THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL. 10 PART 1

APRIL 1917

ADVERTISEMENT INDEX

The A.T.M. Circuit Silencer

(Registered No. 643212)

R 622.

¶ Used at Relay Stations for normally disconnecting the Sounders on through traffic.

¶ The Silencer is controlled by the operator at the terminal station, who can bring the sounder into circuit when required by a prolonged depression (usually 20 seconds) of the sending key.

¶ Special Press Keys (IN and OUT) are provided to enable the Relay Station to bring Sounder into circuit at will.

Width, 7 in. Depth, 3¼ in. Height, 7½ in. Weight, 3 lbs.

Automatic Telephone Manufacturing Co., Ltd.

Head Office and Works:
Milton Road, Edge Lane, Liverpool.

London Office:
Lennox House, Norfolk Street, Strand.

The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL

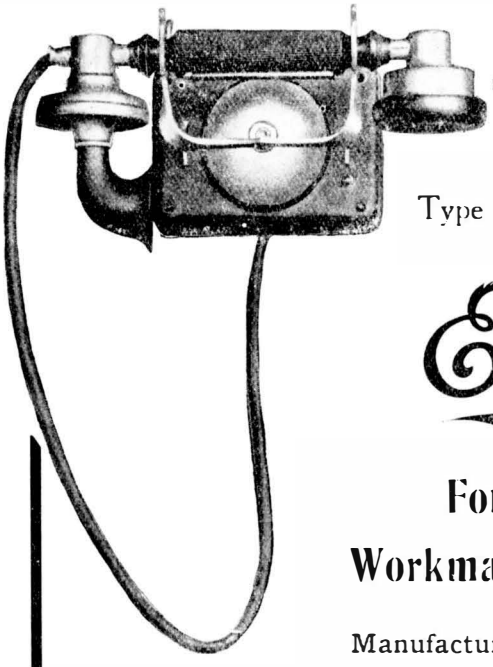
CONTENTS FOR APRIL, 1917.

PUBLISHERS:

H. ALABASTER, GATEHOUSE & Co., 4, LUDGATE HILL, E.C.

Price 1/- net, post free, 1/3. | **Annual Subscription, postage inclusive, 5/-, payable in advance.**

Editorial Communications see page 344.



Type BC 1450.

Ericsson

For High-Grade Workmanship and Finish.

Manufacturers of

Telephones, Switchboards, and Equipment

For Offices, Factories, Mines, and Field use.

ILLUSTRATIONS ARE OF

Local Battery Ringing Telephones, all Steel Cases, Inset Pattern Transmitter and Receiver.

All Enquiries to

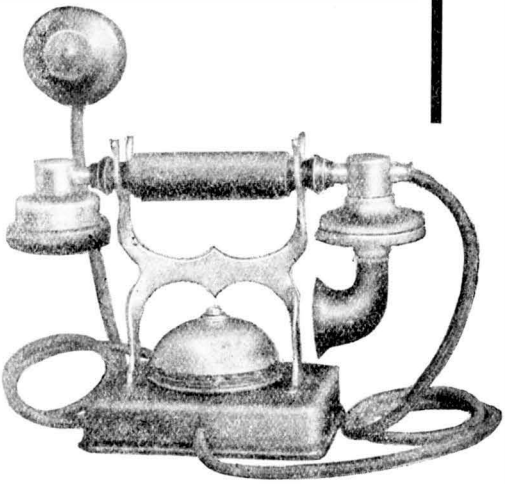
BRITISH L.M. ERICSSON

Mfg. Co., Ltd.

5, CHANCERY LANE, W.C. 2.

Works:

BEESTON, NOTTS, ENGLAND.



Type BC 2100.

THE
Post Office Electrical Engineers' Journal

REPORT OF COMMITTEE APPOINTED TO CONSIDER THE QUESTION OF HIGH-SPEED TELEGRAPHY.

THE POSTMASTER-GENERAL:

(1) In accordance with the instructions conveyed in the Minutes of December 18th, 1913, and January 23rd, 1914, we have examined the question of the present position occupied by various systems of high-speed telegraphy, and beg to submit our report. The terms of reference, as contained in the first minute alluded to, are: "To enquire into systems of high-speed telegraphy and to report thereon."

The primary object in introducing high-speed apparatus is to effect economies by increasing the output of a telegraph wire. Except in the case of very short wires, the additional cost of providing and maintaining such apparatus is less than the cost of providing additional wires to be worked with low-speed apparatus.

Before the introduction of high-speed printing apparatus, the only high-speed systems in use for inland traffic were the quadruplex Morse and the Wheatstone. The former was liable to interruption; the latter was costly in staff and caused delay to the traffic. To avoid these difficulties a number of wires was provided, which in the majority of cases was sufficient to carry the traffic with low-speed apparatus. As the volume of telegraph traffic has not for some years past shown any material growth, there has not been an urgent demand for the increased use of high-speed apparatus.

As a general rule, it would not be remunerative or expedient to take down existing wires in order to justify the application of high-

speed apparatus to remaining wires. A reduction in the number of telegraph wires has, however, been effected by converting some of them into trunk telephone wires, and in the development of the telephone service this policy of conversion must continue to be followed. In this way the economical multiplication of high-speed telegraph circuits can be effected. The economy will be twofold, first, by the saving of wires, and secondly, by the increased output per operator which is yielded by certain of the high-speed systems.

(2) The fundamental method of working any telegraphic circuit is "simplex," *i.e.* with a single operator at each end who both sends and receives messages, but it is possible with almost any telegraphic system to obtain "duplex" working with two operators or sets of operators to work the circuit, one sending and one receiving at each end simultaneously. In the Post Office service the duplex method is normally adopted on all lines where traffic justifies it. A duplex Morse circuit has a speed of thirty words per minute in each direction and a total carrying capacity of about sixty words per minute. All systems which provide a greater output than this we class as high-speed systems.

Of high-speed systems there are two classes, commonly called automatic and multiplex. The first provides an actual higher speed of working with a limit of two channels in opposite directions; the other class distributes the higher speed of the circuit among three or more operators. Of the first class, the Wheatstone, an automatic high-speed Morse, is the typical instrument; of the second class, the quadruplex, as applied to the Morse system, and consisting of two duplex circuits on one wire, is typical. A departure from the Morse system was adopted in the shape of the Baudot telegraph system; this is worked on the multiplex principle, *i.e.* any even number of channels up to twelve can be provided on a single circuit working simultaneously and equally divided between the two directions.

(3) In ordinary Morse telegraphy the method of signalling is by hand direct to line. In Wheatstone the method of signalling is by perforated slips prepared at hand speed by a number of operators and passed in succession through a transmitter, which automatically and rapidly sends Morse signals to line. In Baudot working the method of signalling is also direct by hand to line; but some of the modern developments of multiplex use perforated slip passed simultaneously through a number of transmitters each working direct to line at a relatively low speed.

(4) Numerous experiments have been made by the Post Office with various types of apparatus designed to improve the service, Many of the instruments that were the subject of evidence before this committee had undergone actual trials before its appointment.

Although, as explained in paragraph 6, the carefully designed system of tests which it was hoped would illustrate and support our recommendations could not be proceeded with, still the ample information available has enabled us to make certain definite recommendations without prejudice to further developments which may arise after the war. The following are some of the systems investigated during the last thirty years :

1885. *The Delany Multiplex* (Morse), introduced in 1885, was abandoned about 1903 on account of the difficulties in obtaining the necessary skilled and experienced operators without creating a selected technical staff to specialise on the work of adjusting and regulating the apparatus. This system was the forerunner of tuning-fork or reed control systems.

1897. *Baudot* working (type printing) to France introduced. A Baudot quadruple simplex four channels were installed and connected between Paris and London. This was the first Baudot circuit to be worked in this country.

The Squier-Crehore Synchronograph (Morse).—This system consisted of a method of sending sine waves alone into the line and forming the Morse alphabet by suppressing the alternations as required. Although a considerable increase of speed was obtainable on long direct lines, the system did not lend itself to the use of repeaters, and these when introduced on Wheatstone lines gave better results than the sine wave system.

Where manual transcription of the received messages was necessary no mere increase of speed helped the department, as it had already been found necessary to limit the speed of Wheatstone working.

1898. *The Creed Keyboard Perforator.*—This was a pneumatic keyboard perforator which was used for a number of years for press messages, but was abandoned when the Gell perforator was put on the market, as the latter did not require pneumatic pressure, and was therefore easier to instal and maintain.

1901. *The Pollock Duplex Multiplex* (Morse) was an extensive modification of the Delany system. It was under trial on a London–Liverpool wire for about twelve months and was then withdrawn because of the rather low operator average secured on the eight channels in use. This was attributed to frequent line interruptions and variations. At that time the more stable underground wires did not admit of the necessary frequency of current transmission for operating the system, and Mr. Pollock's suggestion for overcoming the difficulty of using automatic synchronous transmission (which is now used in a number of existing systems) was not adopted.

The Rowland Multiplex (type printing, quadruple duplex), an

American invention, was tried on a 400 lb. copper wire between London and Glasgow. Each arm had a speed of 40–45 words per minute. The sending was effected by a cadence typewriter keyboard and the received signals produced direct printing in Roman letters in column form. Serious inductive effects were felt on other circuits, the apparatus was cumbersome and noisy, and owing to this and the fact that the Murray system, which was then in view, promised better results, the system was abandoned without any traffic having been dealt with. It may be mentioned that Germany abandoned this system after five years' trial.

The Mercadier Multiplex (sound reading).—By this system a series of high frequency signals were sent to the line by means of transformers actuated by Morse keys. Each of the arms was tuned to a certain note, and by making suitable arrangements at the receiving end, the various notes could be selected and received on corresponding telephone receivers. The Morse alphabet was used. As only fragmentary signals were received and pronounced interference was experienced on neighbouring telephone circuits, the system was abandoned for the time being.

The Murray Automatic (type printing).—On this system a slip was prepared by means of a keyboard perforator and it was passed through a transmitter and the received signals actuated a receiving perforator which produced a perforated slip identical with that of the keyboard perforator. This slip in turn was passed through a printer, which produced the message in Roman characters on a telegraph form. An exhibition set was tried between London and Glasgow in October, 1901, after which it was decided that two complete sets should be made at the Holloway factory.

1902. *The Creed Receiving Perforator.*—This consisted of an arrangement whereby ordinary Wheatstone signals could be utilised for reproducing a Wheatstone slip and thus the necessity for re-perforating fresh slip by hand was avoided when a message or an item of news had to be re-transmitted.

As a result of the experimental trial arrangements were made for three of these instruments to be constructed for a commercial test. Additions have been made from time to time and there are now forty-five in use.

The Murray Automatic (type printing) was first used for traffic between London and Edinburgh, but was suspended after two days' trial in order to effect improvements. It was re-introduced for traffic between London and Edinburgh in the following February and continued working for about three years.

1903. *The Buckingham* (type printing) was an automatic system with a maximum speed of a little over 100 words per minute. A slip was prepared by means of a keyboard perforator and passed

through a transmitter. The signals at the receiving end were translated direct into Roman characters on what was practically a page form, although it was cylindrical in shape and had to be inserted in the apparatus by hand for each message. The system was discarded because an error in the punched slip necessitated re-perforation of the whole of the message, while several of the extra signals, such as commas, etc., were not provided for, and the operator in charge of the receiver was under high nervous tension all the time. A staff of fourteen was required when working at about 125 words per minute.

The Mercadier (sound reading).—A fresh trial on a 400 lb. copper wire to Glasgow showed some improvement, but there was no increase of volume of sound, and the interference with neighbouring circuits still existed.

1904. A further trial of the *Mercadier* was arranged, but serious interference on the telephone lines still resulted, and the Company was informed by the Postmaster-General that their system was not suited to the requirements of the Post Office.

The Murray-Creed Typewriter (type printing).—By utilising the Murray typewriter selecting apparatus it was possible to print the message in Roman letters when a perforated Wheatstone slip at the receiving station was passed through the printer. It was installed in the Central Telegraph Office, but suspended till 1906 to allow of improvements being effected.

The Telepost (Morse).—Proposals were made by the Telepost Company for a trial of their automatic system, which, so far as the receiving portion was concerned, was a revival of the long discarded Bain chemical recorder. Speeds of 1500–2000 words per minute were claimed, but such speeds were not required and the proposal was not entertained.

1905. *The Pollak-Virag Photographic System* (automatic writing).—Perforated slips were prepared on keyboard perforators and these were passed through a transmitter. The received signals actuated two telephone diaphragms, one of which governed the vertical and the other the horizontal movements of a beam of light which, acting on a band of photographic paper, caused the messages to be written in characters resembling script.

The system was abandoned after experimental trial on account of pronounced interference on neighbouring lines, the need for two heavy gauge conductors and the high cost of the photographic paper.

The Murray Multiplex (type printing).—A perforated slip is prepared by means of a keyboard perforator and this is passed through a transmitter. The signals are sent out to line *viâ* a distributor (similar to that in use on the Baudot), which connects up the line

in turn to each of the transmitters. At the receiving end of the line a distributor, running in phase with the one at the sending end, distributes the received signals to the receiving printers, which print the message in Roman letters on ordinary telegraph forms.

An experimental simplex set was tried between London and Birmingham, the latter sending and the former receiving. This was so successful that a double duplex equipment was installed on an underground circuit between London and Manchester, and is still in use. A quadruple duplex set is now on order.

The Yetman Keyboard Transmitter (Morse). — This apparatus resembled a typewriter, but in addition to typing the letters on a form it actuated a spindle on which rings were carried, each ring being made of conducting and insulated segments in such a way that a letter of the Morse alphabet could be transmitted to line when it was rotated by means of the action derived from depressing the keys of the typewriter.

It was abandoned because it effected no saving in staff or increase of output.

1906. *The Murray-Creed Printer* (type printing) was installed at Manchester, Liverpool, and Birmingham, and continued in use for about two years, when it was supplanted by the Creed printer.

The Gell Keyboard Perforator.—In this instrument Wheatstone slip is prepared. Each lever of the keyboard selects the punches for the perforation of the slip ; they are then forced through the paper by the action of an electro-magnet. There are now over 150 of these instruments in use.

The Kotyra Keyboard Perforator.—The depression of the keys of this instrument selectively operated three electro-magnets which in turn operated the ordinary manual worked perforator. The apparatus failed principally owing to the indifferent working of the rack contact arrangement by means of which the electro-magnets were worked.

1908. *The Creed Printer.*—This printer is similar in action to the Murray-Creed except that, in place of the Murray selecting device, the Wheatstone slip, in passing through the apparatus, selects a series of slide valves which admit air under pressure to pistons which actuate the required typebars of the printer. There are now forty in use.

1909. *The Baudot* (type printing). — Two quadruple simplex Baudot circuits were installed between London and Amsterdam.

1910. *The Booth-Baudot Duplex.*—The system was extended to Germany in 1910, double duplex, and in the same year a quadruple duplex circuit was formed between London and Birmingham on an underground loop. The latter was subsequently converted to sextuple duplex. There are now six inland circuits worked on this

system and double and triple duplex has been worked to Antwerp and Paris.

The Siemens' Photo Printer.—This was an automatic system. A perforated slip was prepared by means of a keyboard perforator and passed through a transmitter. At the receiving end the signals were translated by means of a rotating disc, which carried the letters in stencils on its outer edge; when the letter to be printed was opposite a moving band of photographic paper an electric spark was produced by an induction coil, with the result that, after being passed through a developing and fixing bath, a photograph of the required letter was obtained.

The system was tried between London and Liverpool and gave fairly satisfactory results when worked simplex, but when duplex was attempted the speed had to be reduced to a low figure on account of its being so sensitive to inductive disturbance and to small balance inaccuracies. The fact that the alphabet was on a 12-unit basis also militated against its adoption, and the system was finally abandoned in 1913.

1912. *The Murray Automatic* (type printing).—Mr. Murray brought to the notice of the department a new form of printer which it was claimed would work at a speed of 200 words per minute. Two complete sets of new apparatus were bought and a practical trial was made. It was found that the printer could not maintain the high speed claimed, and although the speed was subsequently reduced to 150–160 words per minute, many failures still occurred.

1913. *The Kotyra.*—Messrs. Kotyra submitted a new form of perforator devised by Captain Soldatencow. Like the original Kotyra, there were three electro-magnets, but they operated the punches direct instead of operating a manual perforator.

It was abandoned in 1914, as its construction was not sufficiently robust for the wear and tear of a busy telegraph office.

1914. *The Siemens' Automatic* (type printing).—In this system a slip is prepared by means of a keyboard perforator and is passed through a transmitter. This sends currents through a distributor to the transmitting relay, which in turn sends them out to line. At the receiving end the line relay transmits a local current through the brushes of the receiving distributor, which move in phase with those at the sending end. A series of five relays is thus actuated and the required letter is selected and impressed on the paper by means of an electro-magnet, which presses the paper against a wheel carrying the letters on its periphery.

The apparatus is placed on an underground loop and works between London and Liverpool at a duplex speed of 160 words per minute in each direction. It is still in use.

The Kleinschmidt Keyboard Perforator.—The mechanism of this

instrument is very similar to that of the Murray Perforator, except that a differential feed is provided on account of the varying lengths of the letters in the Morse alphabet. It has proved successful in its working and a number of them are now in use.

1915. *The Telepost* (Morse).—The representatives of the Telepost Company brought a set of their apparatus to make a demonstration of its powers in the laboratory. The system was tried on underground and on aerial lines, with the usual underground sections, to Birmingham and back. The maximum speed obtained was about 250 words per minute. It thus did not show any advantages over the existing systems in use and it possessed marked disadvantages.

The Western Electric Multiplex (type printing).—As in the Murray system, a keyboard perforator is used to prepare slips for passing through a transmitter. The signals are sent to line through a distributor, which is driven by a phonic wheel motor and kept to a constant speed by means of a vibrating fork. At the receiving end the line relay sends a local current through the brushes of a distributor (which are in phase with those of the sending distributor), and thence in turn to each of the printers, which have a selective arrangement similar to that of the Murray Printer; a type wheel is thus caused to rotate until the selected letter is opposite to a roll of paper, when a hammer placed behind the paper presses it against the type wheel, and causes the letter to be printed. A feature of this system is that the distributors are kept in synchronism by means of the ordinary signalling currents.

A quadruple duplex circuit is now working between London and Manchester on an underground loop, and is giving very satisfactory results.

