore, with the central line of holes in a Wheatstone perforated slip. Those acquainted with the code will readily see that the perforations represent the words printed beneath.

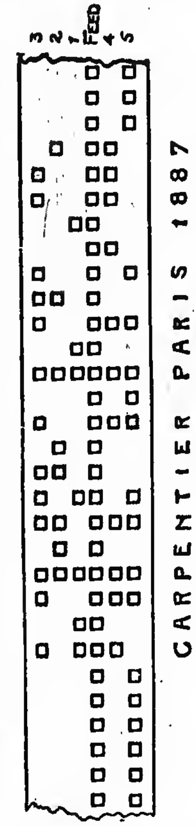

FIG. 88.
BAUDÔT PERFORATED SLIP.

The transmitter (Fig. 89) is practically a 5-key keyboard controlled by the slip. There are five springs B, which are connected to the respective segments of ring 2 in place of the key levers, and normally rest against the contact R, to which the negative battery is joined. T is connected to the positive battery.

The paper slip passes through from P to D, and is fed forward one step or one letter at each revolution of the distributor by the cadence current which passes through the electro-magnet E, attracting the armature A, pivotted at H and K. The bent levers G are thus drawn backward, and when the armature is released, the left-hand armature support, under the action of the large spiral spring, forces forward the bent levers, and with them the paper slip The points of the bent levers that come beneath holes in the paper slip pass through them and engage the lower extremity of the levers L, whose upper ends act on rods F and deflect the springs from the negative to the positive contact. This change of battery is maintained until the next revolution of the distributor, when the cadence current again passes through the electro-magnet of the transmitter, and the springs B return to R, due to their own tension.

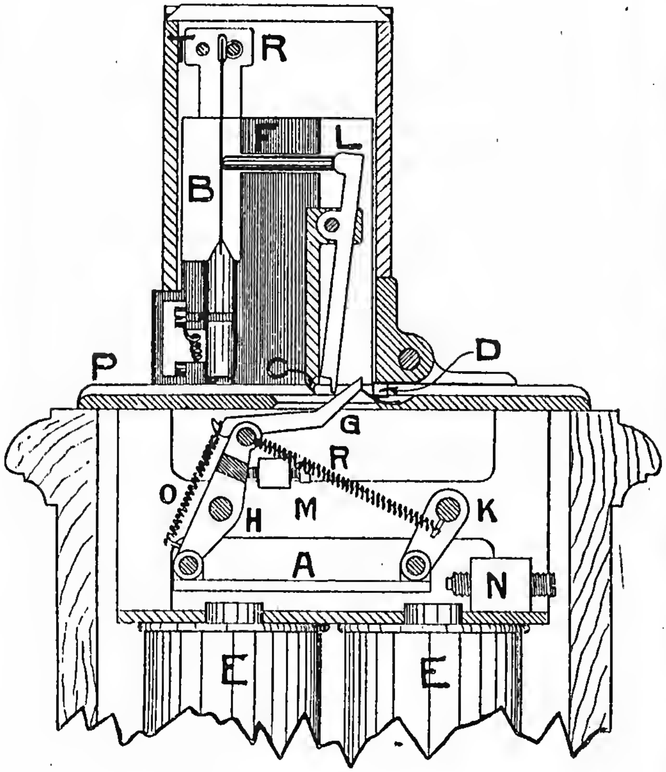

Fig. 89.
BAUDÔT AUTOMATIC TRANSMITTER.

CHAPTER XI

ADJUSTMENTS AND FAULTS

Before considering the treatment of adjustments and faults peculiar to the Baudôt apparatus, it may be advisable to briefly notice the three general faults to which a telegraph circuit is more or less liable.

(1) **Disconnections** may be caused by a broken wire, a loose wire on test board or instrument terminal, a switch in an open position, or two contact points insulated by oil, dirt, or dust.

One effect is that reception ceases, and, on a simplex circuit, an absence of a deflection on the galvanometer when the Morse key is depressed. Should, however, the line be insulated at a considerable distance, a small deflection may then be observed, caused by the leakage current, and, in the case of underground or submarine lines, a momentary kick may be noticed, due to the remaining capacity of the line.

The position of the fault may be localized by *earthing* various points in turn, and ascertaining up to which of them the circuit is perfect, and beyond which point it is defective. For this purpose an earthed battery joined to a galvanometer is applied between two testing points.

(2) **"Earth"** may be due to the conductor touching damp ground or water, and to instrument leads with defective insulation making contact with iron framework of tables or other earth connection. Sometimes earth is indicated by an apparent reduction of the line resistance, although the incoming currents are diminished or cease. Localization of the fault may proceed as in the instance of a disconnection, but the various testing points must be *disconnected* in turn, and the absence of a deflection on the testing galvanometer proves the circuit clear between the two testing points.