1915. *The American Telegraph Typewriter.*—This machine is a page-printing telegraph with a direct action type keyboard. As submitted it is constructed for one-way working only, but it can be adapted to duplex. It is capable of a maximum speed of forty words per minute. It is well designed and strongly constructed, but is probably too expensive for the short lightly-loaded lines of the British Post Office, and has not sufficient carrying capacity for the long lines.

(5) It will be interesting to show to what extent other telegraph administrations have adopted high-speed telegraphy. The figures which are given on the next page are taken from the last 'Statistique Générale de la Télégraphie' issued by the Bureau International de l'Union Télégraphique.

These figures sufficiently indicate the relative position of British high-speed telegraphy. As regards the United States no figures are issued in the 'Statistique Générale,' as the two telegraph adminis-

trations are in the hands of private companies. Both companies, however, use the Morse as their general system, and have only adopted Wheatstone—in some cases with Barclay or Creed accessories—on a small scale. The Western Union Company has adopted the Western Electric Multiplex System on its more important long-distance lines.

Country.	Number of Morse and Hughes low-speed instruments.	Number of high-speed instruments.
Austria	7,105	8 Baudot.
Denmark	401	7 Creed.
France	12,714	1,155 sectors Baudot.
Germany	12,455	30 Baudot. 27 Wheatstone. 1 Murray. 16 Siemens.
United Kingdom	11,061	670 Quadruplex. 795 Wheatstone. 22 Baudot.
Italy	15,514	19 Wheatstone. 59 Baudot double. 93 ,, quadruple. 4 Rowland.
Norway	383	14 Quadruplex. 23 Wheatstone. 2 Murray.
Holland	926	
Russia	9,796	121 Wheatstone. 115 Baudot. 3 Murray.
Spain	1,843	19 Baudot.
Sweden	3,395	19 Wheatstone.
Switzerland	2,128	8 Baudot.

(6) In views of the terms of reference we considered it desirable to institute a series of tests designed to show as accurately as possible the best results which the various competing systems could produce under identical conditions. These tests are described in Appendices B. and C., but the main principles which governed them were:

(i) The employment of equally expert operating staff at each instrument under test;

(ii) The evaluation of attendant factors, such idle time due to absence of traffic, apparatus faults, and line faults;

(iii) The relation of theoretic speed to actual output;

(iv) The comparative assessment of first costs, maintenance costs, and depreciation costs;

(v) The flexibility of the apparatus in relation to fluctuations of traffic and atmospheric conditions.

Unfortunately, the outbreak of war in August, 1914, cut short these tests after the first of the series had been completed, and as

the staff selected for the purpose had immediately to be broken up and assigned to other and more urgent work, nothing further in the direction contemplated has been possible.

(7) The absence of these comparative statistics prevented the complete examination of all the claims of rival inventions based upon the conditions referred to above. A series of tests on the plan contemplated by us would be valuable and instructive, and as soon as circumstances permit it will probably become desirable that such tests should be undertaken. But as matters stand at the moment, we are convinced that the considerations on which our recommendations have been framed are sufficiently powerful. We have indicated in our report the directions in which further investigation could most usefully be made, and it is only in connection with such future investigation that we think minute statistical comparisons are likely to be of prime value.

(8) Before passing on to the actual matter of the report, we should perhaps say that, in view of the sittings of Sir Archibald Williamson's Committee on Telegraph Administration, appointed subsequently to ourselves, we have endeavoured as far as possible to refrain from touching specifically upon those questions of staff organisation and finance with which that Committee is understood to be concerned; and we have aimed at confining ourselves to the work of comparing the advantages and defects for traffic purposes of the various systems of telegraph working which we have examined.

(9) We have had twenty-eight meetings and have received evidence from the Creed-Bille Telegraph Company (twice), Mr. Donald Murray (twice), Mr. John Gell, the Western Electric Company of America, the Eastern Telegraph Company, Mr. Newlands, Controller of the Central Telegraph Office, two witnesses representing the provincial Press, Messrs. Siemens Brothers, and the Automatic Telephone Manufacturing Company. Of the various witnesses Mr. Newlands and Mr. Ryan, Assistant Electrician-in-Chief to the Eastern Telegraph Company, gave evidence at our request in order that we might have the benefit of their wide experience of the supervision of telegraph work. The representatives of the Press gave evidence at their own request, and their evidence, as being that of customers of the Post Office, is in a special category.

(10) It will perhaps be useful if we indicate the main systems or appurtenances to systems in the interests of which evidence was given. The statement does not purport to be exhaustive, and is given here for the sake of convenience:

Messrs. Creed, Bille & Co., Ltd.—Makers of receiving perforators and printers for use at the receiving end of Wheatstone automatic circuits.

Mr. Donald Murray.—Maker of the Murray automatic and

multiplex systems of telegraphy and of various appurtenances for use with other systems, notably with the Baudot.

Mr. John Gell.—Maker of (i) a keyboard perforator for punching the slip at the sending end of a Wheatstone automatic circuit; (ii) a device for use at the sending end of such circuits, whereby line time is saved by the passage of successive messages to line from each of two or more separate transmitters.

Messrs. Siemens Bros. & Co.—Representatives of the Siemens Halske direct printing automatic telegraph.

The Western Electric Company.—Makers of the Western Electric multiplex printing telegraph, and of a printing telegraph for lightly loaded circuits.

The Automatic Telephone Manufacturing Company.—Makers of a new multiplex printing telegraph, and of a printing telegraph for lightly loaded circuits.

Kleinschmidt Company.—The second appearance of Messrs. Creed and Bille as witnesses was devoted to evidence given on behalf of the Kleinschmidt Company of America. The special piece of apparatus described was the Kleinschmidt keyboard perforator, which performs functions identical with those of the Gell and other keyboard perforators for Wheatstone slip.

It may be added here that the inventions named under the first three witnesses had been tried on public work by the Post Office before our appointment. Since our appointment additional apparatus has been obtained from Messrs. Creed, Bille & Co., including twenty Kleinschmidt perforators. An order for a quadruple-duplex set of his new multiplex system has been given to Mr. Donald Murray, and the systems of Siemens and the Western Electric Company have been tried on public work. Owing to labour troubles and to the urgency of war munition work, the Automatic Manufacturing Company have not been able to supply us with a set of their multiplex apparatus; this is the more regrettable as the system is one which is not unlikely to come prominently under notice in the near future. It will call for special consideration, inasmuch as the object of the inventor is to supply an instrument which will not only meet the demand for a high-speed system for heavy traffic, but will also provide an economical printing telegraph apparatus for routes with lighter traffic.

(11) In addition to these systems and forms of apparatus, we have, of course, taken into consideration the claims of the older systems, namely, the Wheatstone high-speed automatic system (without sending keyboard perforators and receiving perforators and printers) and the Baudot multiplex system. The conditions of the British telegraph service, together with the general tendency of telegraphic practice, gradually narrowed down the problem of high-

speed telegraphy in the Post Office to a rivalry between the two systems of automatic high speed on the one hand and multiplex on the other; and although the Creed inventions and the advent of various keyboard perforators had tended to place the automatic high-speed system in a new perspective, and the inventions and writings of Mr. Murray had also intensified interest in high-speed telegraphy generally, the state of affairs at the time of our appointment was still essentially as we have indicated. In these circumstances it is a noteworthy fact, and one which encourages us to believe that our labours have not been inopportune, that we should have had occasion to consider three new and important systems in the automatic printing telegraph of Siemens and the multiplex systems of the Western Electric and the Automatic Telephone Manufacturing Company.

(12) We have thought it well to print a schedule (Appendix E) showing the names and main features of the instruments which from time to time have been brought under observation by the British Post Office or other telegraphic administrations, with brief notes as to their usefulness. The Hughes type-printing telegraph was much more favourably regarded on the continent of Europe than in the United Kingdom, where the whole tendency has been to use the Morse system almost exclusively; it is, however, essentially a low-speed system and is limited to duplex working. It may be generally said that throughout the telegraphic world the three systems of the Wheatstone, the Hughes and the Baudot have alone taken a permanent place beside the hand-worked Morse, and that the part which they have played has been a minor one.

(13) The "Morse" printed code is made up of combinations of dots and dashes, the dash being equal to three dots, the group of symbols for the different letters being of varying length, but on the average being equal to eight units where the length of the dot is the unit. The five-unit code is an arrangement whereby permutations of positive and negative impulses, always five in number, are used. The Morse is used for Wheatstone working—indeed, the Wheatstone is an automatic high-speed Morse; the five-unit code is used on the Baudot, Murray, Western Electric and Automatic Telephone Company's multiplex systems and on the automatic systems of Murray and of Siemens. There has been some controversy over the merits of the two codes, but it is manifest that for printing telegraphs a code which has the same time value for each letter and symbol has substantial advantages. There is something to be said for the legibility of Morse signals, *i.e.* they can be read at an intermediate point, whereas the impulses of the five-unit codes are meaningless until a printing mechanism with an appropriate means of selection translates them into type letters. But making full allowance for

this fact, the advantage lies undoubtedly with the five-unit code. The general adoption of this code, in one or other of its forms, is a fact which we cannot neglect. Experts generally, approaching the subject from different points of view, have reached the same conclusion, certainly with no prepossessions in the Baudot direction. No new printing telegraph has been offered to us which uses the Morse code.

(14) We proceed now to a few brief remarks on the various systems and apparatus which we have examined. These remarks should be prefaced with a few words on the historic Wheatstone system, which, though not a type-printing telegraph, occupies a unique place among high-speed systems and is of importance to the Post Office service, both in itself and in its bearing on later inventions. In point of fact the only full test conducted under our auspices was that of the Wheatstone; and it will be seen from the table appended to our report (Appendix D) that in the hands of the capable and experienced Wheatstone operators engaged upon the test the operator average secured was of high order.

Although the transmission of press news has been done by Wheatstone since the transfer in 1870, there have been some changes and developments of opinion as regards the use of Wheatstone for commercial traffic.

(15) The history of Wheatstone working in relation to the commercial telegraph traffic of the Post Office was fully reviewed in a memorandum submitted to the Secretary in November, 1910, by the Committee under the chairmanship of Mr. Leonard, which preceded us in the present field of inquiry. It will suffice for the purposes of our report to confine ourselves to saying that after the Wheatstone patents came into the possession of the Post Office at the transfer of the telegraphs, there was a period of some dozen years during which opinion was divided on the expediency of regularised Wheatstone working (*i. e.* the regular day-to-day working at particular hours of certain circuits as Wheatstone circuits), and that in 1884 regularised Wheatstone working was abolished as the result of a committee's recommendations, rules being drawn up for the adoption of so-called "spasmodic" Wheatstone working, *i. e.* the occasional use of that method at times of pressure. In the next fifteen years the stringency of these rules became gradually relaxed, until in 1900 another committee re-enacted rules still more repressive of any undue tendency to resort to Wheatstone working, and the revival under the name of "systematic Wheatstone working" only dated from about 1907, when improved keyboard perforators at the sending end and the introduction of slip gumming at the receiving end began to show signs of alleviating the most serious drawbacks attendant upon a wide use of the system.

(16) In the early days of our appointment, before any evidence had been heard by us, a meeting of provincial telegraph superintendents and others prominently concerned in the control of Wheatstone working was held, and in the paper then read powerful arguments were brought forward in support of the view that in a service where the only alternatives are Morse sounder with spasmodic Wheatstone and Morse sounder with systematic Wheatstone, the latter is the preferable course. This position need not now be discussed ; the fullest recognition of its cogency does not affect the fact that the disadvantages of systematic Wheatstone working for ordinary traffic have always been recognised, and although keyboard perforators and the gumming of slip have done much latterly to smooth away the difficulties, the system still presents problems in organisation which are only tolerable in so far as they are unavoidable, or avoidable only at the expense of greater evils. These problems have been further modified by Creed working.

(17) Special conditions of Wheatstone working obtain when the inventions of the Creed-Bille Company are used at the receiving end of Wheatstone circuits. The writing up of the received Wheatstone tape on which the dots and dashes of the Morse code are printed (*i.e.* its translation into ordinary writing by telegraphists who can read the Morse characters) presents one of the main difficulties of organisation connected with the Wheatstone system. The Creed inventions aim at meeting this difficulty by producing by means of their receiving perforators a punched or perforated slip identical with the perforated slip at the sending end. This re-perforated slip can either be run directly through a Wheatstone transmitter for onward transmission, or the perforations can be translated into type letters by the Creed printer if the message is one for delivery from the receiving station.

(18) The addition of the Creed inventions to the framework of the Wheatstone system does not render that system a desirable one for commercial telegraph work. In the first place, the problem of obtaining corrections (R Q's) is no nearer solution. Multiplex working has the outstanding advantage of placing operator in direct association with operator, exactly as if they were working low-speed duplex, so that any apparent error or failure can at once be rectified. To obtain corrections or repetitions on a high-speed system where the operators at each end are not in direct communication one with the other entails delay and the transmission of telegrams is frequently interrupted. Further, while the use of Creed re-perforators and printers goes far to remove the difficulties created by a large number of slip-writers, it cannot be overlooked that new difficulties arise in other directions. The working speed of the printers does not exceed 120 words per minute, and this rate, though sufficient for ordinary

purposes if fully maintained, cannot be kept up without a heavy strain on the delicate mechanism of the apparatus—a strain found to result in frequent small breakdowns which in the aggregate gravely prejudice the system.

Messrs. Creed have urged upon the Post Office the facilities possessed by their machine for extensive re-arrangements of telegraph traffic circulation which would have as their object wholesale saving in circuit equipment, and which would take the form of having Creed re-perforators at central points upon which transmitted telegrams would be concentrated. While this system is used for news, for long wires worked to cable stations and for special season traffic, there is a serious difficulty in the way of its wide diffusion for ordinary commercial work. It presupposes an extensive use of Wheatstone working. A system of inland telegraphy which relies on the principles of concentration and retransmission must increase the transit time of a large proportion of work; each such retransmission involves additional delay and increased cost of plant, office accommodation, staff, and supervision at the larger offices, where such costs are exceptionally high. There are not many cases in which the closing down of the less important direct circuits by means of an additional transmission is desirable.

(19) The greatest objection to the extensive adoption of the Creed instruments is their cost. They are expensive to acquire and difficult and expensive to maintain, and the advantage gained by their use with the Wheatstone system on commercial circuits cannot be put higher than an increase in operator-average which must be regarded as too dearly bought when the cost and complexity of the re-perforators and the printers are taken into consideration. No doubt it might be possible, as the inventors assert, for the Post Office to obtain results from their apparatus which would up to a point show decided improvement upon the existing results if the Post Office were to abandon its general policy and were to restrict rotation of duties and to adopt specialisation in Creed working; but this is a matter on which all inventors are on an equality.

(20) So long as a new system is on its trial there can be no objection to the practice of selecting a few specially adaptable operators to manipulate it; and under such conditions any system should give its best results. A national telegraph service involves the use of several types of apparatus, and it is essential that the general body of operators shall be expert with more than one type; otherwise there will be considerable waste of staff. The principle of specialisation would also operate prejudicially against those operators selected for the rare or special types of apparatus, as they would be incapable at a later period of acting as supervising officers. It follows, therefore, that when a system has once been adopted for

continuous use specialisation among the operators must, in the interests of both the service and the staff, be very sparingly permitted.

Ever since the transfer of the telegraphs to the State in 1870 it has been a guiding principle to extend the telegraph system even to remote villages, and this involves the employment of various types of apparatus and makes it impossible to adopt one particular system to the exclusion of all others. Such a course would be most prejudicial to the public interest. Large sums of money would have to be expended upon costly apparatus which could only be used for a small portion of the day, and the general adoption of any one system would render difficult the introduction of any new system.

(21) The inventions of Mr. Gell are the keyboard perforator and the alternate transmission method of Wheatstone working. Mr. Gell's keyboard for the perforation of Wheatstone slip at the sending end of a circuit is one of the most efficient instruments which the Post Office has tried for this purpose, and to assist in the recent revival of systematic Wheatstone working a large number of these machines has been bought, about 150 being now in use. The Gell keyboard perforator is convenient in shape and dimensions, suitable to Post Office requirements except for a slight hardness in touch, and of good design and construction, but the cost, even for a first-rate piece of workmanship, is very high.

(22) The second of Mr. Gell's inventions is a system under which an automatic switch is used to connect two or more Wheatstone transmitters direct to line in turn, the main duty of the "Key Clerk" necessary in ordinary Wheatstone work thus being performed mechanically. A further advantage is that messages are sent successively to line, and that by avoiding the use of separate short slips line time is economised. This highly ingenious invention, if perfected, would improve systematic Wheatstone working. It was twice tried with indifferent success on the ordinary circuits from Bristol to Leeds and Liverpool to Glasgow shortly before our appointment, but the inventor appears in the meantime to have made substantial improvements which would justify a further trial. It was our purpose, therefore, to include the system among our series of tests, and notwithstanding our general recommendation against Wheatstone working for ordinary traffic, we think that such a further trial should be made. If successful, Mr. Gell's system will effect a slight increase in the operator average with the ordinary Wheatstone methods with the Creed attachment.

(23) The Kleinschmidt keyboard perforator is an instrument fulfilling the same functions as the Gell perforator. Evidence on behalf of the inventors was laid before us by Messrs. Creed, Bille & Co., who have a business arrangement with the Kleinschmidt

Company in the same way as they formerly had with Mr. Gell, the Creed receiving apparatus requiring at the sending end the use of a suitable keyboard perforator. Two Kleinschmidt perforators, purchased at our instance, have been tested, and as the result of the trial twenty additional perforators have been purchased. They are considerably cheaper than the Gell perforator, and appear to be thoroughly satisfactory for their purpose. We do not, however, anticipate any further considerable demand for Morse keyboard perforators unless it should be proved that they are more suitable for news work than other perforators.

(24) The need in connection with both typewriters and typewriter keyboards for Post Office use has been to come to a conclusion as to the standard forms best adapted for general use. A small committee presided over by one of us has recently reported on this question in its relation to high-speed telegraphy.

(25) The Post Office has had considerable experience of the Murray automatic high-speed system, and, despite its undoubted ingenuity, that experience has not been wholly favourable. It is, however, scarcely necessary to enter at length into an estimate of the merits of this invention, as Mr. Donald Murray has arrived at the conclusion that his automatic system—like automatic systems in general—is not so well adapted for Post Office needs as multiplex systems.

(26) The Siemens-Halske is a direct printing system, printing messages on slip. It provides a method of transmission with keyboard perforators at the sending end similar in operation to the Wheatstone automatic, but with receiving perforators at the receiving end. It possesses the advantage—which it shares with the Western Electric and Murray Multiplex instruments—that the received impulses act directly, without the interposition of a perforated slip, on the printing mechanism. Each perforating keyboard becomes a re-perforator by means of the insertion of a plug with a loose cord. The system makes use of a five-unit code and a method of perforating which differ from those in use on the multiplex systems, and this prejudices the value of the apparatus in its present form to an extent which makes it somewhat inferior to inventions supplemental to the Wheatstone system for work involving retransmission.

(27) The systems to which we have referred are all automatic high-speed, and the multiplex systems have now to be considered. We are satisfied that for ordinary commercial telegraph work between the main centres of the British Post Office service the inventions based on the multiplex method are superior. Multiplex systems conduce to economy in staff and in office equipment, they are subject to less serious stoppages and delays than automatic systems, and necessitate less spare plant and less costly main-

tenance, and they are economical in respect of lines and of paper tape for transmission.

(28) The fundamental principles of nearly all multiplex instruments are based on the Baudot system, invented over thirty years ago. Ten years later it assumed, under the hand of the original inventor, practically its present form. Although some of its main principles had been anticipated by earlier inventors, Baudot was the first who combined them into a system of practical utility, and the production of the system may be regarded as marking an epoch in the history of telegraphy. The leading features of the Baudot system are: (i) Its method of obtaining synchronism; (ii) its direct transmission from keyboard to line; (iii) its cadence and speed; (iv) its direct printing on slip.

(i) "Synchronism" is a feature of all multiplex systems, essential to the maintenance of correspondence in speed between the distributors placed at the sending and receiving ends of the line, a necessity which, in view of the speed of the distributor, involves delicate and complicated mechanism, and is, in fact, both the distinguishing feature and the vulnerable point of multiplex systems. The Baudot maintains synchronism by means of a centrifugal friction governor, a mechanical correcting device and a special correcting signal. In the Western Electric multiplex this special signal is dispensed with and the message signals are utilised for correction of phase. The relative merits of these approved methods of correction are still undecided.

(ii) and (iii) In the Baudot, as usually worked, the sending operators depress combinations of five keys (similar to the white keys of a piano) according to the five-unit Baudot alphabet and transmit the signals direct to line. Each arm of the Baudot is worked regularly at a uniform speed of thirty words a minute, and each operator knows by observing the "cadence" or rhythm of the system when the distributor gives him the use of line wire. In 1887 Carpentier designed a keyboard perforator to be used in conjunction with the Baudot, but it was not brought into practical use.

(iv) The Baudot prints in type letters on a receiving tape. This tape has to be gummed on telegraph forms. In this respect it differs from other systems, which print direct on the forms themselves, and to which reference will be made later.

(29) The Baudot has been in use for a considerable time on an underground loop between London and Birmingham, where it has been worked on the duplex principle with quadruple and latterly with sextuple, that is to say, with four arms in each direction and latterly six arms in each direction. There is quadruple duplex Baudot working (two circuits) on underground wires between London and Glasgow and quintuple duplex working between

London and Liverpool. Baudot has also been installed between London and Brighton. Experience has definitely proved that at least eight channels with thirty words a channel can be provided on a loop or on a single aerial line. As all multiplex systems are now worked duplex, it is of interest to record that this was first accomplished with the Baudot apparatus in 1906 on a method devised by Mr. A. C. Booth, of the engineering staff of the Post Office.

(30) The speed for which the Baudot apparatus has been designed and constructed, viz. thirty words per minute for each operator, could be increased without a radical modification of the system, but experience has shown that a much greater increase of speed can be obtained by the use of type keyboards and perforated slip instead of hand operations, and it is suggested that one or more of the modern forms of keyboard should be applied to the Baudot.

(31) It has been urged in evidence by Mr. Donald Murray that the most advantageous course for the Post Office is to promote development on general Baudot lines, retaining the Baudot receiving methods, but modifying the sending and synchronising processes by the adoption of a different system of motive power for the distributors (together with a vibrating reed in place of the Baudot governor for securing synchronism), and by adopting a free-running keyboard perforator.

The modification of the Baudot principle, as embodied in the Western Electric apparatus, provides a good stable synchronism, and there is no reason to suppose that equally good results in this respect would not be obtained by the use of the new features with Baudot distributors as advocated by Mr. Murray. We think that an opportunity should be taken, when circumstances permit, to try the system, but we do not regard the matter as more than a question of detail.

(32) Mr. Donald Murray's multiplex system has been in use on a London–Manchester wire for four years, working double duplex. It has given good results, and in some respects, notably in the design and working of the keyboard perforator, it is admirable. But its electrical method of controlling synchronism is not so satisfactory as the methods adopted with other multiplex systems. Although the use of the keyboard admits of a speed of forty words per arm per minute, the limitation of the present equipment to double duplex does not afford a complete basis for comparison. This will not apply to Mr. Murray's new multiplex, which, however, is not yet available, as its manufacture has been unfortunately delayed by war conditions.

(33) The Western Electric multiplex apparatus is the most generally satisfactory system for busy lines which we have examined.

A quadruple duplex installation of the system has been working since March last between London and Manchester. The average number of telegrams per operator per hour is consistently well over forty, and has reached forty-nine. The apparatus has dealt with about two-thirds of the whole traffic between London and Manchester on a single circuit. There are not many circuits in the kingdom capable of keeping the apparatus fully fed; but we think that the question of extending the use of the system should be proceeded with without delay, and that the further question of giving greater scope for its use by the making up of "forked" circuits linking up several towns should be pursued as soon as possible. The Western Electric apparatus embodies all those principles which are regarded as desirable; it works with a free keyboard perforator and cross-perforated sending tape, it employs the five-unit code, and it prints direct on the "page." It also adopts a method of controlling the synchronism by the use of the actual message signals which has proved to be efficient. In view of the Post Office experience with the quadruple duplex installation, we also consider that an early trial should be given to the "short line printer" and the "two-way service" installations of the Western Union. It seems likely that both, representing as they do printing telegraphy on the scale of the ordinary simplex or duplex Morse circuit, would go some way towards restricting the use of the Morse at the smaller telegraph offices.

(35) It has been stated in evidence that certain devices in the Western Electric multiplex infringe Mr. Donald Murray's patent rights in this country. This is a question of law on which the Committee cannot express an opinion. Contracts for the supply of telegraph apparatus always contain a clause under which the Postmaster-General is freed from all liabilities which might otherwise attach to him under decisions as to the patent rights of inventors.

(36) We have received evidence from Mr. H. H. Harrison, of the Automatic Telephone Manufacturing Company, of Liverpool, and we have already referred to the circumstances which have prevented us from testing the capabilities of the Company's system, which, as described to us, appeared to possess striking and original features. If the apparatus fulfils the inventor's hopes, it should be of use in the Post Office service.

(37) The question of utilising existing apparatus as well as existing lines cannot be left out of account, and existing Wheatstone apparatus will not be put to the same constant use as at present if multiplex systems be extended as we recommend. The quantity of such apparatus in use at present, leaving out of account instruments such as keyboard perforators and receiving perforators, which are merely complementary to Wheatstone working, is scarcely greater

than it was before the revival of systematic Wheatstone working; and as Wheatstone working will probably be long retained for news and for traffic caused by abnormal events, we do not anticipate that existing Wheatstone plant will be allowed to fall into disuse to any serious extent. There is sufficient diversity in the traffic requirements of the various telegraph circuits and routes of the Post Office service to admit of the profitable use of all existing apparatus until worn out.

(38) The prospect of an extension of multiplex methods makes it necessary again to consider the position of the leading operator, called in France the "dirigeur." We have endeavoured to avoid entering into staff questions in general, but this is a matter directly bound up with the main tendency of our recommendations. The "dirigeur" is virtually the surpervisng officer of a multiplex circuit. He controls the staff of four, six, eight, or twelve operators at that circuit, except that he may have two circuits under his care where the tables are adjacent and other circumstances permit; his control of the working of the circuit is complete, and he has to be a man of good technical capacity, able to apply his technical knowledge and to act promptly. We do not think that the performance of this work can be expected from the general body of sorting clerks and telegraphists or that the scale of pay of sorting clerks and telegraphists provides adequate remuneration for the duties. If the objections to special allowances for leading operators are insuperable, we think that some other way of recognising the value of their work should be found. If they were graded as overseers it would be necessary, in our opinion, to pay less regard than is customary to seniority in making the resulting promotions.

The Committee has no hesitation in expressing the opinion that when once the simplicity of the Morse system is abandoned in favour of more rapid and more economical apparatus, which is necessarily more complex, provision must be made for the employment of a limited number of officers with higher technical attainments and higher pay than ordinary telegraphists.

(39) Our recommendations have, so far, not dealt with the special requirements of news traffic. The system of news distribution is organised territorially; press work is generally transmitted from London over wires, each of which serves a number of towns. Recent developments have tended towards serving a number of towns from a central point at certain hours of the day, but at night every town in which a morning daily newspaper is published is served direct from London, and we recommend that further use should be made of transmission by re-perforators. In the event of any general extension of multiplex methods, it will be necessary to consider how far such systems are applicable to existing methods

of news distribution. This is a point on which some evidence has been laid before us, and it is one which is receiving the attention of the Post Office and of outside inventors. There is no doubt that if Wheatstone methods for news could be gradually superseded by multiplex so as to avoid unnecessary duplication of plant a great advantage would be gained. But the extent to which the outgoing press work of the kingdom centres in London, and goes outwards to the provinces, the high speed of the ordinary Wheatstone circuits, and the fact that the forked wires of the present arrangement serve a larger number of towns than multiplex systems have yet been proved capable of serving simultaneously and satisfactorily, are considerations which suggest the possibility of great difficulties in the way of such a process, and it is not possible in the present state of our knowledge to say whether these difficulties can be surmounted. There is no doubt that the news service at present provided is good.

(40) The press representatives who gave evidence before us frankly admitted that the news service gave general satisfaction, and disclaimed all intention of having asked for a hearing in order to make complaints. One of the two witnesses testified to the satisfactory working of Kleinschmidt keyboard perforators and Creed-Bille receiving apparatus of the 'Glasgow Herald' private wire, and the other advocated the installation of a system of printing telegraphy at the smaller towns where newspapers are published. The admitted fact that Creed receiving apparatus is well suited to the needs of a large newspaper office, which under ordinary Morse methods has to pay high bonuses to the staff lent to it by the Post Office in order to procure a large output, possesses a remote bearing on the problems we have had to consider, inasmuch as the only question for the newspaper office is the cheaper of the two systems, the manual method or the Creed printers. As there is no apparatus other than the Creed which converts the Wheatstone receiving tape into type-printed characters, the newspapers have no third possibility to consider. The evidence given on behalf of the newspapers in smaller towns did not suggest that there was any ground for complaint except for the almost inevitable fact that news does not reach small towns quite as soon as it reaches large ones. The installation of Creed-receiving apparatus at small offices would be impracticable on the ground of expense, and we fear that newspapers published at such towns must continue to receive their news after their competitors, and without the aid of printing telegraphy, until progress has been made which will enable the Post Office to extend printing methods to such offices and to re-model greatly the present methods of news circulation.

(41) Notwithstanding the unforeseen circumstances which cut

short at an early date the tests which we had arranged, it may be useful to describe the arrangements which had been made.

In addition to the laboratory tests—which were for the most part carried out though in a less systematic manner than would otherwise have been the case—we completed arrangements for a full series of tests on public telegraph work, the circuits selected for the purpose being underground loops connecting London with Birmingham and Glasgow respectively. We appointed a sub-committee, under the leadership of Mr. J. Bailey, an assistant controller of the Central Telegraph Office, for the immediate control and supervision of these tests, and we drew up instructions for the guidance of the sub-committee and schedules indicating the form in which the results obtained were to be tabulated. Copies of these instructions and schedules will be found in Appendices B and C, and we hope that they may be of service when new methods come to be tested in future. Provision is made for results being shown in considerable detail, in order to meet the reasonable claims of inventors by making the fullest and most exhaustive scrutiny of the apparatus accepted for trial. One of the duties of the sub-committee was to select a corps of highly experienced and capable operators for the actual manipulative work of the tests, and the capacity of the men selected was amply demonstrated by the results obtained in the completed test of the ordinary Wheatstone system which are tabulated in Appendix D.

(42) We print in Appendix A a list of inventions which have been brought to our notice.

(43) The following is a summary of our leading conclusions :

(i) Systems on the multiplex principle are definitely superior to the automatic high-speed systems on the large majority of main circuits for ordinary inland commercial telegraph work.

(ii) The extension of systematic Wheatstone working should be discontinued, and the question of displacing it by multiplex circuits taken up gradually.

(iii) Of the multiplex systems at present available the Western Electric has given the best results. We recommend that a number of quadruple duplex installations of this apparatus be ordered. We think seven or eight such sets should suffice, as although present conditions favour the rapid application of systems with the greatest output, it is desirable to avoid too great a dislocation of working, and to allow time as far as possible for other makers to demonstrate their capabilities.

(iv) Page or column-printing is preferable to tape-printing on the busiest routes, and the Western Electric Company's page-printing on a continuous roll of paper, cut off after each message, is quite satisfactory. Mr. Murray's system, with a

separate sheet for each message, has been given a trial on his Manchester multiplex, but a fuller trial of his improved method will be necessary. We do not think it desirable that either page or column printing should be adopted throughout the service to the exclusion of tape-printing.

(v) The five unit alphabet as a code for printing telegraphy is better than the Morse code, news traffic and submarine cable communications being left out of account.

(vi) The application of type keyboard signalling instruments to the present Baudot circuits is desirable.

(vii) Creed receiving apparatus can most profitably be used in the Post Office service for news work.

(viii) The application of printing methods to the less important circuits should be kept steadily in view, and early trials of the one-way and two-way installations of the Western Electric and of the light line printer of the Automatic Telephone Manufacturing Company should be made. We are impressed with the possibility of two-way working with one operator at each end, both to signal their messages simultaneously to the other end and then both to gum the tape. An hourly load can be carried in this way equivalent to the average Morse load with two operators at each end, and having the additional advantage of printing the telegrams.

(ix) The introduction of multiplex methods for news work will call for serious consideration in the near future.

(x) The application of multiplex systems to give simultaneous communication on one wire between each one of three or possibly more offices should be kept in view as multiplex methods are extended.

(xi) The pay and prospects of officers selected to be "leading operators" of multiplex circuits should be reconsidered.

(44) In conclusion we desire to record our obligations to our secretary, Mr. Wood, for the able and zealous help he has given us. By devoting much time and labour to exhaustive study of the problems presented, he has acquired such mastery of the details connected with this highly technical work as has enabled him to facilitate greatly the performance of the task committed to us.

CECIL NORTON (*Chairman*).
J. GAVEY.
JOHN LEE.
W. M. MORDEY.
A. M. OGILVIE.
W. SLINGO.
A. B. WALKLEY.

G. O. WOOD (*Secretary*),
19th January, 1916.

The following appendices are issued with the report:

A. Instruments which came under the notice of the Committee.
B. Memo. as to appointment and duties of Sub-Committee appointed.
C. Schedules for tabulation of results of trials.
D. Return showing amount of traffic during trials.
E. Summary of various systems of printing telegraphs and appurtenances thereto.

The report is published by H.M. Stationery Office, and may be obtained through any bookseller.

THE BAUDOT SYSTEM IN FRANCE: ITS ADAPTABILITY AND ECONOMY IN WORKING.

By E. MONTORIOL,
Inspector of Posts and Telegraphs, Paris.

(Specially written for the POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.—*Translated by J. G. Hill*).

THE Baudot system has undergone numerous changes since 1877, when the first Paris–Bordeaux quintuple was brought into use. It would take too long to enter into the details of these changes here (see 'Annales des Postes Telegraphes et Telephones,' December, 1916, p. 367). The degree of perfection which has been attained, and the remarkable flexibility with which the system has been able to adapt itself to the most varied combinations, have made it the keystone of telegraphic working in France. Thus, all services where a single Hughes would be insufficient are provided for by Baudot, either double, triple, quadruple, or sextuple, according to the importance of the traffic; it is only in very rare cases and for occasional or temporary requirements that one finds two towns connected by several wires worked by Morse or Hughes.

As compared with these latter, it is true that systems of automatic transmission admit of a considerable increase in output being obtained from lines, and such systems were for a long period used by the French service. The reasons for giving the Baudot the preference which it at present enjoys are not—as one might be tempted to believe—of a sentimental order; they are, on the contrary, the result of long experience, and the comparison of the two methods in question, *i. e.* multiple transmission and automatic transmission. In the first place certain apparatus of the latter type employs the Morse code, which is much less rapid than that which consists of five elements.

Again, all systems which require preliminary preparation and automatic transmission involve certain difficulties in working: firstly, a "normal retardation," which is a consequence of the various stages (perforation, transmission, translation) through which every telegram must pass before it is completed at the receiving station. With multiple transmission, on the contrary, a text sent directly by hand is immediately received, gummed up a few seconds afterwards, and at once put into circulation. Finally, in the case of automatic transmission, if any error whatever is observed at the receiving station, whether it results from a false touch of the perforating apparatus or the incorrect reading of a badly written text, or, again, if it be caused by a failure of apparatus or line, the request for correction, and afterwards the reply, must follow the same stages, and the normal retardation becomes appreciably augmented.

"Not infrequently the preamble of a message is imperfect, and the absence of these essential particulars retards the correction of this and other messages. It is consequently necessary to augment the R.Q. staff; even then the service compares unfavourably with the expeditive treatment of the direct multiplex operations" ('The Telegraph and Telephone Journal,' London, December, 1916, No. 27, p. 40, col. 2).

As a matter of fact, in the Baudot the sectors are grouped in pairs, comprising one sector for transmission and one for reception. The requests for correction are transmitted between two telegrams, and are immediately received by the transmitting officer at the other station; they always relate, therefore, to a telegram of the series in hand, or to one of the last of the series which has just been finished, and the loss of time is reduced to a minimum. Finally, disagreements or misunderstandings, such as inevitably occur in every continuous service, are settled directly by those concerned, and this considerably shortens their duration.

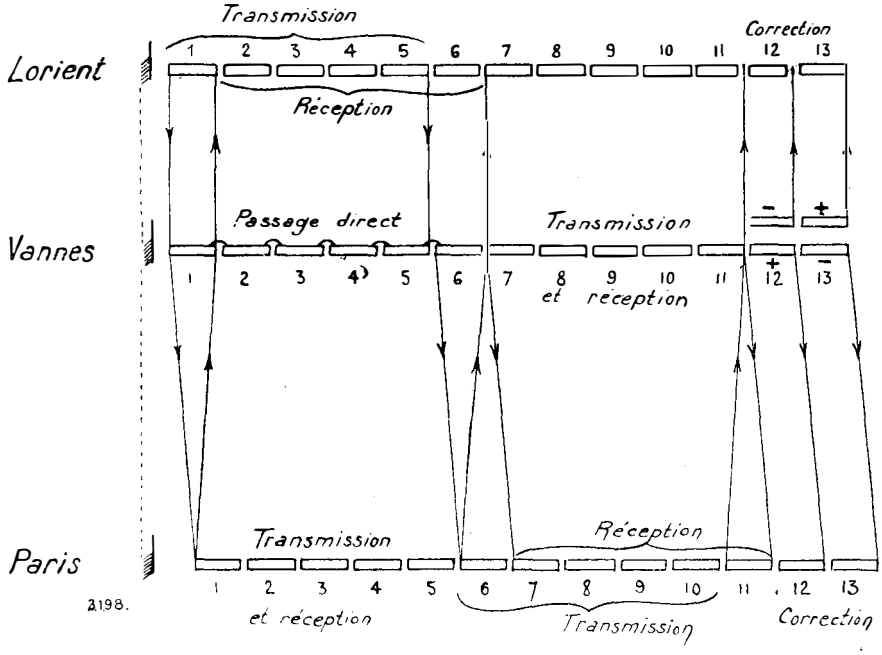
It is true that transmission by perforated slips offers certain advantages in England, in the multiple transmission of press messages. In France, however, similar services are arranged in quite a different way, and as a consequence this particular need does not exist. All these considerations explain the exclusive use of the Baudot in the French service.

Installations arranged for Circuit Extension (Omnibus Circuits).

Independently of the ordinary services mentioned above, the Baudot system has permitted of the inclusion of three towns on the same wire. The first installation of this kind was established in

1889 on the Paris–Vannes–Lorient line ; previously a Paris–Lorient wire passing through Vannes was available alternatively for use between the two extreme towns and Paris. 1 shows the arrangement of an installation which gives a Baudot sector continuously to each of them, and this constitutes an appreciable increase in the means at their disposal, and in addition avoids the delay which inevitably resulted from the periodical sharing of the wire.

A little later the installations were arranged in such a way that the intermediate and terminal offices could communicate with each



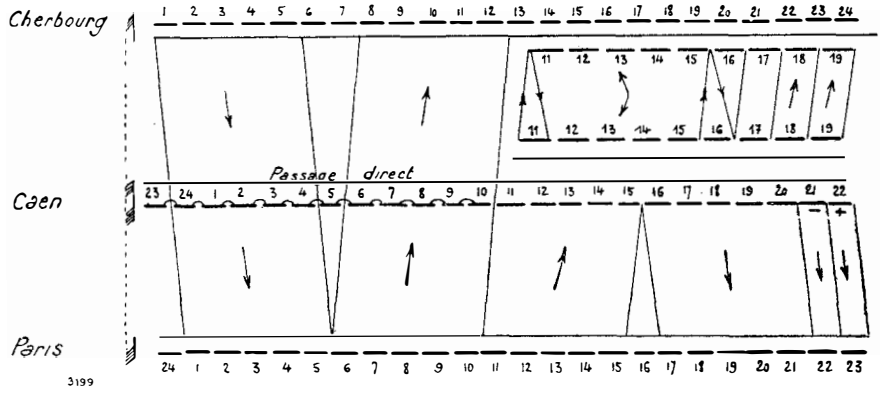
1.—Extension Installation—Simplex Type : Paris–Vannes–Lorient.

other. The use of these various forms of installations has been extended, and even extended to towns which previously had a separate wire to Paris, such towns as Auch and Tarbes, Montauban and Perpignan, Rodez and Albi. This procedure threw considerable lengths of wire spare, and these lengths were appropriated for other purposes, thus avoiding the construction of new lines. The diagram below shows the arrangement formerly adopted for the Paris–Caen–Cherbourg circuit. The two latter towns each made use of two sectors of a quadruple with Paris and one sector of a triple between themselves. Their requirements having since increased, they are now connected with Paris by independent quadruples.

Re-transmitters.

Re-transmitters are receivers which are so arranged that the signals they register are automatically re-transmitted on a second line.

In the first model, invented by Baudot in 1894, this function was fulfilled by an ordinary Baudot receiver, of which the selectors, in passing from one channel into the other, moved spring contacts acting on the second distributor. Then came the "dumb re-transmitters" (non-recording re-transmitters) of Robichon in 1901, and of Lesaffre and Chattelun in 1909; these constitute veritable keyboards, of which the keys are actuated by receiving electro-magnets as they would be by the fingers of an operator. Whatever model may be in use, the re-transmitters give the Baudot an incomparable



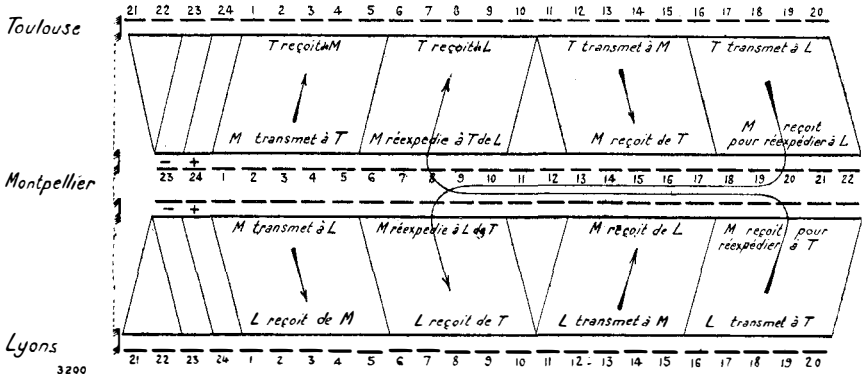
2.—Extension Installation, Complete Set. Type: Paris–Caen–Cherbour g .

flexibility and permit of a large number of combinations, of which a few examples will suffice to show the importance. In 1894 the quadruple installation Paris–Central–Milan–Central served for the transit of the telegrams which were exchanged between Paris-Bourse and Milan-Bourse. An automatic re-transmitting device permitted of these two latter offices having direct communication during market hours by means of two sectors of the old quadruple; that is to say, one thus obtained two communications, Paris Central–Milan Central, and two, Paris Bourse–Milan Bourse.

By means of the same arrangement the central offices and the Bourses of Paris and Madrid are at present connected.

The two Bourses are placed in communication by the simple turning of a switch. The central offices are thus able at any moment to come in circuit in case of difficulties between the two ends and resume possession of the sections as soon as the traffic has subsided.

The connection of stations by the aid of re-transmitters is more simply and completely effected than in the case of the Paris–Caen–Cherbourg circuit (**2**); that which has been carried out on the Lyons–Montpellier–Toulouse line (**3**) is worked quadruple from one end to the other, thus giving two channels between Lyons and Montpellier, two Lyons–Toulouse and two Montpellier–Toulouse.



3.—CIRCUIT EXTENSION BY RE-TRANSMITTERS. TYPE: LYONS–MONTPELLIER–TOULOUSE.

French Phrase.	*English Translation.*
T reçoit de M	*T receiving from M.*
M transmet à T.	*M transmitting to T.*
T reçoit de L	*T receiving from L.*
M reéxpédie à T de L	*M re-transmitting to T from L.*
T transmet à M	*T transmitting to M.*
M reçoit de T	*M receiving from T.*
T transmet à L	*T transmitting to L.*
M reçoit pour ré-expédier à L	*M receiving for re-transmission to L.*
M transmet à L	*M transmitting to L.*
L reçoit de M	*L receiving from M.*
M ré-expédie à L de T.	*M re-transmitting to L from T.*
L reçoit de T	*L receiving from T.*
M reçoit de L	*M receiving from L.*
L transmet à M	*L transmitting to T.*
M reçoit pour ré-expédier à T	*L receiving for re-transmission to T.*
L transmet à T	*L transmitting to T.*

The intermediate station possesses two quadruple plates mounted on the same distributor frame. The brushes which traverse both are carried by the same axle, and this ensures perfect concordance between the two distributors. One of the plates communicates with Lyons and the other with Toulouse; Montpellier is the connecting station on both sides, that is to say, that the two terminal stations are synchronised by that station in the usual way. It is very important to notice that in spite of this common drive of the brushes one may consider this installation as if it gave *absolutely independent channels*. As a matter of fact, at the moment of commencement, Montpellier establishes connection first of all with Lyons, let us say. As soon as the latter has established synchronism Montpellier regu-

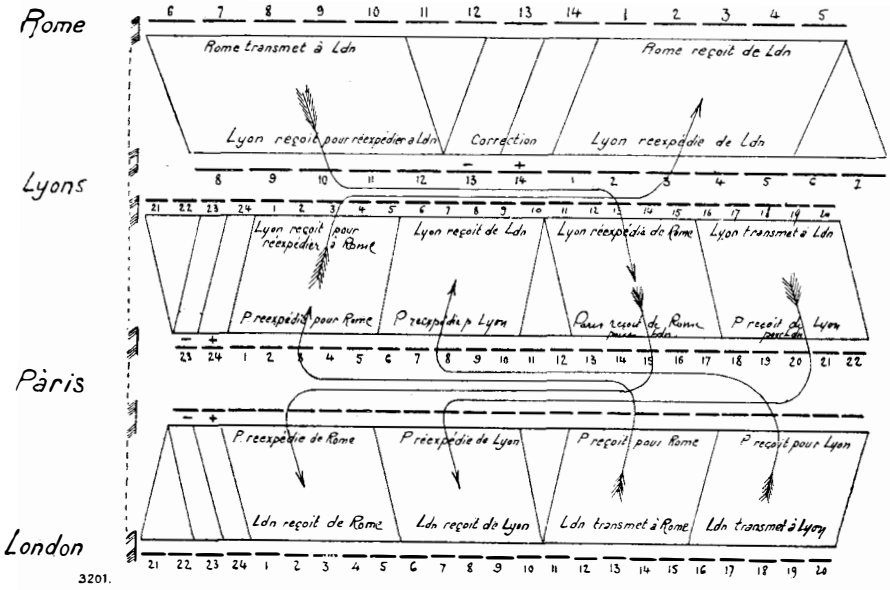
lates his distributor plate and his relay according to the state of the line without troubling the least in the world about the Toulouse line, but in such a way as to obtain correct reception from Lyons on the two sectors. Having terminated this first operation, Montpellier then regulates his second installation on the Toulouse side just as if the Lyons installation did not exist. As soon as he is able to communicate properly with each of the terminal stations, taken separately, the Lyons–Toulouse communication is assured, because it is sufficient that the reception from Montpellier be correct to ensure that its re-transmission should be correct also. This arrangement therefore permits of two stations, widely distant from each other, having direct communication; the distortion to which the signals in the first section of the line are subject disappears with automatic re-transmission, and the final reception is only affected by the deterioration resulting from any imperfections that may arise in the second circuit. The correcting device at the receiving station is therefore in the best condition for eliminating the deterioration in its turn. It is the same as regards the time occupied by the propagation of the signals, which only comes into play for each section of line taken separately, and is never cumulative for the whole; this permits of the margin provided in ordinary distribution never being absorbed, whatever may be the entire length of the line.

The re-transmitters may advantageously be substituted for ordinary repeaters. Their use in these conditions is theoretically *unlimited;* indeed, we have just seen that as every re-transmission constitutes in reality a new transmission, just as if it were affected by an ordinary manual keyboard, the distorted signals, as they arrive at the repeating station are sent on absolutely corrected. One might therefore place in series an indefinite number of translations without the reception at the terminal station ceasing to be correct *and without being obliged to decrease the speed of transmission,* as is the case with long lines worked on other systems where several successive translations are involved. It is the same for the speed of propagation, as has been stated above. In practice, the limit of the range of speed is fixed by the consideration that the interruption of a single line section due to wire failure stops all the others. It is therefore advantageous, from this particular point of view, not to carry to an extreme the number of sections thus connected, in order not to increase the chances of interruption at one point or another, and the range is restricted to lengths, in which the necessary resources are available for replacing any faulty wire without delay.

It should, however, be noted that in cases where such replacements are not possible, the two translating stations situated on one side or the other of the interruption may work the good portions of the interrupted channels and receive at their offices the traffic from

the terminal stations, which they forward by the best means available; consequently, even in this case the communication which is momentarily interrupted is not completely stopped.

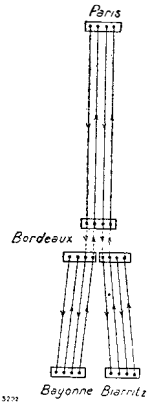
The traffic between England and the Continent has benefited by a notable increase thanks to the use of re-transmitters; thus, London communicates simultaneously with Lyons and Rome on a single Baudot quadruple wire with automatic re-transmission at Paris and Lyons (4).



4.—Extension Installation with Re-transmitter acting as Repeater. Type: London–Lyons–Rome.

French Phrase.	*English Translation.*
Rome transmet à Londres	*Rome transmitting to London.*
Lyon reçoit pour ré-expédier à Londres	*Lyons receiving for re-transmission to London*
Correction	*Correction.*
Rome reçoit de Londres	*Rome receiving from London.*
Lyon ré-expédie de Londres	*Lyons re-transmitting from London.*
Lyon reçoit pour ré-expédier à Rome	*Lyons receiving for re-transmission to Rome.*
P ré-expédie pour Rome	*Paris re-transmitting for Rome.*
Lyon reçoit de Londres	*Lyons receiving from London.*
P ré-expédie pour Lyon	*Paris re-transmitting for Lyons.*
Lyon ré-expédie de Rome	*Lyons re-transmitting from Rome*
Paris reçoit de Rome pour Londres	*Paris receiving from Rome for London.*
Lyon transmet à Londres	*Lyons transmitting to London.*
Paris reçoit de Lyon pour Londres	*Paris receiving from Lyons for London.*
P ré-expédie de Rome	*Paris re-transmitting from Rome.*
Londres reçoit de Rome	*London receiving from Rome.*
P ré-expédie de Lyon	*Paris re-transmitting from Lyons.*
Londres reçoit de Lyon	*London receiving from Lyons.*
P reçoit pour Rome	*Paris receiving for Rome.*
Londres transmet à Rome	*London transmitting to Rome.*
P reçoit pour Lyon	*Paris receiving for Lyons.*
Londres transmet à Lyon	*London transmitting to Lyons.*

Another very advantageous grouping of stations is that by bifurcation. For example, a Paris–Bordeaux quadruple channel is forked in this latter town, two segments being appropriated for Bayonne and the two others for Biarritz; as the two branches of the fork are also both worked quadruple, Bordeaux has two segments available on each for communication with Bayonne and Biarritz. We therefore obtain altogether two channels between Paris and Bayonne, two



5.—Forking of Circuits by Re-transmitters. Type: Bordeaux { Bayonne. Biarritz.

Paris–Biarritz, two Bordeaux–Bayonne, and two Bordeaux–Biarritz. Similar arrangements connect London–Paris { Genoa, Marseilles, Paris–Bordeaux { Agen, Pau, Paris–Toulouse { Montauban, Tarbes, Paris–Lyons { Valence, Nimes, etc.

Duplex.

The Baudot works duplex perfectly; one may even say that it enjoys, from this point of view, a great advantage over most other systems, and, in particular, over the Hughes; indeed, the imperfect balancing of the artificial line, especially as regards the capacity, manifests itself principally at the commencement of signals. It has, therefore, an immediate effect on the Hughes apparatus, which comes into action at the beginning of the change of current; the Baudot, on the contrary, due to its arrangement for correcting received signals, only utilises the middle portion of the signals, and the disturbance in question may within large limits pass unnoticed; this favourable circumstance gives a large range in the adjustment of the balance. The duplex is employed with success on the Marseilles-Algiers submarine cables, as will be seen later. Duplex

Baudot has also been installed between London and Paris on lines passing through the Dieppe and Havre cables, and at the present moment there are two doubles and a triple working in these conditions.

Baudot Installations on the French-Algerian Cables.

It was in 1898 that Pierre Picard commenced his experiments with the object of adapting the Baudot to submarine cable transmission. At the present time the combination of re-transmitters and duplex has permitted of maintaining the French-Algerian service in excellent condition and with a minimum of cable. Thus Paris communicates with Algiers by a Paris–Marseilles quadruple on an aerial wire, which is connected by re-transmitters to one of the Marseilles–Algiers cables and worked *double duplex*; another cable worked *triple duplex* serves to provide two auxiliary channels between Paris and Algiers, two Paris–Oran, and two Marseilles–Constantine, this latter having an automatic re-transmission at Algiers. Finally, two other cables, worked double, permit of communication between Marseilles and Algiers.

Conclusion.

The exclusive employment of the Baudot in France is justified in the first place by the considerations relating to its working and the methods of its use as indicated at the beginning of this article. On the other hand, the system of automatic re-transmission permits of all requirements—permanent or occasional—being met in the most favourable conditions; we have seen, as a matter of fact, that re-transmitters do not require installations of the same kind at the stations which it may be decided to put in communication. A message received on a quadruple, for example, may be forwarded indifferently on a double, a triple, or another quadruple (see **4**, where one message received at Lyons on a quadruple Lyons–Paris is forwarded on a Lyons–Rome double, and inversely). This special feature has permitted of a scheme being prepared for the provision of supplementary communication to provide against stoppages of short duration on important circuits. If Paris should be without a wire to Toulon or Nice, for example, Marseilles is brought into circuit, and that office, by means of re-transmitters which are mounted on an apparatus set connected with Paris and with the office whose wire has failed, re-establishes direct communication, thus avoiding the block and delay which would result from having to handle the traffic at an intermediate office. This plan, which will be followed after the war, will re-establish communication with Bordeaux or Montpellier *viâ* Toulouse, with Lyons by Clermont–

Ferrand, etc., in such a way that, even in case of disturbances in the system, Paris will never be totally deprived of its communication with the regional centres.

Combinations of the type indicated above have allowed of important wire economies being effected; for example, the connection of the existing Lyons–Montpellier and Montpellier–Toulouse wires (3) has provided a Lyons–Toulouse circuit, thus avoiding the construction of 570 kilometres of circuit; the London–Rome wire, previously worked Hughes, now provides two Baudot segments between the two capitals, thus providing increased facilities, but, in addition, it provides two other segments between London and Lyons (4), which corresponds to nearly 1000 kilometres of line. Finally, the Paris–Bordeaux $\left\{\begin{matrix}\text{Bayonne}\\ \text{Biarritz}\end{matrix}\right\}$ forked circuit (5), utilising the two Bordeaux–Bayonne and Bordeaux–Biarritz regional wires, which maintain their original service, has, by the single expense of a Paris–Bordeaux wire (580 kilometres), enabled two circuits, each 780 kilometres in length, to be obtained; here, again, we have an economy of more than 900 kilometres of wire.

As may be seen from these few examples, it is by thousands of kilometres that one must reckon the economy in conductors resulting from the extension system. The lines thus freed are employed either to make up new circuits or as reserve wires. In either case they contribute, without additional expense, to the improvement of the conditions governing the general flow of traffic.

POST OFFICE STANDARD RELAY "G."

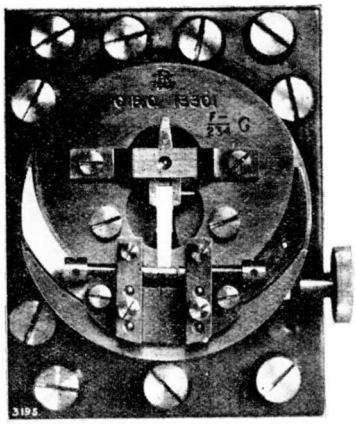
By E. LACK.

THE Post Office relay standard "G" is a modified form of the Gulstad relay, already described in vol. 7, pp. 183–188 of this JOURNAL. By making use of the ordinary Post Office relay and adding the necessary coils, etc., a very robust form of Gulstad has been obtained which is little, if at all, inferior to the Gulstad relays now in use by the Post Office, and has the great advantage that it can be employed on either "bridge" or "differential" duplex circuits.

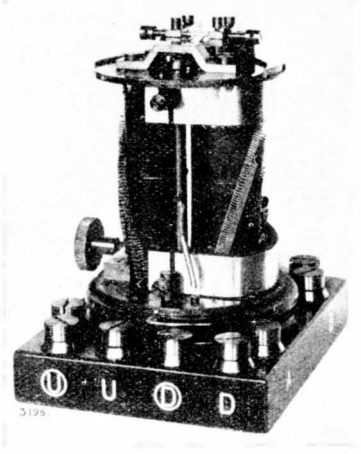
The relay has been constructed with a rectangular base so as to be suitable for repeater boards which are equipped with spring clips (see 1 and 2).

There are four "line" terminals, marked D, (D), *U*, and (U), and three others, lettered respectively *A*, *B* and *C*, to which the "auxiliary" coils are connected in a manner to be described later There are also the usual *M*, *S* and *T* terminals.

The "line" coils consist of single silk-covered enamelled copper wire $5\frac{1}{2}$ mils. in diameter, and are wound on the bobbins in the following manner. The bobbins are divided into two sections. Each section is double-wound with the above-mentioned wire, which is first threaded through a small hole in the ebonite cheek separating the two sections, the ends fastened down and the first section is wound; the ends which have been threaded through the ebonite cheek are then joined to another length of double wire, and the second section is wound by spinning the bobbin in the reverse direction.



1.—"G" Relay. Plan.



2.—"G" Relay. Back of Relay, Cover removed.

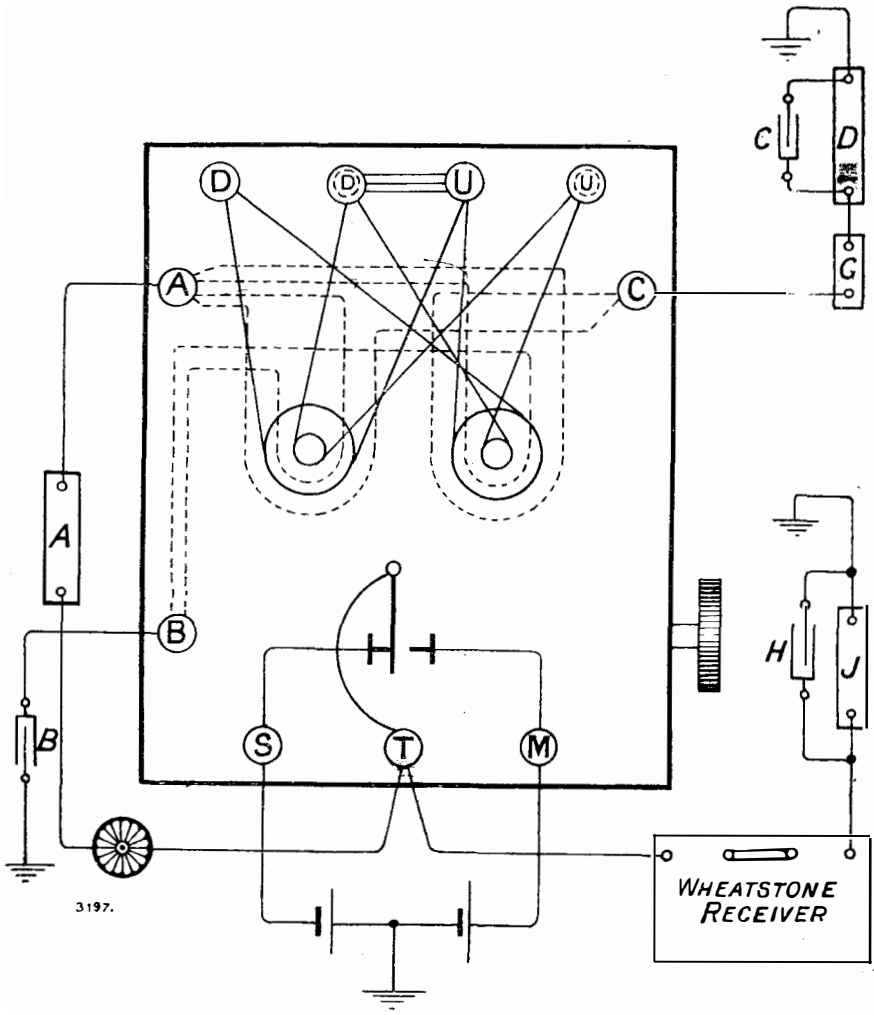
The "auxiliary" coils are wound in like manner above the "line" coils, and consist of single silk-covered enamelled copper wire 3 mils. in diameter.

Each of the wires on each completed bobbin is of 200 ohms resistance. The similar windings of the "line" coils on each bobbin are joined in multiple, one pair being joined between the terminals *D* and *U* and the other pair between (**D**) and (**U**), thus giving a final resistance of 100$^{\omega}$ between each pair of terminals.

The "auxiliary" coils are dealt with in like manner, with the exception that the ends of the coils, which are equivalent to *D* and (**U**), are connected to *B* and *C* respectively, while the other four ends, equivalent to (**D**) and *U*, are connected to the terminal *A*. A glance at 3 will make this clear. Each winding on the same bobbin has the same number of effective turns, so that the relay is perfectly "differential."

In the event of a disconnection in the line coils, it would be

possible to utilise the "auxiliary" coils as "line" coils, and thus possibly prevent a stoppage of working, though the relay would then be somewhat less sensitive than a Post Office relay standard "B," and, of course, would no longer be able to act as a Gulstad relay.



3.—"G" Relay. Circuit Connections.

The figure of merit of the relay is as follows:

"*Line*" *Coils.*—For working a sounder at key speed, 0·5 milliamperes.

(Four "*Y*" cells dry, 12,500 ohms external resistance, and the "auxiliary" coil circuit open.)

For repeating at the rate of 400 words per minute, 7·5 milliamperes.

(One hundred and twenty volts, 4000 ohms external resistance, and a reading condenser and shunt of 0·5 micro-farad, and 12,000 ohms respectively; "auxiliary" coil circuit open.)

"*Auxiliary*" *Coils.*—For repeating at the rate of 350 words per minute, 7·5 milliamperes; the conditions being the same as in the previous test. Line coil open.

The top plate of the relay is marked with the letters *GPO* and the distinguishing letter "*G*."

A number of experiments were carried out on an underground circuit 240 miles in length.

In each case it was found that a considerable increase in speed was obtainable with the "G" relay when compared with the Post Office standard "B" relay.

Increases varying from 30 per cent. to 50 per cent. resulted from the use of the "G" relay, the majority of the results being of the latter figure.

Several circuits have been equipped with the new type of relay and very satisfactory results obtained. In at least one instance it has been instrumental in allowing a repeater to be dispensed with without any loss of speed on the circuit.

The methods of adjustment described in the article on the Gulstad relay apply equally well to the "G" relay, the only difference being that, when worked on the "differential" system, the values of resistances *A*, *G*, and *D* are less, and the capacity of condenser *B* is generally greater than when working on the "bridge" duplex system.

COLONIAL TELEGRAPHS AND TELEPHONES.*

By R. W. Weightman, M.I.E.E.

At the outset, the author points out that in the Dominion of Canada the methods in use are based on American practice, as distinguished from British Post Office practice, which is followed more or less throughout the other dominions and colonies; throughout his paper, therefore, Canada is not included in any reference to the "dominions and colonies" unless expressly stated.

A generous tribute is paid to the services rendered to the colonial administrations by the late Sir William Preece, who, as far back as 1868, undertook the training of a number of student engineers for the Government of India, and whose advice was sought subsequently by practically all the colonial governments. The

* Abstract of a Paper read before the Institution of Electrical Engineers on December 14th, 1916.

result is that, to-day, the colonial systems constitute a not unworthy monument to his memory, and it has followed, almost as a matter of course, that, with due allowance for climatic differences and local conditions, British Post Office practice is the bedrock of the methods now in vogue.

It was originally the general rule, in appointing engineers in the colonial services, to select men trained in the home service, but with the improved educational facilities since acquired by the dominions, that policy is now confined mainly to appointments in the Crown colonies. In many of the latter the conditions are very trying to Europeans, and a generous provision of leave is essential for the purpose of returning home: this, however, adds largely to the cost of living, and the author is convinced that, in the interests of colonial engineering, and in the higher interests of colonial administration, the margin of difference between colonial salaries and those paid in England is generally insufficient. He is also of opinion that an engineer in a Crown colony should be specially commissioned to visit England at least every three or four years to enable him to keep in touch with developments.

Sources of Supply of Stores.

Sources of Supply and Delays in Delivery.—Of all the dominions and colonies Canada is the only one that has made any headway in the manufacture of apparatus and material for telegraph and telephone purposes. Practically all wire, cable, subscribers' instruments, and manual exchange equipment used throughout the telephone services of the country are made in the dominion. Automatic exchange apparatus, where this is in use, is obtained from the United States, but even this is now being assembled and built up in Canada. Copper wire, iron wire, and pole fittings are also made to a large extent. Telegraph apparatus is generally got from the States, and also the glass insulators so largely used. Porcelain insulators, where these are used, have been obtained to some extent from the Continent.

In Australia, cast-iron pipes, stoneware conduits, copper tapes and binders, and certain of the pole fittings are manufactured in the country. Prior to 1913, practically all the insulators used came from Germany, but insulators of both porcelain and stoneware are are now being made within the Commonwealth. A fair amount of magneto telephone apparatus and switchboard material is obtained from Sweden, while some of the larger exchange switchboard plant and the Strowger automatic apparatus now being introduced come from America. Wire, cable, telegraph apparatus generally, and material of a kindred nature are obtained almost exclusively from

Great Britain. It is the rule to invite tenders for all supplies and to give preference to goods of British manufacture.

The other dominions and colonies import practically all their plant. This is largely obtained from England, but quantities of telephone apparatus, especially, have in the past been supplied both from the continent and the United States.

The great distances these countries are situated from their sources of supply, and the delays in delivery that have taken place, have been serious drawbacks to the smooth working of most of the colonial engineering departments. The engineer in a colony has to prepare his estimates of expenditure well in advance, but he cannot send off his indents for materials until the funds are actually sanctioned by his Government and voted by his legislature. His estimates cover new works which cannot be proceeded with until the materials arrive, and as it has taken anything from three to twelve months to get supplies from British manufacturers, it follows that in many cases the votes have lapsed to the Treasury before the materials reach him, the money is no longer available, and the work cannot go on until the "ins-and-outs" of the whole matter have been explained to the Government. In the meantime the workmen, who have been retained in anticipation of the material coming to hand within a resonable time, have had little or nothing to do, but their salaries have had to be paid just the same. Strong complaint is frequently made by colonial engineers in this connection, and the author would like to impress upon manufacturers of telegraph and telephone plant the great need there is for the more prompt execution of orders from the colonies. Before the war, it was no uncommon thing to hear an engineer say he would not put up with the dilatoriness of British manufacturers, and that he would send his orders to the Continent, and in some instances orders were actually sent there.

In the dominions and in some colonies these difficulties are got over by the establishing of "reserve stores," in which ample supplies are kept to meet all ordinary demands. This is a plan which every colony, with any considerable system, should adopt. It involves the sinking of a certain amount of capital in the stock, but the convenience and saving of money in workmen's wages are worth more than the amount of interest incurred. Under this system all materials are purchased from the stores, and as they are issued the stores account is credited with their value from the funds provided for the works for which they are required. Delays in carrying out works are thus reduced to a minimum.

Overhead Construction.

Pole Lines.—There is practically no overhouse construction in any of the dominions or colonies, and the chief difference in the construction of pole lines lies in the character of the pole employed. This, again, mainly depends upon whether or not a country produces timber. Where timber is plentiful, and there are no local drawbacks to its use, wood poles are the rule, but where it is scarce or not of suitable size or quality, or where it is liable to be attacked by white ants or destroyed by grass or bush fires, iron poles are used.

White ants abound practically in all the tropical colonies, and while it is usual in such countries to find an indigenous wood which is more or less immune from their attacks, like the teak-wood of Burmah, the cedar of British East Africa, and the "sneeze-wood" of South Africa, it is not always suitable for use as telegraph poles. In South Africa, "sneeze-wood" is the only indigenous timber that will withstand the ravages of the white ant for any length of time, but even this wood is not free from attack. This ant will drive its tunnels from the bottom of the pole to the top through the outer rings of the wood, but as it approaches the core of the tree it will stop, because the core is too hard for it to penetrate. The core of the "sneeze-wood" is almost as hard as iron while yet as flexible as whalebone, and the author has heard of only rare cases in which the ant has been able to eat into it.

In Australia both wood and iron poles are used, the choice depending generally on the degree of liability to damage from white ants and bush fires. All the wood poles are obtained from trees indigenous to the country. There is a great variety of these and they are practically all of the hard wood class. They have not the straight, clean appearance of the red pine pole used in England, but they are required to be straight and round and as free as possible from irregularities and inequalities. Up to the present no treatment for the prevention of decay has been applied, but the question of introducing creosoting plant for this purpose at the larger centres is under consideration.

In New Zealand (where there are no white ants and damage by fire is rare), poles of wood, tubular iron, reinforced concrete, and discarded railway rails are in use. The wood poles are mainly got from indigenous trees, the totara and silver pine being found to be the most suitable. They stand well in the ground, but timber generally is scarce and the supply of trees suitable for poles is limited. A good many poles of iron-bark wood have been obtained from Australia. Other kinds of Australian woods have been tried, including stringy bark and jarrah, but they do not stand so well. The wood poles are not treated in any way.

In Canada (where, also, white ants are unknown) neither iron nor reinforced concrete poles are in use. Wood poles obtained from timber grown in the country are used on both telegraph and telephone lines and are generally of cedar. They are straight and of good appearance and are not treated with any preservative. Damage by fire is of rare occurrence on the railway lines, but in some of the districts poles are occasionally destroyed by prairie fires.

Iron Poles.—In the Crown colonies two types of tubular iron pole, each consisting of a cast-iron base and one or two wrought-iron tapering tubes, are in general use. In one type the lower end of the base is solid and pointed to permit of its being driven into soft ground by means of a special rammer; in the other the lower end of the base has a flange to which a buckled base plate—or "steady" plate—may be bolted. In both cases the length of the base is sufficient to ensure that, when the pole is properly set, no part of the wrought-iron tube is in contact with the soil.

In South Africa a parallel pole of a more ornamental type is in use for special street work. In this case a cast-iron base is not used, but protection from corrosion at and below ground level is secured by means of a sleeve which is shrunk on the lower end of the tube.

The "Hamilton" pole, which is largely used by the Indian Government, has also been adopted in some of the Crown colonies. This pole consists of a cast-iron base and sole plate and two or more rivetted tubes of galvanised sheet steel, each 8 ft. in length, the design providing for a maximum height of 58 ft. above ground level, which involves the use of eight tubes.

In Australia and New Zealand several types of iron and steel poles are in use, including the Siemens and the Oppenheimer patterns.

In many of the Crown colonies, as in India, fairly considerable use is made of discarded railway rails.

Reinforced Concrete Poles.—This type of pole has not been adopted on a large scale, the chief instance of their use being in New Zealand, where a solid tapering pole of rectangular cross section is employed.

Pole Fittings.—Except in Canada, the principles of British Post Office practice are followed in the main, though there are many variations in the length of arm and the spacing of wires. Tubular iron arms and solid and tubular brackets are largely used in connection with iron poles.

In Canada, where telephone wires are run straight, with transpositions or "crossings" on the system of the American Telephone and Telegraph Company, 6-wire and 10-wire arms are the standard

items, and, in addition, for telegraph lines, 4-wire and 8-wire arms are used. The spacing between arms is generally much greater than in this country, the maximum centre-to-centre distance being 24 in.

Insulators.—The standard items in the colonies are of the double-shed white porcelain pattern, but for special purposes, *e.g.* farmers' lines, a small single-shed is in use, and barrel or "reel" insulators are also employed. Single-shed glass insulators are largely used in Canada, but on long lines and in wet localities it has been found necessary to employ the double-shed porcelain type.

Line Wire.—Generally speaking, the practice, as regards the class and gauge of wire used, is based on similar considerations to those which govern Home practice, *i. e.* galvanised iron is employed where its life is normal and its conductivity or transmission value adequate, but for telephone circuits the great bulk of the material is copper, bronze being used in some instances for distribution work. The experience of "bi-metallic," or copper-clad steel wire, has not been such as to encourage its use on a large scale.

Aerial Cables.—In sections where the number of wires was considerable lead-covered aerial cables have been used somewhat freely in developing local exchange systems in some of the colonies, but the later tendency is to provide a system of underground cables either armoured or accommodated in pipes or ducts.

Underground Construction.

The methods adopted in the case of underground work follow generally the principles of British Post Office current practice ; but in some instances the arrangements provide for the use of items not employed by the Post Office, *e.g.* in South Africa American fibre ducts have been introduced in the later work.

Telegraph Systems.

In the Crown colonies British Post Office standard apparatus is in general use, and the circuits—single needle, single and double current sounder, quadruplex, etc.—are to Post Office diagrams. The Vyle polarised sounder is now replacing the relay and local circuit sounder, and is also being adopted on central battery omnibus (condenser impulse) circuits. The Baudot system has been installed on the Colombo (Ceylon) Madras circuit, which is 800 miles in length ; the installation consists of a "double duplex"—equivalent to quadruplex—and, although the circuit usually works through one repeater, direct working is often carried on satisfactorily.

In South Africa, also, Post Office standard apparatus is in general use, and, as in the Crown colonies, the Vyle polarised sounder is

making considerable headway. One of the longest quadruplex lines is that between Durban and Johannesburg, about 350 miles by line, and this works quite satisfactorily without a repeater. Wheatstone automatic has been in use between the main centres for many years, and the Creed apparatus has been introduced more recently. The decision to adopt this latter system followed an investigation by the Engineer-in-Chief of South Africa of the various heavy traffic systems in use in Europe and America, and for the conditions prevailing in South Africa and the system of traffic circulation proposed it is admirably suited. Wheatstone apparatus was already in use at all the principal centres, so that it was an easy matter to add the Creed outfit. Long distances separate the chief towns, and in the event of a line breakdown the work can be punched up at each end ready for passage through the transmitters once communication is restored. Another point of value is that if the special apparatus should fail the stations can fall back on ordinary Wheatstone working. The Creed circuits are worked duplex, and high-speed duplex repeaters are employed on them where necessary. One of the longest of these circuits is that between Cape Town and Johannesburg, about 1000 miles, and this has two repeaters on it. The latest type of sounder silencer, that recently brought out by the Automatic Telephone Company, on the principle suggested by Major A. C. Booth, of the British Post Office, is being installed. Motor-driven transmitters have been introduced, the motors being of the type adopted by the Post Office.

In Australia the minor circuits are equipped with Morse printers, sounders or telephones, and Morse duplex or quadruplex is employed where the traffic is heavier. Wheatstone automatic is in constant use between the main centres for both ordinary and press work, and this system has recently been extended. Creed apparatus is in use on a circuit which is worked each evening between Perth and Melbourne, *viâ* Adelaide, the length of the line (which passes through four repeaters), being 2300 miles. A reorganisation of the circulation of traffic from small offices has recently been made. Where formerly a number of small offices situated at great distances from the Chief Office of a State, worked direct with the Chief Office on one wire, they are now subdivided and connected, on short lines, with distributing centres which have fast direct communication with the Chief Office. This involves an extra transmission, but the experience is that the traffic is handled more rapidly and congestion is reduced to a minimum.

In New Zealand single-current Morse (both open and closed circuit), Morse duplex and quadruplex are the principal systems in use, and the apparatus is generally of British Post Office type. Single needles have never been used, and the Wheatstone automatic

was discarded some years ago owing to the delay which was found to be incidental to it. The Murray multiplex is being introduced with two quadruple sets at Wellington, which will connect with a similar set at Auckland, and another at Christchurch. It is considered that this system will solve the traffic problems of the Dominion better than any of the other type-printing systems.

In Canadian practice, minor circuits are worked single-current on the closed-circuit system, the battery power being divided generally between the two terminal stations. In some cases the battery power is all at one end. On the more important lines double-current duplex and quadruplex are in use. The Morkrum printing system is also in use on several of the lines of the Canadian Pacific Company. The apparatus generally is of American make and the circuits of American design.

There is one Wheatstone circuit between Montreal and Bamfield, B.C., which is leased by the Canadian Pacific Company to the Pacific Cable Board, but on the public lines there is no Wheatstone, Creed, Baudot, Vyle, or single-needle apparatus in use.

On many of the longer telegraph circuits, repeaters are employed. The longest lines and the number of repeaters on them are as follows:

Company.	Line.		Distance in miles.	System.	No. of repeaters.
	From	To			
Canadian Pacific .	Montreal	Vancouver	2900	Duplex	2
Canadian Pacific .	Montreal	Winnipeg	1400	Printer duplex	2
Great North-Western .	Toronto	Winnipeg	1800	Duplex	2
Grand Trunk . .	Winnipeg	Prince Rupert	1746	Simplex	1
Grand Trunk . .	Edmonton	Prince Rupert	953	Simplex	1

TELEPHONE SYSTEMS.

In the Crown colonies, practically all the standard arrangements, other than the automatic system, are represented, *e.g.* British East Africa and Uganda have several small exchanges of magneto type with plug-restoring line signals, and galvanoscope clearing-indicators operated by relays in bridge across the cords; at Georgetown, British Guiana, there is a magneto exchange equipped with a multiple and "self-restoring" indicators, but no automatic signalling; at Hong Kong and Singapore, magneto lamp-signalling multiple boards (of an ultimate capacity of 5000), with automatic supervisory lamp-signals, are in use; whilst at Port of Spain, Trinidad, there is a common battery multiple board equipped for 1200 lines, with a separate magneto trunk section.

In South Africa, common battery manual boards are in use at

Johannesburg (capacity, 9000 lines), Durban (7200 lines), Cape Town, Pretoria, and several of the important towns on the Witwatersrand. At nearly all the other towns magneto boards on the "ring through" system are employed, some of the boards being equipped for automatic clearing. The installation of an experimental automatic exchange was decided upon some time ago, but the war has interfered with the project.

In Australia, whilst both magneto and common battery exchanges are in use, very considerable progress has been made in installing the automatic system, and probably no country in the world has taken up automatic telephony so whole-heartedly as the Commonwealth. In 1912 the Chief Electrical Engineer personally investigated the systems then in use in America and Europe. His report, dated October 10th, 1912, deals in a very thorough manner with the comparison which may be made between manual and automatic systems. In his review of the question of the suitability of automatic systems for the conditions existing in Australia he attached great weight to the difficulty of obtaining adequately trained and disciplined operators for manually-operated exchanges, but it is not clear to what extent this difficulty influenced the decision to adopt automatics. In comparing the semi-automatic with the full automatic he contended that the view that it is desirable to interpose an operator to control the series of operations that have to be made and to check and correct failures when these occur, is wrong, and he declared himself emphatically in favour of the full automatic for Australia. Since then important headway has been made, and full automatic equipment has been installed in ten exchanges, the largest of which is Perth, with over 3000 subscribers. Six other exchanges are in course of construction or approved, tenders have been invited for a further eighteen, and fourteen others are under consideration. The exchanges so far opened are all equipped with the Strowger system, but both the Siemens and the Western Electric Company's systems are to be tried.

New Zealand was very early in the field in establishing telephone exchanges at its principal centres, and many of the exchanges installed between twenty and thirty years ago are still in operation. The boards are mostly of the old Western Electric magneto type with branching multiple and with drop-shutter line and ring-off indicators. There are also other makes of magneto boards in use. Many of the larger exchanges have become quite inadequate for present requirements, and the question of substituting more efficient systems has been before the authorities for some years past. The introduction of the common battery manual system was contemplated, and three Western Electric common battery exchanges were installed, but the administration hesitated to introduce this system

generally, in view of the development of automatic systems. In 1911, the Chief Electrician of the Department was deputed to inquire into the various systems in use in America and Europe, and as a result of very exhaustive investigations he recommended the adoption of automatic exchanges for several of the principal towns. Experiments were carried out with several automatic systems available at the time, and the Western Electric Company's full automatic system was decided upon as being the best calculated to meet the varied services of the Dominion. Contracts were entered into with this company for exchanges for the Wellington and Auckland telephone areas, and for separate single exchange installations for Masterton, Hamilton, Oamaru, and Blenheim. Masterton and Hamilton are being equipped with 800 lines, and Oamaru and Blenheim for 600 lines. The ultimate capacity of each of these exchanges is the same, viz. 1800 subscribers' lines, and 200 junction lines for special services.

In Canada the Bell Company have magneto boards in the small exchanges and common battery manual boards in the larger exchanges, *i.e.* they have as yet no automatic exchanges; the practice of the Manitoba Government is similar; but in Alberta and Saskatchewan, in addition to magneto and common battery exchanges, the Strowger automatic system is in operation at Calgary, Medicine Hat, Lethbridge, Regina, Saskatoon, and Edmonton: the latter installation was started in 1907 with a 500 line equipment, but it now provides for 10,800 lines (of which 9300 are connected), and comprises four exchanges and an area of, roughly, 20 square miles.

There is no through communication yet between the eastern and western shores of Canada. There is a break of 600 miles between Fort William and Kenora in which there is no telephone line at all, and the Rocky Mountains form another break between Alberta and British Columbia. The longest lines regularly in use in Canadian territory are those between Montreal and Windsor and Montreal and North Bay, distances of about 600 miles. Loading coils are in use on both open wire and underground sections of the long-distance circuits. Communication is given with a large number of places in the United States through the trunk lines of that country, the longest distances being Montreal to San Francisco, 3800 miles, and Toronto to San Francisco, 3200 miles. (Communication has since been arranged between Montreal and Vancouver, *viâ* the American trans-continental line, a distance of about 4000 miles.)

Lightning Discharges and Protectors.

This subject is of special importance in tropical and sub-tropical climates, and the paper concludes with a review of various methods of protection of which experience has been gained.

DISCUSSION.

A very interesting discussion followed the reading of the Paper, but, unfortunately, space does not permit of anything beyond the names of the speakers, namely: Col. A. M. J. Ogilvie, Messrs. Llewellyn Preece, McBerty, Sir William Slingo, Messrs. A. Moir, Walker, Crawter, Monckton, D. H. Kennedy, W. Aitken, F. Gill, Major A. C. Booth, Messrs. H. W. Pendry, G. F. Mansbridge, Kingsbury, Williams, Lieut. McArthur, Messrs. J. Newlands, Harrison, Byng, and Mr. Weightman, in reply.

BLACKBURN AUTOMATIC EXCHANGE.

By S. UPTON,
Sectional Engineer, Blackburn.

As was announced in the Headquarters Notes in the last issue of the JOURNAL the new automatic exchange, the installation of which was considerably delayed by conditions arising out of the War, was opened on October 14th last. This constituted—by a final series of operations occupying a period of seventy seconds—the transfer of 1600 subscribers, including ninety P.B.X.'s and totalling 2200 stations, from one of the oldest magneto systems in the country to a system which can justly be described as embodying the latest improvements in the latest system.

Telephonically, Blackburn is amongst the most important towns in the Kingdom, and with its very high calling-rate is a useful test of the capacity of an auto-exchange to meet the needs of a large business community somewhat exacting in its requirements. It is noticeable that the business people of Blackburn take up a more than usually intelligent and critical attitude towards the telephone service, arising perhaps out of their close association with the National Telephone Company through their prominent townsman, the late Mr. Eli Heyworth; there has, therefore, been widespread interest in the recent change, and the general comments (for the most part favourable) on the quality of the new service are of considerable value.

A full and interesting description of the plant, which was installed throughout by the Auto-Telephone Manufacturing Company, Liverpool, was contributed by Mr. Hedley to the July, 1915, number of the JOURNAL.

The auto-switches, power plant, and main frame are conveniently laid out in a well-lighted room with lino-covered cement floor. The subjoined photographs of the plant may be of interest to readers.

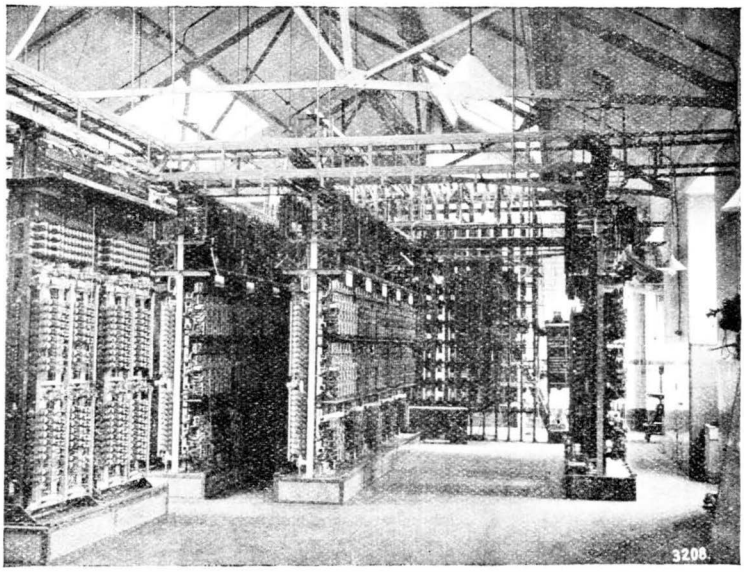
The power plant consists of:

Two batteries of 25 cells. } Each battery has a capacity
Seven counter E.M.F. cells. } of 545 ampère hours.

One motor generator:

Motor side, 440 volts; 16 H.P.
Generator side, 65–80 volts; 160 ampères.
One ringer worked from the 220 volt supply mains.
One dynamotor worked from the exchange batteries.

A special feature, employed for the first time in this country, is direct auto-working between the subscribers of two separate exchange



I.—General View of Primary and Secondary Line Switches and M.D.F.

areas, viz. Blackburn and Accrington. Multi-office automatic working is described by Mr. Hedley in the article referred to, but it may perhaps be useful to include in the present short article the following summary of the connections and operations involved:

Accrington numbers are in 2000 series only.

Blackburn numbers are in 4000, 5000, and 6000 series.

Auto-call from Blackburn subscriber to Accrington subscriber:

(1) Second level of first selectors at Blackburn routes auto-calls to auto-repeaters, the line side of which are connected to junctions terminated on the second selectors at Accrington.

(2) Last three digits of subscriber's number energise second selector and connector at Accrington in ordinary way.

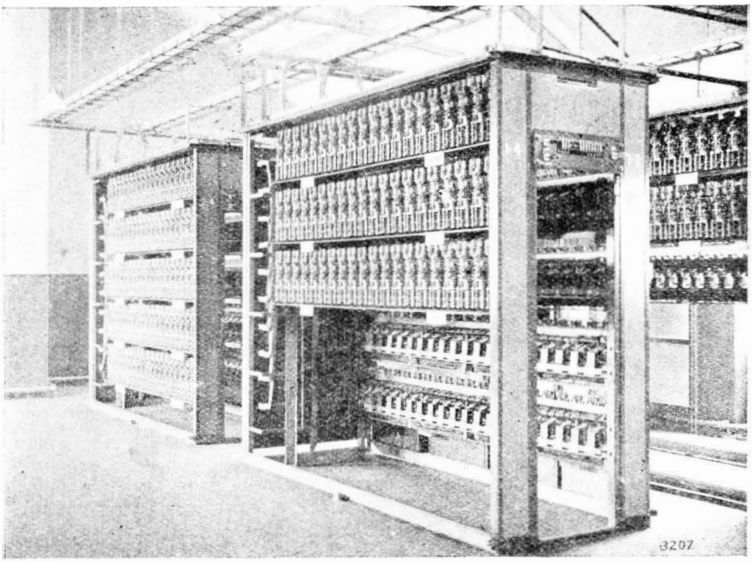
(3) When call answered, reversal in direction of current energises

double-wound relay associated with repeater, which effects necessary reversal of current to caller's loop to register the call.

(4) When wanted number engaged, "busy" tone is transmitted inductively between line and local sides of repeater; no register on meter.

(5) Operations similar, in calling from Accrington subscriber to Blackburn subscriber, but instead of one group of repeaters, as at Blackburn, three groups are necessary to provide for the three levels 4, 5, and 6.

Eighteen junction circuits carry the traffic from Blackburn to



2.—SELECTOR RACKS.

Accrington and sixteen from Accrington to Blackburn—total, thirty-four junction circuits.

The repeating coil arrangements work admirably, and the thirty-four junction circuits have up to the present proved sufficient to carry the peak load of the Accrington–Blackburn and Blackburn–Accrington traffic without serious overflow.

The manual switchboard, consisting of fifteen operators' positions, is on the floor below the auto switch-room. This board carries trunk and outgoing junction traffic only, the incoming junctions being routed through the auto-equipment for direct dialling-in from outlying exchanges.

THE SIMPLIFICATION OF LINE TESTING.

By GEO. F. TANNER, A.M.I.E.E.

IN every case where a loop test is made the question which at once arises to the orthodox is, " What is the weight per mile of the conductor under test ? " In the generality of cases, as for instance, in testing over a paper cable where the conductors are of the same gauge, or it is possible to obtain similar conductors, this knowledge is not only unnecessary, but frequently contributes to a less accurate result.

There is no originality about the following method, yet, as it appears to be seldom used, it is perhaps excusable to bring it under notice.

Providing the conductors comprising the loop under test are of the same gauge, the only known factor required is the distance between the two testing points.

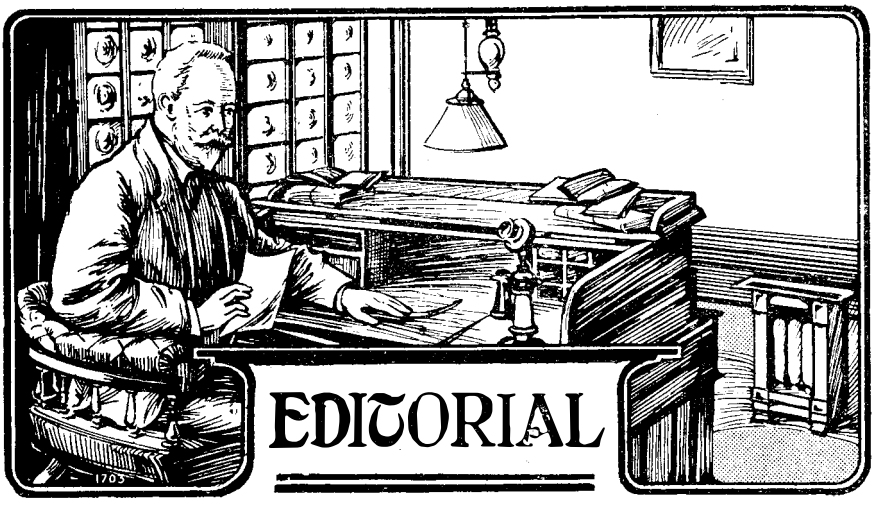
Assuming the conditions of the ordinary Wheatstone Bridge test for an earth fault: then, calling result of resistance of loop test $TS - BM, L$; and result of distance test l, and distance to Birmingham D miles, the distance of fault in miles

$$= \frac{l}{\frac{L}{2}} \times D \text{ or } \frac{l}{L} \times 2\,D.$$

That is, result of first test divided by result of second test, multiplied by twice the distance, gives the distance of the fault in miles.

It will be seen that the result of expressing the distance of the fault as a fraction of the loop is to fractionise also all inaccuracies due to slight variations in weight per individual mile. This method produces a truer result than by slavishly working out the problem on a resistance-per-mile basis.

It came under the writer's notice that the weight-per-mile principle is not quite good enough, as manufacturers infrequently supply slightly more copper than is specified. In short, without going into details, variations do occur from various causes in actual practice. A method was, therefore, sought to combat this source of error, and the foregoing suggested itself. I may add that its application has yielded more successful results in practice than the older and more general method ; it also has the advantage of being much simpler.



EDITORIAL NOTES AND COMMENTS.

The High-speed Telegraphy Committee's Report.

The report of the influential committee appointed by the Postmaster-General "to inquire into systems of high-speed telegraphy and to report thereon" has been laid before the Houses of Parliament, and we publish it verbatim (with the exception of the Appendices) in our present issue. The importance of the subject, not only from a scientific point but from its economic effects upon the body politic, warrants the closest attention being directed to it. The accurate and rapid manipulation of the telegraphs is intimately associated with and is reflected in the commercial life of the country, and the recommendation of a committee of experts, which embody drastic changes in methods, marks the beginning of an epoch that may have far-reaching results.

The problem tackled by the committee was an intricate one. The development of the high-speed printing telegraph reached its present promising condition in time to cope with a traffic which had reached its zenith a few years earlier. Owing to telephone developments in local areas and the progressive extension of trunk-line facilities, the number of telegrams dealt with annually has shown no tendency to increase during recent years, despite the praiseworthy efforts made to co-ordinate the two systems. The existing line plant is sufficient to meet the demands of the traffic, and the main

improvement to be sought for is to reduce the total time occupied in the transmission of messages from the moment of handing in to the time of the actual delivery to the addressee. Fortunately, the line conditions between many important commercial centres have become more stable by the provision of an underground system, and the electrical characteristics of these circuits are more favourable for the operation of duplex multiplex systems than for duplex Wheatstone. The first costs of the apparatus, maintenance, and depreciation had to be considered in addition to its claims for rapid disposal of traffic. Further, and not the least important, was the question of how the staff would be affected. Complexity in machinery generally is introduced with the direct object of increasing the output and reducing the labour charges. The latter is increased by additional maintenance costs, but not in the same proportion as the labour bill should be reduced. The telegraph staffs in the large centres to-day are highly skilled in Morse and Wheatstone operating, but the condition that best meets the claims of printing telegraphs presupposes a less skilled and consequently a less paid operator. It is with some personal interest that we observe the provision of a recommendation, No. 11 in the report, that will tend to safeguard the interest of the telegraphist who will adapt himself to the new conditions.

The recommendations of the committee will meet with the approbation of nearly all telegraph engineers. For some years they had studied the coming of the printing telegraph on multiplex methods, and it only required a decision from a responsible body like the present committee to clinch the matter. The original Wheatstone was beaten early in the struggle, and the question developed into a competition as to whether the Wheatstone plus a keyboard perforator was less efficient than the multiplex printer for ordinary commercial traffic. News and cable work were wisely left out of account, The distribution of news from London as centre has become a highly specialised organism of which the Wheatstone automatic with double-deck perforators operating on lines with several stations in series in each is a very important member. Syphon recorders and undulators possess many advantages for cable work to which the printing telegraph at present lays no claim. The committee was much impressed by the fact that for minor circuits one operator in charge of a channel of a multiplex printer could send at the same time that he was receiving a message. The message is ready for delivery immediately it comes off the line. In theory a Wheatstone message can be written up from the slip at once, but one has only to think of the troubles of the harassed assistant superintendent during a rush of work to remember that theory is not always borne out in practice.

In the development of the printing telegraph the British Post Office has borne no mean part. The Telegraph Section of the Headquarters Staff has initiated many improvements, and experimented with and tested types and systems almost without number. It will be interesting to trace the origin and note the steps that have led to the production of the system most highly recommended by the committee. Everyone will agree that the beginning lay in the invention of the Baudot quintuplex, using a 5-unit alphabet, in 1877. In 1887, the duplexing of the Baudot was tried in France on a single channel between Paris and Nantes, but was abandoned. In the same year an alphabetical keyboard and automatic transmitter were made by M. Carpentier, the Paris maker of French Baudot sets, but the idea was not pursued. In 1905–6 the quadruple Baudot was duplexed, giving an 8-channel circuit, by Mr. A. C. Booth, of the Engineer-in-Chief's Office, and in the same year Mr. Donald Murray invented his 2-channel simplex printer. It was not possible to obtain sufficient Baudot apparatus in this country to instal the duplex circuit till 1910, when a double duplex set was installed between London and Berlin and a quadruple duplex set between London and Birmingham. The apparatus was fitted in the Berlin office by British Post Office engineers. Triple duplex was installed in 1913, quintuple and sextuple duplex in 1914. The German administration installed other sets in 1910, Belgium and France began in 1914, and Holland had agreed to work it in 1913, but apparatus was not available. In the meantime Mr. Donald Murray had introduced the duplex principle on his 2-channel multiplex about 1912. He later sold his rights to the Western Union Company of the United States, and the further work of development was taken up by the sister manufacturing company, the Western Electric Company, one of whose principal engineers was Mr. J. H. Bell, formerly a British Post Office engineer in the Telegraph Section and one time Secretary of our Institution. He brought the first two sets to this country in 1913. Since then it has been given an exhaustive trial, and is giving, it is believed, excellent service on the heavy inter-city lines of the Eastern states.

The main differences between the Western Electric Company's system and the Baudot lie in the provision of a typewriter keyboard which prepares slips for passing through an automatic transmitter, and a page-printing receiver in the case of the former, as against direct sending from a 5-unit keyboard and a tape-printer in the Baudot system. With regard to the question of speed there is not much in it either way, as it is possible to increase the normal speed of running the Baudot from 30 words per minute per channel up to the 40–45 words per minute of the other. Manufacturers of the Baudot should be able to compete on fairly level terms after the war,

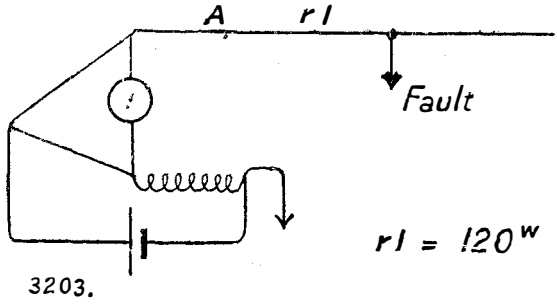
and the price of the Western Electric Company's apparatus should exceed that of the Baudot duplex only by the value the purchaser is prepared to place upon the page-printed method of reception.

The shortage of paper, owing to the policy of the reduction in imports, compels us to reduce temporarily the size of the JOURNAL. The Magazine has now been firmly established for nine years, and we shall endeavour to maintain the continuity, as the Board is convinced that a stoppage even for a short period would have an adverse effect and might endanger its development after the war. The JOURNAL has secured for itself a definite position in the technical literature of the world to-day, and its stoppage would be received by electrical students and workers with the greatest regret. We appeal for the support of our readers everywhere "during the period of the war."

LOCALISATION OF FAULTS IN UNDERGROUND CABLES.

The Managing Editor, THE POST OFFICE ELECTRICAL ENGINEERS JOURNAL.

DEAR SIR,—Mr. Medlyn's article in the January issue reminds me of a simple test which may be of interest to the readers of the JOURNAL, and which I do not remember having seen mentioned previously. In the case of a fractured dry-core cable it is very often the case, especially in small cables, that a good wire is not available



I.—SINGLE WIRE TEST.

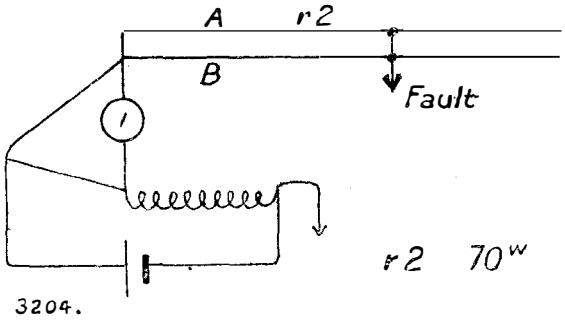
to enable the various loop tests to be applied. In such a case satisfactory results have been obtained by proceeding as follows:

An ordinary conductor resistance test of a single faulty wire is taken to the fault and the reading obtained is, say, 120 ohms. The other wire of the pair or, for that matter, any other wire of similar gauge in the faulty cable is taken and bunched with the first wire tested and the conductor resistance to the fault measured. Assume

the reading to be 70$^{\omega}$, a reduction of 50$^{\omega}$ has therefore been effected by placing the two wires in parallel:
120 − 70 = 50, 50 = ½ resistance of *A* or *B*, ∴ resistance to fault = 100$^{\omega}$.

In other words, the resistance of the line to the fault has been halved and the amount by which the reading has been reduced represents that half.

The resistance of the "earths" is eliminated from the result,



2.—Two Wires Bunched.

which is an advantage and one which is obtained without the necessity of testing from the opposite end of the cable.

Where water has penetrated the cable this test can nearly always be applied, as there is generally no difficulty in obtaining two or more wires of similar gauge showing the same conductor resistance to the fault, the only condition which is necessary to render the test accurate enough for ordinary purposes.

The test has the merit of simplicity both as regards its application and the determination of the results.

Yours faithfully,
Jas. A. Jack.

Glasgow,
February 9th, 1917.

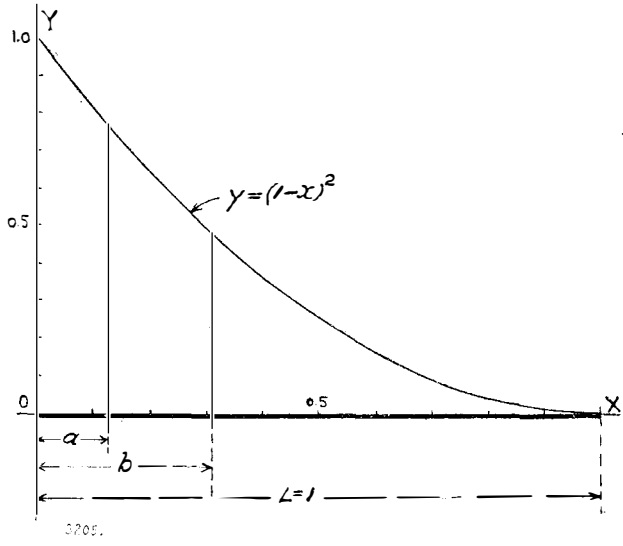
The Balancing of Duplex Circuits.

The Editor, The Post Office Electrical Engineers' Journal.

Dear Sir,—I see now, after reading Mr. Morice's article, that in spite of the fact stated in my letters of April last, viz. that the quantities of electricity for charging the line and the compensating circuit are not equal, yet the instantaneous values of the currents may be made so, and therefore the equivalences given by Mr. Morice in vol. 8, part 3, and by Mr. Hay in vol. 9, part 1, comparing constant capacity with constant voltage arrangements, really exist, which I am glad to acknowledge.

I believe, however, that other statements made in my letter maintain their value, and the deductions made to show that in a real line the sum of the infinite number of products of the capacity elements by the resistances of their discharge paths is equal to $\frac{1}{6}CR$, may be applied to find the correct values of the timing resistances for balancing a real line which are not given by Mr. Morice.

Instead of assuming the line as formed by an increasing number of condensers, it is possible to suppose it as divided into a number of portions having equal discharges, each portion to be balanced by one condenser in the compensating circuit. The problem then consists in finding for each condenser and its timing resistance, the



1.—Discharge Curve.

values that will balance the average discharge from the corresponding portion of line.

The curve in 1 shows the discharges through origin or sending end, due to each element of line at distances x varying from 0 to 1, the equation of the curve being : $y = (l - x)^2$. The area below the curve is: $\int_{x=0}^{x=1} (1 - x)^2 = \left(\frac{x^3}{3}\right)_{x=0}^{x=1} = \frac{1}{3}$ and represents the total discharge through sending end, assuming $C = 1$, $R = 1$, and $V = 1$.

Now, if we have to balance such a discharge by means of three condensers, as in 13, p. 260, we may suppose the line as divided into three portions giving equal discharges, that is, $\frac{1}{9}$ each.

The first length a should be such that—

$$\frac{1}{3} - \frac{(1 - a)^3}{3} = \frac{1}{9}; \quad 1 - a = \sqrt[3]{\tfrac{2}{3}}; \quad a = 1 - \sqrt[3]{\tfrac{2}{3}} = 0{\cdot}127 \text{ or } 0{\cdot}127\ L.$$

The second abscissa b should be—

$$\tfrac{1}{3} - \frac{(1-b)^3}{3} = \tfrac{2}{9}; \quad 1 - b = \sqrt[3]{\tfrac{1}{3}}; \quad b = 1 - \sqrt[3]{\tfrac{1}{3}} = 0{\cdot}30 \text{ or } 0{\cdot}307\ L.$$

Each of the three portions will give $\frac{1}{3}$ of the total discharge or $\frac{1}{9}\ CV$, and therefore each of the three compensating condensers should have $\frac{1}{9}$ of the total capacity of the line.

To find the timing resistances we have first to determine for each portion of the line what is the sum of all the products of the capacity elements by the resistances of their discharge paths, which, as shown in p. 248, vol. 9, is, for the whole line : $CR\int_{x=0}^{x=1} x - x^2$ or eliminating R and C by making each = 1, $\left(\frac{x^2}{2} - \frac{x^3}{3}\right)_{x=0}^{x=1} = \frac{1}{6}$.

The corresponding value for the first portion is then :

$$\left(\frac{x^2}{2} - \frac{x^3}{3}\right)_{x=0}^{x=a} = 0{\cdot}0074.$$

For the second portion is :

$$\left(\frac{x^2}{2} - \frac{x^3}{3}\right)_{x=a}^{x=b} = 0{\cdot}03.$$

For the third portion is :

$$\left(\frac{x^2}{2} - \frac{x^3}{3}\right)_{x=b}^{x=1} = 0{\cdot}129.$$

Therefore, as each condenser k_1, k_2, k_3 is $\frac{1}{9}\ C$, the timing resistances to give the same average retardations as those of the corresponding portions of the line are :

$$S_1 = 0{\cdot}007 \div \tfrac{1}{9} = 0{\cdot}063 \text{ or } 0{\cdot}063\ R_L.$$
$$S_2 = (0{\cdot}03 \div \tfrac{1}{9}) - 0{\cdot}063 = 0{\cdot}207 \text{ or } 0{\cdot}207\ R_L.$$
$$S_3 = (0{\cdot}129 \div \tfrac{1}{9}) - 0{\cdot}207 = 0{\cdot}954 \text{ or } 0{\cdot}954\ R_L.$$

I am unable to put these results to a practical test, and would suggest that experiments, as per **13**, p. 260, be made with a view to confirm whether more accurate balance is obtained than with other values.

I am, dear sir,
Yours sincerely,
FERNANDEZ LAMOTHE.

Central Argentine
Railway Telegraphs,
December 28th, 1916.

Attention is directed to the article on " The Baudot in France " in this issue. France has given many *objets d'art* to the world ; not the least important is that contributed by M. Baudot.

HEADQUARTERS NOTES.

THE sympathy of the entire service goes out to Mr. Noble, Assistant Engineer-in-Chief, on the death of his only son, Second-Lieut. W. McD. Noble, 9th East Kent, attached to Signal Service, R.E., as Brigade Signal Officer, First Infantry Brigade.

He was wounded near Eaucourt L'Abbaye on December 29th, and after an operation, which at first appeared to be successful, he succumbed to internal hæmorrhage on the 31st.

Lieut. Noble was educated at the Merchant Taylors' School and at King's College in the Strand, and at twenty-one he entered a

Photo by J. Beagles & Co.
THE LATE SECOND LIEUTENANT W. McD. NOBLE.

commercial career which gave promise of being very successful. He occupied a prominent part in the athletic life of his school, playing in the Rugby team, and, developing a fine turn of speed, he won many sprints at distances from 100 yards to the quarter-mile, both before and after joining the Army.

He was President of the Brigade Mess, and endeared himself to his brother officers by his ability and social gifts. In writing home the Brigadier-General, Brigade-Major, and Chaplain testified to the regard in which he was held by all ranks.

A fine lad, ever cheerful and full of spirit, his early death forms another of the innumerable tragedies which this war has brought forth. In this case the sorrow is more acute when one remembers that his mother had passed away only a week or two earlier, and that he had returned from the funeral to duty only a few days before he was hit. When misfortunes come not in single spies but in battalions upon one well-known devoted head, let us hope the force of the blow may be lessened by the sympathy and support which his many friends have hastened to offer.

Mr. A. W. Martin.

It is with much regret that we have to record the death of Mr. A. W. Martin, Staff Engineer in charge of the Headquarters' Telephone Section, which took place, after some months' illness, on February 14th.

Mr. Martin started life in the London, Chatham and Dover Railway Company's service, and entered the Post Office service as a telegraphist in November, 1891. Very shortly after entering the

The late Mr. A. W. Martin.

service he was attracted to the Telegraphists' School of Science, where he was a most assiduous student, and became its most brilliant scholar. Whilst there he obtained a First Class Honours Medal in Electricity and Magnetism, and Medals in Telegraphy, Telephony, and Metallurgy, finally obtaining and taking up a Two Years' Scholarship at the Royal College of Science.

He entered the Engineering Department as a Sub-Engineer in August, 1896, being attached to the Headquarters' Staff. His exceptional ability was speedily recognised, and he was made a Second Class Technical Officer in 1899. He was engaged mainly on submarine and paper cable work, and assisted in the pioneer work of the selection of suitable lengths of pairs for joining together to obtain long balanced lengths in the first London-Birmingham underground paper cable. He also devised the method of obtaining two telegraph channels on a pair of wires on long pair underground cables—one channel round the loop and one channel superposed on the loop.

In collaboration with Mr. Dieselhorst, of Siemens Bros., Ltd. he invented the multiple-twin paper core cable, which has stood the test of time, and is still being manufactured for and used by the Department.

He went to Cambridge as Assistant Superintending Engineer in 1904, where he endeared himself to the staff by the genial manner in which he rendered assistance to all who brought any technical difficulties to his notice. Returning to Headquarters in 1907 as a Staff Engineer in the Research Section, he successfully took up the question of the loading of underground cables, and in 1910 won the Senior Silver Medal awarded by the Institution of Post Office Electrical Engineers for his paper on "The Loading of Telephone Cables." He visited Denmark in connection with this subject, where he was able to convince the technical experts that the Post Office was well abreast of the times.

For a short time he was in charge of the Test Section, and in 1911 he was placed in charge of the Telephone Section. In 1910 he visited America with three Post Office colleagues for the purpose of investigating American telephone practice. He was also employed on the work in connection with the valuation of the National Telephone Company's plant.

For some years he was a member of the Council of the Institution of Electrical Engineers, and also of the Council of the Post Office Electrical Engineers. One might reasonably expect that his time would have been fully occupied with his various duties, but he had a marvellous capacity for work, and was for many years head of the Telegraph and Telephone Department at the Northampton Institute where he was a most popular and lucid lecturer.

He had a lovable nature and winning manner, and in his death at the early age of forty-four the Department loses a most capable and valued officer. E. H. S.

DISTRICT NOTES.

London District.

Internal Construction.

Telephone Lines and Stations.—During the thirteen weeks ended January 23rd, 1917, 1723 exchange lines, 3221 internal extensions, and 250 external extensions were provided. In the same period 1339 exchange lines, 1271 internal extensions and 121 external extensions were recovered, making net increases of 384 exchange lines, 1950 internal extensions, and 129 external extensions.

Large P.B.Xs.—The following large private branch exchanges have recently been provided :

War Office (Trades Intelligence Department).—A 2-position switchboard with 10 exchange lines and 109 extensions.

Director-General of Military Railways.—A 5-position switchboard, 26 exchange lines, 195 extensions.

Board of Agriculture.—Two switchboards, 7 exchange lines, 93 extensions.

External Construction.

For the three months ended January 31st, 1917, the net increase in telephone exchange wire mileage in the London Engineering District was 1151 miles, the increase under the head of Underground being 1666 miles, whilst the open (bare wire) and open (aerial cable) decreased by 47 and 468 miles respectively.

Telephone trunk wire mileage increased by 69 miles, while telegraphs decreased by 41 miles.

Pole line increased by 7 miles.

Pipe line increased by 2 miles.

The aggregate mileages in the district at the end of January 1917, under the various services were as follows:

Line Mileage.

Pole line . .	2536 miles.
Pipe line . .	3519 ,,

Single Wire Mileage.

Telegraphs . .	21,337	Including spare wires.
Telephone Exchange	992,892	Excluding wires on railways
,, Trunks .	32,570	maintained by companies.

The total length of underground cable was 7083 miles.

South Midland District.

The holiday rest of the Headquarters Staff of this district was rudely disturbed on Sunday—Christmas Eve—by the news that the district offices were on fire. The outbreak, the cause of which has not been ascertained, originated at the west end of the building, and resulted in the total destruction of two rooms and the main stairway, and extensive damage by heat to the remainder of the house. The contents of the rooms, with the exception of the two referred to, were saved from actual destruction by the practice of keeping the doors shut although the fire was sufficiently fierce to damage all the passages and doors and to burn right through two of the latter. It was evident from the first that further occupation of the building was impossible, and arrangements to transfer to other premises were quickly made. Fortunately, a number of rooms were available in an adjacent house occupied as engineering offices, and the Post Office Surveyor very kindly altered his staff arrangements and placed at disposal additional accommodation in his premises on the same

road. The removal and rearrangement of furniture and records were effected during Christmas Day and Boxing Day by the ready help-

THE A.S.E.'S TELEPHONE AFTER THE FIRE.

fulness and resource of the members of the staff to whom credit is due for a most commendable exhibition of *esprit de corps*.

I.P.O.E.E.: LONDON CENTRE NOTES.

THE Committee were able to arrange for four general meetings during the Session.

In December Mr. B. O. Anson read a paper on the "Western Company's Automatic Telephone System." At this meeting Sir William Slingo, Colonel Ogilvie, and Mr. McBerty (of the Western Electric Co.) took part in the discussion, and much interest was shown in a working model which had been erected by the courtesy of the Company.

The January meeting was taken by Mr. H. H. Harrison (of the Council of the Institution of Electrical Engineers), who read a most interesting paper on "The Story of the Keyboard Perforator." Mr. Newlands and Messrs. Creed and Donald Murray contributed to the discussion. The two latter gentlemen referred in feeling terms to the trials of the "poor" inventor and the difficulties he encountered in marketing his wares.

Mr. Harrison is to be heartily congratulated upon the contents of his paper, and also for the excellence of his illustrations, which were all that illustrations should be.

An important paper by Mr. Charles Robinson was given in February, the title being "Gas Discharge Telephone Relays and their Application to Commercial Circuits."

It is not permissible to refer to the paper other than to say that when national events make it possible to proceed with its publication it will be found that the research work involved, and the progress made in developing this type of relay, will reflect great credit on the Engineering Staff of the British Post Office, and especially on the Research Section of the Engineer-in-Chief's Office.

Messrs. Stubbs, Hart, Shaughnessy, Pollock, and Tandy took part in the discussion, which will be incorporated with the paper.

On March 19th Mr. G. F. Greenham read a paper on "The Provision of a Telephone Exchange."

In view of the dispersal of many members on war work and the difficulty of conducting a satisfactory election the existing Committee, with the approval of the Council, will continue in office for another year.

W. G. O.

LIST OF OFFICERS IN THE ENGINEERING DEPARTMENT HOLDING COMMISSIONS IN THE ARMY OR NAVY (SEVENTH LIST).

Name.	Office or District.	Rank.	Corps.
A. Speight	E. in C.O.	2nd Lieut.	R.E.
D. H. Kennedy	London	Capt.	Headquarters Staff, Military Air Dept.
A. G. Tremain	,,	2nd Lieut.	R.F.C.
A. E. Godfrey	,,	,,	R.E.
F. C. Barker	,,	,,	21st Batt. London Regt.
T. G. Halsall	,,	,,	R.E., S.S.

LIST OF OFFICERS WITHDRAWN FOR ACTIVE SERVICE UP TILL MARCH 1ST, 1917.

Engineering officers	73
Chief inspectors, etc.	43
Inspectors, etc.	157
Clerical officers	1088

Skilled workmen (established)	1988
,, ,, (unestablished, labourers, youths, etc.)	7146
Other grades	487
Total . . .	10,982

106 Royal Engineers.

PROMOTION.

Captain (Honorary) T. F. Purves, R.E., to be Major (Honorary).

MILITARY HONOURS.

THE Board of Editors has great pleasure in publishing the further list of honours awarded to members of the Engineering Department on active service:

Acting-Lance-Corporal J. Pawson, R.E. Signal Service (Skilled Workman, Class II, North-Eastern District). Awarded the Military Medal.

Lance-Corporal (Acting-Sergeant) T. G. Downes, R.E. Signal Service (Skilled Workman, Class II, Eastern District). Awarded the Military Medal.

Captain (Temporary Major) W. L. de M. Carey, R.E. Signal Service (Executive Engineer, Ireland). Awarded the Distinguished Service Order and Mentioned in Despatches.

Temporary Captain G. H. Comport, R.E. Signal Service (Assistant Superintending Engineer, South Midland District). Awarded the Military Cross.

Temporary Captain A. Evans, R.E. Signal Service (Assistant Engineer, North Midland District). Awarded the Military Cross.

Temporary Lieutenant J. Legg, R.E. Signal Service (Assistant Engineer, Engineer-in-Chief's Office). Mentioned in Despatches.

Sapper W. Cain, R.E. Signal Service (Skilled Workman, Class II, South Wales District). Awarded the Military Medal.

Sapper J. Carter, R.E. Signal Service (Skilled Workman, Class II, North Wales District). Awarded the Military Medal.

Sapper F. H. McLaren, R.E. Signal Service (Labourer, North-Eastern District). Awarded the Military Medal.

Sapper S. Owen, R.E. Signal Service (Unestablished Skilled Workman, North Wales District). Awarded the Military Medal.

Company-Sergeant-Major C. H. S. Rodway, R.E. Signal Service (Second Class Clerk, London District). Mentioned in Despatches.

Sapper A. H. Wright, R.E. Signal Service (Labourer, London District). Awarded the Military Medal.

Brevet-Lieutenant-Colonel (Temporary Colonel) E. V. Turner,

R.E. Signal Service (Superintending Engineer, Ireland). Awarded the Distinguished Service Order and Mentioned in Despatches.

Temporary Captain W. M. Batchelor, M.C., R.E Signal Service (Assistant Superintending Engineer, Northern District). Mentioned in Despatches.

Temporary Captain W. M. Evans, R.E. Signal Service (Assistant Superintending Engineer, Ireland). Mentioned in Despatches.

Temporary Lieutenant P. Dunsheath, R.E. Signal Service (Assistant Engineer, Engineer-in-Chief's Office). Mentioned in Despatches.

Temporary Lieutenant W. J. Gwilliam, R.E. Signal Service (Executive Engineer, South Midland District). Mentioned in Despatches.

Temporary Lieutenant W. S. Mountain, R.E. Signal Service (Principal Clerk, Engineer-in-Chief's Office). Mentioned in Despatches.

Second Lieutenant (Temporary Lieutenant) H. F. Picker, R.E. Signal Service (Assistant Engineer, Engineer-in-Chief's Office). Awarded the Military Cross.

Temporary Second Lieutenant B. J. Stevenson, Intelligence Corps (Second Class Engineer, Engineer-in-Chief's Office). Mentioned in Despatches.

Second Corporal A. Arnold, R.E. Signal Service (Skilled Workman, Class II, Scotland West District). Mentioned in Despatches.

Driver G. A. J. Hale, R.E. Signal Service (Youth, Engineer-in-Chief's Office). Awarded the Military Medal.

Sapper H. Kandes, R.E. Signal Service (Youth, South-Western District). Awarded the Military Medal.

Sergeant H. S. Bryant, R.E. Signal Service (Skilled Workman, Class II, South Wales District). Mentioned in Despatches.

Sapper G. H. Daitry, R.E. Signal Service (Unestablished Skilled Workman, London District). Awarded the Military Medal.

Lance-Corporal E. Scatchard, R.E. Signal Service (Unestablished Skilled Workman, South Midland District). Awarded the Military Medal.

Sergeant H. J. White, R.E. Signal Service (Skilled Workman, Class II, London District). Awarded the Meritorious Service Medal.

Sergeant W. F. Adams, R.E. Signal Service (Third Class Clerk, London District). Awarded the Military Medal.

Sapper E. Bulloch, R.E. Signal Service (Unestablished Skilled Workman, Scotland West District). Awarded the Military Medal.

Sapper J. O'Brien, R.E. Signal Service (Unestablished Skilled Workman, Scotland West District). Awarded the Military Medal.

Sapper J. O'Connor, R.E. Signal Service (Skilled Workman, Class II, Scotland West District). Awarded the Military Medal.

Sapper H. Smith, R.E. Signal Service (Unestablished Skilled Workman, North Wales District). Awarded the Military Medal.

Major J. Day, R.E. Signal Service (Executive Engineer, Ireland District). Awarded the Distinguished Service Order and Mentioned in Despatches.

Captain A. Lloyd Owen, R.E. Signal Service (Executive Engineer, Ireland District). Awarded the Military Cross.

Temporary Second Lieutenant (Temporary Captain) A. G. Lee, R.E. Signal Service (Assistant Staff Engineer, Engineer-in-Chief's Office). Mentioned in Despatches.

Sapper W. J. J. Daines, R.E. Signal Service (Youth, Eastern District). Awarded the Military Medal.

Lance-Corporal M. B. Rogers, R.E. Signal Service (Unestablished Skilled Workman, Eastern District). Awarded the Military Medal.

Acting Corporal H. Rose, R.E. Signal Service (Skilled Workman, Class II, South-Eastern District). Awarded the Meritorious Service Medal and Mentioned in Despatches.

Captain A. Evans, R.E. Signal Service (Assistant Engineer, North Midland District). Awarded the Order of the White Eagle, 5th Class (with Swords), Serbian.

Pioneer B. Crabb, R.E. Signal Service (Labourer, Scotland East District). Awarded the Military Medal.

Sapper (Acting Second Corporal) E. H. Game, R.E. Signal Service (Unestablished Skilled Workman, South-Eastern District). Awarded the Medal of St. George, 3rd Class, Russian.

Sapper W. Miller, R.E. Signal Service (Unestablished Skilled Workman, Scotland West District). Awarded the Gold Medal, Serbian.

Sapper W. J. Morton, R.E. Signal Service (Unestablished Skilled Workman, Eastern District). Awarded the Military Medal.

Sapper J. B. Sullivan, R.E. Signal Service (Unestablished Skilled Workman, South-Eastern District). Awarded the Silver Medal, Serbian.

Temporary Second Lieutenant C. W. Taylor, Royal Fusiliers (Assistant Clerk, London District). Awarded the Military Cross.

Sapper P. J. Dunne, R.E. Signal Service (Unestablished Skilled Workman, Ireland). Awarded the Military Medal.

Sapper (Acting Lance-Corporal) H. N. Ford, R.E. Signal Service (Skilled Workman, Class II, Eastern District). Awarded the Military Medal.

Sapper (Acting Sergeant) F. R. Hammond, R.E. Signal Service (Unestablished Skilled Workman, South Lancashire District). Awarded the Military Medal.

Second Lieutenant (Temporary Lieutenant) H. Cranage, R.E.,

Signal Service (Chief Inspector, South Wales District). Mentioned in Despatches.

Sapper A. Geraghty, R.E., Signal Service (Labourer, North-Western District). Mentioned in Despatches.

ROLL OF HONOUR.

THE Board of Editors sincerely regrets the deaths on active service of the undermentioned members of the Engineering Department. Tenth List.

Name.	Rank.	District.
T. Armstrong	Unest. Skilled Workman	Scot E.
E. Astle	Temporary Draughtsman.	London.
W. Bamber	Labourer	N. Wales.
R. Biddle	Unest. Skilled Workman	S. Wales.
G. Bradley	Labourer	London.
J. C. Bray	Clerical Assistant	N. Mid.
A. T. Ekers	Skilled Workman, Cl. II	S.E.
H. Elliott	Youth	S. Lancs.
E. C. Evans	Unest. Skilled Workman	London.
A. W. Eyles	Labourer	,,
J. A. Exley	Youth	,,
J. Finch	,,	N. Wales.
C. Garrick	Boy	Scot. E.
W. H. Goodall	Labourer	Eastern.
F. Green	Skilled Workman, Cl. II	Scot. W.
W. Hamilton	Labourer	,,
H. A. Harris	Unest. Skilled Workman	N. Wales.
E. Hill	,, ,, ,,	Scot. E.
G. Holt	Labourer	S. Lancs.
J. Holt	,,	S. Mid.
B. Kempsey	,,	N. Wales.
F. G. Lee	Unest. Skilled Workman	Met. Power.
G. Maclean.	Labourer	Scot. E.
C. E. J. Mansell	Unest. Skilled Workman	S. Wales.
J. Mansell	Skilled Workman, Cl. II	S. Wales.
J. W. Marsden	Youth	North-Western.
W. M. More	Unest. Skilled Workman	London.
A. H. T. Morgan	Inspector	S.W.
R. Oxley	Unest. Skilled Workman	S.E.
D. L. Parker	Youth	Scot. W.
J. Parker	Labourer	London.
A. H. Pearce	,,	Eastern.
A. Rankin	Unest. Skilled Workman	London.
J. P. Ross	Clerk, Third Class	Scot. W.
C. E. Russell	Unest. Skilled Workman	London.
G. F. Sharpe	Skilled Workman, Cl. II	Scot. W.
J. Shiels	,, ,, ,,	Ireland.
A. A. Stooke	Skilled Workman, Cl. II	N. Mid.
H. C. Stretch	Labourer	Eastern.
A. B. Tatlow	Clerical Assistant	N. Mid.

Name.	Rank.	District.
G. F. Trotman	Labourer	London.
B. Tupper	Youth	,,
F. E. Ward	Labourer	S. Mid.
A. E. Western	,,	London.
E. R. Whitehead	Youth	,,
J. B. Wilks	Unest. Skilled Workman	S. Wales.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

RETIREMENT.

Name.	Rank.	District.	Date.
Crane, J.	Executive Engr.	S. Lancs.	31 : 12 : 16

TRANSFERS.

Name.	Rank.	Transferred from.	To.	Date.
De Wardt, R. G.	Asst. Engr.	E. in C.O.	Scotland West	22 : 1 : 17

DEATHS.

Name.	Rank.	District.	Date.
Martin, A. W.	Staff Engineer	E. in C.O.	14 : 2 : 17
Stubbs, W. J.	Executive Engineer	N. Mid. Dist.	16 : 2 : 17
*Brooks, A. A.	Clerk, 3rd Class	S.E. Dist.	14 : 11 : 16
*Powell, S. A.	,,	S. Mid. Dist.	17 : 11 : 16
*Ross, J. P.	,,	Scot. W. Dist.	27 : 12 : 15
Austin, F.	,,	S. Mid. Dist.	18 : 2 : 17

* Killed in action.

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, G.P.O. West, London, E.C.

Binding covers and copies of the Contents Index for Vol. 9 are now available, and may be obtained from the local agents for 1*s.* and 2*d.* respectively. Subscribers can have their copies bound, with index included, at a cost of 1*s.* 9*d.*, by sending the JOURNALS to the local agents. Orders should indicate whether the original binding covers, or the later pattern, are required.

A supply of the first instalment of the Station List of Engineering Officers eligible for membership of the Institution, issued with the April, 1914, number of the JOURNAL, and including all officers down to Assistant Engineers, is in stock, and copies can be obtained on demand, price 3*d.* each.

INDEX TO ADVERTISERS.

Printed and Published by H. Alabaster, Gatehouse & Co., at 4, Ludgate Hill, London.